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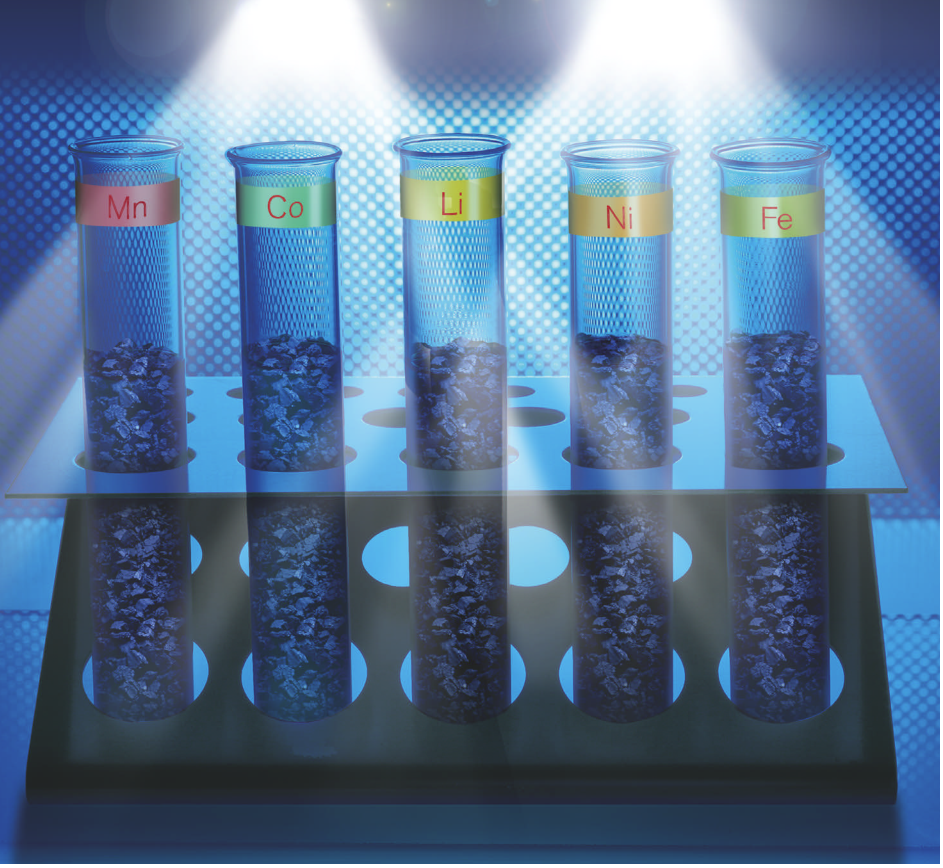

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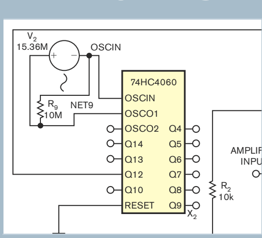

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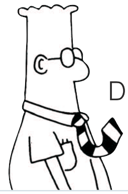

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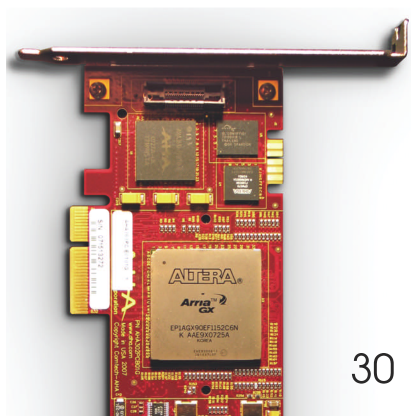

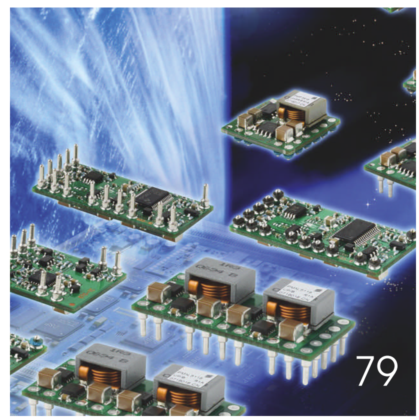

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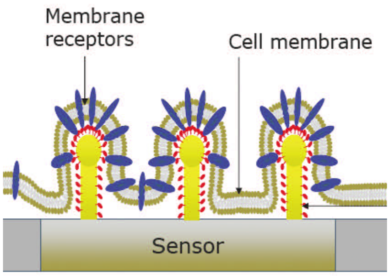

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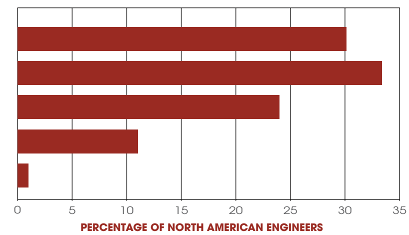

SALARY SURVEY

How does your salary stack up?
EDN recently completed a study of salaries and career trends among engineers. Our 2007 Salary Survey looks at salaries, job responsibilities, career satisfaction, essential skills, and the outlook for the profession around the world. Find out how much engineers make in your region and abroad, how engineering salaries are increasing, how many hours engineers are working, whether their companies are outsourcing (and where to), and much more.
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The salary survey was part of *EDN*'s 2007 *Global Report*. Read more on the survey in Editorial Director Maury Wright's article: **Globally, engineers share similar gratification and concern**
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BY MAURY WRIGHT, EDITORIAL DIRECTOR

Mechatronics vision requires data standards and interfaces

This year, *EDN*, along with sister publications *Design News* and *Control Engineering*, launched the Mechatronics Zone Web site (www.designnews.com/mechatronicszone). As you all know, engineers have long integrated electronic-control systems with mechanical sensors and actuators to create products that span a wide range—from factory automation to toys. Of late, however, more and more people, ranging from academics to chip and software vendors, are talking about mechatronics as a distinct engineering discipline. I'm not sure that I buy that distinction.

But the Mechatronics Expo, which we co-hosted last month in Burlington, MA, revealed some interesting ideas on modeling electromechanical systems. *EDN* and its sister publications comprehensively cover the mechatronics arena; that coverage led to our partnership on the Web site and the Mechatronics Expo. (See "Mechatronics Expo helps define the field, integrate engineering disciplines" at www.controleng.com/article/CA6490445 for a summary of the presentations from the expo.)

"Mechatronics" is not a new term; its usage dates back at least 25 years. Search the Web, and you will find many definitions. Basically, mechatronics combines electronic engineering, mechanical engineering, and computer science. A growing number of universities, including Rensselaer Polytechnic Institute (www.rpi.edu) and the University of California—Berkeley (www.berkeley.edu) offer degrees in mechatronics, generally within their mechanical-engineering departments.

To me, the idea of modeling a complete electronic and mechanical system was by far the most interesting concept the expo presented. In the electronics arena, we are comfortable using modeling and simulation tools. There are fewer such tools in the mechanical arena, although tools such as SolidWorks (www.solidworks.com) do support modeling of mechanical systems. Today, however, no currently available tools allow you to model both the electronic and the mechanical systems and allow them to interoperate during development. Such an electromechanical-modeling and -simulation environment would speed product development by allowing work to proceed simultaneously in both domains and by allowing designers to catch problems early in the design cycle.

National Instruments (www.ni.com) has been among the most ardent promoters of an environment in which you jointly model and simulate an electromechanical system. At this year's National Instruments Week conference (www.ni.com/niweek), which took place in Austin, TX, in August, the company presented a demonstration of a SolidWorks model working with a control system that NI developed in LabView. It was a compelling demo but a long way from having broad applicability.

Our Mechatronics Expo revealed the obstacles to mechatronics modeling and simulation. The electronics domain has modeling and simulation standards and technologies galore. No analog-component vendor would release a product without offering a SPICE model. Those models are one piece in a large stack of technologies that allows electronics engineers to model complete electronic systems.

The mechanical domain, however, lacks a foundation for modeling. There are no standards, such as SPICE, for modeling baseline components, such as sensors and actuators. So, is there life in a vision of a new approach to mechatronics-system design with modeling and simulation? Or is the mechatronics trend at the university level just an indication that more and more from the mechanical domain has moved into the electrical domain? Mechanical engineers can now take advantage of complex electronic devices, such as microcontrollers and FPGAs, because the software tools have become so easy to use.

I'm struggling with the mechatronics trend. I see possibilities in modeling and simulation. But that vision will require the creation of standards for models. It will require data-interface standards that allow software tools from different domains to interoperate. The electronics industry has been working on the electronics side of the issue in the EDA arena for more than 25 years, and the EDA world is far from perfect. Integrating electronics and mechanics in the modeling domain will be a stiff challenge.

I'd like to know what you think about mechatronics. Do you consider yourself a mechatronics engineer? Along with the Web version of this column at www.edn.com/071122ed1, we are hosting a brief survey on mechatronics. Please take a few minutes to respond.**EDN**

Contact me at mgwright@edn.com.

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Powering FPGAs Using LM201xx PowerWise® Synchronous Buck Regulators

Application Note AN-1745

P. Ranucci, Design Engineer

The LM201xx PowerWise® synchronous buck regulators are full-featured products, capable of delivering up to 5A of continuous output current. The devices in the family operate from input voltages between 2.95V and 5.5V and convert down to outputs as low as 0.8V. The integrated low RDSon FETs enable a very efficient power supply solution for the multiple rails required to power a FPGA. All of the devices are current-mode controlled providing excellent line regulation and load transient response, and require only two external components for compensation. They feature precision enable, soft-start, tracking, UVLO, OVP, over-temp protection, and PGOOD. The soft-start pin can be used with a capacitor to control start-up inrush current or with an external voltage source to track or sequence multiple supplies. All devices can start into a pre-biased output without discharging it, and they have a diode emulation mode for higher efficiency at light loads. The devices are differentiated by output current capability (3A, 4A, and 5A), frequency (500 kHz, 1 MHz, and 1.5 MHz), and synchronization mode (free-running, sync-in, sync-out, and external resistor adjust). Based on the supply requirements of the FPGA design, an appropriate combination of devices can combine to create a small, efficient, and complete solution.

FPGA Power Supply Requirements

There are several high performance FPGAs currently on the market such as the Xilinx Virtex and Spartan series, and the Altera Cyclone and Stratix series. All of these require multiple power rails including the FPGA core, the I/O, as well as additional rails for powering clocks, PLLs, transceivers, and other circuitry. The core voltage in FPGAs can currently be as low as 0.9V with the current demand for this rail being highly dependent on the utilization of the FPGA. FPGA manufacturers offer power estimation software which assists users in identifying their power needs based on the performance requirements of the design. The I/O rail can also have demanding power needs depending on the number of I/O registers employed in the FPGA design. Most of the latest generation FPGAs have internal POR circuitry which can eliminate the need for power rail sequencing. Select FPGAs specify input inrush currents for particular power-up sequences and others require sequencing rails to avoid start-up or latch-up problems. Start-up time requirements for FPGA rails are varied ranging from 100-200 us at the fastest and 50-100 ms at the slowest.

Example FPGA Power Supply Design

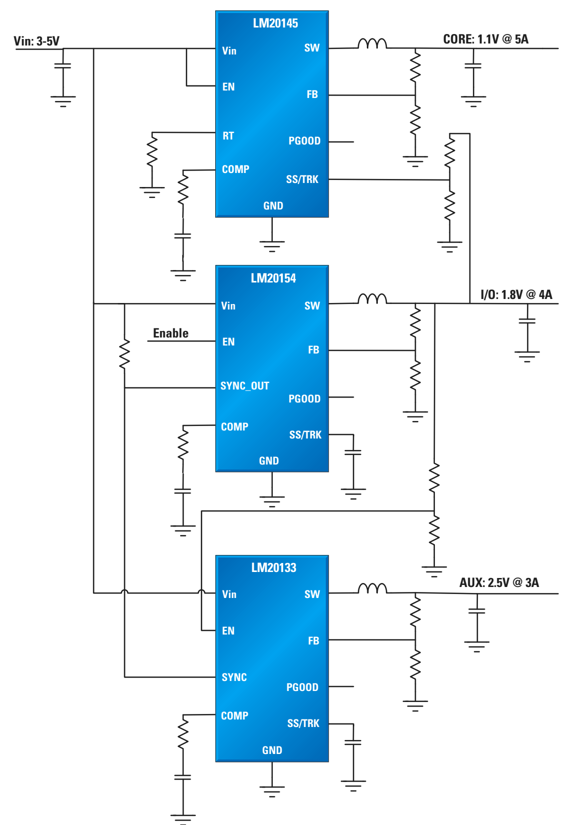
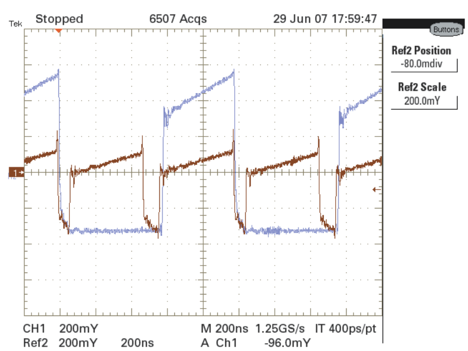


Figure 1. Example FPGA Power Design

For the purposes of illustration, an example FPGA power supply design is shown in block diagram form in ***Figure 1***. This design features a LM20145 supplying a core voltage of 1.1V capable of delivering up to 5A, a LM20154 supplying an I/O voltage arbitrarily chosen as 1.8V capable of delivering up to 4A, and a LM20133 supplying an auxiliary rail of 2.5V at 3A. Output voltage rails can regulate within 1.5% over temp and are also easily scaled by a resistor divider between the output and the FB pin. All of the devices are packaged in a slim exposed pad TSSOP-16 package enabling a compact power supply design. Additionally, they are pin-to-pin compatible so output current capability can be easily scaled to the FPGA design's power requirements simply by choosing different devices in the family.

Design Features

One of the features highlighted in this design is the many useful frequency synchronization options available. The LM20145 has a resistor adjustable frequency which can be tuned to keep switching noise within a particular spectrum. The LM20133 is a sync-in part which can be synchronized to an external clock signal to achieve the same effect. In this case the LM20133 is synchronized to the sync-out signal coming from the LM20154 which has the added benefit of synchronizing the two parts 180° out of phase. This reduces input ripple current on the input power supply and can thus reduce the input capacitor requirements. *Figure 2* shows an example of input ripple current reduction using out of phase converters.



Ch1: i_{Cin} (2A/div), Ref2: i_{Cin} (2A/div), Time scale: 200ns/div

Figure 2. Input Capacitor Current Comparison of LM20134/LM20154 (out of phase) and LM20154/ LM20154 (in phase) based Buck Regulators

All of the devices have flexible sequencing options as shown in *Figure 3*. In the example design, the LM20145 is "tracked" off of the I/O rail by using the SS pin with a resistive voltage divider. This type of sequencing, known as simultaneous sequencing, allows the voltage difference between the two rails

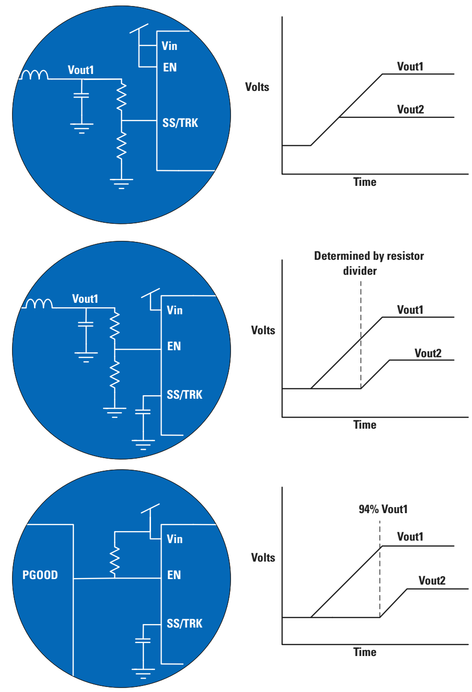


Figure 3. Multiple sequencing options

to be minimized which can eliminate parasitic conduction paths between the two rails. The precision EN pin on the LM20133 allows it to be sequentially sequenced by the LM20154 using a voltage divider from the I/O rail. Another method for sequencing involves attaching the PGOOD pin of one part to the EN pin of another. In that case the second part will enable when the output of the first has reached 94% (typ) of its final value.

Conclusion

The LM201xx family offers a full range of features and options enabling a FPGA designer to fully customize their power solution to meet the system application needs. Full details of the many options and useful features of the entire LM201xx family can be found in the product datasheets at www.national.com/switcher.

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Embedded computer aids military missions

Targeting military-embedded-system applications, such as mission-management computers, heads-up-display controllers, radar-signal processors, and IED (improvised-explosive-device) vehicle-protection subsystems, Aitech Defense Systems recently announced the C108 single-board computer. The rugged, 6U, single-slot VME computer offers as much as 1.4 GHz of processing power through the G4+ PowerPC MPC7448 processor, along with multiple memory options for design flexibility. In addition to the 1 Gbyte of onboard SDRAM, the C108 features 128 Mbytes of flash memory for user-application storage, 32 Mbytes of boot-flash memory, and as much as 4 Gbytes of high-density flash memory for mass data storage.

The C108 supports new and legacy systems through a host of I/O interfaces, including a GbE (Gigabit Ethernet) port, two Fast Ethernet ports, two dual-redundant military-standard-1533B interfaces, two USB ports, eight serial ports, 16 discrete I/O channels, and an optically isolated CAN (controller-area-network)-bus 2.0B interface. Two PMC (PCI-mezzanine-card) expansion slots accept standardized plug-ins to increase the board's performance. The C108 also features two independent PCI buses to maximize PCI-bus usage and to enable various configurations. The first bus can operate at 33 or 66 MHz, and the second operates only at 33 MHz to help separate fast and slow devices and enable each to operate at its maximum speed. Both buses support 64-bit operation and fully comply with PCI Revision 2.2. A board-support package for the new C108 is available for Wind River's (www.windriver.com) VxWorks and Green Hills Software's (www.ghs.com) Integrity, and other real-time operating systems are available upon request. Prices for the C108 start at $6640.


Aitech's new rugged, 6U C108 VME single-board computer offers military designers 1.4-GHz processing power, optional PCI-bus architectures, and multiple I/O interfaces.

—by Warren Webb

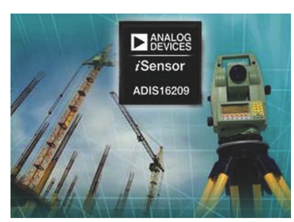
▷**Aitech Defense Systems Inc**, www.rugged.com.

MEMS-based inclinometer brings accuracy, ease of calibration to industrial applications

Inclinometers, which are specialized versions of accelerometers, indicate deviation from the vertical by sensing the downward G force. Some consumer-game controllers have used versions selling for approximately $3, but industrial applications require a higher level of accuracy as well as ease of calibration that lower-cost consumer-grade devices can't provide. Targeting the industrial market, Analog Devices has introduced the programmable, dual-mode—that is, vertically or horizontally mounted—MEMS (microelectromechanical-system)-based ADIS16209 inclinometer, which can measure dual-axis tilt with less than 0.1° error across a ±30° range in a horizontally mounted setup. The sensor data is available through an industry-standard serial-peripheral-interface port and includes inclination with 0.025° resolution, acceleration with 0.244-mg resolution, and temperature. The device also has a 12-bit auxiliary ADC input and a DAC output.

Typical industrial applications for inclinometers include surveying equipment, satellite-antenna-stabilization systems, automotive-wheel alignment, and autonomously piloted farm equipment.

The device sells for $34.40 (1000) in a 9.2×9.2×3.9-mm, laminate-based LGA package.



The programmable, dual-mode, MEMS-based ADIS16209 inclinometer measures dual-axis tilt with less than 0.1° error across a ±30° range.

—by Margery Conner

▷**Analog Devices**, www.analog.com.

Semiconductor-characterization system eases capacitance/voltage testing

Keithley Instruments has announced a new CV (capacitance/voltage)-measurement-instrument module for its model 4200-SCS (semiconductor-characterization system). The 4200-CVU module plugs into the 4200-SCS and allows measurement of capacitance from femtofarads to nanofarads at frequencies of 10 kHz to 10 MHz. The design, for which eight patents are pending, enables point-and-click setup, permits simple cabling, and features built-in element models and an extensive set of test libraries that eliminate guesswork. According to the company, the module enables users at all experience levels to perform these tests as easily as experts can.

To further improve testing efficiency, the 4200-LS-LC-12, a special switch matrix and card with cables and adapters, enables tightly integrated CV and IV (current/voltage) testing with a single prober touchdown. An optional kit allows easy connection to the most widely used probers, making the setup and execution of comprehensive CV tests as easy as those of IV tests.

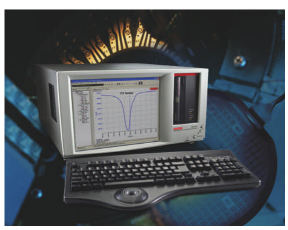
According to a company spokesperson, the 4200-CVU and optional modules solve the problems of other characterization systems that either lack integrated CV and IV testing and pulse capabilities or offer limited support in their user interfaces and software libraries. Moreover, the system's capable test-execution engine simplifies combining IV, CV, and pulse tests in the same test sequence, enabling the 4200-SCS to replace a variety of electrical test tools. Nevertheless, the system will continue to support CV, IV, pulse, and other test methodologies through several third-party instruments. Together with its compactness, these characteristics suit the system to materials and device research, development of semiconductor technology and processes, and reliability evaluation.

According to Keithley, many instrument manufacturers produce products that are incompatible with each other; announcements of new products, therefore, often signal the end of previous offerings—leaving earlier investments unprotected. Keithley's policy of continuing hardware and software upgrades means that you can retrofit the 4200-CVU, along with all associated software and optional hardware, into all the previous 4200-SCS models. This scenario eliminates the need to buy a new parametric analyzer every few years to accommodate innovations in device and materials technology. Cost-effective upgrades enable current systems to keep pace with evolving test needs, so capital investments in the 4200-SCS stretch further than do investments in competing products. These upgrades also minimize expenditures for external hardware and test-program development.

US prices for the model 4200-CVU module, 4200-LS-LC-12 kit, 4200-prober kit, and 4200-CVU-upgrade (hardware and software for an existing 4200-SCS) are $13,000, $7270, $2000, and $15,500, respectively.

—by Dan Strassberg

▷**Keithley Instruments**, www.keithley.com.



With the addition of a 4200-CVU module, this 4200-SCS (semiconductor-characterization system) performs CV tests as easily as it performs IV tests. Moreover, an upgrade package can adapt even the earliest version of the 4200-SCS to the 4200-CVU.

DILBERT By Scott Adams

11.22.07

ANALOG-OUTPUT BOARD PACKS IN 32 CHANNELS

With applications requiring multiple analog waveforms or accurate switched stimuli in mind, UEI (United Electronic Industries) recently released the DNA-AO-332 with 32 channels of 16-bit-resolution analog output covering a ±10V range. A 1024-sample FIFO on each channel allows 10-kHz updating of each DAC without data loss. You can also set all outputs to update simultaneously. The board can drive ±10 mA, and per-channel digital offset and gain calibration limit gain and offset errors to ±450 and ±305 μV, respectively.

