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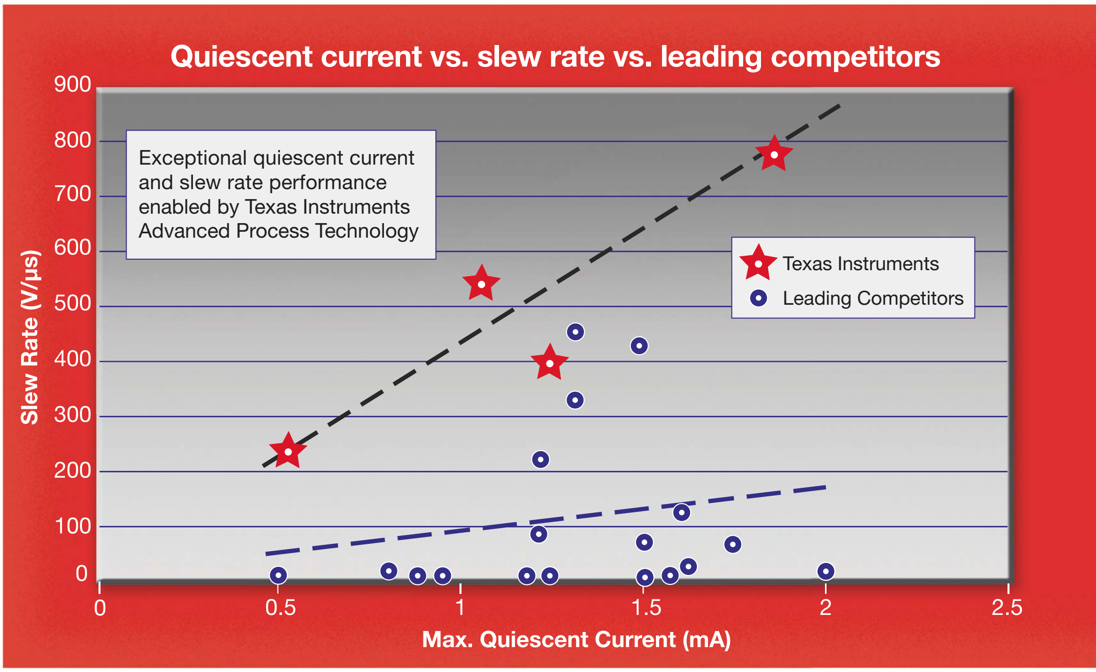

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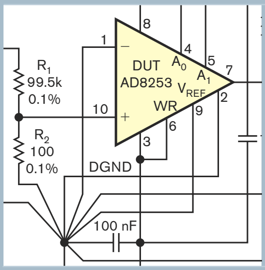

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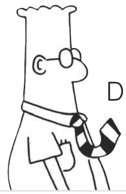

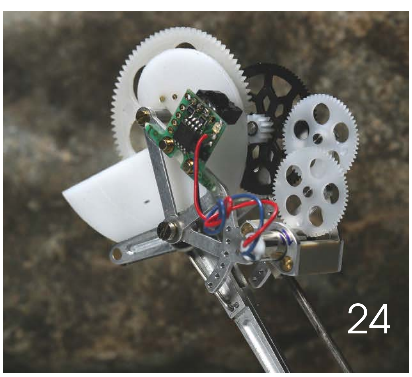

DEPARTMENTS & COLUMNS

PRODUCT ROUNDUP

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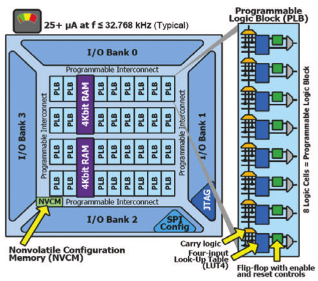

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The vendor claims its clean-sheet-of-paper design results in significant power savings and eliminates external-configuration memory.
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Direct-write e-beam system shows major promise for volume production
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IBM cools 3-D chips with water
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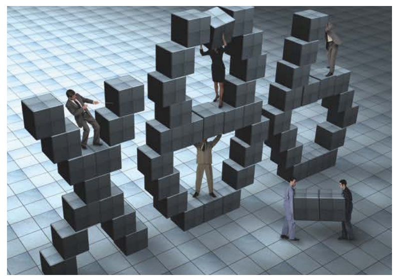

READERS' CHOICE

A selection of recent articles receiving high traffic on www.edn.com.

Embedded x86: keystone of your non-PC design?
x86 microprocessors may not have the absolute lowest power per megahertz, absolute highest performance per clock tick, or optimum code efficiency. Bundle up the features, though, and the total "kit" often stacks up favorably versus the competition.
→www.edn.com/article/CA6562580

Pointy tips: how to straighten bent oscilloscope-probe tips
Howard Johnson's high-speed-oscilloscope probes were bent so badly that they looked like elf shoes. Here's how he fixed them.
→www.edn.com/article/CA6562588

Intel, Micron launch 34-nm, 32-Gbit NAND-flash memory at solid-state drives
Chip giant Intel and memory leader Micron Technology roll out what they say is the first sub-40-nm NAND-memory device—a 34-nm, 32-Gbit multilevel-cell NAND-memory chip designed with solid-state-drive applications in mind.
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Intel's Montevina notebook chips delayed
Microprocessor giant Intel confirmed there will be delays in the rollout of its upcoming Montevina-notebook platform, with the discrete iteration now shipping July 14 versus the initial target of late June.
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TREASURE TROVES

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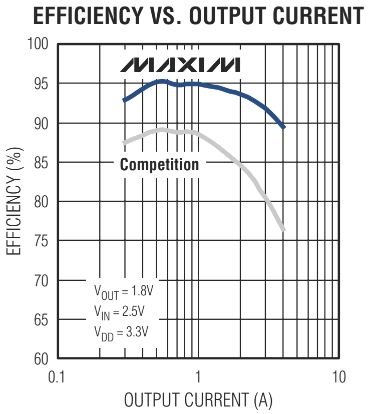
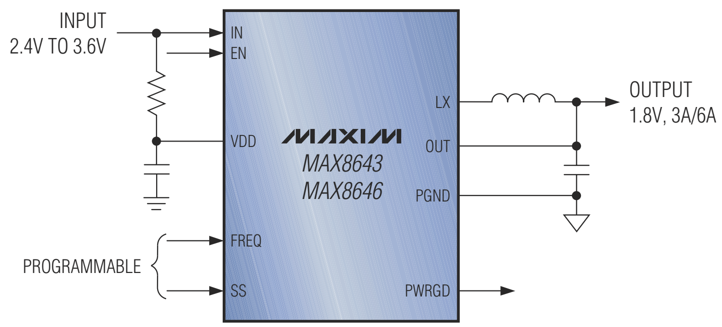
Buck regulators with integrated MOSFETs simplify designs up to 25A/phase

High efficiency





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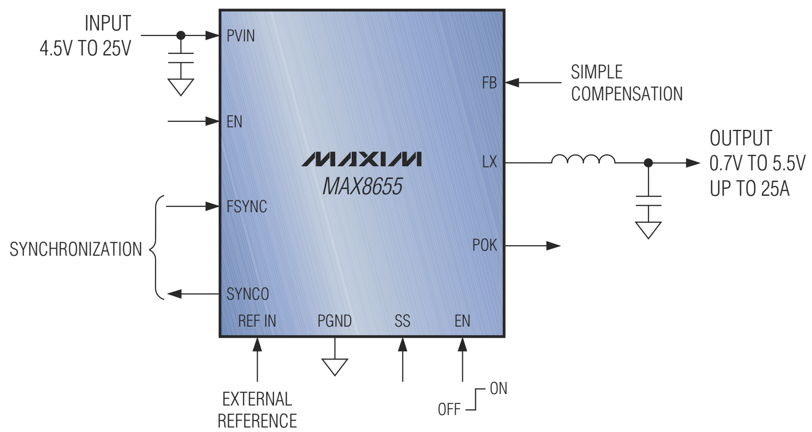

Dual output flexibility

- Fully protected
- Tracking/sequencing
- All-ceramic capacitor design
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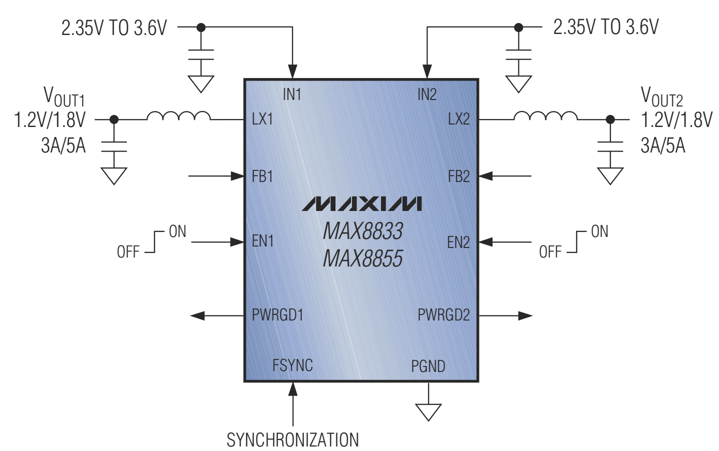
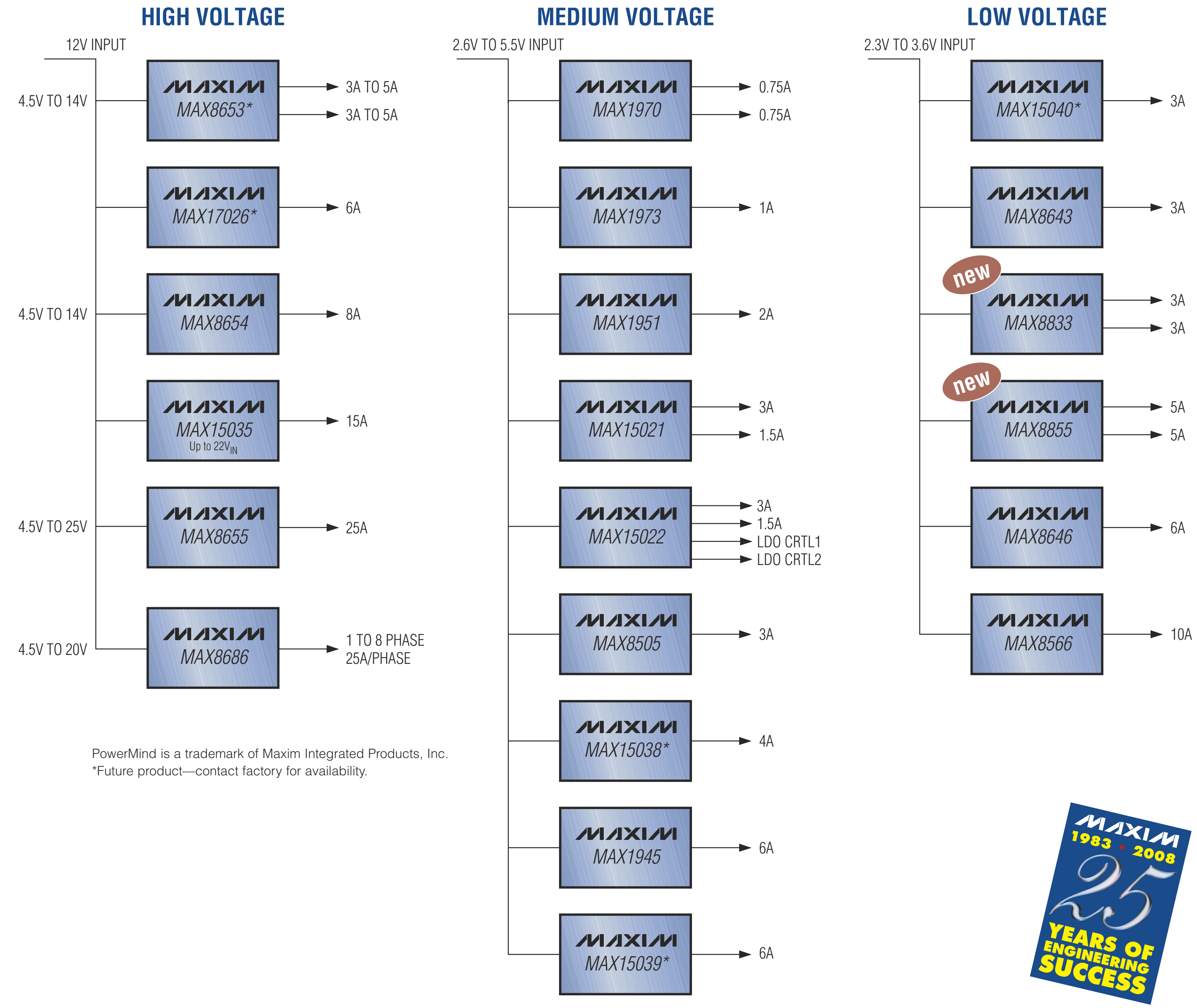
- 5mm x 5mm, 32-pin TQFN package



Maxim's PowerMind™ family of integrated buck regulators simplifies your toughest design challenges. These regulators provide high efficiency in compact, simple, cost-effective solutions that have the industry's lowest EMI.



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BY RICK NELSON, EDITOR-IN-CHIEF

The design-and-test merger

Are the design and test disciplines merging? You might get that impression from reading some recent items in the news. I addressed the design-and-test relationship with an earlier commentary (**Reference 1**). That editorial was a response to an article by Executive Editor Ron Wilson (**Reference 2**). I stand by my March 20 conclusion that "it would be a mistake to assume that embedded instruments will make external instruments go away." But recent news and events suggest that embedded instruments will continue to make inroads.

First, Asset InterTech (www.asset-intertech.com) announced last month that it is positioning the company, its products, and its technologies to provide open tools for embedded instrumentation in design-validation, test, and debugging applications because, according to Asset President and Chief Executive Officer Glenn Woppman, established validation and test technologies are inadequate for high-speed chips and I/O buses. Chip geometries at 45 nm or smaller, as well as chip-level packaging technologies, such as SIP (system in package), he says, are making validation, test, and debugging difficult if not impossible with traditional technologies.

Embedded instrumentation naturally requires a design element. Instrumentation—in the form of BIST (built-in-self-test) or DFT (design-for-test) structures—won't get embedded if chip designers don't do the embedding. Prasad Mantri, a staff engineer at Sun Microsystems who focuses on DFT, commented on that topic in his June 5 presentation during the third annual Global STC (Semiconductor Test Consortium, www.semitest.org) Conference, which took place June 4 through 6 in San Diego. During that presentation, titled "Design for Test: Small Price to Pay on Silicon for High Product Quality," he said that the high cost of production-worthy ATE (automated test equipment) represents a problem, one that transferring the test function from ATE to the design stage would alleviate—"as if design wasn't already hard enough."

Mantri noted that DFT is necessary because of increasing chip complexity: I/O count increases linearly as feature size shrinks, and gate count or flip-flop count increases in a squared relationship with feature-size shrinkage. He added that the DFT process has become as complex as any other part of the electronic-design-automation flow. DFT insertion is no longer accomplished using point tools after designers complete a design through gate simulation and then "throw it over the wall" to the DFT engineers. In fact, he said, designers are not simply tolerating DFT because it's part of a design specification; they are also asking for it as an aid to debugging, diagnosis, and field-failure analysis.

Sanjiv Taneja, vice president of the Encounter Test division at Cadence Design Systems (www.cadence.com), also addressed the relationship between design and test at the STC conference with a presentation titled "Cooperation between EDA and ATE: Now More Important Than Ever." He said that test and EDA vendors need to look beyond the interoperability issues that they addressed in the 1990s to provide interoptimized, end-to-end technologies. An effective design-and-test strategy, he said, will require a holistic effort across the entire chip-design and -production ecosystem, consisting of ATE, EDA, and semiconductor companies; foundries; assembly-and-test houses; IP (intellectual-property) providers; and even universities.

I think that both Taneja and Mantri would agree with me that external testers are here to stay. In fact, Mantri said he sees a growing role for DFT-focused testers as well as protocol-aware functional testers. He noted that some DFT proponents have tried for many years to put test-equipment vendors out of business. But, he said, addressing the test-equipment-vendor representatives in the STC conference audience, "You guys are still here."

For more on design and test, see our special issue *Innovators 2008*, particularly the interviews with Antun Domic, a senior vice president and general manager of the implementation group at Synopsys (www.synopsys.com), and Mike Santori, technology and business fellow at National Instruments (www.ni.com). If you don't have a copy of *Innovators 2008*, please go to www.edn.com/innovate08. EDN

REFERENCES

1 Nelson, Rick, "External instruments here to stay," *EDN*, March 20, 2008, pg 12, www.edn.com/article/CA6541381.

2 Wilson, Ron, "As SOCs grow, test-and-measurement instruments move on-chip," *EDN*, Feb 21, 2008, pg 31, www.edn.com/article/CA6531583.

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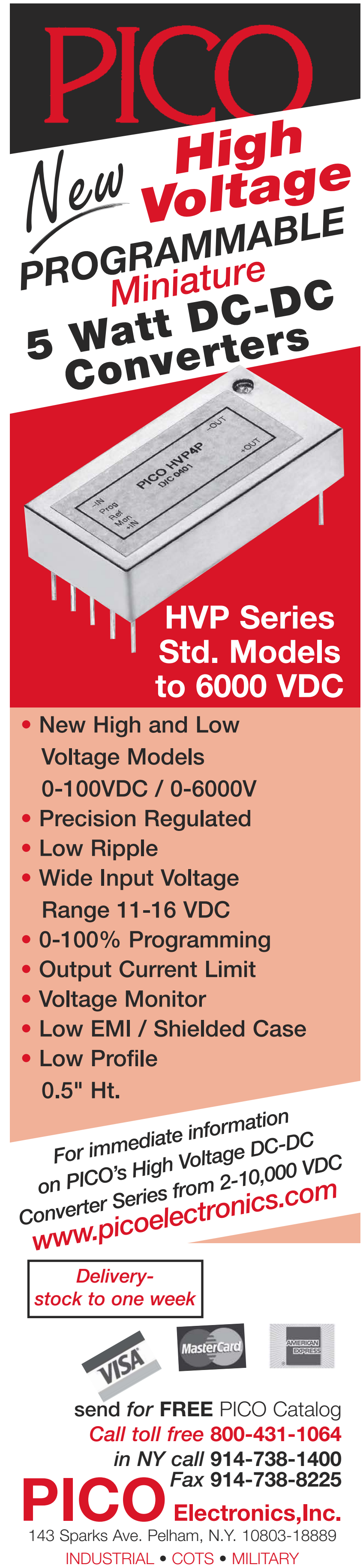

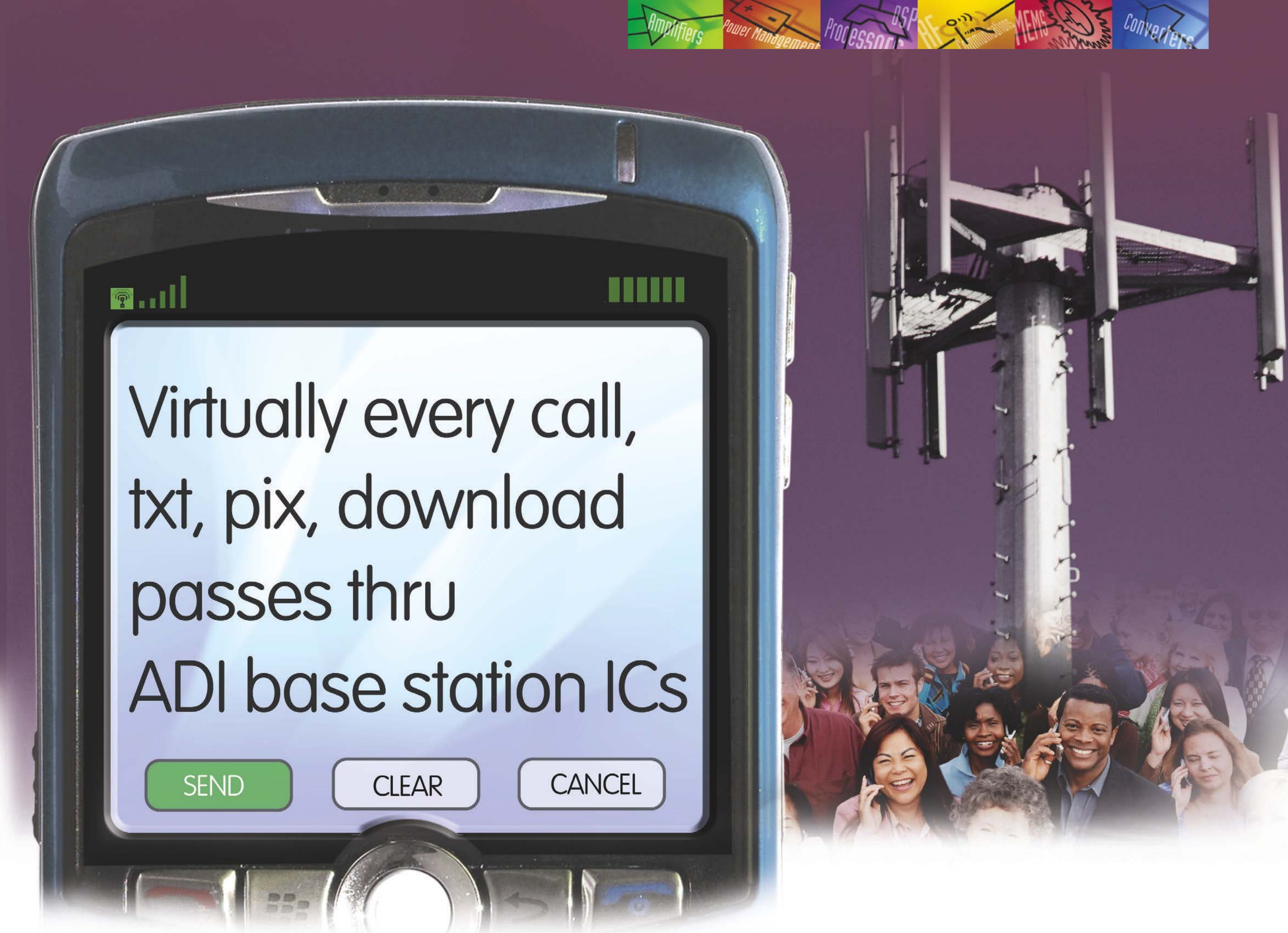

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INNOVATIONS & INNOVATORS

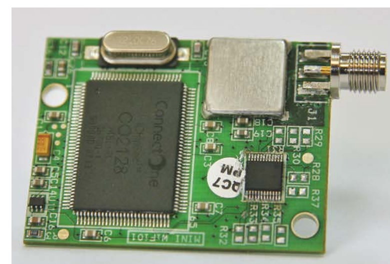
Tiny module unites industrial applications

Following the small-form-factor trend in embedded devices, Connect One has just introduced the Mini Socket iWiFi serial-to-Wi-Fi module for connecting industrial devices running machine-to-machine applications to 802.11b/g wireless networks. The company based the device on the iChipSec CO2128 communication-controller chip, and it integrates wireless and SSL (secure-socket-layer)-encryption algorithms and serves as a firewall to protect the embedded-system application from the Internet. To facilitate mobility, Mini Socket iWiFi supports seamless roaming between access points.

The board's 31×41-mm dimensions and advanced power-conservation features make it an effective technology for mobile, battery-operated embedded devices.

The module has several sleep modes and the ability for the host application to turn off the wireless communications, minimizing power requirements. In deep-sleep mode, the module's power consumption is only 30 μA. Simple text commands drive the Mini Socket iWiFi, which offloads the Wi-Fi drivers, WPA (Wi-Fi-protected-access) supplicant, Internet security, networking protocols, and all communication tasks from the host application. The module operates at an industrial-temperature range of −40 to +85°C (−40 to +185°F), complies with ROHS (restriction-of-hazardous-substances) directives, and is available now. Prices start at $59.**—by Warren Webb**

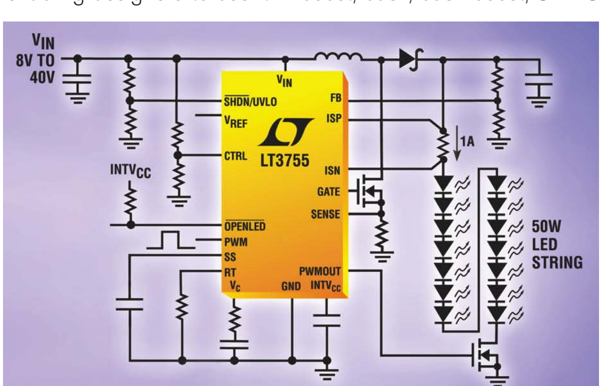
▷**Connect One**, www.connectone.com.



The Mini Socket iWiFi enables secure-Wi-Fi connectivity for Internet Protocol-based industrial devices over IEEE 802.11b/g networks.

60V output buck, boost, or buck-boost LED controller

Linear Technology Corp's new LT3755 LED controller has a 4.5 to 40V input-voltage range. It drives external FETs to illuminate as many as 14 1A white LEDs from a nominal 12V input, delivering in excess of 50W. The part uses a high-side-current sense, enabling designers to use it in boost, buck, buck-boost, SEPIC (single-ended-primary-inductance-converter), and flyback topologies. The LT3755 can deliver efficiencies of more than 94% in boost mode. A frequency-adjustment pin permits the user to program the frequency between 100 kHz and 1 MHz. The device also features programmable undervoltage lockout with hysteresis. Shutdown current is less than 1 μA.



The Linear Tech LT3755 LED controller delivers more than 50W of LED power.

The LT3755 uses True Color PWM dimming, which delivers constant LED color with dimming ranges as great as 3000-to-1. Alternatively, you can use the control pin for a 10-to-1 analog dimming range. A fixed-frequency, current-mode architecture provides stable operation over a range of supply and output voltages. A ground-referenced voltage-feedback pin serves as the input for several LED-protection features, making it possible for the converter to operate as a constant-voltage source.

The LT3755 has an open-status pin, and the LT3755-1 replaces the status pin with a frequency-synchronization pin. Both parts come in 16-pin, 3×3-mm QFN packages and sell for $2.75 (1000). The parts are also available in industrial-temperature-rated versions.**—by Paul Rako**

▷**Linear Technology Corp**, www.linear.com/pr/3755.

Units underscore importance of USB-based modular instruments

Agilent has underscored USB's importance as an instrumentation platform with the addition of digital-oscilloscope and waveform-generator modules to an already-broad, but little-publicized, line of USB-based plug-in instruments that you can also use as stand-alone units. Although several data-acquisition-equipment manufacturers offer USB-based instruments that depend on a host PC for their operator-interface and control functions, you may not have heard about USB-based modules that you can connect individually to a host PC or plug into a chassis. Such a chassis is Agilent's $1186 U2781A, which contains a USB hub and incorporates an ac-operated power supply because some modules use more power than the bus can provide. It also includes synchronization facilities for as many as six 1-in.-wide, 4.13-in.-high, 6.87-in.-deep resident modules, some of which may occupy multiple slots. The chassis' master/slave-triggering capabilities enable synchronization of nearly all slotted modules, even those that perform different functions. By removing hardware that protects against mechanical shock in portable-system applications, you can fit the 10.63×7.76×10.68-in. chassis into a 4U, 7-in.-high rack space. For engineers who design compact moderate-performance instrumentation systems for use in development and production testing, the availability of this chassis and the large and growing module family marks USB-instrument modules as potentially worthwhile alternatives to PXI (PCI extensions for instrumentation) and similar units.

“You may not have heard about USB-based modules that you can connect individually to a host PC or plug into a chassis.

The new USB modular instruments include the $1329, 100-MHz-bandwidth U2701A and the $1638, 200-MHz-bandwidth U2702A oscilloscopes, which offer sampling rates to 1G sample/sec, and the $1638, 20-MHz U2761A function generator, which produces sine, square, triangular, pulse, ramp, exponential, modulated, and arbitrary waveforms. The lineup also includes the $2165, three-channel U2722A source/measure unit, which offers four-quadrant source and measurement capabilities for parametric testing, and the $936 U2751A switch matrix, a four-by-eight-point, two-wire design with 32 channels that provide additional test points for functional tests.

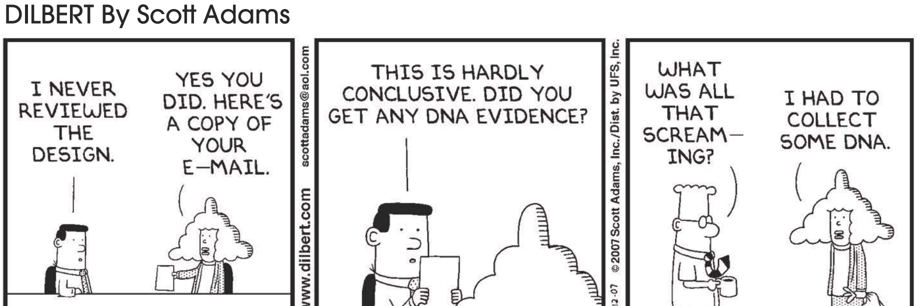
The included Modular Instruments Measurement Manager software enables measurements without programming, thanks to a graphical interface that provides user-friendly configuration and makes functions easily accessible. Bundled drivers allow you to program with Agilent VEE, C#, C++, Microsoft (www.microsoft.com) Visual Basic, or National Instruments (www.ni.com) LabView.

—by Dan Strassberg

▷**Agilent Technologies,** www.agilent.com/find/usbmodular.

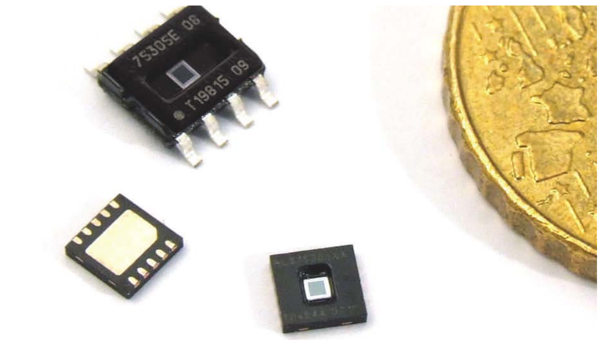
The U2700A series turns USB into a plug-in modular-instrumentation platform. The portable chassis at right, which you can also mount in an equipment rack, houses and powers the modules, which you can also connect individually to a host PC. The chassis provides facilities for synchronizing the operation of the modules it contains. Included software (background) makes short work of common functions, such as specifying waveform parameters.

DILBERT By Scott Adams



Light sensor integrates photodiode, transimpedance amp, and linear-voltage-output stage

Melexis has introduced the MLX75305 light-to-voltage sensor for high-volume automotive, industrial, and consumer applications. By integrating the photodiode, transimpedance amplifier, and voltage-output stage into one chip, Melexis has ensured that the part will provide a stable responsivity over time and temperature. The voltage output is highly linear and relatively insensitive to temperature. The device also has better noise performance than that of a discrete photodiode. The company assembles the sensor with high positional accuracy and a pin-to-photodiode accuracy of more than ±85 microns.



The MLX75305 integrates a photodiode, a transimpedance amplifier, and a linear-voltage-output stage in a 3×3-mm package.

Melexis claims a 15-year lifetime for the part based on accelerated aging in high temperatures. The accelerated lifetime applies to a part operating at 55°C. The second offering in the company's SensorEyeC series, the device complements the MLX75303 optical switch.

The MLX75305 is available in large quantities with a 16-week leadtime. It has an extended-temperature range of −40 to +125°C and meets AEC (Automotive Electronics Council)-Q100 automotive specs. A version targeting consumer use operates at 85°C. The device comes in 3×3-mm, 0.65-mm-high DFN and SO-8 packages. It sells for 30 cents (medium quantities), and samples are available now.

—by Paul Rako

▷**Melexis**, www.melexis.com.

