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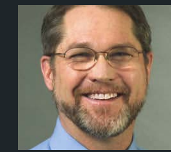

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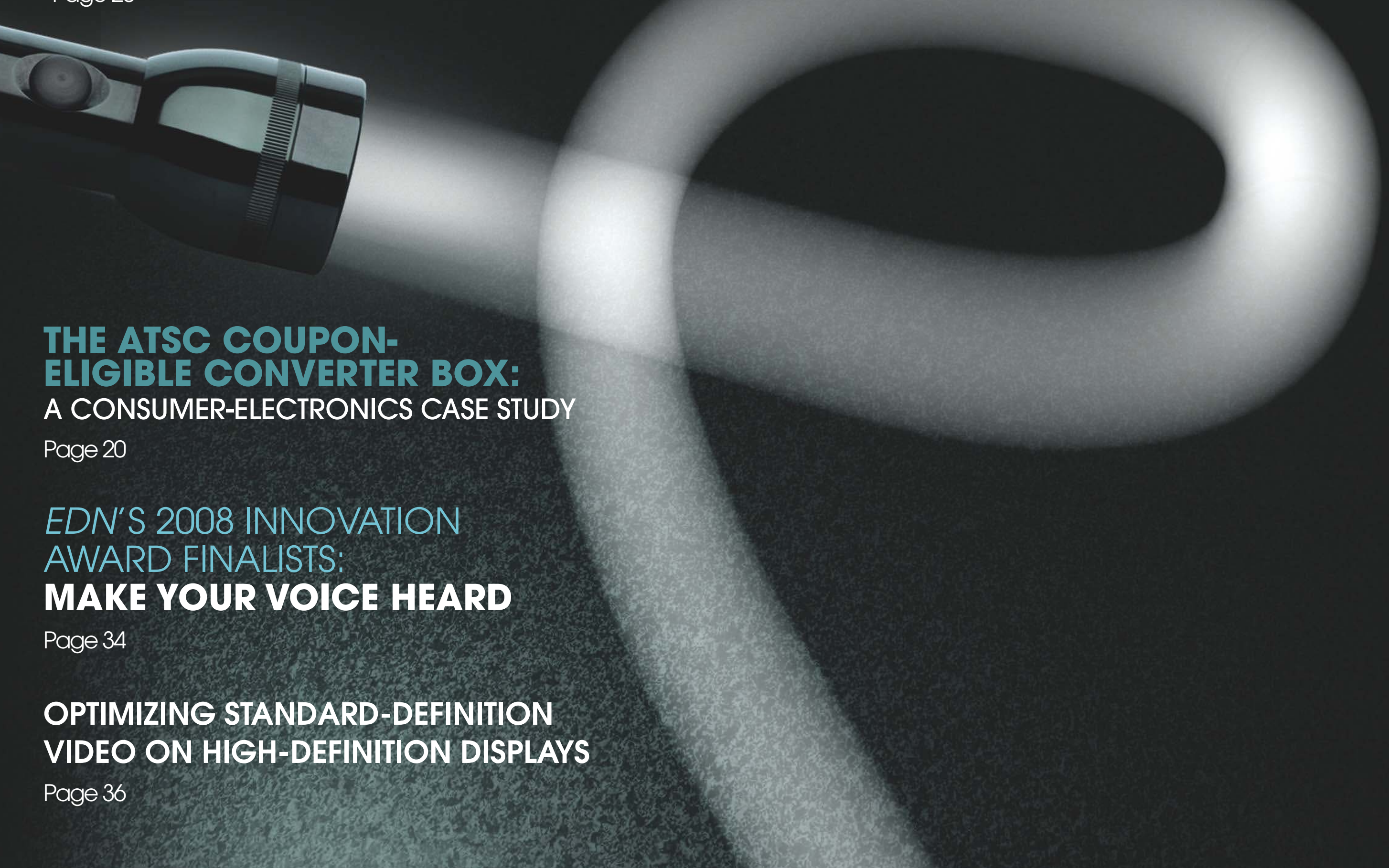

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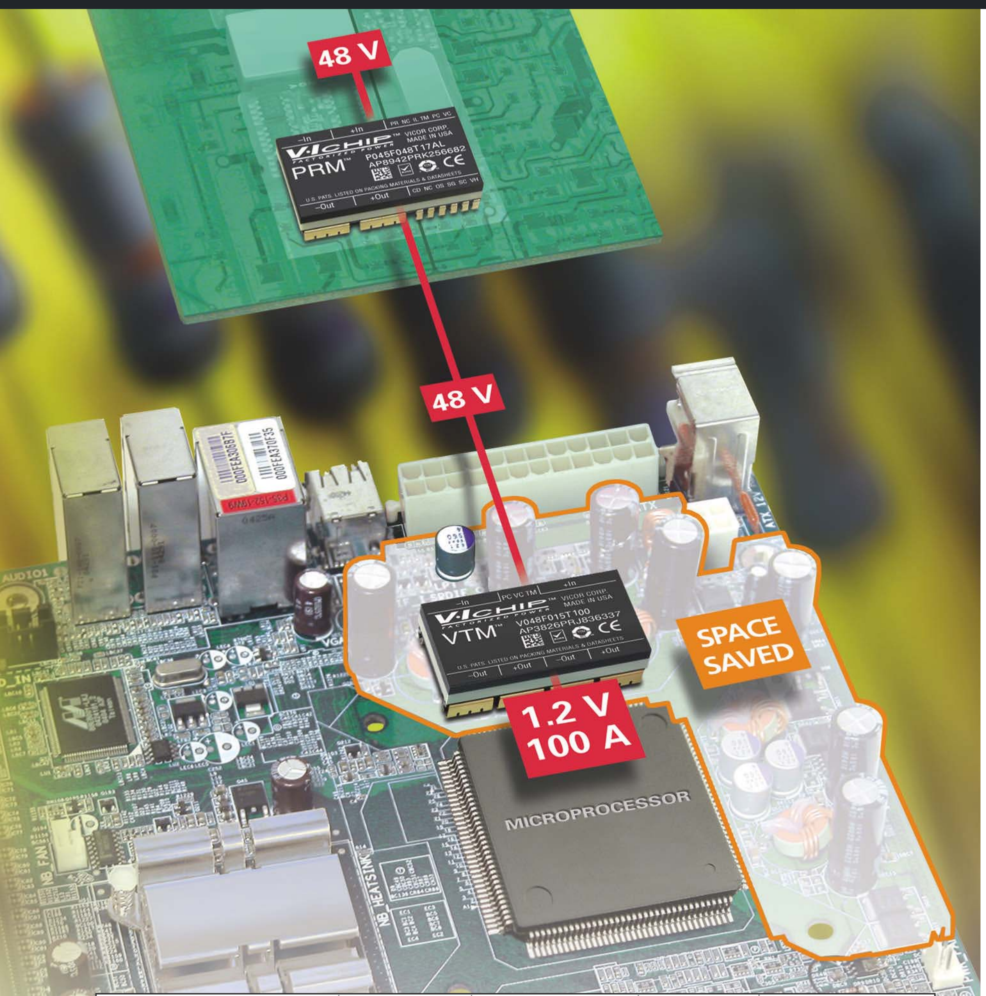

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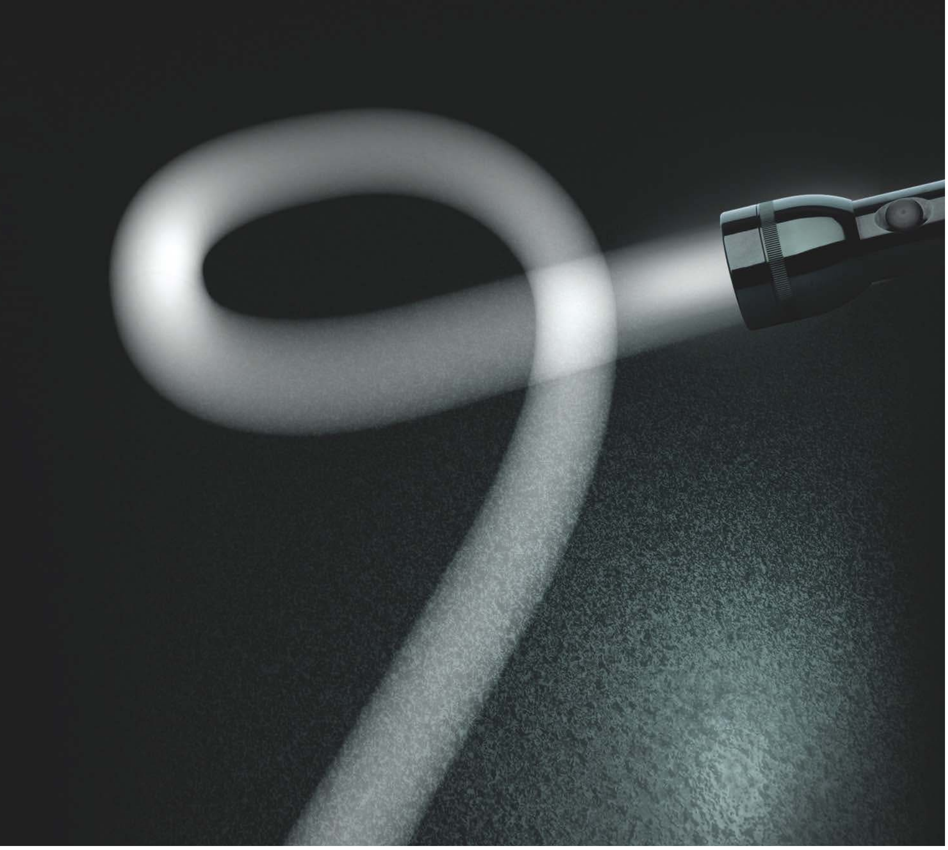

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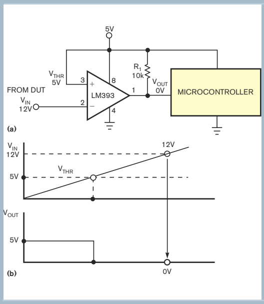

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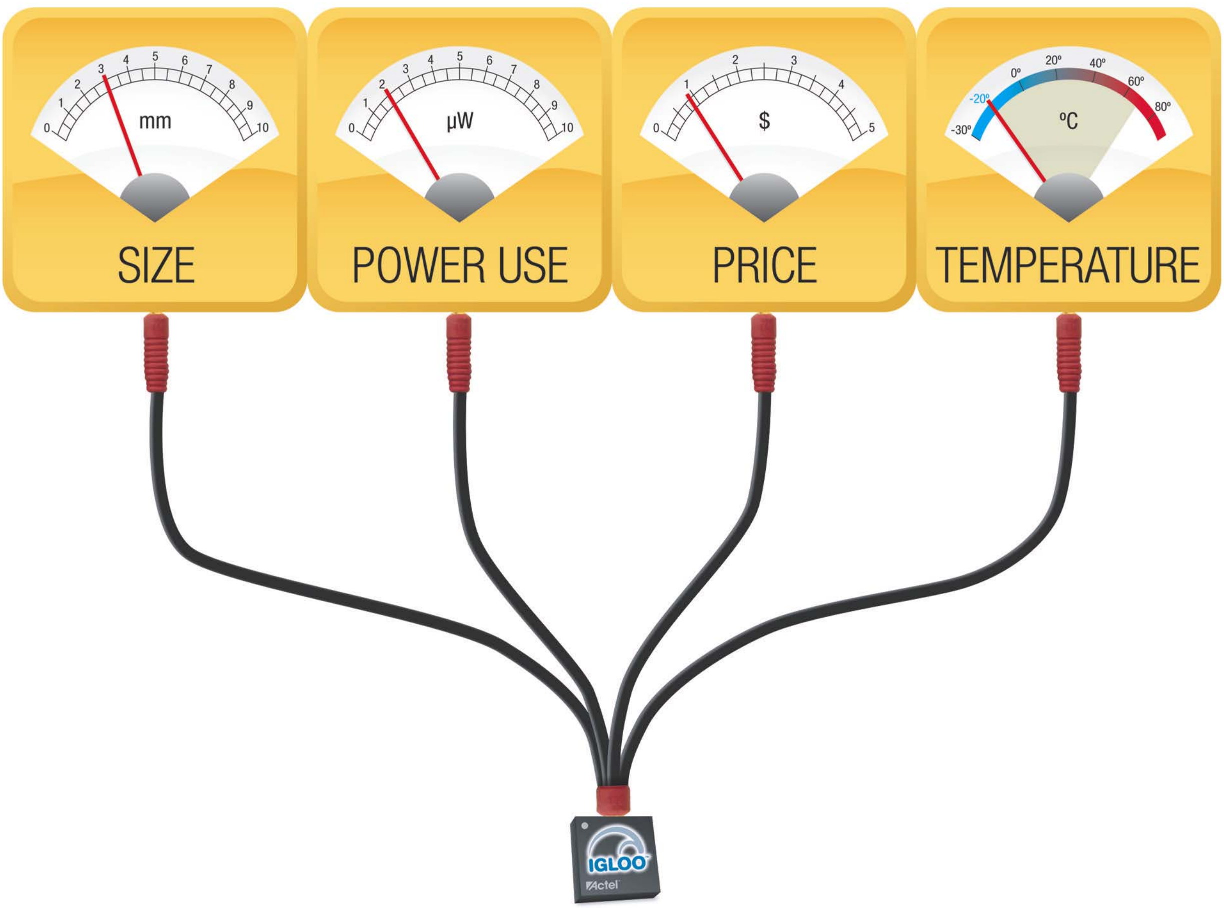

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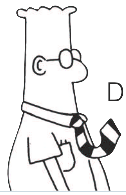

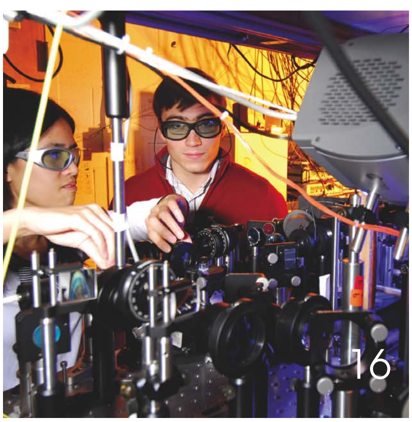

DEPARTMENTS & COLUMNS

PRODUCT ROUNDUP

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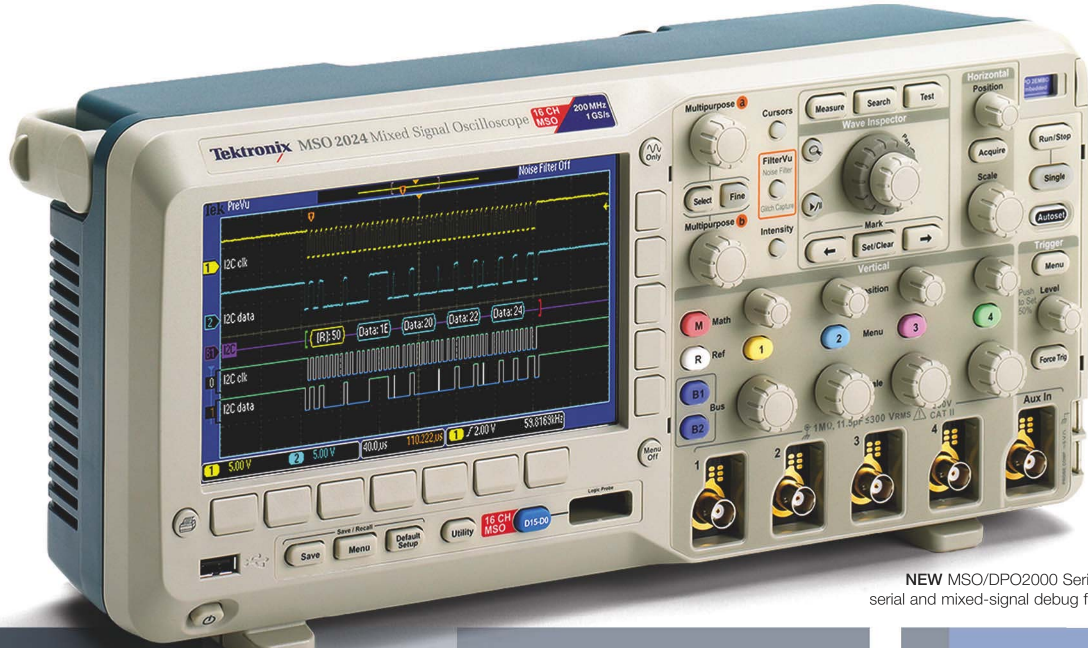

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DPO3000 Series

Bandwidth	100 MHz to 500 MHz
Analog Channels	2, 4
Digital Channels	—
Record Length	5 M on all channels
Display	9.0 inch
Serial Bus Trigger and Decode	I²C, SPI, RS-232/422/485/UART, CAN, LIN

NEW! MSO2000/DPO2000 Series

Bandwidth	100 MHz to 200 MHz
Analog Channels	2, 4
Digital Channels	16 (MSO2000 Series)
Record Length	1 M on all channels
Display	7.0 inch
Serial Bus Trigger and Decode	I²C, SPI, RS-232/422/485/UART, CAN, LIN

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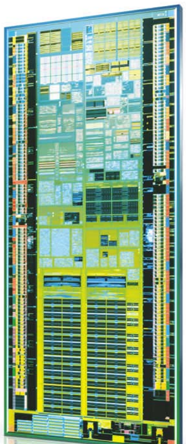


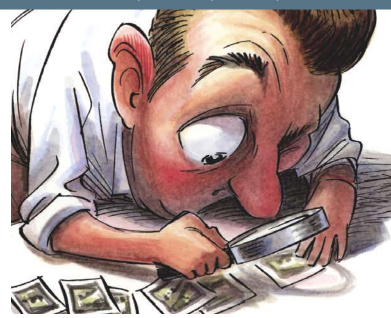
The price of falling prices and a path to Intel's potential demise
Atom is a short-term success, but does the netbook trend represent a long-term threat to Intel's beefy revenue and profit margins—as well as a potential salvation for graphics-processor makers?
→www.edn.com/article/CA6627620

EDA CEOs waltz on the tilting deck
Leading executives as part of an EDA Consortium panel discussion did their best to display necessary optimism in the face of dismal economic conditions.
→www.edn.com/article/CA6629903

Leaded parts still in high demand
The aerospace and defense industries are scouring the market for leaded parts.
→www.edn.com/article/CA6630671

Electronic virtualization for the US auto industry: Is survival in the balance?
Automotive companies that embrace a leading-edge system- and software-development methodology based on electronics virtualization have addressed one of the key success factors to their survival, argues VaST Chief Technology Officer Michael Paczan.
→www.edn.com/article/CA6630338

A LOOK AT GLOBAL COMPENSATION AND JOB SATISFACTION
Engineers worldwide reported varying levels of job satisfaction as their salaries struggle to keep pace with inflation, according to a comprehensive *EDN* study of career trends among electronics engineers. In addition to tracking salary trends, the survey asked questions on topics such as global-design-team communication, critical skills in today's work environment, and the impact of outsourcing.
→www.edn.com/article/CA6608539



READERS' CHOICE

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

A bad-capacitor story ends happily
When the same capacitor ends up charred in too many systems to dismiss the failures as statistically probable, an engineer must approach the problem using old-fashioned layout inspection.
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Low-power-wireless performance starts with CMOS elegance
→www.edn.com/article/CA6626088

Blu-ray's continued struggles and the ramping ascendancy of online
→www.edn.com/article/CA6627924

The Hot 100 Electronic Products of 2008
→www.edn.com/article/CA6622869

MIT researchers claim 50% increase in solar-cell output
→www.edn.com/article/CA6625447

Bulb within a bulb protects and hides CFL spiral
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BY BRIAN DIPERT, SENIOR TECHNICAL EDITOR

OLEDs: better off once the delusion is dead

When fiscal times get tight, R&D budgets fade. I realize that, at first glance, this statement seems elementary and obvious. However, you may be surprised by how quickly those with a vested interest in finding exceptions to the rule can rationalize them.

How does this relate to OLEDs (organic light-emitting diodes)? The technology is still largely in the R&D realm, with a few low-volume-production exceptions. Yet, Samsung in December forecast that, once everyone had purchased an LCD TV, the company would be able to upgrade consumers to OLED-based displays. The very next day, Sony announced massive layoffs and budget cutbacks.

Sony is the same company that in late September 2007 introduced and, at the subsequent CES (Consumer Electronics Show), showcased an 11-in., $2500 OLED TV that it managed to get into limited production—an OLED TV that quickly ended up in Sam's Club's bargain bin precisely because it was minuscule, expensive, and power-hungry. In addition, the TV's screen had a short life span.

So, Samsung, which hasn't yet brought an OLED TV to market, thinks it will move the world from LCD to OLED in a few years. And Sony, which has brought an OLED TV to market, is rapidly retrenching, especially in risky technology areas.

I've always found the LCD-killer aspirations of OLED supporters to be a fool's delusion. On the one hand, I understand them: Televisions, standalone computer monitors, and laptop-inclusive displays collectively compose a huge amount of LCD volume each year, and snagging even a small percentage of that business is nothing to sneeze at. When I try to think of what might motivate an LCD customer to seriously consider a switch to OLED, however, I draw a blank.

Self-illuminated OLEDs could have had a slender chance in the CCFL (cold-cathode-fluorescent-lamp)-backlight era. One may make a credible argument that CCFLs, although a low-cost and proven technology, were too thick, too power-hungry, or too uneven in their illumination to keep up with evolving high-volume computer- and TV-display requirements. But fast-ramping and cost-effective LED backlights make tangible—and more than sufficient—improvements in all of these areas.

