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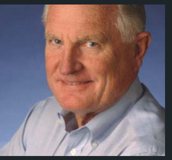

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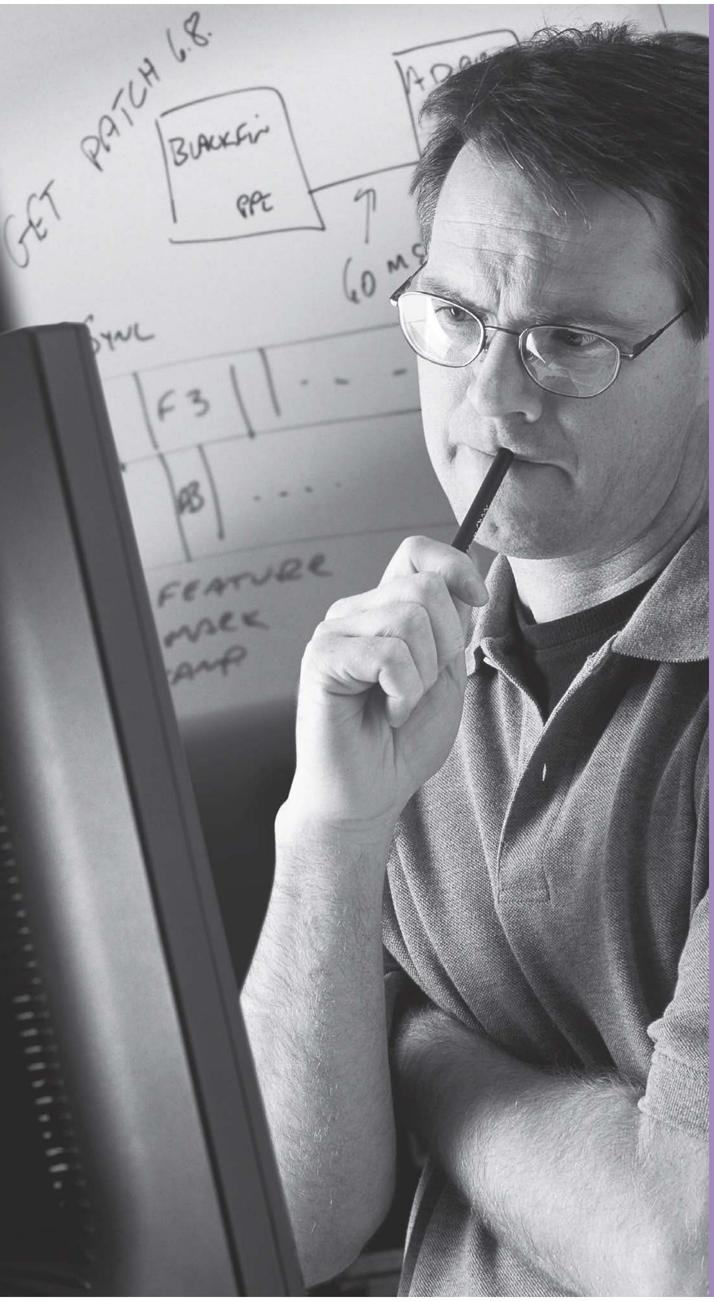

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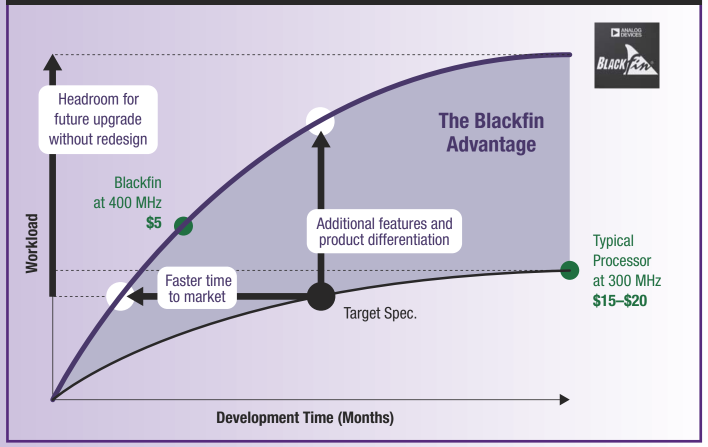

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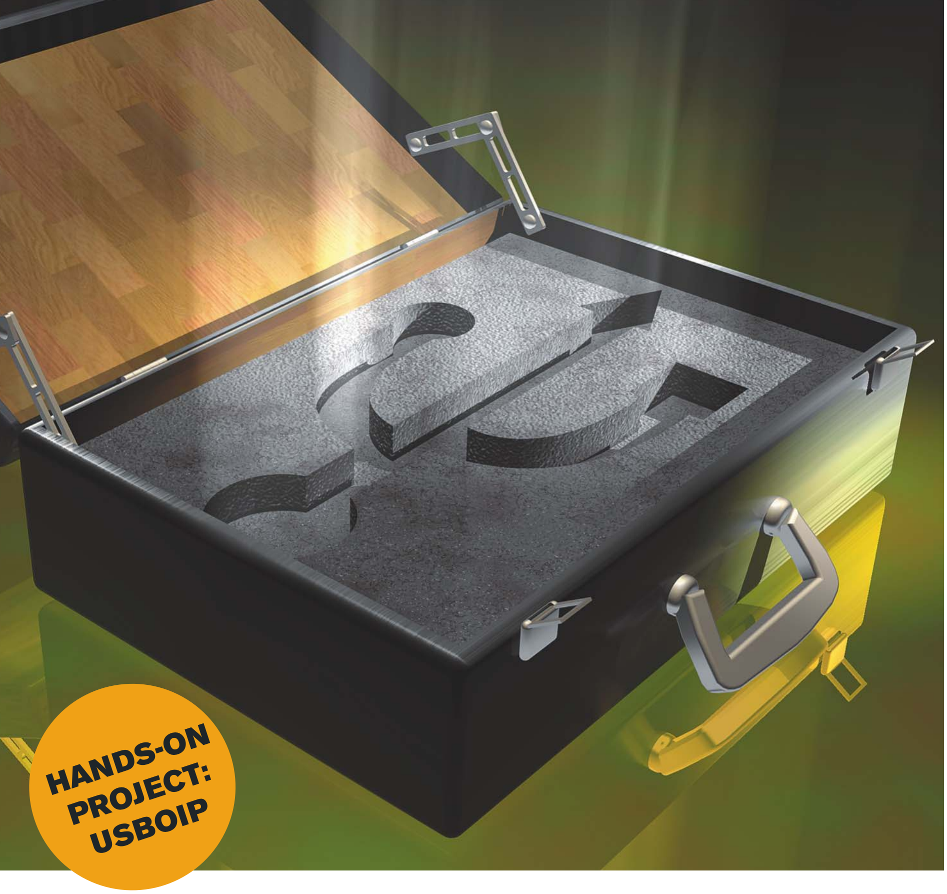

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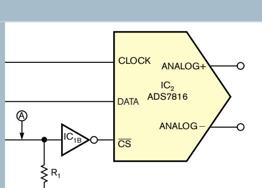

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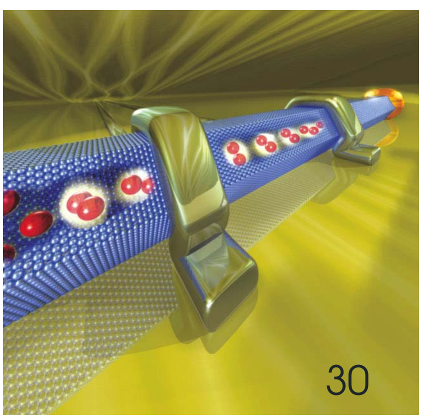

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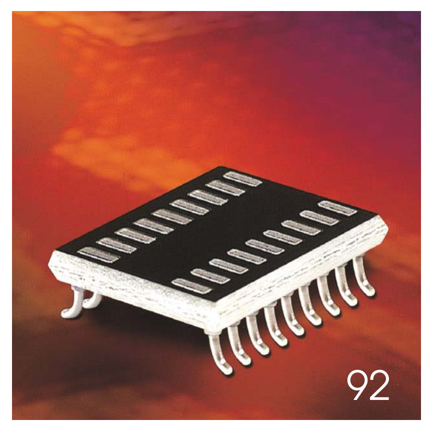

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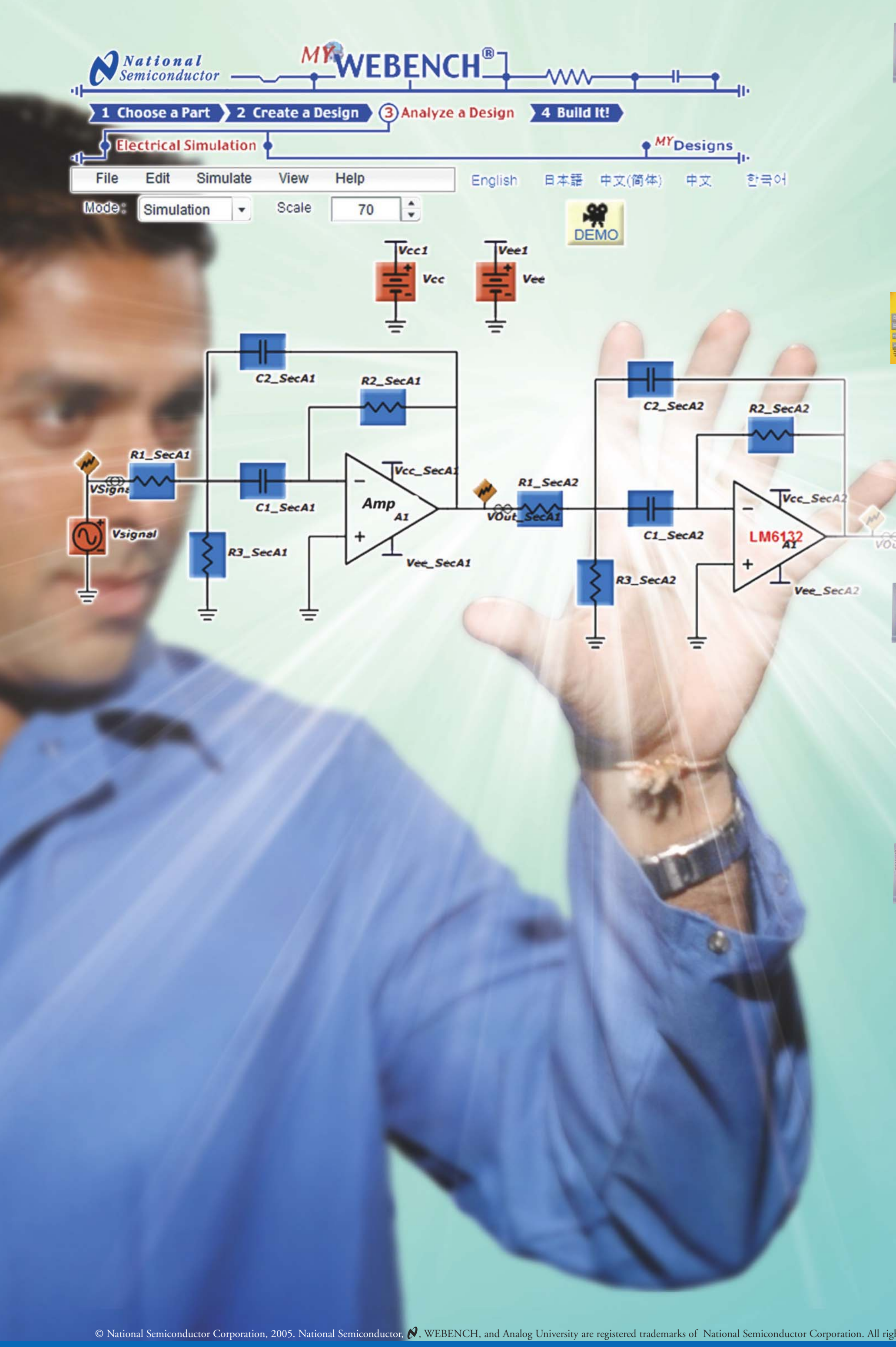

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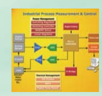

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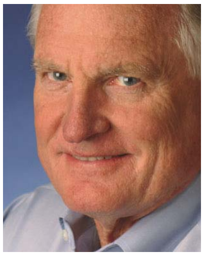

BY CRAIG BARRETT, CHAIRMAN, INTEL CORP

Sputnik, races, and the state of US education

"The harsh fact is that the US need for the highest quality human capital in science, mathematics, and engineering is not being met."—US Commission on National Security for the 21st Century

As *EDN*'s US readers, you represent the cream of the engineering community. How many of you have children or friends who have children who are studying an engineering-related curriculum and show zeal to be the future technology-designer all stars? I'm betting the percentage is small even for this esteemed group and certainly smaller than it would have been if we had asked ourselves this question 25 years ago, let alone 10.

Why is it, when over the past decade we've seen the most exciting technology innovations in history with personal computing, the rise of the Internet, wireless computing, smart phones, digital cameras, and much more, that our children aren't interested in pursuing science and technology as a career?

This year, the University of Illinois tied for 17th place in the ACM (Association for Computing Machinery) International Collegiate Programming Contest (**Reference 1**). That ranking is the lowest for the top-performing university in the 29-year history of the contest. Students from China's Shanghai Jiao Tong University took the top honors, continuing a gradual ascendance of Asian and Eastern European schools during the past decade or so. The last time a US institution won the world championship was in 1997.

So what? Well, this is only one of many indicators that we in the United States are in danger of losing our leadership in technical fields and thus, innovation. We may have already lost it.

As technology experts, evangelists, and engineers, why do we care? I think the answers are obvious. Science and technology drive innovation, which in turn drives much of the global economy, and much of the US standard of living. Economists have estimated that innovation has generated half of the growth in the US gross domestic product over the past 50 years. Our economic future depends on how many new ideas we bring to reality.

This time isn't the first that the United States has had to respond to such a challenge. In 1957, Sputnik shocked us into action, and the result was a national commitment to win the "space race." In 1958, we passed the National Defense Education Act, which encouraged students to study science and mathematics, among other subjects, by providing low-interest loans and federal aid to schools. Then, 11 years later, we watched a man walk on the moon. Flash forward to 2005. Is this Sputnik Part 2?

We are facing a new and even more serious challenge. The unhappy fact is that, as a nation, we are producing fewer of the people we need to ensure the health of our economy and our national security. Although the demand for skilled engineers is growing at a rate five times that of other occupations, the supply is not keeping pace. We're experiencing a graduation gap among the growing number of mathematically and scientifically literate people we need. Fewer US graduates have the training and skills to do the high-end jobs we used to think of as our birthright. Although many US citizens still believe that foreign workers are no match for US workers in knowledge, skills, and creativity, evidence to the contrary exists.

I could list the dismal rankings and stats versus other countries, such as China, Finland, Japan, South Korea, and many others. But you know these stats; *EDN* has reported on this topic. It's all over the news, and I've pointed out a few of my favorites. So, I'm not going to keep trying to sell you here on the problem we're facing.

At Intel and, I imagine, at many of the employers you work for, we're alarmed. About 85% of our employees have a technical background. Our demand for those with master's degrees and doctorates has grown significantly over the years. Indeed, the typical mix in our college-recruiting program is

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only about one-third at the bachelor's degree level, whereas more than 50% of those Intel hires come with master's degrees or doctorates.

Much of the discussion about the future of technology in the United States centers on the well-known problems with math and science education in the kindergarten through grade 12 system. And this concern is growing and critical—as it should be. But we also need to focus on what is happening in our higher education system.

We know that we need to improve the quality of math and science education. In part, that improvement requires that our politicians, parents, and citizens at large understand the importance of these subjects to our nation's future. The keys here are accountability and better trained and more highly qualified teachers.

To encourage more students to enter technical fields, we need to provide increased incentives and support. We need a national focus on providing a greater number of scholarships to those attracted to technical-degree programs and more low-interest student loans to make such education available to a broader range of students. In addition, we should set up loan-forgiveness programs for those who graduate with technical degrees and choose to teach in our elementary, middle, and high schools for a certain number of years.

We need to reform our immigration system to enable us to attract top scientific and technical talent from around the world to study in the United States and encourage more of them to remain in this country rather than return home to compete against us.

Probably most important, we need to promote innovation at our universities by increasing funding for basic R&D—the foundation of our nation's standard of living, economic stability, and national security. The high-technology industry has invested billions of dollars every year on R&D to foster innovation and competitiveness. But, to succeed we need partnerships that bring together the resources of government, higher education, and business.

We need to promote innovation at our universities by increasing funding for basic R&D.

Unfortunately, US government spending on basic R&D in key areas of the physical sciences and engineering has been flat and has dropped significantly over the past 20 years as a percentage of the gross domestic product. This decrease is a mistake.

The federal government must prioritize investment in the industries of the future. Federal investment in basic R&D is critical because it benefits the entire scientific and engineering community. Basic research means research that involves a high degree of uncertainty in technical success and commercial value but that can lead to revolutionary breakthroughs that can help create products, jobs, and wealth. Our leading universities are the best places to perform this type of research. Some of the most significant innovations of the past 20 years, including the Internet and fiber optics, are products of basic R&D.

This issue of basic R&D is not solely the domain of the government; industry also has a role. For example, When the US government stopped funding the National Laboratories for future lithography research, for example, Intel and other semiconductor companies began financing this initiative. Today, the private sector has spent more than $250 million to continue this effort and commercialize the technology. The semiconductor industry, along with the Defense Advanced Research Project Agency, supports five research centers currently comprising more than 30 universities studying the future technological challenges to Moore's Law. And Intel funds more than 300 research projects at almost 100 universities worldwide. The company has also established Intel Research Labs, a group of research facilities adjacent to the University of California—Berkeley, Carnegie Mellon University (Pittsburgh), and the University of Washington (Seattle)—where faculty, graduate students, and Intel researchers work together on exploratory research. Many other private companies have similar efforts, but we need more.

To remain competitive, the US government should increase the budgets of public-research agencies such as the National Science Foundation by 10 to 12% a year over the next five to seven years to double federal spending in higher education for basic research.

In short, we have to recognize that our future in many ways depends on our bright young people graduating from our universities. We must accept the fact that the United States will retain its competitive edge only as long as it nurtures the best and the brightest. This time we have no satellite beeping up in the heavens to convince us that we face a challenge. But it is a challenge we must face. We cannot risk becoming a second-rate scientific and technological power in the 21st century. The risks for all of us—and for our children and grandchildren—are too high.

I suspect I am not telling you anything new. I also know our collective industry loves races, just as the United States did with Sputnik. You may disagree with some of my recommendations, but that should not stand in the way of our raising our collective voices regarding this problem. *EDN*'s readers are engineering and technology experts and, as such, should all make sure that, through education and innovation, the United States continues to lead the world. **EDN**

REFERENCE

1. Association for Computing Machinery, International Collegiate Programming Contest, http://icpc.baylor.edu/icpc/.

Craig Barrett holds a bachelor's degree, a master's degree, and a doctorate in materials science from Stanford University (Stanford, CA). He joined Intel in 1974 as a technology-development manager and rose through the ranks.

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DESIGN | *idea:* **Solar Cell Remote Sensors ▶▶▶**

Featured Products

Sub-1 µA 12V Op Amp with Rail-to-Rail Inputs

The LPV511 is a unity gain stable micropower operational amplifier that operates from a voltage supply range as wide as 2.7V to 12V, with guaranteed specifications at 3V, 5V, and 12V. The excellent speed-to-power ratio draws only 880 nA of supply current with a unity gain bandwidth of 27 kHz. The LPV511 has an input range that includes both supply rails for ground and high-side battery-sensing applications. The output swings within 100 mV of either rail to maximize the signal dynamic range in low supply applications.

Features

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- Supply current less than 900 nA
- Output voltage swing of 100 mV from rails
- Rail-to-rail inputs and outputs
- High PSRR (84 dB) ensures higher accuracy in battery applications
- Unity gain stable with 50 pF load

The LPV511 is ideal for applications including battery-powered systems, security systems, solar-powered systems, and remote sensor amplifiers. The LPV511 is available in the space-saving SC70-5 package, and is built on the advanced VIP50 process technology.

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Features

- Ultra-low power consumption 580 nA
- Propagation delay 6.6 µs
- Wide supply voltage range 1.8V to 5V
- Rail-to-rail inputs and outputs

The LPV7215 is ideal for applications including mobile phones, PDAs, notebook computers, and window comparators for voltage detection. The LPV7215 is available in space-saving SC70-5 and SOT23-5 packages, and is built on the advanced VIP50 process technology.