MICROCONTROLLER FAMILY EXTENDS PERFORMANCE OF ULTRALOW-POWER DEVICES

Texas Instruments' MSP430F5xx family of 16-bit microcontrollers improves peak processing performance over previous-generation MSP430 devices by more than 50%. With a maximum operating frequency of 25 MHz, the processors support an active-power draw of 220 µA/MHz over the operating-frequency range. For designs requiring the lowest-possible active-power draw, the devices' power-management module supports a power draw as low as 160 µA/MHz with the core voltage at the lowest voltage setting, 1.35V, and operating as fast as 12 MHz.

The devices support a 32-bit real-time clock with an alarm that operates with a standby-current draw of 1.5 µA. The processor family can complete a wake-up in less than 5 µsec with full status retention from both standby and sleep modes.

The MSP430F5xx family can deliver ultralow-power operation and support processing performance to 25 MHz.

The new power-management module includes four frequency and voltage entries that enable designers to dynamically choose the optimum core voltage and guarantee perfect power-on-reset and supply-voltage supervision with monitoring. Supporting designs based on two AAA batteries, the devices support read/erase/write capability to as low as 1.8V, enabling writes to flash down to the battery's end of life of 0.9V for each battery. The unified-clock system supports operation without a crystal to save costs. The DMA (direct-memory-access) controller can have as many as eight channels and supports data exchange with peripherals while the processor core remains in low-power modes, and digital and analog peripherals consume no power when they are not operating.

The family provides as much as 1 Mbyte of linear-memory mapping, and it is 100%-set-compatible with earlier MSP430 devices. The F54xx devices integrate as much as 16 kbytes of RAM and 256 kbytes of flash, which doubles the maximum flash and RAM available on previous MSP430F2xx, F1xx, and F4xx devices. The devices are available in 80- and 100-pin QFPs. The 128-kbyte-flash, 8-kbyte-RAM MSP430F5419 device is available for $3.61 (1000). The 256-kbyte-flash, 16-kbyte-RAM MSP430F5438 is available for sampling now and sells for $4.85 (1000). More devices will be available for sampling in August at prices ranging from $2.99 (10,000) for the MSP430F5418IPN to $4.28 (1000) for the mid-sized, 192-kbyte-flash, 16-kbyte-RAM MSP430F5436. Future devices will include USB, encryption, RF, and LCD interfaces.

—by Robert Cravotta

▶**Texas Instruments, www.ti.com.**

06.26.08

CMOS-clock chip replaces crystal, PLL circuit

Stable, accurate reference frequencies are basic to almost all digital electronics. The most common references combine quartz crystals with clock-generator circuits, often employing a PLL (phase-locked loop). However, temperature changes can affect the bulky, multimodule crystal-PLL circuits, which are less accurate at higher frequencies. To address these problems, Mobius Microsystems aims to obsolete the venerable crystal-oscillator frequency reference with the new MM8511 spread-spectrum clock IC, which the company based on its CHO (CMOS-harmonic-oscillator) technology.

The MM8511 CHO replaces the quartz crystal and PLL with a monolithic CMOS die, which generates spread-spectrum clock frequencies without the need for an external resonator.

The device uses an LC-harmonic-oscillator circuit that relies on a high-precision inductor and multiple high-precision capacitors. The chip employs a real-time analog algorithm to monitor the temperature, voltage, and process variables. As any of the parameters vary, the algorithm can switch in a capacitive value to compensate for circuit variables in real time, not only allowing for highly accurate frequencies, but also minimizing phase shift and jitter.

The MM8511 operates from a 3.3V supply and can generate frequencies as high as several hundred megahertz; Mobius has factory-programmed the initial products at common interface frequencies of 10 to 100 MHz and spread-spectrum modulation of 0 to 6%. The MM8511 comes in proprietary eight-pin, 3×3-mm DFN packages and nine-pin, 1.6×1.6-mm CSPs, as well as eight-pin, 3×6.4-mm TSSOPs, drop-in replacements for common spread-spectrum PLL ICs. The evaluation board for MM8511 will be available this month, and production samples of the product will be available in July. Price for the chip is $1.35 (1000).

—by Margery Conner

▷**Mobius Microsystems**, www.mobiusmicro.com.

Primary-side control boosts efficiency of ac/dc-switching ICs

Most consumer-targeted power adapters for devices such as cell phones and MP3-player chargers use optocoupler circuits to feed back voltage information from the secondary side to the regulator circuitry. Designers use these optocouplers because most ac/dc-power-supply transformers have a tolerance range of 10% or more, making it difficult to use a transformer winding to sense and regulate input- and output-power levels. The devices in Power Integrations' LinkSwitch-II ac/dc-power-conversion family of ICs address this problem by measuring the inductance of the transformer using a known current. In this way, the chip can rely on a primary-side transformer winding to sense voltage and current variations, eliminating the need for optocoupler-feedback circuitry and providing constant-voltage and constant-current regulation. This regulation is important in applications such as ac/dc adapters and chargers for cell phones and MP3 players, which rely on constant-voltage supplies, and high-brightness LEDs, which require constant-current supplies.

LinkSwitch-II simplifies the design of constant-voltage, constant-current converters by eliminating the need for optocoupler-feedback circuitry and enables consumer products to meet Energy Star 2.0 efficiency specifications for external power supplies.

The elimination of secondary feedback-sensing components increases LinkSwitch-II-powered chargers to efficiency levels as high as 80%. No-load power consumption is less than 30 mW. For example, in a 5V/1A, 5W cell-phone-charger reference design, LinkSwitch-II achieves Energy Star EPS (external-power-supply) 2.0 compliance with average efficiency levels as high as 75% at 25, 50, 75, and 100% loads across a 115 to 230V-ac input range. The chip integrates all control and protection circuitry plus a 700V MOSFET in an eight-pin package and sells for 60 cents (10,000).

—by Margery Conner

▷**Power Integrations**, www.

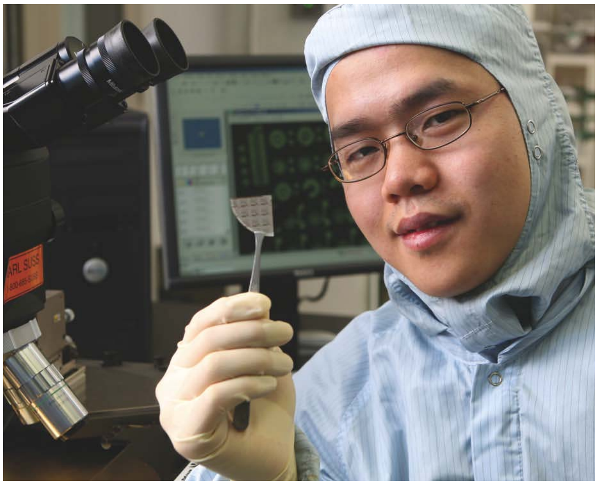
FEEDBACK LOOP

"It is admirable that Maxim has done a nice job of chopping out most of (the noise) with this amplifier, but I am quite sure some is still there if one looks carefully (and long!) enough. When one sees the absolutist word 'no(ne)' in connection with any noise issue, the eyebrows should raise …"

Reader Brad Wood, in *EDN*'s Feedback Loop, at www.edn.com/article/CA6541377. Add your comments.

RESEARCH UPDATE

BY MATTHEW MILLER



Weixao Huang's invention offers higher power-handling capacity and temperature tolerance than conventional silicon transistors.

Student develops attention-getting gallium-nitride MOSFET

A student researcher at Rensselaer Polytechnic Institute has developed a gallium-nitride MOSFET that, thanks to its ability to operate in extreme power and temperature conditions, captured the attention of top automakers even before the student graduated in May.

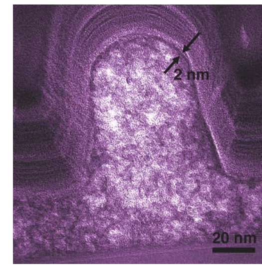
Weixao Huang, the son of rural Chinese farmers, developed a new process that enables the construction of the transistor. The resulting device not only tolerates extremes of heat and power, but also reduces energy losses, he reports. The MOSFET's resilience could make electronics viable in environments too harsh for today's silicon transistors and will allow higher integration and efficiency in current applications, according to Rensselaer.

▷**Rensselaer Polytechnic Institute**, www.rpi.edu.

Nanoimprint lithography stamps out encouraging results

Researchers at NIST (National Institute of Standards and Technology) have put NIL (nanoimprint lithography)—a potential next-generation IC-fabrication technology—through its paces and pronounced the technique capable of accurately producing delicate insulating structures on advanced ICs. NIST reports that NIL, which essentially embosses a pattern onto a thin film atop a semiconductor wafer, creates structures that are more robust than those researchers can create using conventional lithography.

The process limits the number of troublesome large pores that form within the SOG (spin-on-organo-silicate-glass) material the process uses as an insulator; increases the number of beneficial smaller pores; and forms a tough, 2-nm-thick skin upon the structures it creates, the researchers report.



A microcircuit feature formed using nanoimprint lithography exhibits a beneficial level of porosity and a protective 2-nm-thick skin.

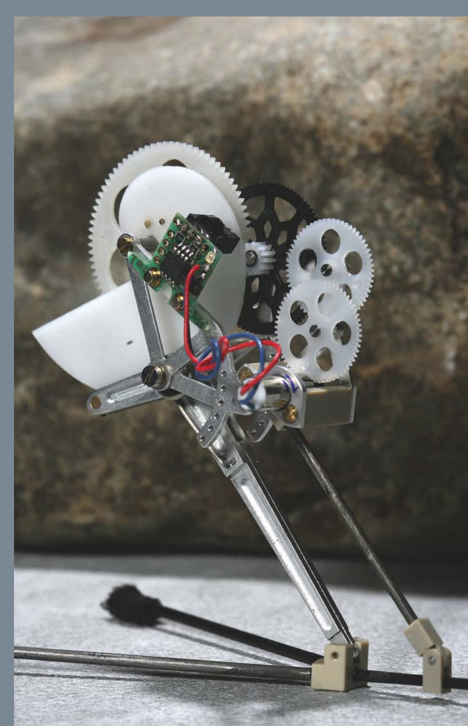
▷**National Institute of Standards and Technology**, www.nist.gov.

ROBOTIC GRASSHOPPER LEAPS AS HIGH AS 27 TIMES ITS HEIGHT

Researchers at the Laboratory of Intelligent Systems at EPFL (École Polytechnique Fédérale de Lausanne) in Switzerland have built a 5-cm-tall robot that takes its design cues from grasshoppers and locusts and can jump as high as 1.4m. The 7g critter uses a 0.6g pager motor to slowly charge two torsion springs and then explosively releases that energy.

The device's battery can power 320 jumps at 3-sec intervals. Before you start entertaining visions of new thrill rides or worrying about swarms of lethal-attack hoppers, however, go to www.edn.com/080626ru and check out a video clip; the researchers may have mastered takeoffs, but landing still appears to be a bit of a problem.

▶École Polytechnique Fédérale de Lausanne, lis.epfl.ch.



This robotic grasshopper measures 5 cm high and weighs 7g, and it can jump as high as 1.4m.

06.26.08

BY HOWARD JOHNSON, PhD

EM-simulation software

Bruce Archambeault, PhD, distinguished engineer at IBM, IEEE fellow, and the author of the *EMI/EMC Computational Modeling Handbook*, responds to my questions about EM (electromagnetic)-simulation software.

I've heard you say that measurements may be a great emotional comfort to the user but sometimes provide little usable information. Please explain.

A Too many engineers just accept whatever they see on a measurement device as gospel. In reality, every measurement provides ample opportunity for mistakes. Your probe may load down the circuit, you may fail to use an appropriate reference connection—that is, ground connection—or fail to account for a changing antenna factor when operating near a metal floor. I firmly believe that measurements are important, but you must question everything—both measurements and simulations—to ensure correctness.

Let's say I'm designing a differential via. What kind of simulation tools might I need?

A That [answer] depends on the frequency range for your signal and the physical size of the vias. Below a few gigabits per second on a board of normal thickness—60 to 100 mils—a 3-D quasistatic field solver provides adequate values for simulating the circuit as a simple LRC lumped-element object. If you move to higher frequencies and thicker backplanes, the quasistatic assumptions break down. There you should use 3-D, full-wave tools to build S-parameter models for the vias and plug them into a Spice simulator that accepts S-parameter models.

What must a user know to obtain accurate answers from a full-wave-simulator tool?

A Every tool gives accurate answers to the questions you put to it, but there is a catch. You must know what questions to ask. A basic understanding of physics and electromagnetics on your part is required. Lacking that understanding, no tool can create useful models, but every tool will give impressive-looking answers. That's the pitfall. Let me emphasize that you must also understand a range of modeling techniques and the limitations of each. There are many techniques. Each excels in some areas, not in others. For example, the MOM [method-of-moments] technique excels when calculating emissions from long wires but performs poorly when calculating the effectiveness of shields. The FDTD [finite-difference-time-domain] and FIT [finite-integration-technique] algorithms perform well for shielding but not for long wires.

The relatively new PEEC [partial-element-equivalent-circuit] technique works well for many PCB [printed-circuit-board] simulations. It can work in both time and frequency domains. It is a full-wave-analysis technique that can do, among other things, power-plane analysis. It is unique in that it allows lumped elements, such as capacitors, resistors, and inductors, to be easily added to the full-wave simulation without adding a significant computational burden, as happens for some of the other techniques.

Will computers ever replace the need for an understanding of basic physics?

A When I was in school, my EM professor once said, "All the world is an analog stage, in which 'digital' plays only bit parts." That [idea] seems even truer today as we face the age of 'microwave digital' circuits. To be effective at those frequencies, you must understand high-frequency effects.

Certainly, software tools help. I use full-wave tools for analysis of complex electromagnetic structures and simple rule checkers to make sure the physical-layout designer followed my established rules. But beyond that, the basic design rests on my knowledge of EM. Some so-called expert system manufacturers will imply that their tools can be used by someone who does not know anything about engineering and physics fundamentals, but, in my experience, that [implication] is not true. Any person who wishes to design very-high-speed circuits must understand basic EM. Otherwise, he is designing blindfolded. EDN

The advanced electromagnetic-simulation tools that Archambeault creates for IBM are available through Moss Bay EDA at bruce@mossbayEDA.com.

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+ Go to www.edn.com/080626hj and click on Feedback Loop to post a comment on this column.

Howard Johnson, PhD, of Signal Consulting, frequently conducts technical workshops for digital engineers at Oxford University and other sites worldwide. Visit his Web site at www.sigcon.com or e-mail him at howie03@sigcon.com.

BY PALLAB CHATTERJEE, CONTRIBUTING TECHNICAL EDITOR

Third-party-IP providers: physical-design questions, part two

Engineers often overlook one physical-design issue for qualifying IP (intellectual-property) blocks: handling routing blockages and overlayer-routing conditions. Traditionally, IP designers created blocks with their routing on layers M1 through M3, leaving layers M3 to M6 for block-to-block signals, global routing, clocks, and power supplies. Today's less-than-90-nm processes support as many as 12 layers of metallization, however, so the guidelines for handling in-block and overblock routing have changed.

Placement-and-routing environments use abstract descriptions of the IP block in LEF (library-exchange-format) and DEF (design-exchange-format) files. These descriptions detail pin locations, types, and layers; the data extent of the IP; power and clock paths; and blockages so that the automatic routers do not use specific wiring channels for interconnect. In older process technologies, designers identified blockages in the LEF and DEF files as paths for the wider power-supply metal, feed-through paths for known block-to-block-interconnect signals in prerouting, or areas for clock-buffer insertion. These blockage identifications occurred only on the M1 through M3 layers and dealt only with the placement of wires.

The abstract descriptions of the blocks for both primitives and higher functions contain no instructions about how interconnect layers above the block should behave. The only mechanism for controlling routing in the higher metal layers is the ability to add a blockage if necessary. Modern processes with many interconnects and those using advanced CMP (chemical-mechanical polishing) also have nonwiring and wire-class-blockage requirements.

Examples of nonwiring blockages are those for minimum square-metal fill on certain layers, identification of where to place fill to accommodate wire spreading, spacing regions for OPC (optical-proximity-correction) and PSM (phase-shift-mask) artifacts, BIST (built-in-self-test) regions, in-die-pad regions, and TSV (through-silicon-via) targets. These blockages reside on layers, such as metal layers M4 through M12, where there is no data. Designs can now require clock-, power-supply-, and power-down-class wire-class blockages. Most of the current SOC (system-on-chip) designs use multiple clock domains. Special-function IP may have a large disparity between its operating frequency and the high-frequency clocks running some of the I/Os, memory, and data-path blocks.

Because the layers above the IP block require metal fill for CMP, a source of coupling from multiple layers results from these clocks and signals in the IP. Identifying clock-class blockages is a method of isolating harmonics that the interaction of these multiple clock frequencies causes, preventing them from causing non-buffer-related clock skew.

To build electronic systems with multiple functions, the SOCs rely on multiple power supplies to build the application-specific modules. As a result, even small to midsized designs commonly have two or more power-supply and signal levels. The lower-voltage cells have necessarily scaled-down switching levels with increased sensitivity to noise and to false switching. This sensitivity results from the simultaneous switching of signals on other higher-voltage pairs. Identifying power-supply-class blockages clears sensitive areas of overblock signals that could cause false switching and increased ground noise. This precaution is key to maintaining signal integrity in the design, and it is necessary to any design-verification strategy.

Similar to the power-supply blockages, SOC designs have multiple power-operation modes. In the reduced-power states, techniques such as the use of retention registers or multithreshold logic ensure that the block returns to proper operation. However, using these techniques can incur the risk of false data registration due to noise from switching signals in overblock routing during the power-supply restoration. To minimize this hazard, designers should identify blockage areas so that this large-signal coupling cannot take place.

It is important to verify that any IP, especially for less-than-180-nm processes, includes application-based blockages, such as those described, so that a parametric-driven physical-design flow can complete its task, giving you a high degree of confidence. **EDN**

Contact me at pallabc@siliconmap.net.

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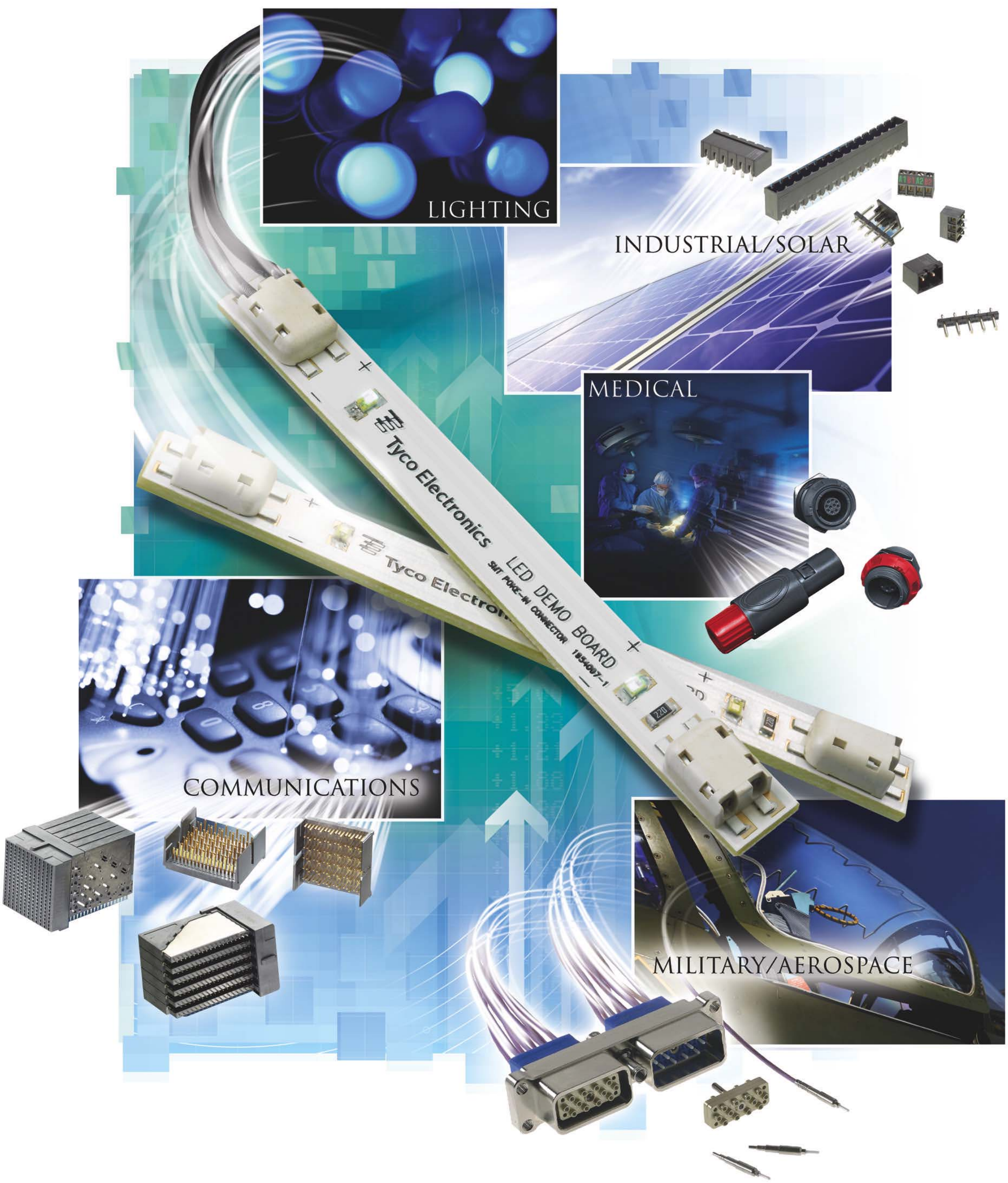
Go to www.edn.com/080626pc and click on Feedback Loop to post a comment on this column.

Innovations *in* DISTRIBUTION



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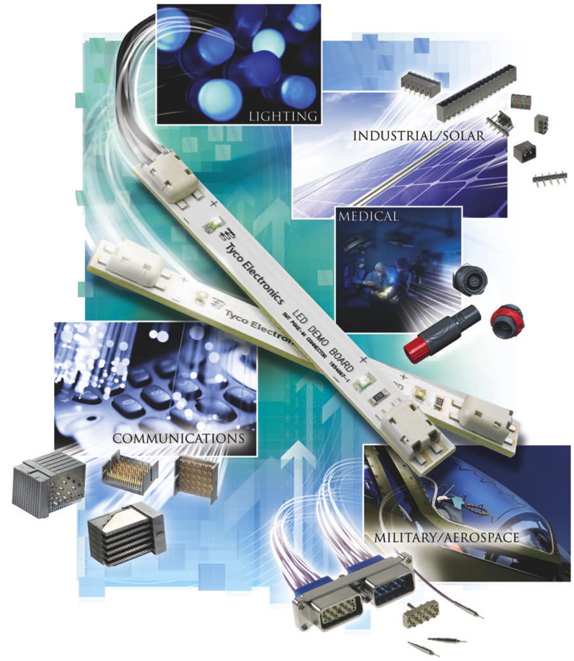
Innovations *in* Distribution



As system architectures become more complex, silicon vendors have found that they need to offer engineers more than just hardware. Engineers evaluating a processor, for example, will likely spend more time with development tools and off-the-shelf software than measuring a processor's specs. Engineers have a design they need to bring to reality and what matters to them is the overall capabilities of a product line, not whether a particular function is implemented in hardware or software.

This trend of wanting more from vendors has extended into the supply chain. In the past, distributors performed primarily an inventory function for manufacturers and provided one-stop shopping for a wide range of components to simplify parts acquisition. They also offered components for sale in smaller lots than most manufacturers could afford to support. That has changed significantly.

Today, distributors manage the flow of information between suppliers and engineers, becoming an integral part of a product's design team. Partnering with one's distributor and suppliers has become a vehicle not only for securing availability of product but also for bringing in additional sets of technical eyes that have seen a wide range of applications and an even wider variety of components. They are consultants that are successful when their customers are successful.

In the articles that follow, I'll explore some of the insights two major players in the electronics industry – Avnet Electronics Marketing and Tyco Electronics – have discovered through their synergistic relationship. With their industry-wide perspective, these companies have identified several trends driving the direction of innovation across several industries: medical, lighting, industrial/solar, military/aerospace, and communications. In addition to a brief overview of key design challenges arising in each of these industries, engineers will learn how they can leverage the integral relationship between distributor and supplier to get more from their supply chain than just simple delivery of components.

Nicholas Cravotta
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Off-The-Shelf, Single-Use Technology

The medical industry has long been founded on custom engineering to meet the extreme design specifications required to guarantee quality, reliability, and safety. As a result, it is one of the few markets where cost is not the primary purchasing factor. However, as the expense of medical equipment and services continues to rise, increasing pressure is being put on OEMs to place more focus on reducing cost.

"You cannot discount the impact that the impending wave of baby boomers due to enter the elderly generation will have on the medical industry," says Pat Wastal, senior vice president of IP&E for Avnet Electronics Marketing Americas, a business region of Avnet Inc. The anticipated increase in strain on hospital resources is expected to significantly change how medicine is practiced, specifically by dictating a need to decrease the overall time a patient stays in the hospital for any particular treatment. More procedures will be outpatient-based, going from today's 65 percent of procedures completed without a hospital stay and increasing to 80 percent over the next 10 years.

> More procedures will be outpatient-based, going from today's 65 percent of procedures completed without a hospital stay and increasing to 80 percent over the next 10 years.

To meet these changes efficiently and cost-effectively without compromising patient safety, hospitals will need to be able to provide more localized treatment while minimizing recovery time. Key factors to achieving success in this endeavor include moving to single-use designs and reducing the need for customized components.

The Single-Use Advantage

While there are many trends affecting design of medical equipment, perhaps the most relevant is a move towards single-use components. Single-use devices, also referred to as one-time use or disposable, increase procedural efficiency while improving infection control and patient safety. "Revenue from disposable components is growing faster than reusable components because of the tremendous volumes involved," says Avnet's Wastal. Moving to single-use components generally does not change the internal technical design of medical equipment; rather, the existing invasive components of a system are partitioned as single-use.

Single-use components are attractive because they are sterile, hermetically sealed, and ready for use. Preventing infection is a key driver for moving to single-use technology. According to the New England Journal of Medicine, approximately 90,000 deaths each year are attributed to hospital infections (*Reference 1*). In 2005, insurers reimbursed $11.5 billion for healthcare-associated infections, while hospitals suffered $9 billion in associated losses (*Reference 2*). Also relevant is the movement by Medicare to eliminate reimbursements for any preventable infection.

From a procedural perspective, another advantage of using single-use components over reusable components is faster throughput. Depending on the procedure, reusable devices must undergo some type of sterilization, a process that adds tens of minutes to equipment turnaround time. With case loads expected to increase, single-use components help meet the goal of speeding treatment times without compromising treatment efficacy.

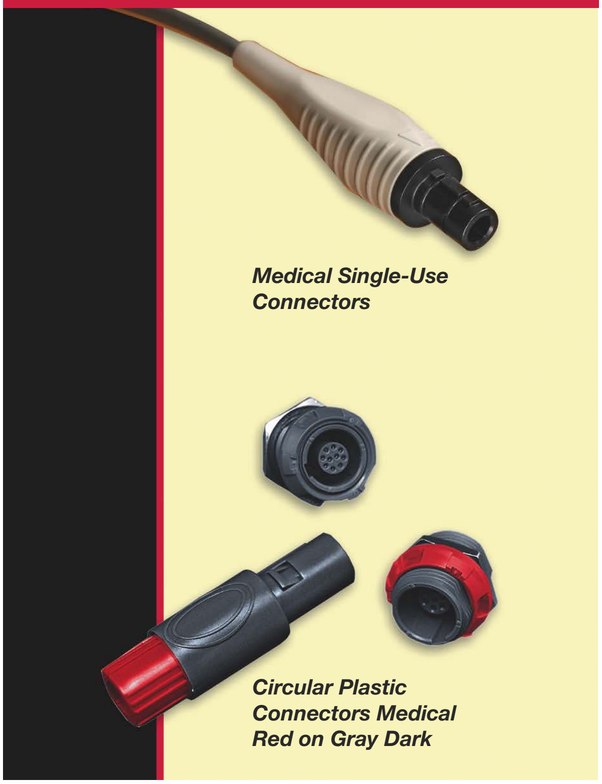
Custom Off-The-Shelf

Component suppliers have identified the need for enhanced features in medical components and recognize that, for their own reasons, one manufacturer may want a particular feature while another may not. The Medical-CPC (Circular Plastic Connector) family of connectors, for example, is a large portfolio of devices offering a wide range of built-in features giving engineers access to highly specialized connectors off-the-shelf rather than as custom components. Built-in features range from integration of transducers, temperature sensors, and ID technology, to name a few.

Medical-CPCs are generic connectors primarily designed for electro-surgical devices. They provide up to 14 pins which can carry either power up to 2 amps (3 amps for 10-pin connectors) or data signals up to 100 MHz. Pins can be configured as needed, and two pins can be used to define a differential signal.

Connectors and cabling have always been an integral part in the design of next-generation medical

Key Medical Products



Medical Single-Use Connectors

Circular Plastic Connectors Medical Red on Gray Dark

equipment. However, what used to be a single unit, reused over and over, is now potentially thousands of units and so becomes a major cost factor. "Selecting the optimal cabling and connector components becomes paramount," says Marc Socquet, Technical Marketing Manager at Tyco Electronics.

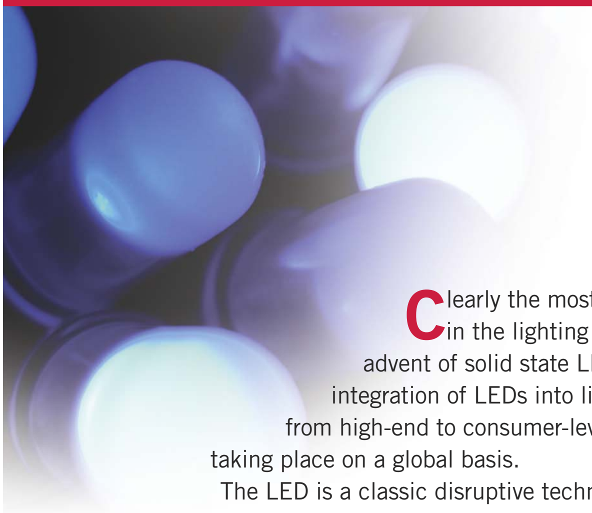
Proper connector definition and selection can be one of the most difficult aspects of design. For this reason, manufacturers often choose to engage with field applications engineers from the supply chain to help them understand the ramifications of particular design decisions. Additionally, because distributors are also helping with sourcing semiconductor components, their engineers can look ahead – called "strategic synergy" by Tim Beck, Product Manager at Tyco Electronics – to decide what each connector will need to provide.

Driving Down Cost Through Volume

Single-use components also introduce new inventory challenges for manufacturers used to providing reusable components. Now they need to be able to manufacturer thousands of units where they used to supply only a handful. Savvy manufacturers will explore the options in inventory management distributors can offer to simplify this transition. Manufacturers will also need to develop smaller-sized packaging to alleviate inventory issues at hospitals.

The high volumes of single-use components have another impact on the supply chain. Traditionally, medical equipment requires a high degree of customization. This arises from the relatively low volumes involved, as well as the highly specialized components needed to meet the extreme constraints typically required in medical applications. Single-use units drive the necessary volumes to enable the supply chain to offer more specialized components as off-the-shelf and catalog parts. By being out in the field, supply chain partners are able to directly observe the challenges medical manufactures face and what components would best meet their needs. With this inside market knowledge, they can help engineers move away from proprietary interconnect technologies and take advantage of the cost efficiencies other industries enjoy. ■

Reference 1: NEJM, Vol 348:651-656, Infection Control - A Problem for Patient Safety.
Reference 2: Landro L., The Informed Patient - Hospitals Take Stronger Steps Against Bacteria, Wall Street Journal, March 2006



A Whole New Game

Clearly the most dominant trend in the lighting industry is the advent of solid state LEDs, and the integration of LEDs into lighting fixtures, from high-end to consumer-level products, is taking place on a global basis.