Don't get me wrong. Plenty of applications for OLEDs do exist, which, for example, require screens so small that it'd take an innumerable volume of them to fill a single LCD glass plate. Applications exist for which any backlight thickness—or, for that matter, incremental power consumption—would be a deal killer, or at least a major hassle to design around. Applications exist that can exploit OLEDs' flexibility and other unique attributes. And applications—consumer electronics, for example—exist that can tolerate OLEDs' limited lifetimes.

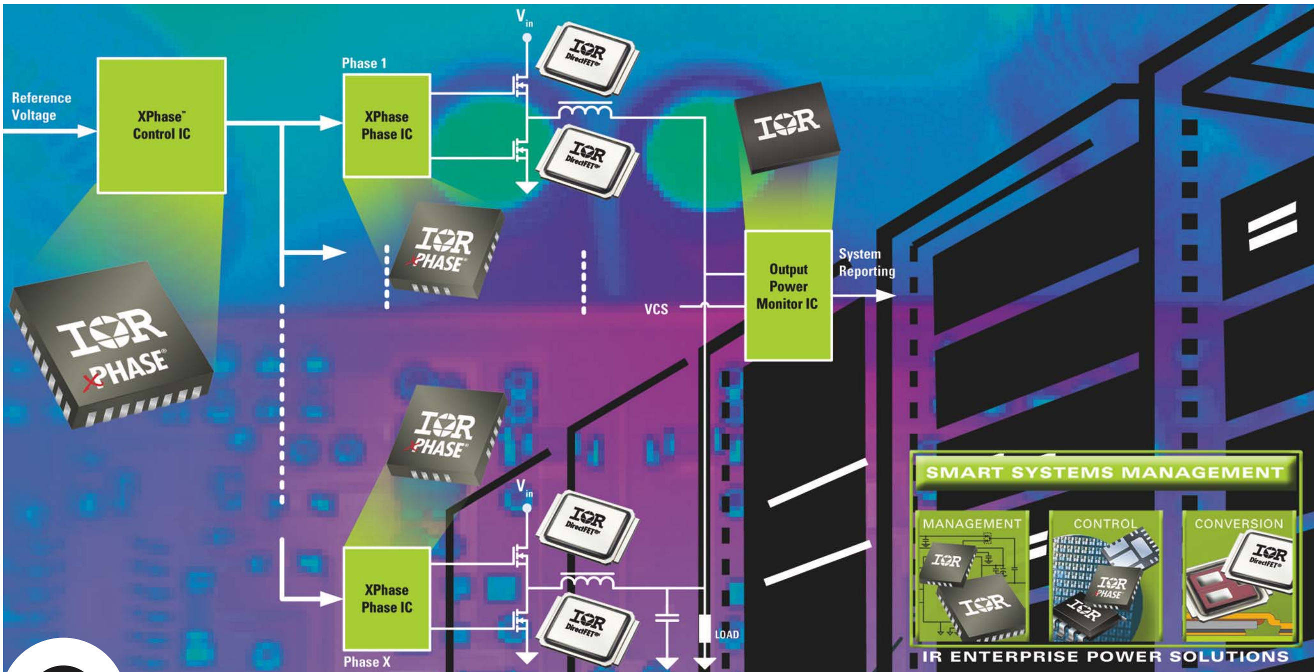
A historical analogy: From the beginning of flash memory's life in the mid-1980s, pundits proclaimed the pending demise of DRAM. After all, flash memory's single-transistor structure rendered it even more lithography-scalable than DRAM's transistor-plus-capacitor combo, and, unlike DRAM, flash memory was nonvolatile. However, flash memory's low write speeds, even lower erase speeds, lack of per-bit erase capability, and not-unlimited erase-cycle counts were deal killers.

History proved the more conservative stance but only after a lot of time, money, and manpower were spent foolishly chasing after the DRAM-killer dream. Flash memory did end up clobbering EPROM and mask ROM, arguably due to the volume-boosting assistance of two unstable software applications: PC-power management and the GSM (global-system-for-mobile)-communications digital-cellular protocol. But the bulk of flash memory today sells into mass-storage applications tailored to its strengths and able to deal with flash's shortcomings.

The initial hype for OLED is already deflating and will continue to do so. Slowly but surely, OLED-optimal applications will emerge and ramp, and additional OLED volume will come from applications that LCD vendors consciously choose to exit. It's conceivable that LCD-glass-economics trends will eventually translate into panels that are too big for most potential customers' needs, thereby prompting a widespread OLED conversion. But don't hold your breath waiting for that day to come anytime soon. **EDN**

Contact me at bdipert@edn.com.

+ Go to www.edn.com/090205eda for a more in-depth discussion of this topic.



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IRF6795MPBF	DirectFET MX	25	20	1.4	2.4	35
IRF6797MPBF	DirectFET MX	25	20	1.1	1.8	45

Power Monitor ICs

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IR3721MTRPBF	Analog	10 L 3x3 DFN	2.5% @ 65°C	0.5V - 1.8V	+3.3V +/- 5%	0 °C - 125 °C
IR3720MTRPBF	Digital	10 L 3x3 DFN	3.3% @ 85°C	0.5V - 1.8V	+3.3V +/- 5%	-10 °C to 150 °C

XPhase™ Phase ICs

Part Number	Package	PSI Capable	Switching Frequency	VccL, max
IR3507MPBF	20L 4x4mm MLPQ	Yes	250KHz - 1.5MHz	8V

XPhase™ Control ICs

Part Number	Package	PSI Capable	Processor type	System Accuracy
IR3514MPBF	40L 6x6mm MLPQ	Yes	AMD® PVID/SVID	0.5%
IR3502MPBF	32L 5X5 MLPQ	Yes	INTEL® VR11.0, VR11.1	0.5%

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INNOVATIONS & INNOVATORS

Regulated charge pump delivers 30 mA at 5V

IC maker austriamicrosystems has released the AS1302 inductorless dc/dc boost converter, which can deliver output currents as high as 30 mA from a voltage input of 2.9 to 5.12V. The output-voltage regulation is 3%. The part operates at a 1.2-MHz switching frequency and provides low-noise operation with low input and output ripple voltages. Under light-load conditions, the device operates at 49 kHz for better efficiency. It provides 99% efficiency in the 1-to-1 mode and better than 90% efficiency in 1-to-2 or 2-to-3 boost ratios for the charge-pump section. The linear-output-regular section of the part causes a loss depending on the voltage across it and the current thorough it. In the 1-to-2 boost mode with a 2.9V input, the device delivers 30 mA with 85% efficiency. In the 2-to-3 boost mode, the part delivers 30 mA from a 3.8V input, also with 85% efficiency.

To deliver full current, you can use the part with two 220-nF flying capacitors and two 220-nF bypass capacitors. Commensurately smaller capacitors can supply smaller loads. The device's shutdown quiescent current is 10 nA in a mode in which the output is fully disconnected from the input and 1 μA otherwise. The AS1302 includes built-in undervoltage-lockout, short-circuit, and thermal-protection circuitry.

The AS1302 charge pump comes in a minuscule chip-scale package.

Because the AS1302 provides a regulated output, you can use it to boost the voltage of two AA cells or a single lithium-ion cell to 5V. Because the device uses no inductors, boost conversion generates less EMI (electromagnetic interference). The device's compact size and thickness make it suitable for use in portable electronics.

The AS1302 comes in 1.2×1.2-mm WL-CSP-8 and 3×3×0.8-mm 10-pin TDFN packages, operates in the −40 to +85°C industrial-temperature range, and sells for 49 cents (1000).**—by Paul Rako**

▷**austriamicrosystems**, www.austriamicrosystems.com/dc-dc-step-up-converters/as1302.

FEEDBACK LOOP

"Zero-operand addressing and dataflow architectures are good fits for stack machines. And they don't need pipelines—an uglification. Or branch predictors—another uglification. And, because of their simplicity, you don't need a billion dollars to design a processor. You don't need clock trees. Power management is handled by turning off unused hardware automatically. Oh yeah. One other thing you don't need: Intel."

—Designer and *EDN* reader M Simon, in *EDN*'s Feedback Loop, at www.edn.com/article/CA6627620. Add your comments.

Embedded module simplifies local networking

Connect One's new Nano LANReach embedded-LAN module easily connects any embedded device to 10/100BaseT LANs with minimal programming. Measuring only 2.5×3.5 cm, including a built-in RJ-45 connector, the Nano LANReach offers plug-and-play serial-to-LAN functions with a full suite of Internet protocols, applications, and security engines. Nano LANReach offers the latest Internet SSL (secure-sockets-layer) encryption algorithms and uses the same pinout as the Nano WiReach Wi-Fi module, allowing one PCB (printed-circuit-board) design to support either LAN or Wi-Fi connectivity.

The module operates at an industrial-temperature range of −40 to +85°C (−40 to −185°F) and complies with ROHS (restriction-of-hazardous-substances) directives. Prices for Nano LANReach start at $38.**—by Warren Webb**

▷**Connect One**, www.connectone.com.

The Nano LANReach module simplifies network integration with plug-and-play capability and a full suite of Internet protocols, applications, and security engines.

$695 board offers 16 isolated differential-analog inputs, two isolated analog outputs

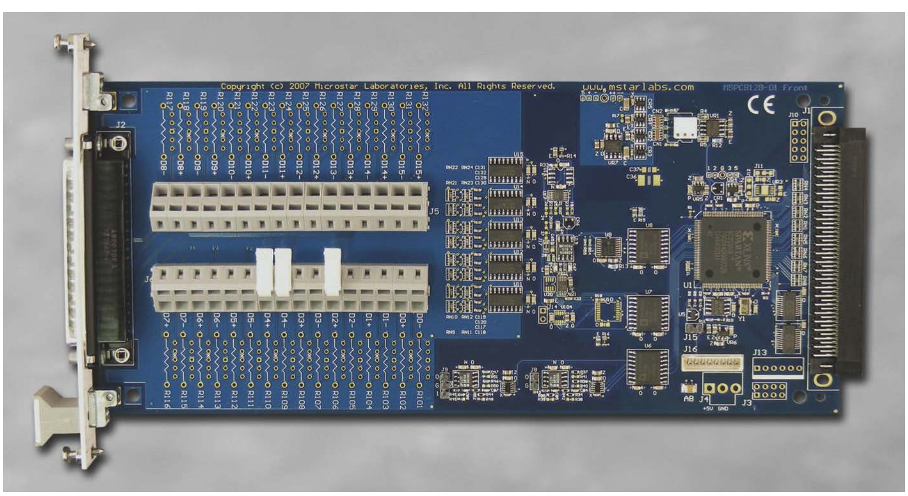
Microstar Laboratories, maker of DAP (Data-Acquisition Processor) boards and network-ready DAPservers, recently announced the MSXB 085 isolated analog expansion and termination board. Each board provides 16 isolated analog inputs and two isolated analog outputs. All inputs are differential, with onboard 16-bit data conversion to minimize exposure to noise elsewhere in the system. The board can sample signal inputs at 333k samples/sec and can update both analog-signal outputs at 500k updates/sec. A DAP board can support as many as eight MSXB 085 boards.

MSXB 085 boards fit into a backplane in a standard industrial enclosure, as do other signal-conditioning products that conform to the external-hardware specifications of the Microstar channel architecture: Signal connectors are on 3U, 100-mm-high, 220-mm-deep Eurocard B boards, which often preprocess signals. Signals connect to a DB37 male connector or to Wago (www.wago.us) connectors. A backplane connector on each board connects it to a digital backplane that is factory-fitted into the industrial enclosure. An interface board, which also plugs into the backplane, sends digitized waveforms to a DAP board that you control from a PC or a DAPserver. MSXB 085 boards also fit directly into DAPservers to form networked, isolated instruments. If your application requires isolated digital inputs and outputs in addition to the MSXB 085 boards' isolated analog inputs and outputs, you can add MSXB 078 boards. If your application requires additional isolated analog outputs, you can add MSXB 076 boards.

DAP boards make a robust platform for high-performance data-acquisition and -control systems. PCs and rack-mountable DAPserver-system packages each can contain and control more than one DAP board. Every DAP board includes an onboard processor running a real-time operating system. Windows applications that support DLL (dynamic-link-library) calls can control DAP boards by communicating with this onboard operating system. You can control a DAP board from DAPstudio—a Windows application from Microstar—as well as from third-party or your own software. You can perform this function from any PC that communicates with the DAP board over a network. In smaller systems, you can connect a DAPserver to any PC that provides an Ethernet connection, or you can attach a keyboard and screen to the DAPserver and control it directly using factory-preloaded software.

The MSXB 085 targets applications that involve several analog inputs and a smaller number of analog outputs in which the signals require isolation to protect them from noise and individual signal grounds to protect against ground currents. You can install the boards either in an industrial enclosure that you connect to a PC-controlled DAP board or directly in a DAPserver that contains one or more DAP boards, thereby forming a single-package, network-ready isolated instrument. To control the DAP boards, you can use DAPstudio or other Windows software on any networked PC. You can download an unrestricted evaluation version of DAPstudio. To try all of the software package's features, you need a DAP board, which Microstar provides free for evaluation purposes. Prices for the MSXB 085 board start at $695.**—by Dan Strassberg**

▷**Microstar Laboratories**, www.mstarlabs.com.



The $695, 3U MSXB 085 Eurocard provides 16 differential, galvanically isolated analog inputs and two galvanically isolated analog outputs. The unit performs 16-bit-resolution analog-to-digital conversions at 333k samples/sec and 16-bit-resolution digital-to-analog conversions at 500k updates/sec.

DILBERT By Scott Adams

Module offers seven-year production support

Targeting high-performance applications in medical imaging, gaming, test, and industrial automation, Adlink Technology recently announced the ETX-AT single-board computer as the newest member of its COM (computer-on-module) family. The company based the module, which measures 3.7×4.9 in., on the ETX (embedded-technology-extended) 3.02 form-factor standard, which the ETX Industrial Group (www.etx-ig.org) maintains. Power consumption of less than 10W makes the ETX-AT suitable for fanless or deeply embedded systems.

The module features the 45-nm Intel (www.intel.com) Atom Processor N270 with 512 kbytes of L2 cache, and it supports as much as 2 Gbytes of DDR2 memory on a single SODIMM. The Mobile Intel 945GSE Express chip set integrates the Intel 950 graphics-media accelerator, which provides CRT and standard- and high-definition TV-output signals, and it also supports single- or dual-channel LVDS (low-voltage-differential signaling). The module also incorporates an Intel-based 10/100BaseT Ethernet port and provides two parallel ATA (advanced-technology-attachment) channels, a dual-port SATA (serial-ATA) controller, four USB (universal-serial-bus) 2.0 ports, two serial ports, one parallel port, one PS/2 keyboard/mouse interface, and Intel high-definition audio.

> An optional solid-state drive provides as much as 4 Gbytes of IDE-based bootable flash storage.

You can optionally equip the ETX-AT with a solid-state drive that you solder onto the module to provide as much as 4 Gbytes of IDE (integrated-drive-electronics)-based bootable flash storage. The module comes with support packages for Windows XP, Windows XP Embedded, Windows CE, Linux, and VxWorks. Single-unit prices for the ETX-AT start at $300. The revision-controlled ETX-AT targets applications that require guaranteed long production-life support.

—by Warren Webb

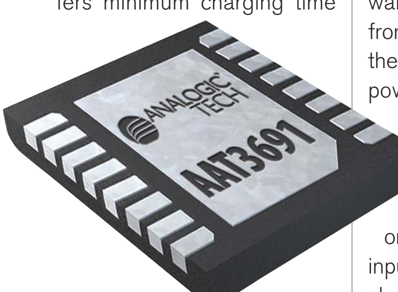
▷**Adlink Technology**, www.adlinktech.com.

Dual-input charger IC operates from USB or wall adapter

Advanced Analogic Technologies has introduced the AAT3691 dual-input battery-charger IC with overvoltage protection to 28V with a response time of less than 1 μsec. The IC assesses which input source offers minimum charging time and modifies the charge path accordingly. It can operate from ac-adapter inputs and USB (universal-serial-bus) ports across a 3 to 6.75V range. You can choose external resistors to set charge current as high as 1.6A from the wall-adapter input and 0.5A from the USB input. Whenever the wall-adapter or USB input power exceeds 6.75V, an internal series switch opens, preventing damage to the battery or charging circuit. The power path's on-resistance is 600 mΩ. An input feature lets you suspend charging if no cell is present and protects the circuit from defective battery traces or connectors. Safety features include thermal shutdown protection, power-on reset, and soft start.

The AAT3691 regulates battery-charge voltage and current for 4.2V lithium-ion battery cells in a variety of portable-system applications, such as mobile phones, digital still cameras, and other handheld devices. Because the device incorporates its own overvoltage protection, you need not add this feature externally, reducing space requirements in space-starved handheld-system applications. The AAT3691 comes in a 3×4-mm 16-pin TDFN package, operates in the −40 to +85°C industrial-temperature range, and sells for $1.12 (1000).**—by Paul Rako**

▷**Advanced Analogic Technologies**, www.analogictech.com.



The AAT3691 battery-charger IC charges lithium-ion cells from either a wall adapter or a USB port.

NONMAGNETIC-CONNECTOR FAMILY SUITS MRI EQUIPMENT

MRI (magnetic-resonance imaging) uses a powerful magnetic field to create an image of what's happening under a patient's skin. Because of these magnetic fields, the components within the MRI scanner must be nonmagnetic, such as those in new connectors from Phoenix of Chicago. The company's connectors protect signals from magnetic-field distortion in MRI equipment to ensure that scans are not compromised. Phoenix tests the connectors' magnetic characteristics at 1.00010 μ_r (relative permeability). The connectors are available in snap-on, push-on, or threaded couplings and in low- to high-frequency bands. Their price ranges from $2 to $12.

—by Margery Conner

▶**Phoenix Company of Chicago, www.phoenixofchicago.com.**

Nonmagnetic connectors help to ensure distortion-free images in MRI equipment and any industrial application requiring connector metals to be high-purity, noncorrosive, and lightweight.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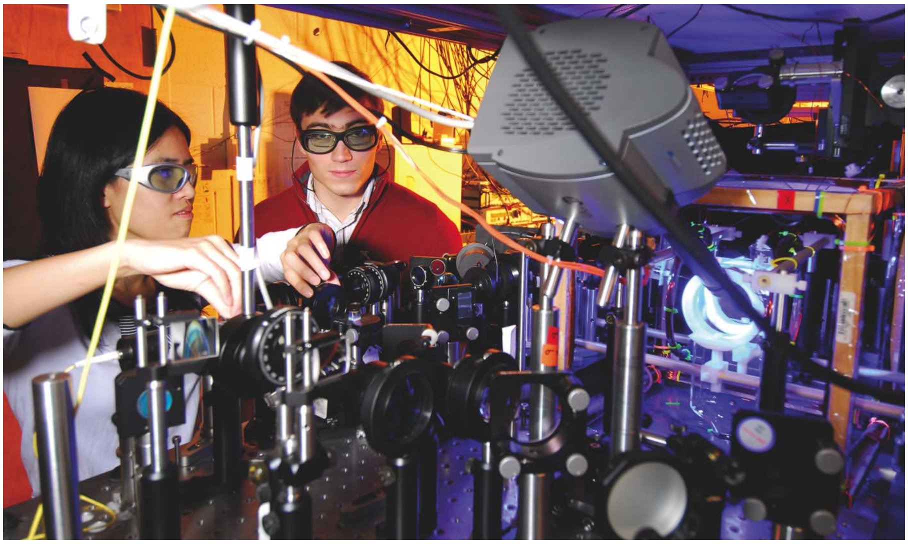

Ran Zhao and Yaroslav Dudin, graduate students in the Georgia Tech School of Physics, adjust optics in a system for studying quantum memory.

RESEARCH UPDATE

BY RON WILSON

Researchers advance quantum-memory-retention time

Researchers at the Georgia Institute of Technology have announced a significant advance in the retention time of multiatom quantum-memory devices—from a previous maximum of 32 μsec to 7 msec. The significance of the advance is that, with retention time of milliseconds, a bit in quantum memory now lasts longer than the time it would take a photon to travel through 100 km of optical fiber from one repeater to another in a long-range quantum network. Quantum networks function by distributing entangled quantum qubits between two repeaters, so modifying the qubit on one end modifies it on the other end, as well.

The Georgia Tech team based its quantum memory on supercooled rubidium-87 atoms. The team arranged the atoms so that arriving light would imprint its phase information on the array. The challenge then was to keep the atoms stable long enough for a laser read-beam to recover that phase information milliseconds later. This task required two approaches.

First, the researchers contained the rubidium atoms within an optical lattice of laser beams. This step significantly reduced the scope of the already-slowed random motion of the atoms by biasing them toward specific positions in the lattice. Second, by pumping the atoms to what is called the clock-transition state, in which the atoms are relatively insensitive to external magnetic fields, the researchers reduced another potential source of disruption. The result was a set of atoms that stayed near their initial position long enough to preserve the phase information they had received from the incoming light.

Researchers emphasized that, although this advance is both necessary and significant, we are still at least a decade away from a quantum network that can operate outside a laboratory environment.

▷**Georgia Institute of Technology**, www.gatech.edu.

GERMANIUM-ON-INSULATOR MATERIALS HAVE HIGH HOLE MOBILITY

As device designers look beyond 22 nm, it is becoming clear that we are simply running out of carrier mobility. Strain engineering has helped a lot. By applying physical strain to the channel of a MOSFET, you can significantly increase the carrier mobility–enough at even 45 nm to make up for many of the other shortcomings of the device and end up with reasonable current. But many researchers now agree that, at some point, we will have to abandon silicon channels and move to a material with higher carrier mobility.