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DESIGN | *idea*

Walter Bacharowski, Applications Engineer
National Semiconductor

Energy Scavenging for Remote Sensors

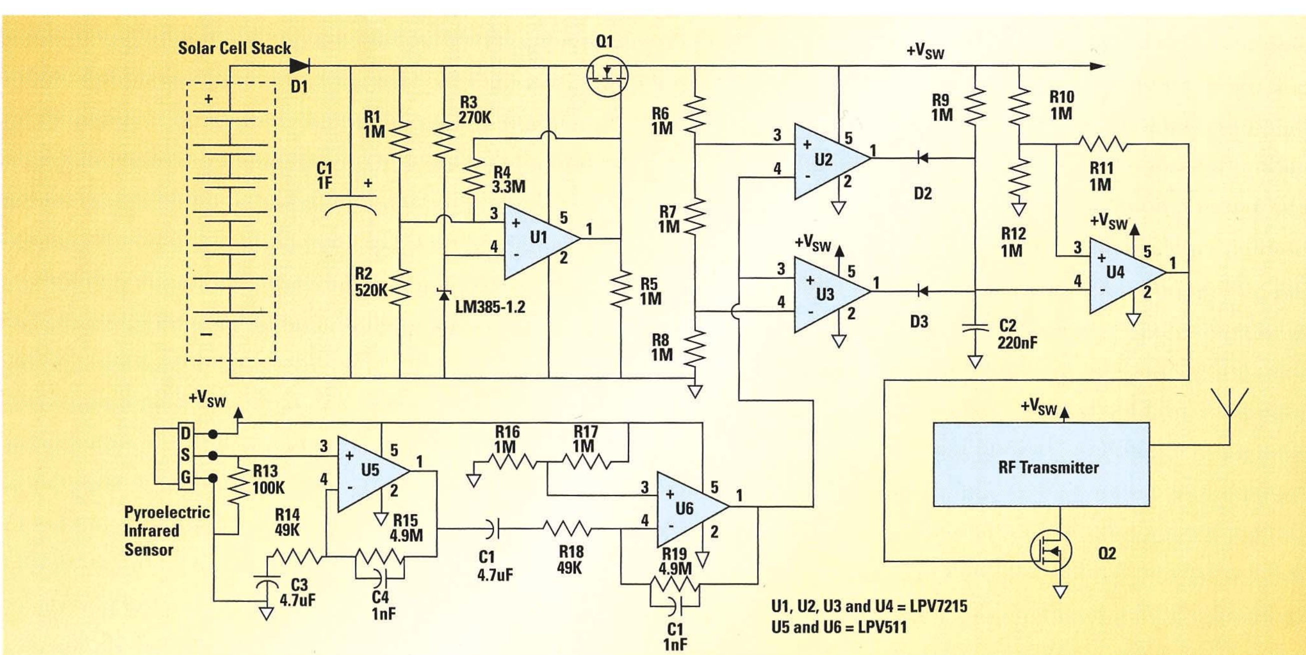
A recent concept being implemented to power circuits is using energy scavenging. This makes use of energy collection through solar cells, piezoelectric generators, or other energy conversion devices. These devices collect energy from diffuse sources, convert it to electricity, and typically store it in a capacitor until it is required. In many situations, the sensor circuitry is not required to operate continuously and the energy storage is replenished during the sensor off periods. In this example, a solar cell and a one-farad capacitor are used to power a remote motion-detector that uses an RF link to transmit the occurrence of any moment to a central monitor. This type of sensor is advantageous because wiring is not required and battery replacement is eliminated.

Some circuitry is required to monitor the voltage on the capacitor and to signal other circuits that there is enough voltage to turn on and perform some processing. When the capacitor voltage drops below a predetermined voltage, the circuitry is disabled. In conjunction with the capacitance, the voltage on the capacitor is a measure of how much energy is available to power the external circuits. Typically, the energy scavenging transducers cannot supply enough energy to power the circuitry continuously. The capacitor is used to accumulate enough energy to power the circuitry for a period of time.

In this example (***Figure 1***), amorphic silicon photovoltaic cells are used, which are low-cost devices that can power circuits from ambient indoor lighting as well as outdoor lighting. Trade offs can be made in the size of the cells, size of the storage capacitor, and how often the circuitry must operate. The voltage monitoring circuit is used to isolate the load circuitry from the energy scavenging components until enough energy is available for the circuitry to complete a task. The solar cell stack (D1 and C1) is the energy collection and storage component.

The monitoring circuitry must be very low power and operate over a wide supply voltage range. The circuit in ***Figure 1*** uses the LPV7215 comparator, which has a typical operating current of 580nA for the monitor function. The LPV7215 is used with the threshold and hysteresis setting resistors R1, R2, and R3, and the LM385-1.2 voltage reference to control a FET switch, Q1,

Figure 1. Solar Powered Motion Detector with an RF Link



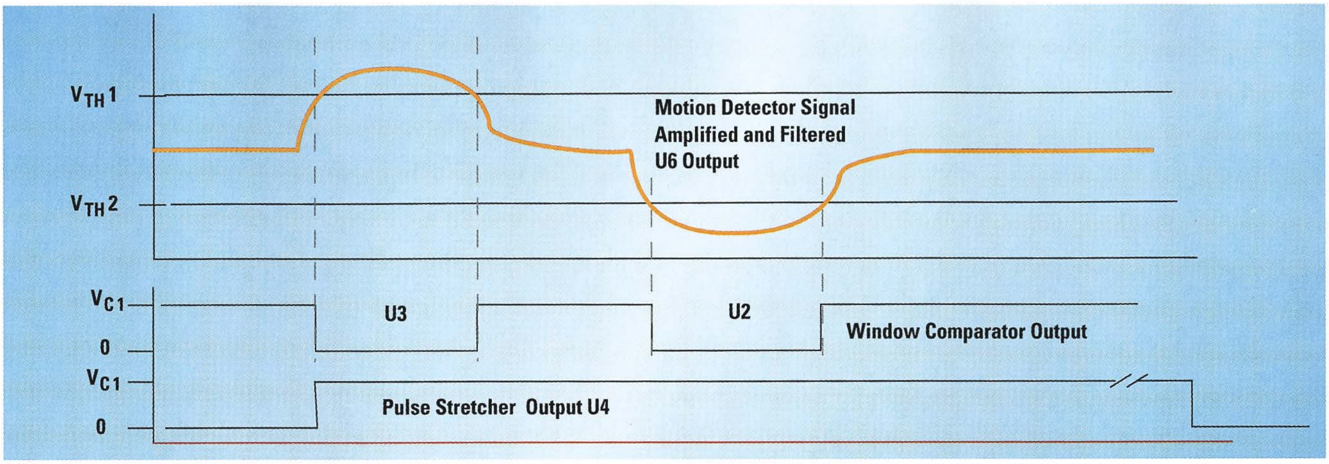


Figure 2. Motion Detector Signals

to turn on power to the motion detection circuitry. The FET is on when the voltage on C1 is greater than 4V and off when the voltage on C1 is less then 3V.

The motion detection circuitry uses a pyroelectric sensor followed by a high-gain band pass filter. The amplifiers U5 and U6 are LPV511 and have a typical operating current of only 880 nA while maintaining a 27 kHz gain bandwidth. The complete motion detection circuit only requires about 4 µA total. ***Figure 2*** shows the output of amplifier U6 when a warm body moves across the field of vision of the pyroelectric sensor in addition to the window comparator and pulse stretcher signals.

The output of U6 is the input of a window comparator made from two LPV7215 comparators, U2 and U3, and resistors R6, R7, and R8. The threshold voltages are set at 1/3 and 2/3 of the switched voltage, +Vsw. The comparator's output switches low when the motion detector signal swings above or below the threshold values. The outputs of the comparators are OR'ed together into a pulse stretcher through diodes D2 and D3. The pulse stretcher, which is composed of U4, an LPV7215 comparator, and C2, R9, R10, R11, and R12, generates about a 0.5 second pulse that turns on the RF transmitter though Q2. The RF transmitter requires about 25 mA while the detection and monitoring circuitry requires only about 20 µA.

Calculating the capacitor size for energy storage requires an estimate of the current flow in the circuitry, what is the voltage change on the capacitor and how much time is required complete a task. For example, when the transmitter is active, the circuitry of ***Figure 1*** requires about 25 mA for operation. The solar cell selected can supply about 5.5V at 10 mA and can charge C1 to about 4.9V. (Solar cell voltage minus the diode, D1, equals voltage drop of about 0.6V.) The time the circuitry can operate for a change in C1 capacitor's voltage from 4.9V to 3.0V is calculated from:

$$t = \frac{CdV}{i} = \frac{1F \bullet 1.9V}{0.025A} = 76 \text{ secs}$$

The transmitter is turned on for 0.5 seconds for each transmission so the motion detector can transmit about 156 times (76/0.5), without any recharging, before the capacitor is drained below the turn-off voltage of 3V. During normal operation, the solar cell is constantly recharging C1 when light is available.

The second area of concern for the energy storage is how long the motion detection circuit can operate without the capacitor being recharged. Using the equation above, calculate the operation time for the motion detection and voltage monitoring circuits using an estimated current of 20 µA and a change in capacitor voltage from 4.9V to 3.0V:

$$t = \frac{CdV}{i} = \frac{1F \bullet 1.9V}{0.000020A} = 95000 \text{ secs} = 1.1 \text{ days}$$

A final concern is when this circuitry is first installed. It will take some time to charge C1 to the circuit's operating voltage. This can be estimated by the following calculation:

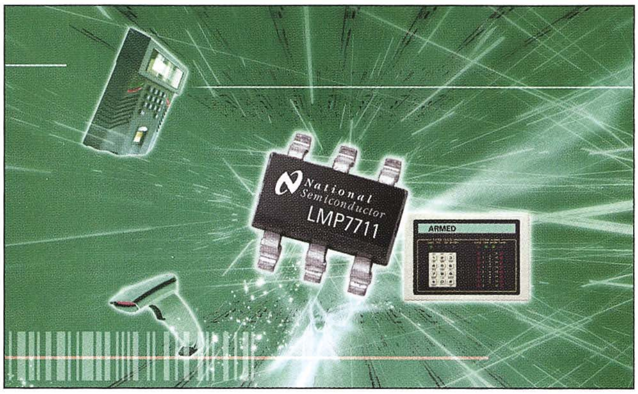
$$t = \frac{CdV}{i} = \frac{1F \bullet 3.0V}{0.010A} = 300 \text{ secs}$$

An alternative to waiting for the solar cell to charge C1 is to connect C1 to a 5V source and charge it just before installation.

This example demonstrates the use of very low-power amplifiers and comparators to implement remote wireless self-powered sensors. The motion detector circuitry shown here can be replaced with many other types of sensors such as temperature, humidity, and leak detectors. ■

Visit edge.national.com for the online Analog Edge technical journal and an archive of design ideas, application briefs, and other informative links.

Featured Products



17 MHz, Rail-to-Rail Output, Low-Noise, Low-Power Amp

The LMP7711 is a low-noise, low-voltage, low-power amplifier with a very low offset. The unity-gain bandwidth is 17 MHz with a low-input voltage-noise density of $5.8\text{nV}/\sqrt{\text{Hz}}$, and a quiescent current of 1.4 mA (max). It provides rail-to-rail output swing into heavy resistive or capacitive loads. The LMP7711 has a built-in enable feature minimizing current consumption to 140 nA. The maximum input offset voltage is only 150 µV. The operating voltage range of this amplifier varies from 1.8V to 5.5V.

Features

(Typical 5V supply, unless otherwise noted)

- Guaranteed 1.8V and 5.0V performance
- Low 1/f noise $5.8\ \text{nV}/\sqrt{\text{Hz}}$ at 400 Hz
- Supply current: 1.15 mA
- Input bias current: 100 fA
- High PSRR (100 dB) ensures higher accuracy with noisy supplies
- High CMRR (100 dB) ensures high accuracy over a wide input range

The LMP7711 is ideal for applications including high-impedance sensor interfaces, battery-powered instrumentation, high-gain amplifiers, active filters, pH electrode buffers, and audio front-end buffers. The LMP7711 is available in thinSOT23-6 packaging and is built on National's advanced VIP50 process technology.

www.national.com/pf/LM/LMP7711.html
www.national.com/see/VIP50

High Common-Mode, Bidirectional Precision Voltage Difference Amp

The LMP8271 is a fixed-gain differential amplifier with a -2V to 27V input common-mode voltage range and a supply voltage range of 4.75V to 5.5V. This precision amplifier will detect, amplify, and filter small differential signals in the presence of high common-mode voltages. The LMP8271 also can operate over an extended voltage range of -2V to 36V with reduced specifications. This feature makes the device suitable for applications with load dump in automotive systems. The mid-rail offset adjustment pin enables this device to be used for bidirectional current sensing.

Features

(Typical Values, TA = 25°C)

- Bidirectional current sense capability
- Internal set gain of 20V/V with filter network feature
- Input offset voltage: ±1 mV max
- TCVos ±15 µV/°C max
- CMRR: 80 dB min
- Extended CMVR -2V to 36V
- Output voltage swing Rail-to-Rail
- Bandwidth: 80 kHz
- Supply voltage: 4.75V to 5.5V
- Supply current: 1 mA

The LMP8271 is ideal for applications including fuel injection controls, high- and low-side driver configuration current sensing, and power management systems. The LMP8271 is available in SOIC-8 packaging.

www.national.com/pf/LM/LMP8271.html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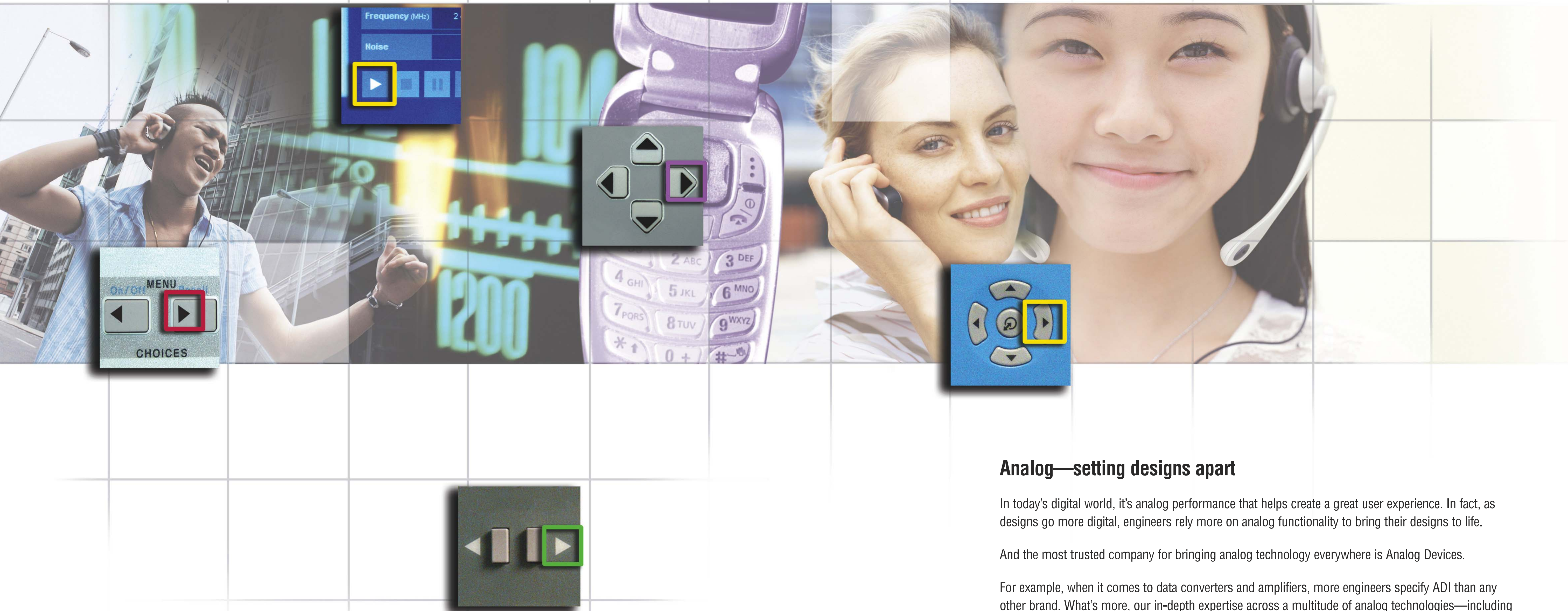
2.

Amplifiers to ADCs, Shanghai to San Jose, analog is everywhere.



Analog—setting designs apart

In today's digital world, it's analog performance that helps create a great user experience. In fact, as designs go more digital, engineers rely more on analog functionality to bring their designs to life.

And the most trusted company for bringing analog technology everywhere is Analog Devices.

For example, when it comes to data converters and amplifiers, more engineers specify ADI than any other brand. What's more, our in-depth expertise across a multitude of analog technologies—including power, RF, and MEMS—helps optimize performance in countless applications, from automotive GPS and advanced TV to MP3 and medical imaging equipment.

For more than 40 years, ADI has been delivering innovative, reliable analog solutions that meet the most demanding performance and budget requirements.

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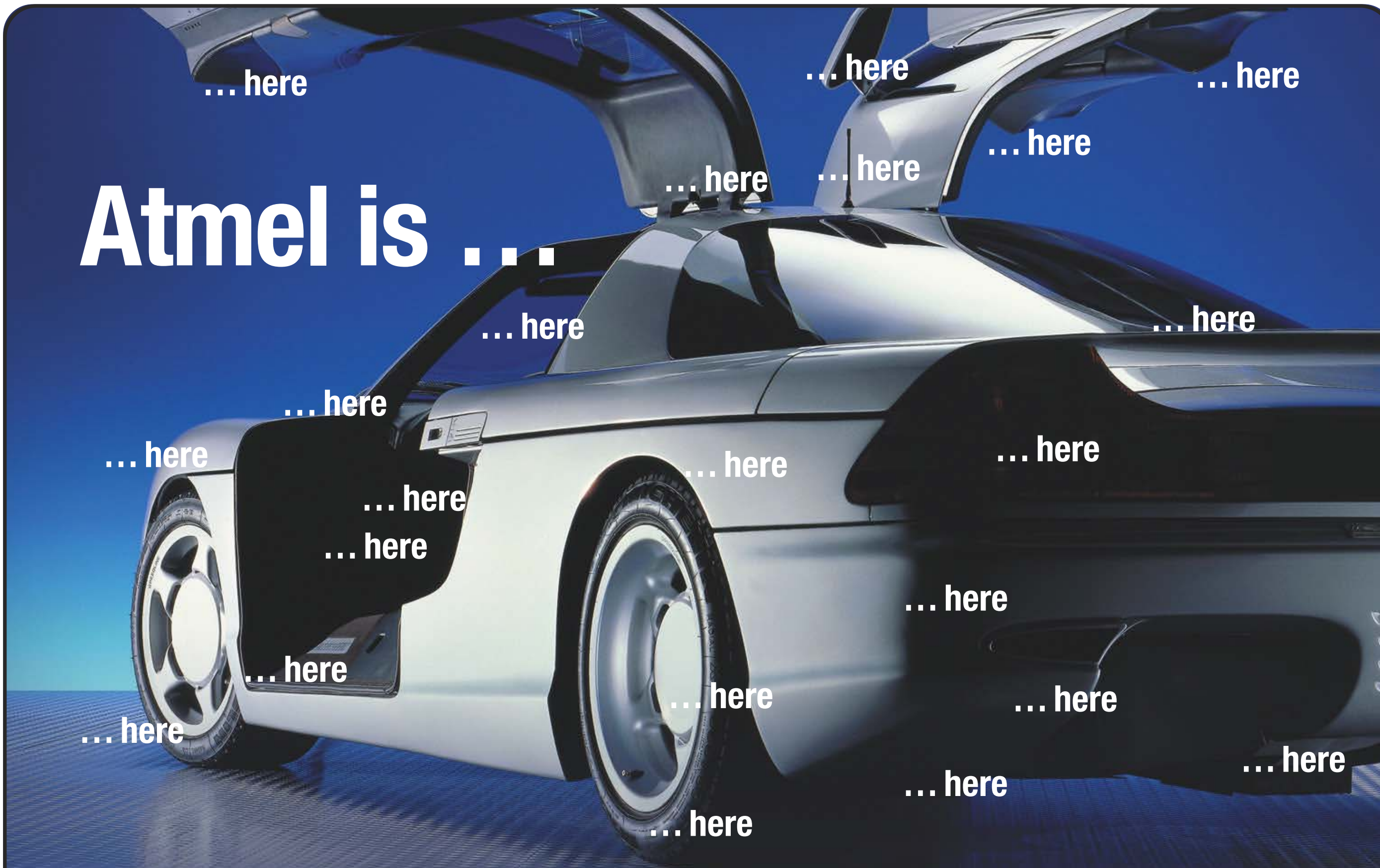

Atmel is …
… here

EDITED BY FRAN GRANVILLE

pulse

INNOVATIONS & INNOVATORS

Noninductive resistors handle high power with aplomb

Using a series of TO-class packages with an integral thermal and mounting flange, the MHP series of low-inductance power resistors is available with maximum power ratings of 20, 35, 50, 100, and 140W.