The LED is a classic disruptive technology. It provides on the order of 50,000 hours of operation while offering extreme efficiency, high reliability, and anticipated future lower costs compared to other lighting technologies. "The changes wrought by the LED have occurred at a more accelerated pace than many industry players anticipated," says Avnet LightSpeed Director Cary Eskow. Avnet LightSpeed is the solid state lighting and LED business unit of Avnet Electronics Marketing Americas.

From an ecological standpoint, LEDs are extremely green: environmentally friendly, energy efficient, and requiring reduced maintenance. LEDs don't have the hazardous mercury issues associated with compact fluorescent fixtures, and because of their longer life, less material is destined for the landfills. The long life of LEDs also substantially reduces maintenance costs. LED fixtures do not have to be serviced as frequently as other lighting technologies, reducing personnel burden and other associated costs such as having to restrict access when servicing lights roadside, on the side of buildings, or in tunnels.

Repurpose No More

When LEDs first became available, engineers had to decide whether to go with a custom connector since few connectors were specifically designed for LEDs. LED designs, however, tend to have aggressive time-to-market targets and so there often isn't time to wait for a custom connector. Given the wide range of connectors available across the electronics industry, odds were a reasonable connector could be found. Even if an off-the-shelf connector wasn't quite perfect for an application, it tended to be less expensive than developing and waiting for a custom connector. Repurposing components, however, often carried with it a price (for overdesigned components) or reliability (if underdesigned) penalty.

As the LED market has matured, engineers no longer have to make do with repurposed components. Tyco Electronics, for instance, has modified its Micro MATE-N-LOK family of connectors not only to meet lower profile requirements but also to move the latch from on top to the side to avoid having the connector cast a shadow.

Many components today offer a range of application-specific features specifically designed for use with LEDs. The Hermaphroditic Blade and Receptacle Connector from Tyco Electronics, for example, provides "multi-axis mating," an ideal mechanism for joining a multitude of strip light LEDs. The connector mates horizontally and vertically (at 90º or 180º), allowing the creation of arrays of PCBs. From a maintenance perspective, these connectors simplify strip light replacement by enabling technicians to remove center strips individually rather than having to remove all the lights from one end until the strip needing servicing is reached.

The changes wrought by the LED have occurred at a more accelerated pace than many industry players anticipated.

Originally designed for the computer industry, similar hermaphroditic connectors were current-limited due to their small pin size. This restricted their reliability in many applications. In optimizing these connectors for LED applications, they have been modified to carry the higher currents required.

Complementary Life Cycles

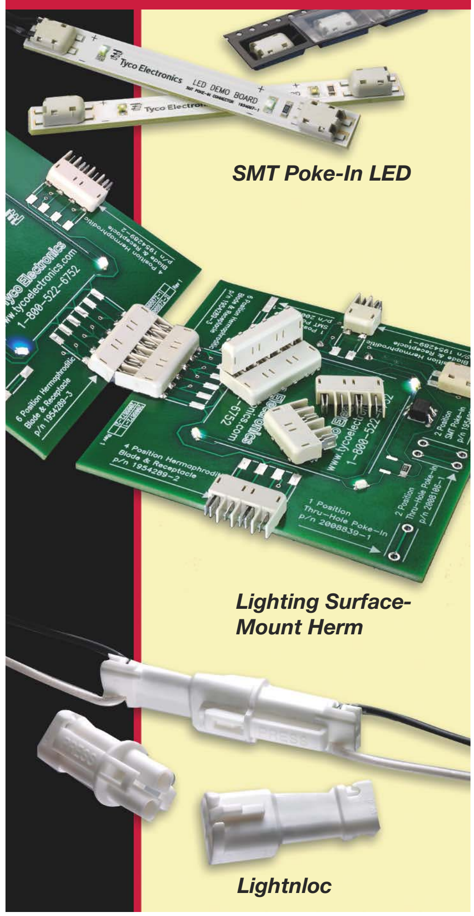
Working with LED technology involves a completely new way to design compared to traditional bulb and ballast systems. Different components are required, as well as how they are integrated together, and different design issues are relevant, such as localized thermal management. For engineers new to LED design, it can be challenging to achieve an optimal architecture without an introduction to the myriad options available. For example, it may not be immediately obvious how one connects to an LED the size of a pin head.

Many engineers perceive that the primary challenge of working with LEDs lies in optimizing the optics and electronics. Certainly it takes significant design effort to produce consistently colored LEDs; while manufacturing processes continue to improve, the LEDs themselves still vary in projected color. Additionally, as color is directly impacted by temperature, much effort is expended ensuring that a design is thermally sound and controlled. Only after all of these challenges have been addressed do many engineers then consider what interconnect technology they will use.

As with any technology, there are certain physical laws that effect design choices. One common design shortcut and cost-cutting measure is to select a lower cost connector that may be close but is not sized properly from an electrical and mechanical standpoint for a particular application. Many LED applications, for example, use a class 2 power supply with a 5 amp rating. Even though a connector rated at 1 amp will work for a time, eventually the 1 amp connector will begin to exhibit undesirable behavior.

For example, this past December saw a setback for the LED industry with the plethora of LED-based Christmas lights which failed to meet consumer expectations of "long life." What happened in this case was not brought about by a lack of LED reliability but, rather, was a consequence of manufacturers using low quality wires and connectors. According to Paul Farrell, Global Director, Lighting at Tyco Electronics, "System reliability is only as good as its weakest link." Rather than specifying complementary components in terms of expected life cycle – 10-year connectors to match the 10-year life of LEDs – manufacturers focused on low cost and used connectors that became the weakest point in the product chain. As a result, the lights failed because they exceeded the expected life of the connectors, not the LEDs.

Key Lighting Products



SMT Poke-In LED

Lighting Surface-Mount Herm

Lightnloc

Early Planning

Thinking ahead about all the components of a lighting system can avoid imposing undesirable limitations late in the design cycle. For example, high brightness LEDs are often mounted on an aluminum metal clad PCB which dissipates heat during operation. Unfortunately, this same PCB also dissipates heat during soldering, making it difficult to achieve a reliable connection between the power trace/wire and each LED.

An alternative to hand soldering is to use an SMT Poke-In connector from Tyco Electronics. This connector provides a lead in which to insert the power wire normally soldered to the system board. This connector comes on tape and reel and can be pick-and-placed at the same time LEDs are placed. Overall, the SMT Poke-In connector simplifies manufacturing while increasing the reliability of the connection.

To take advantage of a connector like the SMT Poke-In, its form factor and limitations on design must be considered during initial component placement so that power pads can be spaced appropriately. Attempting to bring in these connectors late in the design process may result in substantial layout changes.

Another factor to consider early on is whether the connectors in a design are going to be the only components that cannot be pick-and-placed. While designs don't need to 100 percent surface mounted, each manually placed component increases system cost. By considering the connector early on, engineers can avoid discovering that the best connector for the job, based on their layout and specifications, is the only manually placed component in the design.

While each family of components offers different features, don't assume that among the myriad connectors that there is a perfect fit for a finished design. Rather, engineers should confirm that they have access to connectors that can accommodate the wire sizes and currents they wish to use. In terms of mounting, if a particular orientation or profile such as a vertical header is required, they should make sure that one is available that meets the design's specifications.

With the SMT Poke-In, for instance, engineers have the option of using one- or two-lead configurations. If the two connections are coming from the same orientation, the two-lead configuration serves well. However, in those cases where the connections have different orientations, engineers can use two one-lead SMT Poke-Ins connected via a trace, enabling them to be displaced in relation to each other and in different orientations. ■

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At Avnet Electronics Marketing, support across the board is much more than a tagline for us. From design to delivery – we are deeply committed to driving maximum efficiency throughout the product lifecycle. And we have supplier partners like Tyco Electronics who share that philosophy.

Tyco Electronics is a worldwide provider of components with a product portfolio of roughly half a million part numbers including connectors, relays, fiber optics and wireless components. Tyco Electronics' legacy dates back to 1941, when the company developed connector technology for the budding modern day electronics industry. Avnet's own commitment to the marketplace has been equally as storied, dating back to the inception of component distribution itself.

Together, Avnet and Tyco Electronics have built an impressive combination of engineering savvy and electronics industry heritage. At the inception phase, they can work with end customers to either update a current application or help bring a design concept to fruition. Once the design is complete, Avnet offers an array of value added services including custom assembly and connector assembly programs, plus logistics services to get the product to market.

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Understanding Your Options

Whether you're developing solar or industrial equipment, one thing is common: it pays to understand your options. Suppliers of solar technology offer highly specialized components that meet exacting and rapidly changing industry specifications. For industrial applications, the options are so numerous it can be difficult to know which components are optimal.

In these markets, it is just as important for suppliers to know what OEMs are designing as it is for OEMs to be aware of the range of components available. When deciding upon which of the myriad directions they should expand upon in future product variants, suppliers often have limited information. They know what their customers are buying, but not necessarily what they need. Put another way, engineers looking through a catalog will select the best component available for a given application, but this doesn't tell suppliers what components engineers would use if they were available. "A tight distributor/supplier relationship can result in substantial cost savings for OEMs as distributors working with design teams can pass 'wish list' features and requirements back to suppliers," says Pat Wastal, senior vice president of IP&E for Avnet Electronics Marketing Americas, a business region of Avnet Inc.

Going Solar

One of the most important trends of the new millennia is alternative energy sources. Solar or photovoltaic (PV) generation of electricity is an attractive technology for many applications, potentially freeing remote systems from having to be connected to the power grid.

The primary concern for solar designs is cost per watt. Silicon-based photovoltaic generators achieve up to 20 percent efficiency while thin film reaches up to the mid-teens. "Interconnection efficiencies are extremely important in a PV system as they have a direct impact on overall cost per watt of the electricity being generated," says Sean McKenna, industry manager at Tyco Electronics.

UL and IEC specifications control the performance of solar products. These organizations aim to improve the reliability of solar devices in an effort to protect the public. To ensure qualification of their designs, engineers should consider incorporating components that have been specifically designed to meet these specifications. For engineers designing products for use around the world, they'll want a strong partner in their supply chain familiar with the different regional photovoltaic requirements.

Part of maintaining the reliability of a solar system is protecting it from the elements. This is typically achieved using a junction box filled with potant to seal it from the elements. Potant can also act as a heat sink to minimize the diode junction temperature. In addition to material cost, drawbacks of adding this material to junction boxes are assembly delay while waiting for curing and taking up scarce factory floor space. Potant also makes it impossible to service the now embedded electronics in the future. The TE junction box, for example, is designed to eliminate the need for potant material.

For engineers designing products for use around the world, they'll want a strong partner in their supply chain...

A junction box, however, can provide more value than just housing vulnerable electronics. Tyco Electronics Micro SolarLok junction boxes enable fast foil termination without the use of special tools. These clamps have a high normal force which provides a gas-tight connection between foil and rail to prevent oxidation. Engineers also have the option of an integrated diode optimized for the current it will carry so that heat sinking becomes unnecessary. A lid gasket seals the junction box, completely eliminating the need for potant.

With the increase in the use of flexible thin film, despite its lower efficiency, engineers have various junction box options. As thin film generates fewer watts per module compared to silicon, it can be housed in smaller and less expensive form factors such as the line of SolarLok junction boxes.

Interconnect reliability can be further enhanced by selecting components with mechanical latches that prevent cabling from pulling free or vibrating loose and that have polarity so connectors cannot be installed backwards and damage electronics. Given the relatively low efficiency of photovoltaic collectors, it is important to minimize all losses throughout the system.

The most significant trend within the industrial market is increased need for communication between the front office and the factory floor. OEMs are moving away from expensive proprietary interconnect technologies and spanning Ethernet across the factory environment. 100Base-T has already entrenched itself with 1 GE working its way in as well, and engineers are developing ways to efficiently connect a widening network of machines and equipment.

Raising Standards

The factory floor, however, is nothing like home or office environments. Bringing Ethernet up to industrial standards – i.e., to where it can survive high temperatures, electrical noise, dust, etc. – is primarily an interconnect challenge. The standard RJ-45 connector used in office networks simply isn't rugged enough for the factory floor. With Ethernet's growing presence, the features required to bring RJ-45 up to industrial standards no longer need to be implemented with custom connectors as they are available off-the-shelf. As a result, Ethernet components are widely available from multiple sources.

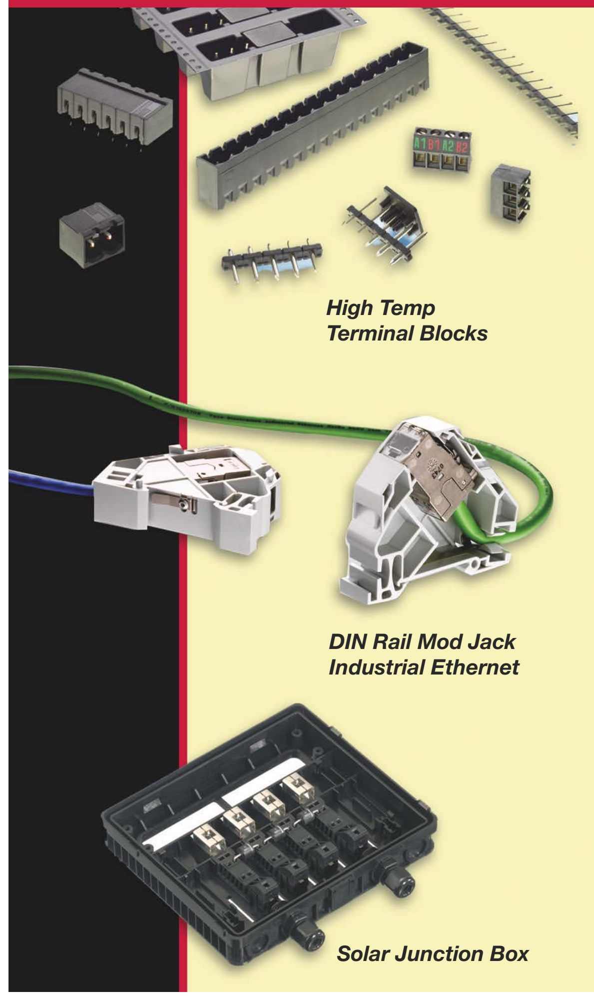
There are various types of industrial Ethernet connectors available to address particular needs. For example, field technicians can utilize connectors with a tool-less IDC (Insulation Displacement Connector) crimp to accomplish field installation of Ethernet cabling. Other connector types address the need to meet IP67 sealing requirements. Additional strain relief is also a necessity since industrial cables tend to be heavier than commercial grade cables and is achieved by adding metal locking tabs and cable glands to the RJ-45 connector.

From an industrial Ethernet switch perspective, equipment can be ruggedized for the factory by supporting a wider operating temperature range. Hardened cases, versus plastic, better protect switch components. Industrial Ethernet switches are also DIN-rail compatible, making them ready-to-mount without requiring additional hardware.

With electronics in general moving to lead-free and RoHS compliance, there is a need for higher temperature tolerance in components which can have a substantial impact on how industrial products are manufactured. With lead out of the soldering process, higher temperatures are required, even with wave soldering.

For example, terminal blocks are a common field-installable connector. Surface-mount pads can't hold up to the force necessary to operate a screw or spring, so terminal blocks require the mechanical strength of a through-hole. Boards that mix surface mount and through-hole technologies require two mounting operations: first the surface mount components are placed, followed by a secondary wave or hand soldering operation for through-hole devices.

Key Industrial/Solar Products



In many applications, terminal blocks are the only through-hole component on the board. As high-temperature terminal blocks can withstand the higher temperatures of surface mount processing, such terminal blocks can be mounted using a paste-and-hold process which eliminates the need for any secondary soldering.

Unfortunately, high-temperature components present several issues for suppliers and OEMs. Such components need to be made from different materials, as well as packaged on tape and reel, which may not be the current method used for a particular component. Additionally, some components, including terminal blocks, have thousands of different styles. This is where a close relationship with a distributor can pay high dividends. "Because distributorsy diverse teams, they are able to aggregate the design needs of the industry," says Wastal. "With such information we can guide suppliers into prioritizing the migration of components to high-temperature materials and packaging in a way that best meets the needs of the majority of OEMs." ■

High Pressure Design

If you're developing military/aerospace equipment, you may have noticed a requirement for lighter weight designs. In addition to asking its suppliers to reduce equipment weight, the aerospace and military market is also taking a more network-centric approach to warfare by bringing many of its field units online. Additionally, while OEMs are still required to provide the highest reliability, they are facing difficult cost and time-to-market pressures. "Engineers must manage all of these challenges," says Tyco Electronics Vice President of Worldwide Sales Aerospace & Defense Frank Breslin. By working closely with supply chain partners like Avnet Inc., OEMs can keep abreast of new technologies and components designed to specifically address these trends as well as take advantage of supply chain services that accommodate the high dwell time typical of military and aerospace applications.

Speed Saves Lives

Time-to-market has taken on greater importance in military applications. There is an urgent need to accelerate the design of new equipment that can save the lives of soldiers today.

To help speed up the design cycle, members of the supply chain are working at the front-end of the design process by integrating their technical staff within a customer's design team. In this way, key design constraints can be identified early in the design cycle. As new issues arise, they can provide immediate feedback, presenting viable alternatives in order to minimize delays. It is also important to have ready access to components so they can be evaluated with expediency.

Reliability is paramount for military field equipment, and higher data rates increase the probability of electromagnetic interference (EMI) problems.

Managing inventory is another service offered by distributors of which engineers can take advantage. Avnet Electronics Marketing, for example, has a variety of logistical programs where components are kept in Avnet's own inventory, at the customer site, or at a location close to the OEM's manufacturing facility. How much inventory is kept is based on projections for current and future projects. Avnet will also guarantee the availability of components or their equivalent to accommodate the long dwell time between project development and production. Additionally, as a project progresses, new components better suited to an application may become available, and these will be shared with the OEM. "Military programs, which tend to extend over years and may have budgets that are prone to unexpected shifts, will find these services of high value," says Bryan Brady, vice president, director of Avnet Electronics Marketing Americas Defense Aerospace Business Unit.

Lighter Weight Requirements

With rising fuel costs, reducing weight has become an important factor in designing military equipment. In addition to designing more space-efficient components, Tyco Electronics is addressing this need by developing new types of composite connectors. These connectors use molding compounds such as Ultem and PEEK instead of traditional metal components. Also, customers are requesting lighter weight wire that offers the same performance and reliability compared to traditional wire technologies.

No Vehicle Left Behind

The military is implementing higher bandwidth communications across the board through its Vehicular Inter-communication System—Expanded (VIS-X) program. VIX-S calls for the retrofitting and upgrading of existing vehicles so that all units in the field can be interconnected and exchange real-time information. Vehicles will also have their own internal network to transport voice, video, and data streams to systems throughout the vehicle. In this way, real-time data can be streamed to and from the battlefield, enabling control of units in a way never before seen.

Reliability is paramount for military field equipment, and higher data rates increase the probability of electromagnetic interference (EMI) problems. For this and other reasons, many engineers are considering moving to fiber optic technologies. In addition to providing higher bandwidth and immunity to

EMI, fiber is more difficult to tap into, making it more secure as well as lighter in weight. Fiber is meeting some resistance for being a new technology in military communications, and its durability (glass versus copper) may be perceived to be issue even when it is not. For example, Tyco Electronics offers its Expanded Beam products as well as its LuxCis system, a small form factor fiber optic system contact designed to meet the rigors of military applications.

The increased demand for electrical energy has driven system voltages and currents to higher standards. Switching these higher voltage requirements with new Tyco Electronics' Kilovac high voltage contactors enables designers to use these higher electrical levels to optimize new design packaging.

Moving to higher bandwidth over copper or fiber also potentially reduces system weight, as existing network paths can meet the need to carry more data without introducing additional cabling. Tyco Electronics has developed an extensive connector portfolio that can mix power, signal, and optical performance in a single interconnect to address the extreme environmental conditions of military and aerospace applications.

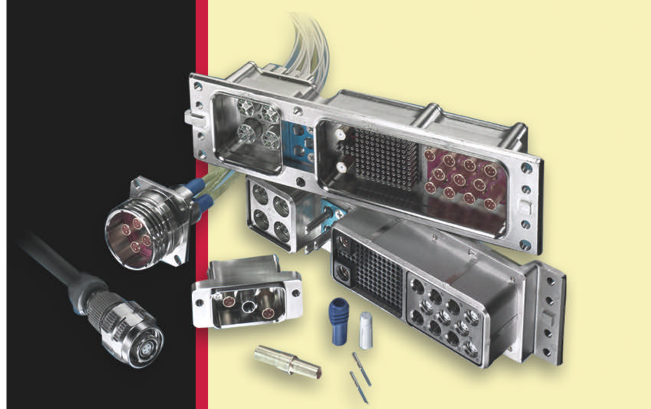
Risk-Sharing

Another key value distributors and suppliers are bringing to manufacturers of military and aerospace equipment is that of risk-sharing. Risk-sharing takes the form of the supplier or distributor absorbing its design-related costs. In other words, they amortize these costs over longer periods of time. For example, suppliers may provide several system's worth of components to an OEM for developing its first production units.

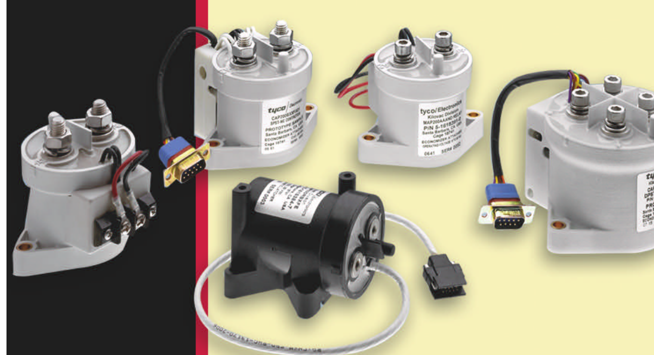
Technical staff can be called upon to help in narrowing down the wide variety of options engineers have available to them. For example, deciding between whether to use military or commercial grade components can be a difficult decision in terms of balancing safety, reliability, weight, and cost. Technical staff can help engineers understand the specifications and limitations of component families and types, as well as their strengths and differences, to facilitate more informed component selection.

Engineers will also want to consider the global reach of their distributors and suppliers. Military contracts may include requirements for working outside the country as a way to stream revenue to international allies. "Having a local supply base located in the appropriate regions can reduce undesirable supply chain delays, as can access to local technical support," says Brady. ■

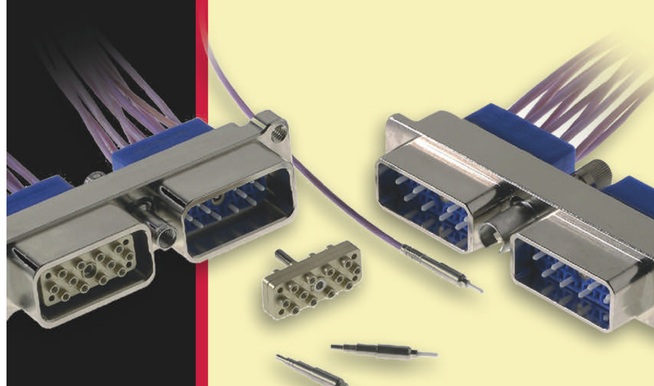
Key Military/Aerospace Products



Quadrax Contacts, Connectors and Cables



High Performance Relays and Contactors



LuxCis Optical Terminal Connector

Carrying Convergence Into The Future

Throughout the network one can see the ongoing convergence of different protocols across common platforms. The ability to merge multiple networks – as well as consolidate network administration – onto a single platform promises substantial capital and operational cost savings to network operators. For example, instead of maintaining a separate SAN and LAN infrastructure, the ability to carry Fibre Channel over Ethernet will enable operators to combine multiple network interfaces onto a common switching platform.

In order to best capitalize upon the benefits of convergence, engineers will need to be aware of all of their options. With the tremendous number of new products available from month to month, however, it isn't possible for engineers to keep up with the latest advancements across the range of technologies they need to employ in a design. In many cases, competition for lean magazine pages limits the number of new products announced publicly, and engineers have few ways of hearing about these products other than through direct mail from the supplier or through a field engineer familiar with the product family.

The First To Know

As distribution partners keep up-to-date with the latest product developments from their suppliers, they are often the first to learn about the introduction of new products. "By working with design engineers directly, we are able to recognize upcoming design needs and bring specific products to the design team's attention," says Pat Wastal, senior vice president of IP&E for the Avnet Electronics Marketing Americas business region of Avnet Inc. Additionally, they can help secure difficult-to-get samples as well as project a component's realistic delivery schedule. For example, a distributor will be able to identify a higher density component that has only just been made available to an OEM trying to increase port density on a line card.

One way for engineers to enable convergence while reducing cost is to consolidate line card designs to a single architecture that can accept the various I/O interfaces utilized in a network via interchangeable modules. Rather than change out an entire card to support Fibre Channel or Ethernet, electrical or optical cables, the line card effectively undergoes a "personality change" by employing an I/O module card with the appropriate interface.

A modular approach also enables network operators to more easily scale the network over time while minimizing the cost to upgrade by reducing the amount of hardware required to upgrade a link. The use of I/O module cards makes it possible to keep mission-critical links up-to-date with the latest data rates and reliability features. Engineers must also take into account how module cards connect to the line card. Stacking connectors offer a lower profile, higher speed, and more flexible architecture as opposed to coplanar connectors which position modules at a right angle.

In addition to the I/O density, engineers are considering the card pitch to support growing bandwidth demands. This is driving an effort to minimize the line card profile as well as the I/O modules. Network and communciations OEMs looking to support 10 Gbps per differential pair across the backplane can consider a more compact profile down to 0.6 inches.

Just as engineers are increasing the functionality captured through modularity, component manufacturers are seeking ways to increase the interconnect functionality. Tyco Electronics, for example, is developing new Power over Ethernet Plus (PoE+) RJ-45 jacks that drive double the power capacity of standard PoE. "With PoE+, engineers will be able to move beyond simple IP phones to create a wide variety of devices that run off a network connection alone," says Terry Mosbaugh, Tyco Electronics' product manager.

Within datacenter applications, the new Small Form Factor Pluggable (SFP), and its successor SFP+, define a smaller connector size that enables both a wider range of ports as well as higher port densities. Currently, the SFP+ form-factor supports Ethernet, up to 10 Gbps, and Fibre Channel, up to 8 Gbps, as well as both electrical and optical cabling. Such I/O flexibility on line cards will not only simplify inventory management, installation,

One of the key challenges for engineers in the communications industry is sufficiently future-proofing designs.

and operational upkeep, it also allows consolidation – and corresponding cost savings – at the switch level.

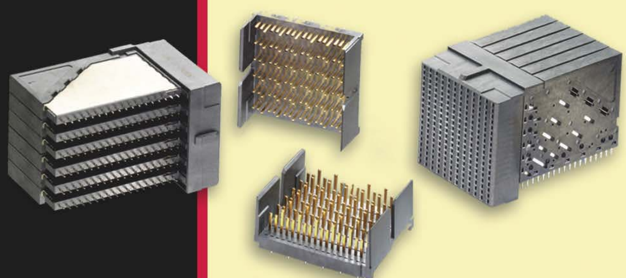
Future-Proofing Networks

One of the key challenges for engineers in the communications industry is sufficiently future-proofing designs. As the reach of the network continues to expand, platforms must offer enough headroom to increase data throughput over time without imposing burdensome investment requirements today. Determining just how much headroom is enough can be difficult given the extended lifecycle of backplanes and the impact on efficiency if an older backplane cannot accommodate next-generation data rates.

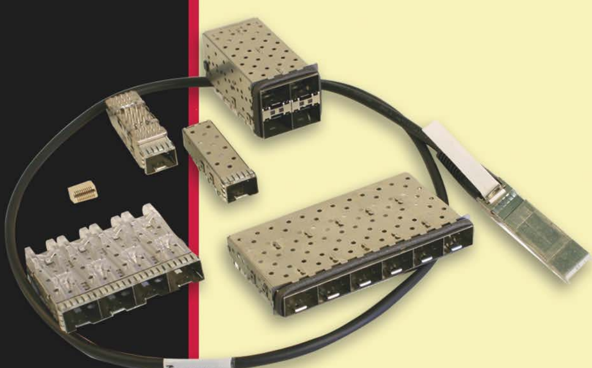
Today's backplanes utilize XAUI as a physical standard over which to run a variety of protocols. XAUI supports four data channels each operating at 3.125 Gbps to accommodate 10 Gbps links. Network operators, however, are already calling for 10 Gbps-capable backplanes. The industry continues to look toward the future with industry groups designing both backplane and I/O channels to support both 40 and 100 Gigabit Ethernet. While it is unclear when a full 100 Gbps link will be available or needed, today's backplane vendors are already planning for the future. "25 Gbps will be an intermediary step to 100 Gbps just as 2.5 Gbps has enabled the transition to 10 Gbps," says Avnet's Wastal. "Backplanes limited to 10 Gbps will be unable to carry the network forward without a forklift upgrade." Network operators don't know what capacity they will need to support in the future, or when, so backplanes that can physically support 25 Gbps links as they become available will be more attractive than those limited to 10 Gbps.

The traditional backplane, typically supporting two switch cards and eight line cards, will need to undergo a major transformation to support these higher data rates. In order to switch this much data reliably, the number of switch cards may increase, driving a thicker, more expensive, and complex backplane. To support greater overall bandwidth, backplane vendors are developing what are called "orthogonal architectures utilizing a midplane interconnect system." Put in different words, line cards are installed up and down on one side of the mid-plane while switch cards are installed left to right on the opposite side of the mid-plane using special high-speed connectors such as those in the Z-PACK TinMan product family. This effectively connects all switch cards to all line cards through the thickness of the mid-plane, minimizing trace lengths between line cards and switch cards and providing the increased processing capacity necessary to truly achieve 25 Gbps links. ■

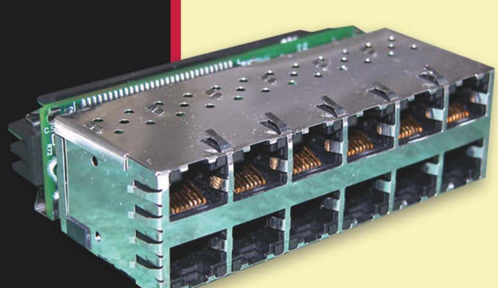
Key Communications Products



Z-PACK TinMan Orthogonal Connector System



SFP+ Product



Power Over Ethernet (PoE) RJ-45 Product

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AS NEW EMBEDDED DESIGNS COMBINE HIGHLY INTEGRATED SILICON, PORTABLE PLATFORMS, AND SOARING DATA RATES, THE INDUSTRY IS ADOPTING SMALLER FORM FACTORS THAT EMPHASIZE COOLING, RELIABILITY, AND PERFORMANCE.

Figure 1 The CC40x single-board computer from General Micro Systems packs the Atom processor, memory, and peripherals onto a conduction-cooled, 3U CompactPCIe module.

SHRINKING STANDARDS SQUEEZE EMBEDDED DESIGNS

BY WARREN WEBB • TECHNICAL EDITOR

Continued pressure to reduce the size of industrial, medical, consumer, and other space-critical applications has sparked a new wave of embedded computing platforms with extremely small form factors. Employing both open standards and proprietary designs, these new platforms give system designers a growing selection of off-the-shelf computing and peripheral modules to simplify size-constrained applications. Despite their compact size, these miniature system components take advantage of new computing elements, serial communications, and clever heat-dissipation techniques to deliver significant processing power and I/O performance.

Smaller form factors are possible because of fundamental changes in the architecture and design of embedded devices and systems. The latest silicon technology can integrate multiple processors, graphics elements, and networking interfaces onto a single-chip device, thereby saving enormous board area. High-speed data rates have also pushed designers to change from parallel, multidrop-bus structures to serial-switched-fabric technology, with the added benefit of reduced real estate. Product developers have also found new techniques for power delivery, cooling, and packaging that minimize the overall system size.

With new, smaller size requirements, embedded-system designers are turning to pre-engineered, off-the-shelf modules that integrate the latest CPU technology with standard peripherals. These standardized computer modules allow designers to trade substantial savings in nonrecurring-engineering costs for slightly higher recurring costs. A replaceable processor section provides several technical and economic advantages over traditional single-board designs. For example, designers can provide their embedded systems with a more sophisticated processor section to take advantage of advanced features, such as networking, graphical displays, complex software, and real-time operating systems, that would be difficult or impossible to implement on a limited design budget.