For holes, the most likely suspect today appears to be germanium, which has a higher intrinsic hole mobility than silicon. Engineers have begun to integrate germanium into CMOS processes–ironically enough, as a way to apply strain to silicon channels. Researchers are also exploring the process implications of forming transistor channels from germanium at small geometries, however.

That fact makes a recent report by IMEC (Interuniversity Microelectronics Center) an item of importance. IMEC researchers reported recently that they had fabricated SiGe (silicon-germanium) films on an SOI (silicon-on-insulator) substrate by a process of condensation. Specifically, the researchers created a SiGe film by epitaxial growth on the SOI. Then, in successive steps, they selectively oxidized the silicon atoms out of the lattice to obtain higher germanium concentration and annealed the resulting, thinner film. The result was a pure-crystal structure and high hole mobility–about twice what other researchers had reported for similar thicknesses of normal SOI material.

▶Interuniversity Microelectronics Center, www.imec.be.

RAQ's

Rarely Asked Questions

Strange stories from the call logs of Analog Devices

Contributing Writer Rob Reeder is a senior converter applications engineer working in Analog Devices high-speed converter group in Greensboro, NC since 1998. Rob received his MSEE and BSEE from Northern Illinois University in DeKalb, IL in 1998 and 1996 respectively. In his spare time he enjoys mixing music, art, and playing basketball with his two boys.

Are Your Filters Filtering?

Q. Why is my A/D converter's anti-aliasing filter showing inadequate spurious and noise rejection?

A. It is important to realize that an A/D converter's internal front-end bandwidth, sometimes referred to as full power bandwidth, can be very wide, even if the A/D converter is "slow." The converter needs bandwidth on the internal front-end in order to settle in time for the next sample, preserving the information the designer is trying to capture and represent digitally.

An anti-aliasing filter (AAF) typically precedes the A/D converter and can vary from a simple single-pole RC network to complicated multi-pole topology. In either case the idea is the same, to remove unwanted noise and spurs that can fold back, or alias, into the frequency band of interest. Designers should use caution when building or using an AAF. It is important to understand not only the band of interest (pass band), but the out-of-band (stop-band) rejection of the filter design.

The stop-band should continuously reject unwanted frequencies well beyond the converter's analog internal front-end bandwidth (e.g. ADC sample rate is 100MSPS, input bandwidth is 1GHz; AAF must reject frequencies up to 1GHz, not Nyquist (50MHz)!). Otherwise, if the stop-band frequency response begins to rise, it will create a second pass-band region within the filter design. If this second pass-band region—in the assumed stop-band—is still within the converter's analog internal front-end bandwidth, then it could allow unwanted noise and spurs to fold back into the real band of interest.

To get around this, it's important to understand the filter design, both in and out of band. Check the converter's datasheet to understand its input bandwidth as well. Some filters, such as elliptical, Chebyshev and multi-stage topologies, are more susceptible to inadequate stop-band rejection than others. Understand this before choosing a specific filter design. Adding a couple of additional components on the last stage of the AAF to create a simple low pass filter can help. The trade-off, however, is more components and additional attenuation through the band of interest.

One way to guard against such a problem is to measure the frequency response of the filter.[1] Measuring the frequency response shows the amplitude outline of the filter's response and attenuation. Measuring the filter's frequency response well beyond the band of interest and the converter's internal front-end bandwidth will indicate how the filter's stop-band region is performing.

For additional information on filters, topologies, and AAF, click on the links below.

1 AN-835 - Understanding High Speed ADC Testing and Evaluation.

To Learn More About A/D Converters
http://designnews.hotims.com/23091-101

Have a question involving a perplexing or unusual analog problem? Submit your question to: china.support@analog.com

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ANALOG DEVICES

BY HOWARD JOHNSON, PhD

Unified electrodynamic force

Fire two charged particles at the same moment, with the same initial velocity, into a perfect vacuum (**Figure 1**). The two particles, having the same electric charge, repel one another. This repelling electric force, *F*, makes the particle tracks diverge.

Given the magnitude of the electric force and the masses and internal velocities of the particles, you can, if you know a little college physics, predict the rate of divergence—but you'd be wrong. The actual particle tracks diverge at a slower rate than electric-field considerations alone predict.

If French physicist and mathematician André-Marie Ampère were alive today, he would explain the diminished divergence as the result of magnetic forces. Ampère's laws describe a mechanical force that pulls together parallel wires carrying current in the same direction. Simplified to the case of only two charged particles moving in space, the pull of Ampère's magnetic force partly counteracts the electric repulsion to produce the actual trajectories shown in **Figure 1**.

Case closed? Hardly. Follow me to the next level.

Place yourself in a chair moving alongside the two particles. From your perspective, as the electron guns recede leftward, the two particles appear stationary. The only movement you perceive is their gradual vertical divergence. From your perspective, the particles have no horizontal motion, so there is no magnetic force. From your perspective in the chair, the particles diverge at a rate that solely their electric-field interactions determine.

Yet, from my perspective standing on the ground beside the electron guns, a magnetic force indeed seems to exist, and it slows the divergence of the two particles. Which of us is right?

The key to this paradox may shock you because it sounds like the theme of a science-fiction novel: My time and your time are different. Your velocity induces a tiny dilation of your scale of time relative to mine. From my perspective, that time dilation slows your predicted rate of divergence just enough so that your rate precisely matches mine.

In this experiment, the choice of reference frame modulates the existence of the magnetic force. You can turn it on or off depending upon where you stand or sit. It is therefore not a "real" force. It is nothing more and nothing less than a direct consequence of Einstein's theory of relativity.

Standing on the ground observing the experiment, I can view the result in three ways:

- using the reference frame of your chair, computing a purely electric-field interaction, and adjusting the results to account for the relativistic time dilation between us;
- accepting at face value Ampère's fictional magnetic force as apparent from my perspective; or
- in full realization that only one force, the electric force, is in play, with its magnitude modified according to the relative velocities of the particles and observers involved.

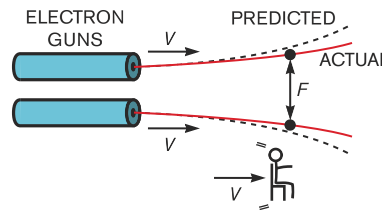

Figure 1 The electric force between two charged particles makes their trajectories diverge.

Reference 1 outlines the third method. It makes interesting reading for those ready to embrace the full brilliance of relativity and the true meaning of the unified electrodynamic force. The treatment is highly mathematical.

The characterization of magnetic force as a relativistic effect in no way diminishes the importance of magnetic-field calculations in ordinary circuits. The magnetic-field illusion is an extremely useful means of understanding and designing all sorts of things—from motor-generators to high-speed transmission lines. **EDN**

REFERENCE

1 Fukai, Junichiro, *A Promenade Along Electrodynamics*, Vales Lake Publishing, 2003.

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.

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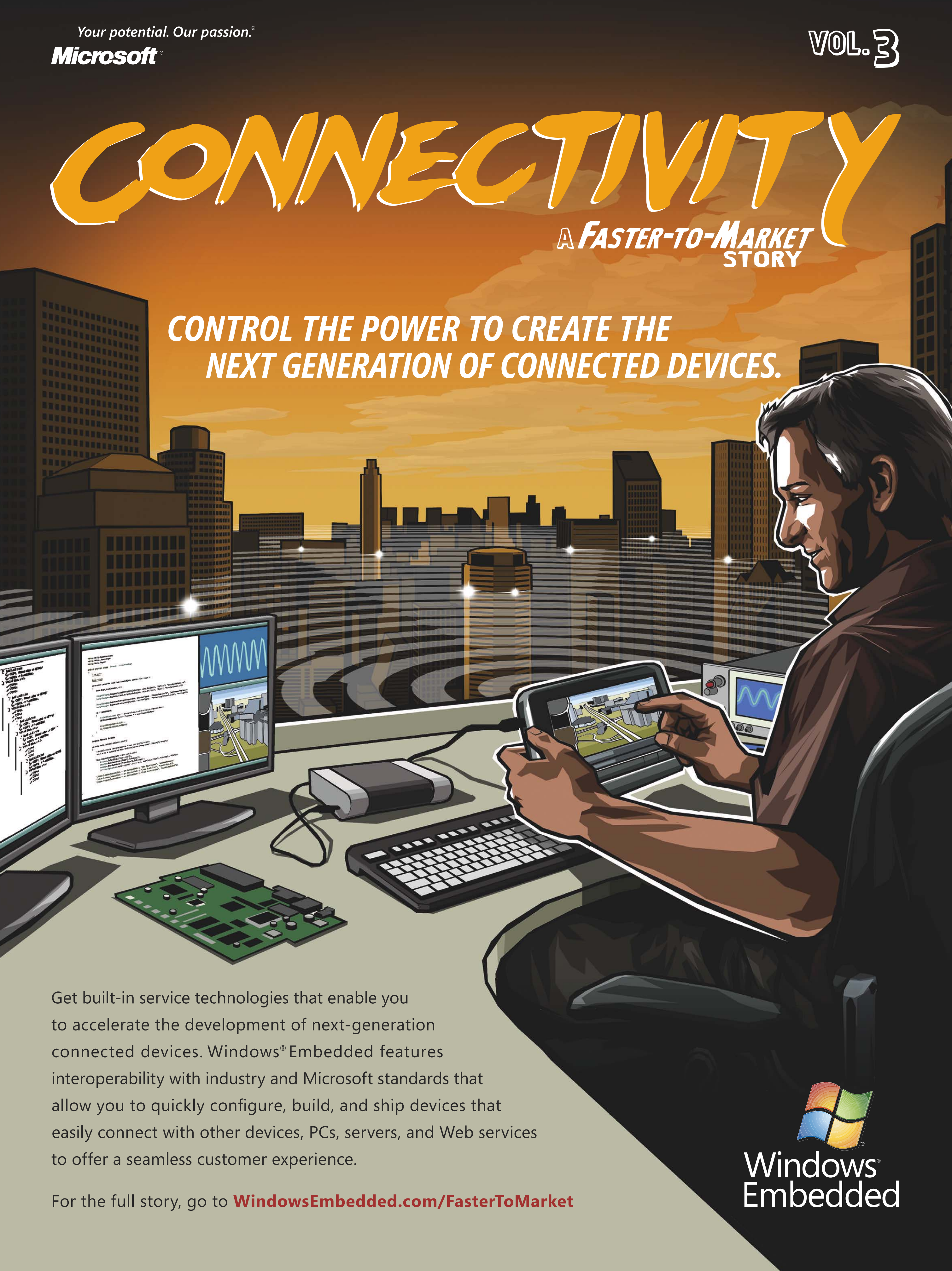
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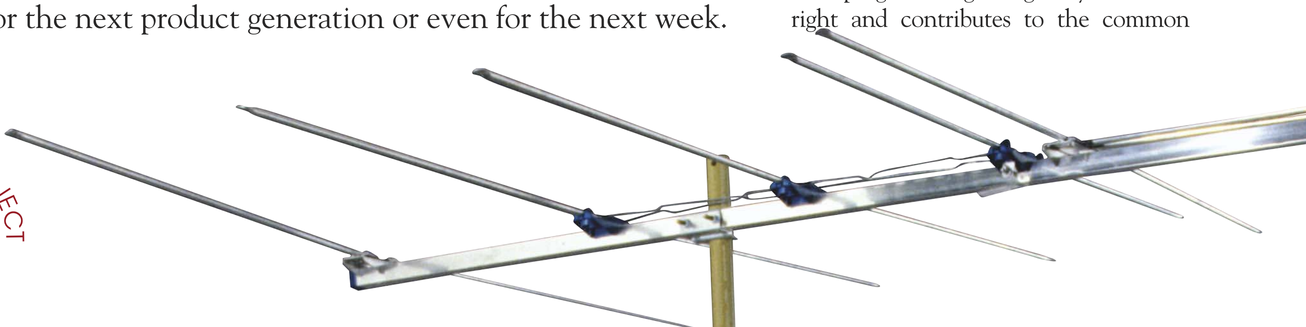
EDN HANDS-ON PROJECT

THE ATSC COUPON-ELIGIBLE CONVERTER BOX:

A CONSUMER-ELECTRONICS CASE STUDY

BY BRIAN DIPERT • SENIOR TECHNICAL EDITOR

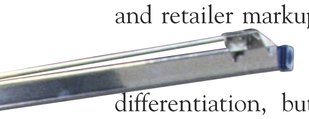
THE PENDING NTSC SHUTOFF HAS US CONSUMERS CLAMORING FOR REBATE-ELIGIBLE HARDWARE THAT WILL STAVE OFF THE LOSS OF OVER-THE-AIR TELEVISION. HOW DO MANUFACTURERS DISTINGUISH THEMSELVES FROM OPPONENTS IN SUCH A HYPERCOMPETITIVE MARKET?



No segment of the electronics industry is immune to competition, but skirmishes in the consumer-electronics segment are arguably among the bloodiest. Scant per-unit profit margins are the norm, not the exception, and, therefore, manufacturers rely heavily on robust volume shipments as the path to fiscal triumph. The difference between a runaway success and a never-left-the-runway failure sometimes hinges on the slimmest of feature, price, and other differentiators, and potential customers' notorious fickleness is no guarantee that what works today will continue to appeal for the next product generation or even for the next week.

Take CECBs (coupon-eligible converter boxes), for example. The intent of the US-government-funded CECB program is to ensure that individuals without access to alternative television services, such as cable, satellite, or IPTV (Internet Protocol television), and lacking the funds necessary to purchase a full-featured ATSC (Advanced Television Systems Committee) set-top box or ATSC-supportive television can still access over-the-air, "free"—that is, advertising-supported—television. Access to such programming is arguably a citizen's right and contributes to the common good by virtue of the broadcast of emergency alerts, government policy sessions, election debates, and the like.

CECBs whose retail price comes close to—or matches—the $40-per-coupon, at two coupons per request, government-rebate amount translate to a free or nearly free end-customer expense. Perhaps not surprisingly, those CECBs will likely constitute the lion's share of all CECB sales. The $40 price needs to comprehend not only BOM (bill-of-materials), development, and manufacturing costs, but also shipping and warehousing expenses, along with distributor and retailer markups. With these criteria, there's seemingly no opportunity for differentiation, but creative engineers and their marketing counterparts have nonetheless still managed to create a diverse product smorgasbord. How? Four products provide case-study examples.



A PROGRAM BACKGROUNDER

The CECB program aims to provide continued broadcast-television reception for those who, for geographic or financial reasons, cannot access alternative TV services or purchase full-featured ATSC-cognizant gear. In developing the program, the US government strove to avoid excessively burdening the taxpayers who finance it (**references 1** and **2**). According to the NTIA (National Telecommunications and Information Administration) program-managing organization, CECBs cannot offer high-definition video-output capabilities; this constraint disallows HDMI (high-definition-multimedia-interface), DisplayPort, DVI (digital-visual-interface), RGB, and component-video outputs. It even disallows the 480p (480-line progressive-scan) video mode, as well as digital audio or greater-than-two-channel analog-audio outputs. CECBs also cannot support encryption-free

AT A GLANCE

- Given a free or nearly free after-rebate target, design engineers and their marketing partners have multiple paths to potential success.
- Even considering the NTIA's (National Telecommunications and Information Administration's) stringent list of dos and don'ts necessary for CECB (coupon-eligible-converter-box) certification, several companies have discovered differentiation possibilities through hardware, software, or both.
- Single-chip integration doesn't necessarily translate to design superiority, especially in non-space-constrained applications and when you factor in costly heat sinks.
- The designs in this article don't indicate strong endorsements for silicon tuners' claimed abilities to deliver tangible benefits over their "can" predecessors.

Figure 1 Multiple paths to a $40–or $40.01–retail price point include Access HD's DTA-1080D (a), Apex Digital's DT502 (b), Dish Network's TR-40 CRA (c), and Sansonic's FT-300A (d). Sansonic's retail partner, Meritline, even included an Artec AN2 antenna (e).

TABLE 1 CECB KEY SPECIFICATIONS

Product	After-rebate price	Chassis construction	Dimensions (width ×height×depth) (in.)	Bundled accessories
Access HD DTA-1080D	1 cent	Plastic	5×1.25×5.25	User manual, coaxial cable, remote control and batteries, wall wart
Apex Digital DT502	1 cent	Metal	9×1.75×6	User manual, coaxial cable, remote control and batteries, analog audio/composite video cable, ac power cord
Dish Network TR-40 CRA	Free	Plastic	6×1.25×4.5	User manual, coaxial cable, remote control and batteries, wall wart
Sansonic FT-300A	Free	Metal	7×1×5	User manual, coaxial cable, remote control and batteries, wall wart, antenna

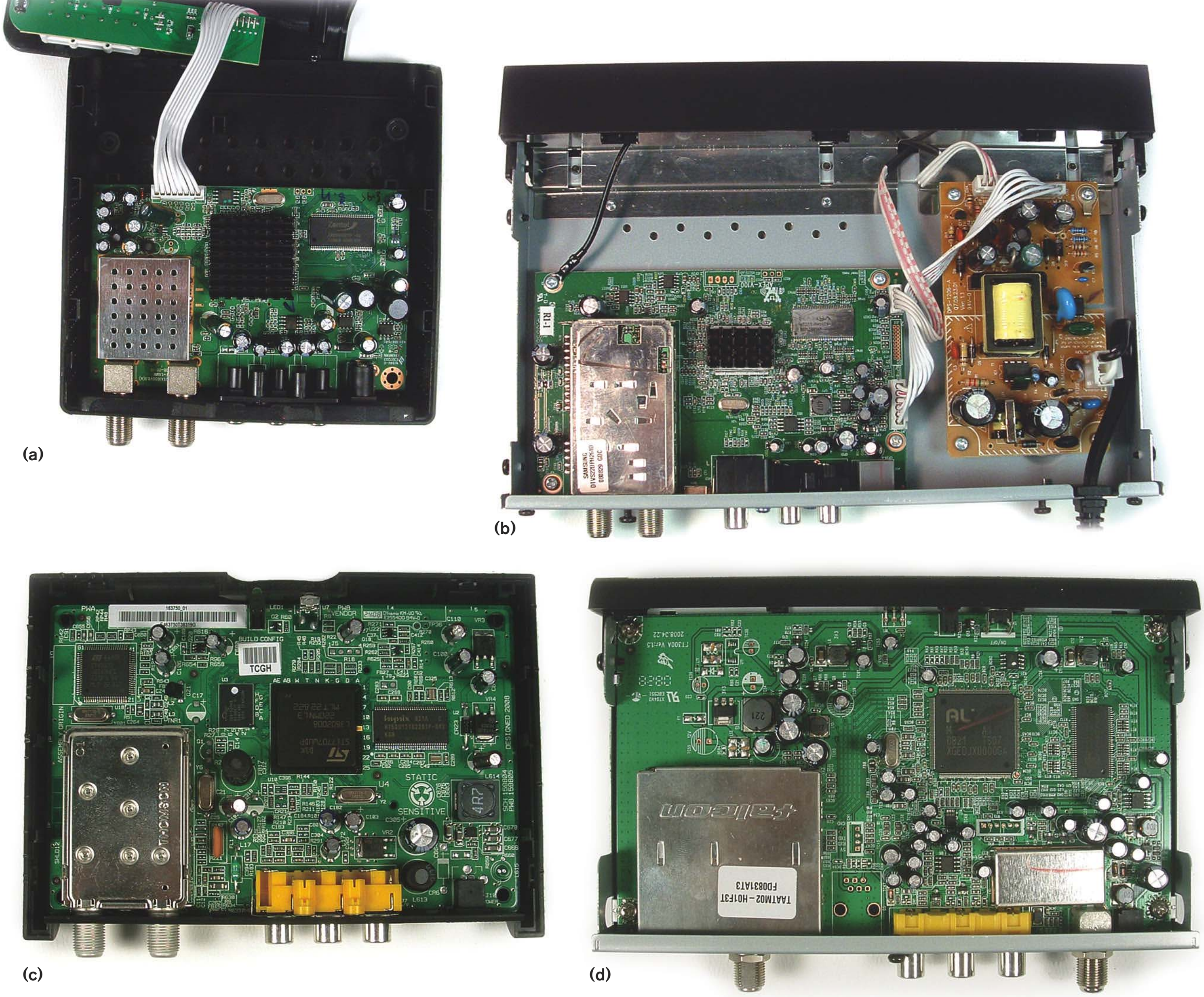


Figure 2 Notable internal disparities magnify noticeable exterior differences among Access HD's DTA-1080D (a), Apex Digital's DT502 (b), Dish Network's TR-40 CRA (c), and Sansonic's FT-300A (d). Note that the excess thermal paste in the area surrounding the DT502's Realtek RTD2885 was the inadvertent result of my removal and replacement of the SoC's passive heatsink; the excess paste was not present when the CECB originally came to me.

"clear QAM" (quadrature-amplitude modulation) for cable-television support. Simply stated, CECBs strictly convert ATSC to NTSC (National Television System Committee) for legacy-TV compatibility.

These stringent restrictions couple with equally stringent requirements, such as a host of broadcast-reception and decoded-video minimum-quality specifications that the NTIA tests before giving a product the CECB blessing. Units must be capable of both center-cropping and letterboxing a 16-by-9-aspect-ratio program for compatibility with 4-by-3-aspect-ratio displays. They must offer composite video and two-channel analog-audio outputs, as well as a merged audio-plus-video RF output (**Reference 3**). They must also include a dedicated remote control and offer compatibility with universal remotes. Bit-stream compatibility extends beyond basic MPEG-2 (Moving Picture Experts Group) video and Dolby Digital audio to additionally comprehend EAS (emergency-alert-system) messages, V-chip rating descriptors,

TABLE 2 CECB PROMINENT ICs

Product	Tuner	Demodulator	Decoder	DRAM	Flash memory
Access HD DTA-1080D	Microtune MT2131 (silicon)	Zoran SupraHD 741		Zentel A3S56D40ETP	Spansion SPI
Apex Digital DT502	Samsung DTVS22D (can)	Realtek RTD2885		Nanya NT5DS16M1CSS	Spansion SPI
Dish Network TR-40 CRA	Thomson DTT76809 (can)	STMicroelectronics STV0373	STMicroelectronics STi7707WUDP	Hynix HY5DU121622DTP	Spansion parallel interface
Sansonic FT-300A	Microtune MT2131 (silicon)	Auvitek AU8515	ALi M3601C	Etron EM6AA160TS	SPI

and closed-captioning info, along with PSIP (Program and System Information Protocol) data. And CECBs must burn no more than 2W of power with audio and video outputs disabled, as well as support automatic power-down capabilities.