In the world of microwatts and milliamps, many applications, such as power supplies, motor controls, industrial equipment, and UPS systems, still need real power and heat dissipation. Offering these features, the MHP series from the BI Technologies SMT Division of TT Electronics provides 20 to 140W resistors at −55 to +155°C. The resistors come in TO-126, -220, -263, and -247 packages and integrate a thermal flange to facilitate thermal flow from the resistive element away from the package. Their low inductance also makes them suitable for RF sources, amplifiers, and circuit terminators.

Within each package style, you can select resistance values of 0.01 to 220Ω, tolerance of 5 or 1%, and temperature coefficients of 50 to 250 ppm/°C. Higher resistance values are available at reduced power levels. The family members differ primarily in available package, resultant thermal impedance from resistor core to flange, and power rating. Prices range from $1.25 for the 20W unit to $4.20 for the 140W unit (volume quantities).**—by Bill Schweber**

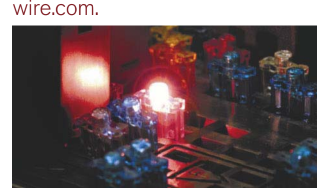
▷**TT Electronics, BI Technologies SMT Division**, www.bitechnologies.com.

Bright light, blown fuse: an obvious yet handy feature

Waytek's ATO and ATM minifuses include internal LEDs that light when a fuse blows, so that you can quickly identify the circuit that needs checking or the fuse that needs changing. Rated at 32V and available in 3 through 40A capacity, the color-coded fuses allow quick amperage identification. They cost 34 cents each (high quantities).

—by Bill Schweber

▷**Waytek Inc,** wwwwaytek wire.com.



An integral indicator LED in the ATO and ATM minifuses shows which fuse is blown.

Automotive FPGA family adds high-end models

Xilinx has added five Spartan 3E devices and a Virtex 4 device, which includes a hard-wired PowerPC core, to its XA automotive FPGA lineup. When the company last year introduced the XA family, it included mostly CoolRunner II CPLDs and Spartan-IIE and Spartan 3 FPGAs. According to David Gamba, senior marketing manager, customers have asked for higher end FPGAs. To fill that need, the company is offering the Virtex 4 FX XA, which includes a 32-bit PowerPC core delivering 700 Dhrystone MIPS at 450 MHz, DSP multipliers, and 10/100/1000 Ethernet MAC (media-access-controller) blocks. "We're seeing it used as the central gateway to the backbone of the vehicle," Gamba says. "It is controlling all of the network and subprocessors." The device costs $40 (100,000).

Xilinx is also offering low-price-per-gate Spartan 3E XA devices with 100,000 to 1.6 million system gates (30,000 to 533,000 ASIC gates). The 100,000-gate version sells for $3 (100,000). According to Kevin Tanaka, manager of automotive marketing and product planning, Xilinx has put all of the XA devices through extensive testing, and they comply with numerous automotive standards. "We have a zero-defect initiative and have taken great steps in this area for automotive," says Tanaka, who notes that Xilinx conforms to ISO TS16949, the AEC-Q100 qualification flow, and the PPAP (production-part-approval process) and complies with ISO 9001 and 41001, QML, and TL 9000. The devices operate at −40 to +100 or −40 to +125°C, depending on version.**—by Michael Santarini**

▶**Xilinx,** www.xilinx.com.

Innovative construction puts new twist on old principle

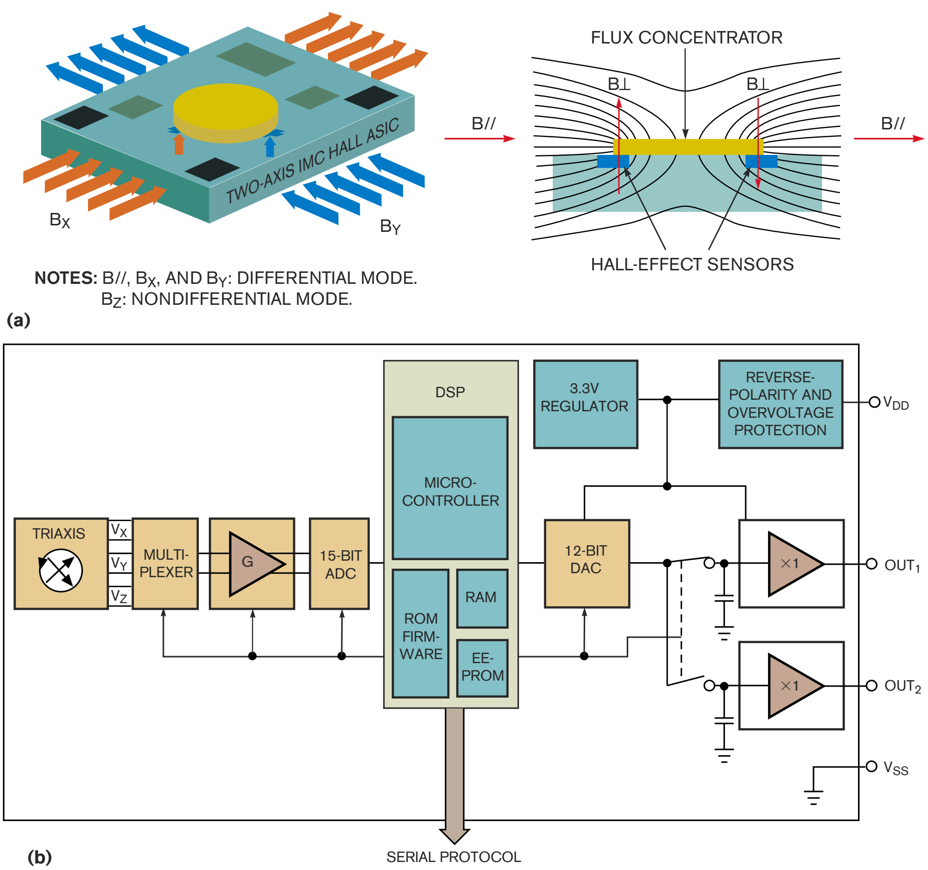
Designers have used millions of Hall-effect sensors for contactless switching and position sensing, but rotary sensing using this phenomenon has mechanical and alignment difficulties. A new design from Melexis overcomes the limitations and provides noncontact 360° rotary sensing using an inexpensive magnet with self-compensation for inherent, unavoidable drift. Vincent Hiligsmann, product-marketing manager for automotive sensors at the company, says "The manufacturing and thermal tolerances are compensated at the IC level."

The MLX90316 uses four Hall sensors and support circuitry and builds a ferromagnetic concentrator disk above the Hall devices to steer the flux lines in the z-axis direction; thus, the device senses in the x, y, and z planes. The outputs of the Hall sensors go to signal-conditioning circuitry, A/D converters, a DSP/microcontroller, and D/A converters to yield output information in multiple formats. The formats include analog-sine/cosine, quadrature x/y signals, which imply rotary angle, along with a 12-bit PWM output and a digital-serial-protocol output. By design, the user-programmable monolithic device is ratiometric and thus is relatively insensitive to inevitable variations in flux-density strength due to temperature, aging, and air-gap variations.

> The device is relatively insensitive to inevitable variations in flux-density strength.

The surface-mount device is available in an eight-lead SOIC for conventional applications or as a redundant design with two fully independent, isolated die in a TSSOP-16 package for critical applications, such as automotive steering or throttle (accelerator) sensing. The design also includes self-checking and internal diagnostics. The MLS-90316 Triaxis Hall device sells for less than $1 (high volumes).**—by Bill Schweber**

▷Melexis Microelectronic Integrated Systems NV, www.melexis.com.



The reality-tolerant, multisensor Melexis MLX90316 Hall-effect sensor has 360° rotary positions. It includes a flux concentrator above the passivation layer.

DILBERT *By Scott Adams*

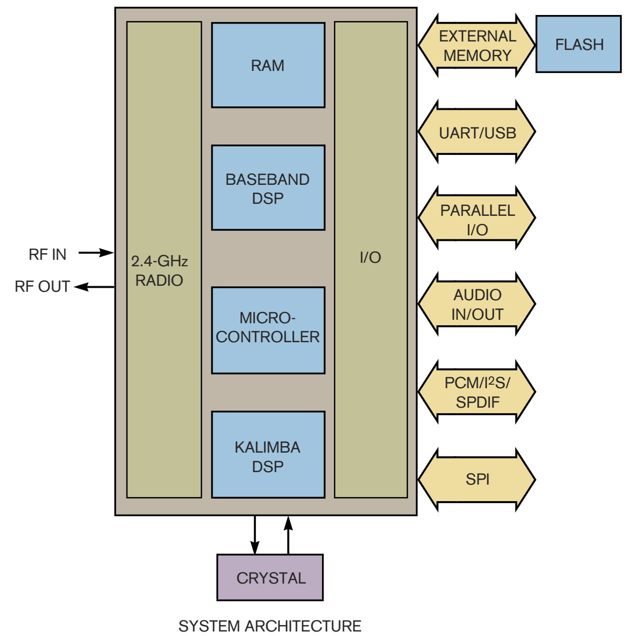
Bluetooth IC introduces fifth generation

The BlueCore 5 multimedia external IC from CSR (Cambridge Silicon Radio) is the fifth generation of the company's hardware and software product for 2.4-GHz Bluetooth applications. This version has 64-MIPS internal-DSP-coprocessor power—double that of its two-year-old predecessor. The new device has 156 kbytes of SRAM, extended data rates, and a 90-dB-SNR stereo-analog codec. It also embeds a second generation of ClearVoiceCapture technology from Clarity Technologies Inc (which CSR acquired in March), which improves echo-cancellation and noise-suppression performance.

The 144-ball BGA device has a 1.5V core and has internal linear and switch-mode regulators to derive needed power from a single external supply. It also supports collocated 802.11b/g systems through a hardware interface for basic activity signaling, as well as Intel WCS (wireless-coexistence-system) sensitivity and channel signaling. The built-in USB and dual-UART ports reach 4 Mbps, and the I/O also includes an I^2S and SPDIF (Sony/Philips digital interface). The BlueCore 5 sells for \$3 to \$5 (volume quantities).

—by Bill Schweber

▷**Cambridge Silicon Radio**, www.csr.com.



Packing more power, performance, and features into an 8×8-mm BGA, the BlueCore-5 multimedia external IC extends data rates and adds multimedia support.

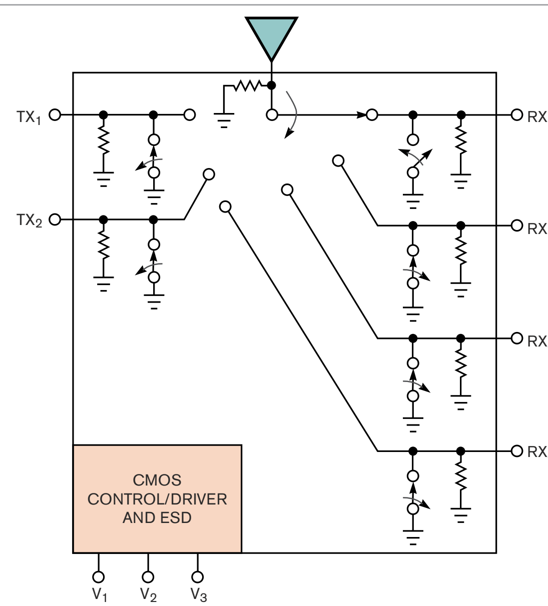
RF switch hits quadband-GSM-handset target

Peregrine Semiconductor now offers an SP6T (single-pole, six-throw) RF switch for 100- to 3000-MHz use that exceeds the tight performance standards necessary for cell phones in GSM (global-system-for-mobile-communications) and WCDMA (wideband-code-division-multiple-access) systems. The monolithic PE42660, targeting use in antenna-module subsystems of quadband-GSM handsets, uses Peregrine's proprietary, mixed-signal RF UltraCMOS process. It combines low-voltage CMOS-logic control with high-level ESD tolerance at all ports, also critical to these handsets. In addition, the device integrates a SAW filter with overvoltage protection. Peregrine officials say that the process, a variation on silicon-on-insulator technology, is less costly and provides better performance than GaAs (gallium-arsenide), SiGe (silicon-germanium), and other CMOS processes.

The switches offer second- and third-harmonic distortion of −88 and −85 dBc, respectively. Transmitter-path insertion loss is less than 0.55 dB at 900 MHz and 0.65 dB at 1900 MHz. Isolation between the transmitter and the receiver sides is better than 48 and 40 dB, respectively, at those frequencies. The 2.75V device has a switching time of less than 2 μsec, and typical and maximum operating currents are 13 and 20 μA, respectively. ESD protection is 1500V per the human-body model at all ports for the 50Ω device, which sells for 60 cents (10,000).

—by Bill Schweber

▷**Peregrine Semiconductor Corp**, www.psemi.com.

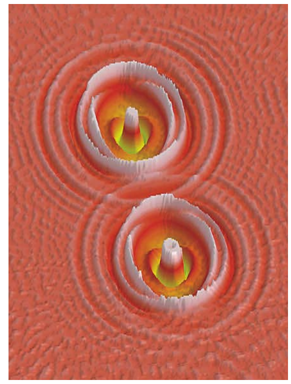


Switch your RF path among six ports, with the nearly RF-transparent SP6T CMOS switch, which meets the stringent mandates of GSM/WCDMA applications.

RESEARCH UPDATE
BY MATTHEW MILLER

Nanoscale oscillators synchronize for strength

Scientists at the NIST (National Institute of Standards and Technology) have discovered that nanoscale oscillators can naturally synchronize their output under certain conditions, a phenomenon that may lead to more compact microwave transceivers for cell phones and other applications. The researchers built 50-nm-wide sandwiches comprising a nonmagnetic layer of copper between slices of magnetic film. Placing multiple such oscillators within 500 nm of each other caused them to synchronize, boosting the power of the generated signal. Whereas a single oscillator generates 10 nW, the output of synchronized oscillators increases by the square of the number of devices taking part. Therefore, an array of 10 oscillators could produce a useful 1 μW or more and occupy less space than other components, according to NIST.
▷**NIST**, www.nist.gov.



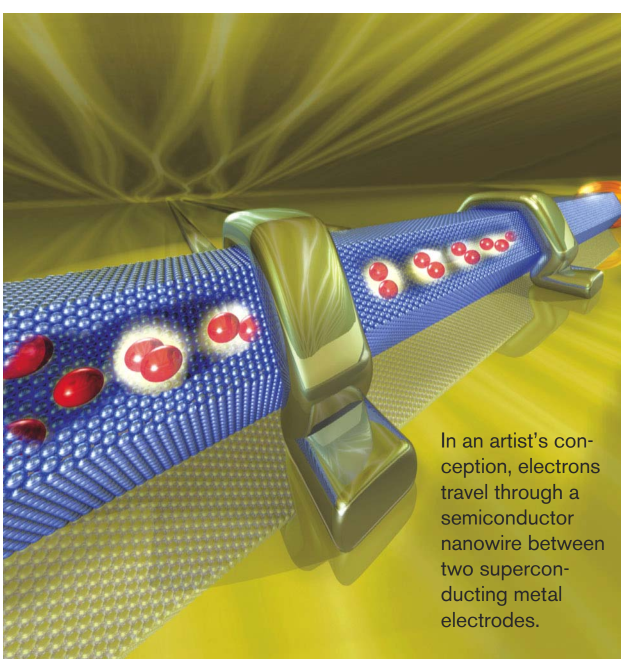
The ability of tiny oscillators to synchronize their output may lead to wireless components that are cheaper and smaller than today's components.

Technology boosts capacitor density 50 times

STMicroelectronics claims that a new technology enables the fabrication of capacitors with densities of more than 30 nF/mm^2, a 50-fold improvement over conventional processes based on oxides or nitrides of silicon or titanium. The technology employs PZT Perovskites, a class of materials that combines lead, zirconium, titanium, and oxygen and offers a dielectric constant of approximately 900—200 times greater than silicon dioxide. The technology will be available as part of STMicroelectronics' IPAD (integrated-passive-and-active-device) manufacturing process, which can integrate more than 30 discrete devices on a single die.
▷**STMicroelectronics**, www.st.com.

Laser makes a kinder, gentler neural interface

Laser-technology company Aculight and Vanderbilt University (Nashville, TN) have won a contract from the National Institutes of Health (www.nih.gov) to develop a compact, low-cost neural stimulator. The device would assist in the treatment of Parkinson's disease, epilepsy, and other conditions without causing the tissue damage that electrical stimulation can cause. The company's fiber-coupled laser generates pulsed, midinfrared light, enabling better spatial precision than electrical stimulators. The device will allow medical researchers and physicians to activate individual nerves, according to Aculight.
▶**Aculight**, www.aculight.com.



In an artist's conception, electrons travel through a semiconductor nanowire between two superconducting metal electrodes.

Semiconductor nanowires yield superconducting transistors

A team of researchers in the Netherlands has created what it claims are the first superconducting transistors based on nanometer-scale semiconductor wires. The combination could enable electronic circuits based on dissipation-free superconducting elements. In the experiments, a supercurrent (a current without resistance) flowed through an indium-arsenide nanowire between aluminum-based superconducting contacts. The team reports that it can control the supercurrent using a gate voltage, making the structure a supercurrent transistor. The work may lead to circuits that would find use in quantum-computing architectures. The team included scientists from the Kavli Institute of Nanoscience at Delft University of Technology and Philips (www.philips.com).
▶**Kavli Institute Delft**, qt.tn.tudelft.nl.

11.10.05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GLOBAL DESIGNER

RAMless LCD driver supports QVGA

Hong Kong-based Solomon Systech's SSD1279 LCD driver cleverly exploits the abundant memory resources available in advanced mobile phones that typically feature a microcontroller or DSP and an image processor. The SSD1279 takes advantage of the image processor's large display SRAM to improve overall display efficiency of the phone system.

The SSD1279 LCD driver measures 24×1.5 mm^2 and can drive TFT (thin-film-transistor) LCD panels as large as 4 in. Using the RGB interface, the LCD driver communicates with a common image processor, a TFT graphics controller, and a baseband processor on advanced mobile phones. This connection is particularly useful when you are using the CMOS/CCD camera in the smart-phone system. In addition, the driver's small die allows for a thinner contact ledge for the LCD module, enabling compact mobile phones. The SSD1279 consumes 6.9 mW when driving a 2.2-in. TFT LCD with 240×320-pixel QVGA resolution.

The SSD1279 LCD driver uses SRAM to improve overall image quality.

CK Chow, product-marketing manager of Solomon Systech, envisions a trend in advanced phones with RAMless LCD drivers. "Smart phones already have powerful DSPs, which do the image processing, so you don't need RAM-based display drivers for graphics control. Also, you can reduce the driver's die size and reduce the overall phone-system cost and save on power consumption," he says.

—by NS Manjunath, *EDN* correspondent, Hong Kong

▷**Solomon Systech**, www.solomon-systech.com.

FEEDBACK LOOP

"Touting a power-supply chip as more efficient than an analog part is damning with faint praise. I should hope it's more efficient."

Bradley Albing in *EDN*'s Feedback Loop at www.edn.com/article/CA6268902. Add your comments.

Design software complies with ROHS

11.10.05

ROHS (restriction-of-hazardous-substances) features are popping up in pc-board-design software. The ROHS directive, which strictly limits six substances, including lead, in electronics products for sale in the European Union after July 2006, is moving from a manufacturing to a design problem. "You have to solve the compliance issue as far upstream as possible," says Manny Marcano, president of EMA Design Automation Inc.

EMA provides a function for Cadence Design Systems tools that puts parametric information for ROHS compliance on the desktop. At the design stage, an engineer can call up an approved-vendor list that provides ROHS-compliant parts. "Today, engineers are picking parts from their old libraries and designing boards that may or may not be compliant," says Marcano. "When it gets to manufacturing, it's too late, and, if the part is noncompliant, you've got to do iterations of that design cycle."