While increasing data bandwidth, switched-fabric technology also offers a major benefit to system size by reducing the number of pins and board area necessary for board-to-board communications. Switched-fabric architectures, such as Ethernet, PCIe (peripheral-component-interconnect express), Rapid I/O, and InfiniBand, are the latest board standards, and they eliminate many of the problems associated with parallel-bus schemes. Each connection is a direct point-to-point datapath yielding better electrical characteristics and higher bandwidth than bus architectures. Datapaths may also change dynamically to support multiple simultaneous data transfers and to route data around malfunctions. PCIe is one of the more popular fabric technologies because of its compatibility with driver and operating-system software. The basic PCIe link comprises two signal paths that use small differential-voltage swings and constant-current line drivers to communicate at speeds as high as 4 Gbps in each direction. Designers can increase the bandwidth of an individual PCIe link by simply adding signal pairs, called lanes, until they achieve the desired performance level. The PCIe specification supports one-, two-, four-, eight-, 16-, and 32-lane widths.

EXPRESS LANES

Almost all of the major board standards have included PCIe along with other fabric extensions to boost data rates for high-performance applications. For example, PICMG (PCI Industrial Computer Manufacturers Group) followed the lead of desktop technology and incorporated PCIe into the CompactPCI specification. CompactPCIe offers scalable, high-bandwidth datapaths, packetized data protocols, and compatibility with PCI hardware and driver software. One of the latest incarnations of CompactPCIe in a small form factor comes from General Micro Systems. The company's conduction-cooled, 3U CC40x single-board computer has a typical operating power consumption of 3.5W (**Figure 1**). General Micro based the module on Intel's Atom processor operating at speeds as high as 1.6 GHz with 512 kbytes of L2 cache. The board

AT A GLANCE

- The latest fabric-based module computers package the processor, mass storage, and peripheral interfaces in a reduced-footprint, replaceable module.
- Standards organizations are constantly updating board specifications to provide embedded-system designers with off-the-shelf sources of pre-engineered products.
- Most small-form-factor board-level specifications have opted for PCIe (peripheral-component-interconnect-express) serial communications to retain software compatibility with PCI-based software.
- New module standards struggle to increase computing and communications performance and retain electrical and mechanical compatibility with legacy hardware.

delivers as much as 1 Gbyte of SDRAM and as much as 16 Gbytes of bootable flash memory, six USB-2.0 ports, two serial ports, and two SDIO (secure-digital-input/output) ports for custom I/O. In addition, the CC40x provides users with high-performance graphics with 3-D acceleration and supports video resolutions as great as 1280×1024 pixels at 85 Hz. Prices for the conduction-cooled version start at $3110.

Continuing the small-form-factor theme, MEN Micro recently introduced the XM1 computer module, which the company designed to comply with the proposed ANSI-VITA (American National Standards Institute VMEbus International Trade Association) 59 RSE (Rugged System-On-Module Express) mezzanine standard (**Figure 2**). The module couples the Intel Atom processor with 1 Gbyte of soldered DDR2 SDRAM for lower power dissipation and a reduced form factor. RSE combines the computer on a mezzanine model with advanced cooling technologies, the latest serial buses, and rugged components to ensure reliable operation in the harsh environments of railway, avionics, industrial-automation, medical-engineering, and mobile applications. The Intel-based XM1 offers a screened-temperature range of −40 to +85°C. MEN Micro distributed the electrical signals on two 120-pin connectors and defines the signals only for modern serial buses, thereby eliminating legacy compatibility. For PCIe, designers can configure four single-lane ports and one port as 16, eight, two×four, or two lanes. Other ports include three GbE (Gigabit Ethernet), eight USB, and several utility signals. Prices for the XM1 start at $567.

Conceived in the late 1980s to use desktop architecture in embedded systems, PC/104 is one of the oldest and most popular small-form-factor open standards. With a connector arrangement meant for stacking boards without a card cage or a backplane, a PC/104 computer board can also serve as a mezzanine processor on an embedded baseboard. The developers of PC/104 derived its name from the PC and the number of interface pins on the 16-bit ISA (industry-standard-architecture) bus. Although the ISA bus is no longer available on the desktop, it still has advantages for embedded systems. Peripheral cards are simple, low-cost, and easy to design, all prime requirements of embedded products. The relatively low speed of the ISA bus also simplifies noise and EMI (electromagnetic-interference)-protection schemes. However, the main reason for its continued popularity is the large number of off-the-shelf products from which designers may choose. The PC/104-Plus specification emerged in 1997, and it gives board designers the choice of incorporating the

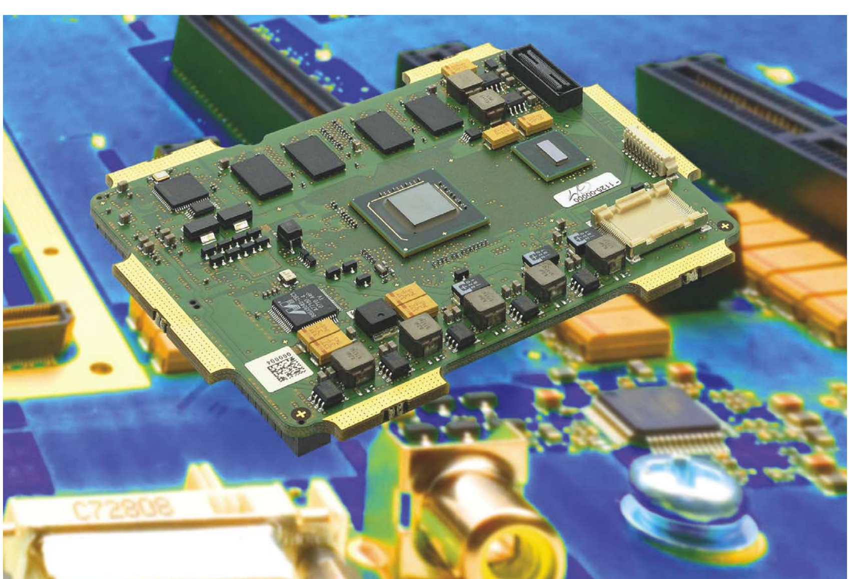

Figure 2 The XM1 computer module targets harsh-environment applications by integrating advanced cooling technologies, the latest serial buses, and rugged components.

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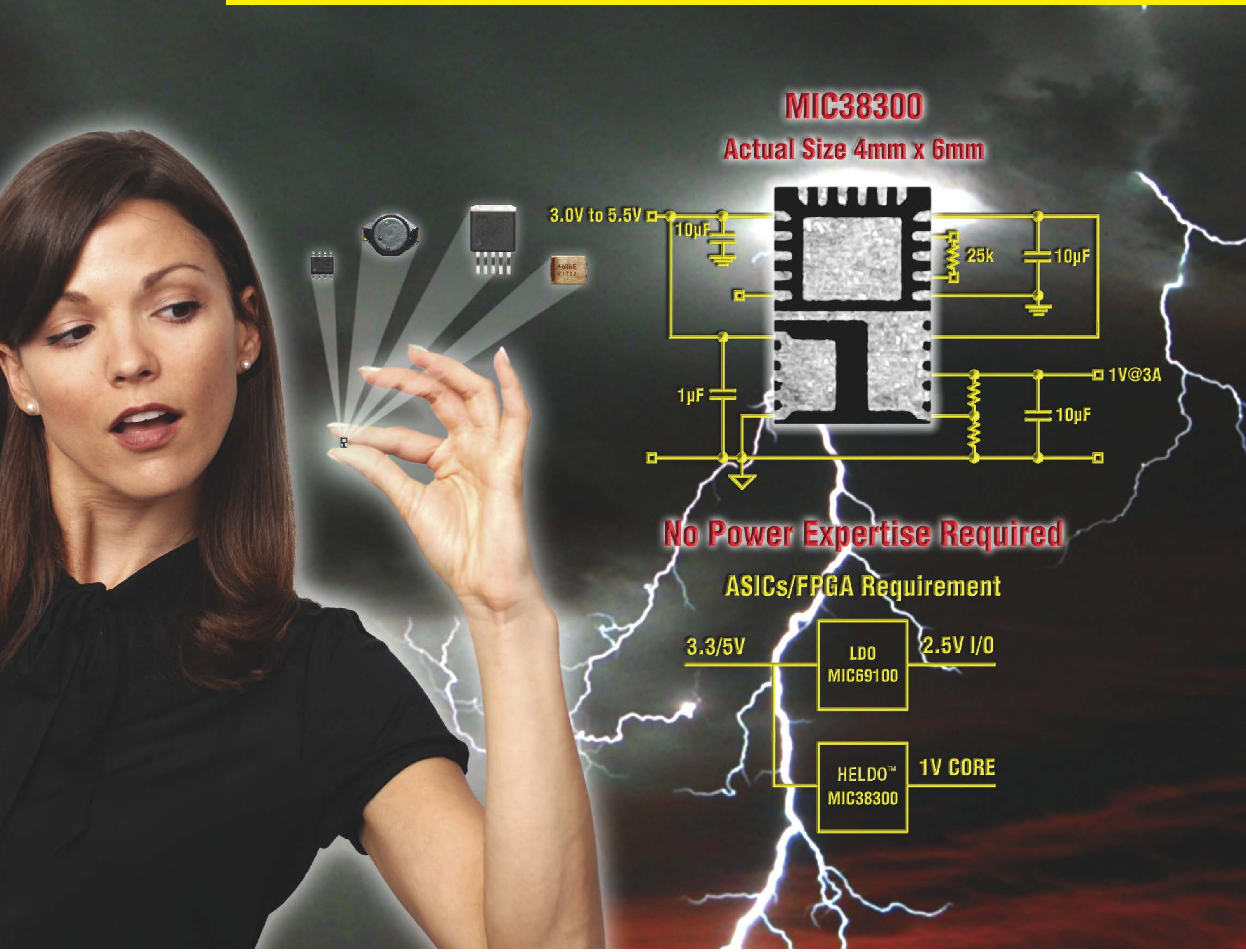

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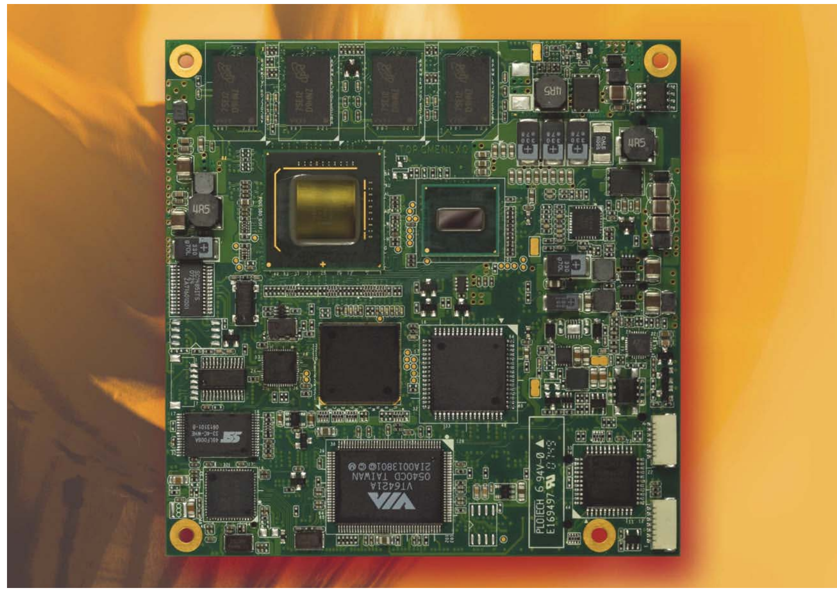

Figure 3 With low-power- and portable-system applications in mind, Congatec recently announced the high-performance conga-CA processor module in a standard COM Express form factor.

ISA bus alone, the PCI and ISA buses together, or the PCI bus alone. PC/104-Plus requires a new connector to house the PCI-bus pins. This loss of board space is one of the few disadvantages of the PCI upgrade.

CONFLICTING STANDARDS

Efforts to further extend the PC/104 specification to take advantage of high-speed data transfers have run into differing opinions within the industry. In March 2008, the PC/104 Embedded Consortium adopted a new PCI/104-Express specification combining the PCI and PCIe buses. For additional room on a module, the PCIe/104 version removes the PCI bus altogether. Developers of the standard designed a new high-speed, surface-mount connector for this application. The connector handles the rugged environments of the embedded-system market, matches the 0.6-in. stack height of the PC/104 architecture, and transports the high-speed PCIe signals over large stack heights. You can download a free copy of the PCI/104-Express specification at the consortium's Web site, www.pc104.org.

Offering a different approach to incorporating PCIe into PC/104 architecture, the SFF-SIG (Small Form Factor Special Interest Group) announced details of the Express104 specification defining a new small, stackable module. Express104 specifies a 90×96-mm board with two 52-pin, high-speed SUMIT (stackable-unified-module-interconnect-technology) connectors that can support PCIe and USB as well as other popular moderate-speed interfaces for I/O expansion. Signal-integrity-test results demonstrate that a stack of Express104 modules support data rates of 5 GTbps, which is required for PCIe Generation 2. Designers can construct Express104 modules with only SUMIT connectors; however, its developers have defined a special configuration to support expansion with legacy PC/104 modules.

Offering a third approach to extending PC/104, Micro/sys Embedded Systems created a stackable architecture that the company based on the PC/104 form factor. Although it does not incorporate PCIe, the new architecture uses a modern communications protocol, USB, and retains the size and stacking advantages of PC/104. StackableUSB supports as many as 16 peripheral boards, takes advantage of USB Plug and Play features, and eliminates the cable with a built-in stack-through connector. Further reducing the size, the StackableUSB organization recently announced two new smaller module concepts that are one-half and one-quarter the size of a standard PC/104 board.

MICRO CHASSIS

PICMG members designed the AdvancedMC (Advanced Mezzanine Card), a relatively new small-form-factor standard, from scratch and based it on switched-fabric architecture. AdvancedMC modules include single-width, double-width, half-height, and full-height form factors. The basic single-width module is approximately 74×183 mm. The basic specification defines a fabric interface with as many as 21 ports or 42 differential pairs, providing full-duplex, point-to-point connectivity between modules or to the baseboard. With a speed of 12.5 Gbps per port, AdvancedMC can handle multiple lanes of modern protocols, such as Ethernet, PCIe, Rapid I/O, and InfiniBand. With the high-performance, hot-swap, switched-fabric, and management features of AdvancedMC, designers suggested using these modules to plug directly into a backplane for small, stand-alone systems. As such, the recently adopted MicroTCA (telecom-computing-architecture) specification provides a stand-alone chassis with a backplane that directly accepts AdvancedMC cards. The smaller form factor makes the concept viable for lower-budget applications in telecom and a wide range of embedded projects.

COM (computers on modules) Express is another open PICMG industry standard for small-form-factor designs. COM Express includes PCIe to replace the PCI bus, PCIe Graphics as a replacement for AGP (Accelerated Graphics Port), and Serial ATA (advanced technology attachment) as a replacement for Parallel ATA. The processor-architecture-agnostic COM Express defines only industry-standard system-I/O interfaces. In support of COM Express, Congatec

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recently released the low-power conga-CA module, which it based on Intel's Atom processor and system-controller hub (**Figure 3**). The conga-CA is available with a 1.1- or 1.6-GHz processor, 512-kbyte L2 cache, and as much as 1 Gbyte of onboard DDR2 memory. Typical power requirements for this module are less than 5W. The conga-CA supports as many as two PCIe lanes, eight USB 2.0 ports, two Serial ATA ports, one IDE (integrated-drive-electronics) interface, and Intel high-definition audio. Additionally, the module features include two SDIO expansion sockets, a multimaster I²C (inter-integrated-circuit) bus, and GbE.

With a new wave of standards and updates that attack the data-transfer and cooling problems of small-form-factor systems, embedded-system designers can purchase many of the most complex portions of compact- or mobile-product development. High-performance, off-the-shelf processor modules with built-in graphics and networking interfaces leave the design team with the application-specific technology plus packaging. With a shortened design schedule and early access to a compatible software-development platform, standardized small-form-factor modules may be just the ticket for your next development assignment. **EDN**

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AUTOMOBILE ACCESSORIES AND CONTROL ELECTRONICS BENEFIT FROM POWER-MANAGEMENT SCHEMES TO PREVENT DEAD BATTERIES AND GAS GUZZLING. LOW-POWER ELECTRONIC SUBSYSTEMS ARE ESPECIALLY IMPORTANT FOR THE NEXT GENERATION OF ELECTRIC CARS AND PLUG-IN ELECTRIC VEHICLES.

AUTOMOBILE ELECTRONICS SEEK TO PLUG POWER LEAKS

BY MARGERY CONNER • TECHNICAL EDITOR

The ideal gas-powered car moves its driver and passengers from Point A to Point B in comfort while sipping gas and producing next to no harmful emissions. However, car buyers have sharply inflated their definition of "comfort" to the point at which many owners now expect their cars to provide satellite navigation, security, climate control, an Internet interface, and even beverage refrigeration. This escalation in features has caused a corresponding increase in the car-battery load when the engine is off and the car's electronics are in a sleep state. Designers of electronics accessories for cars have to balance the power needs of car features and accessories with the finite power that a car battery contains when in a sleep state. In addition, rising gas prices make fuel economy increasingly important to consumers, causing automobile OEMs to turn to complex but efficient electronic-control systems for subsystems such as fuel delivery and air conditioning.

Back when car electronics were primitive and gas was cheap, there was little incentive to conserve the power that the car electronics used. However, designers of automobile accessories and subsystems must make designs that consume as little power as possible because today's cars almost universally rely on a network such as the CAN (controller-area-network) bus and have a stringent sleep-state-power budget for electronic subsystems. Sleep-state-power budgeting prevents, for example, a weary traveler returning to the airport parking lot after a two-week trip from finding that the car's always-on electronics had drained the battery in his absence.

An air bag is an example of a system that turns completely off when the car is parked; there's no need for air-bag deployment in a parked car. Other subsystems that still have a function when the car is parked, such as a key-

less-entry or alarm system, will remain on but in a sleep state, drawing a small "keep-alive" current. They are on a direct battery feed. Car OEMs define the car platform's power distribution within the network architecture so that power is available to always-on systems, while other systems are asleep, waiting for a wake-up signal from the network. Although companies do not make public the sleep-state-power budgets for the accessories and subsystems, Tony Richardson, product-marketing manager of the power-products group at Linear Technology, estimates that [a constant drain of] 20 to 50 mA per day is a good range.

Network architectures and sleep-state power budgets have all but eliminated the dead-battery-at-the-airport scenario for cars with healthy batteries. However, after-market add-on electronics can still pull a battery down. After-market electronics can't tap directly into the network and rely on a power connector, such as the cigarette lighter, for power.

"Each OEM's messaging strategy is tightly controlled, and they don't open it up to after-market guys," says Kevin Anderson, systems and applications manager for the analog-products division of Freescale. "For purposes of data integrity, it's not an open system."

Even when the car's engine is running and electrical power is plentiful, electronics accessories and subsystems still need to conserve power to manage car thermal hot spots and, increasingly, for fuel economy (see **sidebar** "Parasitic power losses"). Semiconductor and IC manufacturers continue to move into the automobile by adding low-power features and intelligence to even relatively simple electronics.

AT A GLANCE

- The sleep-state-power budget allows for less than 50 mA per day; the power regulator alone should have a quiescent current of less than 50 μA.
- Modern networked cars prevent their electronics from draining a car battery when the ignition is off, but after-market electronics can still suck a battery dry.
- The easiest way to increase a car's fuel economy is still to reduce its engine size.

INTELLIGENT SWITCHES

Solid-state devices are replacing relays, once common automotive-load switches, for increased reliability as well as lower on-resistance. Although a relay might have a resistance of 25 to 100 mΩ, an SSR's (solid-state relay's) resistance can be just 2 mΩ, roughly equivalent to a few feet of standard-gauge copper wire. Low resistance is important in subsystems such as the engine starter, in which current can reach 700A. Other circuits' currents vary even as they remain on. For example, when an incandescent headlight first turns on, the bulb element is cold and allows a surge of initial inrush current of 100 to 150A for 20 to 50 msec. As the current heats the bulb, however, the resistance increases, and the current flow drops to 5 to 40A, depending on the bulb size. Intelligent SSRs, such as Freescale's eXtreme Switch product family, allow for the large initial inrush current with a variable setpoint. As the bulb heats up and the resistance changes, the setpoint moves to a new threshold for the lower current. However, if the current suddenly increases at that point, indicating a short circuit, the chip acts as a fuse and turns off, protecting both the switch and the load. These intelligent switches, in addition to being more power-efficient, also increase reliability and lower BOM (bill-of-materials) costs.

Headlights are second only to a car's HVAC (heating/ventilation/air-conditioning) system as an electrical-power load. HB (high-brightness) LEDs (light-emitting diodes) are finding use in city-lighting systems due to their lower power requirements, durability, and long lifetimes, and these same features will probably make them standard features in both interior and exterior lighting for some cars in the next few years. Taillights and daytime running lights use them; Cadillac has announced that they will be available in the Escalade Platinum's headlights this summer (**Figure 1**).

In addition to power efficiency, LED headlights also make it easier to put the light where the driver needs it. Current high-end cars feature electric-motor-driven steerable headlights that track the car's path

PARASITIC POWER LOSSES

Where do car electronics fit in the big scheme of automobile-fuel economy? They are not too high on the list, as you can see from the US Department of Energy's fuel-economy Web site (Reference A): Less than 13% of the energy from the fuel you put into your tank serves to actually move your car. You lose the rest of the energy to engine and driveline inefficiencies; idling; and accessories, such as air conditioning. Table A shows the overall breakdown.

This breakdown leaves you with 12.6% to drive the car down the road. Although some improvements in fuel economy will come from aerodynamics and mechanical enhancements, there's still room for improvement due to electronic controls. For example, using an integrated starter that turns the engine off at a stoplight and automatically restarts when you step on the gas can improve on that 17% you lose to idling.

REFERENCE

A Advanced Technologies and Energy Efficiency, US Environmental Protection Agency, www.fueleconomy.gov/feg/atv.

TABLE A BREAKDOWN OF AUTOMOBILE-FUEL USAGE

Car subsystem	Losses	Causes
Engine	62.4%	Engine friction, moving air, wasted heat
Standby/idle	17.2%	
Accessories	2.2%	For example, air conditioning
Driveline losses	5.6%	

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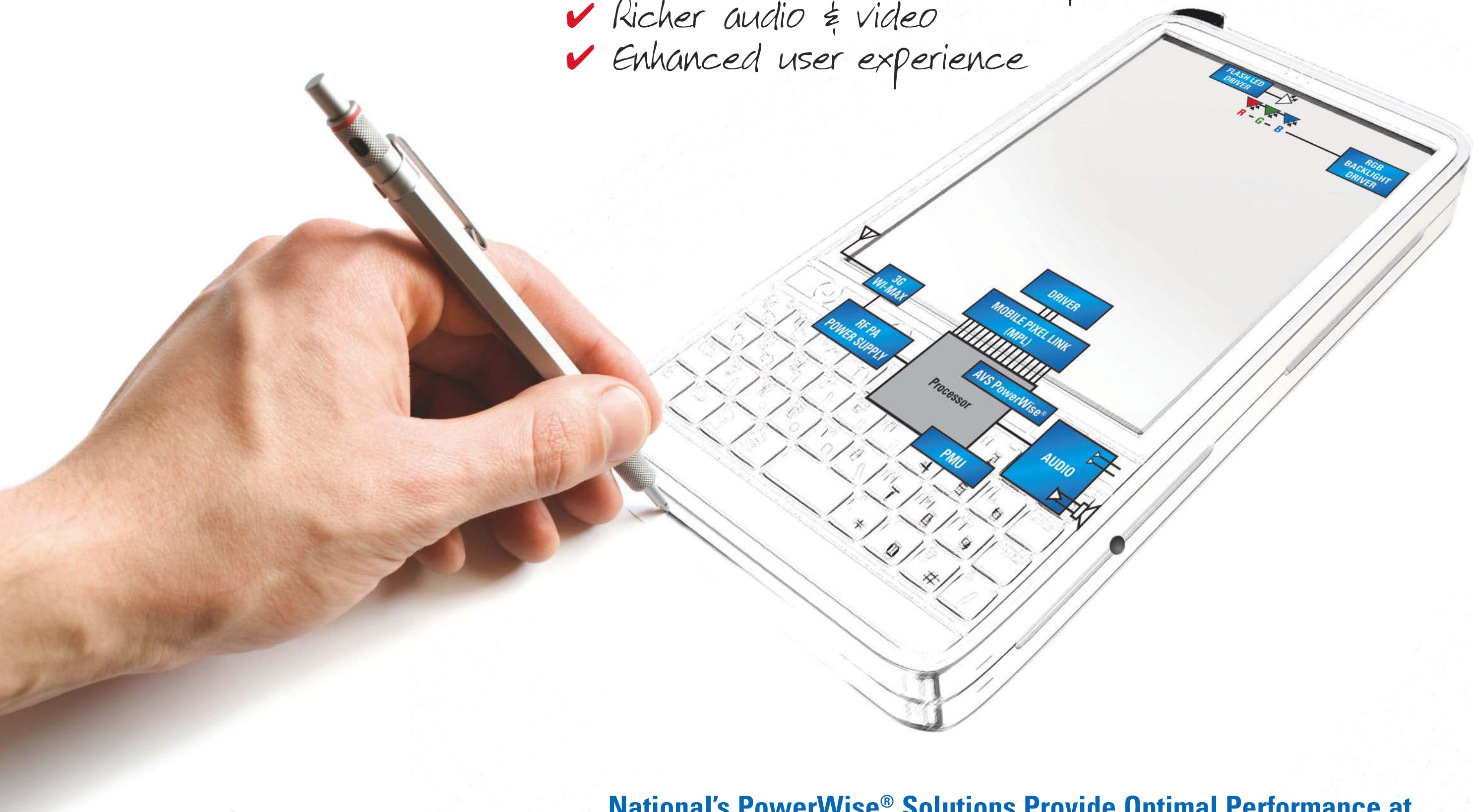

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Figure 1 The Cadillac Escalade Platinum is one of the first production cars to use HB LEDs for headlights. LEDs also find use as indicators, taillights, and cabin lights.

around a turn. An array of LEDs that turn on and off to light the path can eliminate the need for less reliable tracking motors.

The main roadblock preventing solid-state lighting in cars is the cost. HB-LED-production numbers will have to grow to cause the price drop necessary to include them in Chevrolet models as well as Cadillacs. In addition, temperature changes strongly affect LED-light output, with output varying by as much as 50% over the automotive-temperature range of subfreezing temperatures in the winter to triple digits in the summer.

Headlight LEDs require sophisticated power-management ICs. "You don't just drive one LED in a headlight," explains Freescale's Anderson. "You drive multiple ones in strings, and their brightness must remain constant, while the car-battery voltage can range from 8 to 16V in normal-run conditions. You need a switching power supply that will create a constant output with a variable input. Plus, LEDs themselves are not the same brightness universally, and they also age with time, so you have to make adjustments for each LED to make sure you get a constant output."

HB LEDs in headlights are not the only subsystems that can justify the use of switching regulators in cars: Just about any module that the CAN bus controls can benefit from the high efficiency and variable output states of a switching regulator as opposed to the older and simpler but less efficient linear regulators. Although none of the car OEMs publish the power budget for modules the CAN bus connects, Richardson of Linear Technology says that a consensus exists among the OEMs that any power regulator to power the microprocessor in an end system needs a quiescent current in the sleep mode of less than 100 μA, giving the advantage to the more efficient switching regulators. For more on low-quiescent-current-switching design, see **sidebar** "Low-quiescent-current switchers target automotive-electronic design."

Virtually all electronics subsystems include processors, and some core-based processors can conserve power in their system-sleep state by lowering their voltage, frequency, or both (**Reference 1**). For example, Texas Instruments' ARM (www.arm.com)-based TMS470 family uses dynamic-voltage scaling, which allows you to drop the voltage from, say, a normal operating voltage of 1.2V to a sleep state of 1V, a corresponding current savings of 20%. Why not just completely turn off the processor? Even though the system is in a sleep state, it still must be able to respond to some simple commands, albeit at a reduced response rate.

Although such processor-based ICs have voltage management within the chip itself, these parts rely on external power-management parts to take the battery voltage, which is approximately 13V, down to the IC's input voltage range of 2 to 3V. These power-management parts for the automotive world face a tough set of specifications for designs for future cars: They must drop their quiescent current from today's 100 μA to 30 to 50 μA to support the sleep-state-power budget for power-management chips. Plus, they need to work more closely with the CAN bus for system-wake-up commands. Expect to see power-management chips for the automotive market in the coming year begin to integrate CAN transceivers into the power-management and power-regulation chips. In addition, power-management ICs must keep the switching-circuit EMI (electromagnetic interference) from affecting the communication-transceiver portion. These new chips will face tough design criteria to meet the needs of automobile OEMs and module designers.

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As electronic controls creep further into car design, their potential for increases in efficiency goes beyond power-regulation opportunities. A motor-driven compressor can more efficiently perform many functions that mechanical subsystems traditionally performed, such as the belt-drive compressor for air conditioning. Similarly, electric-motor-driven, variable-assist power steering can improve fuel economy by as much as 0.5 mpg in reducing parasitic losses common in belt-driven hydraulic systems. Ford has announced it will be making its six-speed automatic transmission standard in future cars. This transmission, which electronically shifts gears, is more fuel-efficient than current automatic or manual transmissions.

(continued on pg 61)

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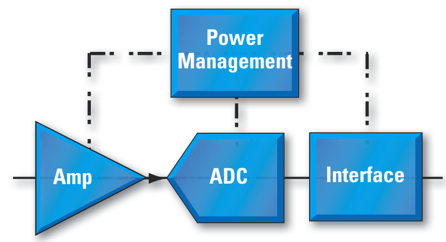

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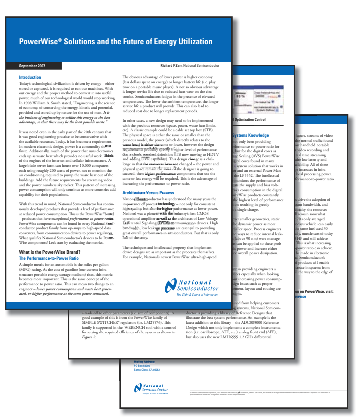

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LOW-QUIESCENT-CURRENT SWITCHERS TARGET AUTOMOTIVE-ELECTRONIC DESIGN

By Tony Armstrong, Linear Technology Corp

Modern automobiles continue to include increasingly complex electronic systems. Furthermore, the automotive environment continues to be harsh for any type of electronics. Wide operating-voltage requirements, large transient voltages, and large temperature excursions combine to make life tough on electronic systems. What's more, the performance requirements continue to become even tougher. Multiple supply voltages are necessary for different portions of the system. A typical navigation system can have six or more supplies, including 8.5, 5, 3.3, 2.5, 1.5, and 1.2V. At the same time, as the number of components increases, space requirements continue to shrink. Therefore, efficiency becomes more critical in space-constrained systems because of the space limitations and temperature requirements. At low output voltages and even with current levels above a few hundreds of milliamps, it becomes impractical to use a linear regulator to generate these system voltages. As a result, over the last several years, primarily due to thermal constraints, switching regulators have been replacing linear regulators. The benefits of a switcher, including the increased efficiency and smaller footprint, outweigh the additional complexity and EMI (electromagnetic-interference) considerations.

A switching regulator in an automotive environment needs a wide input-operating range; good efficiency across a wide load range; low quiescent current during normal operation, standby, and shutdown; low thermal resistance; and minimal noise and EMI emissions.

Any switching regulator would need specification to work over a wide input-voltage range of 3 to 60V and could find use in automotive systems capable of running on 14 or 42V. The 60V rating gives a good margin for 14V systems that usually clamp at 36 to 40V. Furthermore, it allows you to use the device in future 42V systems. Therefore, you can easily upgrade a design for a 14V system for a 42V system without any significant redesign.