The DNA-AO-332 provides as many as 192 analog outputs in a 4×4×5.8-in. form factor. Software for the DNA-AO-332 provides an application-programming interface compatible with Windows, Linux, and most other real-time operating systems. The board also supports LabView, Matlab/Simulink, and DasyLab. The DNA-AO-332 sells for $2400.—by Warren Webb

▶**UEI, www.ueidaq.com.**

The DNA-AO-332 32-channel, 16-bit, analog-output board boosts the signal density for the vendor's cube architecture.

EDA start-up Pyxis unveils yield-driven IC router

With Mentor Graphics' (www.mentor.com) acquisition this year of Sierra Design, IC-design groups have more choices than ever when it comes to shopping for IC place-and-route tools. Now, start-up Pyxis Technology has introduced its commercial place-and-route system, making the selection even larger and the choice more difficult. The NexusRoute hybrid grid- and shape-based router tightly couples to foundry data. The company also announced NexusYield design services to help its customers route blocks and chips.

In preparation for the 45-nm node, the "big four" EDA companies—Cadence Design Systems (www.cadence.com), Synopsys Inc (www.synopsys.com), Mentor Graphics, and Magma Design Automation (www.magma-da.com)—have been diligently adding DFM (design-for-manufacturing) tools to their tool lineups and integrating DFM awareness into their place-and-route flows. Pyxis officials believe that its new offering will give users an edge over the competition because the company built the router from the ground up to incorporate manufacturing data into the routing process. "We are trying to address yield and manufacturability issues," says Phil Bishop, Pyxis' chief executive officer. "There are three major components of yield: random defects affecting random yield; printability issues affecting systematic yield; and copper dishing, or CMP [chemical-mechanical polishing] affecting parametric yield. More and more, we're seeing yield become design-dependent."

Most vendors endorse an iterative flow, in which users perform placement and routing, runtime analysis, and signal-integrity analysis. They then perform a postroute optimization; run DFM analysis, typically including yield, lithography, and CMP; and then run physical verification. This flow typically requires users to run multiple iterations among the various tools before they complete a design, which takes time and money. After they complete the chip design, they send it to the foundry, which may discover further problems that may require changes in the design step or even require new and expensive mask sets.

To address these problems, NexusRoute consolidates routing, timing analysis, signal-integrity analysis, postroute optimization, and DFM analysis into a single-pass flow. Pyxis claims that the tool provides a fourfold reduction in the design-and-manufacturing cycle. "We have zeroed in on a new approach, tightly linking manufacturing with design, to achieve manufacturing closure," says Bishop. "Within the database and the tool, we are looking at the routability, the throughput of the core-based routing, timing closure, and signal integrity. We are also looking at manufacturing effects, such as spreading wires, fattening wires, and protecting vias with secondary shapes or redundant vias. All of these approaches are attempts at removing yield detractors."

The tool allows users to instantly see what effects their designs will encounter in the random-, systematic-, and parametric-yield domains. The company integrated 34 DFM rules into the router to drive functions such as wire widening and spreading; jog elimination; 3-D-wire balancing; metal and via fill; lithography-pattern elimination, including necking and bridging; via minimization; and via protection through the use of double cuts and extra shapes. Pyxis' DFM-analysis partner, PDF Solutions (www.pdf.com), provided much of the data on random and systematic yield for the rules running on the Pyxis tool, and Brion-ASML (www.asml.com) provided data on photolithography analysis. The company also worked closely with Ponte Solutions (www.ponte.com) for analyzing random-yield effects. NexusRoute reads PDF Solutions' yield-ramp-fail-rate-data PDFx models. "We're not just improving yield; we're measuring it and trying to give feedback on exactly what the router has done to incrementally improve the yield," says Bishop.

The PDFx data is especially effective in the router if the customer is targeting a foundry for which PDF Solutions has done characterization services. If customers are targeting a different foundry process, however, they can use generalized PDFx models of a process node. The tool also reads the standard physical-design formats, such as LEF (library-exchange format), DEF (design-exchange format), .lib/Liberty, and SPEF (standard parasitic-exchange format) to interface with other vendors' flows. The company is also a member of OpenAccess (www.si2.org) for interoperability with third-party vendors and has Silicon Canvas (www.sicanvas.com), the provider of the Laker analog and full-custom-layout tool, as a partner.

Primarily a gridded router, the tool is shape-aware, which is important for routing at nodes smaller than 65 nm because designers must perform DRC (design-rules checking) while routing. The multithreaded tool also supports distributed processing to speed runtimes, which is especially useful during detailed routing, when the computationally intensive shape-based features are necessary. The company claims that, in benchmark tests, NexusRoute achieved a 5.1 to 11.1% better yield on 90-nm designs and 6.8 to 7.5% better yield on 65-nm designs than the major competitors in the IC-routing market. NexusRoute sells for $400,000 for a single-year subscription.

—by Michael Santarini

▷**Pyxis Technology**, www.pyxistech.com.

FEEDBACK LOOP

"We must open our borders to qualified, skilled engineers willing to work in this country. We are training them here at our world-class institutions of higher learning but allow that training to leave when we force them to go. The short-term effect of this (situation) is a downward pressure on highly skilled engineers' and scientists' wages."

—Engineer John Weber, in *EDN*'s Feedback Loop, at www.edn.com/article/CA6491148. Add your comments.

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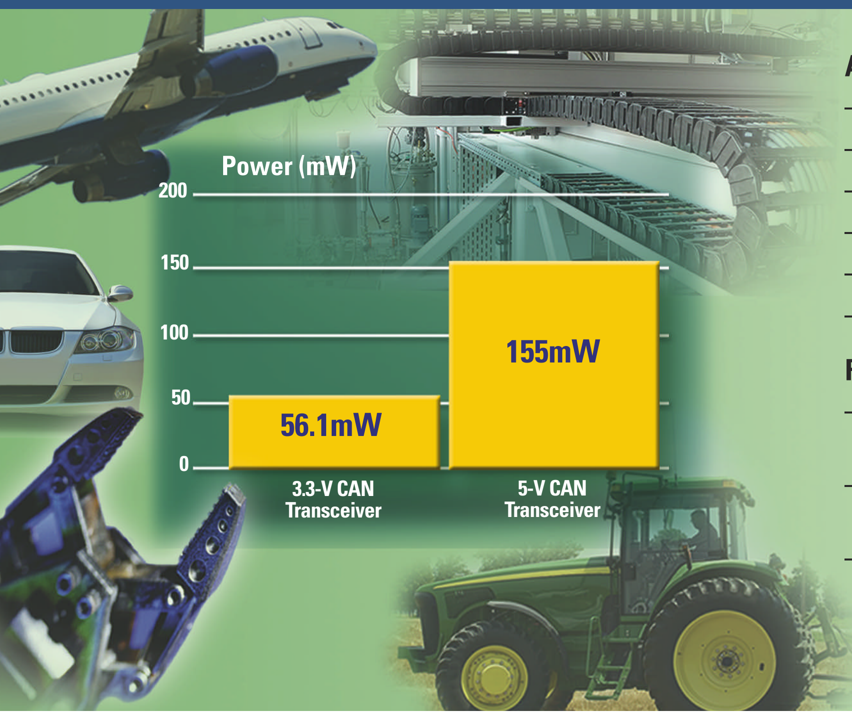

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– NMEA 2000 and SeaTalk2 Marine interface
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SN65HVD231	3	–4 to +16	16	17	0.04 Sleep	Ultra-Low-Power Sleep
SN65HVD232	3	–4 to +16	16	17	NA	Economical
SN65HVD233	3	–36 to +36	16	6	200	Standby, Diagnostic Loopback
SN65HVD234	3	–36 to +36	16	6	200/0.05 Sleep	Standby, Ultra-Low-Power Sleep
SN65HVD235	3	–36 to +36	16	6	200	Autobaud Loopback; Standby
SN65HVD251	5	–36 to +36	14	14	<275	Low-Power Standby
SN65HVD1040	5	–27 to +40	12	10	5	Low-Power Standby with Bus Wake-Up, Dominant Time-Out
SN65HVD1050	5	–27 to +40	8	6	NA	Listen-Only Mode, Dominant Time-Out

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TEXAS INSTRUMENTS

Compact DMM/signal-switching system offers flexibility, speed

Keithley Instruments has announced its Series 3700 family of benchtop DMMs (digital multimeters) and signal-switching cards, from which you can configure automated-measurement systems for data acquisition or functional testing of electronic products and components. Because a full-rack-wide, 2U, 3.5-in.-high enclosure accepts six switch cards and the densest card handles 96 channels, a 2U system can accommodate as many as 576 analog inputs. An optional DMM within the same 2U mainframe provides fast, low-noise measurements with resolutions as great as 7½ digits at prices lower than those of typical 6½-digit DMMs. The manufacturer also calls Series 3700, with its built-in 10/100-Mbps BaseT Ethernet connectivity, the first LXI (LAN extensions for instrumentation) Class B-compliant signal-switching system.

In 3.5 in. of rack space, Series 3700 systems can combine a 7½-digit DMM, which takes 60 readings/sec at full resolution or 10,000 readings/sec at 3½ digits, with signal switching—through plug-in cards—of as many as 576 analog inputs.

The Series 3700 offers four mainframe options. Users can, for example, choose a mainframe without an integrated DMM or one with a DMM but without a front-panel display and keypad. The integrated DMM eliminates the need to coordinate an external meter with a switch topology, freeing up valuable development time. Users who don't network their systems will especially appreciate the front-panel USB 2.0 port, which allows them to save measurements to nonvolatile transportable memory sticks.

The base model 3706 integrates a 7½-digit, high-performance DMM. Among the 13 built-in measurement functions are 1Ω low-resistance and 10-µA low-current ranges. To maximize measurement speed and system throughput, the Model 3706 mainframe incorporates a multiprocessor architecture. It features a single-channel rate of more than 10,000 3½-digit-resolution (dc-voltage or two-wire-resistance) readings/sec to 60 7½-digit, 26-bit-resolution readings/sec.

The Series 3700 also incorporates Keithley's TSP (Test-Script Processor) technology, which allows users to create test scripts and embed and execute them within the instrument. These scripts can contain complete test routines, including complex decision-making and instrument control, enabling the instrument to perform autonomously. For applications that do not require timing synchronization or high throughput, TSP gives users added flexibility by executing line commands just as traditional instruments do.

The TSP-Link communication bus allows configuration of multiple TSP instruments in a master/slave network. TSP-Link also simplifies system expansion, allowing scaling of TSP-enabled instruments according to current and future needs. US prices for Series 3700 mainframes start at $1790; plug-in-card prices start at $925.

Keithley also announced two additions to its Series 2600 SourceMeter line for semiconductor parametric analysis and testing. The single-channel Model 2635 and two-channel Model 2636 offer resolutions as fine as 1 fA (10^{-15}A), which many semiconductor, optoelectronic, and nanotechnology devices can require. US prices start at $8495.

—by Dan Strassberg

▷**Keithley Instruments**, www.keithley.com.

Mentor tool optimizes algorithms, flow for Altera DSP-centric FPGAs

Altera Corp and Mentor Graphics' Catapult C Synthesis Group have collaborated to produce Altera-optimized Catapult libraries to help system architects squeeze the most performance from the DSP blocks in Altera's Cyclone II, III, and Stratix family FPGAs. The libraries include custom operators for Altera's Quartus router to reduce routing delays in Altera's FPGA-DSP blocks, resulting in a 30 to 70% performance improvement over using generic Altera libraries, the companies claim. The companies also claim that the tool produces better optimizations than those from RTL-synthesis tools.

In beta testing, one customer implemented the libraries on a Stratix III with a 32-tap parallel-FIR (finite-impulse-response) filter and gained a 37% maximum-frequency improvement—from 300 to 410 MHz—over the previous library's performance. The customer also gained a 26% improvement (from 128 to 161 MHz) on an edge-detection implementation, 43% improvement (138 to 197 MHz) on a 2-D DCT (discrete-cosine transform), 18% improvement (330 to 390 MHz) on a MAC (multiply/accumulate) operation, and 5% improvement (156 to 164 MHz) on a FFT (fast Fourier transform).

With the Altera/Mentor flow, designers create a floating-point model of an algorithm using an algorithm-development tool. They then convert that model to a fixed-point model, typically in C++. Next, a software engineer typically compiles the model for an off-the-shelf DSP. In the Altera/Mentor flow, however, hardware designers use Catapult C with its Altera-optimized libraries and directly implement the algorithm in the DSP block. The optimized library will come standard with the 2007a version of Catapult C. For more on this product, go to www.edn.com/article/CA6489145.

—by Michael Santarini

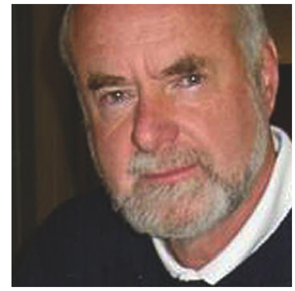
▷**Altera Corp**, www.altera.com.

▷**Mentor Graphics Corp**, www.mentor.com.

VOICES

Dave Fullagar, analog-IC designer and entrepreneur

Dave Fullagar made his mark at Fairchild Semiconductor in the 1960s. He designed the ubiquitous μA741 op amp, perhaps the most successful op amp ever. *EDN* recently had the chance to interview Fullagar. A portion of that interview follows. To read more, go to www.edn.com/071122pulse1.



Were you an electronics genius as a boy? Were you building crystal radios and winding your own slot-car motors?

A I've met very few geniuses in my life, and I'm certainly not one of them! But yes, I was building crystal sets at about age 9. Until I was 12 years old, we lived on the moors in the north of England in a house with no electricity, so a crystal set was my only option. In 1954, I read an article entitled "How to build a radio in a flashlight." It used something called a transistor—a Mullard OC71. I went down to the local radio store to buy one. "Never 'eard of a transistor, boy. Don't know naught about that," said the proprietor in a broad Yorkshire accent. I finally did acquire some OC71s, and I still have them. They are glass-encapsulated junction-alloy devices. To make a phototransistor, you just scrape the black paint off the glass.

The μA741, the first internally compensated op amp, is one of the landmark parts in analog history. How did you come to design this part?

A My assigned task when I joined Fairchild R&D in 1966 was to design the successor to the μA709. The target specification I was given by marketing was of the "let's-improve-all-the-key-specs-by-50%" variety. However, the biggest problems with the 709 were its idiosyncrasies, not its specifications: It was tricky to stabilize, there was no short-circuit protection, and it would latch up and self-destruct in nanoseconds. National Semiconductor's LM101, which [the late Robert] Widlar designed, addressed many of the user-friendliness issues but still required external compensation and had a kludgy front-end bias scheme. Widlar must have come to the same conclusion, because he later redesigned it as the LM101A with a much-improved front end.

I proposed the internally compensated μA741 in mid-1967 to Garth Wilson and Marv Rudin, who ran the Linear R&D Group. Next thing I knew, I was sitting in Gordon Moore's office. He asked me if I'd mind moving to Mountain View [CA] because that would expedite the introduction of the part, which occurred in May 1968.

What parts did you work on at Intersil? Were there any accomplishments you are particularly proud of?

A It's interesting that, as a circuit designer, you get tagged by your best-known design. … I'm known by the 741 op amp. … For me, the Intersil years were the most creative. I developed the first IC logarithmic and antilogarithmic amps and the first monolithic FET-input op amp, the ICL 8007, which dominated the market until the bipolar FETs came along.

I also got to spend a month in Japan designing the first electronic-shutter IC for a single-lens-reflex camera for Canon. This circuit took the logarithm of three inputs—film speed, aperture, and light intensity—summed the result, stored it while the mirror went up, and then took the antilogarithm to generate the shutter speed. It used about 20 transistors in total and was probably my most elegant design. Nowadays, this is done with about half a million transistors in a microcontroller—how prosaic.

Both you and Linear Technology's Bob Dobkin showed me logarithmic-amplifier circuits. What is it about that circuit that you like?

A Interesting—I didn't know that Dobkin also used that circuit. I've been using it since I designed a logarithmic amp for Intersil in 1970. I like it as an interview topic because it isn't something you find in a textbook. The first—relatively simple—challenge is doing the dc analysis. The more interesting part is figuring out the impact on ac stability of having an active element in the feedback and what it takes to achieve unconditional stability.

Maxim copied a lot of Intersil parts as a second source at the beginning. The famous ICL7660 charge pump and the 7106 and 7107 DVM (digital-voltmeter) chips were a few of the parts. Did they keep you going while you designed Maxim parts?

A Absolutely. The original business plan called for the speedy introduction of 14 second-source parts to generate quick cash flow, followed by proprietary parts. Generating positive cash flow in a start-up is key: If you have to go back to the venture capitalists for an unscheduled round of financing, you get taken to the cleaners.

Considering your accomplishments at Maxim, of what do you feel most proud?

A I feel proudest of the design team I recruited. They were—and still are—some of the finest people in the industry, having designed an incredible number of innovative products, as well as serving in senior-management positions.

Any chance that you'll get bored in retirement and design a few parts for some lucky company?

A That's very flattering, but, after being retired for almost nine years and in management for 20 years before that, no one would want my designs today! But if anyone would like me to put together an electronics package for their sailboat, with a voyage to Tahiti included—well, that might be different.**—by Paul Rako**

LEADING inside

A series of engineering insights by Analog Devices.

Analog Is Touching Lives and Going Strong

It's autumn again, a beautiful time of year in New England. My office looks more like my backyard—except the colorful leaves littering the ground have been replaced by papers, trade journals, schematics, IC layouts, test reports, design reviews, pictures, business plans, and spreadsheets. After 38 years, I guess it's time to clean up. Sifting through the piles of papers gives me pause to reflect on the great strides Analog Devices (ADI) as a company and we as an industry have made in a relatively short time and what fantastic opportunities still lie ahead.

The work we do is important and rewarding. Our "analog and digital devices" enable people to live better, to save lives, and to enjoy life. The continuous demand for faster, lower power, more precise ICs that have higher levels of integration, are environmentally friendly, and are low cost, challenge us every day to do better. This call to arms has inspired new processes, ingenious architectures, and countless new products. Many of today's products didn't exist five years ago. I'm particularly proud of the strides we have made in multichannel, highly integrated signal processing ICs and the advances we have made in microelectromechanical systems (MEMS) for motion sensing.

Ultrasound has been a great driver of signal processing IC technology. Years ago, the only types of ultrasounds available were found in specialized hospital clinics. Portability of real-time scanning ultrasound has been a key driver in improving analog front ends (AFEs). The need for portable ultrasound is vital for a variety of settings, ranging from doctors' offices and emergency rescue vehicles to large livestock pens, construction sites, and factory floors.

ADI's AD9271 AFE is one of today's most innovative analog components that enables portable ultrasound equipment. Fabricated on 0.18 μ CMOS, the AD9271 replaces a multichip discrete solution. This AFE integrates a complete 8-channel receiver on a single chip. Each channel contains a low noise amplifier (LNA), a variable gain amplifier (VGA), an antialiasing filter (AAF), an analog-to-digital converter (ADC), and a serial low-voltage differential signaling (LVDS) output. It's a remarkable innovation; the AD9271 has reduced the signal path area by 50% and lowered power consumption by 25%. Analog components like these enable compact life-saving ultrasound systems that now fit in the palm of your hand.

ADI's *i*MEMS® 3-axis accelerometer is another relatively new product. ADI started producing MEMS in 1989. In 1992, an ADI MEMS accelerometer replaced mechanical sensors and found its way into a "little" automotive application: airbag deployment. Today, ADI's MEMS accelerometers play a crucial role in crash detection, rollover detection, and airbag deployment. MEMS sensors are found in numerous automobile makes and models and undoubtedly have saved countless lives—perhaps even the life of someone you know.

ADI's MEMS technology also is finding its way into new applications, such as microphones and RF switches. The ADI *i*MEMS accelerometer is a vital component in truly interactive, lifelike, motion-based video games. It enables the main wireless controller to detect 3-axis movement. ADI's MEMS motion signal processing technology not only allows individuals of all ages to play a variety of virtual action sports and video games, it also has paved the way for countless other applications by exploiting the virtues of motion sensing as a user interface in portable devices. New motion-based wireless game controllers have provided a unique opportunity for users by packaging the accelerometer, along with other electronics, in an inexpensive and accessible medium, perfect for the experimenter in all of us.

These two important applications demonstrate the impact that analog and mixed-signal electronics have in driving end-user technology. As Moore's Law shows, we can continue to scale devices and pack more into less space. However, Moore's Law cannot fully address all the demands of modern chip design: high performance, increased integration, more flexibility, low power, low cost, "green" compatibility, and feature richness. To satisfy these challenges will require the continued cooperation between circuit designers, system engineers, and process development teams. Through innovation, inspiration, and perspiration, we'll forge ahead to tackle the next set of challenges. Speaking of which, I need to get back to raking up the piles of paper in my office. We'll talk again, after the snow flies in Vermont. ▶

*ADI Fellow and VP of Analog Technology **Lewis Counts** retired this year after an illustrious 38-year career with Analog Devices. The impact of his contributions to the field, to his colleagues, and to the company will remain with us for a long time.*

BY BONNIE BAKER

ADC voltage-reference errors impact full-scale conversions

SAR (successive-appoximation-register) analog-to-digital references have more influence on conversion accuracy than you may initially think. **Figure 1** shows the transfer function of an ideal 3-bit ADC and the same converter with gain error. The transfer function of an ADC is equal to:

$$D_{CODE} = (V_{IN} - V_{OS})\left(\frac{2^N}{V_{REF} - V_{GE}}\right),$$

where D_{CODE} is the digital-output code, V_{IN} is the input voltage to the converter, V_{OS} is the converter's offset voltage, V_{REF} is the reference voltage applied to the converter, N is the number of ADC bits or the ADC resolution, and V_{GE} is the combined ADC-gain error, reference-output-voltage error, and reference-voltage noise.

It is easy to see how the voltage reference's specified value affects the ADC's absolute accuracy. For high-resolution converters, the reference-offset error is usually greater than the ADC-offset error, particularly over temperature. You will also notice from the transfer function that the reference errors have more influence on the converter results with higher input voltages.

You can reduce the ADC and reference-source errors with a ratiometric design. This scenario may require additional devices in the circuit or a processor/microcontroller-calibration algorithm. Remember that calibration algorithms require gain and offset characterization for each circuit.

The reference's noise error is a different matter. It affects the SNR (signal-to-noise ratio) and the THD (total harmonic distortion) of a conversion. The reference noise impacts the converter's SNR and THD at higher ADC input voltages (**Figure 2**).

If the converter lacks an internal buffer at the reference pin, you will notice incoming or outcoming current spikes. The converter uses these currents during the conversion cycle to charge internal capacitors. This knowledge may motivate you to insert a low-noise amplifier between the external reference and the ADC.