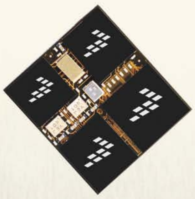
Likewise, Mentor Graphics Corp has announced pc-board-tool support allowing designers to use component data to find ROHS parts. Zuken Ltd's efforts also broaden the company's ROHS offerings. Jeroen Leinders, international distribution manager at Zuken, says that customers asked for support of a new pad shape. Zuken responded with CADstar 8.0 tools incorporating rounded rectangular pads. Leinders claims that using rounded rather than rectangular corners improves the soldering process for lead-free design.

Daya Nadamuni, EDA analyst at Gartner Dataquest (www.gartner.com), says that software companies will continue to enhance their tools for ROHS compliance because the directive involves changing materials and, thus, electrical properties. Designers can set up libraries for processes that recognize electrical properties for materials. "Suppose that a board is ROHS-compliant but doesn't comply with rest of the library," she says. "You may get a simple solder-joint failure that could become a cost." The back end will push compliance issues upstream. "Manufacturing will increasingly tell design-software companies that tools need ROHS functions," Nadamuni says.

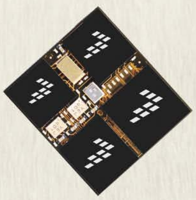
—by Drew Wilson

▶**Cadence**, www.cadence.com.
▶**EMA Design Automation Inc**, www.ema-eda.com.
▶**Mentor Graphics**, www.mentor.com.
▶**Zuken**, www.zuken.com.

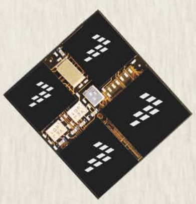
3G Solutions



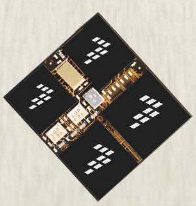
It's the freedom of an open platform.



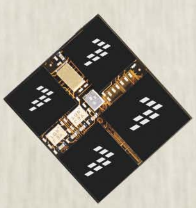
It's the freedom to miniaturize.



It's the freedom to cut costs.



It's the freedom to differentiate.



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BY HOWARD JOHNSON, PhD

Deconstructing gain and impedance from S11

OK, this topic isn't for everyone, but this year, I have encountered so many people struggling with frequency-domain descriptions of transmission-line behavior that I thought I'd pass along some interesting tricks.

My last column extracted a complete curve of pc-board-trace impedance versus frequency from TDR (time-domain-reflectometry) or S11-type measurements (**Reference 1**). This column concentrates on trace gain using a similar trick. For the purpose of this column, the trace gain is the gain measured between two points along an infinitely long structure, where distance x separates the points and the signal travels in only one direction.

To measure trace gain, hook a network analyzer to any short, unterminated pc-board trace and capture its S11 data. Now, convert that data to the time domain and integrate it to produce a picture such as the one in **Figure 1**. (If you have a TDR-type instrument, it may already produce such a picture; otherwise, see **Reference 1** for information about converting from TDR to S11 format.)

This measurement derives from a simulated, 30-in., unterminated pc-board trace. The trace is 0.006 in. above the reference plane and 0.0083 in. wide.

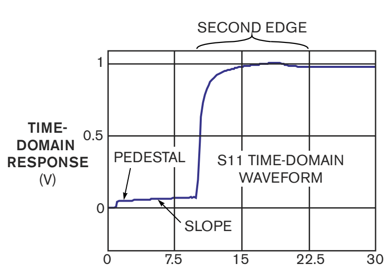

Figure 1 Data following the second edge is a mixture of gain and impedance information.

The small initial positive pedestal suggests that the asymptotic high-frequency value of trace impedance must lie slightly higher than the 50Ω source impedance of the network analyzer.

During the first 10 nsec of this waveform, before the big reflection arrives from the far end, observe the gentle upward tilt of the waveform. This tilt hints at a slow modulation of the characteristic impedance with time—therefore, variations with frequency.

Next, look at the rounded shape of the second edge. This edge has twice traversed the structure. It contains a cornucopia of information about the high-frequency gain of the pc-board trace. Unfortunately, the second edge sits superimposed upon the still-rising form of the characteristic-impedance curve. The two curves interfere with each other.

With one S11 measurement you cannot independently deconstruct the gain and impedance information present in this waveform. A second measurement, however, reveals both.

Make the first measurement as usual, with an open-circuit trace at the far end. Make the second measurement with the trace shorted to ground at the far end.

From the two S11 curves you have measured, now calculate the round-trip gain, $H^2(f)$, of your pc-board trace.

The symbol H^2 should remind you that this gain is the round-trip (two-way) gain, not just the one-way gain. This calculation works at extended frequencies corresponding to the full length of the waveform you have captured, and the reflection time of your TDR test coupon does not limit it:

$$\zeta(f)=\sqrt{\frac{1+S11_{OPEN}}{1-S11_{OPEN}}\,\frac{1-S11_{SHORT}}{1+S11_{SHORT}}};$$

$$H^2(f)=\frac{\zeta(f)-1}{\zeta(f)+1}.$$

Note that these expressions return a pure gain function, independent of loading. The gain function assumes perfectly matched source and end terminations. Perfect terminations are not the same as 50Ω terminations, especially for transmission lines having a length sufficient to force operation even partially in the RC mode, such as long backplane traces. **Reference 2** discusses the gain function *H(f)* at length.

This technique uniquely derives the transmission-line gain from measurements you take at only one end of your pc-board trace. Any digitizing TDR instrument captures the raw data you need to apply this technique. EDN

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2. Johnson, Howard, and Martin Graham, *High-Speed Signal Propagation: More Black Magic*, Prentice-Hall, 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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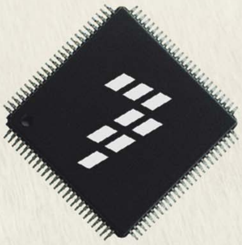

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Parts are parts

In the mid-1960s, when I began designing circuits for military applications, many military-rated parts were available. We still had to occasionally qualify a "nonstandard" part, but it was not a huge ordeal, because manufacturers made the parts mostly in the same way as the military parts—with semiconductors, many capacitors, and other parts in hermetic packages. With the advent of both the military and the civilian space programs, manufacturers supplemented the available parts lines with various radiation-hardened parts.

But when consumer electronics exploded in the '80s, the burden of finding parts rated for military and space applications became more and more difficult. Semiconductor manufacturers, in particular, happily addressed the huge consumer market and soon neglected or discontinued their military and space offerings. The segment went from being the dog to being the tail, and the tail kept getting shorter until, today, it's practically gone.

The COTS (commercial-off-the-shelf) approach gets a lot of press, mostly for subassemblies such as power converters, motor drives, and the like. My experience with COTS at this level has been spotty. Although it works for some ground-based—and even some shipboard—applications, these environments usually require some concessions. And these negotiations can burn up a lot of time and money. Airborne- and space-system applications are more challenging. Commercial satellite manufacturers were among the first to face the electronic-component-availability problem, and their solution was to buy industrial-grade parts from manufacturers of high-quality parts that provided lot traceability and then enhance the parts to match their environmental requirements, including total-dose and single-event radiation testing. These environments also require destructive physical and materials analyses to avoid using parts that support combustion or outgas or poorly made parts that allow metal thinning, have poor connection-system integrity, and allow moisture penetration. This approach to obtaining military and space parts is useful, and the candidate parts can include commercial- and industrial-grade products.

Although commercial parts are inexpensive, upgrading, DPA (defense-procurement approval), material analyses, and radiation testing are not. The end users of these parts must repeat most of the process for every new procurement, because the verification is specific to the part lots; manufacturers of commercial parts are constantly tweaking those parts and changing their fabrication processes. The biggest risk in using upgraded commercial parts in military and space applications is finding that a part is unusable after the developer has already designed it in. Ways to mitigate that risk include choosing multiple suppliers, multiple part types, or both, but having Plan B adds to the cost, too. The push for lead-free components is another major concern, because the alternative seems to be the use of leads with pure-tin plating. (Every 10 years or so, we seem to relearn that pure tin grows metal whiskers, or tiny filiform hairs, which can be troublesome in 0g environments.)

Properly screened and tested inexpensive commercial parts are viable alternatives to the virtually extinct military- and space-rated component types. But the old adage remains true: "If you want economy, you have to pay for it."EDN

Charles Clark is a Technical Fellow with Pratt & Whitney Rocketdyne and is a member of EDN's Editorial Advisory Board. Like Clark, you can share your Tale from the Cube. Contact mgwright@edn.com.

DANIEL VASCONCELLOS

TEXAS INSTRUMENTS

POWER MANAGEMENT

Analog Applications Journal

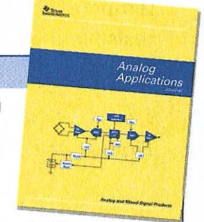
BRIEF

Li-Ion Switching Charger Integrates Power FETs

By Anne Huang • *Marketing Manager*

1. Introduction

Linear battery chargers suffer from excessive power dissipation when the input-to-output overhead voltage and/or charging current are high. Take the example of a typical portable DVD player configuration which incorporates a 2-cell Li-Ion battery pack, a car adapter at 12V and a charge rate of 1.2A; the power dissipation of a linear charger is above 5W on average. A simple solution to overheating is the bqSWITCHER™ bq241xx series switching charger. The internal power FETs are capable of supplying up to 2A of charging current. The synchronous PWM controller operates at 1.1MHz from an input voltage up to 18V, making it ideal for use in systems powered by 1-, 2-, or 3-cell battery packs. The high-voltage, high-current and high-efficiency features together with integrated reverse leakage protection and internal loop compensation are nicely housed in a small 3.5mm x 4.5mm QFN package, saving board space and reducing system design time.



2. Design Example

Adapter Voltage: 12V
Battery Pack: 2S Li-Ion, 1800mAH
Battery Regulation Voltage: 4.2V/Cell
Battery Cutoff Voltage: 3V/Cell
Fast Charge Current: 1.2A
Pre-charge and Termination Current: 120mA
Safety Timer: 5 hours

2.1 Determine the Inductor L

Given 30% ripple current, the inductance is given by:

$$L1 = \frac{V_{IN} - V_{BAT}}{\Delta I_L} \cdot \frac{V_{BAT}}{V_{IN}} \cdot \frac{1}{f_S} = \frac{12 - 8.4}{30\% \cdot 1.2} \cdot \frac{8.4}{12} \cdot \frac{1}{1.1 \cdot 10^6} = 6.364\mu H \qquad (1)$$

Select L = 8.2µH.

The inductor saturation current should be larger than the peak current to prevent inductor saturation.

$$\Delta I_{L\_MAX} = \frac{V_{IN} - V_{BAT}}{L} \cdot \frac{V_{BAT}}{V_{IN}} \cdot \frac{1}{f_S} = \frac{12 - 6}{6.8 \cdot 10^{-6}} \cdot \frac{6}{12} \cdot \frac{1}{1.1 \cdot 10^6} = 0.40A \qquad (2)$$

$$I_{pk} = I + \frac{\Delta I_{L\_MAX}}{2} = 1.2 + \frac{0.40}{2} = 1.4A \qquad (3)$$

Select: Sumida CDRH5D28 inductor (8.2µH/1.6A/39mΩ)

2.2 Determine the Output Capacitor C

The resonant frequency of the internal loop compensation is approximately 16kHz. To achieve optimum loop stability,

$$C = \frac{1}{(2 \cdot \pi \cdot f_o)^2 L} = \frac{1}{(2 \cdot \pi \cdot 16 \cdot 10^3)^2 \cdot 8.2 \cdot 10^{-6}} = 12 \times 10^{-6} (F) \qquad (4)$$

Select: 10µF, 25V X7R 1206 ceramic capacitor.

2.3 Determine the Sense Resistor, R_{SNS}

V_{RSNS}: 100mV to 200mV

In order to get a standard resistance value, select V_{RSNS} = 120mV,

$$R_{SNS} = \frac{V_{RSNS}}{I_{BAT}} = \frac{120mV}{1.20A} = 0.1\Omega$$
$$P_{RSNS} = I_{BAT}^2 R_{SNS} = 144mW \qquad (5)$$

Select: 1%, 100mΩ /0.25W resistor.

2.4 Determine R_{SET1} and R_{SET2}

V_{ISET1} = 1.0V, V_{ISET2} = 0.1V, K_{SET1} = K_{SET2} = 1000V/A,

$$R_{SET1} = \frac{V_{ISET1} \bullet K_{SET1}}{I_{FAST-CHARGE} \bullet R_{SNS}} = 8.33k\Omega \qquad (6)$$

$$R_{SET2} = \frac{V_{ISET2} \bullet K_{SET2}}{I_{PRE-CHARGE} \bullet R_{SNS}} = 8.33k\Omega \qquad (7)$$

Select: 1%, 8.33kΩ resistors.

2.5 Determine C_1

C_1 is used to program the fast charge timer.

$$C_1 = \frac{300\ min}{2.6\ min/\ nF} = 0.115\mu F \quad (8)$$

Select: 0.12μF or 0.1μF/X5R or X7R ceramic capacitor for good temperature performance.

2.6 Determine R_{T1} and R_{T2}

R_{TS}, the resistance of the thermistor, normally drops with temperature. Assume using 103AT-2 thermistor, the resistance at cold temperature and hot temperature is: R_{TS_COLD} = 27306Ω (0°C), R_{TS_HOT} = 4935Ω (45°).

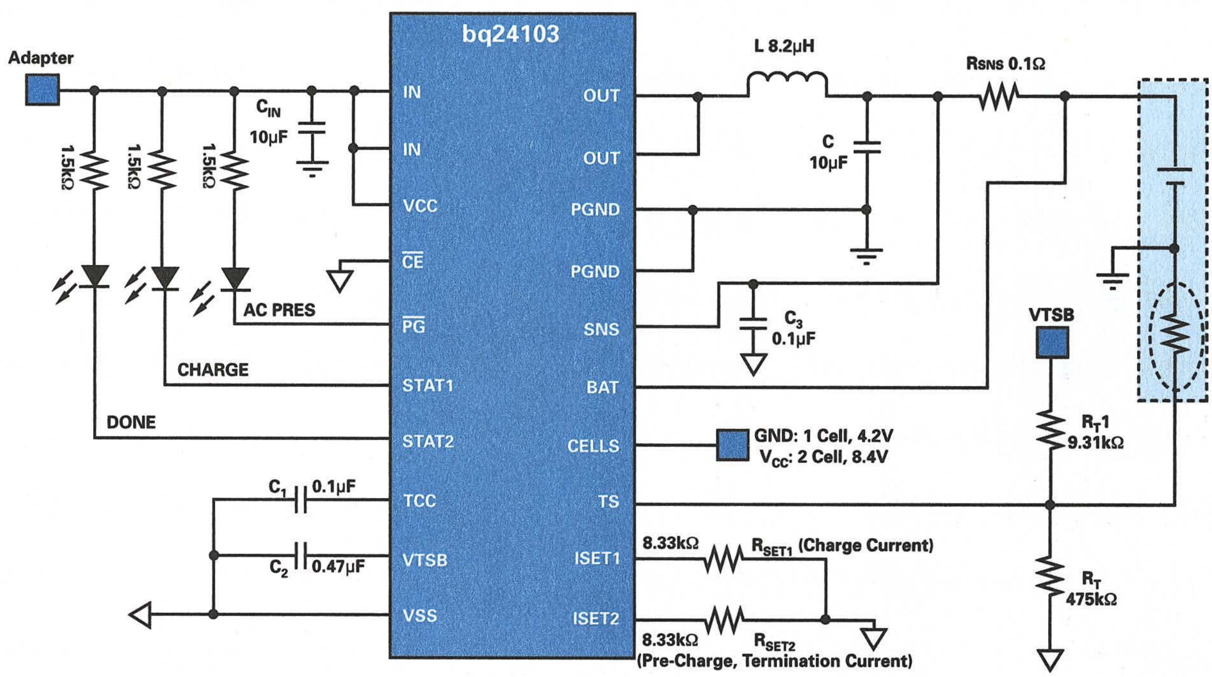
The voltage threshold at cold temperature V_{LTF} = 73.5% • VTSB. The voltage threshold at hot temperature V_{HTF} = 34.4% • VTSB. Therefore:

$$\frac{R_{T2}\ //\ R_{TS\_COLD}}{R_{T1} + R_{T2}\ //\ R_{TS\_COLD}} = 73.5\% \quad (9)$$

$$\frac{R_{T2}\ //\ R_{TS\_HOT}}{R_{T1} + R_{T2}\ //\ R_{TS\_HOT}} = 34.4\% \quad (10)$$

The equations above gives R_{T1} = 9.31kΩ, R_{T2} = 475kΩ

Figure 1: bq24103 Application Circuit

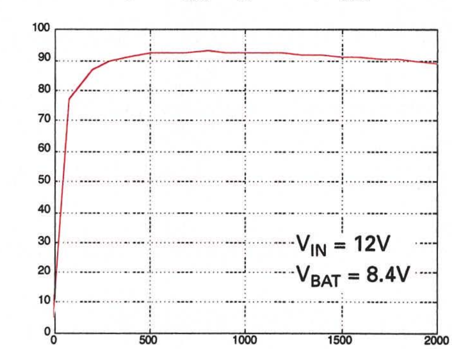


3. PCB Layout Considerations

The measurement of the efficiency using the bq24103 EVM is shown in Figure 2. Below are some layout guidelines to maximize efficiency:

3.1 Make the connections of the power stage as wide and short as possible.
3.2 The ground planes of the power stage and the control stage should run separately, and be connected together at a single point.
3.3 Place the decoupling capacitors close to the pins.
3.4 Minimize the current sensing feedback loop.
3.5 Place the inductor close to the OUT pin.

Figure 2: Efficiency vs. I_{bat} (V_{IN} = 12V, V_{BAT} = 8.4V)



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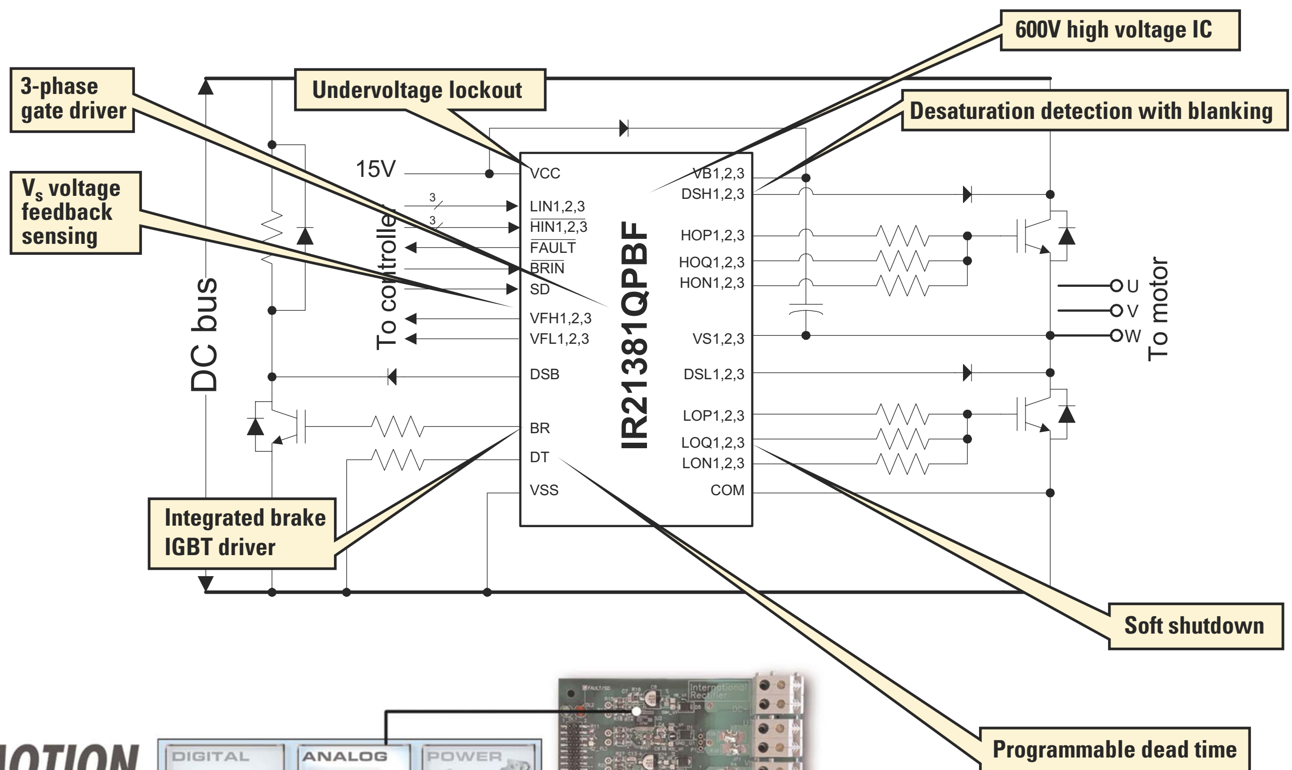

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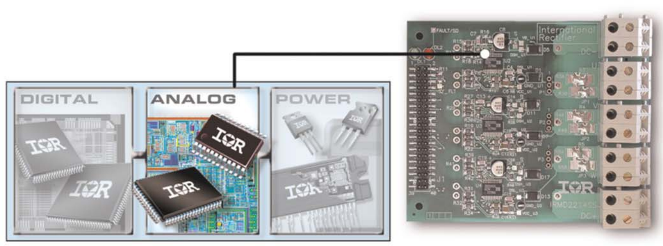

Specifications	IR2136xPbF	IR2130xPbF	IR21381QPbF
Configuration	3-phase driver	3-phase driver	3-phase driver
Voltage	600V	600V	600V
Dead time (DT)	290ns	2.5µs	1µs
Soft shutdown duration time	No	No	6.0µs
t_{on}/t_{off}	400/380ns	675/425ns	550/550/ns
Matching delay	40ns	No	100ns
Drive current I_{o+}/I_{o-}	200/350mA	200/420mA	220/460mA
Desaturation blanking time	No	No	4.5µs
Independent half bridge driver	No	Yes	No
Cross conduction prevention logic	Yes	Yes	No
Undervoltage lockout	Yes	Yes	Yes
Integrated brake driver	No	No	Yes

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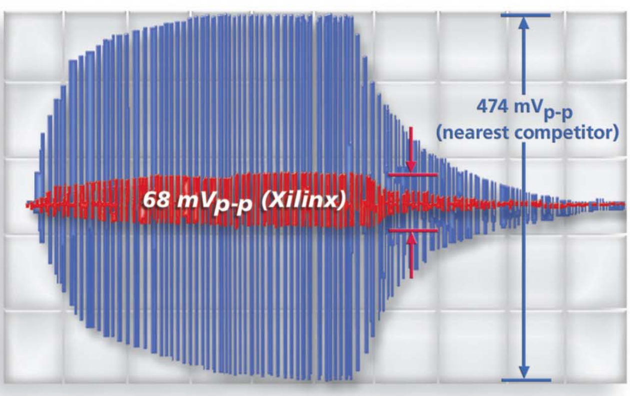

Design Example: 1.5 volt LVCMOS 4mA, I/O, 100 aggressors shown.