High-efficiency power conversion across a wide load range is essential in most automotive systems. As an example, you can expect power-conversion efficiency of around 85% for a 5V output over a 10 mA to 1.2A load range. At high currents, the internal switch needs good saturation–typically, 0.2Ω at 1A. To improve light-load efficiency, drive current is smaller or proportional to load current. Also, a bias pin, which the output can power, could supply power for the internal control circuitry, taking advantage of the power-conversion efficiency of a buck converter. The fact that this bias current draws from the output rather than the input decreases the input supply current for the control circuit by the ratio of the output voltage to the input voltage. For example, an output current of 100 μA at 3.3V requires an average input current of only 30 μA at 12V, minimizing the input current the control circuitry requires and increasing light-load efficiency.

Many applications in automotive systems require continuous power even when the car is parked. Examples include remote keyless entry, GPS (global-positioning-system)-location tracking, and alarm systems. A key requirement for these applications is low quiescent current. The device would run in normal continuous-switching mode until the output current drops below about 100 mA. Below this level, the switching regulator must skip pulses to maintain regulation. Between pulses, the regulator can go into a sleep mode in which only a portion of the internal circuitry receives power. At light load currents, a switching regulator needs to automatically switch to a mode in which the quiescent current drops below 100 μA for a 12 to 3.3V converter. The internal reference and power-good circuit remains active in sleep mode to monitor the output voltage. Quiescent current should be less than 1 μA in shutdown.

Ideally, the junction-to-case thermal resistance should be low. If you expose the backside of the device to copper and solder it to the surface of the PCB (printed-circuit board), you can use the PCB to conduct heat away from the device. Four-layer boards with internal power planes that are common today can achieve thermal resistance of nearly 40°C/W. High-ambient-temperature applications with good thermal conduction to a metal housing can achieve thermal-resistance numbers approaching a typical junction-to-case number of 10°C/W, which helps to extend the useful operating-temperature range.

Although switching regulators generate more noise than linear regulators, their efficiency is far better. Noise and EMI levels have proved to be manageable in many sensitive applications as long as the switcher behaves predictably. A switching regulator switching at a constant frequency in normal mode and switching edges that are clean and predictable with no overshoot or high-frequency ringing minimize EMI. A small package and high operating frequency can provide a small, tight layout, minimizing EMI radiation. Furthermore, if you can use the regulator with low ESR (equivalent-series-resistance) ceramic capacitors, you can minimize both input- and output-voltage ripple, which are additional sources of noise in the system.

Author's biography

Tony Armstrong is product-marketing manager for the power-products group at Linear Technology.

Analog Applications Journal

DESIGN BRIEF

Understanding Output Voltage Limitations of DC/DC Buck Converters

By John Tucker
Applications Engineer

Introduction

Product datasheets for DC/DC converters typically show an operating range for input and output voltages. These operating ranges may be broad and in some cases may overlap. It is usually not possible to derive any arbitrary output voltage from the entire range of permissible input voltages. There are several factors that can cause this, including the internal reference voltage, the minimum controllable ON time, and the maximum duty-cycle constraints.

Ideal Buck-Converter Operation

Consider the theoretical, ideal buck converter shown in Figure 1. The buck converter is used to generate a lower output voltage from a higher DC input voltage.

If the losses in the switch and catch diode are ignored, then the duty cycle, or the ratio of ON time to the total period, of the converter can be expressed as

$$D = \frac{V_{OUT}}{V_{IN}}. \quad (1)$$

The duty cycle is determined by the output of the error amplifier and the PWM ramp voltage as shown in Figure 2. The ON time starts on the falling edge of the PWM ramp voltage and stops when the ramp voltage equals the output voltage of the error amplifier. The output of the error amplifier in turn is set so that the feedback portion of the output voltage is equal to the internal reference voltage. This closed-loop feedback system causes the output voltage to regulate at the desired level. If the output of the error amplifier falls below the PWM ramp minimum, then a 0% duty cycle is commanded, the converter will not switch, and the output voltage is 0 V. If the error-amplifier output is above the PWM ramp peak, then the commanded duty cycle is 100% and the output voltage is equal to the input

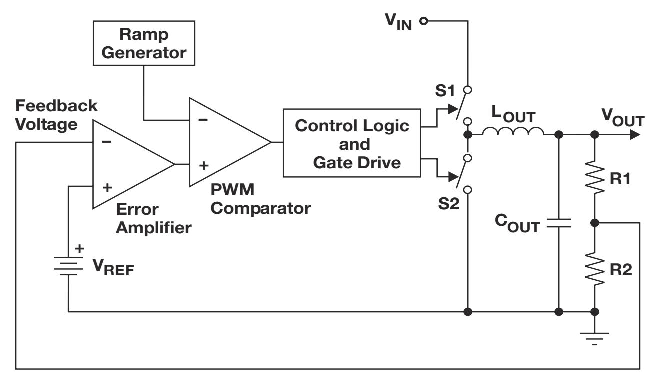

Figure 1. Theoretical, ideal buck converter.

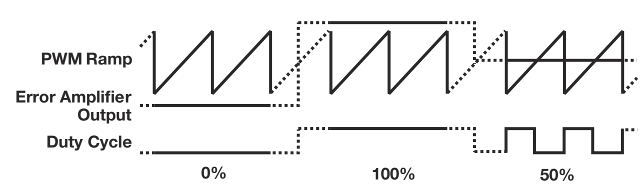

Figure 2. Typical PWM waveforms.

voltage. For error-amplifier outputs between these two extremes, the output voltage will regulate to

$$V_{OUT} = D \times V_{IN}. \tag{2}$$

Practical Limitations

For the ideal buck converter, any output voltage from 0 V to V_{IN} may be obtained. In actual DC/DC converter circuits, there are practical limitations. It has been shown that the output voltage is proportional to the duty cycle and input voltage. Given a particular input voltage, there are limitations that prevent the duty cycle from covering the entire range from 0 to 100%. Most obvious is the internal reference voltage, V_{REF}. Normally, a resistor divider network as shown in Figure 1 is used to feed back a portion of the output voltage to the inverting terminal of the error amplifier. This voltage is compared to V_{REF}; and, during steady-state regulation, the error-amplifier output will not go below the voltage required to maintain the feedback voltage equal to V_{REF}. So the output voltage will be

$$V_{OUT} = V_{REF}\left(\frac{R1}{R2} + 1\right). \tag{3}$$

As R2 approaches infinity, the output voltage goes to V_{REF} so that the output cannot be regulated to below the reference voltage.

There may also be constraints on the minimum controllable ON time. This may be caused by limitations in the gate-drive circuitry or by intentional delays. This minimum controllable ON time puts an additional constraint on the minimum achievable V_{OUT}:

$$V_{OUT(min)} = t_{on(min)} \times V_{IN} \times f_s, \tag{4}$$

where $t_{on(min)}$ is the minimum controllable ON time and f_s is the switching frequency.

The duty cycle may also be constrained at the upper end. In many converters, a dead time is required to charge the high-side switching FET gate-drive circuit. Feedforward circuitry may also cause a flattening of the PWM ramp waveform as the slope of the PWM ramp is increased while the period remains constant. This will limit the maximum output voltage with respect to V_{IN}. Typically, if there is a maximum duty-cycle limit, it will be expressed as a percentage, and the maximum output voltage will be

$$V_{OUT(max)} = V_{IN} \times D_{max}. \tag{5}$$

Effect of Circuit Losses

So far we have assumed that the components in the circuit are ideal and lossless. Of course, this is not the case. There are conduction losses associated with the components that are important in determining the minimum and maximum achievable output voltage. Most important of these are the ON resistance of the high- and low-side switch elements, and the series resistance of the output inductor. Taking these losses into account, we can now express the duty cycle of the converter as

$$D = \frac{V_{OUT} + I_{OUT} \times (r_{DS2} + R_L)}{V_{IN} - I_{OUT} \times (r_{DS1} - r_{DS2})}, \tag{6}$$

where r_{DS1} is the ON resistance of the high-side switch, S1; r_{DS2} is the ON resistance of the low-side switch, S2; and R_L is the output-inductor series resistance. Since the loss terms are added to the numerator and subtracted from the denominator, the duty cycle increases with increasing load current relative to the ideal duty cycle. This has the effect of increasing the available minimum voltage. The worst-case situation for determining the minimum available output voltage occurs when the input voltage is at its maximum specification, the output current is at the minimum load specification, and the switching frequency is at its maximum value. The minimum output voltage is then

$$V_{OUT(min)} = t_{on(min)} \times f_{s(max)} \times [V_{IN(max)} - I_{OUT(min)} \times (r_{DS1} - r_{DS2})] - [I_{OUT(min)} \times (r_{DS2} + R_L)]. \tag{7}$$

In contrast, the loss terms decrease the available maximum voltage, and the worst-case conditions occur at the minimum input voltage and maximum load current. Since the limiting factor, maximum duty cycle, is specified as a percentage, the switching frequency is not relevant. The maximum available output voltage is given by

$$V_{OUT(max)} = D_{max} \times [V_{IN(min)} - I_{OUT(max)} \times (r_{DS1} - r_{DS2})] - [I_{OUT(max)} \times (r_{DS2} + R_L)]. \tag{8}$$

Please see Reference 1 for the complete version of this article, which includes typical application examples with calculated minimum and maximum output voltages.

Conclusion

While the ideal buck converter can theoretically provide any output voltage from V_{IN} down to 0 V, practical limitations do exist. The output voltage cannot go below the internal reference voltage, and internal circuit operation may limit the minimum ON time and maximum duty cycle. Additionally, real-world circuits contain losses. These losses can act to extend the duty cycle at higher load currents and may be an advantage when output-voltage extremes exist.

Reference

1. View the complete article at
http://www-s.ti.com/sc/techlit/slyt293

(continued from pg 58)

There's also opportunity for power savings in the scheme by which the alternator charges the battery itself. If it's a nice day that requires no air conditioning, heating, or lights, the car requires less electrical power and puts a smaller load on the alternator. In most vehicles, however, the alternator provides an output to constantly charge the battery and is sized to provide a maximum load—for example, on a winter night when it's snowing, and the heater and lights are on. A more efficient alternator will vary its speed based on the load.

ELECTRIC CARS AND PHEVs

EVs (electric vehicles) and PHEVs (plug-in hybrid electric vehicles) operating in their battery-only mode require the most power-miserly electronic subsystems (**Reference 2**). General Motors Vice President of Engineering Bob Lutz has talked about the importance of power efficiency in electronic accessories—even the mundane windshield wipers—for the Chevy Volt PHEV because any subsystem that draws on the battery reduces the range of the Volt in its battery-only mode, currently about 40 miles (**Reference 3**).

Tesla Motors is developing a high-end lithium-ion-battery-powered EV with a 240-mile range. As with conventional cars, cabin cooling is the largest accessory load for an EV, and Dan Adams, senior mechanical engineer for systems and integration at Tesla, estimates that it commonly takes about 2 kW of power in an EV. "Cabin heating comes next in power consumption, but for an ICE [internal-combustion-engine]-powered car, waste energy required to cool the engine is enough to heat the cabin and thus is 'free,'" he says. Because the electric power train in an EV is efficient, it takes awhile to heat, and the waste-heat power is much lower than the power available with a gas engine. The 3 kW to conventionally heat a cabin would be a serious drain on the battery's energy. EV manufacturers, such as Tesla, are working on alternative methods for cabin heating, such as relying on seat heaters for localized heat, as well as PTC (positive-temperature-coefficient) heaters for general cabin heating.

Scott Brenneman, release engineer for vehicle electrics at Tesla, comments on how running accessories, such as a heater or a radio, affect the range. "In general, some simple math shows the impact on the range," he says. "In rough terms, a given load would have a quantifiable effect on a 50-kWhr battery pack, assuming you also knew the other loads. Back of the envelope, let's say the range over a given course is 240 miles, driven at an average speed of 30 mph, for a total time of eight hours. I suspect that the effect of most electrical subsystems on range is small except for a few items, such as the HVAC components. For instance, a 1-kW load running half the time would consume 4 kWhr, or 4/50=8% of the range. I think this is an extreme case, since 1 kW of heating or cooling is a lot. Typical 12V loads, such as exterior lights, are less than 0.2 kW in this scenario and thus would reduce range by about 1.5%."

Adams provides some perspective on the quest to eke out relatively small amounts of power efficiency in the ubiquitous automobile. "Cabin comfort [and car transportation in general] requires great quantities of energy compared to the basic scale of human energy needs," he says. "Thus, while a human can ride a bike and transport [himself] using only a fraction of a horsepower, a car driving 20 mph can easily consume 10 kW with another 2.5 kW for HVAC if cooling is on." As a dedicated biker, however, Adams is a bit biased. EDN

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Selecting video op amps

VIDEO AMPLIFIERS HAVE UNIQUE AND DEMANDING SPECIFICATIONS. UNDERSTANDING THEM WILL HELP YOU SELECT AN AMPLIFIER THAT CAN DO THE JOB.

Video op amps have improved significantly since their debut in the early 1990s. The first versions operated from ±15V supplies, featured bandwidths of 50 MHz, and delivered slew rates in the low hundreds of volts per microsecond. Today's fastest amplifiers run on ±5V supplies with bandwidths of 1.4 GHz and slew rates of 6000V/μsec. There are hundreds of versions available, and, to add to the challenge, many applications require the lowest possible supply voltage.

To simplify the design choices, it's important to identify major parameters of interest. Start with the kind of signal the op amp is passing, the available supply voltages, and the power dissipation that an application allows or tolerates. Important intangibles include ease of use and tolerance to board layout. This article covers the signal requirements and then reviews available amplifier topologies. **Table 1** suggests amplifiers for different signals.

VIDEO SIGNALS

The op-amp industry adopted the composite-video format in monochrome form in the early 1940s and the color standard in 1953 (**Figure 1**). White-level, color, and horizontal- and vertical-synchronous signals combine onto one conductor. The synchronous signals originally guided the electron beam's horizontal line-scan in early CRTs. In today's digital televisions they perform memory-mapped data-stream timing.

In US composite video, the synchronous pulses repeat at a 15,734-Hz rate. A flat region that represents a dark display and includes a chroma burst follows each horizontal synchronization. The burst is a number of 3.58-MHz sine waves that serves as a frequency reference for subsequent embedded color information. The composite-video receiver has its own chroma reference oscillator that resynchronizes each burst. The video-line-picture content follows the chroma burst. **Figure 1** shows a sample video content in which a steady color amplitude rides on a white level that increases across the line. Pictures contain fairly unpredictable color and intensity content. The **figure** does not show the vertical-synchronization patterns, which are the same amplitude as the horizontal synchronization but of complex pattern and durations.

The maximum amplitudes of the synchronization feature, the chroma, and the white part of the **figure** are 300, 100, and 707 mV, respectively. These amplitudes make the maximum peak-to-peak standard composite-signal amplitude approximately 1.05V p-p. Not all combinations of chroma and white amplitude exist in the color space of a particular video standard. The amplifier must be biased within its supplies to be able to handle the signal.

One source of video might be a DAC output, such as a cable-tuner box. These sources generally place the bottom of the synchronized signal at ground, with video details going positive. The boxes usually make output data samples at four times the chroma frequency but still have DAC-step artifacts that require filtering before use. Active filters using op amps frequently accomplish this task. Some op amps come with the appropriate filters and buffer the DAC output when you connect them to standard 75Ω video cable. The amplifier typically drives a reverse-termination resistor in series with the cable to absorb any reflections, and this step loses one-half the output amplitude. The amplifier then has a gain of two to recover standard-output amplitude.

It also is important to consider the voltage excursions of the signal with respect to available power supplies. The synchronous amplitude is on ground at the DAC output, and an amplifier has no problem passing this amplitude with a negative-power supply. However, negative supplies are often unavailable. Some amplifiers' inputs can linearly go to ground and have allegedly rail-to-rail outputs, but neither MOS nor bipolar rail-to-rail amplifiers are completely linear closer than about 100 mV from the supply rails. **Figure 2** shows the differential gain measurement of a low-power bipolar op amp running on a single 5V power supply.

Differential gain is a measure of the deviation of ac gain over changing dc operating points. The output gain is stable only above an output dc level of 0.1V. Although the synchronizing level is not critical and may be distorted, forcing an amplifier into output overload incurs a recovery-time penalty when it has to rise back above ground. This recovery time could adversely affect synchronization. In single-supply applications, designers bias the output positive at approximately

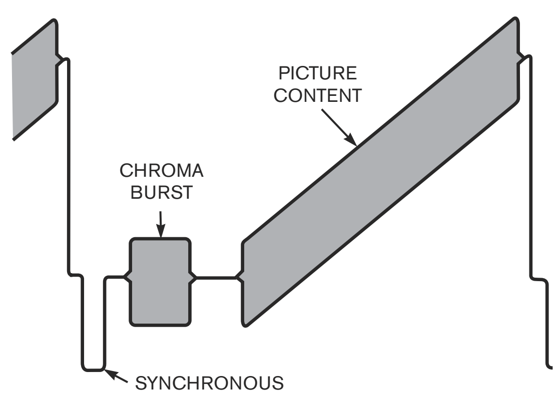

Figure 1 A composite-video waveform combines white-level, color, and horizontal- and vertical-synchronous signals onto one conductor.

200 mV by using offsetting circuitry.

The blue curve in the **figure** has a 150Ω load due to the 75Ω cable and termination in series with 75Ω back-match resistor. It exhibits large differential gain error as the output gets within 0.8V of the supply voltage. This situation occurs at a current of 28 mA, twice that of one standard load and amplitude. The proper way to bias this amplifier would be to offset the input by 100 mV. At a gain of two, this approach produces an output swing of 0.2 to 2.2V. With the positive head room of 0.8V, you establish a minimum supply voltage of 3V.

You use amplifiers to accomplish filtering, clamping, dc restoration, and buffering of the signal. Buffering provides input-termination quality and routes the signal to any manner of nonterminated loads.

Using ac coupling rather than dc restoration or clamping yields a larger peak-to-peak signal to pass. The average level of video signals varies between dark and fully white (**Figure 3**). The average level is the dc bias the amplifier's input pin receives from the input coupling capacitor. The peak negative excursion occurs during a static fully white signal, and the synchronous voltage is the dc bias minus 0.86V. When a long-term, fully dark signal changes to a fully white signal, the first white level is temporarily peaking at dc bias plus 0.64V and slowly sags down to the upper waveform of **Figure 4**. Thus, the amplifier must support a video signal of 1.5V p-p, not 1V p-p, as in the dc-coupled case. This situation can be problematic with low supply voltage.

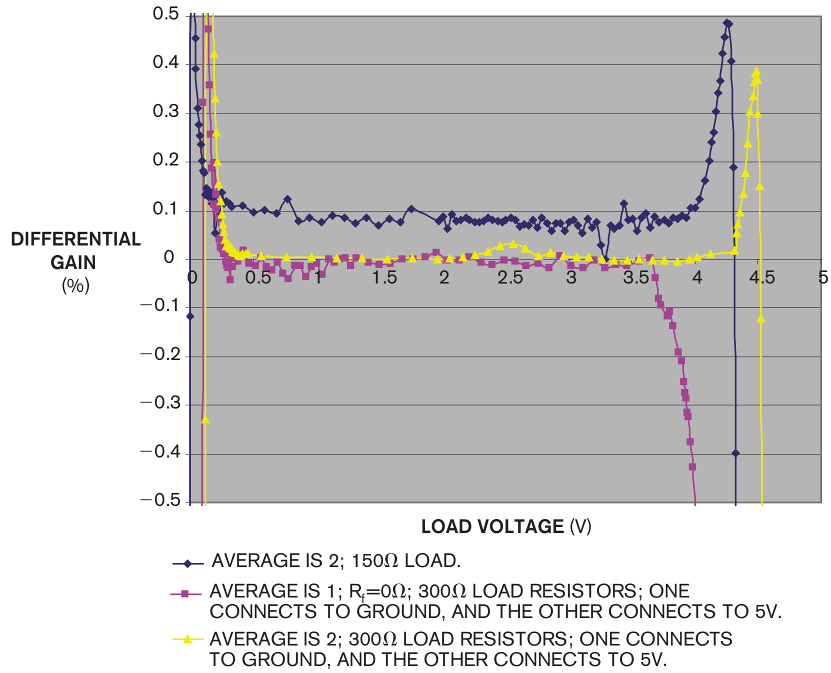

Figure 2 The differential gain measurement of a low-power bipolar op amp running on a single 5V power supply shows that the output gain is stable only above an output dc level of 0.1V.

Generalized methods exist for offsetting or stabilizing dc levels. Circuits that perform dc restoration observe the synchronized signals and use timers to gate the burst-time interval. During this interval, a feedback loop forces the burst's average amplitude to a reference—ground, for example—and the offset correction is in a sample-and-hold activity throughout the rest of the time. Circuits that clamp the synchronous signal's negative-going extreme when you apply it through a capacitor also commonly establish offset.

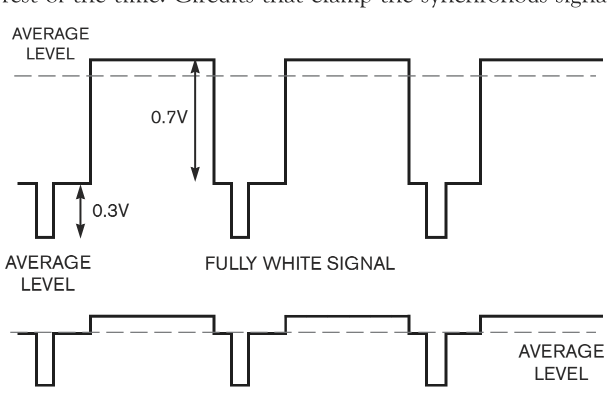

Figure 3 The average level of video signals varies between dark and fully white.

The performance of composite-signal amplifiers has several metrics. The first is differential gain, the measure of stability of ac gain at 3.58 MHz over the video range of dc levels. The required performance is 0.05 to 1% stability, depending on quality level. The differential phase, the variation of phase lag through the amplifier at 3.58 MHz with dc variations through the video region, is similar to differential gain. An excessive deviation of phase manifests itself as color errors on the screen. The range of required performance is 0.05 to 1°. You can think of phase variation with dc level as the frequency response itself varying with output current and voltage. It is worst in low-quiescent-current amplifiers.

Another figure of merit in composite-video-reproduction quality is group delay, the change of delay of signal components at one frequency relative to another frequency within the signal spectrum. Although delay is harmless, variations of delay cause visual edges to smear as different spectral components arrive at different times. Within the moderate spectral content of 4.5 MHz, a group delay constancy of approximately 30 nsec is necessary. This delay is easy for most amplifiers that have at least 50-MHz bandwidth to achieve.

The S video standard places the luminance and synchronous parts of the composite signal onto a Y channel and the color and chroma parts onto a C channel. The C channel has no dc variation, and differential-phase performance is unnecessary. The Y channel has a slightly reduced 1V-p-p swing, and the C channel has a 286-mV-p-p swing. Dual combined DAC filters/amplifiers and DAC filters and combining amplifiers that merge the Y and C channels into a composite output are available.

You can capacitor couple the output to save power. Because no dc current goes through the capacitor, the offset current is zero, and the video content is both sourcing (drawing supply current) and sinking (drawing no supply current). This approach uses three times less supply current than dc coupling. One drawback is that the average video content causes a slow baseline wandering at the load. This wandering decalibrates the video level. To combat the problem, almost all video destinations have dc-restore circuitry that recalibrates baselines at synchronous or burst events.

The other drawback of capacitor coupling is that the capacitor must pass a lot of low-frequency content because the video picture repeats 30 times per second. With an effective 150Ω load and approximately 5-Hz low-frequency cutoffs, you need a 200-μF coupling capacitor, a large and somewhat expensive component.

TABLE 1 VIDEO SIGNALS' PERFORMANCE REQUIREMENTS

Signal type	Constraints	Performance	Amplifier type
Coaxial composite video	Portable: V_S=3V, cost, power	Differential gain: approximately 1%, differential phase: 1°	Single-supply, rail-to-rail output
	Nonportable: V_S=5V, cost, power	Differential gain: approximately 0.05%, differential phase: 0.05°	Single-supply, rail-to-rail output
	Nonportable: V_S=5V, high performance	Differential gain: approximately 0.01%, differential phase: 0.02°	Single-supply, rail-to-rail output
	Nonportable: V_S=±5V, power	Differential gain: approximately 0.1%, differential phase: 0.1°	Dual-supply, current-feedback amplifier
	Nonportable: V_S=±5V, high performance	Differential gain: approximately 0.01%, differential phase: 0.01°	Dual-supply, current-feedback amplifier
Coaxial component video	Consumer: cost, positive power supply only	−3-dB bandwidth of 200 MHz	Single-supply, rail-to-rail output
	Computer RGB, ±5V	−3-dB bandwidth of 600 to 1400 MHz, fast slew	Dual-supply, current-feedback amplifier
	Computer RGB, ±5V	−3-dB bandwidth of 350 to 700 MHz, fast slew	Dual-supply, slew enhanced
	Computer RGB, 5V	−3-dB bandwidth of 400 MHz, fast slew	Single-supply, slew enhanced, rail-to-rail output
Twisted-pair composite video	Differential driver	−3-dB bandwidth of 100 MHz, 1100V/μsec	Single-ended input/differential output
	Differential receiver	−3-dB bandwidth of 250 MHz, 800V/μsec	Differential input/single-ended output
Twisted-pair component video	Differential driver	−3-dB bandwidth of 450 MHz, 900V/μsec	Single-ended input/differential output
	Differential receiver	−3-dB bandwidth of 550 MHz, 900V/μsec	Differential input/single-ended output

Some video amplifiers incorporate so-called sag feedback paths that allow the use of substantially reduced coupling capacitors. They work by feeding back signal from the load side of the coupling capacitor. Feedback induces the amplifier output to rise for low frequencies. Although the coupling capacitor loses low-frequency signals, the amplifier boosts them, and the final output maintains low-frequency gain.

In many designs, you must offset the region around the chroma burst so that it is at ground, and the synchronous signal goes 300 mV below ground. This approach is practical with a negative supply and a dc-restoration or clamp circuit. Fortunately, some amplifiers come with charge-pump switching supplies that create a negative supply and dc-restore circuits that poise the burst interval at ground. Dual and quad devices are also available; they place the burst area of the Y channel of S video at ground and the C midvoltage at ground. These devices also have the appropriate DAC filters. Output-charge-pump noise of representative parts is only 0.3 IRE (Institute of Radio Engineers) p-p. An IRE unit is 1% of the peak video range, or 7 mV.

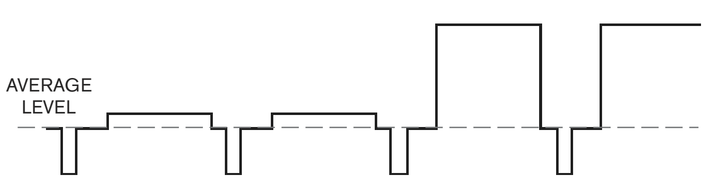

Figure 4 The peak negative excursion occurs during a static fully white signal.

The other kind of analog-video transmission is component and has three color components. RGB (red/green/blue) is the common computer-monitor standard and offers the highest quality of component video. RGB achieves a fully white-to-fully dark transition on adjacent pixels to optimize font appearance. For a common 1280×1024-pixel display with a 60-Hz scan-refresh rate, the pixel rate is nearly 100M pixels/sec. RGB components generally do not use DAC-reconstruction filters, instead transmitting the raw DAC output or a buffered version of it. Amplifier requirements are for a −3-dB bandwidth of 300 MHz, a slew rate of 1500V/μsec, and a settling time of 7 nsec to 1%.

The typical RGB amplifier is a triple with an internally set gain of two. Back-matching resistors are external because IC processes do not give accurate resistor values. Single-supply amplifiers typically have a slew rate of only approximately 500V/μsec and barely settle within a clock time. At the highest pixel counts, the amplifiers typically run on positive and negative supplies; are current-feedback or slew-enhanced, voltage-feedback designs; and have more than enough

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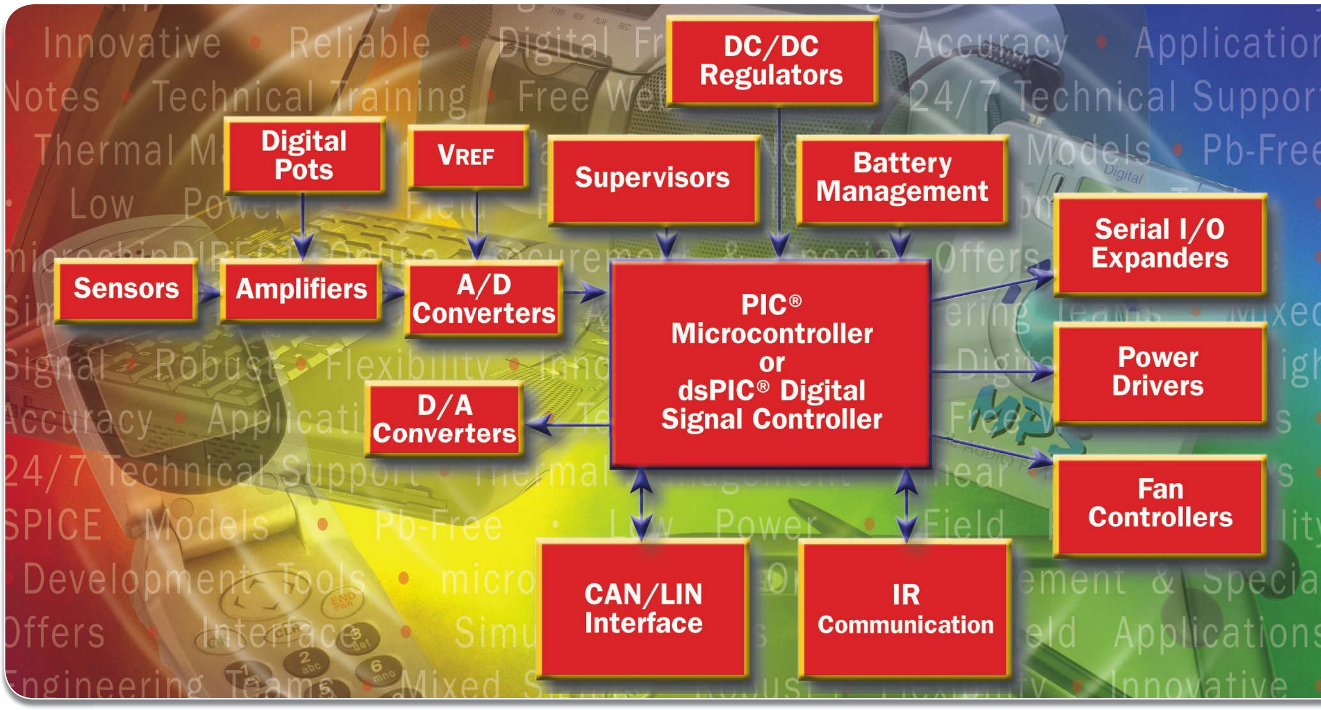

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slew rate and bandwidth. Linearity for these devices should be 1% or better, and dc offsets are not generally important because almost all monitors have a dc-restoration feature for their inputs.

The other common component video is for HDTV (high-definition television), which uses the YPrPb standard. It has an overall luminance channel, Y; Pr, which contains red content minus Y; and Pb, which contains blue minus Y. You derive green from the weighted differences of them all. In 1080i television format, the video has a spectral content of 30 MHz, which a DAC typically generates when running at 135M or 270M samples/sec. An analog filter bandlimits and buffers the output-transmission line. Amplifiers should have better than 0.5-dB flatness at 30 MHz; greater-than-200-MHz, −3-dB bandwidth; a 200V/μsec minimum slew rate; and 0.3% linearity. Complete integrated filters and amplifiers have recently become available, but many designs still use discrete amplifiers as active filters or passive LC (inductance/capacitance) filters with supporting amplifiers.