Don't try to test your ADC with an input voltage of 0V or ground. If you hope to see the effects of your voltage-reference source on your conversions, try to use a dc full-scale input and then a signal input that will help you look at the system's frequency response (**Reference 1**).EDN

REFERENCE

1 Oljaca, Miro and Bill Klein, "Improved Voltage Reference Circuits Maximize Converter Performance," Texas Instruments Webinar on Demand, www.techonline.com/learning/webinar/201307002.

Bonnie Baker is a senior applications engineer at Texas Instruments. You can reach her at bonnie@ti.com.

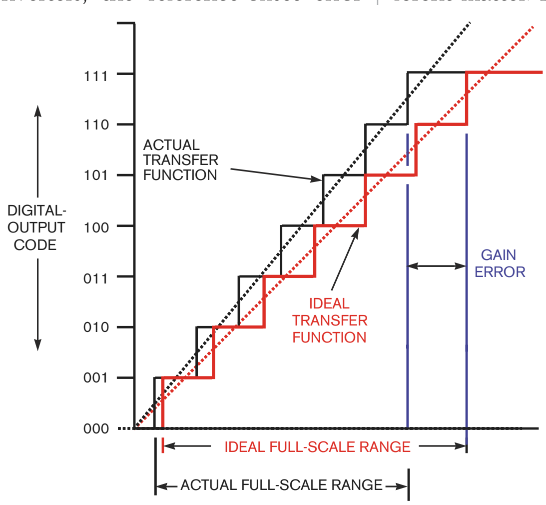


Figure 1 Gain error causes the transfer function of an ADC to rotate around the digital-input code of zero.

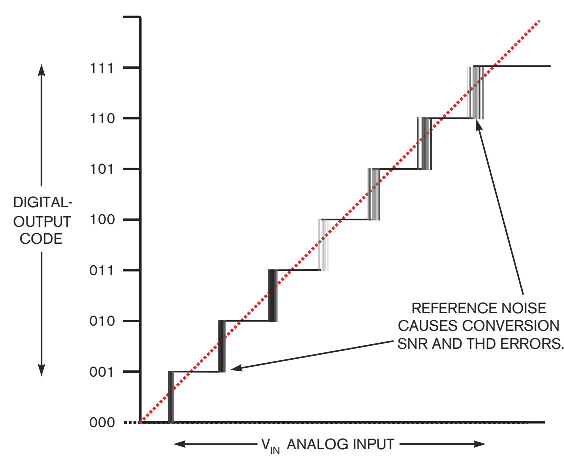


Figure 2 The voltage-reference noise of the ADC grows when output digital codes increase.

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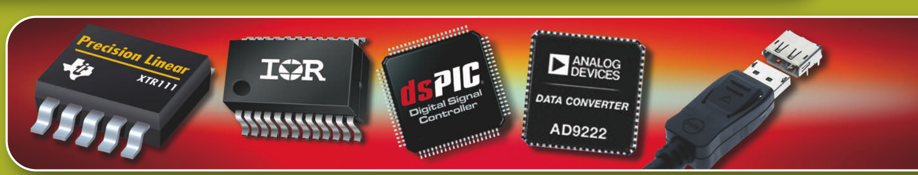

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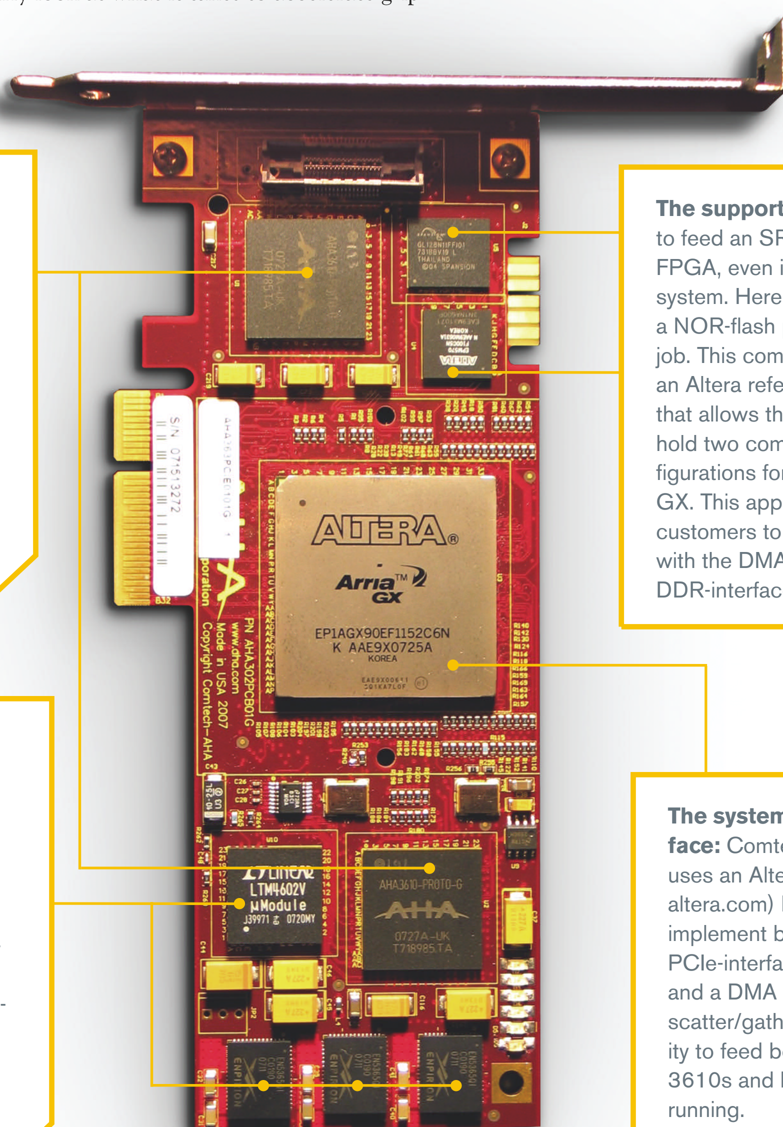
Plugging hardware-based compression into a server

Lossless data compression can be valuable in any number of storage, server, and networking situations, reducing both required bandwidth and storage space without damaging the data. It's too laborious to achieve high throughput in software using the Lempel-Ziv-type algorithms necessary for good compression ratios. One vendor, Comtech AHA Corp (www.aha.com), plans to offer a drop-in PCIe (PCI Express) card as a hardware accelerator for the open-source gzip (GNU-zip) algorithm. The board will be available in the first quarter of 2008, but the company offered *EDN* an early look at what it takes to accelerate gzip.

The crunchers: The AHA 3610s are numerical processors that do the gzip computations. Using internal buffer memory, they can work directly from the host server or the PC's main memory. The data interface is a parallel pair of 16-bit DDR-DRAM interfaces, allowing each chip to compress or decompress data at 2.5 Gbps, with the equivalent of gzip-9 (high-effort) software-compression results.



The support: You have to feed an SRAM-based FPGA, even in a small system. Here, a CPLD and a NOR-flash part do the job. This combination is an Altera reference design that allows the board to hold two complete configurations for the Arria GX. This approach allows customers to experiment with the DMA logic and DDR-interface control.

The power: A Linear Technology (www.linear.com) switching dc/dc converter steps down the 12V supply from the PCIe connector to 3.3V for three Enpirion (www.enpirion.com) buck regulators, which in turn provide 2.5V for SSTL (stub-series-terminated-logic) I/O and 1.2V for core logic to the FPGA and Comtech AHA chips.

The system interface: Comtech AHA uses an Altera (www.altera.com) FPGA to implement both the PCIe-interface logic and a DMA engine with scatter/gather capability to feed both the 3610s and keep them running.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EDN HANDS-ON PROJECT

Homeland security: MONITORING AND MANIPULATING REMOTE RESIDENCES

BY BRIAN DIPERT • SENIOR TECHNICAL EDITOR

Figure 1 This hands-on project's test bed has some particularly challenging attributes: a remote location and inconsistent power.

Ubiquitous network protocols, such as IP (Internet Protocol), TCP (Transmission Control Protocol), and UDP (User Datagram Protocol), in combination with the increased availability and decreased cost of robust broadband-Internet access, have cultivated an upsurge in remote-access and -management capabilities. Numerous technologies exist, for example, to control computers from outside a LAN (local-area network)—from the modest but omnipresent RealVNC (virtual-network-connection) to VPN (virtual-private-network) applications, such as LogMeIn's freeware-plus Hamachi.

Operating-system-specific remote-computer-control variants include Microsoft's Remote Desktop Connection and Apple's Remote Desktop. And, with products such as Sling Media's Slingbox and Microsoft's WebGuide for Windows XP Media Center Edition and Windows Vista, you can peruse live and archived video material from anywhere in the world (see "Homeland security: remotely tune into TV content" at www.edn.com/briansbrain).

This *EDN* hands-on project testdrives the reality behind these concepts' theo-

AT A GLANCE

- Determining your dynamic-IP (Internet Protocol)-based Internet service's address is more complicated than it might appear at first glance.
- Webcams are prone to unreliability due to temperature and wireless-connectivity variations. Watch out, too, for integrated Web servers that unnecessarily restrict you to one browser or operating system.
- Power-line-based control schemes have tremendous potential but, my testing suggests, aren't yet robust enough for widespread adoption. Monitor the *Brian's Brain* blog at www.edn.com/briansbrain for ongoing updates as I continue my Insteon debugging and begin exploring the Z-Wave wireless alternative.

ries. Additionally, it tackles video surveillance, along with a hands-on evaluation of the home-automation technologies that *EDN* previously covered (**Reference 1**). However, whereas the earlier article's focus was on within-the-home control, I've built on its foundation by additionally attempting to control—and monitor—a home from the outside. The study's test bed is a diminutive dwelling built in the mid-1980s, located atop a 7000-foot ridge in the Sierra Nevada mountains and prone to fairly frequent rain-, snow-, and wind-induced power loss of random duration (**Figure 1**).

Although this article's analysis focuses on a secondary residence, if you brainstorm for a few minutes you'll likely come up with a lengthy list of additional uses for this project's results. Consider, for example, a remote office suite whose equipment, illumination, and temperature you might want to be able to remotely monitor and adjust. Assuming that the equipment, along with data stored on hard drives, on optical discs, and in file cabinets, is of substantial value, you might also be motivated to inspect the premises from afar and respond to sensor alerts of a fire, a break-in, or another catastrophe. And don't underestimate this article's applicability to home-based-health-care trends (**Reference 2**). If, for example, a friend or family member stricken with Alzheimer's disease were to wander out the door, wouldn't an e-mail- or pager-based alert be useful?

The journal of my experiences in the following paragraphs will, I hope, smooth the path for those of you interested in following my footsteps. Equally important, I hope that those of you creating technologies and designing products based on them for germane applications will optimize them using this write-up's observations and conclusions as a guide. Remember: If, as an engineer, I struggle with a given technology, the average consumer has even less chance of figuring it out.

DNS ANGST

In researching before the eventual purchase of my mountain getaway, a two-hour drive away from my primary residence at the time, I was pleasantly surprised to find that this second home could access both cable and DSL (digital-subscriber-line) broadband service. An abundance of competing Internet-access options isn't always available, but satellite-Internet service—albeit with the requisite long latency, weather-dependent uptime, performance irregularity, and relatively high cost—should at minimum be an available broadband candidate, as long as you have an unobstructed view of the sky above your dwelling (**Reference 3**). Most broadband providers offer "base" services that employ dynamic IP-address allocation. After a provider-dependent WAN (wide-area-network)-inactivity time period has elapsed, your LAN's allocated IP address releases and returns to an available "pool." The next time any portion of your network connects to the Internet, it's statistically likely that your service provider will assign your LAN a different IP address.

Dynamic allocation precludes the possibility of reliable IP-address-based access to your LAN. Some broadband providers offer their customers optional static-IP addresses but usually at a significant price premium reflecting their "business-class" status. Instead of paying AT&T extra cash for a static-IP address, I evaluated several of the DDNS (dynamic-domain-name-system) services that attempt to address the issue. They work with equipment, such as a router or a computer, within your LAN. When the equipment senses a change in your service-provider-allocated IP address, it automatically connects to the DDNS provider's server and updates your account information. By using the DDNS account-allocated URL (uniform-resource locator) and as-

(a) (b) (c)

Figure 2 The DDNS client in D-Link's DI-524 appears to be nonfunctional (a), and the one in Linksys' WRT54GC is intolerant of lengthy network-initialization sequences (b). DynDNS' client software running on a Fujitsu Lifebook P-2110, however, operates as intended (c).

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POWER MANAGEMENT
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BRIEF

Current Balancing in Four-Pair, High-Power PoE Applications

By Steven R. Tom
Systems Engineer, Power Interface Products

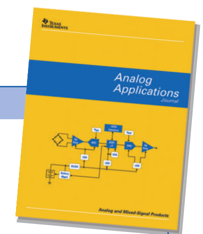
Introduction

Power-over-Ethernet (PoE) parameters are specified by IEEE 802.3-2005 clause 33, which defines both the allowable architectures and the maximum deliverable power for a PoE system.[1] The present standard mandates a two-pair architecture allowing a maximum of 12.95 W at the end of the cable. As end equipment becomes more complex, it requires more power and architectures more flexible than the IEEE standard allows. This article describes a unique current-balancing technique that uses a four-pair architecture to deliver up to 50 W to the end equipment.

Review of PoE Four-Pair Architectures

An end-to-end PoE solution typically comprises a power source, referred to as "power sourcing equipment" (PSE), and end equipment, referred to as the "powered device" (PD). The PSE may be standalone or embedded in a router or switch. Most Ethernet cable used today is Category 5E (CAT5E) cable composed of four unshielded twisted pairs of copper.

The IEEE standard specifies that power may be delivered in a single loop over either of the two pairs but not over all four pairs simultaneously. Using two current loops over all four pairs, the architecture in Figure 1 increases the available power delivered to the input of the PD. The main advantage of the four-pair architecture is the increased number of conductors, which decreases power loss and increases total power to the end equipment. The main disadvantages are the added cost and the increased complexity needed to ensure that the current is balanced between the two current loops.



In the four-pair architecture, both current loops feed a single DC/DC converter. If the impedances of each loop were identical, current balancing would be unnecessary and each loop would provide half of the needed input current to the DC/DC converter. However, mismatches in the wires, connectors, and components will naturally cause one loop to carry more current than the other. To ensure reliability, the series components in each current loop must be designed to handle the worst-case imbalance while maintaining data transmission. A larger imbalance implies an oversized (and thus more costly) design. Maximum power delivery can be obtained by balancing the current between the line pairs so that each path operates just below its current limit. The following example and analysis show how the worst-case imbalance can be determined and minimized.

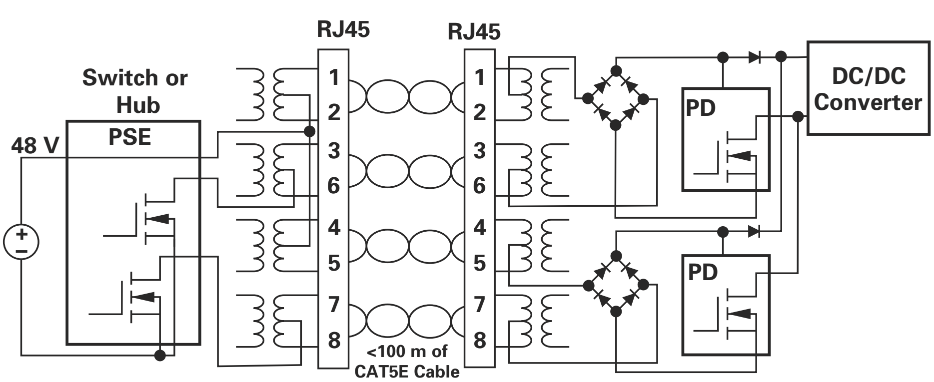


Figure 1. Four-pair architecture for power delivery

Design Example With Current-Booster Circuit

In a four-pair architecture, the detection and classification functions of the PD must be performed on each two-pair current loop, which necessitates the need for two PD controllers. In the design example that follows, two TPS2376-H controllers are used as the PD input source to the DC/DC power supply[2] (see Figure 2). The DC/DC power supply uses a UCC3809-2 in a single-switch flyback topology to provide an isolated 5 V at 8 A to the load.

It is assumed that an available PSE will supply a regulated voltage between 51 and 57 V that is capable of sourcing up to 800 mA for each current loop consisting of two pairs of the CAT5E cable. A reasonable assumption for the loop impedance of each two-pair loop (maximum length of 100 m) is 12.5 Ω. The CAT5E cable will connect to the PD interface and input to the DC/DC converter that will provide an isolated 5 V at 8 A to the load. For simplicity and emphasis on the PD interface, the DC/DC power supply is shown in Figure 2 as a simple black box.

Assuming that the DC/DC converter is ~85% efficient, approximately 47 W of input power is needed. Depending on the CAT5E cable length and the PSE voltage, an input current between 0.825 and 1.2 A is required to meet the input-power specification.

The TPS2376-H datasheet shows the minimum current limit to be 625 mA. It is imperative that the current in either of the two current loops not exceed this value during operation to avoid unwanted shutdown. Because of the TPS2376-H minimum current limit, the current-booster circuitry using Q1 and Q2 was introduced to gain the full potential of the allowable 800 mA of input current per two-pair loop.

Board-Level Results[3]

To emulate worst-case conditions, an evaluation board was tested with a diode and resistor in series with the return path of Paths 3 and 4. The forward voltage drop of the diode (0.7 V) and an additional 0.5-Ω resistance were added to compensate for worst-case diode forward voltage variations and system resistance tolerances. This permitted a reasonable board-level test to be conducted to measure actual current-loop imbalances.

Figure 3 shows that the largest current through either of the TPS2376-H devices is 488 mA with a 100-m cable. The largest current available (in this example, Path 1 plus Path 2) is 648 mA with a 100-m cable. Because the worst-case current imbalance exceeds neither 625 mA through the TPS2376-H nor 800 mA in one current loop, the design remains within the original design specification.

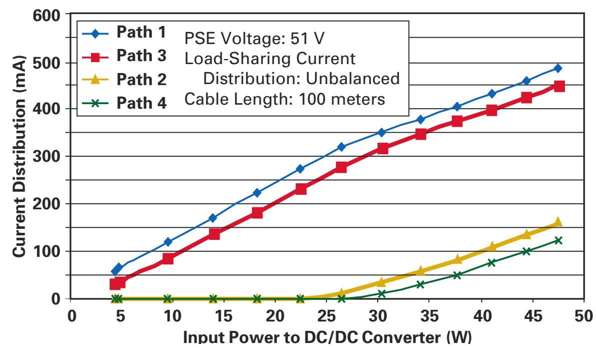


Figure 3. Board-level test results of unbalanced current sharing

Conclusion

Board-level results confirm that the current-booster circuit will meet the initial design requirements for current balancing by keeping the return current through each TPS2376-H under its minimum current limit and under the maximum current allowable in the CAT5E Ethernet cable. The addition of the current-booster circuit improves the current balancing between the two current loops so that the wire, connector, and component tolerances do not cause the design to fall out of the design specifications.

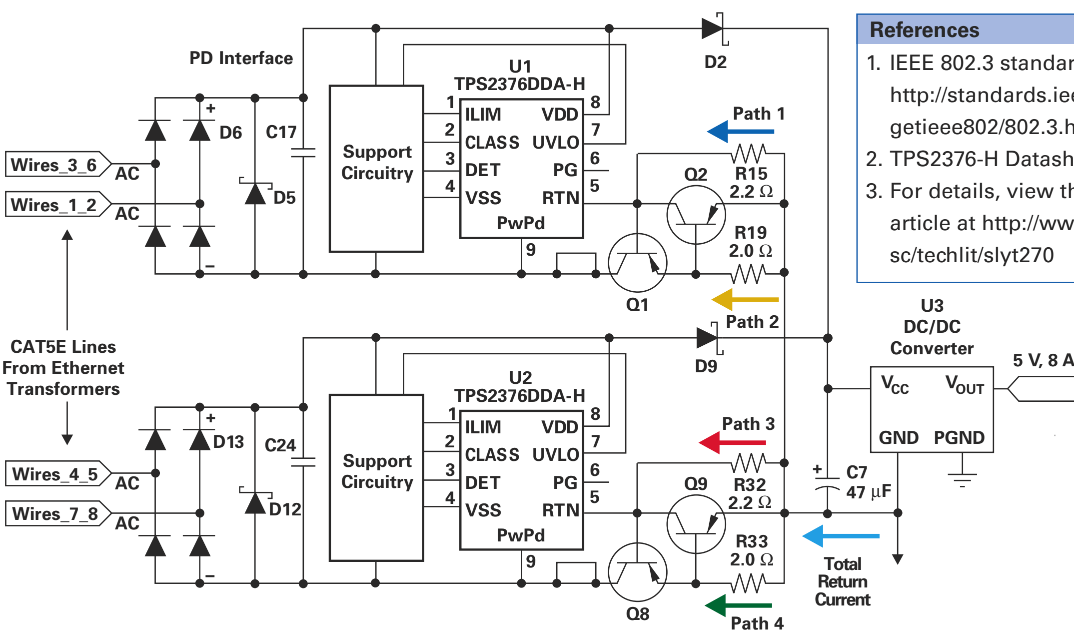


Figure 2. Design example of four-pair architecture with current-booster circuit

References

1. IEEE 802.3 standard, http://standards.ieee.org/getieee802/802.3.html
2. TPS2376-H Datasheet (SLVS646)
3. For details, view the complete article at http://www-s.ti.com/sc/techlit/slyt270

suming that the Internet-service provider you're currently connected to has an up-to-date DNS server, you'll always find your remote LAN regardless of what its IP address is.

The first router I tried, D-Link's DI-524, claims to support DDNS, but DNS-service provider No-IP refused to acknowledge address updates that the DI-524 sent (**Figure 2**). After some research, I discerned that No-IP was likely blocking the update attempts because D-Link's DDNS client historically acts aggressively (**Reference 4**). I couldn't find any reference to the update-server addresses for DynDNS and TZO (Tzolkin), so I couldn't test the DI-524 with either of these two services. Linksys' WRT54GC router also integrates a DDNS client, in this case with built-in support for DynDNS and TZO. However, although the WRT54GC DDNS client generally worked better than the one in the DI-524, its shortcomings still rendered it unusable for my setup.

When my Siemens SpeedStream 4100 B DSL modem initially connects to AT&T's network, it can take a minute or more for the modem—and, therefore, the router—to receive a dynamic-IP-address assignment. My Linksys OGV200 QOS (quality-of-service) network optimizer's autocalibration cycle further extends the delay until initialization is complete. Unfortunately, the WRT54GC's DDNS client seemingly is too unintelligent to handle this deferral. If it is initially unsuccessful at logging into DynDNS' and TZO's update servers, it reports an "error in username or password," "unable to establish HTTP connection," or similar message indicating lack of connection success and doesn't reattempt a later login.