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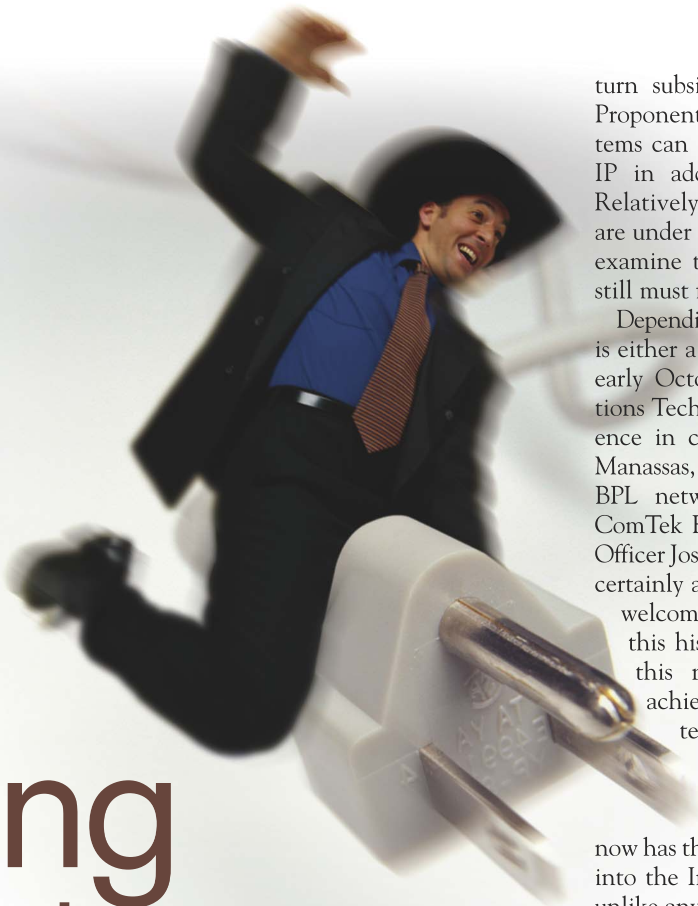

BROADBAND DATA HITCHES A RIDE WITH AN UNLIKELY CARRIER.

Riding the sine wave

BY MAURY WRIGHT • EDITOR AT LARGE

Proponents of BPL (broadband-over-power-line) technology insist that the best wires for the last mile were strung and connected long ago. But BPL still faces technical hurdles, a potentially nasty standards fight, and angry amateur-radio operators.

To many of us that lived the DSL-versus-cable battles, the broadband fight is history. But as alternative schemes such as WiMax are demonstrating, a place still exists for new last-mile broadband technologies. BPL advocates insist that the power grid is the best option yet. The technology offers the potential advantage of a ubiquitous "broadband outlet" on every wall of a house or a business. Moreover, a smart grid could enable applications such as automatic meter reading, load balancing, and even remote control of power-hungry appliances such as air conditioners—in turn subsidizing the Internet service. Proponents even claim that BPL systems can deliver video and voice over IP in addition to Internet services. Relatively small deployments of BPL are under way worldwide. But let's fully examine the real challenges that BPL still must face to go mainstream.

Depending on whom you listen to, BPL is either a panacea or a plague. Back in early October, ComTek (Communications Technologies) held a press conference in conjunction with the city of Manassas, VA, to announce a citywide BPL network. The hype was thick. ComTek Founder and Chief Executive Officer Joseph Fergus opened saying, "It's certainly a pleasure being here today to welcome you all to this great event, this historic event in the history of this nation ... to announce an achievement of a major national technology milestone—the first citywide commercial deployment of BPL. It is no exaggeration to say that Manassas now has the distinction of being plugged into the Internet in a way that is truly unlike any other city in America."

Others weren't quite so taken with the news. Manassas citizen, engineer, and ham (amateur-radio) enthusiast George Tarnovsky stated, "This entire BPL system is a failure." Tarnovsky's point focused not only on emissions from the BPL system that interfere with ham operations, but also on interference from hams and other sources to the BPL system. He continued, "They have no ingress protection."

Sending data over power lines is not a new concept. The HPA (HomePlug Powerline Alliance) has for years touted power-line-based home networking, and HomePlug 1.0 products from multiple vendors offer 14-Mbps maximum data rates—although actual data rates are in the 5- to 6-Mbps range. New HomePlug 1.0 Turbo products are just emerging that extend the maximum speed to 85 Mbps. Meanwhile, the group is working on a new specification, HomePlug AV, which will focus on moving video around a home and offer 200-Mbps rates. That specification is complete, and chip samples that support HomePlug AV are due late this year.

BPL, however, focuses on using the

AT A GLANCE

- BPL (broadband over power line) will compete with DSL and cable and, through the "broadband-outlet" concept, may prove even simpler for consumers to buy and install.
- BPL technologies for various vendors all rely on baseline OFDM (orthogonal-frequency-division-multiplexing) technology, but no universal standard exists.
- The IEEE P1901 committee is working on power-line networking for access and in-home applications, but three consortiums are pushing different technologies.
- BPL systems generate real interference that can hinder amateur radio and other services, but filtering can eliminate the noise.

power grid for the access side of broadband. The power lines that serve homes will also serve up broadband data. Data will still ride fiber optics or other high-speed network media into neighborhoods but will then jump to the power grid to reach the home, thereby eliminating the need for trenching and new wires (see **sidebar** "BPL backhaul"). Presumably, BPL will reach subscribers that DSL or cable doesn't. And, in some cases, BPL will simply compete with the incumbents (see **sidebar** "BPL: Do the economics work?").

There are two choices for when to couple the data to the power line. In some cases, service providers use only the LV (low-voltage) lines for BPL. Typically, in an LV deployment, data enters the grid at the transformer that serves six to eight houses. The transformer and, therefore, the BPL bridge or router may be pole-mounted or may be in a cabinet on the ground when utilities are underground. LV BPL typically works over 110 or 220V systems. In other cases, service providers also send data along the MV (medium-voltage) portion of the grid—lessening the reach required of fiber or other high-speed media. MV architectures vary greatly by utility and world region, but voltage on such lines varies from 5 to 30 kV. Generally, the broadband stream must couple from the MV to the LV lines at each transformer.

Both BPL and in-home power-line networking rely on the same baseline OFDM (orthogonal-frequency-division-multiplexing) technology that DSL and 802.11 wireless LANs use. HomePlug 1.0, for instance, uses 84 equally spaced OFDM subcarriers in the band between 4.5 and 21 MHz.

Unfortunately, OFDM is the only commonality when it comes to competing BPL schemes. There are three main BPL camps today, organized primarily around IC companies. Intellon has long touted power-line networking and has been a leader in the HPA since its inception. Intellon is the leader in HPA chips, although Conexant also offers products, and Arkados is just entering the market. Although HomePlug 1.0 was designed for in-home networking, manufacturers are deploying HomePlug 1.0 chips in LV BPL systems.

Spain-based DS2 (Design of Systems on Silicon) was also once an HPA member but left the organization because of a disagreement over the technology road map. But DS2 has an advantage in working products. The company has chips in production for both in-home and BPL networks that operate at 200-Mbps rates. The third player is Israel-based Main.net Communications. But, although there are BPL deployments based on Main.net chips, the company is supposedly in financial trouble. Representatives did not respond to *EDN*'s requests for an interview.

STANDARDS MURK LURKS

Although the HPA is arguably a standards body and European organization Opera (Open PLC Research Alliance) has adopted DS2 technology, a standards battle is still on the horizon. The IEEE P1901 committee is working on both BPL and in-home power-line networking. Jean-Philippe Faure of Schneider Electric and Jim Mollenkopf of Current Communications Group act as co-chairmen of the committee. Current Communications Group includes both Current Communications, a BPL-service provider, and Current Technologies, a BPL-equipment vendor. Today, Current is clearly in the HomePlug camp; Schneider would probably lean toward DS2.

Still, Faure and Mollenkopf are charged with building consensus and impartial development of the best technology. Mollenkopf, chief architect at Current but speaking in his role as co-chairman, says, "We will choose the best solution. We will choose whatever works best." According to Mollenkopf, the BPL focus is now on the LV flavor, although, he states, "We probably will address the MV side over time." The group is looking for a technology that delivers raw data rates in excess of 100 Mbps.

Mollenkopf admits that three industry consortiums are active in the P1901 committee, including the HPA; the UPA (Universal Powerline Alliance), of which DS2 is a key member; and the CEPCA (Consumer Electronics Powerline Communication Alliance). Panasonic and other consumer-electronics companies drive CEPCA, which primarily focuses on in-home networks. According to Mollenkopf, Main.net is not participating in the committee.

DO STANDARDS MATTER?

In any case, a standard is not forthcoming from the IEEE any time soon. The organization began working on one this summer, and Mollenkopf hopes for a ratified standard by the end of 2006, but he admits that his time line is optimistic. In many ways, the process is no different from other communication technologies for which multiple flavors existed. In the early days of DSL, for instance, there were at least three flavors vying for market share. Vendors shipped multiple flavors while the players worked out the standards issues, and the market succeeded with minimal impediment from the standards carnage.

But BPL is fundamentally different from other broadband flavors. In the case of DSL and cable, for instance, the broadband-access network is completely separate from the in-home network—whether the in-home choice is Ethernet, 802.11, or even HomePlug. In the case of BPL, the technology has to work even if the in-home network is also power-line-based. And no gateway separates the access and in-home networks. Mol-

lenkopf states, "Our biggest focus is on the low-voltage wire for both access and in home. There is not a clean demarcation point that the wires respect."

So, here we have one of BPL's potentially strongest value propositions and a potential Achilles' heel. The HPA promotes the concept of the broadband outlet. In its vision, every power plug is broadband-enabled. A subscriber needs no gateway or router. A subscriber can connect a game console in the family room using a HomePlug modem, a set-top box in the living room using a HomePlug modem, and a PC in the office using yet another HomePlug modem. Current Communications has one of the largest North American BPL deployments in the Cincinnati area in partnership with the Cinergy utility. Current's products rely on HomePlug 1.0 chips, and the company is selling BPL based on the broadband-outlet model. Customers buy HomePlug 1.0 products and install one for each PC or other Internet appliance. The process is purely based on self-installation, and the products sell for as little as $30 at major retailers. BPL offers symmetrical bandwidth, and each modem communicates directly with the bridge/router at the transformer. The HPA and Current claim that this architecture offers better performance than cable or DSL. Current offers the service in Cincinnati for $27 per month regardless of how many modems a customer owns.

The disadvantages of the broadband-outlet concept include security issues, and the absolute requirement of a standard that considers the interaction between the access and the in-home networks because they are physically one and the same. Say you want to share files over your home network and that the connection between two computers is the power line that also serves up your Internet. The files move on a network that you also share with your neighbors. The same concern could hold true with cable modems, but most cable subscribers connect the cable modem directly to a fire-

BPL: DO THE ECONOMICS WORK?

Although most of the buzz surrounding BPL (broadband over power line) has been technology-centric, it's fair to ask whether the world needs yet another broadband-access scheme. In fact, the same question holds for fixed-wireless schemes, such as WiMax. But the WiMax crowd can point to Third World countries where there are no DSL or cable incumbents as markets. Presumably, BPL could serve in those places, as well, although the power grid in such areas more than likely lacks the reliability to serve. So, where will BPL win and at what cost?

In the long term, the success of BPL may depend on power-centric features that a smart power grid enables. Automatic meter reading alone could save utilities major amounts of dollars and help subsidize Internet services. In areas such as California, where rolling blackouts are a threat each summer, the ability to remotely control customers' appliances may be a major money saver.

Oleg Logvinov, president and chief executive officer of start-up IC vendor Arkados, states, "I'm a skeptic of BPL as a pure-play technology." But Logvinov, who comes from the power industry, can give you a dozen reasons that BPL will succeed. He claims that utilities will use the distributed intelligence to do preventive maintenance and better understand where losses occur in the grid. He believes that utilities will ultimately manage reactive power to save energy. Logvinov states, "It's possible to save more than 10% just by optimizing your distribution."

Other players believe that the dollars do add up for BPL as a pure-Internet play. Motorola Business Development Manager Mary Ashe states, "From a pure revenue perspective, from a cost of equipment perspective, it's a very strong business case."

The major BPL deployments that you can consider as examples appear to be competitively priced. The ComTek (Communications Technologies) deployment that covers the city of Manassas, VA, will go head to head against DSL and cable alternatives. ComTek is pricing the service at $29.95 per month. You may find DSL or cable cheaper–especially if you swap carriers and make a long-term commitment–but the ComTek price is competitive. The service passes 12,500 homes and 2500 businesses and, so far, has 700 paying customers. The Current Communications deployment in Cincinnati costs $27 per month.

Note that, in the ComTek case, the deployment is not a pure-Internet play. The Manassas utility is taking advantage of the smart grid to control traffic lights, to connect cameras that enable remote monitoring of substations, and to automatically detect outages. The city is still exploring automatic meter reading.

Ultimately, however, BPL faces an obstacle that cable and DSL don't. A BPL system requires a bridge/router at the transformer to serve a customer. The typical transformer serves only six to eight power customers. If only one customer buys the Internet service, that bridge becomes expensive. Cable and DSL plants don't require gear to be so granular in most cases. In fact, cable and DSL service providers just don't offer service when they can't cost-effectively distribute their investment across many customers. Perhaps those are the types of customers that BPL will win. But will BPL service providers be able to afford to serve customers that the other broadband players can't?

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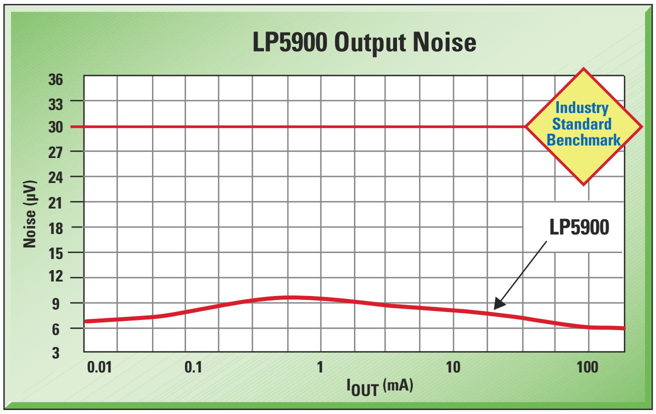

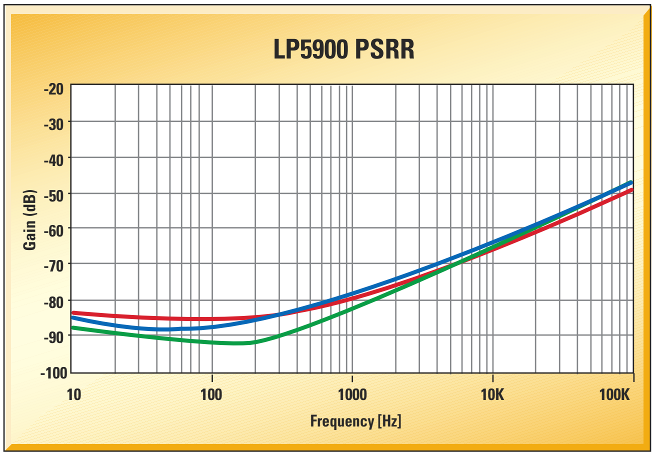

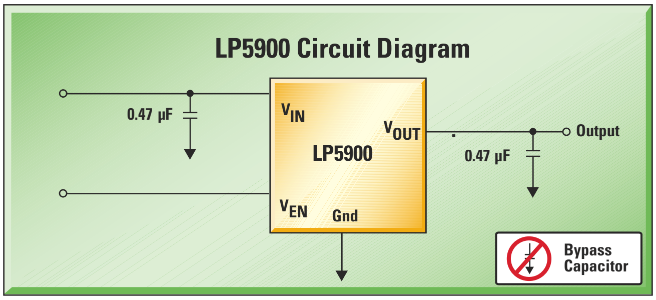

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wall/router, and home-network transfers occur behind the firewall. In the HPA scenario, only the built-in 56-bit DES (Data Encryption Standard) keeps the data passing between two HomePlug modems private—although the HPA will later add more robust security.

As for compatible access and in-home standards, the HPA has simply decided to use the same MAC (media-access-controller) and PHY (physical) layers for both. The HPA has announced that the HomePlug BPL specification due in mid-2006 will use the MAC and PHY that are already parts of HomePlug AV.

As you might guess, not everyone thinks a common access and in-home physical network is a great idea. Motorola, for instance, offers BPL equipment under the brand Powerline LV that the company also based on HomePlug 1.0 chips. According to Principal Engineer Dick Illman, "Our model is still very much like DSL or cable modem. Our intent is one client per house." Motorola Business Development Manager Mary Ashe expects most subscribers to use 802.11 or Ethernet as their home network.

Although Motorola uses HomePlug chips, the company also adds more robust encryption and authentication capabilities. So, customers in a Motorola-based BPL deployment must use a modem from the service provider rather than buy a modem at retail. The result is a more expensive modem, although Ashe claims that prices can still be less than \$100. And the system still relies on a self-installation model. Illman claims that the Powerline LV modems will coexist with a HomePlug home network, although the bandwidth of both would suffer. The CSMA/CA (carrier-sense-multiple-access-with-collision-avoidance) MAC scheme would allow both networks access to the wire.

SEPARATE ACCESS AND HOME

DS2, meanwhile, believes in distinct access and in-home networks. Company Founder Victor Dominguez states, "It's impossible to develop a technology for the home if you don't consider how it interacts with the access network." With regard to the HPA's plan to use the same MAC and PHY layers for access and in the home, Dominguez states, "It makes no sense from the PHY-channel, network-topology, or network-performance perspectives."