The differentiation-cultivating gap between what the converter must include and what it cannot include still ends up being broader than at first glance. Some companies choose to use higher-quality chassis-construction materials or make other cosmetic enhancements. Others bundle additional accessories beyond the minimum set that converter-box specifications dictate. Some vendors offer added hardware-delivered features, and others add capabilities through software.

And then there are those manufacturers that choose none of these differentiating paths; instead, they build a bare-bones set-top box that stays within the NTIA boundaries in all regards. Because there's little to no marketing motivation to sell a CECB for less than $40, these companies end up with a wider-than-average disparity between BOM cost and price. By passing along some or all of this incremental profit to distributors and retailers, they cultivate a retail-shelf-space preference for their products, thereby creating consumer demand by squeezing competing alternatives off re-

TABLE 3 CECB SOFTWARE-ENABLED ADDITIONAL FEATURES

Product	Electronic program guide	Digital closed-caption decoding	Multilingual menus	Reminders	VCR timer
Access HD DTA-1080D	10 hours	Yes	Yes	No	No
Apex Digital DT502	Full and list	Yes	Yes	Yes	No
Dish Network TR-40 CRA	Full (grid)	Yes	No	Yes	Yes
Sansonic FT-300A	Current (banner)	No	No	No	No

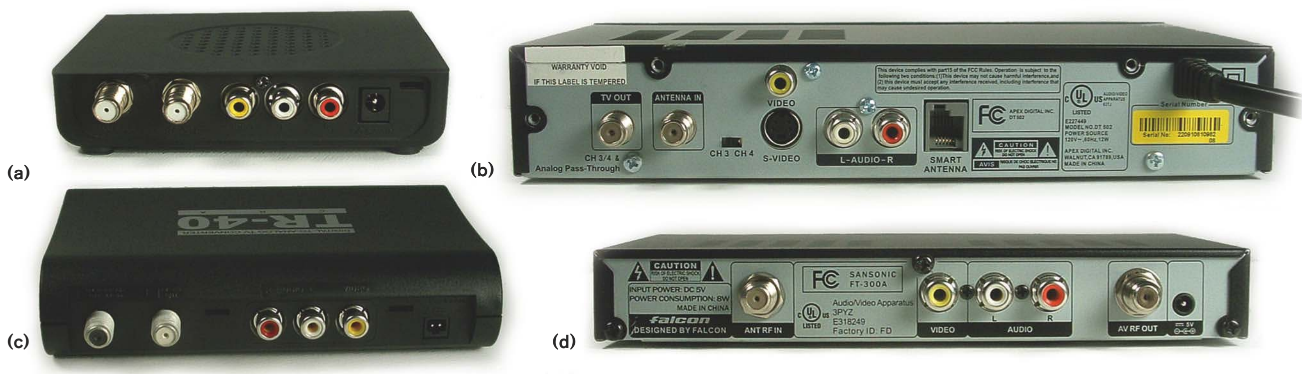


Figure 3 Back-panel perspectives of Access HD's DTA-1080D (a), Apex Digital's DT502 (b), Dish Network's TR-40 CRA (c), and Sansonic's FT-300A (d) reveal the hardware enhancements that Apex Digital's product provides.

BUT HOW WELL DO THEY WORK?

This article intentionally omits hands-on analysis of the four CECBs' (coupon-eligible converter boxes') operational capabilities: reception robustness, audio and video quality, and user-interface comprehensiveness and responsiveness, for example. I still plan, however, to pass along such data online. Also, every reception situation is unique. Although the impressions I ascertained at my home office might provide useful information, they would by no means provide a definitive examination of each set-top box. And, even at my location, reception characteristics are a moving target. The ABC affiliate in Reno, NV, for example, plans to move its digital broadcast from VHF Channel 9 to Channel 8 on the NTSC (National Television System Committee) shut-off date, a migration that I hope will improve my ability to tune it in.

Regularly visit my blog and look for write-ups with "The ATSC coupon-eligible converter box" in the titles, thereby identifying them as Web-site-published addendums to this print piece. Among them, you'll also find high-resolution close-up images of the CECBs' interiors available for download, pinpointing specific ICs. Additionally, augment your *EDN* research at the AVS Forum (www.avsforum.com). This tech-enthusiast nirvana is teeming with information from folks passionate about video in all of its myriad forms, and the information will both get you quickly up to speed and provide you with a comprehensive set of impressions on each CECB you're considering. For example, as of mid-December, just *one* of the several active discussion threads on Dish Network's TR-40 CRA was more than 180 pages long, with each page containing several dozen posts.

⊞ See the "The ATSC coupon-eligible converter box" posts at www.edn.com/briansbrain for supplemental information on this article's topics.

⊞ Go to www.edn.com/090205df to post a comment on this article.

⊞ For more technical articles, go to www.edn.com/features.

tail shelves. By happy accident, the four CECBs that this article analyzes exemplify all of these strategies.

CHASSIS AND ACCESSORIES

The CECBs this article showcases came from the two coupons I requested for my home-office residence, along with two I obtained from a friend. I based my CECB selection on the devices' cosmetic differences, in the hope, which panned out, that these dissimilarities would translate to fundamental design distinctions (**Figure 1**). From CompUSA, I first acquired Access HD's DTA-1080D and Apex Digital's DT502, each for 1 cent after rebate. The two boxes exemplify radically different product strategies; the DTA-1080D includes scant extras: a remote control and two batteries, a wall-wart external ac/dc converter, a slender sheath of paper documentation, and a short coaxial cable. The embedded-power-supply DT502 also comes with a composite video-plus-two-channel-analog-audio cable bundle. And, whereas the DTA-1080D is small, plastic, and conjoined by plastic clips, the larger DT502 offers sturdier metal sheets held together with screws (**Table 1**).

The other two set-top boxes are equally diverse in both design and decor. The free-after-rebate TR-40 CRA—a CECB you can get from Dish Network (as I did), EchoStar, or Sling Media—is reminiscent of the DTA-1080D in assembly—that is, plastic, albeit this time held together with metal screws—external power supply, and scant accessory apportionment. Although the metal-fabricated Sansonic FT-300A, which I obtained free after rebate from Meritline, doesn't include a DT502-reminiscent analog audio/video cable, the company instead thoughtfully includes a flat Artec AN2 antenna. Like the Access HD and Dish Network units, Sansonic's CECB also employs an external ac/dc converter, easing its use in vehicles, for example.

BUILDING BLOCKS

Considering my pleasure with the assembly and accessorizing diversity I discovered upon opening the four products' packaging, you can imagine how much more thrilled I was when I popped off the set-top boxes' chassis panels and encountered four different IC assemblages (**Figure 2** and **Table 2**). Beginning with the tuner, the initial piece of silicon that the incoming ATSC signal encounters, I found that the Apex Digital DT502 and Dish Network TR-40 CRA employ traditional "can" tuner modules from Samsung and Thomson, respectively.

A brief glance at the Access HD DTA-1080D and Sansonic FT-300A might suggest that they're also can candidates, but they aren't. Both boxes use Microtune's MT2131 silicon tuner, albeit in a can-compatible-subsystem form factor that suggests that manufacturing-time comparative price and availability assessments rather than an inherent silicon-tuner technical advantage drove the IC selection on the systems' PCBs (printed-circuit boards).

The next two steps in the ATSC-processing chain are demodulation of the bit stream from its UHF or VHF carrier and decoding the audio, video, and other digital data. Two of the four CECBs, the Access HD DTA-1080D and the Apex Digital DT502, employ a single SoC for both tasks; respectively, Zoran's SupraHD 741 and Realtek's RTD2885. Not coincidentally, I suspect, these units were the only two set-top boxes I analyzed that incorporate cost-incurring passive heat sinks.

On the other end of the integration spectrum, Dish Network's TR-40 CRA leverages an STMicroelectronics STV0373-demodulator and STi-7707WUDP-decoder chip set. Sansonic's FT-300A also uses separate ICs, but the demodulator companion to the Acer Laboratories M3601C decoder is not visible upon initial PCB inspection. Enthusiast-generated Internet documentation claims that the FT-300A employs Auvitek's AU8515 demodulator; I suspect that it is alongside the Microtune MT2131 within the can enclosure that Sansonic's manufacturing partner, Falcon Digital, designed (**Reference 4**).

The set-top boxes' memory architectures also beg for some degree of discussion. They all use a single DDR-400 SDRAM with a 16-bit system interface, albeit in a diversity of densities and from a diversity of sources: Etron Technology's 256-Mbit SDRAM (in the FT-300A), Hynix Semiconductor's 512-Mbit SDRAM (in the TR-40 CRA), Nanya Technology's 256-Mbit SDRAM (in the DT502), and Zentel Electronics' 256-Mbit SDRAM (in the DTA-1080D). Three of the four CECBs employ eight-lead SOIC-packaged SPI (serial-peripheral-interface) flash memory for system code, in two cases from Spansion. The fourth CECB, Dish Network's TR-40 CRA, instead uses a BGA-packaged parallel-interface burst-mode flash memory, also from Spansion.

Although all four STBs implement in-system-upgradable firmware potential, none of them offer a means of enabling consumers to do the upgrades themselves. Internet forums are therefore rife with posts from CECB owners attempting to discern units with latest and greatest firmware versions through product-code and manufacturing-location data, as well as from folks complaining about the need to ship CECBs back to manufacturers—at customer expense and with lengthy servicing delays—for updates to fix bugs and add features (see **sidebar** "But how well do they work?").

ENHANCEMENTS

The NTIA-defined gap between what features the box must include and what it can't include might be slender, but it does exist. A glance at the CECBs' back panels reveals the hardware-based augmentation that Apex Digital chose to include: a higher-quality, albeit still 480-line-interlaced S-video output, along with Smart Antenna array compatibility (**Figure 3**). And all four STBs support analog pass-through mode, enabling their owners to continue to receive signals from low-power stations and regional translator transmitters, neither of which are required to cease their NTSC broadcasts this year.

Software support can enable additional CECB capabilities, assuming that the system contains a sufficiently robust host CPU and adequate memory resources (**Table 3**). They include a variable-duration electronic program guide, digital closed-caption-decoding support, multilingual menus, viewer-reminder notifications of pending programs, and timer-based control of both system operating mode—standby or active—and the channel you are tuning in, so a VHS or DVD recorder, for example, can capture the CECB's output. **EDN**

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Access HD
www.accesshd.tv

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Nanya Technology
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STMicroelectronics
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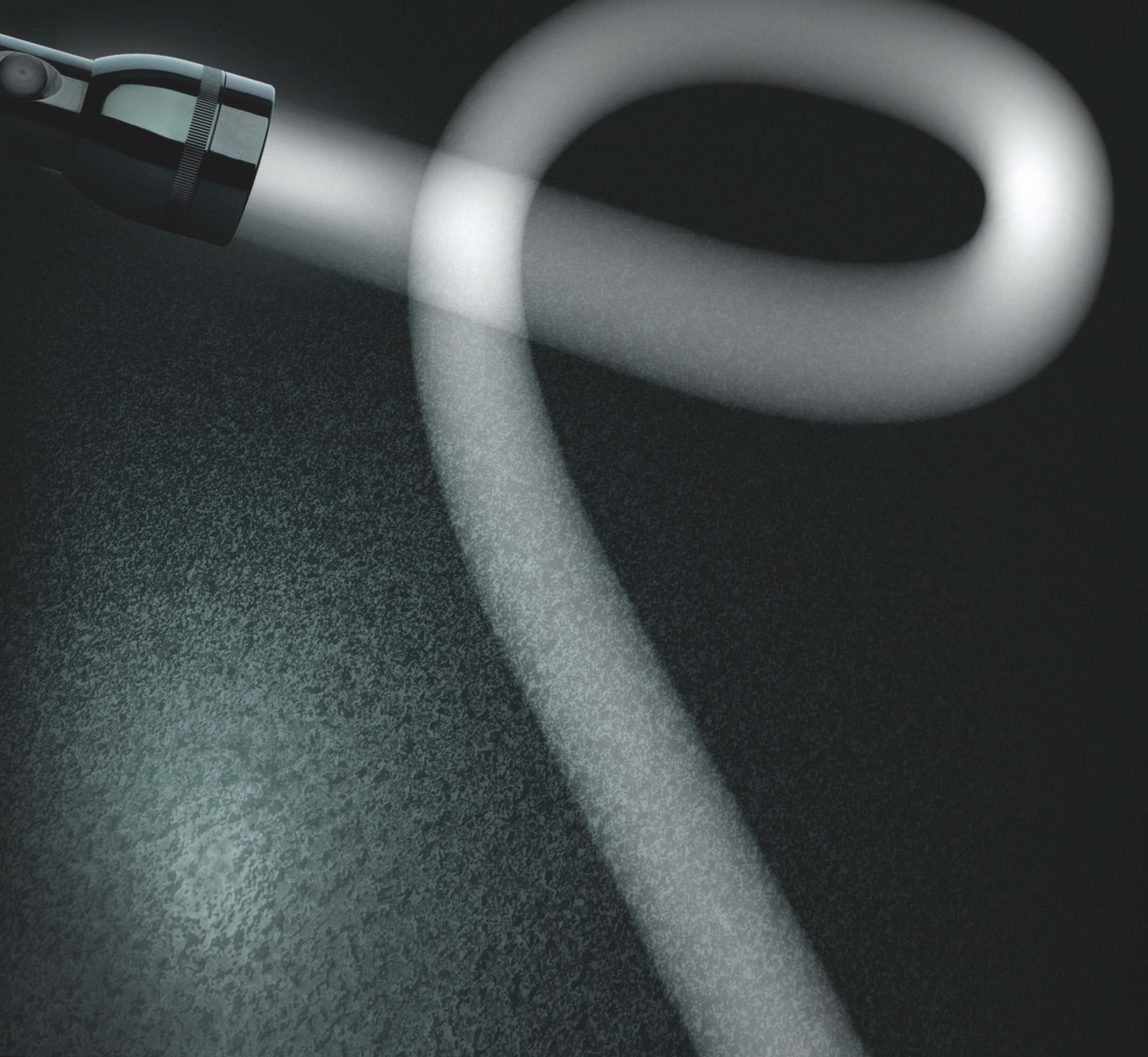
BY MARGERY CONNER • TECHNICAL EDITOR

Electronic and thermal improvements bring advances to lighting technologies

THE DIRECTION OF LIGHT



The desire to cut costs and reduce energy use has led both consumers and businesses to explore more efficient lighting options. By 2012, the United States will begin to implement the first phases of the efficiency standards mandated by the EISA (Energy Independence and Security Act) of 2007 and will begin to phase out the use of incandescent bulbs (**Reference 1**). In the short term, CFL (compact-fluorescent-light) bulbs will be the most common replacements for incandescents, and halogen bulbs will be a distant second. Manufacturers have also begun to deploy SSL (solid-state lighting) employing HB LEDs (high-brightness light-emitting diodes) in applications that can trade off SSL's premium price in exchange for efficiency and ruggedness.

Both CFLs and SSL have drawbacks, however. CFLs had an early history of premature failures, and you must still carefully match them to your application, including on-time and bulb orientation. In addition, some users have concerns about the bulbs' use of mercury, its impact on the environment, and the bulbs' potential for hazardous breakages. The HB LEDs in SSL, on the other hand, struggle with thermal-management challenges and an overall hefty price tag. Fortunately, the two lighting sources can benefit from new circuits, chips, and thermal devices, as well as advancements in manufacturing.

Cost-conscious consumers have recently turned to CFLs to reduce their energy bills. CFLs now account for 20% of light bulbs that users purchase for residential use, and that number will continue to grow because of minimum-lighting-efficiency standards that the EISA set. A common misconception about the EISA is that it bans the sale of incandescent bulbs after 2012. "The [EISA] does not expressly ban incandescent bulbs. … It lays out performance thresholds," explains Alex Baker, lighting-program manager for Energy Star. "If you can make an incandescent bulb that meets those performance thresholds, then you can continue to sell [those] bulbs."

Baker lays out the phase-in schedule for more efficient lights: In 2012, EISA will require an increase of approximately 25% in lumens per watt for 100W incandescent bulbs. In 2013, that requirement will also apply to 75W bulbs and, in 2014, to 60W bulbs.

These restrictions apply only to the traditional Edison-type light bulbs with midsized screw bases. The EISA does not limit the sale of many other bulbs, such as incandescent bulbs with candelabra-type bases; globe-shaped bulbs, such as those that find use in bathroom-vanity fixtures; general-service light bulbs; or modified-spectrum lights, such as GE's Reveal series. "There's still going to be plenty of incandescents out there for many years to come," says Baker.

After the United States passed the EISA in 2007, GE vowed to develop an HEI (high-efficiency-incandescent) bulb that met the standards. However, in November 2008, the company announced that it had suspended the development of HEI bulbs to focus on LED and OLED (organic-LED) lighting because of the two technologies' potential to surpass other energy-efficient tech-

RESIDENTIAL AND COMMERCIAL LIGHTING CURRENTLY ACCOUNTS FOR 20% OF THE ELECTRICITY USED IN THE UNITED STATES. ALTHOUGH CFLs ARE THE BEST OPTIONS FOR INCREASING EFFICIENCY AND DECREASING POWER NEEDS, HB-LED TECHNOLOGY IS ALSO MAKING ADVANCES. BOTH TECHNOLOGIES HAVE DRAWBACKS, HOWEVER, AND STAND TO BENEFIT FROM IMPROVEMENTS IN ELECTRONICS, MANUFACTURING, AND THERMAL MANAGEMENT.

nologies, such as fluorescent, with the additional benefits of long life and durability (**Reference 2**).

Despite its commitment to LED and OLED lighting, GE still sees a strong future for CFLs, as the introduction of its Energy Smart CFL line demonstrates (**Figure 1**). CFLs have an overwhelming advantage in that they are inexpensive and available. However, CFLs have their detractors, who tend to fall into two broad categories: those who object to the CFLs because they contain small amounts of mercury and those who object to the devices' performance.

The mercury problem is complex. A CFL uses a tube filled with pressurized mercury vapor. The CFL's internal ballast transforms the ac-line voltage to create an electrical arc through the mercury vapor, creating UV (ultraviolet) emissions, which strike the phosphor coating on the inside of the tube. The phosphor converts the UV light into visible "white" light. Early CFLs had relatively large amounts of mercury, often exceeding 10 mg per bulb. The dosing method that introduced the elemental mercury into the tube was relatively crude: Energy Star's Baker likens it to using a medicine dropper to add liquid.

Figure 1 GE recently abandoned its efforts to develop an incandescent bulb that meets EISA requirements for efficiency. Its new Energy Smart CFL shoehorns the familiar CFL spiral tube inside the even more familiar incandescent-glass-bulb outline for aesthetic purposes.

The process was difficult to control, and manufacturers tended to err on the side of too much rather than too little mercury. In addition, over time, the mercury vapor tended to bond with the phosphor powder that coated the inside of the tube, and the mercury must be in vapor form to emit UV light.

CFL manufacturers have reduced the amount of mercury the bulbs require by developing a pelletized method of dosing the tubes, allowing for more precise control of the added mercury. They have also developed phosphor coatings that resist mercury bonding. According to Baker, some CFL manufacturers have stated that 1.5 mg of mercury approaches the theoretical minimum. Energy Star standards now cap the maximum mercury amount for CFLs at 5 mg.

European lighting manufacturer Megaman claims that the mercury in its "mercury-liquid-free" line of CFLs remains in an amalgam until it reaches 100°C atmospheric pressure. Normally, because the tube is pressurized, the mercury is a vapor at room temperature. Megaman claims that the amalgam does not pollute water or landfills.

No formal definition of how much mercury is toxic is available. Researchers perform most work on methyl mercury, which is a form of mercury that ends up in the water and eventually in fish. Because a fetus's developing central nervous system is especially susceptible to mercury, the FDA (Food and Drug Administration) and EPA (Environmental Protection Agency) have issued warnings for pregnant women about limiting their consumption of certain kinds of fish from specific waters. Even these amounts are open to debate, however: Because of supposed general-health benefits that eating fish confers, the FDA recently relaxed its stance on how much fish a pregnant woman should eat. Opponents claim that the FDA yielded to pressure from the agricultural industries. These differences in opinion underline the fact that no hard and fast rules exist for methyl mercury, elemental mercury, or mercury vapor. Energy Star's Web site provides detailed guidelines on cleaning up after CFL breakage for anyone who is concerned about mercury's danger (**Reference 3**).