Because I'm powering the DSL modem, QOS processor, and router from a battery-backed UPS (uninterruptible-power supply), you might think this glitch would be easily solvable with a one-time manual login from the router's browser-based GUI (graphical user interface). After all, once the WRT54GC successfully logs into a DDNS server, it adequately handles dynamic-IP-address updates. On at least one occasion, however, the premises' power loss was sufficiently long to completely drain the UPS battery, thereby shutting off all of the network gear. When the premises'

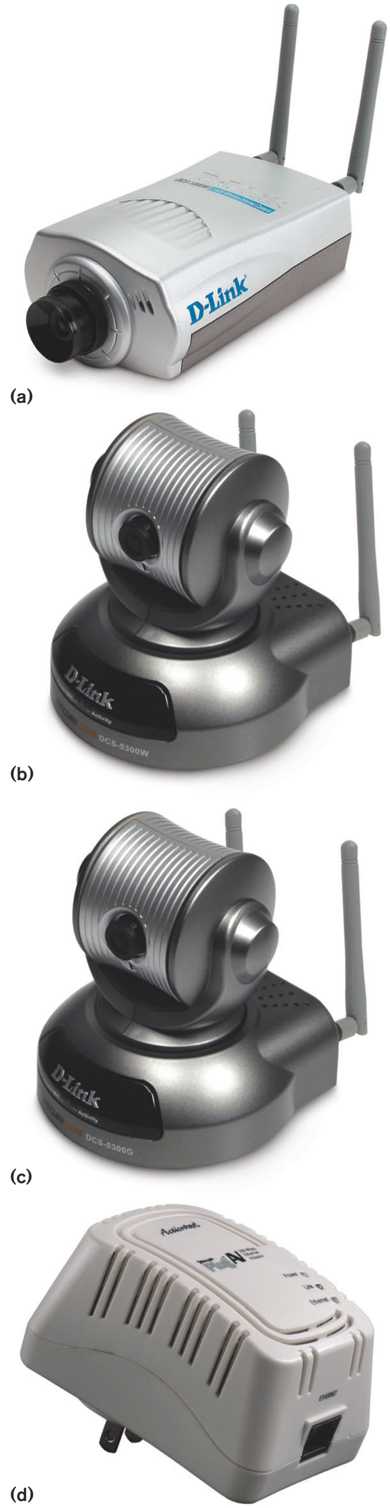


Figure 3 D-Link's DCS-1000W, being Java-based, is browser- and operating-system-agnostic but can't handle sun exposure (a). The 802.11b-based DCS-5300W (b) and 802.11g-supportive DCS-5300G (c) were unreliable over Wi-Fi, but Actiontec HomePlug AV adapters practically solved the connectivity problems (d).

power came back on, the router once again gave up after unsuccessfully attempting to log into my DynDNS and TZO accounts; therefore, I completely lost access to the LAN until I returned to the residence several weeks later.

Ironically, another piece of active equipment on my LAN, the VOIP (voice-over-Internet Protocol) adapter, *also* automatically—and, at least so far, always successfully—logs into a WAN-based server. The IP address associated with my VOIP account is therefore identical to the AT&T-allocated dynamic-IP address for my LAN at any point in time. Unfortunately, neither BroadVoice nor Vonage allows customers to access this information. I plan to eventually test Linksys' WRT54GL router, both with factory-supplied firmware and with DDNS client-inclusive open-source code, such as DD-WRT and Tomato. For now, though, I've resorted to installing DynDNS' client software on a power-efficient Fujitsu Lifebook P-2110 laptop computer. The PC is old and slow, based on an 867-MHz Transmeta Crusoe CPU, but my application isn't performance-critical. To maximize the laptop's probability of surviving a lengthy power loss, I've connected it to both an extended-capacity main battery and an optical-drive-bay-based supplemental battery, with further help from an APC (American Power Conversion) external universal-notebook battery. The environmentalist in me isn't thrilled with the idea of an always-on computer, but, as you'll soon see, I've also found another use for the system.

CONVOLUTED VOYEURISM

Once I figured out how to reliably contact my router from the WAN, the next step was to open up firewall holes so that I could access the LAN gear behind it. I wanted to set up two Webcams, one pointed out the front door—to monitor, among other things, wintertime snow conditions—and the other perusing the home's interior. The first camera I tried, D-Link's now-obsolete, Java-based, 802.11b- and Category 5-cable-supportive DCS-1000W, was browser- and operating-system-agnostic—giving it advantages over ActiveX-based alternatives that you'll soon read about (**Figure 3**). Unlike its successors, it offered no movable-lens capability, and

Figure 4 Smarthome's 2412S PowerLinc Modem is outlet-sensitive, at least in my setup, and it must be fully powered before you power up Universal Devices' ISY-26 to reliably manage it (a). The Smarthome 2443 access points aren't seemingly acting as the wireless phase couplers they're intended to be, although the reason why is unclear (b). Once I get my Insteon network to a more robust state, I'll advance it beyond its current humble implementation, switching two incandescent lamps via Smarthome 2856S3B on/off adapters (c).

it couldn't take the heat in the aptly named sunroom where I installed it. As spring turned into summer, the DCS-1000W began—after a random period of stable operation—ignoring network-access requests until I cycled its power, a difficult task when I was off-site.

My setup now consists of two D-Link DCS-5300 Webcams, both supporting 10/100-Mbps Category 5-cable connections. The DCS-5300W variant is 802.11b-cognizant, whereas its G twin handles higher bandwidth 802.11g. Achieving success was a diagnostic struggle; by the end, the wireless-protocol differences between the two cameras were irrelevant. At first, the no-wires appeal of 802.11 encouraged me to go in that direction. However, despite having no discernible contending 2.4-GHz interference within the premises and using a broadcast channel that didn't overlap any of the nearby neighbors' faint Wi-Fi beacons, any wireless connection I established between the router and either Webcam survived for no more than a few days.

At first, I thought that DHCP (dynamic-host-configuration-protocol) renewals were failing, so I configured both Webcams with static-IP addresses. Although this tack is always a good idea because it provides a stable forwarding destination for firewall holes, it didn't provide any discernible reliability relief in my case. I never figured out the root cause of the wireless-connectivity problem. Were the D-Link Webcams or the D-Link and Linksys routers to blame, was it some nuance of the interaction between them, or could it be as-yet-undetected environmental interference? Not relishing the idea of crawling under the house to run cable through floors and walls, I instead used Actiontec's HomePlug AV adapters, which so far have been generally reliable in operation—albeit with a few hiccups—and deliver discernible audio through the Webcams' built-in microphones and smooth video over UDP (**Reference 5**).

The DCS-5300W and DCS-5300G employ ActiveX-based video add-ins, meaning that—unlike with their Java-cognizant DCS-1000W predecessor—if you attempt to use a browser interface to view the vistas they capture, you can do so only from a Windows-based computer and only from Internet Explorer. Even with those restrictions in mind, I found that two of the four Windows XP-based systems I regularly access cannot view Webcam content from Internet Explorer; I get "HTTP-400-bad-request" errors whenever I make an attempt. I'm more successful in achieving this access using Firefox's IE Tab add-on, which runs the Internet Explorer rendering engine. In this case, I can log onto the Webcams, and, if I repeatedly refresh each frame within a given DCS-5300 Web page, its content will eventually appear.

Neither other folks' PCs nor my other two Windows systems experience the same problem. I suspect that some other installed Internet Explorer add-on is causing a conflict, although I've tried disabling all of the obvious candidates with no effect, or perhaps an obscure Windows-security setting is to blame. Fortunately, D-Link's D-ViewCam application works on every Windows system I've tried it on, thereby providing an alternative access path. Other DCS-5300 grumbles include its somewhat-noisy operation and lack of optical-zoom capability. I like the Webcams' pan-and-tilt feature, however, and I should also note that I haven't yet employed some of the application's advanced features, such as the ability to detect and react to motion, to interface with external sensors, and to periodically—and in response to a trigger event—e-mail images and copy them to an FTP (file-transfer-protocol) server.

CONTROL ISSUES

Except for infrared units, Webcams work only when adequate ambient light allows the devices to capture a meaningful image. For example, if a burglar were prowling around in my home after dark, the camera for viewing the interior would be useless unless the lights were on. Given my "green" leanings, keeping the lights on for hours or days at a time with nobody home is an unappealing solution. This quandary explains one of my motivations for adding WAN-accessible home control to the technology mix: It also would be nice to keep the thermostat low when I'm away and ramp it up from afar a few hours before I return home.

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have supplied me with some Z-Wave-based wireless equipment, I've focused my near-term attention on power-line-control technologies. Part of the reason for this power-line prioritization is my earlier-described frustrations with Wi-Fi. Initially, I planned to tackle X10, spurred on by an excellent reference manual (**Reference 6**). This path was appealing given the wealth of new, often discontinued, and barely used X10 equipment that eBay and other sites offer. In retrospect, this abundance portends potential problems as much as cost-effectiveness. You have to wonder why so much barely used gear is available for purchase.

After a consultation with Smarthome, I became aware of X10's substantial shortcomings, particularly the lack of guaranteed feedback to a control-transition request. Smarthome's literature refers to it as "unacknowledged, 'press-and-pray' signaling" (**Reference 7**). This lack of feedback would be especially problematic if you were attempting to manipulate a remote setup. Instead, I've been experimenting the past few weeks with Insteon technology, which builds on an X10 foundation, from Smarthome's parent company, SmartLabs. For example, the company claims X10 compatibility with Smarthome's model 2412S PowerLinc Insteon modem, which I currently use (**Figure 4**). Before proceeding down the Insteon path, I obtained assurances from Smarthome and HomePlug technology developer Intellon that an Insteon control network would cohabit—although not communicate—with my HomePlug AV setup.

Speaking of HomePlug, I frankly feel like I'm back in the painful days of HomePlug 1.0 as I strive to get the Insteon setup working stably (**Reference 8**). To date, in the spirit of crawling before walking before running, I've attempted to control only two 2856S3B on/off adapters connected to nondimming incandescent lamps. The 2412S can "see" neither of the adapters from two of the three power outlets I've tried

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connecting it to, even though the adapters are in the same room as the modem and less than 10 feet away from each other. Proximity is fairly meaningless when it comes to power grids; nearby 110V outlets may come from different circuit breakers or, even worse, be on opposite phases of the 220V source feed. However, the model 2443 access points I also have installed are supposed to, by RF-linking to each other, bridge Insteon control signals across the two 110V-ac phases. This bridging doesn't seem to be happening, and these setbacks are bothering me because this small, modern home shouldn't present much of a problem to a robust power-line-control technology.

Much of today's home-control equipment, such as the 2412S and its sibling 2414S PowerLinc Controller, still relies on the archaic RS-232 interface. For stand-alone—that is, not PC-based—operation, I interfaced the 2412S to Universal Devices' Category 5- and RS-232-inclusive ISY-26 home-automation controller, which embeds a Java-based, albeit nonintuitive, Web-server user interface. The combination worked fairly well as long as I plugged the 2412S into the correct ac outlet and ensured that the 2412S was fully operational before powering up the ISY-26. In an unstaffed remote environment prone to frequent power loss, this precise power-sequence requirement is untenable. Although the ISY-26 literature clearly documents the sequencing constraint, my Universal Devices contact assures me that in real-life practice it's not necessary. He suspects that I have either a faulty 2412S or an ISY-26 with out-of-date, bug-prone firmware. I'll continue experimenting until press time; monitor my blog for further progress reports.

After encountering the ISY-26's limitations, I also attempted to manage the 2412S from the Fujitsu Lifebook P-2110 laptop with HomeSeer's HS2 home-control software and an SIIG model JU-HS2012-S2 USB-to-dual-RS-232 adapter. Again, as long as I used the correct ac outlet, this combination worked fairly well after I overrode the default, nonfunctional drivers that Windows XP auto-installed when I first plugged the JU-HS2012-S2 into a laptop USB port. I wouldn't recommend exposing the HomeSeer software's Web-server

Rarely Asked Questions

Strange but true stories from the call logs of Analog Devices

Contributing Writer James Bryant has been a European Applications Manager with Analog Devices since 1982. He holds a degree in Physics and Philosophy from the University of Leeds. He is also C.Eng., Eur.Eng., MIEE, and an FBIS. In addition to his passion for engineering, James is a radio ham and holds the call sign G4CLF.

Resistors (and old ladies) have hidden depths

Q. *You recently discussed the thermal noise of resistors. They seem to be such straightforward components with just two connections and one simple property: resistance. Do they have more traps for the unwary?*

A. I recently attended the 80th birthday of a charming white-haired old lady. In conversation, I was amazed to learn of her teenage years in the French Resistance blowing up Nazi ammunition trains.

The other sort of resistance can fool you, too. A resistor's value, and its tolerance, are obvious properties. Power dissipation is also specified, and, occasionally, breakdown voltage.

But there are many other characteristics which may need to be considered. Matching two or more resistors can be critically important to high precision analog circuitry. Precision on its own may be insufficient; two resistors matched at one temperature will be matched at another only if their temperature coefficients (TCs) are also matched. And if their temperatures differ, because of self-heating or other causes, matched TCs will not help (although very low TCs will). Resistors whose matching is important should be on a single substrate: ceramic or glass for separate resistor networks or silicon for precision thin film resistors integrated on an IC. This ensures matching of resistance, TC, and temperature.

Resistors usually consist of resistive material and copper connections. Two dissimilar conductors in contact form a thermocouple, which produces a voltage due to the Seebeck Effect. This is about 40 μV/°C for copper/nichrome, and can exceed 400 μV/°C for carbon resistances. So, if there is a temperature difference between the ends of a resistor there will be a voltage between them, adding a dc error to the circuit. If this matters, we must minimize temperature differentials and perhaps use (expensive!) resistors with low thermoelectric emf.

Resistors have capacitance and inductance as well as resistance. Precision resistors that are wire-wound or have a spiral thin film structure have quite large (many μH) inductance. Even when inductance minimizing techniques are used, the resulting structure does not have very low inductance. At high frequencies, reactance matters and must be considered.

The resistance of many high value (≥50MΩ) resistors varies with applied voltage, causing distortion. This can also occur with poor quality resistors of lower value. Such resistors may also have current dependent noise in addition to thermal noise.

Like my friend, resistors are more complex than they first appear; your circuits will benefit if you understand them thoroughly.

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interface to the WAN through a firewall hole, however, especially over the default HTTP port 80. Two days after I took these very steps, the laptop stopped responding to WAN-access attempts. When I returned on-site nearly two weeks later, I found the system locked up with a blank screen. Power cycling the PC brought it back to life with no apparent ill effects, so I suspect that someone unsuccessfully attempted to hack it. Nevertheless, use a nonstandard TCP port or, better yet, dispense with the direct Web-server interface and instead access the HomeSeer-equipped computer over an encrypted and password-protected VNC or VPN connection, as I'm now doing. **EDN**

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PORTABLE POWER: FEATURES ABOUND, THANKS TO NEW

JUST TWO YEARS AGO, LITHIUM-ION CELLS MAY NOT HAVE MET YOUR SYSTEM'S POWER REQUIREMENTS. BUT TAKE ANOTHER LOOK; YOU MIGHT BE PLEASANTLY SURPRISED BY WHAT'S AVAILABLE NOW.

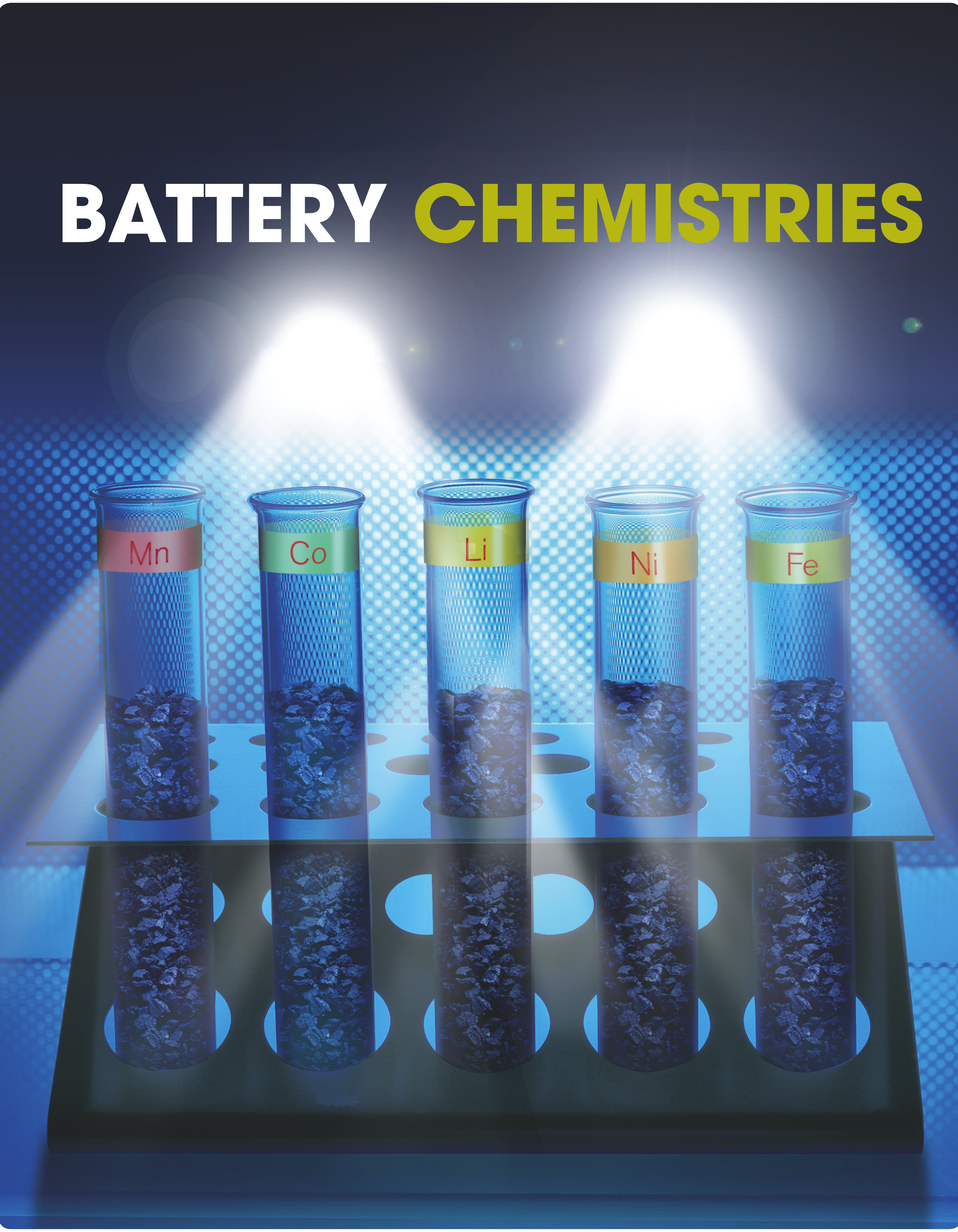
BY MARGERY CONNER • TECHNICAL EDITOR

Things are changing in the usually stodgy world of lithium-ion batteries. Two years ago, the laptop-battery market was the driving force in energy- and power-usage profiles for lithium-ion-battery packs (**Reference 1**). Now, cordless power tools rival laptops in lithium-ion-battery-market share. In 2005, judging by laptop features, laptop-computer vendors ranked the four main characteristics of a lithium-ion battery in descending order: energy storage, speed of power delivery, cost, and safety. A fifth, environmental impact, or "greenness," didn't even make the cut.

The most important energy requirement for laptops and other consumer-electronics products, such as cell phones and MP3 players, is energy-storage capacity. At a minimum, users want to be able to watch a feature movie on their laptops during cross-country flights. Second is the ability to quickly charge the device; laptop users are an impatient bunch. Third is cost: Users see battery packs as commodities rather than features that vendors can charge for. Granted, a laptop user will pay more for increased battery-powered work time, but this increased cost is often the result of clever circuit design and component selection rather than the inclusion of a battery pack with a higher energy capacity. Safety comes next. Although a basic level of safety is a given, some level of failure is acceptable. Manufacturers signaled their acceptance of a certain failure level when they began designing with lithium-ion cells, whose failure mode can be catastrophic.

Standard lithium-ion batteries use a cobalt oxide for the cathode. There are several permutations of this cobalt alloy, such as nickel-manganese cobalt, but the key ingredient is cobalt, which makes for the highest energy storage in the battery. Unfortunately, it also goes hand in hand with a volatile chemistry. Lithium-cobalt chemistries are highly combustible, and cell puncture or drawing too much current can trigger thermal runaway or even a fire. Although uncommon, lithium-ion-cell failures were the cause for

BATTERY CHEMISTRIES



the massive recall of products from Dell, Apple, and others.

Battery manufacturers recognize, however, that applications other than consumer devices, such as laptops and cell phones, have different profiles, and these applications have driven different features requiring different battery chemistries. The first challengers to laptops as drivers for battery technology were cordless-power tools. Power tools still require adequate energy capacity, but they also need large bursts of power at a high current rate. Power-tool users will pay a premium for eliminating the need for an extension cord annoyingly following them all over their work sites or shops. In the past, power-tool designers could get by with battery chemistry such as nickel cadmium, which is adequate for energy storage and can sustain large currents. But Europe's recently enacted ROHS (restriction-of-hazardous-substances) regulations ban most electronic equipment using heavy metals, such as cadmium. So, manufacturers can no longer sell products with "non-green" nickel-cadmium-battery packs. A new requirement for cordless power is also battery-charge- and discharge-cycle life, because users discard most consumer-electronics battery packs after three years, whereas power-tool users keep their equipment longer.

Battery companies A123 Systems, Valence Technology, Altair Nano, and E-One Moli Energy have each developed a lithium-ion chemistry that uses an iron-phosphate-based cathode. By eliminating the use of cobalt, iron-phosphate batteries sacrifice high energy density, but they gain the ability to support higher current and, thus, greater power. They also have no thermal-runaway problems. So, lithium-iron-phosphate batteries became available just as ROHS regulations went into effect. Power tools introduced a new power-usage profile into battery options and enabled other applications. Robin Tichy, PhD, technical-marketing manager at battery-pack-design house Micro Power, gives this example of how applications with common power-usage profiles can leverage battery technology: "Applications that have motors tend to fit the same high-power/high-current capability of power tools. Now, engineers can make a battery-powered version of a motorized application." For example, Valence's lithium-iron-phosphate-battery packs power new versions of the motorized Segway personal-mobility device.

AT A GLANCE

- Laptops are no longer the dominant application driving lithium-ion-cell development.
- Lithium-ion cells with cobalt cathodes provide high energy capacity; cells with iron phosphate provide high power and can sustain high charge and discharge rates.
- Cordless-power tools are big players, with electric cars coming on strong and driving research dollars.
- You can optimize for either energy or power—but not both.