DS2 is unwilling to share the details of its MAC and PHY layers, but Dominguez believes that the first order of business for

BPL BACKHAUL

BPL (broadband-over-power-line) deployments still rely on some type of high-speed backhaul network to succeed. In LV (low-voltage) BPL networks, only the power line between the transformer and the home carries the data stream. In medium-voltage systems, the data rides the power lines significantly farther, but such systems must still link to the telecommunications infrastructure at some point.

A fiber ring that Manassas, VA, installed over the past five years enables the much-hyped, citywide BPL deployment. The network does rely on both medium-voltage and LV lines to carry data from substations to subscribers.

Motorola, conversely, is promoting LV-only BPL. An LV system would normally require a fairly extensive push of fiber into a service area. But Motorola is solving the backhaul problem with its Canopy fixed-wireless offering. Canopy is available in a variety of unlicensed frequency bands and in point-to-point or point-to-multipoint topologies. The service is similar to WiMax, and Motorola will likely move Canopy to the WiMax standard now that the spec is stable. The Powerline LV system relies on a Canopy antenna and receiver that reside on the power pole with the transformer and feed the LV BPL bridge.

any power-line-standards body should be a coexistence layer. He claims that the UPA already has such a layer in place. In addition, the ETSI (European Telecommunication Standards Institute, www.etsi.org) is working on power-line standards. The IEEE P1901 group has a liaison with the ETSI group. Dominguez claims that the ETSI group will early next year define a coexistence layer and that the HPA rejected such a layer. Mollenkopf from the IEEE states, "A potential solution is a common signaling protocol."

With or without a standard, the BPL movement is going full-steam ahead. Another industry group, The United Power Line Council, has a PDF map of BPL installations on its Web site (www.uplc.utc.org/file_depot/0-10000000/0-10000/7966/conman/BPL+Map+updated.pdf), and the number of deployments in North America is amazing even if some are only trials. And Europe is well ahead of North America in BPL deployment. The utilities involved include stalwarts such as Consolidated Edison and Duke Power. And ISPs (Internet-service providers), such as Earthlink, are signing on as partners to provide the Internet backbone.

WHAT IS INTERFERENCE?

With BPL rolling out, however, ham operators around the world are the leading voices of dissent, because some BPL installations interfere with ham operations. There is no question that BPL systems emit energy that acts as interference to radio communications. The overhead power lines are unshielded and cover a lot of geography—especially when a utility runs data along MV lines. Some in the BPL industry have characterized the ham operators as lunatics with nothing better to do than complain. Some of these "lunatics" claim that the BPL industry will interfere with emergency communications, leading to catastrophe. Others argue that the technology ultimately lacks the capacity to serve the stated goals of voice, data, and video. Fortunately, there are some reasonable people on both sides of the issue.

The National Association for Amateur Radio represents the ham operators. The group still uses the acronym ARRL (American Radio Relay League) from its legacy group (www.arrl.org). ARRL Laboratory Manager Ed Hare has been involved with testing BPL systems and has worked with the HPA group and companies such as Motorola to try to make BPL work. Hare states, "My goal is to help BPL succeed. Not all BPL systems will cause interference."

BPL systems operate under Part 15 of the FCC (Federal Communications Commission) rules that cover unlicensed services. Basically, the rule states that such services can't interfere with other authorized radio services. Moreover, the FCC specifically prohibits such systems from using frequencies assigned for emergency service, the police, the military, and others. Last year, the FCC also issued guidelines for BPL systems. For a complete description of the situation, see a review of the FCC rules and order compiled by *Conformity* magazine (**Reference 1**).

According to Hare, both DS2- and HomePlug-chip vendors have worked to minimize interference. To eliminate interference, the chip makers implement "notches" that keep BPL signals out of bands that hams use. The term "notch" is a bit misleading, because it refers to an analog filter. In the OFDM systems, the BPL vendors simply don't use the subcarriers in the frequency bands that the hams use.

Intellon's HomePlug chips come with the notches in place. DS2 offers programmable notches that you can dynamically reconfigure. According to Hare, systems based on HomePlug or DS2 chips are relatively quiet. With the notches in place, Hare claims, an overhead power line would generate a noise level about 15 dB higher than quiet. The noise would not be measurable on underground power lines.

MORE AT EDN.COM

- For more on BPL, visit the following *EDN* blog postings:
  - www.edn.com/051110b1
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  - www.edn.com/051110b4
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- See also "Free from interference: FCC adopts powerline rules" at www.edn.com/article/CA475078.

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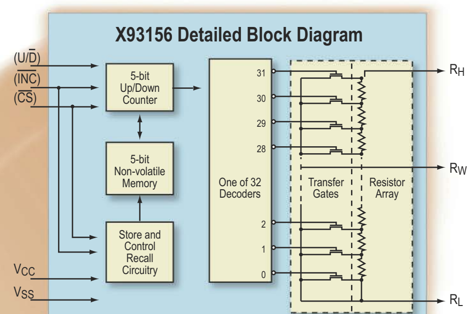

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	X93155	4.5	5	5.5	V
	X93156	2.7	-	5.5	V
End-to-end Resistence		35	50	65	kΩ
R_H, R_L Terminal Voltages		0	-	V_{CC}	V
Power Rating	R_{TOTAL} = 50 KΩ	-	-	1	Mw
Noise	Ref: 1kHz	-	-120	-	dBV
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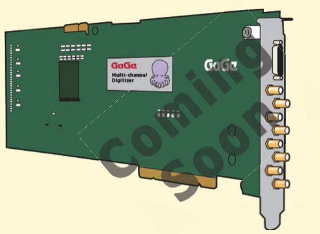


Many in the BPL industry see the notched systems as quiet. The ham operators have long memories regarding what's acceptable when it comes to interference. Neighbors of ham operators have often blamed them for causing interference on TVs. As Hare points out, a TV viewer that gets a herringbone pattern on his picture is unhappy regardless of whether the measured interference is legal. And ham operators would like even the 15 dB of noise to go away.

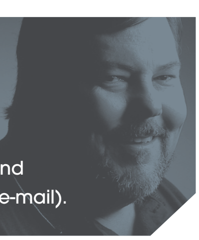
Hare points out that Motorola has eliminated interference in its Powerline LV equipment. Interference is yet another reason that Motorola supplies its own power-line modems rather than relying on off-the-shelf HomePlug modems. Motorola's Illman claims that, even with some carriers turned off in an OFDM system, intermodulation still results in a noise floor in those bands. So, Motorola added filters to its modem to further clean those frequencies. The result is a system that emits no interference and completely rejects interference, as well. Hare has extensively tested the Motorola system and affirms both claims.

Still, even the notched systems that do generate a bit of noise aren't the ARRL's biggest target. Systems without notches are. Hare claims that some service providers using DS2-based gear simply don't enable the programmable notches. And it appears that some Main.net-based systems either lack the ability to notch the frequencies in question or require some type of manual configuration of filters.

Manassas, VA, based its BPL deployment on Main.net technology, and it is noisy, according to local ham operators. Tarnovsky claims that a group of local ham operators surveyed the city and found that, generally, a signal-strength meter on a ham radio measures noise of S9 plus 20 to 40 dB. Such meters use a scale of S0 to S9, and S3 to S5 is considered a quiet environment. More than S9 is at the top of the scale.

Tarnovsky claims that the Manassas deployment primarily uses a first generation of Main.net's chips that you can't program to notch the frequencies of interest. Main.net even sent an engineer to meet with the group of ham operators. According to Tarnovsky, ComTek promised to implement notches, but a ComTek employee acknowledged that the company has yet to do so. A ComTek executive did not return *EDN*'s calls to address these issues.

In mid-October, the ARRL formally asked the FCC to instruct Manassas to shut down the BPL system. At press time, the ARRL was waiting for a response. Tarnovsky claims that the system is unreliable in any event, due to lack of filtering from ingress noise. He claims that mobile-ham operators transmitting around town have locked up portions of the BPL system requiring a reset. I wonder whether that's what ComTek's Fergus means when he states that Manassas citizens have a unique way of connecting to the Internet? **EDN**



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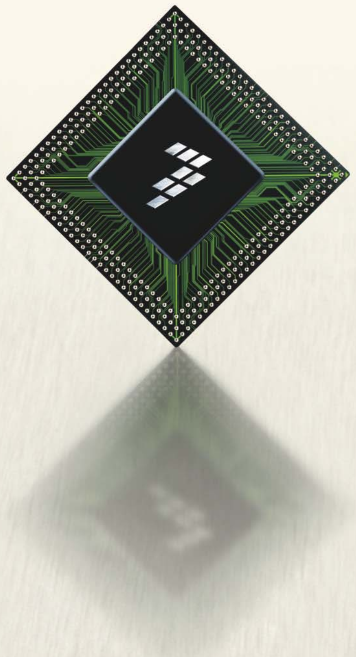

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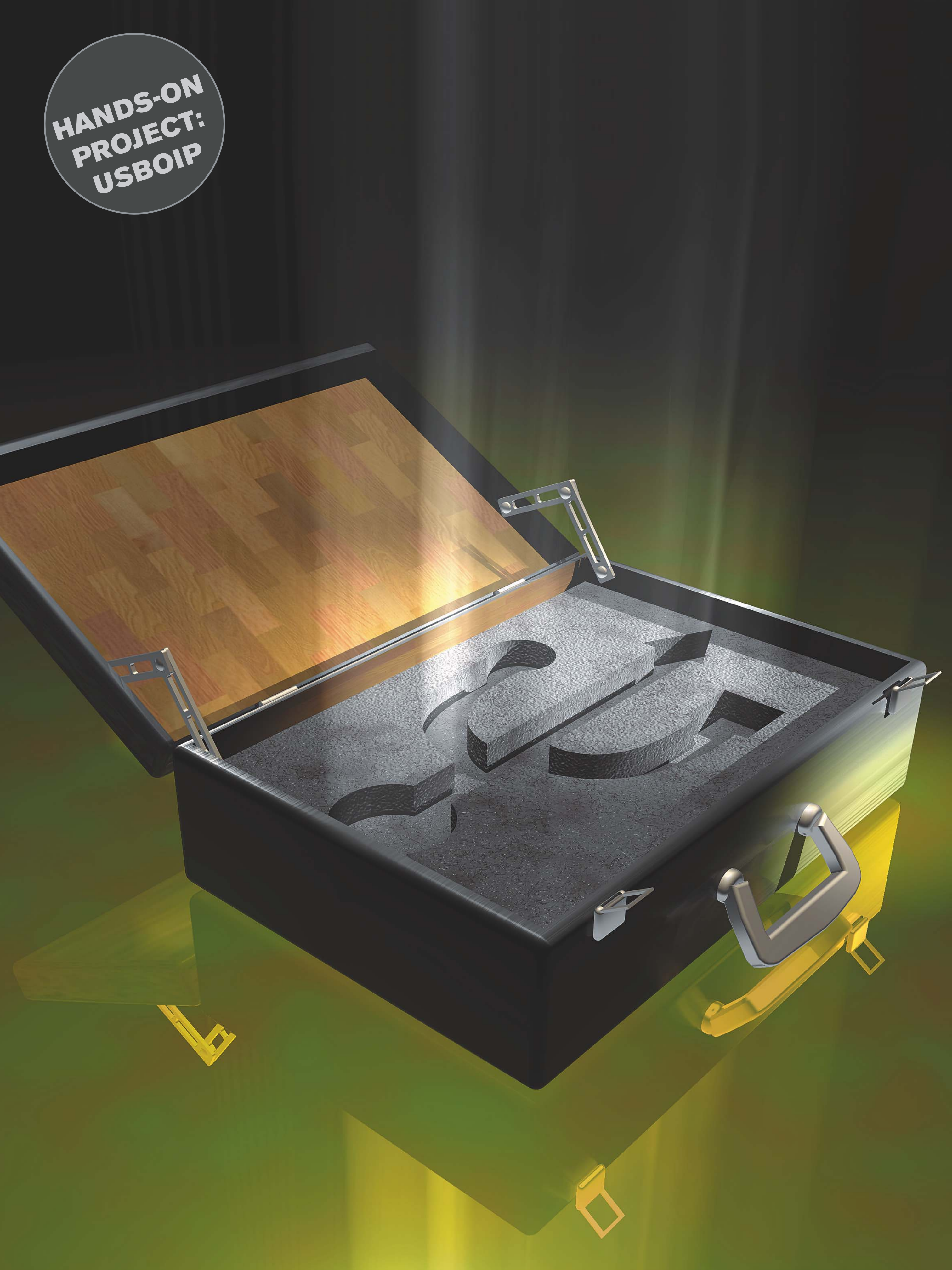
HANDS-ON
PROJECT:
USBOIP

BY ROBERT CRAVOTTA • TECHNICAL EDITOR

PORTABLE CONNECTION

CAN USB WORK OVER A NETWORK?

USB IS A SUCCESSFUL INTERFACE FOR POINT-TO-POINT CONNECTIONS, BUT IMPLEMENTING USB OVER IP PRESENTS CHALLENGES.

This year's USBOIP (Universal Serial Bus over Internet Protocol) hands-on project explores what is necessary to enable USB devices to operate over a network. The project attempts to spark interest and consideration about the emerging methods to extend the functions of USB devices. As with all hands-on projects, the effort for this project spanned several months' research, planning, and implementation. The recently released Wireless USB specification was unavailable during most of the project, so it did not materially affect our effort.

A consortium of seven computer and telecommunications companies officially developed and released the USB specification in 1995. Although USB was originally designed for connecting computers and telecommunication gear, it became a universal bus for the desktop, peripherals, and many consumer-electronics products. There are more than 2 billion wired-USB connections in the world today, according to the USB Implementers Forum. USB has been so successful as a plug-and-play-connectivity tool that it also connects computers to devices that implement other communication technologies, such as USB-to-serial, USB-to-Ethernet, and USB-to-802.11 adapters.

AT A GLANCE

- Designers have successfully used USB (Universal Serial Bus) to bridge other communication technologies.
- Ambiguities are sources of errors and lost time in any project.
- Some USBOIP (USB over Internet Protocol) implementations can enable serial sharing of a device with many host computers.

At *EDN*, we have even bridged the proprietary game-link interface in Nintendo's Gameboy Color with USB for a hands-on project (**Reference 1**). A goal of that project was to demonstrate how designers could use a commercially available device in a novel way—in this case, using a handheld device designed for gaming as a serious business and engineering platform. Readers provided feedback regarding their designs using the Gameboy as a portable platform, including as low-cost medical equipment.

The original concept for *this* hands-on project was to enable a USB host to access a legacy USB device over a wireless-network connection, such that the USB device could work as is and would be unaware of the network connection (see **sidebar** "USB terms"). To allow the USB device to connect over the network, the user would plug the USB device into a small box that would act as a local host and network adapter and manage the transactions with the host computer over the network (**Figure 1**). On the host computer, you would extend the USB-system software to enable it to send and receive USB transactions over the network rather than the default PCI bus. You would extend the system software so that the USB class drivers would be unaware of the changes and be viable as is. This last point is crucial to the ability to support existing USB devices.

This arrangement differs from adapters, such as USB-to-802.11 units, that provide a wireless-network capability through a USB device to a host system. In this case, the adapter is a USB device that can connect only to a host controller (**Figure 2**). As a result, these devices use the USB port to add a connectivity capability to the host controller rather than to another USB device.

EDN determined that a wireless-USB project was too ambitious for a hands-on endeavor, so we reduced the project scope to enabling a USB connection over a wired-network connection. This change was acceptable because we would want to perform a USB connection over a wired connection before taking on the additional complexities of a wireless connection.

To minimize the project's complexity, the project goal was to demonstrate a successful USB session over the network.

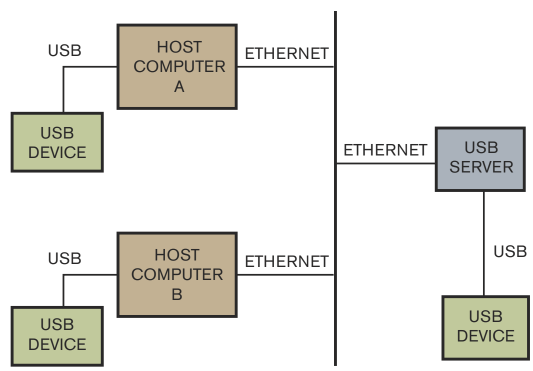

Figure 1 The USB server acts as a host controller to a USB device and coordinates with each host/client to enumerate the USB device on each host computer.

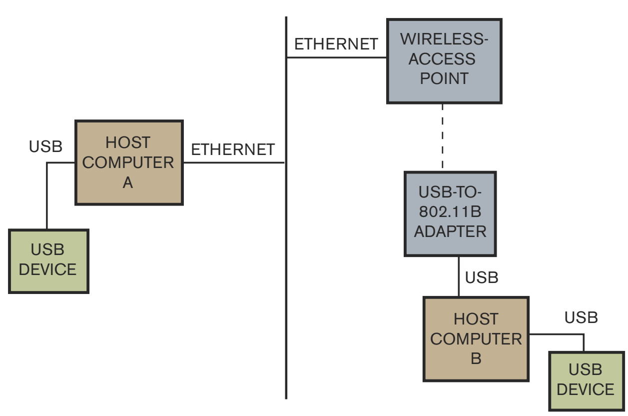

Figure 2 USB-interface adapters extend the interface capabilities for host computers; they do not extend the interface capabilities for other USB devices.

The project timetable was aggressive. (The undertaking is a part-time activity, after all.) So, we were not concerned about making a production-ready demonstration or with delivering maximum performance. To save time, we decided to avoid building the physical components for this project and to use a commercially available processor and board that could support the project.

The board needed to include hardware and software to support the connection of at least one USB 2.0 device, and it needed to be able to connect and operate on the network in our office. These requirements would allow us to focus on developing the new bus drivers for the USB-system software on the host computer and the USB server to demonstrate the concept of the project (**Figure 3**). In the end, Atmel supplied us with an AT91RM9200-EK evaluation board with an ARM9 processor for the project—but not until we had lost project time with our original processor and board selection.

AMBIGUITIES

Like many engineering endeavors, this hands-on project suffered from its share of erroneous assumptions derived from ambiguities. The first such "gotcha" occurred because the electrical and logical interface for USB connections is nonsymmetrical. While shopping the USB silicon providers for a target on which to perform this project, we discussed only what the project aimed to demonstrate at a functional level.

In this case, the target board would not only support an Ethernet connection to the network, but also act as a host to the USB device. The implicit assumption was that the target board would include a USB-host port. After meetings with several chip vendors, we identified a target processor and development board that would support both USB and Ethernet, but the chip and board were in late prerelease development. The delay did not appear to pose a significant risk to the project timing, and

no other target candidates were forthcoming, so we chose to work with the up-and-coming target processor and board.

The target processor was an ARM7-based device. One benefit of using the up-and-coming device and board was that they already had ports of smaller real-time operating systems, which would simplify the project by allowing us to use a simple operating-system architecture. Although operating systems can improve productivity for application developers over several projects by abstracting the underlying hardware, that abstraction was not going to help this project, because we were working on a one-shot deal at a lower level than application developers normally do. In fact, in this case, a heavy operating system would increase the project complexity, because it would require us to spend time learning about its interfaces and architecture.

Progress on the chip and board happened according to plan, but the gotcha reared its ugly head when we examined the data sheet for the new device just before the board's delivery. Although the new chip supported Ethernet and USB on the same device, it sported a USB-device port and no USB-host port. This was a disaster of miscommunication, because a USB-device port connects to a USB-host port and cannot connect to another USB-device port. We quickly identified a new target: an ARM9-based processor resident in Atmel's AT91RM9200EK evaluation kit.

USB TERMS

To develop and support USB (Universal Serial Bus) devices, it is necessary to understand the contents of the USB 2.0 specification and the accompanying OHCI (Open Host Controller Interface) specification (references A and B). We also reference Jan Axelson's book for this project (Reference C). The following paraphrased excerpts from these references may help readers unfamiliar with USB terms.

USB is a polled cable bus that supports data exchange between a host computer and simultaneously accessible peripherals. Any USB system has only one host. The USB interface to the host-computer system is the host controller, or USB host. You can implement the host controller as a combination of hardware, firmware, or software. It initiates all data transfers, so that the attached peripherals can share the USB bandwidth through a host-scheduled, token-based protocol. The bus supports hot-pluggable peripherals that users can attach, configure, use, and detach while the host and other peripherals are in operation. USB 2.0 supports three bus speeds for information transfers: high-speed 480 Mbps, full-speed 12 Mbps, and low-speed 1.5 Mbps.