Another variety of analog video is video over twisted-pair cable. Each component of this video is differential and transmits over Category 5 cable, which normally finds use in digital-network communications. Category 5 cable is less expensive and bulky than standard RGB coaxial cables. Category 5 cable is especially useful when video is concentrated, for instance, when users must access many computers in server clusters from a central control monitor and keyboard. Category 5 cable has four twisted pairs, three of which are for video; the remaining one is for keyboard or mouse signals in the KVM (keyboard/video/mouse) function. Various twisted-pair lines can be single-ended synchronous and computer-control signals. The single-ended, bandlimited signals prevent radio emission, but the twisted-pair, self-shielded, differential signals can operate at full pixel speeds.

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Single-supply, triple-Category 5-cable drivers are available that include common-mode synchronous encoding. Currently, all the differential receivers are ±5V designs, but they effectively reject common-mode interference over wide frequency ranges. Integrated receivers with equalizers can undo the high-frequency losses the cables cause. Time equalizers are also available. Category 5 cable has twisted pairs with different winding pitches, and each pair is a slightly different length. The time equalizers can delay the signals coming in from the shorter lines to catch up with the delayed signals traversing the longer lines.

AMPLIFIER TOPOLOGIES

VFAs (voltage-feedback amplifiers) have noise-versus-slew-rate trade-offs. NTSC (National Television System Committee) video is forgiving of noise, having only approximately 5 MHz of signal bandwidth, and can tolerate a total noise of 50 $nV/\sqrt{Hz}$ p-p in the signal chain for one IRE. The slew-rate requirement is only 22V/μsec. Supply current need not be more than 2 mA for line drivers with filters. Thus, VFAs, including CMOS devices, are good candidates for many applications.

Component video has higher performance requirements, and you can use only the fastest VFAs in this application. These amplifiers require a bandwidth of 200 MHz or more, a slew rate of at least 200V/μsec, and noise in the chain to 20 $nV/\sqrt{Hz}$. CFAs (current-feedback amplifiers) and older slew-enhanced VFAs perform the best but need dual supplies because they require input and output head room. A new amplifier topology, a low-voltage, slew-enhanced VFA, is also now available. These devices can operate on a single supply as low as 3V, their input ranges from ground to the supply minus 1V, and they have rail-to-rail output. The output slew rate, however, is greater than 2000V/μsec, meaning that video waveforms cannot cause slew distortion in these amplifiers. **Table 1** summarizes various signal tasks and recommends some part specifications. **EDN**

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Bluetooth: sufficient fidelity even for average listeners?

APPLICATIONS REQUIRE VIDEO SUPPORT AND ADDITIONAL AUDIO CHANNELS TO COPE WITH STEREO, DRIVING THE NEED FOR LOW-LATENCY CODECS. USING A BLUETOOTH CHIP SET SIMPLIFIES DEVELOPMENT AND ENABLES THE MANUFACTURER TO LEVERAGE THE BRAND RECOGNITION THAT BLUETOOTH NOW ENJOYS AMONG CONSUMERS.

Delivering seamless-quality audio in real time using wireless technology is one of the great challenges facing audio engineers. Bandwidth constraints, coding delays, and the introduction of bit errors can all hamper wireless-audio transfers, thereby causing significant audio-quality degradation.

The mobile-audio-device market has grown rapidly over recent years, producing consumers well-used to scrutinizing audio and less willing to compromise on quality. "Average Joe has grown a set of golden ears," you might say. Reinforcing this claim, in April 2007, Apple announced that, through the iTunes Store, it would be offering tracks at higher-quality, 256-kbps AAC (advanced audio coding), a move signifying the mass market's increasing appreciation of quality audio.

Along with this market trend, real-time wireless audio is experiencing escalating demand from emerging consumer markets, a demand that manufacturers have so far struggled to satisfy. And the convergence of audio with video across the spectrum of consumer devices means that wireless audio has an additional issue to overcome. Any delay on delivery results in lip-synch issues and an unsatisfactory user experience. Wireless headsets for mobile TV, video playback, and gaming, along with wireless speakers for stereo and 5.1-channel surround connected to a video source, require real-time-audio delivery.

Uncompressed CD-quality stereo audio uses a 1.411-Mbps bandwidth. For most wireless applications, this full bandwidth is impractical. Issues of design, efficiency, power optimization, and error resilience put pressure on available data rates. Also, in many standards and protocols, such bandwidth is simply not available. Bluetooth, for example, stipulates a maximum available bandwidth for A2DP (advanced audio-distribution profile) of 768 kbps. So, for high-quality stereo audio, it is necessary to use some form of audio coding to reduce the required data rate.

WIRELESS AUDIO TODAY

The proliferation of wireless technologies, such as Bluetooth and Wi-Fi, has given the consumer the ability to wirelessly receive digital audio wherever he may be and however desired—in the home or on the move, by streaming audio over Wi-Fi from a Mac or PC, or by connecting a transmitter dongle to a mobile-audio device and listening with wireless headphones. However, with every technical advance, there is often a bottleneck in which one aspect of the technology advances beyond the capabilities of another.

Personal wireless audio has experienced such an issue. Bandwidth limitations are an obvious problem for wireless-system applications as manufacturers strive for ultralow-power consumption in mobile devices. For live streaming, audio-coding delays are again prohibitive constraints. Such delays have implications for video applications requiring lip-synching—for example, when using a wireless-stereo headset with a video-playback-supported iPod or a mobile-TV receiver.

In bidding to be free of the wire, designers can take many approaches to handling wireless-stereo audio. For personal audio streaming, the predominant radio frequency is the license-free, 2.4-GHz spectrum because it can provide sufficient bandwidth, range, and power consumption. Bluetooth and other proprietary RF technologies operate in this frequency.

The Bluetooth SIG (Special Interest Group) ratified the A2DP to manage the transfer of stereo audio, and the consumer market has subsequently experienced the arrival of A2DP-enabled products on both the audio-source and the headset sides. Motorola, for example, has come to market with products such

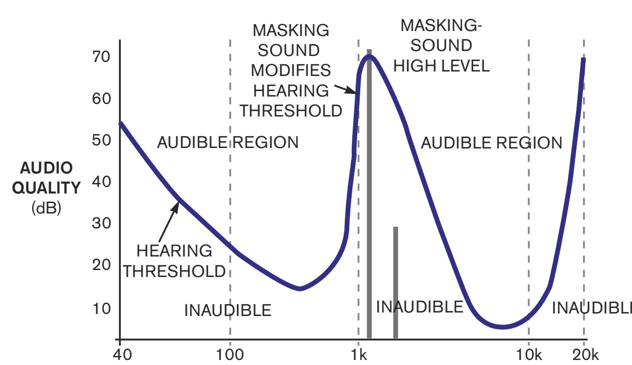

Figure 1 Psychoacoustic techniques enable discarding of substantial portions of the audio information without adversely affecting quality.

as the S9 Bluetooth stereo-active headphones. However, an A2DP-supportive transmitter dongle will be necessary to ensure connectivity to most audio players because audio sources do not yet widely use A2DP. The reluctance of consumer-audio companies to integrate the A2DP profile has predominantly been due to issues of audio quality and coding delay.

The industry regards 16-bit audio as the entry-level quality requirement for audio systems now on the market, along with a minimum sample rate of 44.1 kHz to match that of the venerable audio CD. Consider the dynamic-range capabilities of various sample sizes: 96.32, 120.4, and 144.5 dB for 16-, 20-, and 24-bit digital audio, respectively. To achieve CD-quality dynamic range in bandwidth-limited applications, such as Bluetooth-stereo headsets, necessitates the use of at least 16-bit audio as the raw input; a compression technology that can reproduce virtually all of the original dynamic range subsequently transforms this audio (**Table 1**). The challenge is to find an algorithm that can deliver this quality level with low corresponding latency and maintain efficient processing power to prevent excessive battery drain.

The main difficulty for live audio is the coding-plus-decoding delay of compression technology. Although, in most wired systems, the lengthy video-decoding delay masks the audio-coding delay, wireless-system applications have no such luxury. Developing the ability to lip-synch audio to decoded video after audio encoding, packetization, passage over a wireless link, and decoding is indeed a significant challenge.

When dealing with wireless speakers for high-definition home theater, a delay greater than 10 msec can negatively impact the desirable seamless, full-surround-sound experience for discerning viewers. For gaming applications, 10 msec would again be the target because gamers' reaction times allow no room for delay. It is one thing to hear audio while viewing video, but it is another thing to expect to hear audio and instantly react to it.

Wireless-stereo headsets interacting only with audio sources can accept delays because audio-only applications have no need for lip-synch. However, when using a wireless headset with a video source, the difference is clear. Depending on screen size and distance from the device, the delay target for the industry is currently 40 msec or less. In most applications, the radio has its own inherent delay characteristics and complies with a standard. If you assume that radio delays and the packing and unpacking delays associated with the RF protocol are fixed, you have only the audio-compression delays to work with.

Bluetooth is robust and ensures accurate signal delivery, but this focus on resilience results in fundamental delay issues. Bluetooth uses a series of fixed-size transmission and reception slots, which therefore have response-time limitations. The Bluetooth protocol can retransmit packets to correct errors in the transmitted stream. If you could minimize the retransmissions by using a more robust algorithm, you could improve the system response. In addition, avoiding frame-based algorithms, which require filling an entire frame of audio samples before decoding, further minimizes delay.

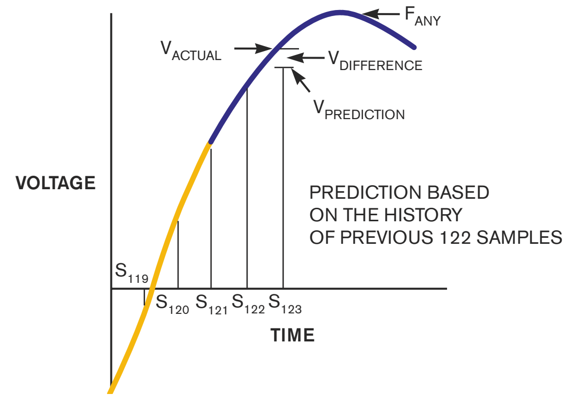

Figure 2 Variable-step-size quantization and differential coding are at the core of the ADPCM compression approach.

THE NEED FOR COMPRESSION

Bluetooth A2DP has a maximum available bandwidth of 768 kbps. So, audio compression is necessary to deliver two-channel digital-stereo sound. Myriad compression technologies are currently available, each targeting and offering benefits in specific applications. However, most of them derive from two fundamental audio-compression processes: perceptual techniques based on psychoacoustic models of hearing (**Figure 1**) and predictive techniques, which as their name implies, employ a system of predictive coding. They are therefore known as ADPCM (adaptive-differential-pulse-code-modulation) codecs (**Figure 2**).

Generally, the higher the compression ratio, the more audio content you lose. With perceptual codecs, such as MP3, AAC, and their derivatives, analysis of the frequency spectrum results in the removal of any content the technology deems imperceptible to the human ear. This technique requires buffering of an audio sample of approximately 512 bytes to perform the analysis. Buffering is often the fundamental source of coding delay. The complexity of the audio can also affect the delay of the encoding process. The psychoacoustic procedure, with its ability to produce high compression ratios and retain reasonably high audio quality, is processor-intensive and therefore not a good approach for power-efficient, battery-powered devices.

ADPCM codecs operate in a different manner, due to their unique characteristics. PCM is the digital representation of an analog signal, wherein regular sampling of the signal magnitude at uniform levels results in quantization to a series of symbols in a digital code. CDs are examples of the implementation of PCM audio. ADPCM involves audio-value encoding as the difference between the current and the previous val-

TABLE 1 KEY AUDIO METRICS

Sampling frequency (kHz)	Resolution (bits)	Per-channel bit rate	4-to-1 compression ratio (bits/sec)
44.1	16	705,600	176,400
44.1	20	882,000	220,500
44.1	24	1,058,400	264,600

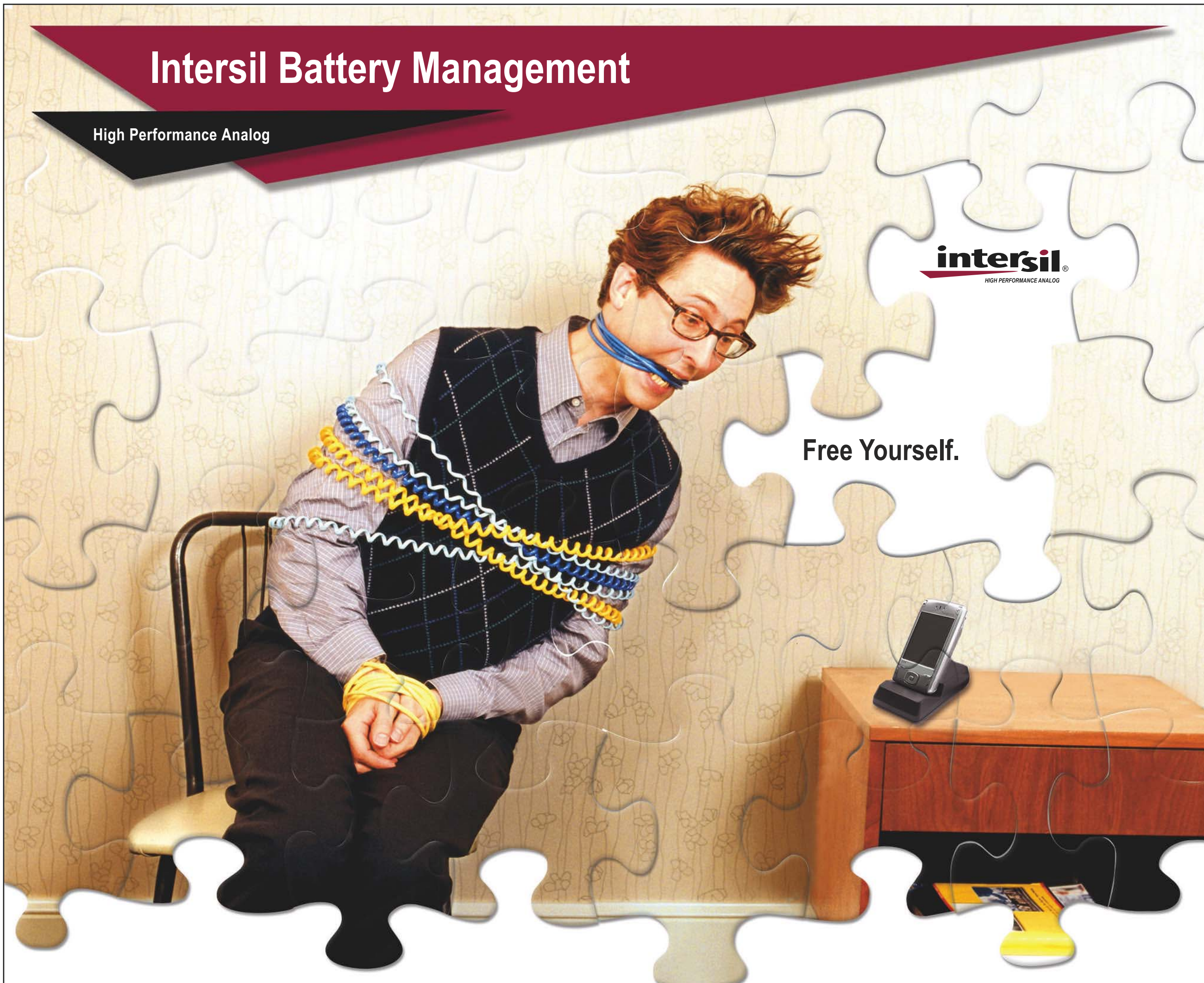

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TABLE 2 AUDIO-COMPRESSION OPTIONS

Algorithm	Compression ratio	Bit rate (kbps)	Encode-to-decode delay (msec)
MP3	12-to-1	128	326 at 128 kbps
AAC	Variable	128 or 256	172
AAC low density	Variable	128	60
SBC	Variable	366 (bit pool: 55)	2.6
apt-X	4-to-1	384	1.87

ues, and the quantization step size varies to allow a bandwidth reduction for a given SNR (signal-to-noise ratio).

The quantization process is by nature lossy, and, depending on the accuracy of the linear predictor and inverse quantization you use, it can produce small errors in the reproduced audio. However, removal of audio content does not occur, and PCM is therefore a popular technique in applications in which issues with tandem coding or transcoding would otherwise exist. ADPCM-based algorithms range from International G.711, G.722, and G.726 codecs for low-bit-rate voice to professional broadcast standards, such as apt-X, for high-quality, multichannel audio (**Table 2**). Their shared feature is their low delay, which enables real-time two-way communication. As the ADPCM technique does not buffer a frame of audio and analyze the full-audio spectrum with each encoding step, the processing delay is also a fraction of that you find in the alternative perceptual-coding approach.

AUDIO-CODING OPTIONS

Some years ago, the Bluetooth SIG selected the SBC (smart-bit-rate-control) compression algorithm, which Philips developed, as a mandatory codec to ensure interoperability for Bluetooth products. The SIG chose this codec for a number of reasons. It was freely available to the Bluetooth SIG, it has low complexity in processing overhead, and it has better encoding-and-decoding latency than alternative compression algorithms, such as MP3 and AAC. With the arrival of Bluetooth-stereo headsets, however, widespread concerns arose regarding SBC's ability to deliver full-bandwidth, high-quality audio. Additionally, providers of Bluetooth A2DP devices claim that, using SBC, their devices could only occasionally achieve the industry target of 40-msec delay for lip-synching.

The wireless link is typically not robust enough to achieve low latency, and high processing and power consumption also do not make SBC viable in certain situations. For these reasons and because of substantial A2DP demand, several fabless-semiconductor companies have brought to market proprietary technologies that offer full-bandwidth uncompressed audio operating over a 2.4-GHz RF spectrum. These approaches aim to match CD-audio-quality requirements and have real-time-transfer ability, but they have drawbacks in power con-

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LTC®3544	300mA + 200mA + 200mA + 100mA				3 x 3 QFN-16
LTC3562	600mA + 600mA + 400mA + 400mA				3 x 3 QFN-20
LTC3445	600mA			50mA + 50mA	4 x 4 QFN-24
LTC3670/72	400mA			150mA + 150mA	2 x 3 DFN-12 / 2 x 2 DFN-8
LTC3100	250mA	800mA		100mA	3 x 3 QFN-16
LTC3446	1A			300mA + 300mA	3 x 4 DFN-14
LTC3541	500mA			300mA	3 x 3 DFN-10
LTC3545	800mA + 800mA + 800mA				3 x 3 QFN-16
LTC3522	200mA		400mA		3 x 3 QFN-10
LTC3520	600mA		1A	LDO Controller	4 x 4 QFN-24
LTC3537		600mA		100mA	3 x 3 QFN-16
LTC3523	400mA	600mA			3 x 3 QFN-16
LTC3527		600mA + 400mA			3 x 3 QFN-16
LTC3547	300mA + 300mA				2 x 3 DFN-8
LTC3419	600mA + 600mA				3 x 3 DFN-10, MS10
LTC3548	800mA + 400mA				3 x 3 DFN-10, MS10E
LTC3407A-2	800mA + 800mA				3 x 3 DFN-10, MS10E
LTC3417A-2	1.5A + 1A				3 x 5 DFN-16, TSSOP-20E

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sumption—because the radio must transmit full uncompressed audio—and Bluetooth-standard compatibility.

Many mobile devices integrate Bluetooth chips, offering monophonic-headset interaction for voice, and several handsets offer the A2DP for stereo streaming. An additional proprietary approach not only requires an additional chip, but also introduces compatibility issues due to the fact that there is no agreed-upon compliance standard for audio transfer between consumer devices.

The ideal scenario for many consumer-electronic and mobile-device companies would be to use Bluetooth and provide full-bandwidth stereo-audio-quality streaming in real time. Only a few companies currently provide products to fulfill this need. Given the issues regarding using psychoacoustic algorithms, you should discount MP3 as a viable technology for wireless transfers. Therefore, you must look at ADPCM-based alternatives. US-based Open Interface North America, for example, in 2003 launched Soundabout eSBC (Enhanced SBC). Based on the same principles as SBC, eSBC allows a 510-kbps data rate and, hence, some quality benefit. However, this higher data rate comes at the expense of power consumption, which can have a significant impact on battery life, and the algorithm offers no latency improvement.

Last year, UK-based Audio Processing Technology partnered with a leading Bluetooth-chip provider to provide an SBC alternative. The company's apt-X audio algorithm also uses ADPCM principles but incorporates additional techniques for accurate linear prediction and inverse quantization to retain optimal audio quality. Matching uncompressed CD quality, apt-X offers a dynamic range greater than 92 dB and runs at 384 kbps. The overall framework of apt-X ensures a robust connection, which enables optimization of the overall Bluetooth system latency. The technology can also synchronize within 3 msec on start-up or in response to a dropout, and the algorithmic coding delay is less than 2 msec to ensure real-time connections. With such offerings now available, it is likely that Bluetooth-stereo headsets will mature in performance and quality throughout 2008 and that the market for these devices will experience strong growth. EDN

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AUTHOR'S BIOGRAPHY

Stephen Wray joined Audio Processing Technology as licensing-business manager in 2005. Responsible for the implementation and execution of licensing-business strategies, he cultivates liaisons with all major licensees, attends trade shows and industry symposiums, and represents APT licensing at industry-networking events. He is a graduate of the University of Edinburgh with an honors degree in electrical and electronic engineering. Wray is a member of the IET (Institute of Engineering and Technology), the AES (Audio Engineering Society), and the CIM (Chartered Institute of Marketing).

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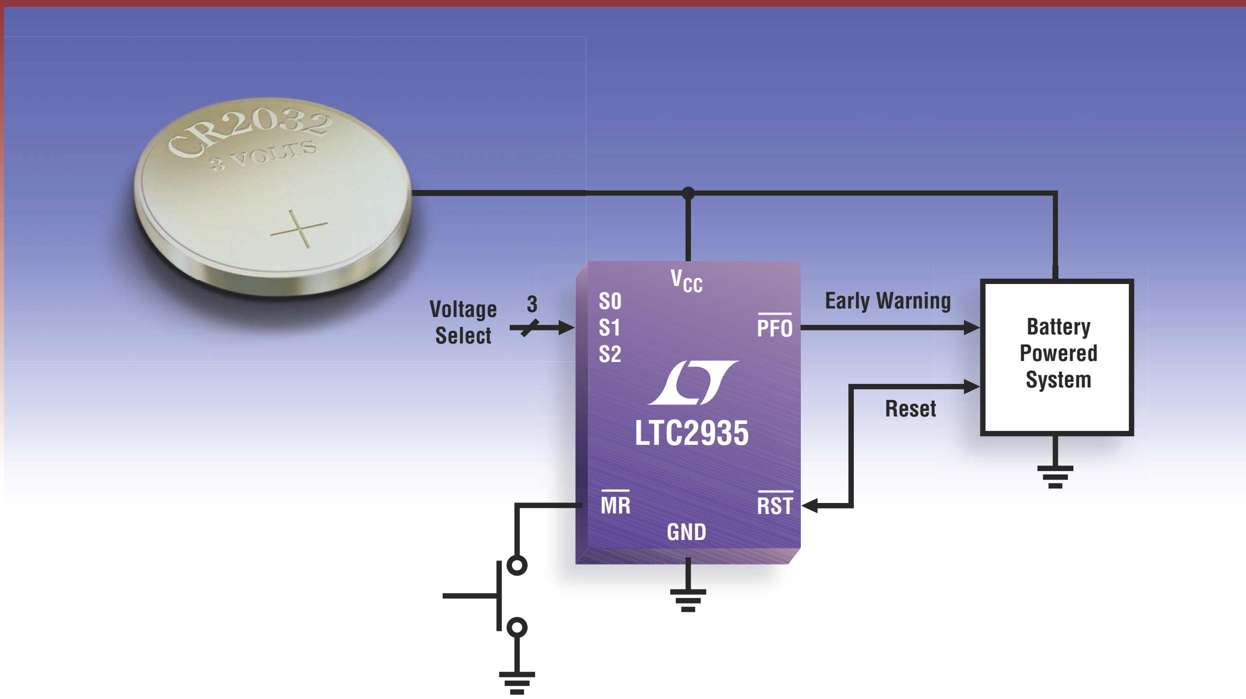

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LTC2453	Analog-to-Digital Converter	I_{SHDN} = 0.5µA	16-bit Delta Sigma ADC, ±V_{CC} Differential Input Range, I²C-Compatible I/O	TSOT23-8, DFN-8 (3x2)
LTC1540	Comparator + Reference	I_Q = 1.5µA	Wide Supply Range: 2V to 11V, 1.2V Reference, Adjustable Hysteresis	MSOP-8, DFN-8 (3x3), SO-8
LT®3009	Linear Regulator	I_Q = 3µA	20mA Low Dropout Regulator, No-Load: I_Q = 3µA; 20mA Load, I_Q = 450µA	SC70-8, DFN-6 (2x2)
LT3481	Step-Down Switching Regulator	I_Q = 50µA	36V, 2A, 2.8MHz Switching Regulator, 50µA I_Q at $12V_{IN}$ to $3.3V_{OUT}$	MSOP-10, DFN-10 (3x3)
LTC3834	Synchronous Step-Down Controller	I_Q = 30µA	Wide 0.8V to 10V, 20A Output Range, ±1% Output Voltage Accuracy, Phase-Lockable Fixed Frequency: 140kHz to 650kHz	TSSOP-20, QFN-20 (4x5)
LT6003	Amplifier	I_Q = 1µA	Single/Dual/Quad Family, 1µA (Max.) per Amplifier, 1.6V to 16V Supply Range, -40°C to +125°C	TSOT23-5, DFN-4 (2x2)

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- Shock Sensor Amplifier (Accelerometer)

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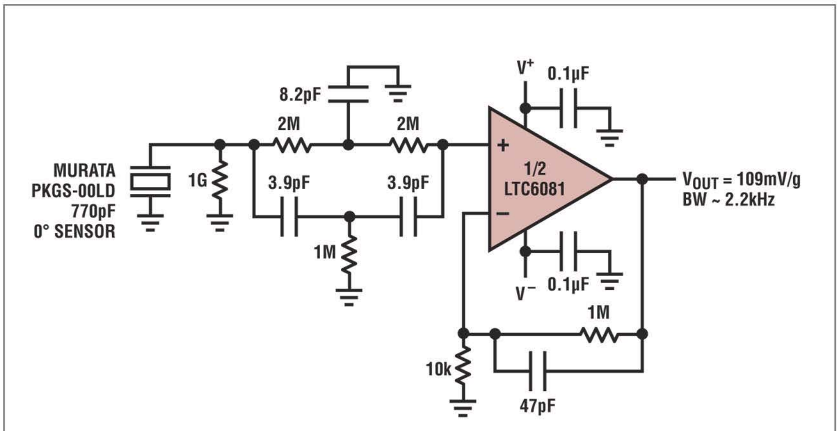
Shock Sensor Amplifier (Accelerometer)



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LTC6082	0.2	70	3.6	0.4	4	TCV_{OS} = 0.8µV/°C Max.	DFN-16, SSOP-16
LTC6087	1	750	14	1.2	2	General Purpose	MS-8, DFN-10
LTC6088	1	750	14	1.2	4	General Purpose	DFN-16, SSOP-16
LTC6078	0.2	25	0.75	0.072	2	TCV_{OS} = 0.7µV/°C Max.	MS-8, DFN-10
LTC6079	0.2	25	0.75	0.072	4	TCV_{OS} = 1.4µV/°C Max.	DFN-16, SSOP-16
LTC6240	0.2	175	18	2.4	1	Low Frequency Noise = 550nV_{P-P}	SOT-23-5, SO-8
LTC6241	0.2	125	18	2.2	2	Low Frequency Noise = 550nV_{P-P}	DFN-8, SO-8
LTC6242	0.2	150	18	2.2	4	Low Frequency Noise = 550nV_{P-P}	DFN-16, SSOP-16
LTC6244	1	100	50	5.8	2	Low Frequency Noise = 1.5µV_{P-P}	DFN-8, MS-8

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Simple fixture statically tests programmable-gain amplifiers

Marián Štofka, Slovak University of Technology, Bratislava, Slovakia

The advent of instrumentation amplifiers with digital gain switching offers obvious advantages, such as board-space saving, higher reliability because of fewer solder joints, and lower total cost. These valuable features stem from the fact that the gain-setting networks are integral parts of the monolithic ICs. This feature makes these IC amplifiers much less sensitive to stray electromagnetic fields because the area of internal resistors is a negligible fraction of the previously used discrete gain-setting resistors. Moreover, the value of the relative permittivity of the plastic package and that of the silicon chip are higher than that of the air. As a consequence, the field strength of the electrical component of any stray field penetrating into the chip is lower than that in the surroundings.

Because the gain-setting circuitry is inaccessible directly, a digitally gain-programmable amplifier is a black box. However, the simple fixture in **Figure 1** can help to evaluate some of the static characteristics of these ICs. The fixture comprises Analog Devices' (www.analog.com) 10V REF01 voltage-reference cell, IC_1, the elderly but still excellent industry standard, and a high-precision fixed resistive divider. These components provide a millivolt-range output voltage.

Multiplying the ratio of the resistive divider by the maximum voltage gain of the tested programmable-gain amplifier should give a value of one. The circuit uses tablet-type film resistors having tolerances of 0.1% maximum, yielding a voltage of 10.02 mV at the output of the divider. The two gain-setting logic inputs of the DUT (device under test), an Analog Devices AD8253, connect to short-stranded conductors, which gold-plated pins terminate. Resistors R_{F1} and R_{F2} force the logic level at gain-programming inputs A_0 and A_1 to be low when you disconnect these pins. To set a high level on either or both pins, insert them into the gold-plated counterparts. Two such counterparts interconnect mechanically and elec-

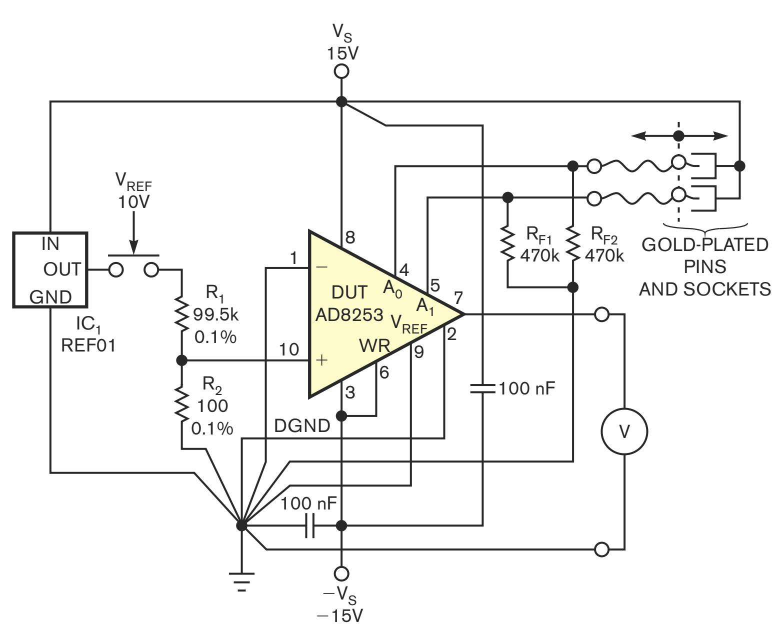

Figure 1 Comprising a handful of components, this circuit allows you to perform your own, independent testing of basic static properties of digitally gain-programmable amplifiers.

trically and remain at the V_S potential. The DUT uses all permutations of the binary values at A_0 and A_1 logic (**Reference 1**). The corresponding voltage gains are one, 10, 100, and 1000.

The evaluation procedure involves measuring the output voltage of the DUT with resistor R_1 both connecting to and disconnecting from the output of IC_1. Thus, you obtain an output voltage of the gain times 10.02 mV and 0V for all voltage gains. The 0V output voltage has a nonzero value because of the input-voltage offset; this voltage might seem high at first glance. However, any fraction of a millivolt of the input-voltage offset times a gain of 1000 yields a fraction of a volt at the output.