All battery manufacturers are eyeing the enormous market potential of EVs (electric vehicles), HEVs (hybrid EVs), and PHEVs (plug-in HEVs). Unlike laptops, the No. 1 battery characteristic for any vehicle is safety. Although consumers will tolerate cell-phone or laptop battery packs' overheating and the—rarely—ensuing fire, they won't accept the potential explosion of tens of kilowatts and the resulting disaster in an EV. So, although lithium-ion-cobalt batteries are attractive for their energy-storage capability, their tendency to have thermal runaway has all but ruled them out for mainstream EVs and HEVs. An exception is the Tesla Motors' Roadster, which has a range of more than 200 miles and an acceleration of 0 to 60 mph in 4 seconds. Although it will use a lithium-ion-cell battery pack, the pack has elaborate power-control and -monitoring electronics. In addition, the high-end-performance car selling for more than $95,000 doesn't target typical consumers (**Reference 2**).

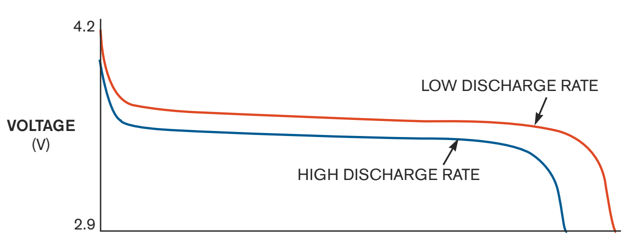


Figure 1 The curve for lithium-ion batteries illustrates a complex relationship based on discharge rate, age, temperature, and other factors.

EVs rely completely on their batteries to store energy and use it to power their motor-driven wheels. HEVs rely on a combination of an internal combustion engine and a battery-powered motor. With the need to rapidly charge and discharge the battery, HEVs and PHEVs are closer in many ways to power tools than to laptops. PHEVs' energy requirements need to meet only a minimum energy capacity, in contrast with laptops, in which more is always better. PHEVs put energy density at the bottom, rather than the top, of their battery-features list.

General Motors' PHEV concept car, the Chevy Volt, will have an all-electric range of 40 miles. Most daily trips in the United States fall within this range, meaning that much of the car's travel will be all-electric. To support this 40-mile range, the Volt will have a 16-kW lithium-iron-phosphate battery. Like most other batteries, lithium-ion batteries operate best within a state-of-charge window: Rather than charge the battery to its theoretical maximum charge and then run it down to a total discharge, the Volt will charge each night from its ac outlet plug to 80% of its theoretical maximum and then discharge down to 30% of its maximum, resulting in a 40-mile range. Once the battery discharges to 30%, then the car's 1-liter internal combustion engine starts, but, rather than directly powering the wheels, the engine generates electricity to keep the battery charged at its 30% level (**Reference 3**). Lithium-iron-phosphate batteries provide "good-enough" energy capacity and have thousands of cycles of rapid charge and discharge currents, making them an enabling technology for PHEVs. For these vehicles, power capacity trumps energy.

Similarly, the battery for an HEV needs to provide power at the expense of energy storage. In city traffic, a battery is constantly charging or discharging, and reliance on the battery for an extended range is rare. A familiar example of an HEV is the Toyota Prius, which debuted in 2004 and is the most common hybrid on

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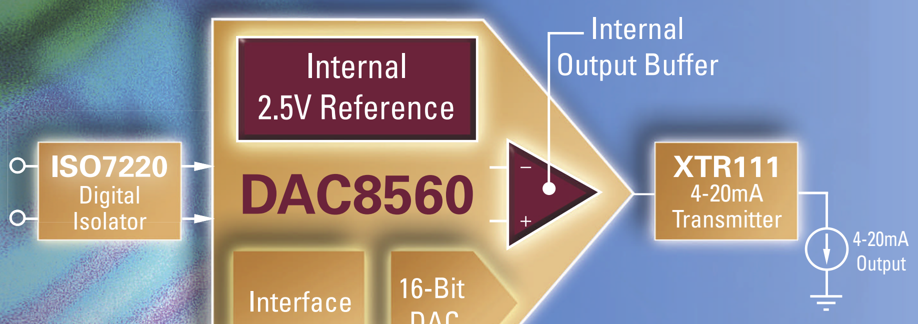

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Technology for Innovators™ TEXAS INSTRUMENTS the road today. The Prius uses a parallel-hybrid configuration, meaning that either the battery or the internal combustion engine can power the wheels. In practice, the battery mainly acts as a power assistant and harvester for the Prius' acceleration/deceleration: It can power the car in EV-only mode for only about two miles. The battery-use profile of such a hybrid places a premium on power, rather than energy, because the car uses the battery to frequently and quickly charge and discharge, rather than to fully charge and then power the car for a long trip. The Prius uses a nickel-metal-hydride battery, which in 2004 was the optimum battery chemistry for repeated rapid charge and discharge cycles.

Toyota is not standing still regarding new battery technologies, but it doesn't appear nearly as confident about lithium-ion-battery development as GM is. Toyota announced this year that it would introduce a hybrid with lithium-ion batteries in 2009, but later said that safety concerns about lithium ion would delay the introduction until 2011. Although Toyota has not provided any details about the type of lithium-ion-battery chemistry it's working on, the safety concerns seem to imply that lithium-ion cobalt is at least one of the chemistries it is investigating. This chemistry is also a strength of Toyota's current hybrid-battery-pack supplier, Panasonic. However, lithium-ion-cobalt batteries' strength is energy storage rather than power storage, so Toyota may lag behind GM in its PHEV-battery development.

Vendors of lithium-iron-phosphate batteries recognize this variation in power-versus-energy-capacity needs of EVs and HEVs. For example, A123 has introduced two battery types rather than a one-size-fits-all device. The 32113 M1 Ultra high-power cell targets HEVs, and the 32157 M1 HD cell uses a higher-energy-electrode design that provides greater battery-only range for PHEVs. Both battery types will deliver more than 10 years and 150,000 miles in engineered automotive-battery packs. A123 is providing batteries for the GM Saturn Vue PHEV-development program, which may reach production status as early as 2009. Users will be able to plug in the PHEV-version Vue at night, but the EV range is only approximately 10 miles.

Figure 2 The XO laptop will cost $100 to $200 and use alternative forms of power to help in the education of children in developing countries.

New battery chemistries and capabilities are not the only changes in portable power; the surrounding electronics are also improving and becoming more complex. Accurate fuel gauging has for years been the Achilles' heel of lithium-ion batteries. Lithium ion has an unpredictable discharge profile: You don't know how much charge remains because it varies, depending on the discharge rate, temperature, and life of the cell (**Figure 1**). Addressing that problem, Texas Instruments recently introduced a the bq27500 battery-fuel-gauge IC incorporating the company's Impedance Track technology, which directly measures the effects of discharge rate, temperature, age, and other factors on cell impedance. The technology, which TI claims offers 99% accuracy, uses these parameters to calculate the remaining battery capacity and full-charge capacity (**Reference 4**).

Battery-fuel-gauge ac-curacy is more important in medical devices than in any other application. Portable medical devices require a series of warning flags indicating a countdown to when the battery will discharge, with a highly accurate countdown beginning at 30 minutes before the battery will die. In the past, portable medical devices have used sealed-lead-acid backup batteries

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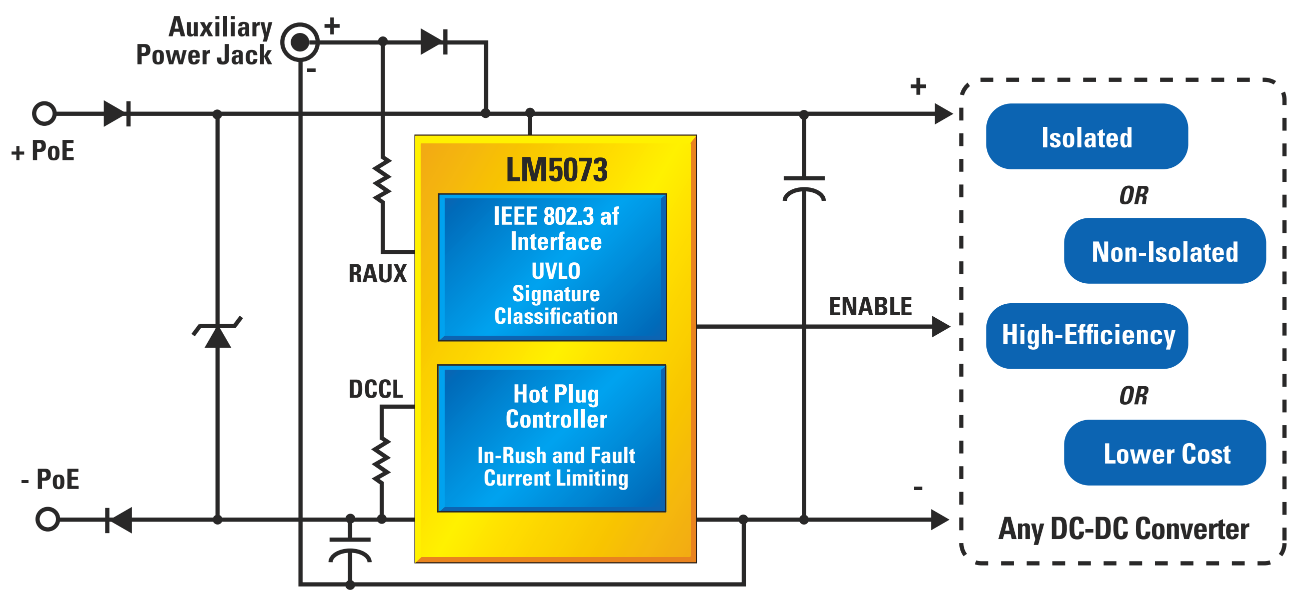

Product ID	Abs Max V_{IN} (V)	Hot Swap FET Rds(on) Typ (Ω)	DC Operating Current Limit	Auxiliary Power Support[1]	Integrated DC-DC Converter	Packaging
LM5070	76	1	Fixed 390 mA	Front only	✔	TSSOP-16
LM5071	76	1	Fixed 390 mA	Front or rear	✔	TSSOP-16
LM5072	100	0.7	Programmable to 800 mA	Front or rear, dominant or non-dominant	✔	TSSOP-16EP
LM5073	100	0.7	Programmable to 800 mA	Front or rear, dominant or non-dominant	—[2]	TSSOP-14EP

[1] Front auxiliary power is coupled though the PD interface. Rear auxiliary power is coupled to the input of the DC-DC converter. Dominant auxiliary power supersedes PSE power when the auxiliary source is connected.
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because they have a predictable constant-slope discharge. However, Micro Power puts lithium-ion-battery packs into medical devices because the Impedance Track technology allows a highly accurate gauging of the battery.

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Alastair Johnson, vice president of marketing and sales for Valence, cautions that designers often overlook the broader issue of battery-management electronics. "For one hybrid-bus manufacturer that we work with, the batteries are as much as 25% of the total cost of the vehicle, which puts battery costs second only to the drive-system costs. Designers need to protect the battery system from any kind of stress. The better your battery-management system is at monitoring and carrying out small adjustments on your pack, the better your extension of the life of the battery, and the better the protection of the customer's ROI [return on investment]."


The Chevy Volt PHEV will have a range of 40 miles traveling on its battery alone.

Even as laptops cease to be the single dominant driver of battery requirements, the laptop itself is changing. Take, for example, the OLPC (One Laptop Per Child) organization's design effort. Its developers initially conceived the idea to provide $100 laptops to children in Third World countries, and the project has had to overcome an almost-overwhelming array of technical challenges. For example, how do you power a laptop in areas without reliable power utilities? The designers have come up with several options, both solar- and human-powered, which the OLPC's XO laptop makes feasible (**Figure 2**). It consumes 2W of nominal power—a tenth of today's standard laptop, according to the OLPC organization. OLPC asserts that the first alternative-energy source for the XO will be flexible thin-film solar panels from ECD Ovonics, rather than the more efficient but less rugged and more expensive silicon/crystalline-based solar panels. OLPC uses the phrase "virtually indestructible" when describing the panels, always a desirable feature for equipment that children use. The laptops will come with a manual crank from Freeplay and a lithium-iron-phosphate-battery pack from Gold Peak and BYD Batteries

What's ahead for batteries? Lithium

derivatives may not be the final word on energy density and safety. ZPower, which is developing a silver-zinc battery for the consumer market, demonstrated a prototype version powering a laptop at the recent Intel Developer Forum in the all-day section on computing. ZPower claims that its batteries will have an energy density of 200 Whr/kg and be completely nonflammable, with no nasty ingredients to end up in landfills. But silver is one of the most expensive battery materials. To offer these batteries at only a 20% or so premium over lithium ion, the company will establish a trade-in policy for its batteries and effectively recycle all of the silver, according to ZPower President Ross Dueber, PhD.

And portable energy storage is no longer limited to batteries. For example, Medis offers a liquid borohydride-powered microfuel cell, the 24-7 Power Pack, which can recharge small consumer electronics, such as cell phones and MP3 players. You activate the device by squeezing it, and it supplies 1W at 3.8 to 5V, enough to power an MP3 player for 60 to 80 hours. The small, recyclable power pack sells for $19.99. **EDN**

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BY SHYAM CHANDRA • LATTICE SEMICONDUCTOR

A −48V hot-swap-controller design targets high-power blades

DESIGNING CIRCUITS THAT ALLOW SAFE REMOVAL AND REPLACEMENT OF HIGH-POWER PLUG-IN BLADES IN MODERN COMPUTING AND COMMUNICATION SYSTEMS IS NOT A TRIVIAL EXERCISE–ESPECIALLY WHEN THE SYSTEM SPECS DICTATE THAT THE OTHER BOARDS IN THE ENCLOSURE MUST CONTINUE TO PERFORM FLAWLESSLY DURING A BOARD SWAP. LOW-COST, PROGRAMMABLE-HOT-SWAP-CONTROLLER ICs GREATLY FACILITATE SUCH DESIGNS, HOWEVER.

Many large telecom and datacom systems use multiple PCBs (printed-circuit boards) or blades that plug into a common backplane within a subrack enclosure. The backplane supplies the power—for example, −48 or 12V—to these blades and to the communication path between them. Because the backplane power is always on, the system is called hot, or live.

A newly inserted blade begins its operation using the power it receives from the backplane. If the system detects a blade fault, you must be able to restore service by removing the blade from its slot and inserting a new blade into the same slot without affecting the operation of the other blades. Hot-swappable blades support hot swapping—the removal of a blade from the live backplane and insertion of a replacement. When you insert a blade into a live backplane, all the capacitors that connect to the backplane on that blade begin to charge, drawing a large amount of current from the backplane. This inrush current can result in a brownout—a momentary dip in backplane voltage—and arcing at the connector. Excessive inrush current can overload the backplane power supply, turning off the supply and affecting the operation of the remaining blades. The blades must therefore limit the inrush current during hot swapping. The hot-swap-controller IC is responsible for inrush-current limiting (**Figure 1**).

When you plug a card into the backplane, MOSFET parasitic capacitance causes current-inrush pulse to flow—typically, for a few microseconds. In addition, connector-contact bounce applies power to the blade in pulses. The hot-swap controller keeps the MOSFET and the dc/dc converter off until the contact bounce stops. The controller then gradually turns on the MOSFET, using the voltage across the current-sense resistor as feedback to limit the inrush current to a value less than the maximum-specified blade-supply current. This current charges the hold-off capacitor until the voltage at the V_{MOSFET} pin is close to −48V. At this point, the dc/dc con-

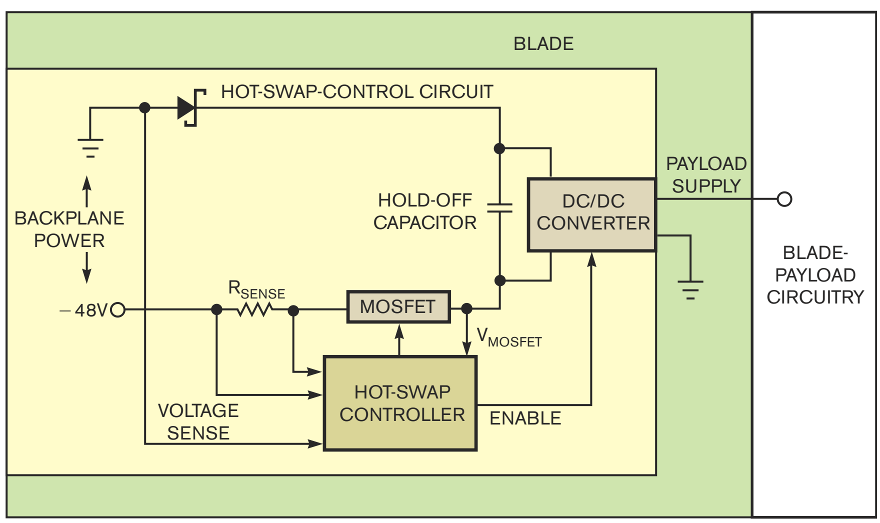

Figure 1 In this hot-swap controller, the ground terminal sends power to the dc/dc converter through a Schottky diode. The dc/dc block is an isolated supply that generates the payload power-supply voltage. The dc/dc converter's negative terminal connects to the −48V supply branch through a MOSFET switch and a current-sense resistor. The hold-off capacitor across the dc/dc converter stores enough charge to keep the board operational during backplane brownouts. The controller uses a current-sense resistor and the V_{MOSFET} signal to monitor the MOSFET's current and voltage, enabling control of the MOSFET power dissipation during inrush.

verter turns on to supply the power to the payload section of the blade.

The hold-off capacitor keeps the board operating when the backplane voltage drops because of insertion of another card. The required hold-off capacitor's value is directly proportional to the blade's total power dissipation and how long the blade can operate under brownout conditions. When a brownout lasts longer than a predetermined limit, the condition is a power-supply undervoltage, and an undervoltage-lockout process begins. Undervoltage lockout shuts off the MOSFET until the backplane voltage returns to normal. A Schottky diode in series with the supply's ground branch prevents reverse-current flow from the hold-off capacitor into the backplane during the brownout.

The hot-swap controller should also be able to detect power-supply faults, such as undervoltage and overcurrent. In both cases, the hot-swap controller should try to reapply power to the blade after the fault clears.

DESIGN CONSIDERATIONS

Not surprisingly, for designs using less than approximately 50W of power, the hot-swap-controller circuit is simple because of the small backplane current. However, modern blades must increasingly dissipate more power because of their higher performance. For example, many ATCA (Advanced Telecom Computing Architecture) blades dissipate approximately 200W. Accommodating today's blades' higher power dissipation requires the use of higher value hold-off capacitors and higher power MOSFETs.

Because the inrush-current magnitude is proportional to the capacitor size, increasing the hold-off-capacitor values can increase the brownout period for the other blades in the enclosure. To enable quick recharging of the hold-off capacitors, the hot-swap controller should keep the MOSFET fully turned on during the time just after the brownout period when the capacitor-charging current can exceed the overcurrent limit. During this interval, the hot-swap controller should temporarily disable its current limit.

When the hold-off capacitor begins to charge, the voltage across it is close to 0V, and the entire backplane voltage appears across the MOSFET. Consequently, the MOSFET's instantaneous power dissipation is large. For example, a 200W blade draws approximately 4A of current from the −48V backplane during normal operation. Such a blade has an overcurrent threshold of 5A, and the hot-swap controller limits the inrush current to this value during power-up. When the hold-off capacitor begins to charge, the MOSFET dissipates 48V×5A, or almost 250W! That much power is typically beyond the SOA (safe-operating area) of the MOSFETs that control 200W blades. To avoid compromising the circuit's reliability, designers must ensure that the MOSFET never operates outside its SOA.

A log-to-log scale graph shows the drain-to-source voltage across the MOSFET on the X axis and the MOSFET current on the Y axis (**Figure 2**). Multiple curves show safe current-pulse amplitudes for various pulse durations. The area below the curve is the MOSFET's SOA. Designers should ensure that the MOSFET does not operate outside the SOA, even during the brief start-up period. Moreover, to avoid damage to the MOSFET, designers should consider the device's average power dissipation during normal operation.

Any number of possible circuit faults can cause a blade to draw large amounts of current. The fault can be on the high-voltage side before the dc/dc converter, on the secondary side after the converter, or within the converter itself. If you insert a blade with an overcurrent fault into the backplane, the hot-swap controller should act quickly to limit the current while operating the MOSFET within its SOA to minimize interference with the other blades in the enclosure. During blade operation, faults can develop either on the backplane supply or in the payload section. A backplane fault can last for a short period, as in a brownout condition, which hold-off timing determines, or for a longer duration, in which the hot-swap controller should wait until the fault clears before trying to reconnect. If the payload section of the blade draws more power than specified, the hot-swap controller should shut down the

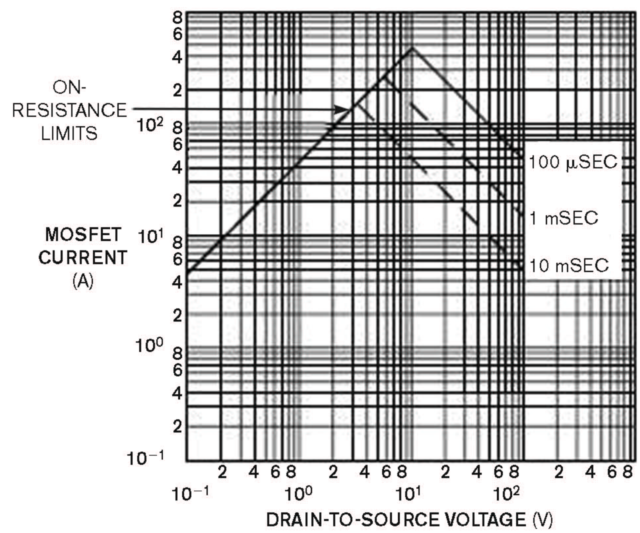

Figure 2 Multiple curves show safe current-pulse amplitudes for various pulse durations. The area below the curve is the MOSFET's safe operating area.

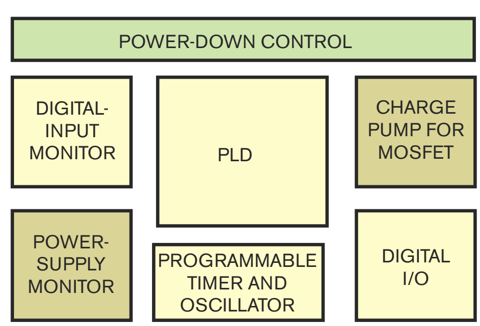

Figure 3 A programmable power-management device, such as the Lattice POWR607, has six functional blocks surrounding the PLD core.

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board. The following hot-swap-circuit example addresses all of these design issues.

DESIGN EXAMPLE

The hot-swap-controller circuit in this section uses a low-cost programmable power-management device, such as Lattice Semiconductor's (www.latticesemi.com) POWR-607 (**Figure 3**). This hot-swap circuit addresses all of the previously noted design considerations. The device uses a set of six programmable-threshold comparators to monitor as many as six PCB power supplies. Additionally, the device provides seven open-drain digital outputs. You can configure two of these outputs as high-voltage MOSFET drivers. Two general-purpose digital inputs can perform miscellaneous control functions. The on-chip, 16-macrocell PLD and four programmable timers provide flexible control over the hot-swap-controller algorithm. This article refers to this power-management device as a PHSC (programmable hot-swap controller).