A function is a USB device that provides a capability to the system, and a single physical device can contain more than one function. USB devices divide into device classes such as a hub, human interface, printer, imaging, or mass-storage device. USB devices must maintain information for self-identification and generic configuration; they also must always display behavior consistent with defined USB-device states. The hub-device class is a USB device that provides USB-device-attachment points.

USB devices connect with the USB host in a tiered-star topology. Each wire segment of the bus is a point-to-point connection between the host and a hub or a function or a hub connected to another hub or function. Hubs are at the center of each star. The host system integrates a root hub to provide one or more attachment points. Hubs maintain status bits to report the attachment or removal of a USB device on one of its ports. The host queries the hub to retrieve these status bits. In the case of an attachment, the host enables the port and addresses the USB device through the device's control pipe at the default address. The USB-cable connectors for the host and device ends of the cable are different and keyed so that users cannot plug them into the wrong device. This constraint is important, because the USB host must meet more requirements than the USB device, including providing power and ground lines for a nominal 5V to each device for up to 500 mA. A cable segment can be as long as 5m, and, by using the maximum five hubs between the host and the device, a peripheral can be as far as 30m from the host. To extend the range of a peripheral beyond 30m, the long-distance cabling must use another interface–for this hands-on project, an Ethernet connection.

The USB data-transfer model between a source and a destination on the host and an endpoint on a device is a pipe. A stream-data pipe has no USB-defined structure, and a message-data pipe does. Pipes have associations of data bandwidth, transfer-service type, and endpoint characteristics, such as directionality and buffer sizes. Most pipes come into existence when a user configures a USB device. One message pipe, the default-control pipe, always exists, once a user powers a device, to provide access to the device's configuration, status, and control information.

Bus enumeration identifies and assigns unique addresses to devices attached to a bus. Because the USB allows USB devices to attach to or detach from the USB at any time, bus enumeration is an ongoing activity for the USB-system software. Bus enumeration also includes the detection and processing of device removal.

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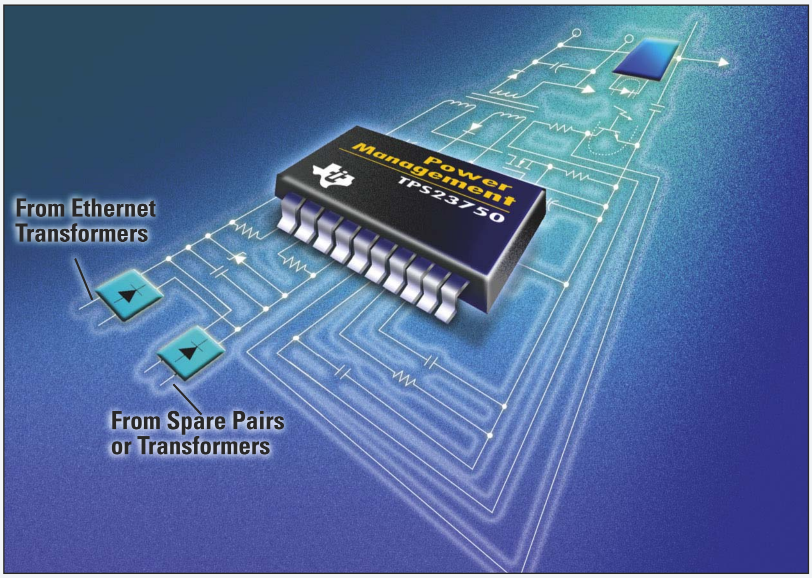

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TPS2377	100V	Legacy	0.6	PG Pin	8-Pin SOIC, TSSOP
TPS23750	100V	IEEE 802.3	0.7	Integrated Controller	20-Pin HTSSOP
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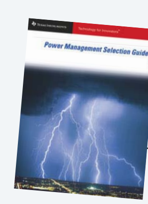

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The change not only cost us a few weeks, but also increased the project's complexity. The operating-system choices were limited to Windows CE or Linux, making the options for operating-system architecture larger and more complex than originally planned. We chose Windows CE because of its more integrated tool suite and because we would also be working with Windows USB support on the desktop portion of the project. An unfortunate consequence of this decision was a longer troubleshooting process due to the difference in time zones between our office in California and the technical-support provider in France.

The evaluation kit with the ARM9 processor core arrived, and the project was on again. However, bringing up the board provided a few more examples of how uncertainty can lead to erroneous assumptions. The process required that we install Windows CE Platform Builder 5.0, ActiveSync 3.7, Embedded Visual C++ 4.0 sp4, and the AT91RM9200EK BSP for Platform Builder on the desktop workstation. Building a CE image for the AT91RM9200EK target was a straightforward, albeit many-stepped, process.

The evaluation board uses a three-step process to load Windows CE because it is too large to reside onboard. The first step involves loading the boot loader from serial-data flash into SRAM and executing it. After establishing and configuring the boot loader through a serial connection, the boot loader loads the Windows CE image from an Ethernet connection into SDRAM and launches. Finally, the Windows CE image executes in SDRAM.

The ambiguity that bit us arose from where to install the serial-data-flash card that contained the boot loader. The board instructions said to insert the card in the bottom slot of the evaluation board and

CABLE REPLACEMENT

Rather than enabling a USB (Universal Serial Bus) device to operate over a network, the Icron approach aims at replacing the USB cable with a dedicated wireless interface. Icron's wireless architecture uses Local and Remote ExtremeUSB subsystem dongles (Lex and Rex) to connect the USB device to the host system (Figure A). There is no modification to the host-USB-system software because the Lex and Rex handle the timing accommodations.

The Turnaround Timer parameter limits the time a host or device may take to respond to a request or to acknowledge receipt of a message. With a wireless approach, this time limit can be affected by the time it takes a half-duplex radio to switch between transmitting and receiving mode, longer transmission times due to restricted bandwidth, lost packets, and a higher transmission-error rate, as well as by delays introduced from error correction and encryption processing.

The Lex and Rex system accommodates this timing constraint by responding to the host system with an NAK (negative acknowledgment) when the Lex subsystem recognizes that a data packet cannot be returned to the host in the allotted time (Figure B). At the same time, the Lex forwards the request to the Rex. The Rex forwards the request to the device and generates a local acknowledgment to the device. The Rex then forwards the message to the Lex. When the host system reissues the request, the Lex recognizes that it is caching the desired information, and it sends it to the host.

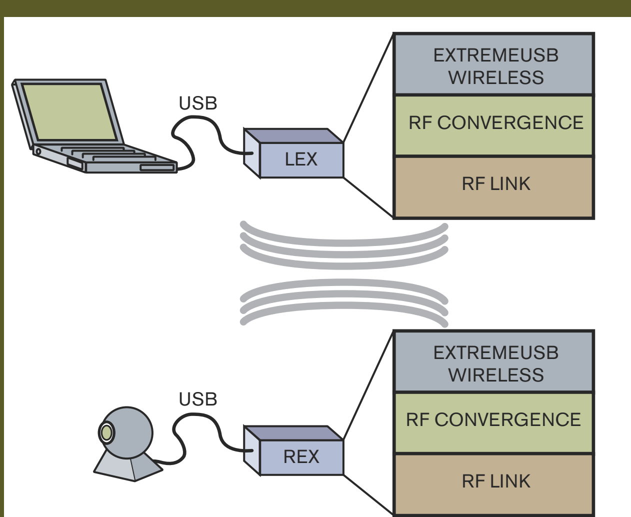

Figure A The Lex and Rex dongles comprise three layers. The top layer is the ExtremeUSB protocol layer, which compensates for the effects of delay. The RF-convergence layer formats USB packets in a manner that is more suitable for transmission over RF (courtesy Icron).

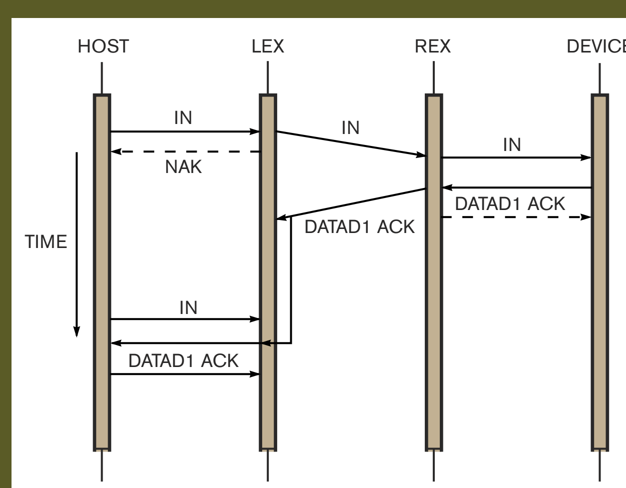

Figure B This diagram shows the NAK and ACK (acknowledge) signal sequence for a USB transaction over the wireless interface (courtesy Icron).

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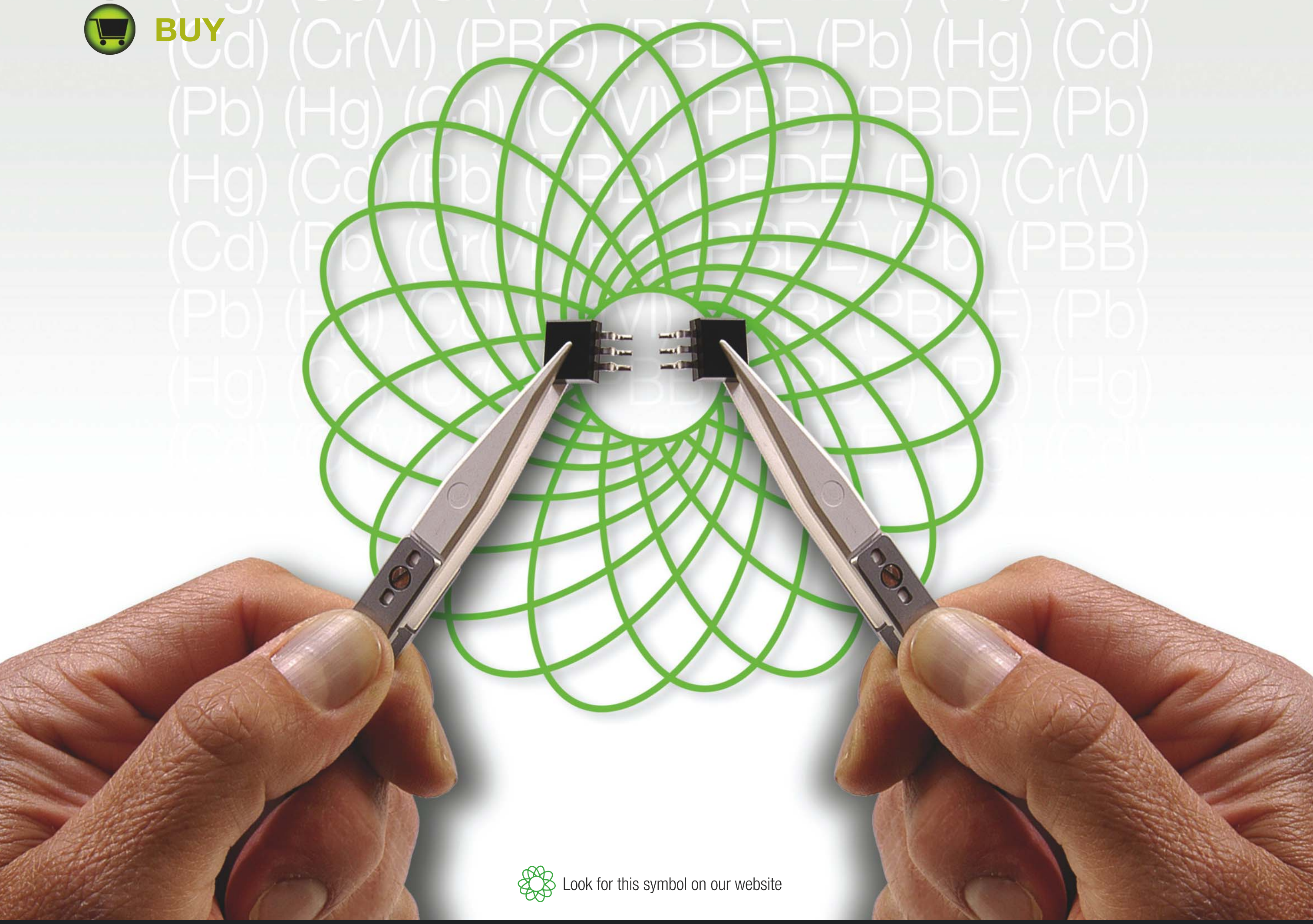

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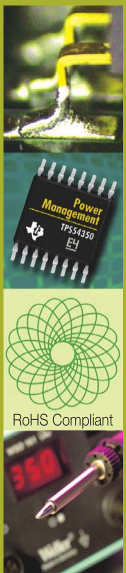

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then boot the board. Doing so, however, created unexpected activity on the serial port. In this case, instead of seeing the loader, we saw the character C repeated over and over. The ambiguity we experienced was due to the wording "bottom of the board." And it was further exacerbated by the fact that the instructions contained no drawings of the board. We eventually discovered another slot on the back of the card at the same location as the slot on the front of the board. By placing the data card in the slot on the *back* of the board, we were able to establish a proper serial-debugging session.

We were able to configure the loader to initiate downloading the Windows CE image from the Ethernet; however, it did not seem like the download was working properly. Eventually, we determined that the Ethernet cable provided with the evaluation board was cross-wired, and we were connecting the evaluation board to a router instead of directly to the workstation. It would have helped if we had spotted the little red sticker on the end of the cable sooner or if the kit included

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two Ethernet cables. Using a cross-wired cable is fine if the workstation is dedicated to communicating with target boards, but, in this case, we used one workstation for everything, and it was therefore connected to the network.

Another source of trouble and lost project time involved establishing an ActiveSync connection under Windows CE over the USB port. This project was not the first time we experienced trouble with the ActiveSync connection, however (**Reference 2**).

USBOIP

After project work had begun, we found Keyspan, a company that offers USB Server, a product (model US-4A) that enables USB devices to connect to a Mac or a PC by means of an Ethernet-based LAN. Keyspan bases the product on an embedded microcontroller and the Cypress USB EZ-Host chip. The approach of USB Server aligned with our goals for the project. Eric Welch, vice president and chief technology officer at Keyspan, offered technical support and helped us with the low-level details for the project. We also became aware of another company, Icron, which offers a USB-cable-replacement approach using a Freescale processor (see **sidebar** "Cable replacement").

To enable USB data to travel over the network between the desktop and the USB server, the software that resides on the host system and the USB server must modify how a normal USB connection is made. The USB server in turn acts as the host controller to the USB device. To avoid confusion, we use Keyspan's term "host client" to refer to the host controller on the desktop, because it is actually communicating with the USB server rather than the USB device. We also adopted Keyspan's term "NHCI" (network-host-controller interface), which replaces the OHCI (Open Host Controller Interface) or EHCI (Enhanced Host Controller Interface) as defined in the USB specification.

On the host-client side, the software enumerates devices connected to the USB server as if they had been plugged in locally, which causes the device manager to load the respective class or vendor driver for that device. These drivers expect to interact with the Microsoft USB stack, so the NHCI host software must also emulate this interface. Therefore, the client-side software has two tasks: to inform the device manager when devices are connected and to emulate the Microsoft USB-stack communication API.

When the class or vendor drivers make requests of remotely connected USB devices, the NHCI protocol packages and sends the requests over TCP/IP. The final piece of the host-client software detects USB servers on the network and makes them visible to the user. It is an implementation detail whether the networking piece should be separate from the USB-

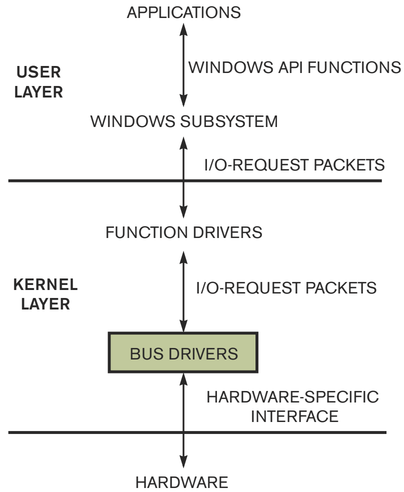

Figure 3 New bus drivers replace the USB/PCI drivers to provide the USB/network capability for the USB-system software on the host computer and the USB server.

stack emulation, such as with two bus-enumerator drivers. For instance, the Microsoft driver-development kit contains a "toast" example, which demonstrates how to write a kernel bus-enumerator driver that reports child devices to the device manager and manages all plug-and-play power requests. The NHCI host-client-side software emulates the local USB and does not operate in any way with the Microsoft USB stack. Rather, it operates in place of it.

In addition to the USB stack operating on the host client, the USB server includes a partial USB-host stack, because it is a host controller to its locally connected devices. The local USB stack allows the server to perform the normal polling activity that the host system would otherwise be sending over the network. The USB server provides hub support so that it can manage local bandwidth and handle devices downstream from the hub separately—that is, so it can connect those downstream devices to different host clients to support serial sharing.

The NHCI software on the host client needs to modify one other aspect of the USB-system software. Because all of the devices on a USB share the bandwidth of the bus, the host controller performs transfer management and allocates bandwidth to each device. However, the data coming from the USB server does not share the bandwidth with any of the local USBs, because the data and messages come over the network. The network can experience longer transit delays than would occur on a local USB. It is therefore necessary to relax the timing requirements within the low-level drivers. This method works as long as the class driver does not require hard time limits; in those situations, hosting the USB device over the network may not work or may work differently from the way that the user expects. This ability to relax the timing requirements at a low level becomes even more critical for accommodating transit-delay problems for wireless connections.

SHARING

This project concept is similar to the various wireless-USB-specification efforts and products that aim to replace the point-to-point wire connecting a USB host and device. One area that these approaches have failed to address, though, is the ability of multiple host controllers to serially share the USB device over a network.

Using the USB Server model to extend USB over a network connection affords this capability, which does not exist with USB. "We see a serial-sharing model as a killer application for USB over network," says Welch of Keyspan. "It enables multiple sharing of all the functions, such as the fax, scanner, and memory-card interfaces on a multifunction printer, as an example. You can get this capability with many of the legacy-USB devices that are out there already without waiting for an engineering redesign."

The recently released Wireless USB Specification addresses what is necessary to replace the connection between USB devices and hosts with a wireless-network capability (**Reference 3**). At this point, the specification focuses only on wire replacement; it does not consider the extension of serial sharing of devices when connecting over a network. The specification acknowledges that USB transactions will need to be able to share the ultrawideband radio with other applications running on the host computer, and the specification places the responsibility for supporting this bandwidth sharing on the wireless-USB host. If the host must consider sharing the bandwidth with other applications, why not take the transition to a wireless-network connection as an opportunity to share the device and bandwidth with other host computers on the same network?

The USB interface has proved itself a useful and successful electrical and logical protocol. Designers have used it to add interface capabilities, such as wireless networking, to host computers, without requiring the user to open the computer case—or to power off the computer, for that matter. This hands-on project demonstrates that it is immediately possible to extend the connectivity and sharability of USB devices without re-engineering and without waiting for future USB devices to directly incorporate the connectivity capability. EDN

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ACKNOWLEDGMENTS

Special thanks to Eric Welch at Keyspan, a division of InnoSys, for sharing valuable insights into the technical issues of bridging USB over a network connection. Also, special thanks to Atmel for providing the target for this hands-on project.

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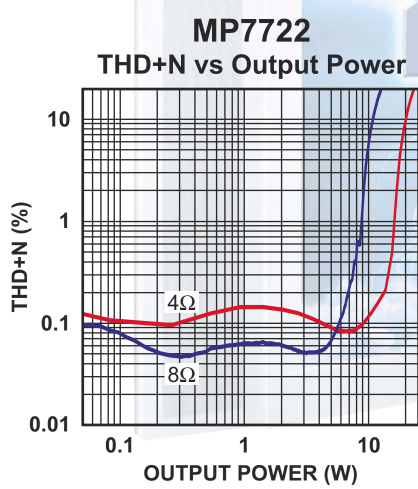

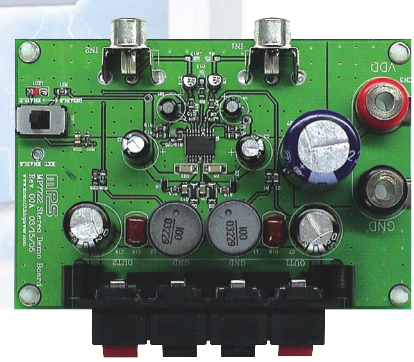

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TIME TO PLAY

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HO, HO, HO, AND ELECTRONICS SHOPPING WE GO

Electronics have for years taken center stage during the holiday-shopping season, and 2005 will be no exception. *EDN* has pulled together a lineup to help you with this year's shopping. First, a word of advice: Check the Internet, because that's where you'll almost always find the lowest prices. Amazon, for instance, gives you multiple online sources, besides its own, for prices. Just make sure the provider is reputable. Thanks go to product specialists Taylor Santos and Kirk Stanford at Circuit City (Burlington, MA) for their picks. *EDN* also relied on the Consumer Electronics Association's TechKnowOverload college-campus tour, *PC World*, *PC magazine*, *CNet*, DemoFall, and *EDN*'s Digital Den. Here are this year's picks.