When you calculate the differences of the 10.02-mV and 0V output voltages for the respective values of gain, you get a pleasant surprise: These values differ from the ideal values of 10.02 mV times the gain by less than 0.05%. Using this test, you can confirm the precision of the laser-trimmed gain settings. The relatively low value of R_2 ensures that the additional input-offset error arising from input bias current of the DUT has a value of less than 3 μV, whereas the typical value is 0.5 μV. Because proper grounding is an absolute necessity when dealing with tens-of-millivolts scale and high-voltage gains, you must connect supply grounds, digital ground, and other rough grounds with the fine signal grounds in one common junction. **Figure 1** illustrates this approach by using unusual slanted lines for grounding leads. EDN

REFERENCE

1 "AD8253 10 MHz, 20V/μs, G=1, 10, 100, 1000 iCMOS Programmable Gain Instrumentation Amplifier," Analog Devices, www.analog.com/pr/AD8253.

Control system uses LabView and a PC's parallel port

Carlos Alberto Aguilar Sández, Centro de Estudios Superiores del Estado de Sonora, Unidad sede San Luis Rio Colorado, Sonora, Mexico

The circuit in this Design Idea controls the inbound and outbound traffic of cars in a parking lot. This project uses National Instruments (www.ni.com) LabView as the main programming tool and a PC's parallel port for I/O. Basically, the circuit uses the PC's status port, 379h, as an input for sensors, which a relay isolates to prevent damage on the PC (**Figure 1**). At the data port, 378h, the D0 bit controls a door, D1 is a stop signal, D2 is the go signal, and D3 is an indicator of when the parking lot reaches its limit. All the signals drive PN2222A transistors having an external power supply—in this case, the PC's power supply. In this way, you can use relays as loads and control ac voltage for the traffic lights and door motor. The transistor, which D0 drives, controls a DPDT (double-pole/double-throw) relay to invert the motor's polarity.

Figure 2 shows the LabView diagrammatic program for controlling the parking lot. The VI (virtual instrument) in **Figure 3a** changes the inputs to a low state because all inputs are high by default inside the status register. All inputs have a low state when you do not ac-

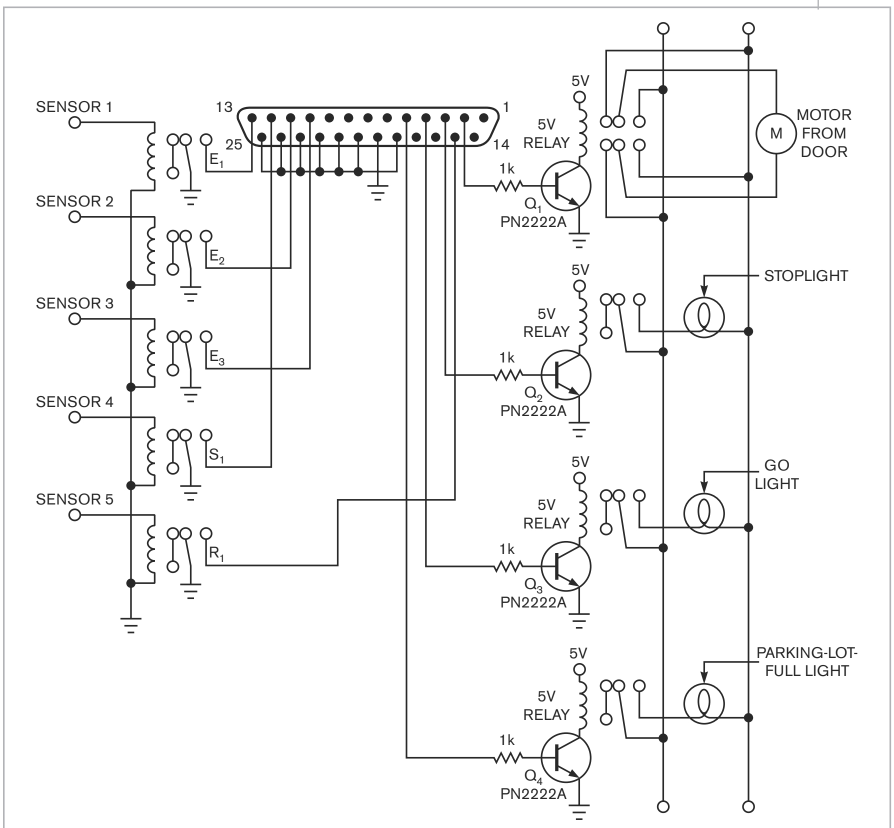

Figure 1 The sensors, indicator lights, and door motor of a parking lot connect through relays to the parallel port of a PC.

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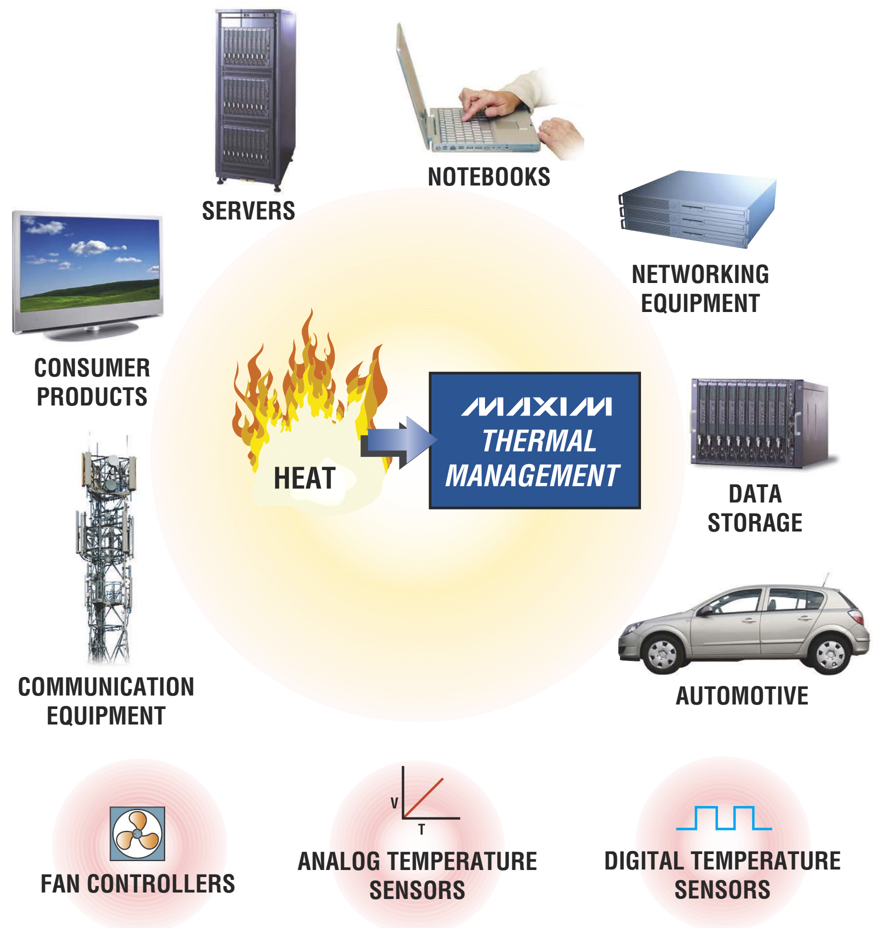

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DS600	Analog temperature sensor with thermostat	±0.5°C accuracy: industry's most accurate analog temperature sensor	Improves system performance
MAX6697	7-channel remote temperature sensor	±1°C accuracy	Reduces board space, saves cost
MAX6514	Temperature switch	±1.5°C accuracy: most accurate temperature switch	Improves system performance, reduces guardbands
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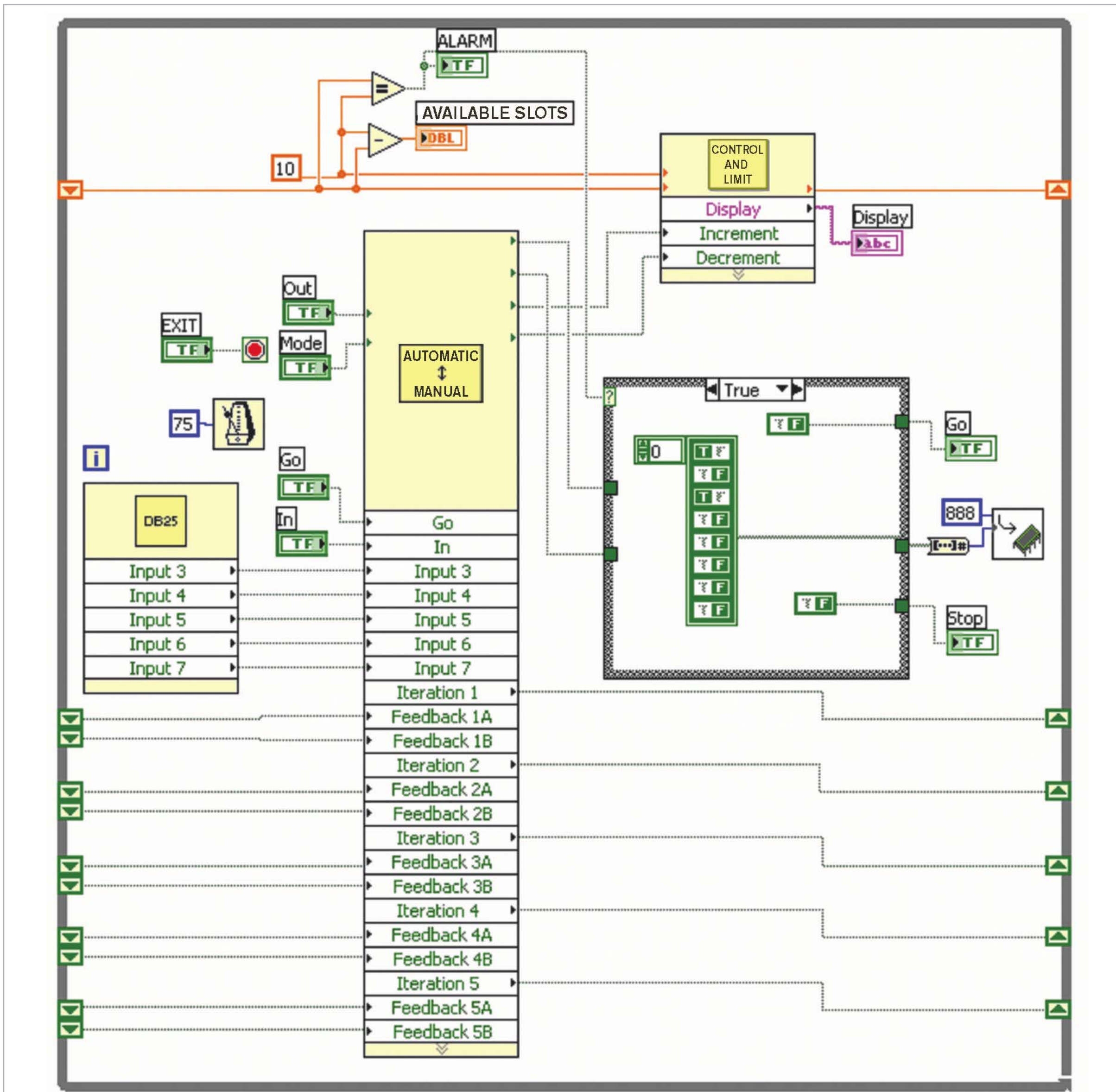

Figure 2 This LabView VI (virtual instrument) controls the operation of a parking lot.

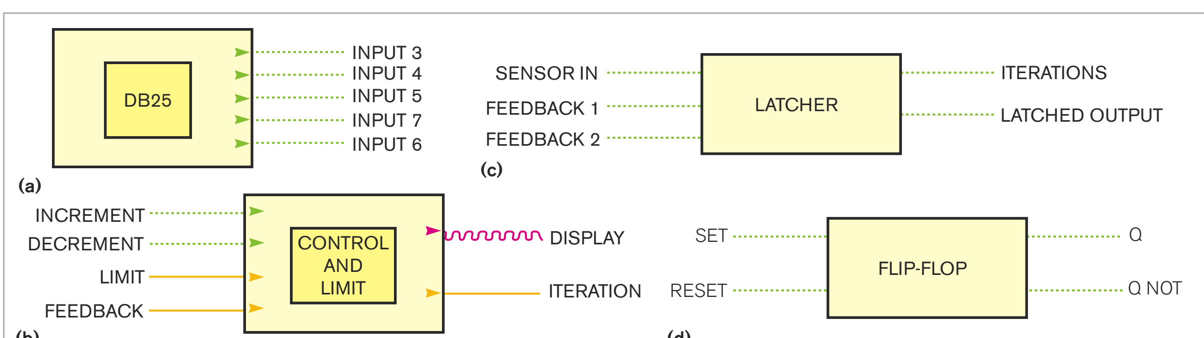

Figure 3 These VIs change the inputs to a low state (a), determine a limit for the number of cars in the parking lot (b), work as a latch-on-release circuit (c), and act as a flip-flop (d).

tivate the sensors. The VI in **Figure 3b** determines a limit for the parking lot, allowing incrementing and decrementing the number of cars parked. This VI also drives a user-oriented display and the shift-register connectors, feedback and iteration, on a "while" loop. The VI in **Figure 3c** works as a latch-on-release circuit; it generates a pulse upon an iteration when the circuit releases the high state on any of the input signals. The VI in **Figure 3d** works as a flip-flop. The VI in **Figure 4** allows switching from automatic to manual mode. Feedback and iteration terminals connect to shift registers, so the latches and the flip-flops inside the VI work correctly.EDN

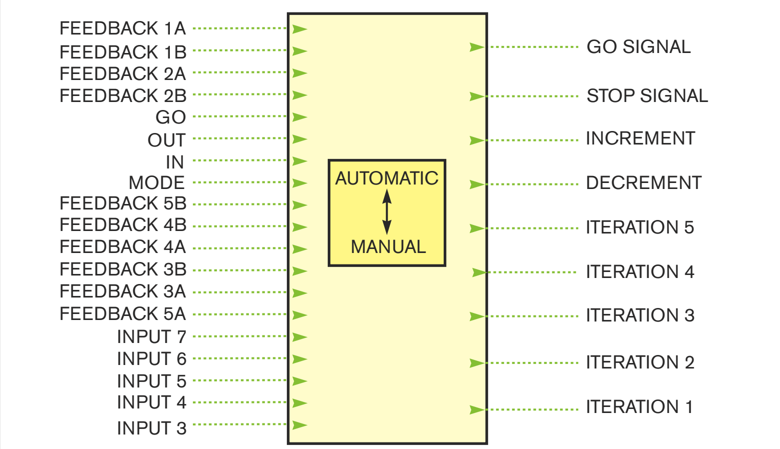

Figure 4 This VI allows switching from automatic to manual mode.

General-purpose components implement USB-based data-acquisition system

V Gopalakrishnan,
Indira Gandhi Centre for Atomic Research, Kalpakkam, India

Figure 1 presents a Design Idea for a USB-based data-acquisition system that uses a serial ADC employing general-purpose components, such as D flip-flops, a binary counter, and a shift register. Using the DLP-USB245M FIFO-to-USB-converter module from DLP Design (www.

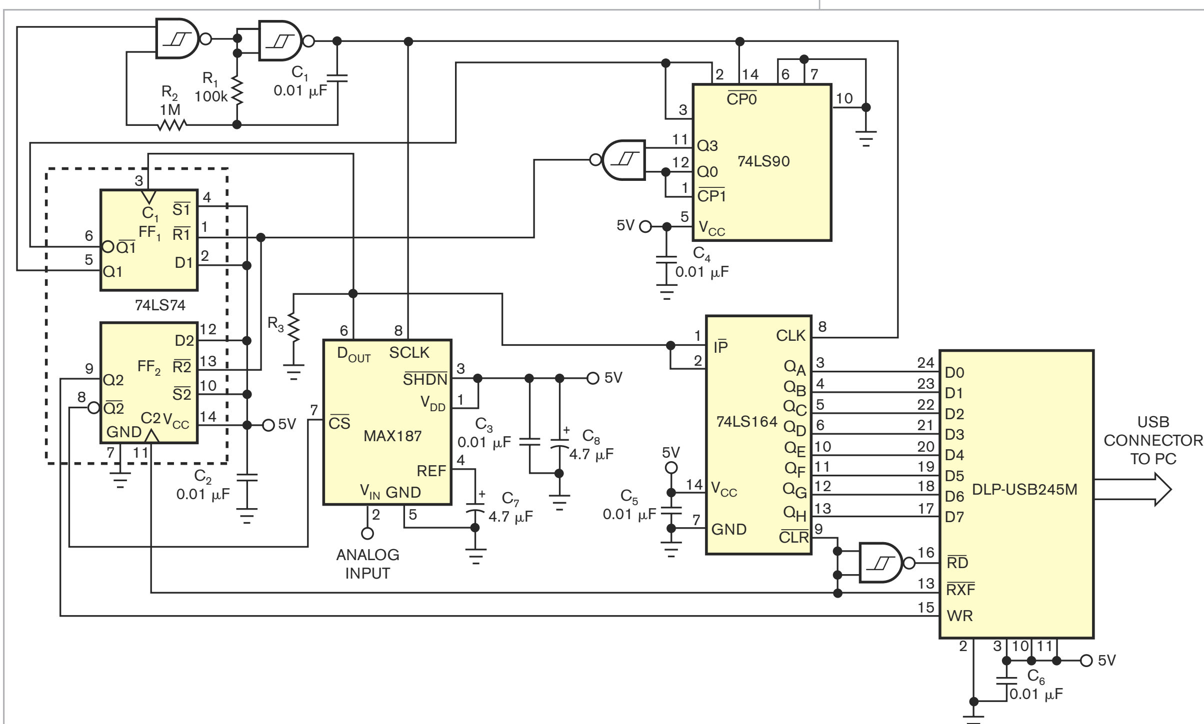

Figure 1 This circuit performs a serial-to-parallel conversion of serial-ADC data and transfers the data to the USB port of a PC.

LINEAR TECHNOLOGY
DESIGN NOTES

Ideal Diodes Protect Against Power Supply Wiring Errors

Design Note 444

Meilissa Lum

Introduction

High availability systems often employ dual feed power distribution to achieve redundancy and enhance system reliability. ORing diodes join the feeds together at the point of load, most often using Schottky diodes for low loss. MOSFET-based ideal diodes can be used to replace Schottky diodes for a significant reduction in power dissipation, simplifying the thermal layout and improving system efficiency. Figure 1 shows the LTC4355 and LTC4354 combining the inputs and returns in a –48V, 5A dual feed application. This solution reduces the power dissipation from 6W using Schottky diodes to just 1.1W with MOSFETs.

With two supply sources and four supply connections there are plenty of ways to incorrectly connect the wires. Although the likelihood of a wiring error is small, the cost is high if downstream cards are not designed to tolerate such errors. Wiring errors could include reverse polarity or cross-feed connections. Knowing this, circuit designers are accustomed to using discrete diode solutions to protect against such mishaps. It is important that active ideal diodes give similar protection.

Types of Misconnections

Figure 2 shows the correct power supply connections. RTNA and RTNB are close in potential by virtue of the common connections to safety ground represented by R_{GND}.

Figure 3 shows a reversed input connection with RTNA and NEGA swapped. The associated ideal diodes are reverse biased, making the wiring error transparent to the load with BATTERY B providing power.

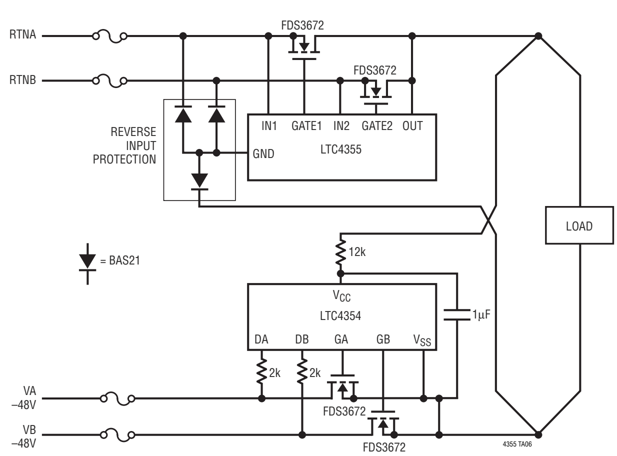

Figure 1. –48V Ideal Diode-OR

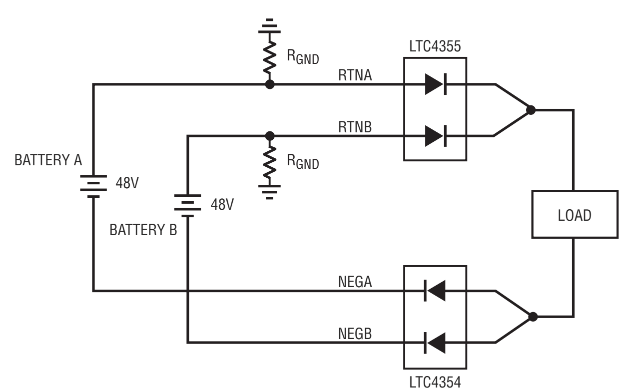

Figure 2. Correct Power Supply Connections

Figure 4 shows another misconnection with RTNB and NEGA swapped, so one power supply is connected across the RTN inputs of the LTC4355 and the other supply across the –48V inputs of the LTC4354. In this case, the reverse input protection network of three diodes shown in Figure 1 prevents damage to the LTC4355. The load operates from BATTERY B, but only after the current has passed through the ground wiring.

Figure 5 shows BATTERY B installed incorrectly. The reversed battery has no effect on the load because the diode connected to NEGB is reverse biased. The voltage across the LTC4354 can exceed 100V and an external clamp may be added to protect its DRAIN pin.

Figures 2-5 have the correct safety ground connections to RTNA and RTNB. Damage can occur if there is a large potential difference between RTNA and RTNB. Figure 6 shows the safety ground, R_{GND}, mistakenly connected to NEGB instead of RTNB. This connects the power supplies in series and the voltage seen across the load nears 100V which can cause damage, a situation no different than encountered with a discrete diode solution. A TransZorb placed across the output protects the load, until a fuse on the input opens to isolate the high voltage from the load.

Conclusion

In dual feed applications, the supply connections can be erroneously wired, potentially causing damage to the load. An ideal diode solution using the LTC4355 and LTC4354 provides protection similar to Schottkys, but with much lower power dissipation. The end result is a compact layout and improved efficiency.

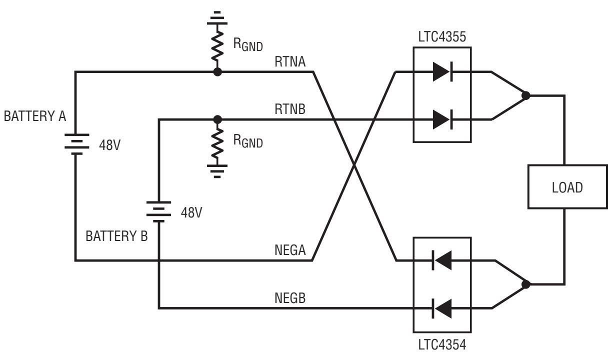

Figure 3. Reversed RTNA and NEGA Connection

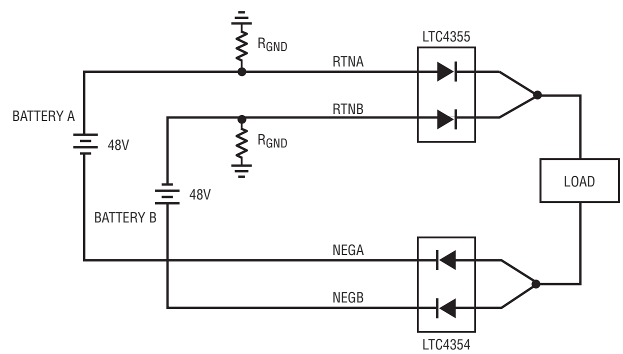

Figure 5. Reversed BATTERY B

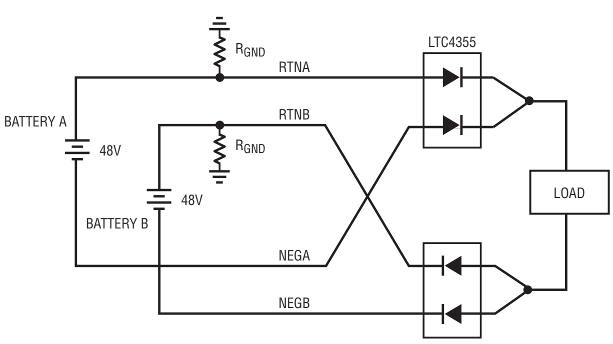

Figure 4. RTNB and NEGA Swapped

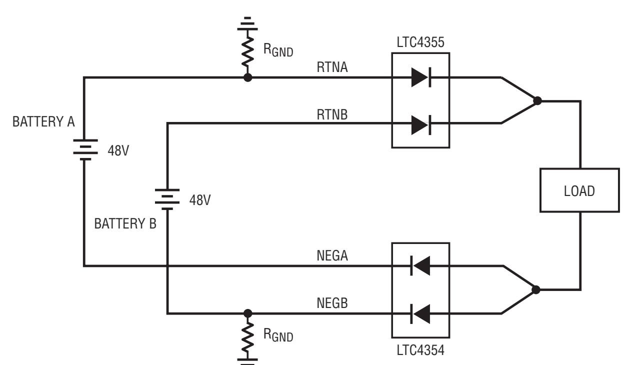

Figure 6. GND Misconnected to NEGB

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dlpdesign.com), you can communicate with the peripheral device through the USB port of a host computer. You can write your own program to read and write the data through this module or simply download free test-application software available from DLP's Web site. Additionally, you could download National Instruments' (www.ni.com) LabView serial-read and-write VIs (virtual instruments).

Writing a dummy block of data from the host computer to the buffer of the DLP-USB245M generates a spike at the module's $\overline{RXF}$ pin, which triggers the D flip-flop, FF_2 of the 74LS74. The flip-flop's $\overline{Q2}$ pin initiates the conversion cycle of the MAX187 serial ADC from Maxim (www.maxim-ic.com) by pulling down its chip-select pin. The ADC's end-of-conversion cycle causes a low-to-high transition from its D_{OUT} pin, which triggers the other D flip-flop, FF_1 of the 74LS74, to generate a gating pulse, Q1, for the serial-clock pulses that read the data from the same D_{OUT} pin of the ADC. The 74LS90 binary counter counts the serial-clock pulses. When the count reaches nine, the counter resets the gating pulse for the serial clock and pushes back the chip-select signal to a high level by resetting both FF_1 and FF_2, ending the ADC's acquisition cycle.

YOU CAN WRITE YOUR OWN PROGRAM TO READ AND WRITE THE DATA THROUGH THIS MODULE.

The system acquires the data at the falling edge of the MAX187's SCLK pin and shifts it into the 74LS164 serial-to-parallel shift register at the rising edge of the next SCLK. The MAX187 needs nine serial-clock pulses to shift valid 8-bit data. This circuit uses only 8 bits of the 12-bit ADC. If the circuit requires all 12 bits, then you must connect all NAND gates at the appropriate outputs of the binary counter to generate a reset signal by its 13th clock pulse, and you must make the shift register larger.

The serial data from the ADC converts to parallel data in the serial-to-parallel shift register; a WR (write) signal to the DLP-USB245M then transfers this data to the PC. This action is a complement of the $\overline{CS}$ signal from Q2 of the 74LS74. The DLP-USB245M's $\overline{RXF}$ pin generates a trigger to initiate the conversion cycle and clears the previous data of the shift register. EDN

Small, simple, high-voltage supply features single IC

Alfredo H Saab and Tina Alikahi,
Maxim Integrated Products, Sunnyvale, CA

Sensors, electrostatic traps, and other applications require regulated, high-voltage power supplies that deliver modest amounts of output current. Simplicity, low quiescent current, and compactness are desirable in such supplies. The circuit of **Figure 1** meets these requirements, and its magnetically isolated output allows you to configure a positive, negative, or floating output. A separate winding that generates a feedback voltage proportional to the output voltage, but lower, enables the floating output. This arrangement eliminates the need for high-value resistors in a resistive-feedback divider, which the circuit would otherwise require for direct sampling of the high-voltage output. This low-voltage divider contains resistors with much lower values, which dissipate much less power.

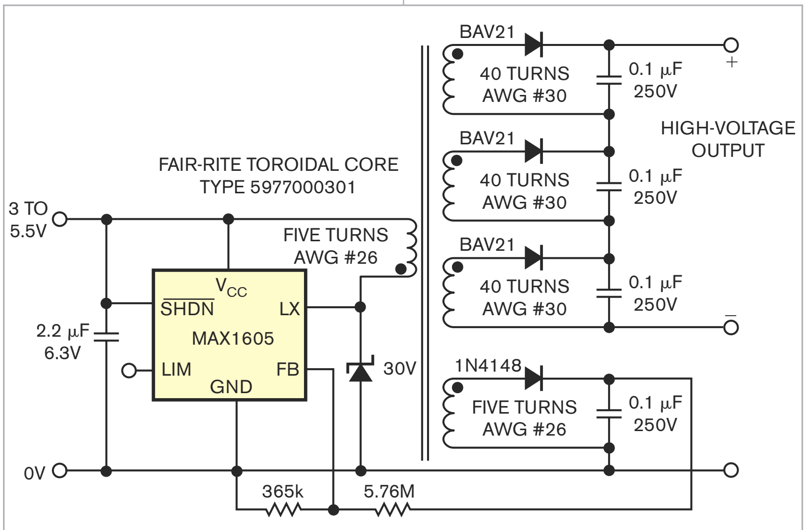

Figure 1 Obtaining feedback from a low-voltage secondary winding, this high-voltage supply generates 500V with low quiescent current.

The MAX1605 IC from Maxim (www.maxim-ic.com) contains the necessary switching regulator, modulator, error amplifier, and power switches (**Reference 1**). It drives the primary of a toroidal transformer that includes a feedback secondary and several output windings. With the component values in the **figure**, the circuit can generate 500V (**figures 2** and **3**). You can vary the output voltage ±30% by adjust-

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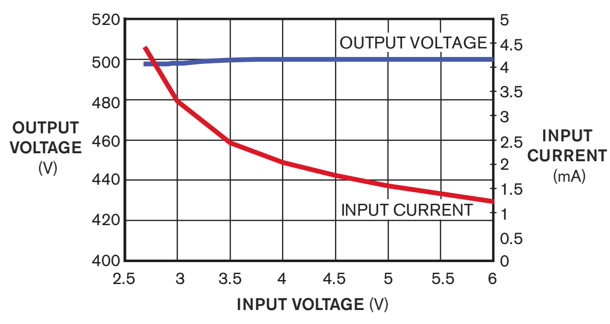


Figure 2 The graph shows output voltage and input current versus input voltage.

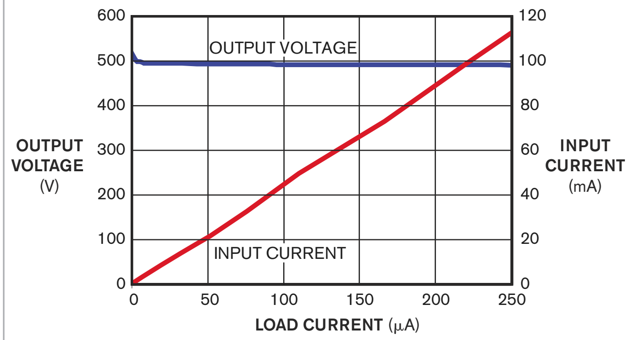


Figure 3 The graph shows output voltage and input current versus load current.

ing the ratio of the resistive-feedback divider. You can also increase or decrease the output voltage in steps by adding or removing the rectifier/capacitor/output-winding modules. The BAV21 is a high-voltage, low-reverse-current, general-purpose diode.