Can using CFLs actually reduce the amount of mercury released into the environment? Maybe. Coal is the source of much of the electrical power that the United States and many other countries generate; coal-fired power generation releases mercury into the atmosphere. Powering an incandescent bulb over its lifetime releases 10 mg of mercury, compared with a maximum of 4 mg for a CFL. Some areas, such as California, rely on hydroelectricity and natural gas, so switching to CFLs in California would not necessarily reduce mercury emissions. On the other hand, when California's demand exceeds its capacity, the state gets its energy from a number of out-of-state sources, including coal,

AT A GLANCE

- CFL (compact-fluorescent-light) bulbs had an early history of premature failures, and you must still carefully match them to your application.
- Some users have concerns about CFL bulbs' use of mercury, its impact on the environment, and the bulbs' potential for hazardous breakages.
- CFL manufacturers have reduced the amount of mercury the bulbs require by developing a pelletized method of dosing the tubes, allowing for more precise control of the added mercury. They have also developed phosphor coatings that resist mercury bonding.
- HB LEDs (high-brightness light-emitting diodes) in SSL (solid-state lighting) struggle with thermal-management challenges and an overall hefty price tag.
- Incandescent light bulbs will still remain in use for a long time to come.
- DORS (dim-on-random switching) allows light to dim with every rapid on/off action in seconds, adjusting from 100% brightness to 66% to 33% and, finally, to 5%. The technology exemplifies the migration of control intelligence from building infrastructures to light bulbs.

through the North American power grid. The savings in energy due to CFLs' greater efficiency remains: CFL users can save $15 to more than $60 over the life of a CFL, assuming a 10,000-hour life and electricity costs of 13 cents per hour. The $15 savings assumes a lifetime of only 2000 hours.

Despite that advantage, however, detractors of the technology usually complain about the lights' failure to meet advertised lifetimes and about the "cold" fluorescent color the bulbs produce. CFLs burn out prematurely primarily because of application mismatches. The ideal long-life application for a CFL is in a table lamp whose bulb points straight up so that the electronics in the base are out of the path of rising heat, the bulb is unenclosed so that heat doesn't build up, and the lamp is on for several minutes at a time. In a harsher application, a bulb could reside in an enclosed light fixture on the ceiling of a closet; in this scenario, users briefly turn the light on and then off. In response to complaints about the short lifetimes of CFLs, Energy Star created a bulb-finder guide to assist users in finding the right bulbs for their applications (**Reference 4**).

Standard CFLs are poor candidates for dimmer-switch-controlled lights in homes because these switches typically

SPACE CONSTRAINTS ARE INHERENT IN HOME AND OFFICE LIGHTING, LEAVING HEAT REMOVAL AS THE DOMINANT ISSUE IN SSL.

use triac-based phase-cutting dimmer circuits. Triac-based wall dimmers work well with resistive loads, such as incandescent bulbs, but perform poorly with capacitive loads, such as CFLs. Using a generic CFL with a triac-based dimmer switch causes the bulb to die immediately or drastically shortens the bulb's life. Most major CFL manufacturers now offer a specialty version of a dimmable CFL bulb.

International Rectifier's DIM8 ballast-control half-bridge driver reduces the component count for the CFL-dimming control circuits, which must fit into the base of the CFL bulb, where space is at a premium. With the addition of a microcontroller, the DIM8, whose prices start at $1.09 (10,000), can serve as a dimming controller inside the CFL. It allows a user to dim the light simply by switching a standard light switch on and off with no additional wiring or wiring changes. This scheme, DORS (dim-on-random switching), allows light to dim with every rapid on/off action in seconds, adjusting from 100% brightness to 66% to 33% and, finally, to 5%. You reset the light to full brightness by switching off the lamp for more than 3 seconds and then switching it on again. DORS exemplifies the migration of control intelligence from building infrastructures to light bulbs.

The combination of cost savings, government regulations, and improvements in CFL technology has convinced purchasers of lights for both residential and office use to make the move to the more efficient lighting. CFLs are not the only efficient light sources, however. SSL using HB LEDs can be as efficient as CFLs; has the potential for unlimited variation in colors, lifetime, and packag-

Figure 2 Nuventix cooling devices consist of a diaphragm mounted in a cavity. An electromagnetic driver vibrates the diaphragm 100 to 200 times per second, forcing tiny jets of air out through openings in the cavity. These devices are virtually silent compared with conventional fans.

ing; and has begun to move into lighting applications in offices, theaters, homes, and city streets.

Standard low- and medium-power LEDs serve as indicators: They create just enough light to draw attention to a system's state and typically draw approximately 20 to 40 mA. HB LEDs typically draw 350 mA to 1.5A. For example, Cree's XLamp XP-E cool-white HB LEDs provide 114 to 122 lumens at 350 mA. SSL HB LEDs have lifetimes in excess of 25,000 hours or 22 years when they remain lit for three hours a day. They are good choices for applications requiring ruggedness or in which it is difficult or expensive to change a light bulb, such as streetlights. Cities such as Austin, TX; Juneau, AK; and Raleigh, NC, have moved to LED streetlights to save on energy bills and maintenance costs.

SSL units include several components—the HB LED; the ac/dc- and dc/dc-power-conversion electronics, which can reduce efficiency by 10 to 15%; and the cooling components—that all play a part in reducing the light efficiency, or efficacy, measured in lumens per watt. In an application in which space is not at a premium, such as a streetlight, you could put an HB-LED die on a huge chunk of aluminum and passively radiate all of the heat the die generates. Space constraints are inherent in home and office lighting, however, leaving heat removal as the dominant issue in SSL.

Figure 3 Cool Innovations' flared-pin fin heat sinks feature an array of sparsely configured round pins that slant outward, a configuration that can cool the HB-LED die in SSL in natural-convection environments.

The combination of an electron and a hole inside an LED produces both radiative and nonradiative recombination. Radiative recombination generates a photon with the energy of the hole-electron-pair bandgap. Instead of producing light, nonradiative recombinations just vibrate the LED-crystal lattice, resulting in heat.

Although LED manufacturers are constantly refining their manufacturing processes to minimize impurities and the resulting nonradiative recombinations, impurities will always be a significant heat generator for LEDs, especially as HB LEDs' die size increases; the probability of defects increases with the larger die. Unlike incandescent bulbs, LEDs cannot radiate heat as infrared energy. The exception is IR (infrared) LEDs, which are comparatively efficient. Adding to the problem, sockets for conventional incandescent bulbs act as insulators rather than heat radiators.

In addition, as an LED's temperature increases, its lumens per amp and its overall power efficiency decrease. Chronically running an HB LED at an elevated temperature results in decreased efficiency, at least a slight color shift, and an overall decrease in life expectancy. Using small electromechanical fans is one way to actively remove heat from HB LEDs, but they require additional power, reduce lighting efficiency, introduce audible noise, and suffer from the decreased reliability to which mechanical moving parts are susceptible. The ideal cooling product for an HB LED must be small, efficient, quiet, and highly reliable.

One approach is the synthetic-jet design Nuventix uses in its SynJet fanless coolers. The SynJet requires much less current than a motor and operates from a 5V power supply. The coolers use an electromagnetically coupled diaphragm that pulses high-velocity jets of air through tiny nozzles. Once the air leaves the nozzle, it entraps the sur-

⊞ For more on new applications and standards for high-brightness LEDs, go to www.edn.com/article/CA6512150.

⊞ For more on control ICs in dimming circuits for energy-efficient CFLs, go to www.edn.com/article/CA6614726.

⊞ For another look at CFLs and their applications, visit www.edn.com/article/CA6607201.

⊞ Find out how to operate an LED "bulb" from a dimmer switch at www.edn.com/blog/1470000147/post/380022638.html.

⊞ For *EDN*'s coverage of Nuventix's SynJet technology when it was still an R&D project at the Georgia Institute of Technology, go to www.edn.com/article/CA376646.

rounding air, pulling that air along with it, in much the same way that a tornado gathers mass by pulling in surrounding air.

Nuventix offers standard SynJet products for HB-LED fixtures. One is an MR-16 configuration; the other resembles a PAR-38-style lamp base. The MR-16 and PAR-style configurations can dissipate as much as approximately 20 and 50W, respectively. A self-contained HB LED with a luminous efficacy of 80 lumens/W can deliver several thousand lumens, according to Cary Eskow, director of Lightspeed, the SSL and LED business unit of Avnet Electronics Marketing. Prices for SynJet start at approximately $15 in low volume (**Figure 2**).

Passive heat sinks are also seeing some innovation. Cool Innovations' flared-pin, finned heat sinks outperform equivalent straight-pin heat sinks (**Reference 5**). A 1.5-in.-tall, 1-in.^{2} straight-pin, finned aluminum heat sink has a thermal resistance of 16.14°C/W, whereas its flared-pin equivalent has a thermal resistance of 12.65°/W, an improvement of 22%. A 2-in.-tall, 5-in.^{2} straight-pin heat sink has a thermal resistance of 0.74°C/W, compared with a flared-pin version of 0.64°C/W, an improvement of 14% (**Figure 3**).

It would be a formidable challenge for SSL to replace the venerable incandescent bulb and, in the longer run, the CFL. The task is so difficult that the Department of Energy last May instituted the L Prize (www.lightingprize.org) for the development of an SSL that "must perform similarly to the incandescent lamps they are intended to replace in … color appearance, light output, light distribution, and lamp shape, size, form factor, appearance, and operating environment. They must be reliable, available through normal market channels, and competitively priced." Industry observers currently forecast the prize to be worth $10 million. EDN

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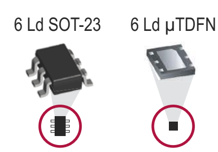

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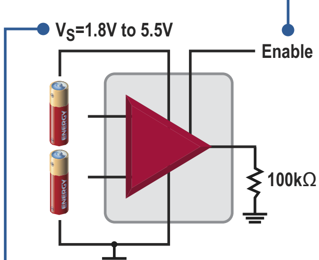

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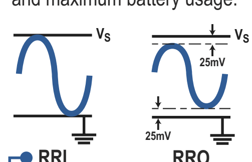

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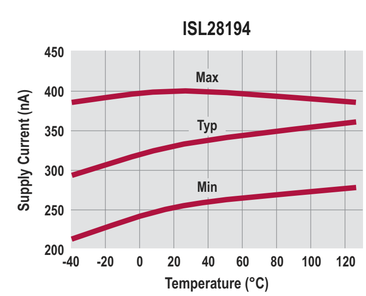

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Glenn Woppman, president and chief executive officer, Asset InterTech

Octasic Opus architecture design team

SiGe Semiconductor SE2593A front-end module design team

ANALOG ICs

AD9272 eight-channel ultrasound receiver, Analog Devices

CLC1001 ultralow-noise amplifier, Cadeka Microcircuits

CS42L55 portable audio codec, Cirrus Logic

LMV1088 analog dual-input-microphone-array amplifier, National Semiconductor

ADCs AND DACs

ADC12EU050 12-bit, octal ADC, National Semiconductor

DAC9881 18-bit DAC, Texas Instruments

MAX5661 single 16-bit DAC, Maxim Integrated Products

SAM1610/05/00 12-bit ADCs, Samplify Systems

RFICs

0150SC-1250M and 0405SC-1000M RF-power transistors, Microsemi

HVV1011-300 RF-power transistor, HVVi Semiconductors

VMMK-2x03 RF amplifiers, Avago Technologies

ASSPs

CX20562 USB speakers on a chip, Conexant

Snapdragon platform with custom CPU, Qualcomm

T1000 single-chip content-inspection processor, LSI Logic

Z-Accel CC2480 2.4-GHz ZigBee wireless-network processor, Texas Instruments

LOGIC AND INTERFACE ICs

26 series SQI (serial quad I/O), SST

ActiveConnect GN8502 multimedia-connectivity solution, Gennum

SN5000A hybrid two-in-one tuner module, Xceive

MEMORY

NANDrive family, SST

SiliconDrive II Blade SSD, SiliconSystems

X-25E Extreme SATA SSD, Intel

XDR2 memory architecture, Rambus

PROGRAMMABLE LOGIC AND FAST-TURNAROUND ASICs

Nextreme-2 45-nm ASICs, eASIC

Stratix IV 40-nm FPGA, Altera

Virtex-5 FXT FPGAs, Xilinx

EDA: DESIGN ANALYSIS

Incisive Palladium DPA (dynamic-power analysis), Cadence Design Systems

JasperGold formal-verification tool, Jasper Design Automation

Olympus-SOC timing analyzer, Mentor Graphics

PowerArtist RTL tool, Sequence Design

EDA: DESIGN CREATION AND IP

C-to-silicon compiler, Cadence Design Systems

Intelli DDR3 memory interface, Virage Logic

PowerOpt RTL tool, ChipVision Design Systems

Zroute chip-level router with integral DFM analysis, Synopsys

EDA: PCB, FPGA, AND MIXED-SIGNAL/RF ICs

Integrated Software Environment (ISE) 10.1, Xilinx

RF Design Solution, Mentor Graphics and Agilent Technologies

Simics Hybrid Simulation solution, Virtutech

Titan platform, Magma Design Automation

EDA: SYSTEM-LEVEL SYNTHESIS

Matlab/Simulink synthesis technology, Altera

Simscape, The MathWorks

Webench power designer, National Semiconductor

Webench sensor designer, National Semiconductor

EMBEDDED-SYSTEM TECHNOLOGIES

Mirasol displays, Qualcomm

PowerBlock 50 computer, Mercury Computer Systems

Single-Board RIO, National Instruments

USB1032 StackableUSB host microcontroller, MicroSys

MICROCONTROLLERS

PIC32 32-bit microcontroller, Microchip Technology

Piccolo microcontrollers, Texas Instruments

R32C/111 series microcontrollers, Renesas Technology

Xmega microcontrollers, Atmel

MICROPROCESSORS

EP80579 integrated processor, Intel

YES, YOU CAN! The 2008 presidential election may be just a distant memory, but another critical choice requires your voice. Our editors have named the finalists for *EDN*'s 2008 Innovation Awards. On these pages, you'll find a list of the finalists in several product and technology categories as well as Innovator of the Year and Best Contributed Article.

Review complete write-ups of the finalists and vote at www.edn.com/innovation. Voting begins Feb 2 and continues through Feb 27.

Your votes determine the Innovation Award winners, who will be honored along with all of the finalists at a reception on Monday, March 30, in San Jose, CA. *EDN* readers are invited to attend; **you can also find event and ticket information at www.edn.com/innovation.**

BEST CONTRIBUTED ARTICLE OF 2008

USB battery-charger designs meet new industry standards, Takashi Kanamori and George Paparrizos, Summit Microelectronics, Feb 21, 2008, www.edn.com/article/CA6531593

Boost efficiency for low-cost flyback converters, John Betten and Brian King, Texas Instruments, April 2, 2008, www.edn.com/article/CA6544742

Designing a short-range RF link into a consumer-electronics product, Eric Welch, Keyspan, July 8, 2008, www.edn.com/article/CA6576137

High-voltage, low-noise dc/dc converters, Jim Williams, Linear Technology Corp, Aug 7, 2008, www.edn.com/article/CA6582859

Lithium-ion-battery-charging IC powered by charge-transfer, control innovations, Randy Torrance, Chipworks, Oct 1, 2008, www.edn.com/article/CA6599222

LPC3130 ARM9 microcontroller, NXP Semiconductors

MIPS32 1004K coherent-processing system, MIPS Technologies

OMAP35x application processor, Texas Instruments

PASSIVE COMPONENTS AND SENSORS

ADXL001 iMEMS shock and vibration sensor, Analog Devices

LX1973B wide-dynamic-range light sensor, Microsemi

MPR03x proximity-sensor controllers, Freescale Semiconductor

OLED SmartSwitch, NKK Switches

BATTERY ICs

bq27500 system-side impedance-track battery-fuel-gauge IC, Texas Instruments

LTC6802 battery-stack monitor, Linear Technology

MC3467x Li-ion-battery-charger ICs, Freescale Semiconductor

POWER-CONTROLLER ICs

ADP1043 digital-power controller, Analog Devices

PX3560 digital multiphase controller, Primarion

POWER ICs: DRIVERS

AAT1282 2A flash-driver IC, AnalogicTech

MAX16826 four-string LED driver, Maxim Integrated Products

SA306-IHZ motor-drive IC, Cirrus Logic

POWER ICs: GENERAL CONVERTERS

FAN5355 800-/1000-mA, 3-MHz buck converter, Fairchild Semiconductor

IRS2530D DIM8 IC dimming electronic ballast, International Rectifier

LTC3642 50-mA synchronous step-down converter, Linear Technology

Simple Switcher controllers and Webench MOSFET-selection tool, National Semiconductor

POWER ICs: MODULES

EP53A8xQI 1000-mA, 5-MHz synchronous buck regulator, Enpirion

LTM4606 ultralow-EMI, 6A dc/dc µModule, Linear Technology

POWER SEMICONDUCTORS

Electronic-current limiter, Bourns

FSFR series Green FPS power switches, Fairchild Semiconductor

Gallium-nitride power-device platform, International Rectifier

TrenchFET Generation III power MOSFETs, Vishay

POWER SUPPLIES

10-kVA Pulsar MX frame or UPS enclosure, Eaton

BMR453 series dc/dc converters, Ericsson

Liebert NXL 250- to 400-kVA UPS, Emerson Network Power

SOFTWARE/EMBEDDED TOOLS

Beagle Board Linux-development board, Beagleboard.org

SES (Smart Energy Suite), Ember

XDS2000i in-socket development system, XtremeData

XtremeDSP video starter kit, Xilinx

OSCILLOSCOPES

90000A series oscilloscope, Agilent Technologies

DPO3000 digital-phosphor oscilloscopes, Tektronix

PicoScope 9201 sampling oscilloscope, Pico Technology

WavePro 7Zi digital oscilloscope, LeCroy

INSTRUMENTS

DPP12500A-4T four-tap digital pre-emphasis processor, Synthesys Research

MW90010A C-OTDR (Coherent OTDR), Anritsu

PNA-X nonlinear vector-network analyzer, Agilent Technologies

PXI Express 6.6-GHz RF instruments, National Instruments

RSA3000B series real-time spectrum analyzers, Tektronix

DESIGN FOR TEST, PRODUCTION TEST, AND METROLOGY

AVS300CL wireless metrology tool, CyberOptics Semiconductor

Cover-Extend technology, Agilent Technologies

ProVision boundary-scan-development-tool suite, JTAG Technologies

BY FRANK KEARNEY • ANALOG DEVICES

Optimizing standard-definition video on high-definition displays

THE AVAILABILITY OF LARGE-SCREEN HD LCD TVs AND PLASMA DISPLAYS IS DRIVING THE POPULARITY OF DIGITAL-TV BROADCASTS AND HD-SIGNAL INTERFACES. HOWEVER, THE ABILITY TO SUPPORT LEGACY SOURCES WITH THE HIGHEST QUALITY REMAINS AN ESSENTIAL REQUIREMENT. THE 3-D-COMB VIDEO DECODER IS A CRITICAL PROCESSING BLOCK THAT CAN HEAVILY INFLUENCE OVERALL SYSTEM PERFORMANCE.

When designers initially developed television, it supported only the broadcast and display of images in monochrome—that is, black and white. As technology evolved, TV broadcasts also supported color, but they still needed to maintain backward compatibility with monochrome-TV-display equipment. They needed to accommodate color information within the avail-

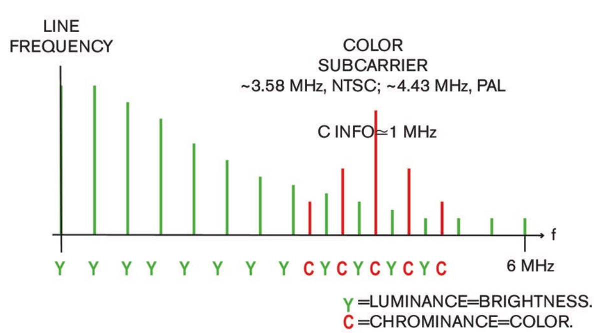

Figure 1 Luminance and chrominance information shares the same spectrum in a composite video signal.

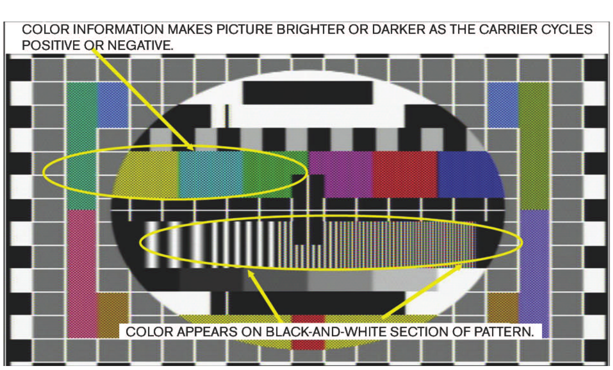

Figure 2 An image with no luminance and chrominance separation contains numerous artifacts.

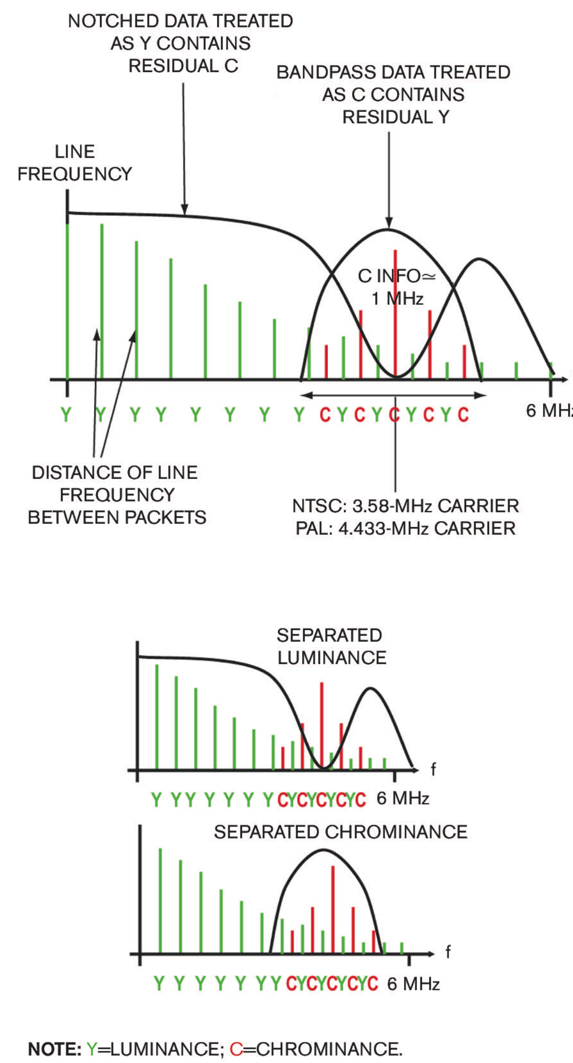

Figure 3 Notch filters and bandpass filters separate the luminance and the chrominance.