> **THE ON-CHIP, 16-MACROCELL PLD AND FOUR PROGRAMMABLE TIMERS PROVIDE FLEXIBLE CONTROL OVER THE HOT-SWAP-CONTROLLER ALGORITHM.**

In the −48V hot-swap circuit, the PHSC controls the STB-120NF MOSFET for inrush-current control while operating the MOSFET within its SOA (**Figure 4**). The controller monitors the circuit current using the current-sense resistor. Two 43/3.3-kΩ voltage dividers enable the PHSC to monitor the backplane voltage and the voltage across the MOSFET. The 6V zener diode protects the PHSC's input section. When you plug the blade into the backplane, the PHSC waits for the contact bounce to settle and then begins to charge the hold-off capacitor using current pulses instead of a continuous-current feed. You can program the current-pulse rate to meet the MOSFET's power-dissipation characteristics. When the voltage reaches a preset value, the current-pulse rate increases, hastening charging of the hold-off capacitor.

After the hold-off capacitor completely charges, the MOSFET fully turns on and the power-good signal activates, enabling the dc/dc converter. The PHSC's two voltage-monitoring inputs monitor the voltage across the MOSFET. The fast-charge duty-cycle threshold programmed into the first voltage-monitoring input determines the changeover from slow to faster hold-off-capacitor charging. The end-of-soft-start threshold programmed into the second voltage-monitoring input signals completion of hold-off-capacitor charging and fully turns on the MOSFET.

The PHSC waits for a preset period, which the short-circuit watchdog timer determines, for the voltage across the MOSFET to drop below the fast-charge threshold. If the voltage across the MOSFET stays above the fast-charge level, the MOSFET turns off, indicating a fault, such as a short circuit. With this implementation, the MOSFET continues to operate within its SOA, even if a short circuit is present.

During normal operation, when the backplane voltage drops below a preset threshold, the PHSC senses the beginning of a brownout period and starts an internal programmable 5-msec time-out. If the power supply recovers within 5

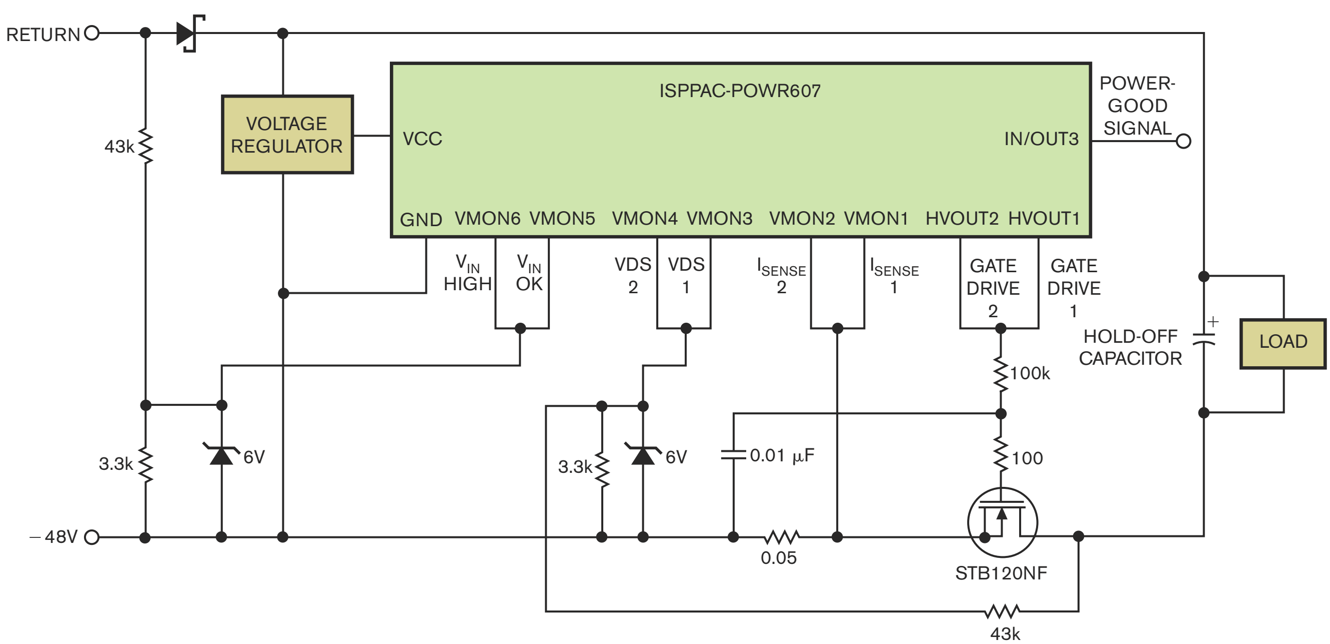

Figure 4 In this −48V hot-swap circuit, the PHSC controls the STB120NF MOSFET (bottom right) for inrush-current control and operates the MOSFET within its safe operating area. The controller monitors the circuit current using the current-sense resistor (to the left of the MOSFET). Two 43/3.3-kΩ voltage dividers enable the PHSC to monitor the backplane voltage and the voltage across the MOSFET. The 6V zener diode protects the PHSC's input section.

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msec, the circuit continues to function normally. If the time-out expires, the hot-swap controller classifies the event as an undervoltage condition and jumps to the power-recycle routine, in which it waits for the supply to stabilize before initiating a hold-off-capacitor recharge. During normal operation, the PHSC also continuously monitors current; should the current exceed a preset limit, the PHSC protects the circuit by immediately turning off the MOSFET.

Figure 5's top trace shows 5-msec-long, 1.5A current pulses charging the hold-off capacitor. The bottom trace is the voltage across the MOSFET during charging of a 4700-μF hold-off capacitor. Two of the PHSC's MOSFET drivers drive the MOSFET gate. One maintains the current amplitude at 1.5A; the second controls the modulation rate. This circuit deliberately limits the modulation rate to one 5-msec pulse every 260 msec. During a short circuit, the MOSFET's worst-case average power dissipation could thus not exceed 1.5A×48V×5 msec/260 msec=1.4W.

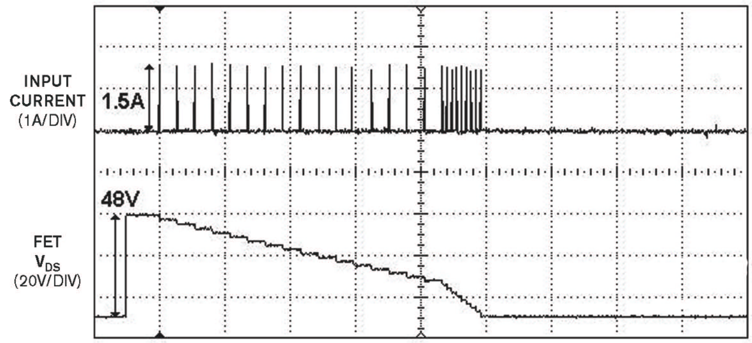

Figure 5 The top trace shows 5-msec-duration, 1.5A current pulses charging the hold-off capacitor. The bottom trace is the voltage across the MOSFET during charging of a 4700-μF hold-off capacitor. Two of the controller's MOSFET drivers drive the MOSFET gate. One maintains the current amplitude at 1.5A; the second controls the modulation rate.

CUSTOMIZING THE PHSC

You can implement the entire hot-swap algorithm within the PHSC's 16-macrocell PLD. You can customize this algorithm to suit your blade requirements by setting the following parameters:

- Short-circuit watchdog duration: If the hold-off capacitor does not charge in the specified period, the MOSFET shuts off.
- Charging-current-pulse duration: The selected pulse width guarantees that the MOSFET operates within its SOA.

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TEXAS INSTRUMENTS

• Charging-current-pulse frequency: This parameter, along with the charging-current-pulse duration, determines the power dissipation for a MOSFET.

• Minimum hold-off time before recycling: This parameter determines the blade's immunity to brownouts.

• Current-sense scaling: This parameter should match the selected R_{SENSE} resistor.

• Charging-current-pulse amplitude: The R_{SENSE} resistor value determines this parameter.

• Circuit-breaker current: This parameter is the maximum current value to initiate shutoff and restart.

• End of soft-start operation: This parameter sets the voltage at which the MOSFET fully turns on and the power-good signal activates.

• Transition to fast-charge duty cycle: This parameter determines the voltage at which the charge-pulse frequency increases to safely reduce the hold-off-capacitor charging time.

• Minimum operating voltage: This parameter determines the backplane voltage below which the brownout process begins.

• Overvoltage lock down: This parameter shuts off the MOSFET to protect the blade.

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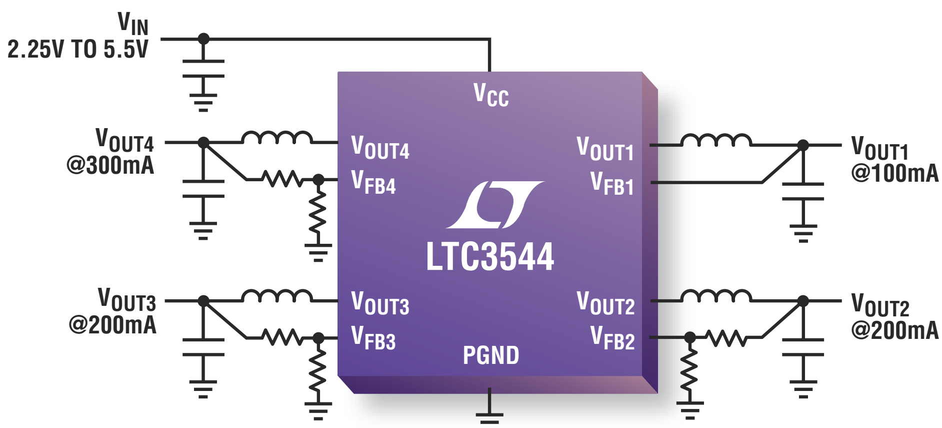
Increased blade capability is increasing blades' power consumption, imposing stringent requirements on hot-swap-controller circuits. Without significant trade-offs, traditional hot-swap-control approaches with limited features no longer meet the requirements of high-power blades.

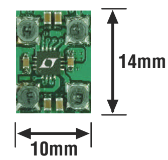
Using a Lattice POWR607 PHSC IC increases the blade's reliability and provides many programmable features that enable designers to meet the challenges of increased blade-power dissipation. This design ensures that the MOSFET operates within its SOA even in the presence of a short circuit in the blade. Improved immunity to brownouts, overcurrent and overvoltage protection, and automatic retry in case of faults further enhance the blade's reliability. In addition, minimizing interference with other blades in the subrack enclosure makes the blade more amenable to hot swapping. By using a device such as the POWR607 and customizing its algorithm to satisfy individual PCB-power requirements, designers can standardize hot-swap-controller architecture across many blade types.**EDN**

AUTHOR'S BIOGRAPHY

Shyam Chandra is product-marketing manager responsible for mixed-signal-product marketing at Lattice Semiconductor (Portland, OR), where he has worked for 17 years. He holds a master's degree in electrical engineering from the Indian Institute of Technology (Madras, India) and lists his personal interests as analog electronics, hiking, biking, and badminton.

Quad Buck





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LTC3407/A	Dual Synch Step-Downs	2.5V to 5.5V	0.6 x 2	0.6	1.5MHz	40	3mm x 3mm DFN-10, MSOP-10E
LTC3419	Dual Synch Step-Downs	2.5V to 5.5V	0.6 x 2	0.6	2.25MHz	35	3mm x 3mm DFN-8, MSOP-10
LTC3548/-1/-2	Dual Synch Step-Downs	2.5V to 5.5V	0.8, 0.4	0.6	2.25MHz	40	3mm x 3mm DFN-10, MSOP-10E
LTC3407-2/-3	Dual Synch Step-Downs	2.5V to 5.5V	0.8 x 2	0.6	2.25MHz	40	3mm x 3mm DFN-10, MSOP-10E
LTC3417A	Dual Synch Step-Downs	2.25V to 5.5V	1.5, 1	0.8	2.25MHz	125	3mm x 5mm DFN-20, TSSOP-20E
LTC3446	Single Synch Step-Down + Dual VLDOs	2.7 to 5.5V	1.0, 0.3, 0.3	0.4	2.25MHz	140	3mm x 4mm DFN-14
LTC3545	Triple Synch Step-Downs	2.25V to 5.5V	0.6 x 3	0.6	2.25MHz	58	3mm x 3mm QFN-16, MSOP-10E
LTC3544/B	Quad Synch Step-Downs	2.25V to 5.5V	0.3, 2 x 0.2, 0.1	0.8	2.25MHz	70	3mm x 3mm QFN-16
LTC3562	I²C Quad Synch Step-Downs	2.7V to 5.5V	2 x 0.6, 2 x 0.4	0.6	2.25MHz	100	3mm x 3mm QFN-20

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Tiny Amplifiers Drive Heavy Capacitive Loads at Speed

Design Note 429

Keegan Leary and Brian Hamilton

Introduction

Parasitic capacitance lurks behind every corner of an electronic circuit. FET gates, cabling, ground and power planes all add to the Farad bottom line. When the capacitive load gets heavy in high speed circuits, careful op amp selection is paramount for optimizing slew rate, current output capability, power dissipation, and feedback loop stability.

Demanding Circuit Requirements

For example, consider a 100MHz, $2V_{P-P}$ sine wave signal driving a 350pF capacitive load. The minimum required slew rate without distortion for this scenario is:

$$SR_{MIN} = 2\pi f V_{PK}$$
$$SR_{MIN} = 2\pi(100MHz)(1V)$$
$$\approx 630\frac{V}{\mu s}$$

The slew rate sets the maximum output current—the amplifiers are charging a capacitor, so the maximum output current occurs at maximum slew.

$$I = C\frac{dV}{dt}$$
$$I = (350pF)\left(630\frac{V}{\mu s}\right)$$
$$\approx 220mA$$

Maximum power dissipation is an important consideration. For an op amp operating from ±5V supplies, and assuming the capacitive load starts at 0V and is charged at maximum current, peak power is:

$$P = IV$$
$$P = (220mA)(5V)$$
$$\approx 1.1W$$

With a package that has a thermal resistance of 135°C/W, this much continuous power would result in a 148°C rise in die temperature. If the ambient temperature is 85°C, this brings the die to a package-melting 233°C!

To isolate C_{LOAD} from the amplifier, a design could use a series resistor, R_S. This technique ultimately limits bandwidth when the resistor or capacitive load gets very large. The bandwidth reduction associated with this RC time constant may limit performance. With a current feedback amplifier, increasing the feedback resistor, R_F, is an alternative compensation method to reduce peaking.

Tiny Current Feedback Amplifiers

For the high speed, large capacitive load example above, the 400MHz LT1395/LT1396/LT1397 family of current feedback amplifiers certainly satisfies the slew rate requirement. The LT1395/LT1396/LT1397 can process large signals with speed and 80mA minimum guaranteed output current. However, for the example above, this amplifier family falls short of the 220mA requirement. In this case one may not be enough, but four certainly are. Paralleling these amplifiers satisfies current requirements while maintaining safe power dissipation and stability.

The LT1397 quad was designed to push big loads of current while maintaining good thermal properties. The copper underbelly of the tiny 4mm × 3mm DFN package brings the thermal resistance down to 43°C/W, and a die temperature rise above ambient of only 47°C for the given example.

Component Selection and Testing

Without assembling the entire parallel configuration, a single-amplifier test circuit can be constructed to check results into the load capacitance divided by the number of amplifiers to be used, $C_{LOAD}/4$.

The remaining task is to select appropriate values of the feedback resistor (R_F) and series resistor (R_S) to maximize

11/07/429

the –3dB bandwidth and sufficiently minimize the amount of peaking in the frequency response. For both R_F and R_S, smaller values result in both additional bandwidth and increased peaking. R_F has a practical lower limit of about 255Ω. As load capacitance increases, R_F and/or R_S values must increase to maintain stability.

Figure 2 shows measurement results using the 4-amplifier circuit of Figure 1 with various R_F/R_S combinations and 350pF of total load capacitance. Measurements were performed at a gain of 1, so R_G was not used.

The effectiveness of the 4-amplifier circuit topology over a single amplifier can be seen in Figure 3. For a more representative effect the load capacitance was tripled to 1000pF. The paralleled 4-amplifier circuit is capable of slewing 4V into 1000pF in under 10ns. This corresponds to a slewing output current of 400mA. The single amplifier current limits at about 140mA, reducing the slew rate into this large capacitive load. The same 4V swing for the single requires 28ns, almost three times longer than the 4-amplifier configuration.

Conclusion

Always consider using all of the amplifiers available in a tiny power-enhanced package to provide the muscle needed to rapidly slew heavy capacitive loads. Also consider current feedback amplifiers such as the LT1397 to make it easy to control a very wide bandwidth circuit.

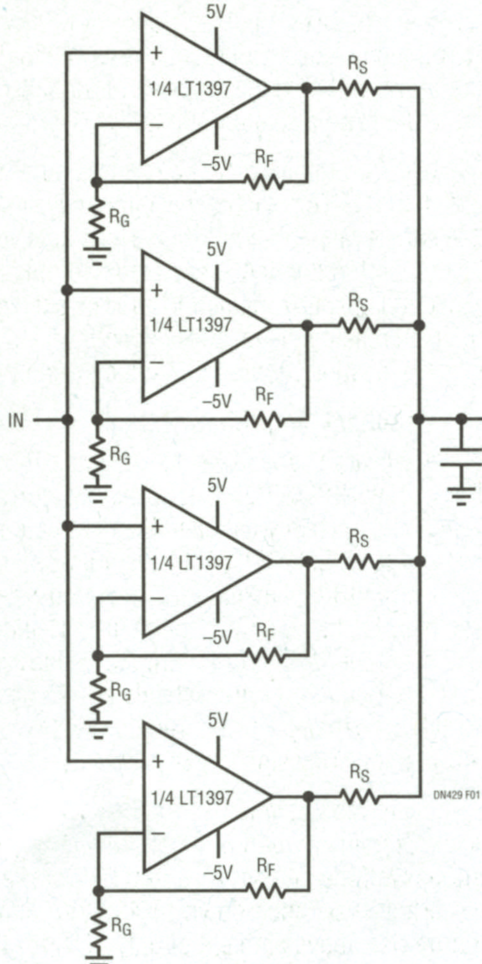

Figure 1. Using All Four Amplifiers of the LT1397 to Drive Large Capacitive Loads

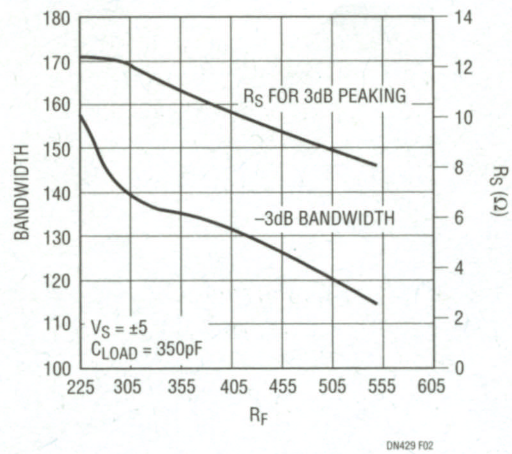

Figure 2. Selecting R_F and R_S to Drive 350pF When Paralleling the Four Amplifiers of the LT1397

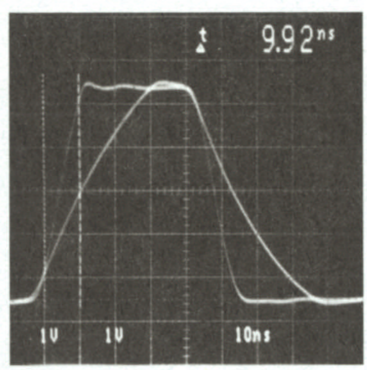

Figure 3. Four Amplifiers Out-Race One Amplifier When Driving a 1000pF Capacitive Load. The Response Time of the Single Amplifier Lags the Quad by a Factor of Three.

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READERS SOLVE DESIGN PROBLEMS

Measure power-line distortion with a mixed-signal-THD analyzer

John R Ambrose, Mixed Signal Integration, San Jose, CA

Because of the performance of compressors and other inductive loads, it becomes more important to monitor the distortion on a power line. With alternative power sources, such as wind or solar, a distorted 60-Hz sine wave is more likely to be present. To measure this distortion, you can use a mixed-signal-THD (total-harmonic-distortion) analyzer to monitor the fundamental frequency amplitude and the second-, third-, fourth-, and fifth-harmonic content of the input signal. The analyzer, from Mixed Signal Integration (www.mix-sig.com) includes five bandpass filters and two op amps. The op amps provide gain and continuous-time filtering. The

DIs Inside

70 Wireless "battery" energizes low-power devices

72 Solid-state analog-data recorder runs for 7.4 days

74 Wideband peak detector operates over wide input-frequency range

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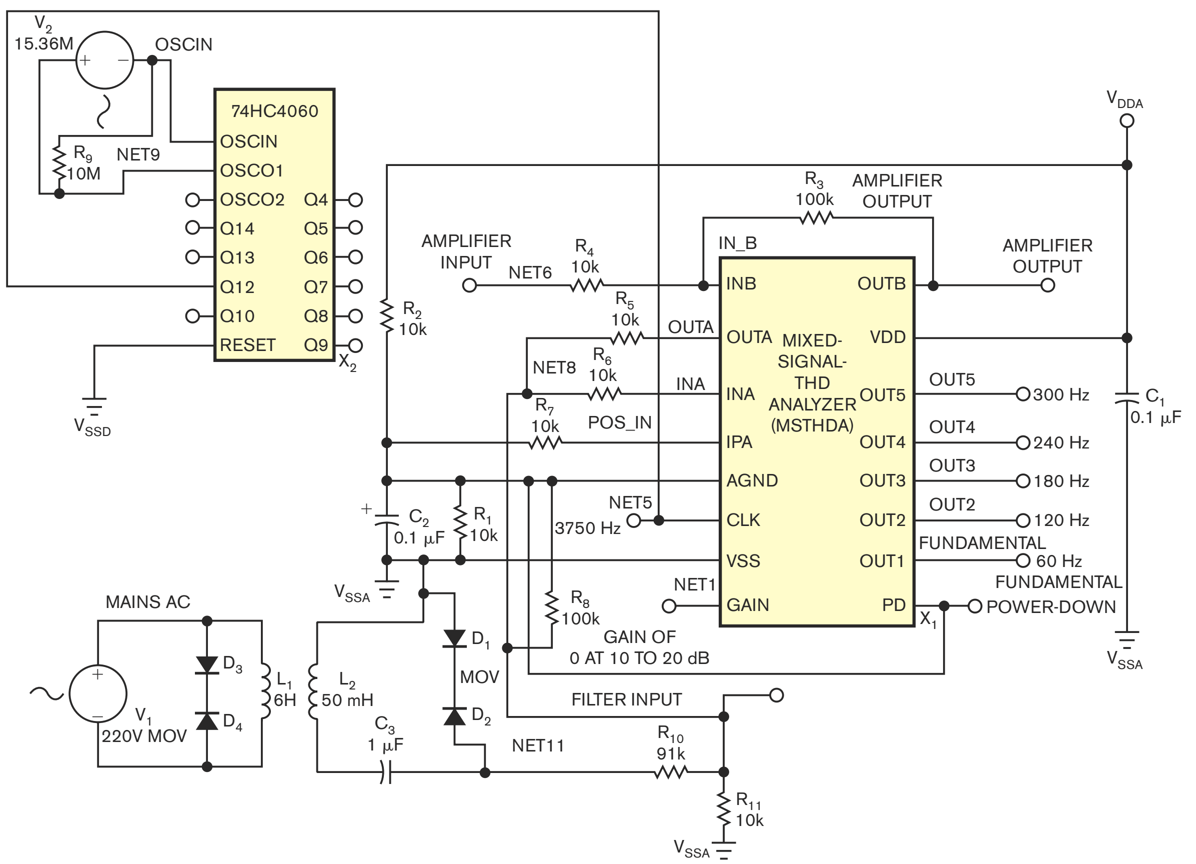


Figure 1 This mixed-signal-THD analyzer monitors the fundamental frequency amplitude and the second-, third-, fourth-, and fifth-harmonic content of the mains-input voltage.

analyzer also has digital-gain control for measurements in which the input amplitude is 10 or 20 dB lower than nominal: 2V p-p. The outputs of the analyzer are analog. Depending on the display that an application requires, you could tie the outputs to a bar-code interface, such as the LM3915 for 3-dB steps, or interface them with a multiplexer on a microcontroller for a digital readout.