As with all switching converters, EMI (electromagnetic interference) and circuit parasitics can present problems. The circuit needs careful PCB (printed-circuit-board) layout, along with filtering, decoupling, and shielding. The high-voltage output has approximately 1% ripple. You can add an RC or an LC filter in series with the output to achieve lower output ripple.EDN

REFERENCE

1 "30V Internal Switch LCD Bias Supply," MAX1605 data sheet, Maxim, October 2003, http://datasheets.maxim-ic.com/en/ds/MAX1605.pdf.

CMOS DACs act as digitally controlled voltage dividers

John Wynne and Liam Riordan, Analog Devices, Limerick, Ireland

Digital potentiometers, such as Analog Devices' (www.analog.com) AD5160, make excellent digitally controlled voltage dividers in applications in which 8-bit resolution is acceptable. This Design Idea shows how to use a CMOS DAC as a voltage divider in applications requiring higher resolution.

Millions of CMOS R2R (resistor/two-resistor)-ladder DACs have found use in attenuator applications in which an external op amp acting as a current-to-voltage converter forces one current-output terminal to a virtual ground. The reference input to the DAC can be ac or dc as long as the op amp can produce the desired output voltage. A phase inversion is normal between input and output, so the circuit requires dual power supplies.

Figure 1 shows a way to rewire this simple circuit to avoid the phase inversion and to operate with a single supply. In this configuration, the DAC acts as a digitally programmable resistor, and the DAC's code changes the effective resistance between the input voltage and the I_{OUT1} output-current terminal of the DAC. **Figure 2** shows a practical implementation using one-half of an Analog Devices AD5415 dual 12-bit current-output DAC operating as a voltage divider. This **figure** omits the DAC's control lines for clarity. Op amp A_1 forces the voltage on the I_{OUT2A} output-current terminal to follow the voltage on the I_{OUT1A} output-current terminal. This approach prevents a voltage differential from developing between these two bus lines, which would result in the application of different gate-source voltages across the internal DAC switches and a deterioration in the DAC linearity.

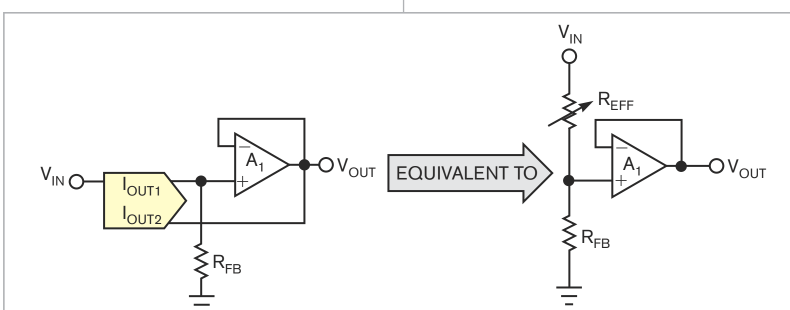
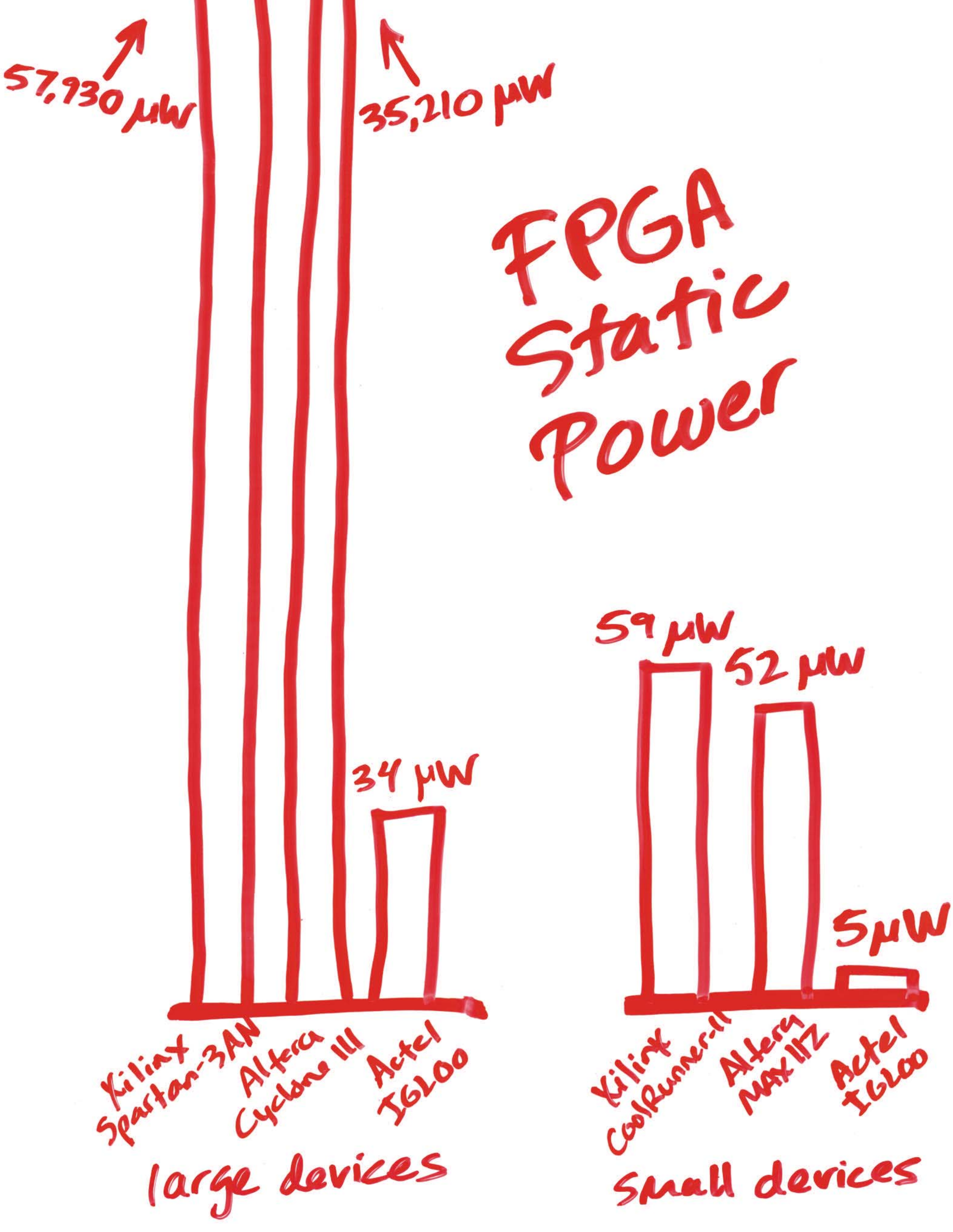


Figure 1 This simple circuit avoids a phase inversion and operates with a single supply. In this configuration, the DAC acts as a digitally programmable resistor.



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Wire the split-feedback resistors, R_{FB} and R_1, to produce a composite-feedback resistor equal in value to the DAC's ladder impedance, R. For this arrangement the circuit-transfer function is $V_{OUT}/V_{IN}=(R)/(R_{EFF}+R)$, where R_{EFF} is the effective DAC resistance that is under digital control. Its value is $R(2^n)/N$, where n is the resolution of the DAC and N is the binary equivalent of the digital-input code. Substituting the second **equation** into the first and assuming zero DAC gain error, the circuit-transfer function for a 12-bit DAC reduces to $V_{OUT}/V_{IN}=1/(1+4096/N)$. With all switches off, the effective impedance between the reference voltage and the I_{OUT1A} terminal is infinite, so the output voltage starts at 0V when you load zeros into the DAC. The output voltage increases linearly with increasing code, ideally to approximately half the input with all ones applied to the DAC.

The threshold voltage of the DAC's internal N-channel-CMOS switches limits the maximum value of the output voltage, so not all configurations can achieve the full code range. The switch-gate voltage remains at the V_{DD} voltage, and the switch-source voltage rises with the voltage on I_{OUT1A}. As this voltage increases, the on-resistance of the switches becomes large and indeterminate, leading to a flattening of the output voltage and the cessation of the circuit as a predictable voltage divider. For proper operation, the V_{DD} voltage must be a few volts higher than the maximum output voltage—that is, half the input voltage. Otherwise, the input voltage must be less than two times the V_{DD} voltage minus 3V. With a V_{DD} voltage of 5V, the AD5415 operates linearly to approximately a 3.33V output but then flattens. If a wider output-voltage range is necessary, you could use Analog Devices' AD7541A, which uses a 15V power supply, in place of the AD5415. This substitution extends the usable output-signal range to approximately 7V.EDN

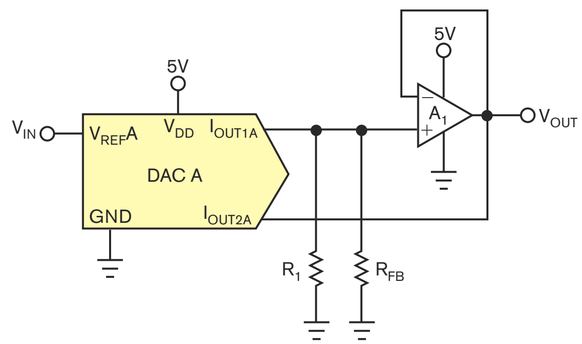

Figure 2 This practical implementation of the circuit in Figure 1 uses one-half of a 12-bit-current-output AD5415 dual DAC that operates as a voltage divider.

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LINKING DESIGN AND RESOURCES

Distributors look to shine with HB-LED opportunity

HB LEDs (high-brightness light-emitting diodes) hold great opportunity for the electronics supply chain and are particularly attractive to distributors, as the technology will require full-system approaches from suppliers and manufacturers.

Analysts estimate that general illumination, signs and displays, and automotive applications will push HB LEDs' high-growth opportunities for driver ICs from 2007 to 2011. Those opportunities will record a combined compound-annual-growth rate of 38% and the total market for HB-LED-driver ICs is expected to grow to more than $1.9 billion in 2011, according to Strategies Unlimited.

Cary Eskow (**photo**), director of Avnet LightSpeed (www.em.avnet.com/lightspeed), at an EDS (Electronics Distribution Show and Conference) panel in May shed some light

on what distributors need to do to win in the HB-LED marketplace. He noted three necessities for success, the first of which is specialized knowledge. "That's the distributor's ability to understand these new types of customers and to speak in their language. This is the language of light. It's not in diodes; it's not in capacitors or microcontrollers. It's a different world."

Eskow said that distributors need to understand the market fully, comprehending its pressures and the legislation affecting it, and then be able to tie all of that information together, which led him to his second strategy for success: recognition that HB LEDs are not single components but full systems.

"It's the understanding that an LED is not a component. It requires thermal heat management and interconnect, knowledge of phosphors, microcontrollers. There's a lot of pull through associated with that. Typically, I would say, for every dollar in HB LED, there are $2 to $5 in pull through," he said, noting that lighting sales leverage the sales of other products on Avnet's line card.

Eskow's third ingredient for success is patience. He noted that a lot of industry analysts, such as Strategies Unlimited, are predicting tremendous growth for HB LEDs but said that such growth is going to be incremental.

"That [growth] will happen, but … the next year or two are going to be slow as things engage," Eskow said.

GREEN UPDATE

ROHS DECABDE EXEMPTION ENDING

After a challenge from Denmark and the European Parliament, the European Commission-granted EU ROHS (European Union restriction-of-hazardous-substances) exemption for DecaBDE (decabromodiphenyl ether) will end on July 1.

DecaBDE is a common flame retardant used in various components and electronics, including HIPS (high-impact-polystyrene) enclosures, polyethylene-wire insulation, and PBT (polybutylene-terephthalate) connectors, as well as in some types of nylon and other plastics.

Experts expect the end of the DecaBDE exemption to be a significant issue for component suppliers, as some of their customers will no longer accept plastics with DecaBDE because of time-line pressure, from buying parts to putting finished products on the market. They also expect a significant problem for manufacturers with stocks of parts containing DecaBDE because they cannot include those parts in ROHS-compliant equipment put on the EU market as of July.

To comment on the end of the DecaBDE exemption, visit www.edn.com/blog/570000257/post/310025831.html.

OUTLOOK

EMS GROWTH CONTINUES AT DOUBLE-DIGIT RATE

While the ODM (original-design-manufacturer) sector continued to grow at the higher rate of 23% in 2007, the EMS (electronic-manufacturing-services) sector still accounted for more than 60% of the industry, growing at an annual rate of 17% in 2007 and generating $268.1 billion in revenues, according to recent research from IDC (www.idc.com).

Computers and consumer devices remained the two largest product segments, respectively making up 36% and 29% of last year's EMS industry revenue.

"While computing remains the largest single sector, followed by consumer devices, the industrial segment experienced constant solid growth for EMS firms and displaced servers and storage as the third-largest product segment for the industry," says Michael Palma, senior research analyst for IDC's semiconductor group.

"ODMs need to evaluate current product and customer portfolios, and look beyond notebooks and mobile phones for future growth. EMS and ODM firms should also take steps to mitigate effects from a likely US recession," he urges.

According to IDC, Foxconn maintained its lead in the market, with 16% of all industry revenues in 2007, growing by 46% from 2006.

productroundup

OPTOELECTRONICS/DISPLAYS

LED constant-current demonstration board suits pairing up with VTM transformers

This LED constant-current PRM (power-regulator-module)-regulator demonstration board aims at LED applications, including street and stadium lighting, high-end projectors, active-outdoor advertising, and architectural installations. The board provides an adjustable current as high as 240W or 5A at 48V when you use it as a stand-alone, nonisolated source. You can combine the device with the vendor's range of transformers to provide an adjustable isolated current as high as 100A. The PRM/transformer pair uses less than 1W for every 1000 lumens the LEDs generate. Kelvin connections allow you to measure the component's efficiency independent of load-connect losses. The PRM-LED demonstration board costs $125. Oscilloscope-probe jacks are also available for measuring output voltage, including output-voltage ripple.

Vicor Power, www.vicorpower.com

Wireless remote-control RGB-LED kit targets color lighting

Combining the TPS62260LED board with the vendor's eZ430-RF2500 development tool, the wireless remote-control RGB-LED-design kit provides a supported platform for designing color lighting suiting consumer, commercial, professional, and architectural applications. The board controls lamp color and brightness or runs an automatic color-light animation program. Three Osram high-brightness LEDs generate red, green, and blue. An MSP430F2131 ultralow-power microcontroller controls the brightness of each LED using constant current that the three TPS62260LED drivers generate. The development tool provides wireless communication and plugs directly into the board, allowing designers to create a lightning network of RF-controlled lamps. Available with a populated and preprogrammed MSP430 microcontroller with board documentation, the TPS62260LED board costs $19. The eZ430-RF2500 development tool costs $49.

Texas Instruments, www.ti.com

Evaluation kit has dedicated test pin for DMX512 protocol

Providing firmware to create ColorLock drivers in PSOC (programmable system-on-chip) Express, the CY3263 evaluation kit includes a color sensor and control loop targeting the LCD-backlight, architectural-lighting, and general-signage markets. A dedicated test pin for the DMX512 protocol makes the evaluation kit suitable for intelligent lighting networks. Additional features include a MiniProg; a 5V LCD; a USB cable; and a CD with PSOC Express, Gerber files, and schematics. The evaluation kit costs $249.

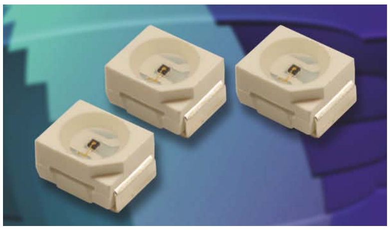
Cypress, www.cypress.com

Snubberless triac-drive optocouplers have improved dV/dt rating

Aiming at motor-control, power-switch, and lighting-control applications using random-phase, snubberless triac-drive optocouplers, the FOD420 and FOD4208 triac-drive optocouplers provide a built-in active dV/dt clamp. These devices provide 10,000V/μsec-dV/dt noise immunity, compared with the typical 1500V/μsec-dV/dt rating of monolithic triacs. Improving the dV/dt rating eliminates the need for an RC-snubber network for lowering dV/dt-rated monolithic optotriac drivers. Providing 5000V of isolation while controlling the power triacs switching the load, the triac-drive optocouplers suit use with the vendor's discrete power triacs. The

FOD420 and FOD4208 triac-drive optocouplers cost $1.71 and $1.89 (1000), respectively.

Fairchild Semiconductor, www.fairchildsemi.com



Surface-mount LEDs claim to increase operational life

The OP180 and OP280 surface-mount infrared-LED series features a silicon encapsulant, increasing the operational life of the component. The OP180 uses a high-power gallium-arsenide material with 940-nm peak wavelength, 0.5-mW/cm^2 apertured power, a 20-mA forward current, and a 100° half-power angle. The OP280 provides an 850-nm invisible class 1 VCSEL (vertical-cavity surface-emitting laser) with 2.5-nW/cm^2 apertured power, a 7-mA forward current, and an 18° half-power angle. The LEDs suit noncontact-position-sensing, datum-detection, machine-automation, and optical-encoding applications. Available in PLCC-2 packages, the OP180 and OP280 infrared LEDs cost 22 cents (1000) each.

Optek, www.optekinc.com

Optocouplers have extended operating-temperature range

The EL30XX portfolio includes 21 random-phase and zero-crossing triac-driver optocouplers operating over a −55 to +100°C temperature range. Features include 250 to 800V peak blocking voltages and 5-, 10-, and 15-mA low-trigger currents. The vendor claims improved design flexibility in designs interfacing low-current dc-control circuits and ac-power loads as high as 380V. Zero-crossing versions provide added protection using a zero-cross-detection circuit connecting to the gates of each SCR (silicon-controlled rectifier). This feature prevents current surge, reduces EMI (electromagnetic interference), and improves dV/dt-transient immunity. The 800V series claims an improved margin for control of offline voltages of 380V. The EL30XX series is available in DIP-6 packages, and prices range from 20 to 40 cents.

Everlight Electronics Co Ltd, www.everlight.com

MICROPROCESSORS

16-bit microcontrollers suit servers and communication equipment

Part of the vendor's 16-bit H8S microcontroller series, the H8S/2153 and H8S/2164 microcontrollers provide 40 kbytes of RAM and 512 kbytes of flash memory. Aiming at advanced communications equipment, the H8S/2153 includes four unified-I^{2}C-bus channels and an LPC bus. The device also includes an eight-channel, 10-bit ADC; an eight-channel event counter; and a data-transfer controller. Using a 34-MHz H8S/2600 microprocessor core with a built-in MAC (multiply/accumulate) function, the 3.3V H8S/2164 provides a 16550-compatible UART with a snoop option suiting baseboard-management-controller applications. The device also features six I^{2}C-bus channels; an eight-channel, 10-bit ADC; a 16-channel event counter; a data-transfer controller; a bus-state controller; 8- and 16-bit timers; and a watchdog timer. The H8S/2153 and H8S/2164 microcontrollers come in 10×10-mm BGA-112 and 16×16-mm TQFP-144 packages, respectively, and each costs $15.

Renesas Technology America, www.renesas.com

2-Mbit serial FRAM has a high-speed SPI

Manufactured on a 130-nm-CMOS process, the 2-Mbit FM-25H20 serial FRAM provides a high-speed SPI (serial-peripheral interface). The high-density nonvolatile memory suits serial-flash replacement. Organized as a 256-kbit×8-bit nonvolatile memory, the device draws 1 mA for reads/writes at 40-MHz bus speeds, 80 mA in standby, and 3 mA in ultralow-current sleep mode. The FRAM retains data for 10 years, has a hardware- and software-write-protection feature, claims unlimited endurance, and operates at 2.7 to 3.6V over a −40 to +85°C temperature range. The device complies with ROHS (restriction-of-hazardous-substances) directives and has an SOIC-8 footprint. Available in a 5×6-mm TDFN-8 package, the FM25H20 costs $10.20 (10,000).

Ramtron International Corp, www.ramtron.com

DSC features 16-bit audio DACs

Six 28- and 44-pin, 16-bit dsPIC DSCs (digital-signal controllers) each include a dual-channel, 100k-sample/sec, 16-bit audio-DAC module. The DMA-enabled devices have 16 kbytes of RAM, including 2 kbytes of dual-port RAM, and offer 64 and 128 kbytes of flash memory. The DSCs provide speech-compression libraries, such as G.711 at 64 kbps, ADPCM (adaptive-differential-pulse-code-modulation) G.726A at 16 to 40 kbps, and Speex at 8 kbps. Operating over a −40 to +85°C temperature range or a −40 to +125°C extended-temperature range, the devices also include CRC (cyclic-redundancy-checking)

productroundup

MICROPROCESSORS

hardware, a PPS (peripheral-pin-select) function, and a parallel master/slave port. Additional features include two analog comparators, a user-selectable 10- or 12-bit ADC, and a real-time clock and calendar. Serial peripherals include two UARTs, two SPIs, I²C, and CAN (controller-area-network) 2.0B. Four of the devices provide a codec interface supporting I²S and AC (audio codec)'97 protocols. Two of the 44-pin controllers offer motor-control and power-conversion peripherals, including a three-phase PWM (pulse-width modulator), a power-factor-correction PWM, and two quadrature-encoder interfaces. The dsPIC DSC devices are available in QFN-, SOIC-, and SPDIP-28 or QFN- and TQFP-44 packages, and prices range from $3.67 to $4.18 (10,000).

Microchip Technology, www.microchip.com

EMBEDDED SYSTEMS

Digital-receiver card supports 160M-sample/sec analog rate per channel

The rugged XMC-E2201 high-speed XMC (express mezzanine card)/PMC (peripheral-component-interconnect mezzanine card) speeds the integration of high-performance signal acquisition into rugged deployed COTS (commercial off-the-shelf) VPX, VME (Versa-module-eurocard), and CompactPCI subsystems. The device's analog inputs provide dual-synchronous channels, 16-bit resolution, and 160M-sample/sec analog-sampling rates. The XMC-E2201 digital-receiver card costs $9620.

Curtiss-Wright Controls Embedded Computing, www.cwembedded.com

Single-board computer suits geocentric-orbit applications

Targeting mission-critical space environments, the 3U CompactPCI radiation-tolerant, single-slot, single-board S950 computer suits low-earth orbit, Mars-terrestrial, and geocentric-orbit applications. The single-board computer uses 13.5W at full operation, 8W in nap mode, and 10W at limited performance, based on a 733-MHz core-processor speed. The device allows a user to initiate a variety of power-saving options, depending on application requirements. The S950 costs $24,200.

Aitech Defense Systems, www.rugged.com

LED-driver boards have extremely low profile

Aiming at use in industrial and medical LCDs, the Smart Force LED-driver boards provide power for high brightness and reduced power consumption. The SFDE economical and SFDM mini series feature brightness stability over a wide input voltage and power as many as six LED strings. The SFDE measures 28.2×78.7×5 mm, and the SFDM measures 24.4×55.6×5 mm. The Smart Force SFDM and SFDE cost $12.99 and $15.73, respectively.

Endicott Research Group, www.ergpower.com

LAN and wireless-LAN devices provide machine-to-machine connectivity

Based on the vendor's CO2128 Internet-controller chip, the Secure iLAN and Secure iWiFi devices enable secure-Internet, machine-to-machine communication in RS-232- and RS-485-port devices using LAN and wireless LAN, respectively. Features include a high-speed serial interface, an integrated Web server, hardware-based SSL (secure-sockets-layer)-standard encryption, and firewall functions. The devices also provide remote configuration and management and firmware upgrades. A suite of Internet protocols and applications includes TCP/UDP (transmission-control protocol/user-data protocol), SMTP/POP3 (Simple Mail Transfer Protocol/Post Office Protocol Version 3), MIME (multipurpose Internet-mail extension), HTTP (HyperText Transfer Protocol), WAP (wireless-application protocol), FTP (file-transfer protocol), and Telnet. The Secure iLAN and Secure iWiFi cost $75 and $85, respectively.

Connect One, www.connectone.com

Dual-core VME board includes a 2eSST high-speed VMEbus interface

The MVME7100 VMEbus single-board computer includes a dual-core PowerPC processor and a 2eSST (dual-edge, source-synchronous-data-transfer) high-speed VMEbus interface. The vendor based the device on Freescale Semiconductor's system-on-chip MPC8641D with dual PowerPC e600 processor cores, DDR2 memory, PCI-X, USB, and as much as 8 Gbytes of NAND flash. The series also features dual integrated memory controllers, a DMA engine, a PCIe (peripheral-component-interconnect-express) interface, GbE (gigabit Ethernet), and local I/O. The MVME7100 costs $5495.

Emerson Network Power, www.emersonnetworkpower.com

Simulink addition aims at communication systems

The Communications Blockset 4 extends Simulink with a library of blocks for designing, simulating, and verifying the physical layer of communications systems. This version provides blocks for designing and simulating the physical layer of communications systems, including source coding, block-and-convolution coding, interleavers, filters, and modulators. The tool provides sources, including random-integer and binary generators and PN- and Gold-code sequences, as well as error-rate calculations, eye diagrams, and constellation plots. Features include integration with Matlab and Communications Toolbox for postsimulation analysis, and a channel-visualization tool allows you to visualize and explore time-varying

EMBEDDED SYSTEMS

communications channels. Additional features include channel models such as AWGN (additive white gaussian noise), multipath Rayleigh and Rician fading, and RF impairments, including nonlinearity, phase noise, thermal noise, and phase and frequency offsets. Available for Windows, Linux, Solaris, and Macintosh platforms, the Communications Blockset 4 costs $1000.

The MathWorks, www.mathworks.com

XMC uses new general-purpose-computing process

Using AMD's ATI Radeon HD 3650 graphics-processing unit, the Sentiris 5140 XMC (express mezzanine card) uses general-purpose computing on graphics-processing units, enabling computation and visualization. This device also provides better per-watt processing than traditional processors, according to the vendor. The Sentiris 5140 XMC costs $4085.

Qantum3D, www.quantum3d.com

ESMexpress-based module aims at communication applications

The ESMexpress-based, 1.5-GHz XM50 module uses the PowerQUICC (quad-integrated-communications-controller) III MPC8548 processor and integrates high-performance interfaces, making it suitable for use in communication-intensive applications in the railway, avionics, medical-engineering, and industrial-automotive markets. Accommodating 2 Gbytes of soldered DDR2 SDRAM with ECC (error-correcting code), the module also provides nonvolatile SRAM and FRAM. The carrier board supports USB-flash-memory elements. Interfaces include three GbE (gigabit-Ethernet) channels, six USB ports with a host function, one USB interface with a client function, and three SATA (serial-advanced-technology-attachment) connections. The processor supports the PCIe (peripheral-component-interconnect-express) link, allowing configuration with one, two, four, or eight lanes. Legacy I/O interfaces such as COM or PATA (parallel-advanced-technology-attachment) allow designers to use the module on a standard-carrier board. The XM50 module costs $1432.

MEN Micro, www.menmicro.com

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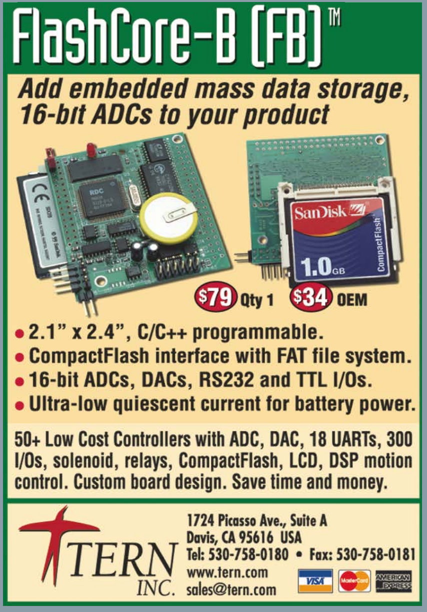

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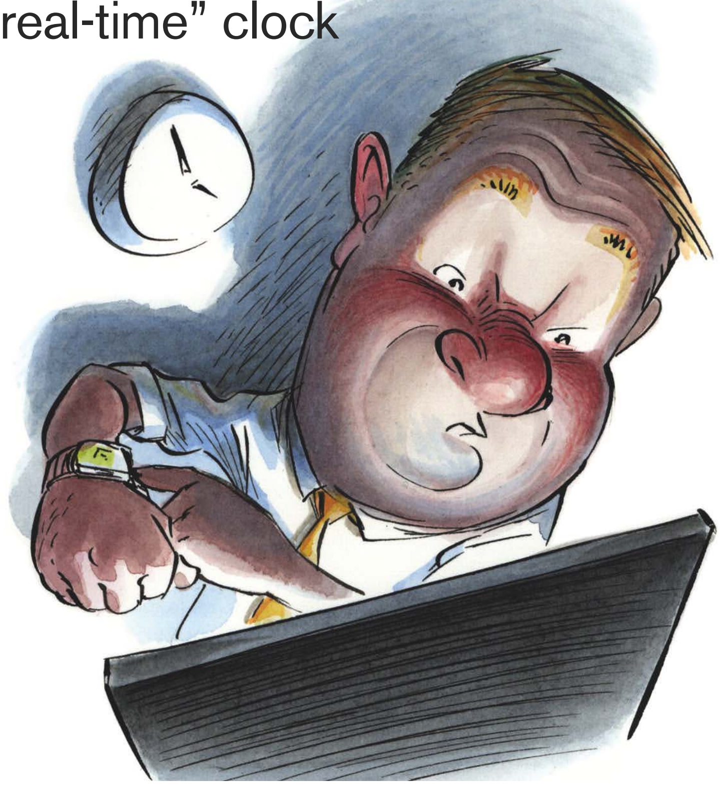
Theory of relativity visits "real-time" clock



DANIEL VASCONCELLOS

I wanted to test some signals in my design using a logic analyzer. After walking around the laboratory, I found a good, old Tektronix instrument and its bag with data pods. But when I turned it on, two things were wrong. First, the device had lost its date and time settings. Second, each application I tried to start simply failed with an error message. It seemed as though the application would start but then immediately abort. At first glance, I didn't see any connection between the two problems.

I needed a replacement battery to address the first problem, and I needed to know its type or at least its size. Opening the cover was no big deal, and, within a couple of minutes, I was able to access two processor boards. Each board had Motorola 68000 series processors, but only one of them contained a coin-type lithium battery. I measured its voltage and wrote down the battery type. I also traced the battery's positive terminal to see what it was powering, and I turned on the mains and measured a real-time-clock-supply voltage. Everything looked fine, and I started to look for a clock-adjustment utility. This task was difficult because the utility wasn't on the hard disk. When I located the utility, I found that the date and time settings worked as I expected. I started the time-setting utility from a floppy disk.

It didn't help, though. All the applications still failed to start. Just to make sure I hadn't missed something in the clock-setting procedure, I did it again. Nothing changed in the application's behavior, but I noticed something strange to say the least: The clock ran much faster than its normal speed each time I started the time-setting utility. It came to its normal speed when I entered the correct date and time settings, however. So, it probably had a good reason to come back to its higher speed because, the next time I entered the time-setting utility, it was again speeding up. Turning the instrument off for a longer period was helpful: The next time I turned it on, I saw a noticeable advance in its clock. The clock sped up immediately after power-down.

My next test was simple: I performed all the same steps except for power cycling, ignoring the advice in the manual. Everything worked fine, and the picture became clear. Lowering the supply voltage of the CMOS inverter in the 32,768-Hz clock oscillator causes higher gain but longer gate delay. Now, it was possible to more easily satisfy the phase- and magnitude-balance conditions for the third or fifth overtone than for the crystal-fundamental tone. I saw similar problems when trying to build a crystal oscillator based on a CD4000 series XOR gate connected as an inverter. Once it enters this mode, the oscillator stays in it, even when its supply voltage ramps up to its nominal value. Only writing a new time setting at nominal supply voltage can turn the oscillator back to its crystal-fundamental frequency. Possibly, it disables and then re-enables the oscillator when accessing internal chip registers.

The next day, I got a replacement battery and put it into the instrument. Just in case someone might have the same problem, I sent a short e-mail describing it to Tektronix support. From this experience, I learned a principle of relativity: You may have an application time out not only because the application is too slow, but also because your real-time clock is too fast! **EDN**

Vadim Demidov is an engineering manager at Giesecke & Devrient. Like him, you can share your Tales from the Cube and receive $200. Contact edn.editor@reedbusiness.com.