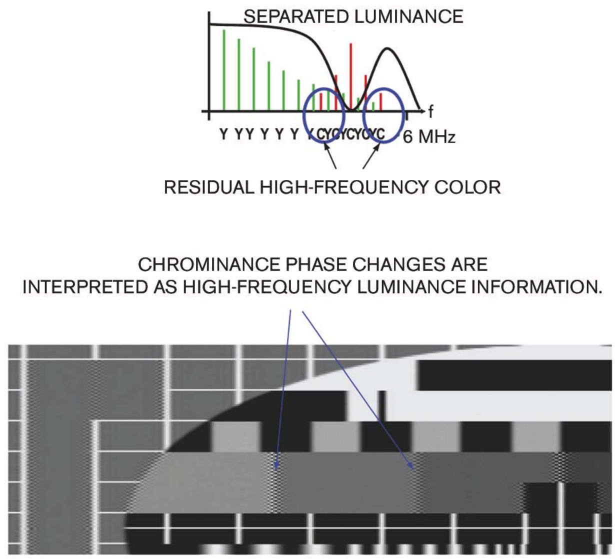

Figure 4 The TV falsely interprets residual color within the luminance path as luminance information, resulting in an undesirable dot-crawl effect.

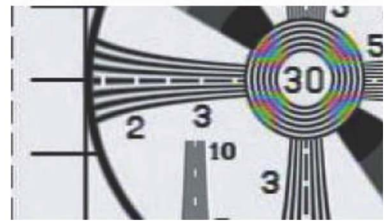

Figure 5 Residual luminance within the chrominance path causes cross-color artifacts.

able bandwidth and in such a format that earlier TVs would continue to show undistorted black-and-white displays.

In a composite video signal, color information shares the same bandwidth as the available luminance information. A sine wave with varying amplitude and phase represents the chrominance content of any transmitted image (**Figure 1**). You must therefore separate the chrominance and luminance from each other to correctly display the picture.

Chrominance information resides at the high end of the frequency spectrum and at multiples of the line length. The challenge on the display side is to correctly extract the luminance and chrominance information and to maintain the full bandwidth without causing display artifacts. If no luminance-versus-chrominance separation occurs, color information makes the picture brighter or darker as the carrier cycles positive or negative. Color information also incorrectly appears within black-and-white sections of the image (**Figure 2**).

Using a simple notch or bandpass filter to separate luminance and chrominance results in residual chrominance in the luminance signal path, and vice versa (**Figure 3**). The residual information that remains can result in severe image artifacts, such as "dot crawl" (**Figure 4**). Residual luminance information within the chrominance path can also cause artifacts such as "cross color" (**Figure 5**).

A comb filter adds a delayed version of a signal to itself, causing constructive and destructive interference. The frequency response of a comb filter comprises a series of regularly spaced spikes, giving the appearance of a comb. A 2-D comb filter provides higher video-decoder performance than that of notch and bandpass filters (**Figure 6**). It operates on the principle that, if an image has similar lines above or below the line of interest, you can more completely separate the chrominance and luminance. In the case of NTSC (National Television System Committee), the chrominance sine wave changes 180° from line to line. If any two consecutive lines are added together, luminance content doubles and chrominance content cancels. Conversely, if two lines are subtracted, the luminance content cancels and the chrominance content doubles. In an example with full-frame color bars, every active line is visually identical. At a given signal level, the luminance content of each line is the same. Apart from the phase changes, the chrominance content of each line is also the same.

Video decoders, such as those from Analog Devices (www.analog.com), use a five-line, 2-D comb filter, which provides better performance on NTSC and PAL (phase-alternating-line) sources. The comb processor must determine, depending on the complexity of the image, whether to combine the current line with the previous line or with the next line. It cannot perform any line combinations for certain images, and, in this case, it may instead notch the current line. An adaptive 2-D-

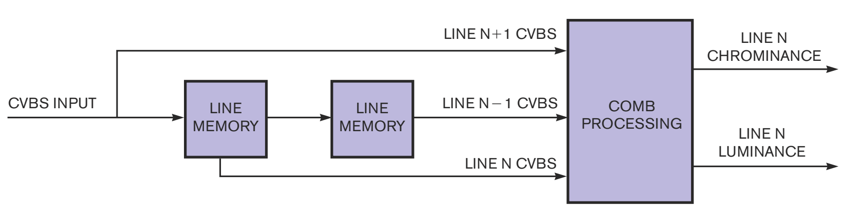

Figure 6 A three-line, 2-D comb would introduce a one-line delay from input to output.

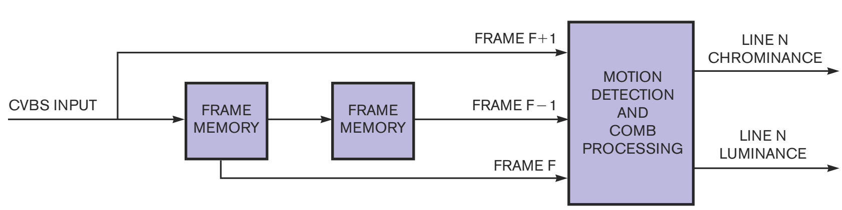

Figure 7 A typical 3-D-comb decoder architecture supplements the previous-generation 2-D comb's spatial implementation with added temporal cognizance.

comb video decoder can provide an acceptable level of performance. However, when consecutive lines are dissimilar, the 2-D comb cannot properly work and reverts to a notch filter to separate the luminance and chrominance for that area of that line.

Although it's important to successfully achieve luminance and chrominance separation without introducing image artifacts or bandwidth limitations—which translate into soft images—many other aspects of the video signal, such as a poor timebase or weak, nonstandard RF signals, also present challenges. Artifacts or image imperfections that were acceptable on smaller CRT displays become unacceptable on the new generation of LCDs and plasma displays. Due to higher resolutions, larger sizes, and greater display contrast ratios, even small image imperfections are now noticeable.

ADAPTIVE 3-D-COMB TECHNOLOGY

The combination of HD (high-definition) source material, a digital interface, and a high-resolution display provides an outstanding viewing experience. However, with the press of a channel change or input button, a user can go from viewing a beautiful HD image to viewing a legacy CVBS (composite-video-broadcast signal). Dramatic improvements in SD (standard-definition)-composite-video-image quality are achievable with the implementation of high-quality, adaptive 3-D-comb technology (**Figure 7**).

A 3-D comb is similar to a 2-D comb in that it separates luminance and chrominance by combining pixels from certain lines. The major difference is that, whereas a 2-D comb combines pixels from consecutive lines of the image, a 3-D comb combines pixels from the current line with pixels from the same line in a time-delayed version of the image (**Figure 8**).

The implementation of 3-D-comb video decoding delivers superior video. This approach can virtually eliminate objectionable image artifacts, such as dot crawl, "hanging dots," and cross color. In addition, owing to the manner in which 3-D-comb video decoding separates the luminance and chrominance, the approach maintains the full bandwidth of both luminance and chrominance data packets. Full luminance bandwidth maintains the high-frequency content, providing sharp, clear images that allow the user to distinguish fine detail. Full chrominance bandwidth ensures brighter and better-defined colors.

Although 2-D combing relies on processing the adjacent ac-

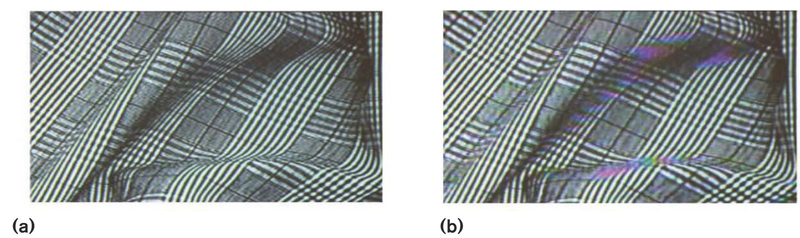

Figure 8 Adaptive 3-D-combing (a) results visibly improve on 2-D-only combing (b).

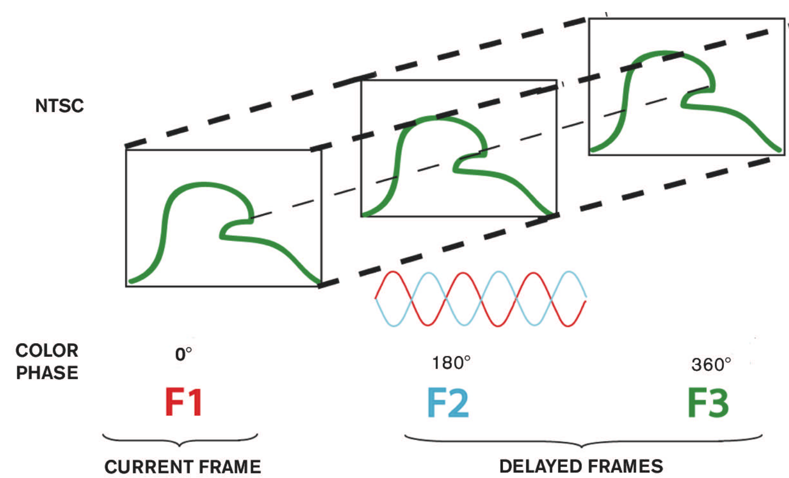

Figure 9 A typical NTSC frame sequence showcases the 3-D-comb filtering technique.

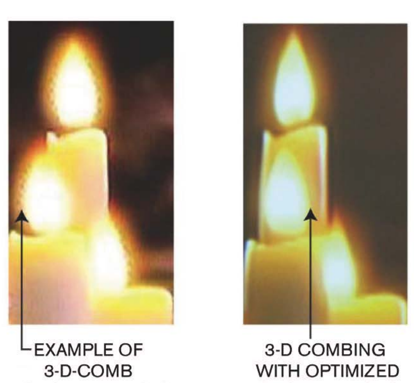

Figure 10 Combing images with motion introduces egregious artifacts.

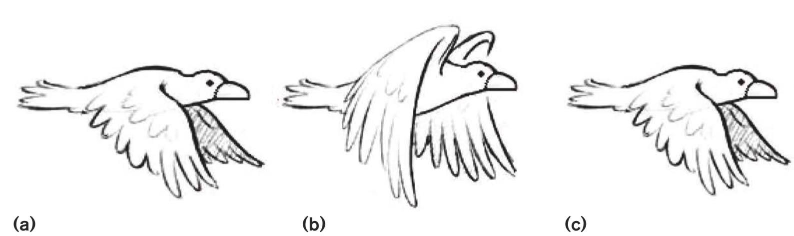

Figure 11 Adaptive 3-D combing relies on the ability of the decoder to correctly detect motion. This sequence is the normal order of events as a bird flaps its wings—in the down position (a), the up position (b), and returned to the down position (c).

tive video lines, analyzing them, or both, 3-D processing compares frame-to-frame video-pixel information (**Figure 9**). It compares data from the current frame with data from a previous frame in memory. If you add both frames together, chrominance information for each pixel cancels, whereas luminance pixel data doubles. Likewise, if the previous frame subtracts from the current frame, luminance pixel data cancels, whereas chrominance information doubles.

Despite the advantages of 3-D-comb processing, designers must address its performance limitations and challenges. A 3-D comb allows perfect separation of luminance and chrominance in images that would cause legacy 2-D comb or notch filters to fail. However, it can achieve that goal only if the pixels in the image are absolutely still. Conversely, if the image is moving, and, hence, pixel data from two consecutive frames differs, you cannot use 3-D combing on the image (**Figure 10**). It is critical for the video decoder to examine each pixel, comparing it with previously stored pixel data, to determine whether motion has occurred and then decide on which type of comb to implement.

Because motion detection is complex, the approach you use must analyze every active pixel from the current and stored frames to determine which type of separation method to use. The 3-D-combing technique combs pixels with no motion, 2-D combing works on areas that are not complex with motion, and notch filters work on areas that are complex with motion. The key challenge of a 3-D-comb decoder is not the 3-D-combing process itself, but the complex motion detection and adaptive switching between 3-D, 2-D, and notch.

(a) (b)

Figure 12 An invalid determination of 3-D-combing relevance results in visible mesh artifacts (a). With the corrected motion, no mesh artifacts occur (b).

WHEN GOOD COMBS GO BAD

Adaptive 3-D combing relies on the ability of the decoder to correctly detect motion. Failing to do so causes the comb to incorrectly process pixel data, resulting in motion artifacts (**Figure 11**). The bird's wings are in the down position in **Figure 11a**. In **Figure 11b**, the wings have moved to an up position, and, in **Figure 11c**, the wings have returned to the down position. This sequence is the normal order of events as a bird flaps its wings.

Many 3-D-comb decoders examine frames 1 and 3 and, finding them the same, incorrectly assume that no motion has occurred. Therefore, they decide to 3-D-comb the data (**Figure 12**). High-performance video decoders with 3-D combs, in contrast, use many frame memories to more accurately detect motion between all of the frames. Using a large number of frames is necessary for the decoder to make accurate decisions about where and when to apply the 3-D comb.

MAXIMIZING FEATURES

For a 3-D comb to properly function, memory buffers store the frames of video-pixel data for analysis and processing. Decoders such as Analog Devices' ADV7802 12-bit SDTV/HDTV video decoder with a 3-D comb filter and a graphics digitizer maximize memory usage by using it for other non-3-D-combing tasks, such as advanced temporal-noise reduction. As with 3-D combing, the ADV7802 uses techniques that compare pixel data from the current frame with previously stored data to filter and remove noise from the image.

External memory can also find use in implementing advanced timebase correction. Frame-based timebase correction ensures that the decoder always outputs a fixed output clock, a fixed number of samples per line, a fixed number of lines per frame, and the correct field sequence. Although this feature is not normally a requirement for TV applications, an increasing number of manufacturers are moving much of the receiver and control electronics into separate remote boxes to minimize the display panel's depth. This type of design also limits the number of cables you need to interface directly with the TV, which might be in a location in which wiring is awkward or difficult (**Figure 13**).

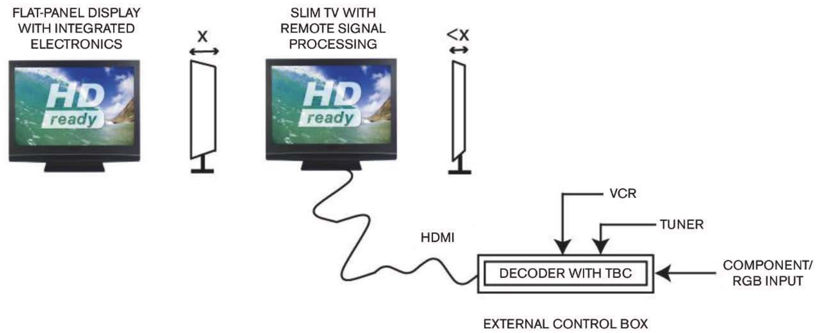

Figure 13 A low-profile display panel moves receiver and control electronics into a separate unit.

The remote box feeds the display through an HDMI (high-definition multimedia interface) or similar link. For this type of link to work, the TV requires stable pixel and clock data. Since timebase correction allows direct connection between the video decoder and the link's transmitting device, the decoder provides solid timing and pixel data even for nonstandard inputs.

Apart from luminance and chrominance separation, many other aspects of composite video processing directly influence display quality. The performance of the input ADC is critical to the overall video quality the display receives. Professional-quality video decoders, such as the ADV7802, deliver better than 62-dB SNR (signal-to-noise ratio) using a 12-bit ADC. It is important to note that the differential-phase and -gain figures for performance-driven applications can exceed 0.45° and 0.45%, respectively. Cost-sensitive applications may use a video decoder with nine-bit ADCs, such as the Analog Devices ADV7180.

The decoder must also be able to process nonstandard and weak broadcast-signal sources. TV customers and manufacturers continue to put great emphasis on these requirements. Consumers who have just purchased a new, high-end, large-screen plasma or LCD TV may continue to connect it, for example, to a 12-year-old VCR and an analog-RF-cable system. They expect at least the same level of performance from their HDTV when using their VCR as they had with their old CRT TV. This requirement means that the video from the VCR should be stable and continue to maintain lock even in "trick modes"—that is, when a user pauses, fast-forwards, or rewinds it.

Weak RF signals should also remain synchronized with color lock, even when the input signal drops below 25 dBμV. Low-level RF signals and video signals with old, nonstandard systems present decoder designers with numerous challenges. The algorithms implemented are important considerations when you are benchmarking the quality level of the decoder. Many manufacturers market their capability to successfully process such signal sources. Analog Devices, for example, uses technology in its video decoders that incorporates synchronization detection and extraction, resampling, and advanced back-end FIFO management.

Intelligent filter algorithms, such as those in the ADV7802, use PLL (phase-locked-loop) blocks along with HSYNC (horizontal-synchronized) and VSYNC (vertical-synchronized) processor blocks to ensure the correct extraction of the synchronization information. The filters ensure that the decoder gates the time period in which it looks for synchronization information. The synchronization PLL blocks and processor blocks ensure the correct alignment of the detected synchronization. **EDN**

AUTHOR'S BIOGRAPHY

Frank Kearney is an applications-staff engineer with the advanced-TV segment of Analog Devices. He received a degree with distinction in electronics and telecommunications from the Limerick School of Engineering (Limerick, Ireland). Kearney has worked for the last seven years on customer applications involving high-performance video encoders, video decoders, video DACs, video codecs, and, more recently, silicon TV tuners.

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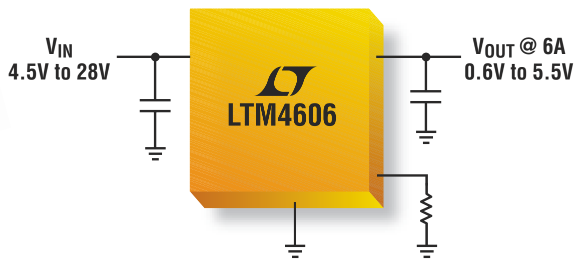

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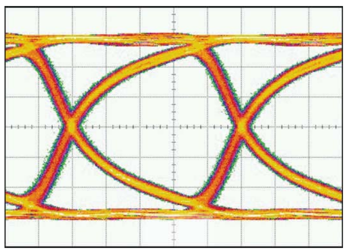

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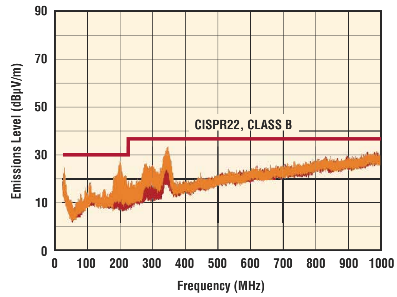

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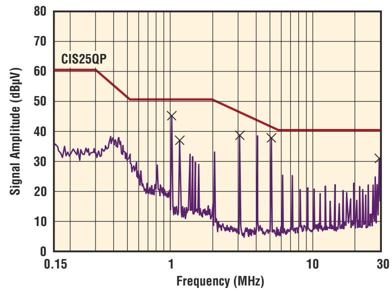

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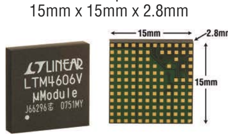
Narrow Voltage Range						Pin Compatible 15mm x 15mm x 2.8mm 
LTM®4606	4.5V to 28V	0.6V to 5.5V	6A	CISPR 22 Class B	Powers Multigigabit Transceivers	
Wide Voltage Range						
LTM4612	4.5V to 36V	3.3V to 15V	5A	CISPR 22 Class B	N/A*	

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Convert signals to proper logic levels

Abel Raynus, Armatron International Inc, Malden, MA

When designing a test station incorporating a microcontroller, you often face voltages in the test that exceed the maximum input level permitted for the microcontroller. For example, if a microcontroller uses a 5V power supply, then the maximum input signal should also be 5V. When a test voltage exceeds 5V, you might think to reduce the voltage with a voltage divider. A voltage divider can influence the DUT (device under test), however. So, a signal conditioner needs high input impedance. Also, the signal conditioner's output signals should match the logic levels of the microcontroller despite some fluctuation of the measured signal. It allows you to use the regular microcontroller-input pins instead of ADC ones.

Engineers often use a noninverting op amp to bring signal voltages in line. However, most op amps have differential-input-voltage ranges matching their power-supply voltages. Thus, you need one more power-supply voltage with a higher voltage and several extra resistors to lower the op amp's output to the microcontroller level. Moreover, the output will follow the measured input-signal variations, so it needs analog-to-digital conversion in the microcontroller.

A better approach is to use a small-signal MOSFET in the voltage-repeater configuration (**Figure 1**). You can use the BS107A from On Semiconductor (www.onsemi.com) for this task. You can consider the gate-to-source area of the MOSFET as a capacitor with a value of approximately 60 pF. To discharge it in the absence of the DUT, connect a resistor of ap-

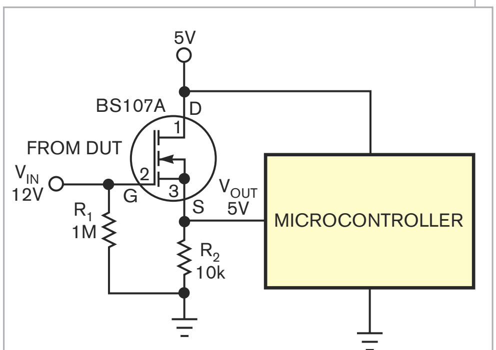

Figure 1 You can use a small-signal MOSFET to provide overvoltage-signal conditioning.