Figure 1 shows the connections of the analyzer to the mains supply. A "wall-wart" transformer reduces the 120V mains voltage to 9V ac. This transformer provides 1500V isolation from primary to secondary and has low-distortion performance. The resistors in the divider act as fuses in case of a large surge voltage, and they reduce the voltage you apply to the analyzer. The back-to-back diode clamp protects the analyzer during momentary overvoltage conditions. In addition, a 220V MOV (metal-oxide varistor) across the transformer's primary protects the transformer. The analog ground centers on 2.5V and is derived from a 100-kΩ resistor-divider network. A 0.1-μF capacitor provides ac filtering. A 74HC4060 operates at 15.360 MHz; the divide-by-4096 (Q12) output connects to the analyzer's input-clock signal and supplies the clock for the device's switched-capacitor filters. **EDN**

Wireless "battery" energizes low-power devices

Carlos Cossio, Santander, Spain

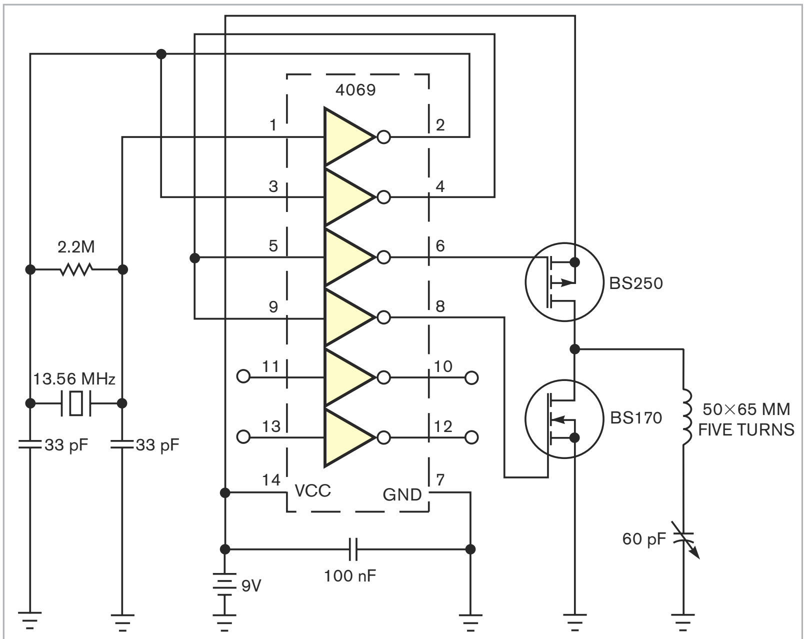


Figure 1 A simple 13.56-MHz oscillator energizes an antenna coil, broadcasting power to the receiving circuit in Figure 2.

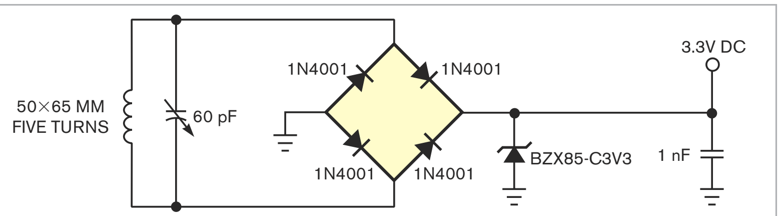


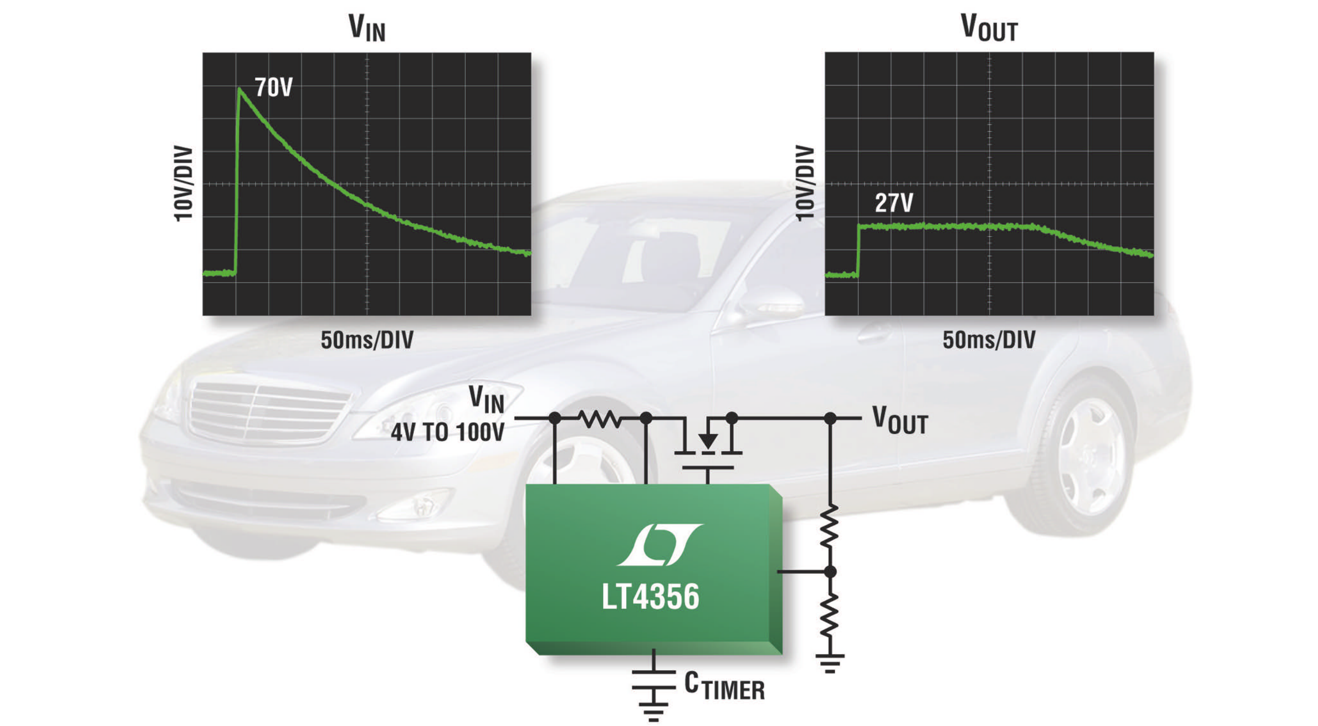
Figure 2 This receiver rectifies the signal from the oscillator in Figure 1, powering low-current consumer gadgets.

Wireless connectivity is a growing trend in portable consumer gadgets. Unfortunately, designs cannot achieve true mobility because of short battery life, so the power cord still must connect the device to the power grid to get the required energy or to recharge the batteries. However, thanks to the low-power requirements of today's electronic devices, it is feasible to power them wirelessly. This Design Idea describes a simple approach to wirelessly transmitting energy to low-power devices at distances as great as 10 cm. This design uses the resonant-inductive-coupling principle working at 13.56 MHz. The system comprises the RF-power transmitter and the RF-power receiver.

Figure 1 shows the transmitter circuit, which incorporates a 13.56-MHz oscillator. The oscillator encompasses a CMOS 4069 inverter using power from a 9V battery to get a wide voltage swing. The oscillating signal then passes through a push-pull output stage comprising two small-signal MOSFETs to get enough current in the output coil. Finally, the output signal broadcasts to the outside by means of a serial-resonant-LC circuit incorporating a coil and a 60-pF variable capacitor tuned to 13.56 MHz.

Figure 2 shows the receiver circuit, which comprises an LC network tuned to a carrier frequency of 13.56 MHz. It includes a coil and a 60-pF variable capacitor in parallel with the coil. A full-bridge rectifier comprising four 1N4001 diodes rectifies RF power. Rectification efficiency is approximately

Surge Stopper



Regulate Overvoltages & Overcurrents

Electronic systems prone to overvoltage and overcurrent events require sound front-end protection to ride out surges and maintain reliable operation in high availability systems. The LT®4356 replaces complicated protection circuitry with a simple IC/FET solution. During an overvoltage event, the LT4356 regulates the output to a user-defined voltage, while a fault timer ensures safe shutdown of the MOSFET if the fault persists. The LT4356 offers complete protection with inrush limiting, overcurrent and reverse input protection.

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- Reverse Input Protection to -30V
- Adjustable Fault Timer
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LINEAR TECHNOLOGY

50%. Reaching 3.3V of output voltage requires a 9V p-p ac voltage across the coil's pins. A shunt regulator incorporating a 3.3V zener diode provides voltage clamping beyond 3.3V to prevent power-level variations with distance. Finally, a 1-nF capacitor after the full-bridge rectifier decouples the power supply. The two coil antennas use five turns of 1-mm enameled-copper wire in a rectangular, 50×60-mm shape.

As an improvement, if your application requires greater distance, you can increase the power supply to 15V to get a greater voltage swing on the transmitter coil, thanks to the CMOS technology the oscillator design employs. In addition, designing a larger-coil antenna in the transmitter and the receiver sides helps to increase the distance of operation.EDN

Solid-state analog-data recorder runs for 7.4 days

S Vinay Kumar, Mysore, India

The solid-state data recorder in **Figure 1** can continuously record the temperature for approximately 178.42 hours, or 7.434 days. The LM35DZ transducer converts the temperature to an analog-voltage equivalent. The analog voltage then goes to the HI5812 ADC, and the digital data gets stored in the nonvolatile DS1270W SRAM at a rate of 3.265 samples/sec. To retrieve the analog signal, the digital data in memory goes to the DAC08. The output of the DAC then goes to the current-to-voltage converter, then to analog switch MC14066, and finally to the output buffer. The address generator is a simple counter, the MC14040. A record-and-play circuit uses an MC14049, and analog switches control the read and write states of the nonvolatile SRAM. A 10-kΩ potentiometer sets the reference voltage of both the ADC and the DAC.

Pressing and releasing the reset button once causes the recording or playing to start from the beginning of the memory location; the recording or playing function depends on the position of the record-and-playback switch. If you close the record-and-playback switch, recording takes place; if the switch is open, playing occurs.EDN

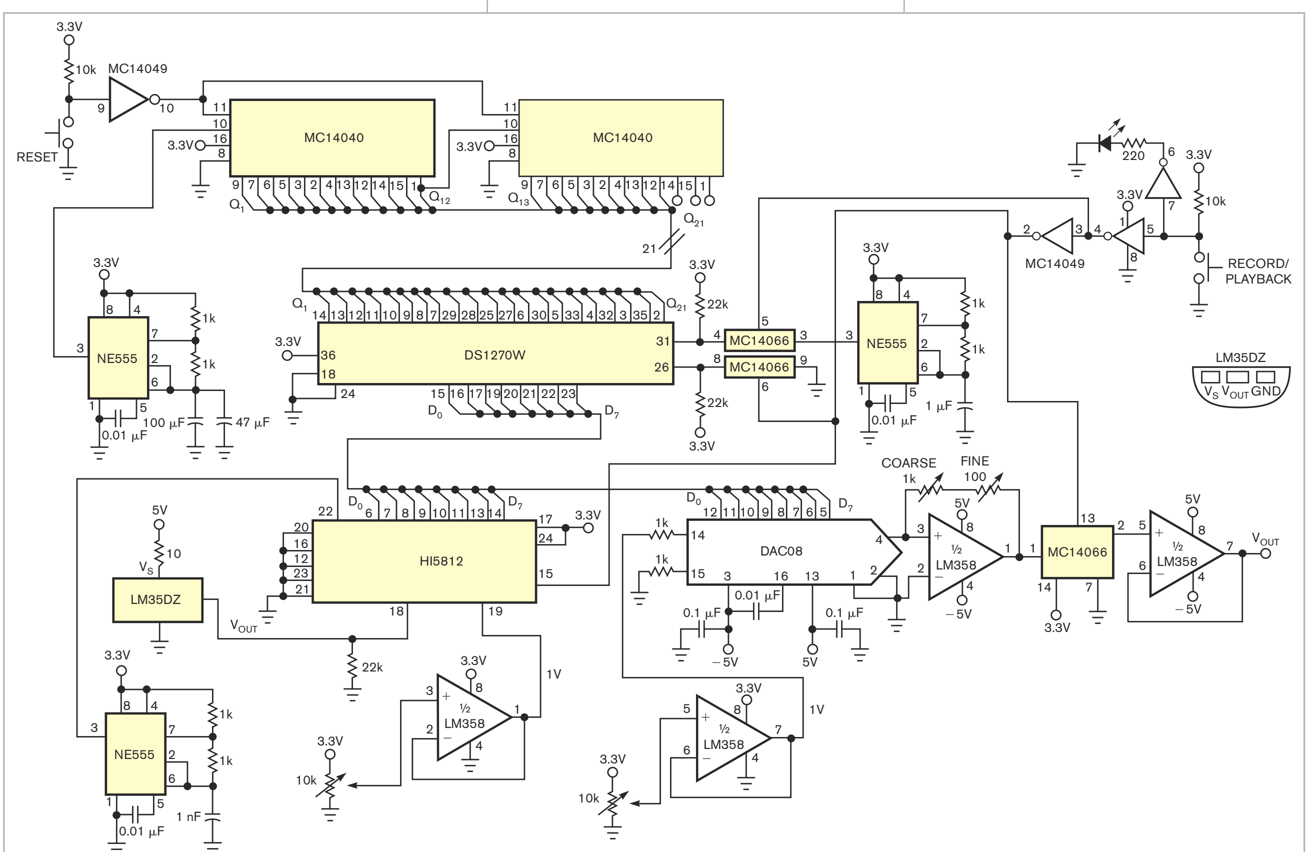

Figure 1 This solid-state data recorder uses an ADC to digitize data, which gets stored in a nonvolatile SRAM. To read back the analog data, the memory's contents shift to a DAC, depending on the state of the record-and-playback switch.

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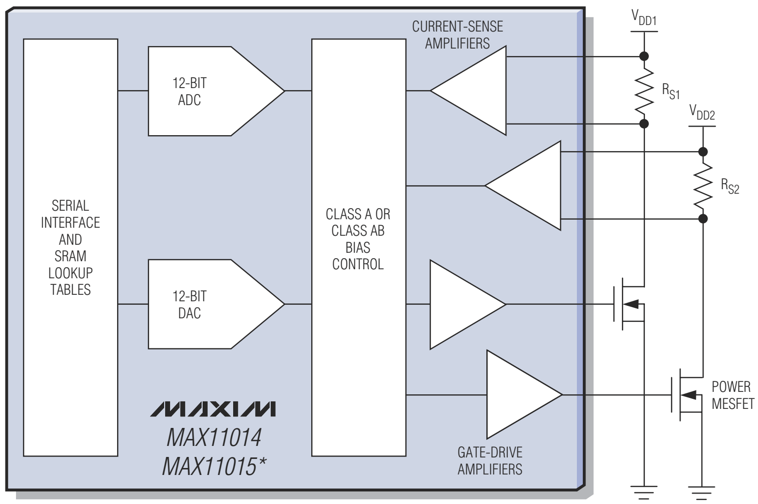

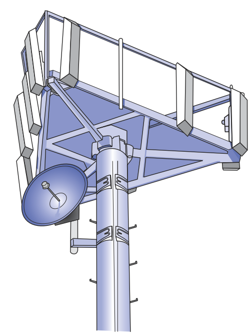

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Wideband peak detector operates over wide input-frequency range

Jim McLucas, Longmont, CO

This Design Idea builds on a previous one (**Reference 1**) to realize a precision peak detector with a bandwidth of 15 to 30 MHz or more, depending on the maximum input-signal level of your application. The crucial feature of this Design Idea is an ultrafast comparator that provides the high slew rate and low propagation delay that this application requires. The comparator in this design is the Analog Devices (www.analog.com) AD8561, a 7-nsec device (**Reference 2**). This peak detector provides accuracy from 100 Hz to more than 14 MHz at input-signal levels of 100 mV p-p to 6V p-p. At higher frequencies, the maximum usable input-signal level decreases. The circuit exhibits an accuracy of ±3% over much of the input-level range. Also, its high input impedance of about 100 kΩ in parallel with 3 pF does not significantly load the circuit under test in many applications; 3 pF results in an impedance of 3.5 kΩ at 15 MHz.

Referring to **Figure 1**, the high-input-impedance buffer comprising IC_1 and its associated components provides the ac signal to the ultrafast comparator, IC_3. The output of IC_1 centers on 0V dc by the action of op amp IC_{2A} and its associated components, which sample the dc level at Pin 6 of IC_1 and then provide a dc-correction voltage to Pin 3 of IC_1. This action virtually eliminates the effects of IC_1's input-offset voltage and input-bias currents. R_1, R_4, and C_1 provide a small amount of gain boost as the frequency increases to 25 MHz, and C_5 then begins to roll off the gain.

The input signal capacitively couples to the input buffer, so, for proper operation, the input-ac signal must have a symmetrical waveform, such as a sine wave. An unsymmetrical waveform has a shift in its peak value after passing through C_2, and, as a result, the output of the peak detector will be inaccurate.

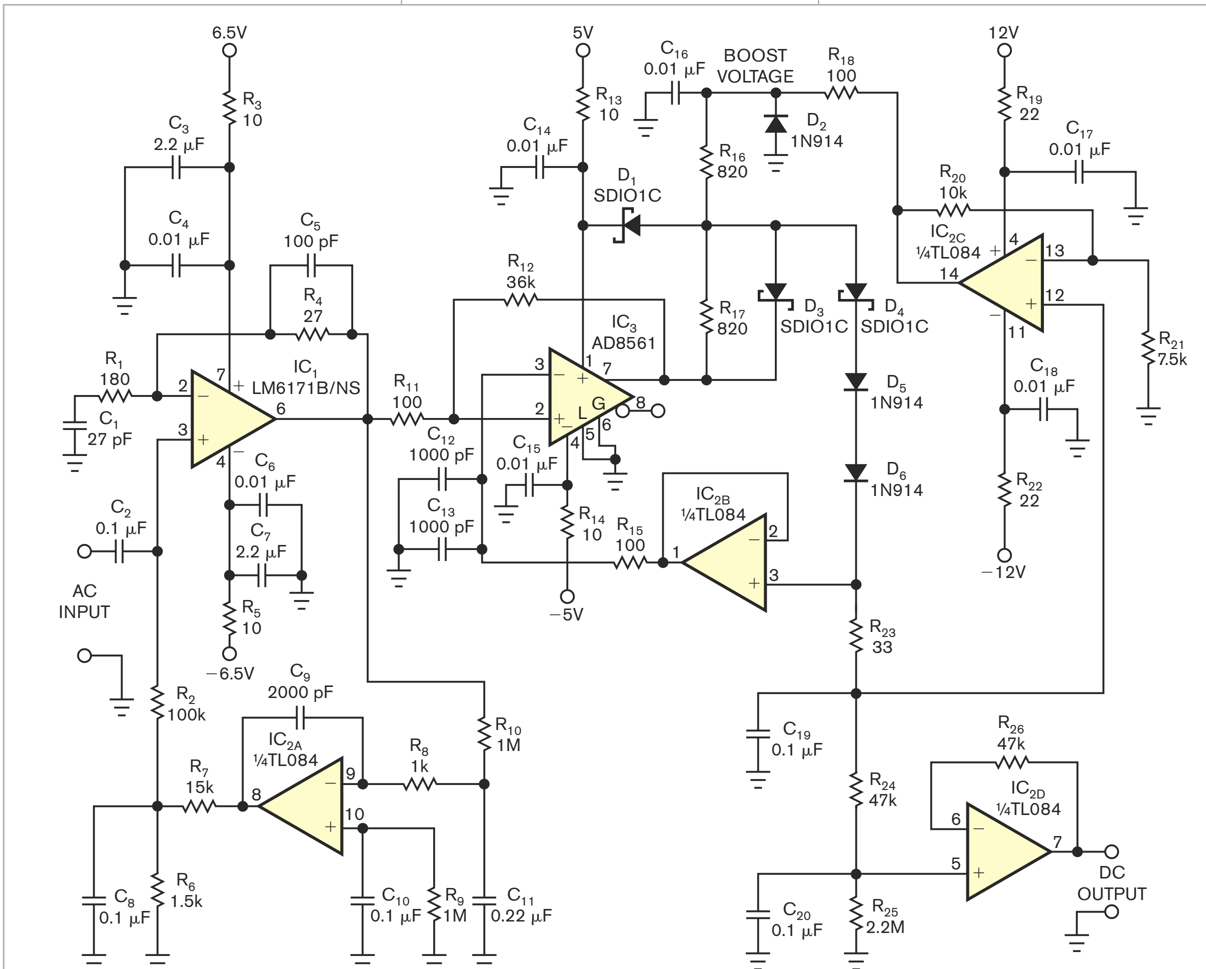

Figure 1 This precision peak detector uses an ultrafast comparator to achieve high accuracy over a wide input-frequency range.