DIs Inside

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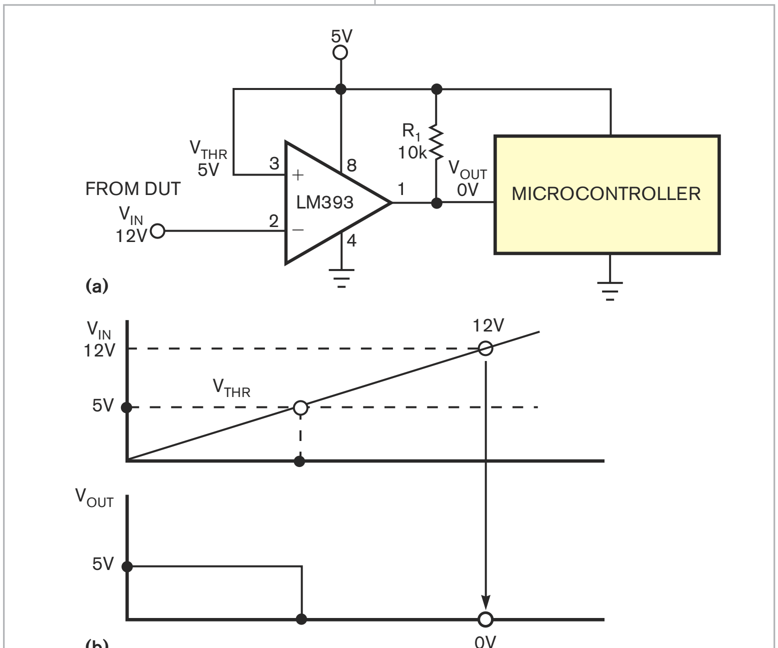

Figure 2 Another approach to signal conditioning is to use dual- or quad-voltage comparators (a). The 5V power-supply voltage acts as the positive-threshold voltage. The output is 5V for input signals lower than this level. If the input signal exceeds 5V, the output voltage drops to 0V (b).

proximately 1 MΩ between the gate and ground. Also, the input voltage should be more than the MOSFET's gate-threshold voltage, V_{THR}, of 3V dc but less than the maximum rated gate-to-source voltage, V_{GS}, of 20V dc. In this **figure**, the output voltage never exceeds the power-supply voltage, and variations of the input voltage have no effect on output as long as they happen in the saturation region. A drawback of this approach is that you must use as many transistors as the number of test-points in the DUT.

Another good option is to use any dual- or quad-voltage comparator. You can use an LM393 from National Semiconductor (www.national.com) because it's inexpensive and widely available. **Figure 2** shows a simple configuration with few components. The 5V power-supply voltage acts as the positive-threshold voltage. The output is 5V for input signals lower than this level. If the input signal exceeds 5V, the output voltage drops to 0V. Resistor R_1 connects an open collector of the LM393 to the supply voltage.

Sometimes, a zero-output signal is undesirable. A missing power-supply voltage, a bad solder joint, or a broken wire in the test fixture could cause this zero-output signal. Use a logic high level when the signal under test is present and logic low when it's absent. At first glance, it seems that just switching the comparator pins of the input and the threshold voltages provides an acceptable approach. However, that assumption is invalid because the positive input voltage may exceed the power-supply level only as long as the other voltage remains within the common-mode range. The upper limit of common-mode input voltage for the LM393 is 1.5V less than the power-supply voltage, or 3.5V. Thus, you should use the voltage divider comprising R_2 and R_3 for the threshold voltage (**Figure 3**).EDN

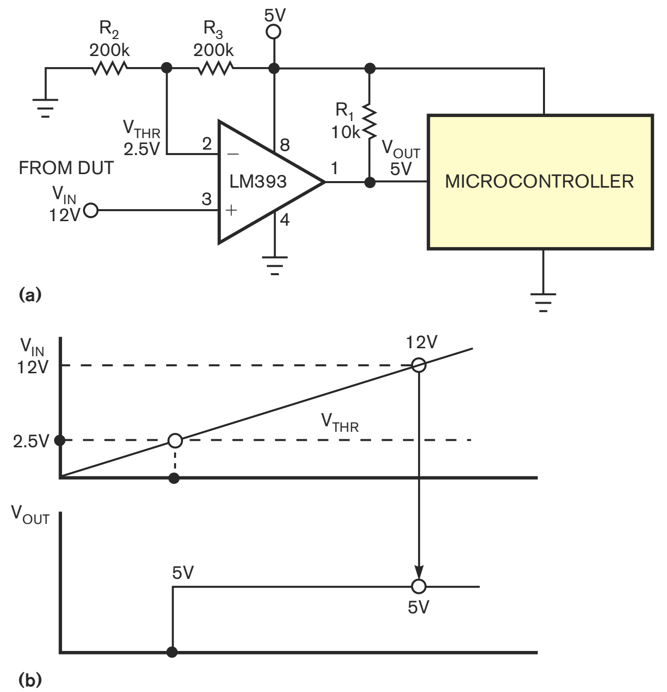

Figure 3 Use the voltage divider comprising R_2 and R_3 for the threshold voltage.

DDR-differential-clock source on SOC drives two DDR-memory chips

Goh Ban Hok, Infineon Technologies, Singapore

Many system engineers assume that a differential-clock source should drive just one chip. If a system design requires driving two DDR-memory chips, however, the design would inevitably need a differential-clock buffer. This Design Idea describes a circuit that drives two DDR chips without a clock-source buffer yet does not sacrifice much of the signal integrity.

The cost-saving nature of an SOC (system-on-chip) design dictates the need for fewer pins. Such designs typically have only one pair of differential signals available for external-memory-chip connection. When the system design requires more than one DDR chip, designers typically use a clock buffer.

Figure 1 shows an SOC with an embedded DDR controller, which connects the SOC's differential clock to two DDR-memory chips. Differential signals CLK and CLK− from SOC chip IC_1 connect to series resistors R_1 and R_2, respectively. The differential traces then connect to DDR-memory chips IC_2 and IC_3 with a 120Ω termination resistor near IC_2.

Figure 2 shows the equivalent PCB (printed-circuit-board) layout. The PCB comprises a four-layer FR4 material with a ground plane under differential lines CLK and CLK−. The CLK and CLK− signals are routed close to each other and pass through series resistors R_1 and R_2, which are also placed close to each other, to provide proper termination. The closely spaced differential signals connect to

LINEAR TECHNOLOGY
DESIGN NOTES

Buck Converter Eases the Task of Designing Auxiliary Low Voltage Negative Rails

Design Note 458

Victor Khasiev

Introduction

Many system designers need an easy way to produce a negative 3.3V power supply. In systems that already have a transformer, one option is to swap out the existing transformer with one that has an additional secondary winding. The problem with this solution is that many systems now use transformers that are standard, off-the-shelf components, and most designers want to avoid replacing a standard, qualified transformer with a custom version. An easier alternative is to produce the low negative voltage rail by stepping down an existing negative rail. For example, if the system already employs an off-the-shelf transformer with two secondary windings to produce ±12V, and a –3.3V rail is needed, a negative buck converter can produce the –3.3V output from the –12V rail.

Leave the Transformer Alone: $-3.3V_{OUT}$ from $-12V_{IN}$

Figure 1 shows a negative buck converter that generates –3.3V at 3A from a –12V rail. The power train (indicated by bold lines in Figure 1) includes an inductor L1, a diode D1 and a MOSFET Q1. The LTC3805-5 controller includes short-circuit protection (the current level can be precisely set), enable control and a programmable switching frequency. An internal shunt regulator simplifies biasing this IC directly from the input rail.

Despite the simplicity of this topology, there are some design hurdles. The first is that the feedback loop must control a negative output voltage via the controller's internal positive reference. The second is that the on/off signal is referenced to the system ground.

To solve the output reference polarity problem, the regulation loop uses a current mirror based on transistors Q2 and Q3. Resistor R_{PRG} programs the current flowing into resistor R_{FB} which sets the output voltage. In this example, when the output voltage is at the desired –3.3V, the current through the 3.31k R_{PRG} resistor is 1mA. This

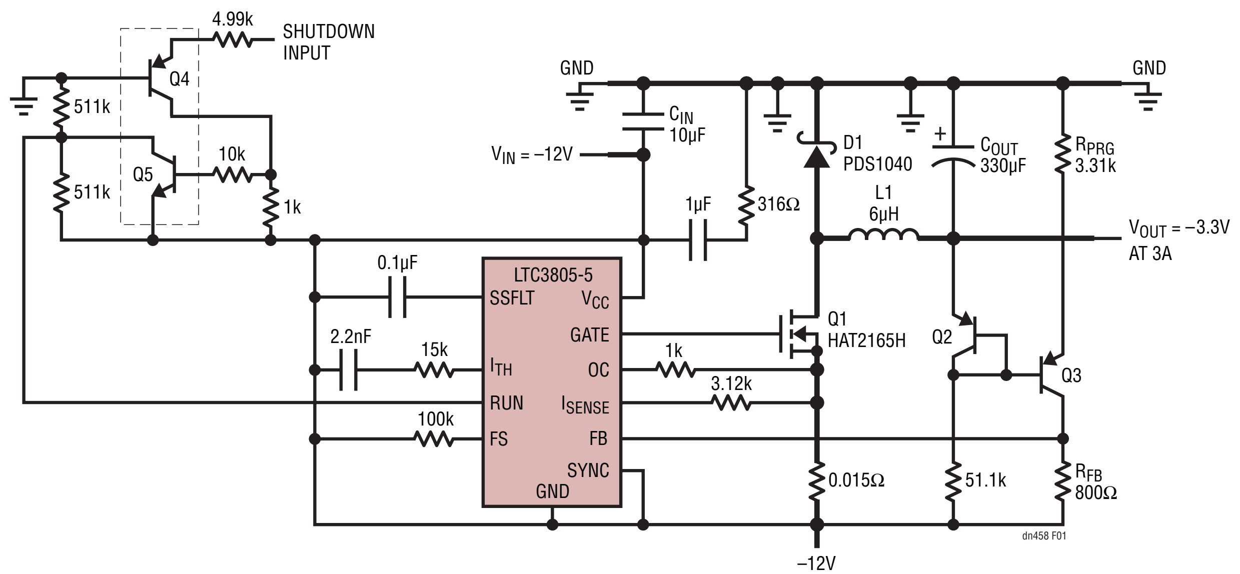

Figure 1. A Negative Buck Converter Based on the LTC3805-5 Produces –3.3V at 3A from a –10V to –14V Input

current creates a 0.8V drop across resistor R_{FB}, which is equal to the reference voltage, V_{REF}, of the internal error amplifier:

$$V_{OUT} = \frac{V_{REF} \bullet R_{PRG}}{R_{FB}}$$

There is also an optional on/off circuit based on transistors Q4 and Q5. If 5V is applied to resistor R8, the LTC3805-5 shuts down. Both circuits are referenced to the system ground. The voltage stress on the power train components, the transfer function and other parameters are similar to positive input voltage buck converters.

This circuit operates at 90% efficiency, as shown in Figure 2. Figure 3 shows the progressive overcurrent protection as the load current increases. The output voltage drops at loads exceeding 4.5A, and at 5A the converter enters into a short-circuit protection state where the power is limited to 0.25W. The output voltage recovers after the short-circuit is removed. In addition, the line and load regulation has a maximum deviation of less than 1%. Figures 4 and 5 show the start-up and transient response waveforms, respectively.

Conclusion

A negative buck converter is an easier way to generate an additional negative rail in systems that already have a larger negative voltage supply. This avoids undesirable replacement of standard transformers or modular components.

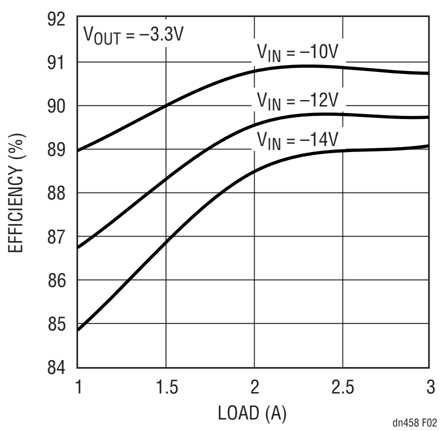

Figure 2. Efficiency vs Input Voltage and Output Current for the Circuit in Figure 1

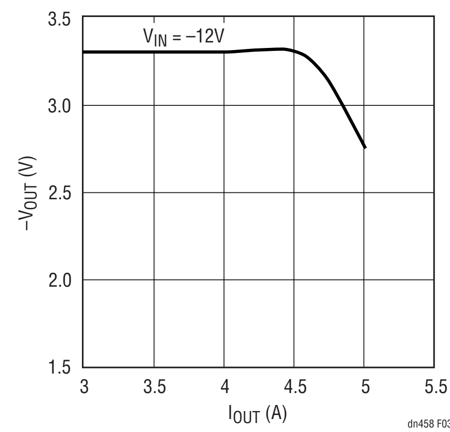

Figure 3. Output Voltage vs Output Current, at –12V Input Voltage for the Circuit in Figure 1

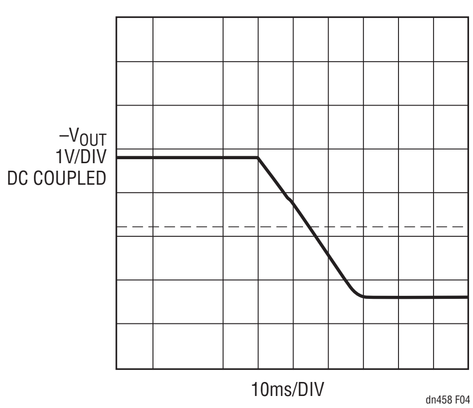

Figure 4. Start-Up into Full Load

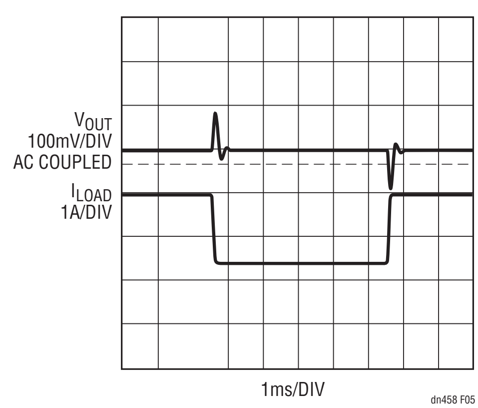

Figure 5. Transient Response for a Load Current Step from 1A to 2.5A

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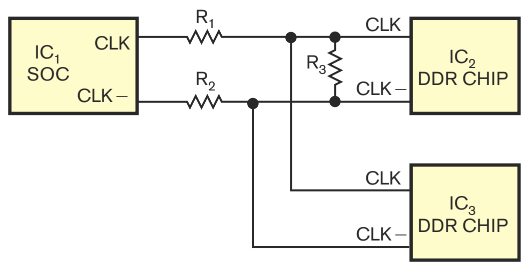

Figure 1 This circuit for an SOC-differential-clock source drives two DDR chips.

Figure 2 The bare PCB shows the differential-signal traces from the SOC to IC_1 and IC_2.

IC_2 with the 120Ω termination resistor, R_3. The bottom-layer traces are necessary to connect the differential signals to IC_3. The total length of the differential pair is approximately 2.5 in. from the SOC chip to the DDR chips.

The SOC provides DDR differential clocking. With various values for R_1, R_2, and R_3, the best results occur when R_1 and R_2 are 0Ω and R_3 is unconnected. Figures 3 through 7, which are available with the Web version of this Design Idea at www.edn.com/090205dia, show various waveforms for the signals. EDN

Flying capacitor and negative time constant make digitally programmable-gain instrumentation amplifier

W Stephen Woodward, Chapel Hill, NC

Numerous and evil are the forces of darkness that conspire to frustrate accurate analog-to-digital conversion of wide-dynamic-range analog signals. Among these gremlins lurk common-mode-voltage noise and signal amplitudes too variable to fully use ADC-input span and conversion resolution. Proven charms against common-mode noise are differential inputs, and you can exorcise variable signal amplitudes by implementing digitally programmable gain. DPGIAs (digitally programmable-gain instrumentation amplifiers) combine both useful features (**Figure 1**).

Microcircuit—even monolithic—DPGIAs, such as the Linear Technology (www.linear.com) LTC6915, are available. But this Design Idea describes a DDENT (differential-divergent-exponential-negative-time-constant) DPGIA employing the concepts of the "flying"-capacitor differential input and the DDENT curve, which provide an interesting alternative.

You control DDENT operation with the amplify/$\overline{\text{track}}$-bit mode. Track mode connects flying-capacitor C to the positive and negative differential-input terminals, which acquire the input voltage, V_{IN}. The transition to the amplify mode isolates C from the input and initiates regenerative negative-time-constant exponential amplification of the input voltage. From that point (**Reference 1**) until the moment when a connected ADC ultimately samples and converts the

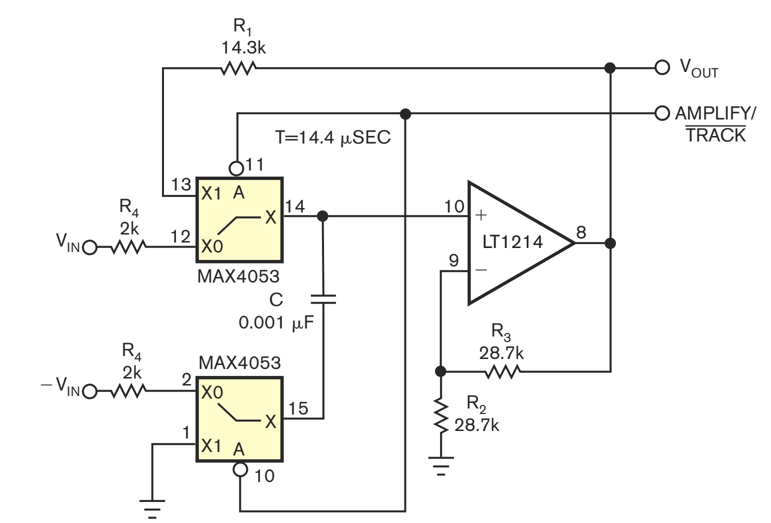

Figure 1 The behavior of the RC topology is still simple when you replace the resistors with an active circuit that synthesizes a negative resistance.

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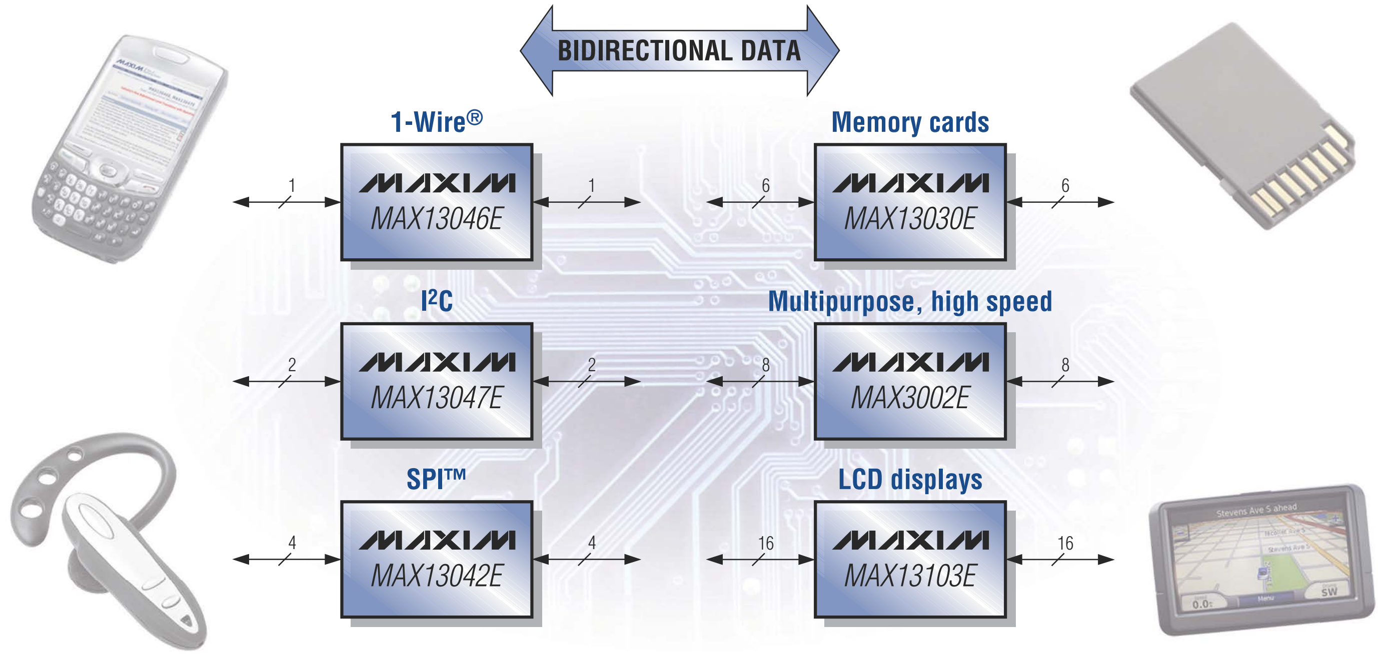

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MAX13046E	1	1.1 to 3.6	1.65 to 5.5	8	High-Z	High-Z	6-µDFN (1 x 1.5)
MAX13047E	2	1.1 to 3.6	1.65 to 5.5	8			10-UTQFN (1.4 x 1.8)
MAX13042E	4	1.62 to 3.2	2.2 to 3.6	100			12-UCSP (1.5 x 2.1)
MAX13030E	6	1.62 to 3.2	2.2 to 3.6	100			16-UCSP (2 x 2)
MAX3002E	8	1.2 to 5.5	1.65 to 5.5	20		6kΩ to GND	20-UCSP (2 x 2.5)
MAX13103E	16	1.2 to 5.5	1.65 to 5.5	20		High-Z	36-UCSP (3 x 3)

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output voltage, V_{OUT}/V_{IN} is a divergent exponential function of time: $gain=2^{(t/10\ \mu sec+1)}$.