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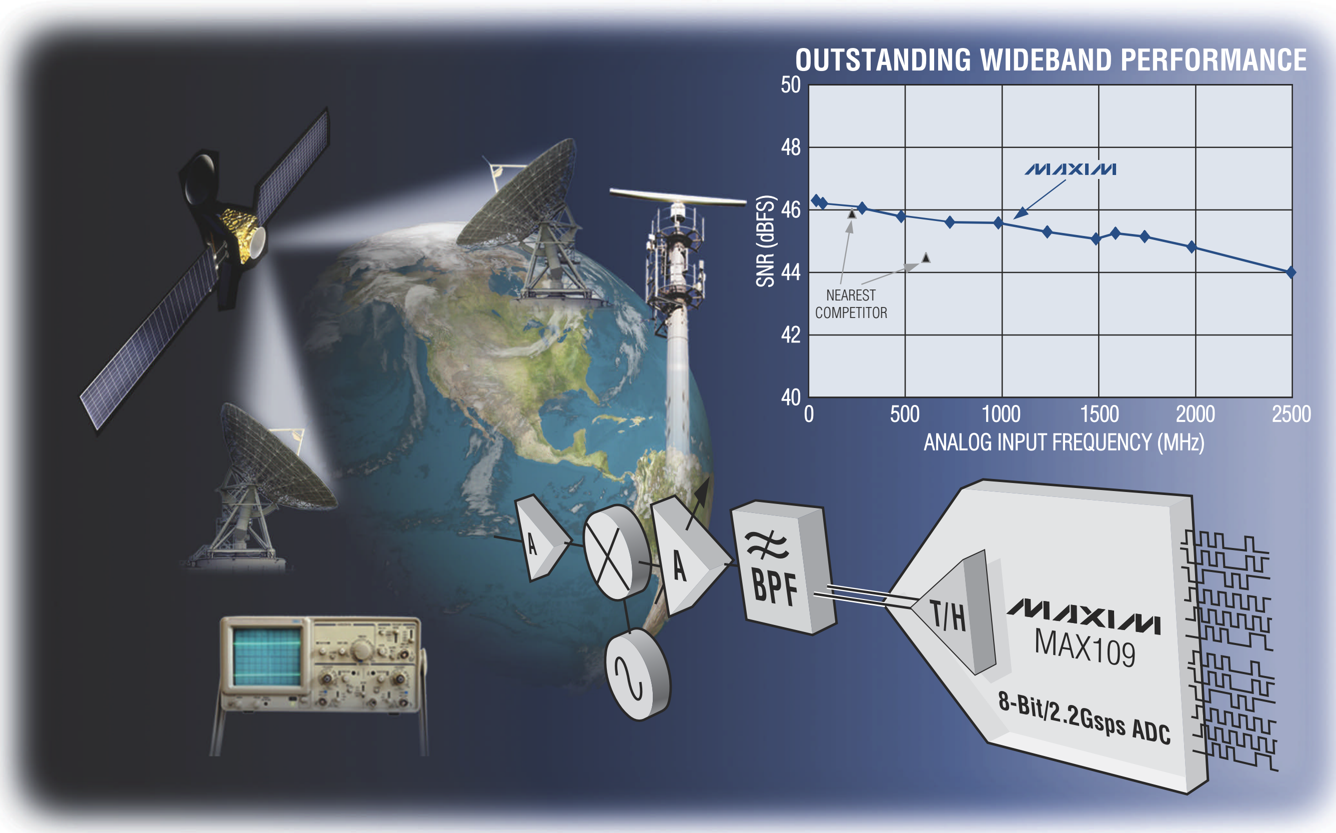

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The output of comparator IC_3 swings high when the input at Pin 2 is higher than the dc level at Pin 3. This action, in turn, charges holding capacitor C_{19} through R_{17}, D_4, D_5, D_6, and R_{23}. When the voltage on C_{19} is higher than the peak signal level at Pin 2 of IC_3, the comparator stops providing charging pulses at its output. At equilibrium, the comparator provides output pulses with the correct amplitude and width to maintain the voltage on C_{19} at approximately the peak level of the input signal. The high-input-impedance dc buffer, IC_{2B}, minimizes the discharging of C_{19} between charging pulses.

The network comprising R_{24}, R_{25}, and C_{20} filters and attenuates the dc output by 2.1%. This attenuation is necessary because the output tends to be slightly higher than the actual peak level of the input signal at Pin 3 of IC_1. The circuitry comprising IC_{2C} and its associated components provides a novel feature: a voltage boost at Pin 14 of IC_{2C} as the voltage on holding capacitor C_{19} increases. The circuitry then applies this voltage boost to R_{16}, which in turn causes the voltage swing at the junction of R_{16} and R_{17} to increase as the charge on C_{19} increases. This action causes the amplitude of the pulses driving D_4 to increase. This action maintains a relatively constant drive to C_{19} as its charge increases.

Diode D_1 keeps the voltage at the output of IC_3 from exceeding its supply voltage. Diode D_2 keeps the boost voltage from going to a large negative level at start-up, which could cause the circuit to latch up. The switching action of the comparator and diode D_3 prevents latch-up due to a large positive-boost transient. This circuit exhibits no indication or tendency for instability. The maximum input signal is 6V p-p because of the input common-mode-voltage specification of the AD8561 comparator. The supply voltages for the input buffer are ±6.5V to avoid the possibility of severely overdriving the comparator.

You can improve the precision of the circuit by substituting a 100-kΩ potentiometer for R_4 to provide an output-level adjustment, and a dc-offset adjustment would improve accuracy at low signal levels.

This circuit used a 300-MHz-bandwidth oscilloscope to make the performance measurements. As a result, the data in **Table 1**, which is available in the online version of this Design Idea at www.edn.com/071122di1, may include some measurement errors. Therefore, take the results in the **table** as representing the circuit's performance rather than as precise data. The data is simply the result of the best equipment on hand when the measurements were made. **EDN**

REFERENCES

1. McLucas, Jim, "Precision peak detector uses no precision components," *EDN*, June 10, 2004, pg 102, www.edn.com/article/CA421510.
2. "AD8561 ultrafast 7 ns single supply comparator," Analog Devices, www.analog.com/UploadedFiles/Data_Sheets/AD8561.pdf.

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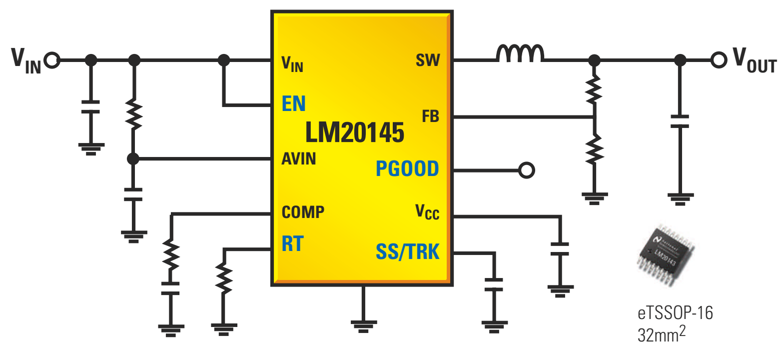
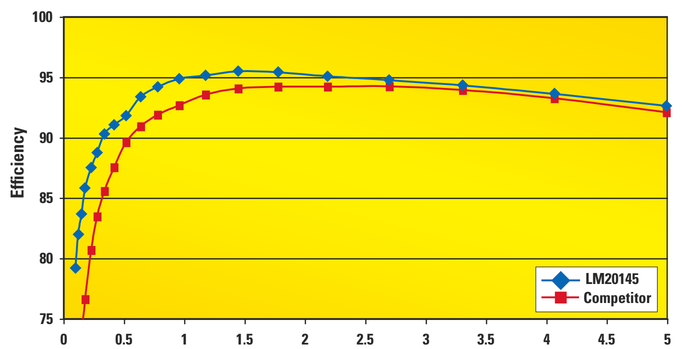


Efficiency vs Output Current (V_{IN} = 5.0V, V_{OUT} = 3.3V, fSW = 500 kHz)



Product Number	V_{IN} (V)	I_{OUT}	SYNC IN	Frequency Adjust	SYNC OUT	Frequency
LM20123	2.95 to 5.5	3				1.5 MHz
LM20133	2.95 to 5.5	3	✔			Sync
LM20143	2.95 to 5.5	3		✔		500 kHz - 1.5 MHz
LM20124	2.95 to 5.5	4				1 MHz
LM20134	2.95 to 5.5	4	✔			Sync
LM20144	2.95 to 5.5	4		✔		500 kHz - 1.5 MHz
LM20154	2.95 to 5.5	4			✔	1 MHz
LM20125	2.95 to 5.5	5				500 kHz
LM20145	2.95 to 5.5	5		✔		250 kHz - 750 kHz
LM20242	4.5 to 36	2		✔		250 kHz - 750 kHz

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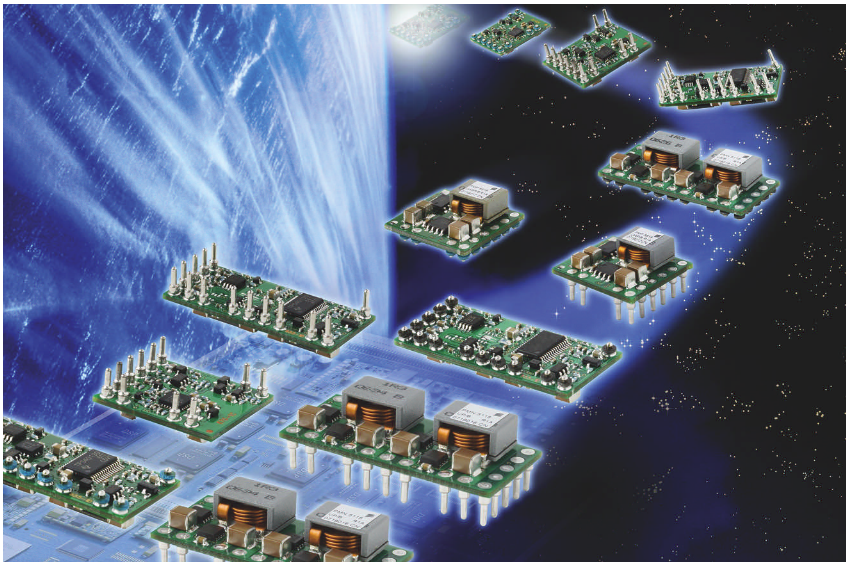


POLA modules have a wide input range

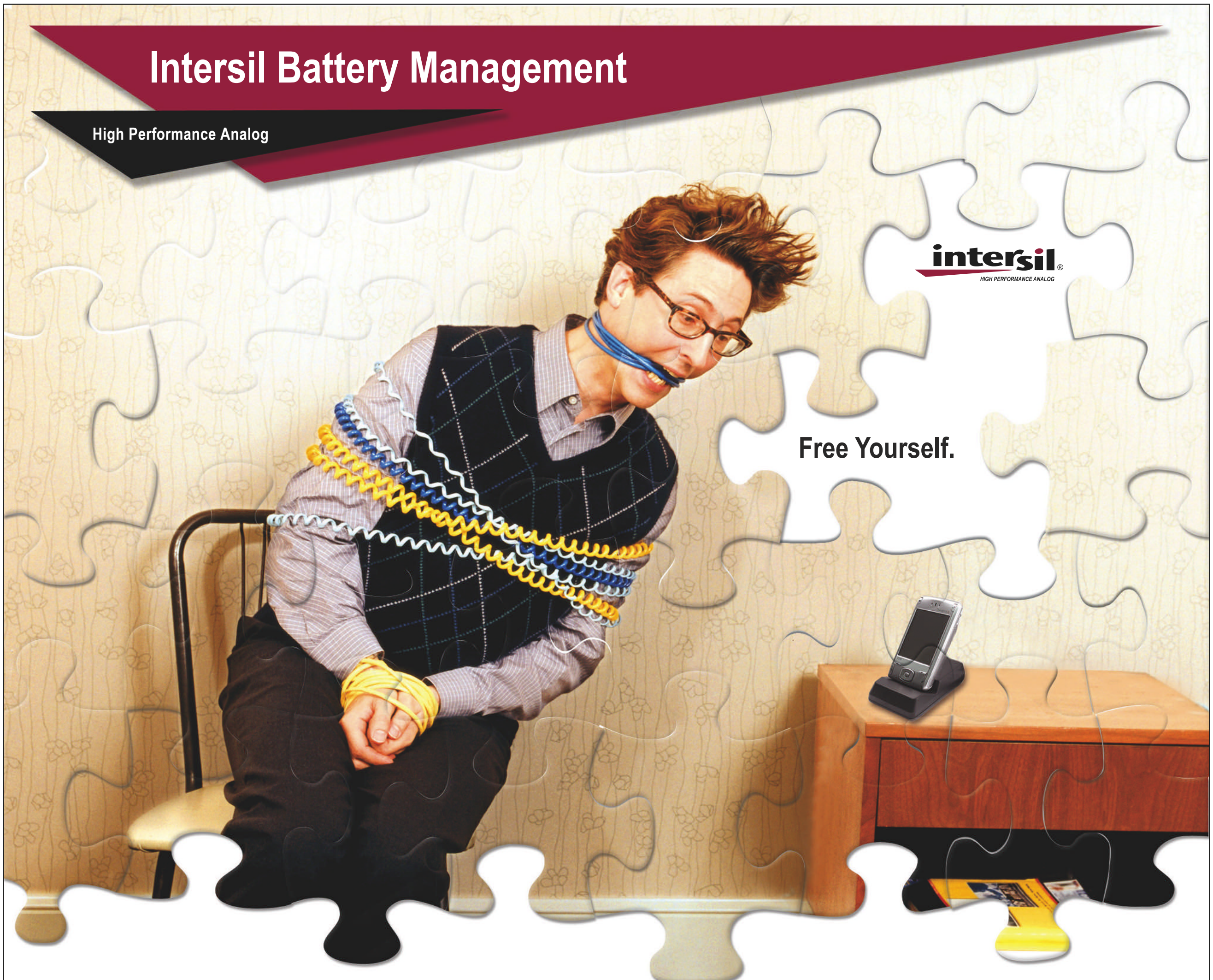
The PMN and PMP series point-of-load modules provide an interoperable second source in accordance with POLA (Point-of-Load Alliance) specifications. The PMN 5118U has a 4.5 to 5.5V input-voltage rating with 0.7 to 3.6V at 30A. The PMN 8118UW features a 5.5 to 14V input-voltage rating with 0.7 to 3.6V at 30A. The PMP 5818UW provides a 4.5 to 14V input-voltage rating with 0.7 to 5.5V at 16A. The PMP and PMN series POLA modules cost $10 and $15, respectively.
Ericsson Power Modules, www.ericsson.com

Switch-mode regulator suits military applications

Part of the vendor's family of μModule dc/dc regulators targeting rugged military and avionics applications, the 10A LTM4600HVMPV-encapsulated switching dc/dc-regulator system provides a −55 to +125°C temperature range. A built-in inductor in the synchronous step-down regulator supports power components and compensation circuitry. Operating from a 4.5 to 28V input-supply range, the device regulates a 0.6 to 5V output voltage. The regulator delivers a 10A continuous-load current and a 14A peak-load current and claims 92% efficiency. The device requires only input and output bulk capacitors and a resistor for setting output voltage, allowing for a simplified design. Available in a 15×15×2.8-mm military-plastic LGA package, the LTM-4600HVMPV costs $36.95 (1000).
Linear Technology, www.linear.com

Power module targets military dc/dc systems

The vendor's VPTPCM-12 preconditioned-power-module series suppresses transient voltages in dc/dc-power systems. Features include 600V-dc transient suppression, 120W output power from a single unit, and an input range that provides 12 and 28V dual nominal-input voltages. The device suits mili-



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The ISL9214 allows the flexibility to use either fast-charging rates of an AC adapter or the convenience of a USB charger.

Cradle Input: The max input voltage tolerance is 28V, programmable end-of-charge current, and the included end-of-charge latch is the default input source.

USB Input: Takes input from USB port or other low-voltage supply, fixed charge current at typically 380mA, and only charges when cradle source is not connected.

End-of-charge indicator is latched, based on completed charge.

When the battery voltage falls below minimum spec, the charger operates with a trickle charge current of 14% of the programmed cradle input or at 53mA for USB power.

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tary-standard-1275 requirements for vehicles and 704 requirements for avionics. Measuring 2.35×1.55×0.465 in., the VPTPCM-12 line-conditioning module costs $269.
VPT, www.vpt-inc.com

15W converter series has a small metal footprint

Suiting low-power board-mounted designs, the 15W JTH15 dc/dc-converter series accommodates a 4-to-1 ratio for 9 to 36 or 18 to 72V-dc input-voltage ranges. The single-output device comes with 3.3, 5, 12, or 15V rails, and the dual version has ±5, ±12, or ±15 outputs. Providing a 1500V-dc input-to-output isolation, the models also include ±0.5% line regulation and ±0.5% load regulations at a 10 to 100% load. Available in a 2×1-in. metal footprint, the JTH15 converter costs $32.50.

XP Power, www.xppower.com

Fuel gauge combines a lithium protector and SHA-1 authentication

Integrating a one-cell lithium protector and SHA-1 authentication, the single-cell DS2784 stand-alone fuel gauge fits on the side of a prismatic-battery cell. The device combines a precision analog front end for measuring current and voltage with an embedded fuel-gauge algorithm. The fuel gauge estimates available capacity based on coulomb count, discharge rate, temperature, and cell characteristics. The lithium protector monitors for cell overvoltage, undervoltage, overcurrent, and short-circuit conditions. Available in a 3×3-mm TDFN package, the DS2784 fuel gauge costs $2.94 (1000).
Maxim Integrated Products, www.maxim-ic.com

Quarter-brick dc/dc converters have a high- and flat-efficiency curve

Providing a high- and flat-efficiency curve, the iQE quarter-brick 100 to 200W isolated dc/dc converters suit high operating efficiency over a range of load conditions. The devices claim a 90% typical efficiency over a 20 to 100% load range of the maximum-rated current; this efficiency is flat for 80% of the power curve. Features include 18 to 36 or 60 to 75V-dc input-voltage ranges and 3.3, 5, 8, 12, or 15V-dc output voltages with a ±10% user-adjustment range. Prices for the iQE converter series start at $51.50 (100).
Lambda Americas, www.lambdapower.com

EMBEDDED SYSTEMS

Security device comes in two enclosed platform and motherboard versions

The PL-01039 1U rack-mount, high-performance security platform and the MB-09042 motherboard support single Intel Dual-Core Xeon LV/ULV processors with a 667-MHz front-side bus. Features include two Ethernet modules with eight GbE (Gigabit Ethernet) ports; LAN modules with four to eight ports of copper, fiber, or mixed media; and support for four GbE Intel 82571EB PCIe (PCI Express) ×4 and four GbE Intel 82573L PCIe ×1. The eight GbE SFP (small-form-factor-pluggable) or copper ports with the optional

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bypass function on four ports are accessible from the front panel. Front-panel access provides a USB 2 port, an RS-232 serial port, an LCM (liquid-crystal module), a four-button keypad, a 32-bit PCI connector, and a Mini PCI socket. The PL-A1039 with eight copper ports and four ports with the bypass-function LCM costs $897. The PL-B1039 with four copper ports and four SFP ports with the bypass-function LCM costs $948. The MB-09042 motherboard with Intel Dual-Core Xeon and 8 GbE costs $333.

WIN Enterprises, www.win-enterprises.com

M-Module features upgraded analog output

Improved analog-output performance with four grounded-voltage or -current channels gives the M37N M-Module a less-than-8.5-μsec acquisition time. Features include a −10 to +10V voltage range, a 0- to 20-mA output-current range, and 16-bit voltage resolution with 0.1% accuracy. Targeting automated test environments, process-control systems, and sensor-measurement applications, the M37N costs $932.

MEN Micro, www.menmicro.com

Development tool provides a graphical view of real-time-system events

The TraceX host-based embedded-development tool enables visualization of real-time systems. The device allows developers to see system events, such as interrupts and context switches, occurring out of view of standard debugging tools. Targeting the vendor's ThreadX RTOS, the development tool collects a database of system and application events on the target system during runtime. The events include thread-context switches, pre-emptions, suspensions, terminations, and system interrupts, all of which generally escape detection in a standard debugging environment. Logging the events in the database using the ThreadX under-control program, the product features time-stamping and active-thread identification so that the events display in the proper time sequence. Suiting use on

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EMBEDDED SYSTEMS

Windows hosts, the TraceX costs $1000 for all target architectures that ThreadX supports.
Express Logic, www.expresslogic.com

CompactPCI enclosure has built-in system monitoring

Providing redundancy and hot-swap ability, the Type 39 CompactPCI enclosure also includes built-in system monitoring. The Type 39c chassis features a 3U 4 hot-plugging configurable system monitor with Ethernet, RS-232, Web, and CLI (command-line-interface) capabilities. The device monitors as many as eight voltages, 12 fan-fail signals, eight temperature sensors, and the speed of the fans, depending on the temperature buildup. Additional features include a CompactPCI or PICMG 2.16-compliant backplane in as many as eight slots. The backplanes have three pluggable, 47-pin connectors for hot-swapping power supplies for a 500W, N+1 device. The Type 39c chassis family costs less than $700, depending on configuration and options.
Elma Electronics, www.elma.com

GbE board has four copper ports

Targeting wireless- and storage-networking equipment, the LAN AdvancedMC board with a native PCI Express design offers four GbE (gigabit-Ethernet) copper ports. The vendor bases the board on two Marvell Yukon 88E8062 GbE controllers. The quad-port LAN AdvancedMC board costs $1011.
One Stop Systems, www.onestopsystems.com

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LOOKING AHEAD

TO THE CONSUMER ELECTRONICS SHOW

That great meat grinder of the consumer-electronics industry, the CES (Consumer Electronics Show), will struggle to life and lumber about Las Vegas Jan 7 through 10. As always, the show offers an enormous range of exhibits, special-interest tracks for everyone from investors to electronics retailers to development engineers, and an exhausting array of speakers. Indicative, perhaps, of the growing interest in developing economies as the next growth markets for consumer electronics, a program track will study “technology and emerging countries: advancing development through technology investments.” Nicholas Negroponte, co-founder of the Massachusetts Institute of Technology’s (www.mit.edu) MIT Media Lab and founder of the OLPC (One Laptop Per Child) project (http://laptop.org), will deliver a keynote address for this track.

LOOKING BACK

AT THE NEVER-ENDING EFFORT TO SPEED UP TRANSISTORS

A new process developed by Philco Corp produces transistors capable of operating through the entire VHF and part of the UHF spectrum. MADTs (micro-alloy diffused-base transistors) operate at switching speeds comparable to the speed of light, speeding logical computational performance of computers. Reports indicate that the units are a large advance in the capability of transistors and will provide high performance for radar IF amplifiers, wideband-video amplifiers, and other circuitry. MADTs incorporate the same electrochemical techniques as surface-barrier transistors.—*Electrical Design News*, November 1957

LOOKING AROUND

AT THE CONVERGENCE ZONE BETWEEN NANOELECTRONICS AND BIOTECHNOLOGY

Research reports from IMEC (Interuniversity Microelectronics Center, www.imec.be) last month showed how much fundamental progress researchers are making in applying the tools of microelectronics and nanofabrication to the problem of interfacing electronics directly to living cells. Process scaling has advanced so far that IC features are now small enough to interact with portions of cells. And understanding of both how to create nanostructures and how to bind inanimate objects to organic molecules is increasing rapidly. The result could be a revolution in the way we interface to, diagnose, and treat living creatures—if we can educate young scientists and engineers in a blend of two historically antagonistic disciplines (see “IMEC research explores the chip/cell interface,” *EDN*, Oct 26, 2007, www.edn.com/article/CA6494779).

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