Building on the assets of that earlier design, this new circuit features CMR (common-mode rejection) that neither resistor-network matching nor the CMR of the op amp limits. Stray-capacitance issues impose the only limits, but you can minimize these issues with careful circuit layout. The circuit has rail-to-rail inputs, virtually unlimited programmable gain, and gain-set resolution that only the resolution of the amplify-interval timing limits. The circuit also has settling time 10 to 100 times faster than that of the exemplary LTC6915 and ±10V output-amplitude capability—two to four times greater than that of monolithic DPGIAs. Besides the inherent dc accuracy of the op amp you choose, the accuracy and repeatability of the timing of exponential generation, ADC sampling, and RC-time-constant stability are the only limits on the amplifier's signal-processing performance and precision. In the sample circuit, in which T=14.4 μsec, 1 nsec of amplify-timing error or jitter equates to 0.007% of gain-programming error.EDN

THIS NEW CIRCUIT FEATURES CMR THAT NEITHER RESISTOR-NETWORK MATCHING NOR THE CMR OF THE OP AMP LIMITS.

REFERENCE

1 Woodward, W Stephen, "Digitally programmable-gain amplifier uses divergent-exponential curve," *EDN*, Jan 8, 2009, pg 49, www.edn.com/article/CA6625454.

MOSFET prevents battery damage

Santosh Bhandarkar, Wep Peripherals, Mysore, India

Sealed-lead-acid batteries, which find wide use in power-electronics products, such as UPS (uninterruptible-power supplies), inverters, and emergency lamps, supply power to the load whenever utility power is unavailable. When you restore utility power, a charger supplies the power to the load and charges the batteries (**Figure 1**).

You can add a diode to protect a load from current resulting from a reverse-connected battery. The diode, however, won't protect a reverse-connected battery from the charger circuit. If the charger is on, a potentially dangerous current can flow into a reverse-connected battery. The battery voltage, which normally opposes the charging voltage, now aids it, which lets a higher current flow into the battery.

If you add an N-channel MOSFET to the circuit, you can protect the battery from this damaging condition (**Figure 2**). The MOSFET conducts only when the battery is correctly connected, which lets the battery charge or discharge. In this condition, the transistor gets forward-biased, which switches on the MOSFET. If the battery is reverse-connected, the transistor and MOSFET turn off, thus preventing current flow. This simple circuit provides reverse-battery protection in both charger and battery paths, thereby protecting the battery, the charger, and the load. You can use a microcontroller to measure battery current and make a decision on appropriate action, as well.EDN

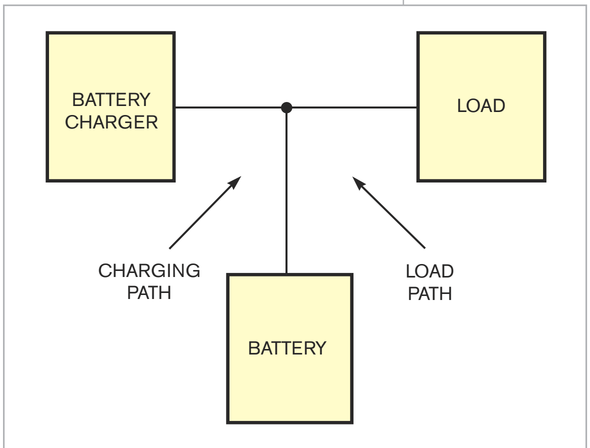


Figure 1 Batteries provide power to a load when utility power is off.

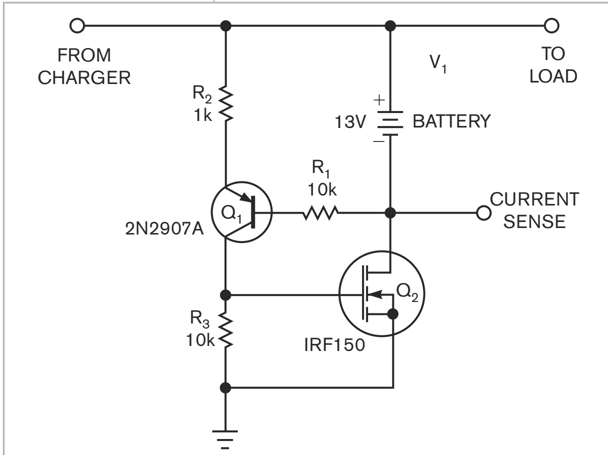


Figure 2 MOSFET Q_2 protects the battery from excessive current.

Voltage doubler improves accuracy

S Chekcheyev, Tiraspol, Moldova

The voltage doubler in **Figure 1** provides more accurate voltage doubling than does the conventional voltage doubler in **Figure 2** because it uses transistors instead of diodes. You can express the output voltage of the conventional doubler as $V_{OUTDC}=2V_{INAC}-2V_D$, where V_{OUTDC} is the output dc voltage, V_{INAC} is the amplitude of the input ac voltage, and V_D is the voltage across the forward-biased diodes. The error of the conventional voltage doubler is $2V_D$. Transistors Q_1 and Q_2 in **Figure 1** are saturated during the positive and the negative half-cycles, respectively, of the input ac voltage. The operation of the saturated transistors is similar to the operation of the forward-biased diodes in **Figure 2**. The collector-emitter voltage of the saturated bipolar transistors, however, is substantially smaller than the voltage across the forward-biased diodes. Thus, the error of doubling decreases.

Transistors Q_1 and Q_2 are reverse-biased during the negative and the positive half-cycles, respectively. The reverse beta of the bipolar transistors is small; consequently, the operation of the reversed transistors in **Figure 1** is similar to the operation of the reverse-biased diodes in **Figure 2**. Both circuits underwent tests with a resistive load of 10 kΩ and a 50-Hz, 2V-amplitude sinusoidal signal applied to the input. The measured output voltage of the conventional voltage doubler was 2.8V, and the error of doubling was 2×2V−2.8V=1.2V. The measured output voltage of the proposed voltage doubler was 3.8V, and the error of doubling was 2×2V−3.8V=0.2V. **EDN**

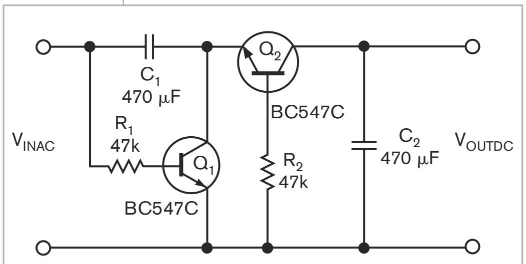


Figure 1 An improved voltage doubler uses transistors for better accuracy.

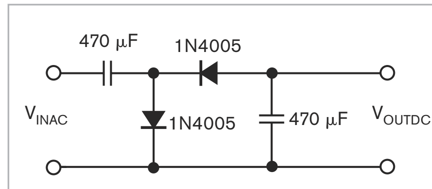


Figure 2 A conventional voltage doubler uses diodes.

Troubled economy could open more doors to outsourcing

Manufacturers that shunned outsourcing may change their tunes during this economic downturn. One area of potential growth for EMS (electronic-manufacturing-services) providers is with portions of the electronics market, such as the defense, aerospace, and medical-equipment industries, that have not yet adopted outsourcing. Proprietary concerns may close the door on outsourcing for defense, but medical and aerospace are on the radar for EMS companies seeking new customers.

"There has been some movement in medical equipment as EMS providers have been trying to convince medical manufacturing companies that they can meet their hybrid work and sterile environments," says Matt Chanoff, chief economist at Technology Forecasters Inc (www.TechForecasters.com).

Japan is also a possible outsourcing target that may be susceptible to the economic jolt. "Japan is 10 to 20% of the total available market. The [country doesn't] normally outsource, but, if it did, that change would be huge," Chanoff says.

Outsourcing of engineering support, software development, and IT work will likely increase more than manufacturing during the economic downturn. Companies are looking into moving more of these tasks out, and much of that work may go to Asia.

"We're seeing companies investigating India and China," says Phil Fersht, research director for global services and outsourcing at AMR Research (www.amrresearch.com). Fersht notes the interest in outsourcing engineering services has increased with the downturn. Yet, he warns companies against making hasty decisions in the interest of quickly cutting costs.

Because the economic pressures are global, manufacturers are finding a ripe market when they look for companies to take on more of their work. "We're seeing companies vigorously seeking better deals in their outsourcing," Fersht says. "And we're seeing downward pressure on prices because so many companies [in India and China] are trying to get this work."**—by Rob Spiegel**

GREEN UPDATE

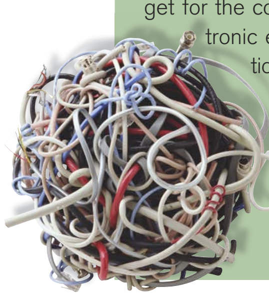
CHANGES TO ROHS COMING

The EC (European Commission) in December 2008 released its proposed changes to WEEE (waste in electrical and electronic equipment) and ROHS (restriction of hazardous substances), aiming to improve and simplify the environmental regulations.

Specific to recycling, the proposed revised WEEE directive sets a new binding target for the collection of electrical and electronic equipment. The current collection target of 4 kg per person per year does not properly reflect the situation in individual EU member states, the EC says. The EC has proposed setting mandatory collection targets equal to 65% of the average weight of electrical and electronic equipment placed on the market over the two previous years in each member state.

The proposed revised ROHS directive would cover medical devices and monitoring and control instruments, which had been excluded from ROHS' reach. Further, the EC will assess in line with the EU REACH (registration, evaluation, authorization, and restriction of chemicals) regulation a list of "priority" substances that it considers to pose particular environmental concerns when used in electrical and electronic equipment—with a view of a possible ban in the future.

For more on the possible changes to the two directives, visit www.edn.com/090205sca.**—SD**



OUTLOOK

CE SALES SHRINKING

US sales of CE (consumer electronics) are expected to be down in 2009 for the first time in recent history. Despite the fact that the CE industry reached new sales highs in 2008, it is expected to dip 0.6% year over year in 2009 and generate $171 billion in US-shipment revenues, according to the forecast that the CEA (Consumer Electronics Association, www.CE.org) released last month.

"The CE industry is resilient but not immune to the business cycle," said CEA's president and chief executive officer, Gary Shapiro, at January's 2009 International CES. "In a tough economy, our products offer high value for entertainment and an entry point for entrepreneurs."

The primary revenue driver for the industry continues to be DTV (digital-television) displays, making up 15% of total industry-shipment dollars. CEA reports that, with the transition to digital television, DTV unit shipments will near 35 million in 2009, an increase of nearly 6% over 2008 shipments.

CEA further reports that Blu-ray players are expected to experience major growth in 2009, with revenues projected to surpass $1.2 billion. Gaming also remains a bright spot. CEA data forecasts 11% growth in 2009, generating nearly $22 billion in revenue.**—SD**

productroundup

PASSIVES

Tantalum capacitors use a new termination design

The vendor claims that its new termination style for the TLN MnO2 series and the TCN polymer series of tantalum capacitors reduces internal construction space by 60%. The capacitors' configurations replace J leads with undertab terminations that do not protrude outside the outline of the case. The design claims an increase in volumetric efficiency and allows the spacing of PCB-footprint pads to be slightly wider than the part. Additional features include a 22- to 680-mF planned capacitance range and a 4 to 10V working voltage. The TLN and TCN series cost 24 and 39 cents, respectively.

AVX Corp, www.avx.com

High-current inductor has 1-MHz maximum frequency

Operating over a 1-MHz frequency range, the IHLP-2020CZ-11 high-current inductor suits use in voltage-regulator modules and dc/dc converters. The device offers a 0.10- to 22-µH inductance range, a 1.7 to 25A saturation-current range, a typical 2.6- to 250-mΩ dc resistance, and a 2.9 to 260-mΩ maximum dc resistance. The inductor handles high-transient-current spikes without hard saturation. The inductor operates over a −55 to +125°C temperature range. Available in a 2020 case size with a 3-mm profile, the IHLP-2020CZ-11 costs 35 cents (10,000).

Vishay Intertechnology, www.vishay.com

Molded-inductor family targets miniature and custom devices

Capable of controlling power losses at 300-kHz to 1-MHz switching frequencies, the HM72A molded-inductor family uses a pressed, powdered-iron-alloy-core construction, suiting miniature and custom devices. The inductor features 100-nH to 33-µH inductance values, with 80A saturation levels, and a −40 to +155°C operating temperature with a maximum temperature-rise rating of 50°C. The devices measure 6×6×1.6 mm, and prices range from 55 to 85 cents.

BI Technologies, www.bitechnologies.com

PASSIVES

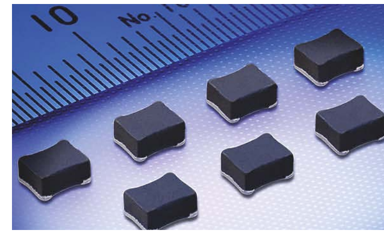
Current-sense chip resistors use resistive alloy

The CSS/CSSH ultrastable-metal-element current-sense chip-resistor series uses a resistive alloy, enabling accurate control of power systems. The series includes a 3W 2512-size chip and a 4W device in a 2725 or 2728 package and has a metal construction, eliminating the problem of part or solder-joint cracking. The devices have resistance tolerances of 0.5% and 15-ppm TCRs, allowing for precision power management over a range of ambient temperatures. The units come in ROHS (restriction-of-hazardous-substances)-compliant packages and in 7-in. reels; prices range from 20 to 50 cents.

Stackpole Electronics, www.seielect.com

Wire-wound power inductors come in EIA 1210 form factor

The BRL3225 wire-wound-power-inductor series aims at switch-mode-dc/dc-converter applications in digital cameras, portable games, hard-disk drives, and other high-current-use



devices. The BRL3225T-1R0M has a 2.4A rating at 1-μH inductance when providing 0.043Ω dc resistance. Available in an EIA 1210 form factor, the low-profile inductors use a sleeveless square-core winding design. Measuring 3.2×2.5×1.7 mm, the BRL3225 chip inductors cost 20 cents each.

Taiyo Yuden, www.t-yuden.com

INTEGRATED CIRCUITS

Temperature switches allow programming with one resistor

You can program the MCP9509 and the MCP9510 logic-output temperature switches using one external resistor. Targeting battery-powered systems in industrial, automotive, medical, appliance, and consumer devices, the switches provide 2.7 to 5.5V operating voltage over a −40 to +125°C temperature range and a user-programmable 2 and 10°C typical switch hysteresis. The MCP9509 has a 30-μA static operating current and provides an open-drain output. The MCP9510's user-selectable output configurations include an active-low push-pull, an active-high push-pull, and an active-low, open-drain output with an internal 100-kΩ pullup resistor. The MCP9509 and the MCP9510 switches come in five-pin SOT-23 and six-pin SOT-23 packages, respectively, and cost 61 cents (10,000).

Microchip Technology, www.microchip.com

FIR filter integrates gain and compression

The QF1Da512 audio Savfire engine suits audio-application-specific FIR (finite-impulse-response) filters with integrated gain and compression. The FIR engine supports 512 taps with 32-bit coefficients and a 12- to 24-bit user-defined data-word width, providing applications with superior audio quality. Features include a 24-dB positive-digital gain and 2.8-mW power consumption. The engine processes the equivalent of 50 million MAC (multiply/accumulate) instructions/sec and supports sample rates of 1 Hz to 500 kHz. Available in a 3×3-mm QFN, the QF1Da512 audio Savfire costs $1.

Quickfilter Technologies, www.quickfiltertech.com

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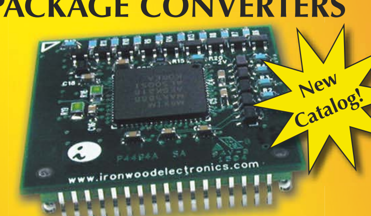

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Getting real with the real-time clock

DANIEL VASCONCELLOS

In the 1990s, I was the lead servo-system engineer for the world's largest radio telescope (**Reference 1**). Our team was responsible for real-time motion control of 30 45m-diameter giant antennas that composed the radio telescope. Astronomers sitting at a central console focused the antenna position on the target—the radio star under observation. Because the rotation of the earth causes apparent drift in the position of the target, the antenna had to track the target by moving accordingly. The servo system was supposed to "servo track" this motion under the supervisory control of the central computer. By 1993, a few of the prototype antenna systems were undergoing proving trials, which uncovered many painful surprises. The chief astronomer reported that the antenna was drifting off the target by minutes—and that was just one of our problems.

Surprisingly, the antenna time would remain accurate when antennas were not moving. To catch the culprit, we installed a spy counter in an embedded timekeeping routine. The counter would drift only when antennas were in tracking motion. The system would then periodically send the counter value to the central computer, which would record the signature of all the events occurring when the counter reported a miss. Heavy traffic comprising instantaneous trajectory information always coincided with the time slippage.

Analysis proved our worst doubts true. The onboard software RTC (real-time clock) was lagging behind whenever the CPU was busy servicing the dense traffic arriving from the central computer. Because this traffic was absent when the antenna was still, the software RTC in that case would be accurate. This board unfortunately lacked a hardware-RTC chip; hence, we had to implement a software RTC, which proved accurate enough during bench trials. Apparently, we could not accurately simulate the dense traffic from the central computer.

The project received its finances from the public, and redesign would have been suicidal. We had two options: Provide the single-board computer with a hardware RTC without touching the PCB (printed-circuit board) or wind up the project.

Fortunately, PCs were then widely using the cheapest RTC with nonvolatile RAM that we could afford. Unfortunately, the chip included the notorious multiplexed address/data bus. A little thought revealed that a bit of smart coding can indeed infuse enough intelligence inside those parallel I/Os to mimic a multiplexed bus. We successfully tested the idea and deployed it after necessary software changes (**Reference 2**).

Once we equipped the antennas with the RTC daughterboards, the antennas started obediently counting the time with accuracy within milliseconds. Modern embedded-system engineers may not make the mistakes we made during the design stage. However, this story amply illustrates how a clever piece of engineering can always pull you out of a crisis! EDN

REFERENCES

1 "Giant Metrewave Radio Telescope," Tata Institute of Fundamental Research, www.gmrt.ncra.tifr.res.in.

2 Vaidya, Vishwas, "I/O bus emulates multiplexed address/data bus," *EDN*, Feb 15, 1996, pg 120, www.edn.com/archives/1996/021596/04di7.htm.

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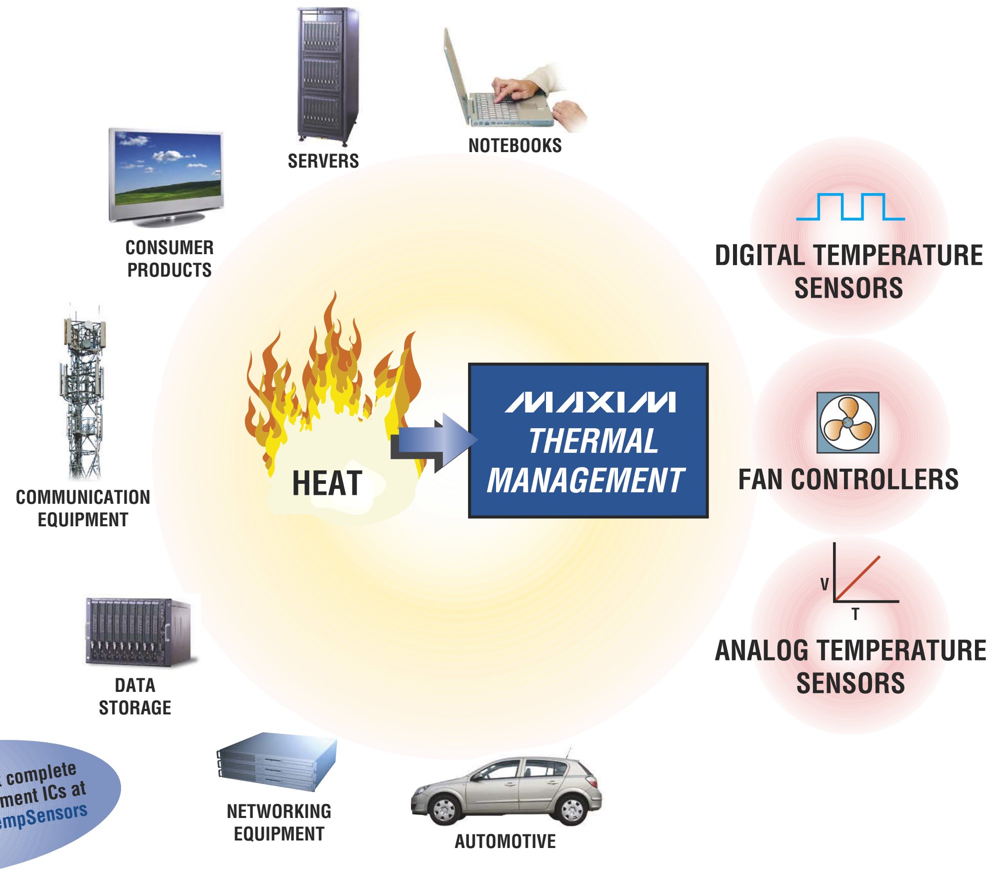

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