HIGH-DEF CAMCORDER DOESN'T MISS A TRICK

Train a high-definition HDR-HC1 Sony Handycam camcorder on your arm, and you'll see every hair, freckle, discoloration, and goose bump. The company claims the device, which it introduced in July, is the smallest, lightest high-definition camera. For a $1800 street price and a $2000 manufacturer's suggested retail price, it *should* be good. CNet labeled it a good "first effort" but added that only high-definition-product "fanatics" should consider it. The unit occupies the "prosumer-lite" market that sits just below several professional-grade videocameras for a few hundred bucks more.

▶**Sony,** www.sonystyle.com.

MIGHTY MAC MINI

No one, except for Steve Jobs, perhaps, thought that an Apple Macintosh could sell for $500 to $700. Nonetheless, Apple accomplished this task with the Mac Mini system. With prices starting at $499, this 2.9-lb, 6.2-sq-in., 2-in.-high box packs incredible power for handling music, video, and general-purpose computing tasks. Add your own keyboard and display, turn it on, and OS X shows the way. Apple's marketing says it best: "Everything you ever wanted, nothing you don't need."

▶**Apple Computer**, www.apple.com/macmini.

GET SIRIUS

If you're getting a Sirius satellite radio for your home, make sure the unit has a built-in AM/FM tuner. Tivoli's tabletop unit is a good bet. For XM needs, the tiny Delphi Roady 2 car receiver, which has FM and sells for $50, is a hard deal to beat. Sirius' least expensive car unit as of press time, the Starmate, also has FM and sells for $80.

▶**Sirius**, www.sirius.com.
▶**Tivoii Audio**, www.tivoliaudio.com.
▶**XM Radio**, www.xmradio.com/roady2.

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NO CHEESY MOUSE

The Logitech Laser MX 1000 laser cordless mouse is pricey at a manufacturer's suggested retail price of $80. However, some retailers offer healthy rebates, and you can order it online for considerably less. Logitech boasts that the mouse is 20 times more sensitive than traditional optical-based units and equals the performance of a corded USB mouse. It comes with a base station for recharging, a new thumb-button control, and side-to-side scrolling with zoom. The company also offers other noteworthy products. At $400, the Z-5500 digital home theater offers good sound at a reasonable price. And the Harmony line of remote controls, selling for $100 to $250, helps tame the complexity in controlling home-audio and -theater systems. The company's wireless iPod and MP3-player headphones are nifty, too.▶**Logitech**, www.logitech.com.

WHO NEEDS WIRES IN THE WALLS?

With Yamaha's MusicCast, you need no wires to create an integrated audio system in every room of your house. The MusicCast MCX-1000 digital-audio server uses 802.11b technology to wirelessly broadcast music to strategically placed "clients" and "speakers." MusicCast centralizes 1000 CDs on an 80-Gbyte hard drive on the server—a feature that the iPod also offers. Still, Yamaha has a long history of innovation in music and the instruments from which it emanates. Check out its EV-204 and EV-205 electric string violins, which musicians can play "silently." And don't overlook a boatload of new XM Radio-ready receivers and home-theater systems from the company. ▶**Yamaha**, www.yamaha.com.

FINDING MR (WIRELESS) GOOD SPOT

IOgear's WiFi Finder key-ring fob locates wireless-network hot spots, supporting 801.11b and 802.11 b/g. The 8-oz unit, which has a list price of $30, finds use in mobile workers of all types and promises to detect networks as far away as 500 ft of open space.
▶**IOgear**, www.iogear.com.

XBOX 360 TO TAKE THE LEAD—FOR NOW

The Xbox 360 game console, which is due to debut around press time, sells for $300 and comes with accessories that add $100. It promises dramatic, life-like, high-definition action. What's more, you can rip music on it, instantly plug into Xbox Live to play against other gamers, or watch DVDs. It processes 500 million triangles/sec.
▶**Microsoft**, www.microsoft.com/xbox.

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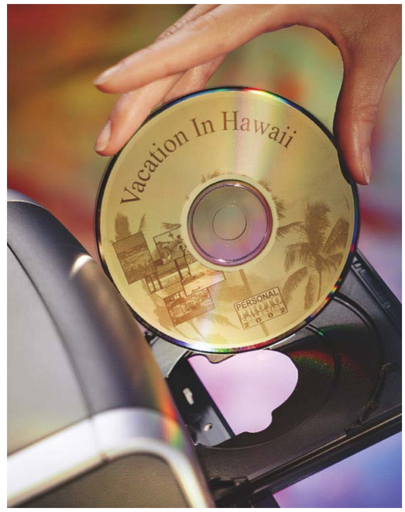
BURN, FLIP, AND BURN

Printing DVD or CD paper labels is a pain, and scribbling on them with an indelible marker makes you look like a slob. The LightScribe disc-labeling system lets you burn gray-scale images onto specially coated CDs or DVDs. To use the system, you need a LightScribe-enabled burner, specially coated DVDs or CDs, and one of a half-dozen labeling-software packages. LightScribe burners sell for $75 to $125 online, and a box of the CDs or DVDs sells for $5 to $40, depending on quantity. HP also optionally builds the LightScribe into PCs.
▶**LightScribe**, www.lightscribe.com.



WIDE SCREENS ARE SIMPLY BRILLIANT

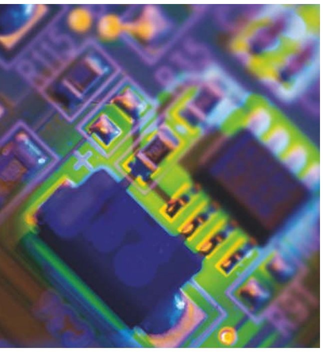
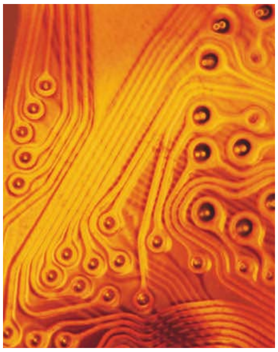
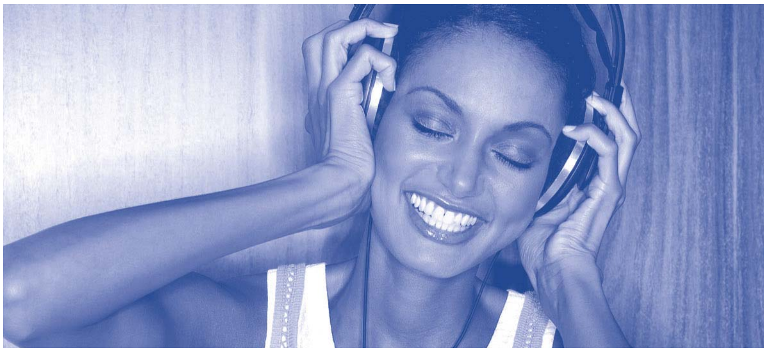
The first thing you notice about Sony's Vaio FS780/W notebook is the 15.4-in. Xbrite wide-screen display. Xbrite LCD technology produces vivid, brilliant colors. And with 1 Gbyte of RAM, a 120-Gbyte hard drive, and Pentium M 750 and Nvidia GeForce Go 6200 graphics, this notebook rocks. Wide-screen units are bulky, but that price is a small one to pay for the awesome display. And at 6.28 lbs, the FS780/W is comparatively svelte. Expect to pay around $2200.
▶**Sony**, www.sonystyle.com.

CRANK UP THAT RADIO

With all of the hurricanes this year, we naturally assume that power outages will occur. Batteries can last only so long. So hand-cranked radios could be just the thing. For just 90 seconds of cranking to recharge its batteries, the Eton FR300 emergency AM/FM radio from Grundig plays for 40 to 60 minutes. This unit also broadcasts National Oceanic and Atmospheric Administration weather forecasts and has a VHF TV tuner. After hurricanes Katrina and Rita, no one in the path of a hurricane should be without one. You can get one for $50 at Amazon (www.amazon.com).
▶**Eton Corp**, www.etoncorp.com/US.

LEARNING IN LEAPS

The new handheld Leapster L-Max learning system from Leapfrog Enterprises helps teach just about everything that a student in kindergarten, preschool, or the elementary grades needs: math, reading, spelling, science, writing, language, art, music, and logic. Aimed at four- to 10-year olds, the $100 unit, which uses a Linear Max II CPLD, makes learning fun. The portable device has its own screen, and kids can also use it with a TV or computer monitor.
▶**Leapfrog Enterprises**, www.leapfrog.com.

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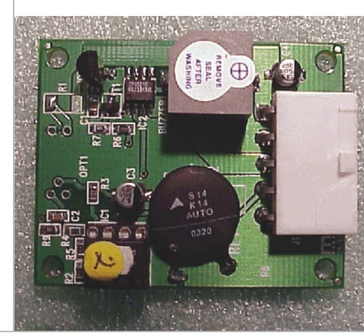
PUT YOUR PC INTO YOUR POCKET

U3 this fall introduced the concept of smart USB drives, which hold a lot more than just data. They store a mirror image of your PC, including applications, folders, e-mail, and data. Just plug them into any computer, and you don't need your PC. USB-drive vendors Sandisk, Verbatim, Memorex, and Data Traveler have rallied around the U3 technology. Many of the devices store 1 or 2 Gbytes.
▶**U3**, www.u3.com/smartdrives.

GET A HANDLE ON KEYLESS CAR ENTRY

Do you ever want to lock your car and go to the gym, pool, or track but have no place to store the key? Geocentric Systems has the answer with its Know-Key programmable unlocking system. This electronic retrofit allows a car's owner to gain entry by lifting the door handle to input a digital code. The small electronic device fits out of sight inside the car door and eliminates the need for the ugly keypad you find on some car doors. There are as many applications for the $149 Know-Key as there are things—like the liquor cabinet from your teenager, for example—that you need to lock.
▶**Geocentric Systems**, www.geocentricsys.com/reps2.htm.



DVR IS BUILT-IN

LG's 50PX4DR has a built-in digital-video recorder, including a 160-Gbyte hard drive, yielding a ton of high-definition TV for $3700 to $4000, depending on where you buy it. How deep is the discounting? Consider that the list price for this unit is still $6000. With DVR, you can record any cable or antenna-fed programming instead of paying your cable provider to do it or shelling out bucks for Tivo.
▶**LG**, http://us.lge.com.

IT'S BETTER TO LOOK GOOD THAN TO FEEL GOOD

The Minolta Dimage X1 camera looks good. And when you use it, you should feel good, too. This 8 million-pixel device measures only 0.8 in. thick with its lens retracted and is about one and a half times bigger than a deck of cards. It boasts powerful antishake technology and records movies at a respectable 20 frames/sec. And you can get this slick number in red, black, or silver.
▶**Minolta**, www.konicaminolta.com.

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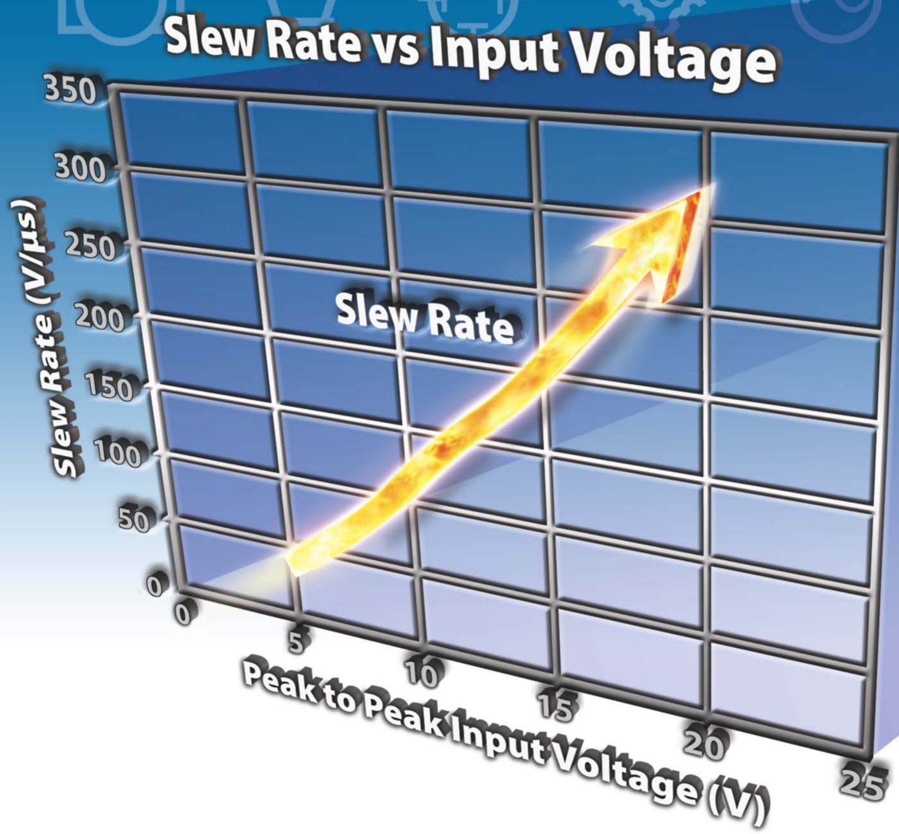

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Precision ICs

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PA69A	±100	75	250	200	$13.60
PA86	±100	100	350	300	$18.15
PA86A	±125	150	350	300	$21.60
PA78	±175	150	350	200	$24.85

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POWER, PERFORMANCE, VALUE

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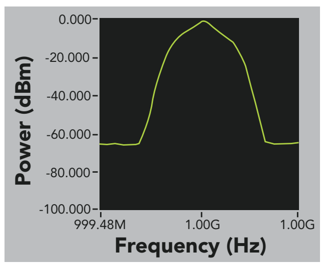
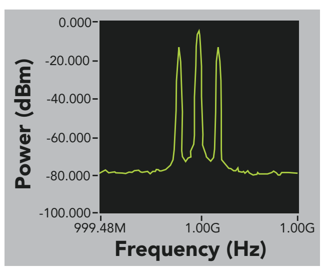
THE DATA DETECTIVE

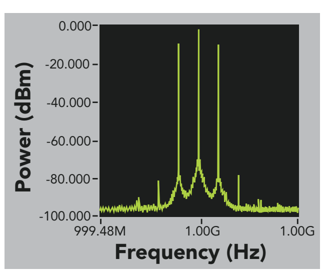
Fourier Rules in the Frequency Domain

The widespread design of wireless devices forces many engineers to move from the time domain into the frequency domain. An instrument such as a spectrum analyzer and a tool such as the Fourier transform can present frequency-domain information in easy to understand formats.

Still, frequency-domain measurements require a bit of explanation, starting with the discrete Fourier transform (DFT), an algorithm that operates on discrete time samples acquired by an analog-to-digital converter (engineers often call a discrete Fourier transform a fast Fourier transform, or FFT). A DFT produces information about the average frequency content of a signal during the period sampled. Thus, the DFT serves well when frequency content remains constant.







By taking more samples over a longer time, you can decrease the resolution bandwidth and separate nearby signals from one another. The better resolution comes at the cost of longer processing times, though.

A DFT plots both “positive” and “negative” frequencies on either side of a 0-Hz (DC) reference. The negative information is redundant, but it represents half the power in the signal. So, a DFT routinely doubles the power represented at each positive frequency value. In effect, this power represents the root-mean-square (rms) amplitude of the sine-wave component at a given frequency.

The frequency range and resolution a DFT provides depend on the sample rate (F_S) and the number of data points acquired (N). The DFT puts out frequency information between 0 Hz and (F_S/2) - (F_S/N). The frequency lines, or bins, occur at intervals of F_S/N. Thus, the sampling frequency determines the frequency range or the bandwidth. The number of sampled points determine the frequency resolution, also called the resolution bandwidth (RBW).

As you lower RBW, a DFT better resolves signals, so individual frequency components become visible (see figure). Notice that decreasing the RBW also lowers the displayed noise floor. But, the finer frequency resolution and lower noise come at a price; longer acquisition times, which mean you must take more samples. Thus, data-transfer and computation times increase and overall measurement throughput decreases.

The lower noise floor effectively increases dynamic range, but this situation applies only for narrowband signals, such as pure sine waves. The bandwidth of such signals fits entirely within one frequency bin. Observe caution when measuring modulated signals. Their power spans several frequency bins, and you’ll observe their average power reduced by an amount that equals the observed noise-floor reduction due to decreasing the RBW. Thus, the dynamic range for these signals remains constant. Reducing RBW does not improve the dynamic range for broadband modulated signals.

You also can use a preamplifier to help an RF analyzer measure signals that may remain hidden beneath the instrument’s noise floor. Suppose you apply signals with -110 and -145 dB amplitudes to an analyzer with a -140 dB noise floor. The latter signal falls below the noise floor, so the analyzer cannot detect it. A preamp with a 30 dB gain would boost the two signals to -80 and -115 dB, which raises the weaker signal above the noise floor. The analyzer’s software then “lowers” the measured spectrum by 30 dB. In effect, the two signals now exist at their original levels of -110 and -145 dB and the noise floor moves down by 30 dB to -170 dB. Obviously you cannot change the actual noise floor, but the relative difference between the signals is correct due to amplification of the signal. In effect, you can increase the effective sensitivity of the analyzer and lower the noise floor in relation to the signals.

Who’s Got the Spur?

Phil’s production-line test instruments indicate a signal source produces one or more spurs that shouldn’t exist in good products. But Jane, an engineer in the development lab, can’t detect and measure any spurious signals.

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BY YAN GOH • WOLFSON MICROELECTRONICS

Challenges for designers of digital-camera audio subsystems

MORE THAN A FEW DESIGN TRICKS GO INTO PROVIDING THE IMPRESSIVE AUDIO PERFORMANCE OF LOW-COST DIGITAL-VIDEO CAMERAS.

From a system designer's point of view, digital-video cameras combine the worst of the portable consumer and home-entertainment worlds. There are rigid constraints on space, power consumption, and component cost. But end users still expect their recordings to look and sound well when played back on stationary equipment in which recording flaws are much more visible—and audible. High-quality microphone recording is therefore indispensable. Acoustic- and mechanical-noise issues associated with handheld use in outdoor environments, as well as electrical interference from switching power supplies, motors, and digital circuitry within a camera, make it all the more difficult to achieve good sound quality.

Audio playback presents additional challenges. The tiny loudspeakers that portable equipment uses limit both audio volume and audio quality. Fortunately, countermeasures ranging from analog-circuit design to DSP (digital-signal processing) and pc-board layout are available to address these issues.

THE SIGNAL CHAIN

Consumer cameras have one or more internal condenser microphones as well as an input jack for external condenser or dynamic microphones. A preamplifier, an ADC, and DSP functional blocks follow these elements (**Figure 1**). Each stage adds noise and distortion. Without external noise sources, the weakest link in this chain limits the overall SNR and THD (total harmonic distortion). The weakest link is usually the preamp or the ADC, in which audio performance is most expensive, not only in component cost, but also in power consumption.

An electret condenser-microphone capsule incorporates a built-in FET buffer that makes the signal less susceptible to interference on its way to the preamplifier. However, the FET also generates thermal noise. Moreover, any noise in the microphone-bias voltage that powers the buffer also adds to the audio signal, severely degrading the SNR because of the very low signal amplitude at this point. Providing a clean supply is therefore even more important for the microphone capsule than for the subsequent stages.

Handheld and built-in microphones also require ALC (automatic level control) to counteract seemingly random variations in signal volume as the microphone moves toward or away from the sound source. The ALC keeps the recording volume approximately constant by introducing a variable gain or attenuation stage into the signal path. This variable gain affects not only the signal, but also the noise added before the ALC stage.

In all-digital implementations operating on the digitized signal, the result is that the ADC's constant quantization noise is amplified along with the signal during quiet passages, progressively worsening SNR as the signal volume decreases. Amplifying the signal in the analog domain, before the ADC adds its quantization noise, results in better SNR.

However, even analog ALC circuits amplify thermal noise

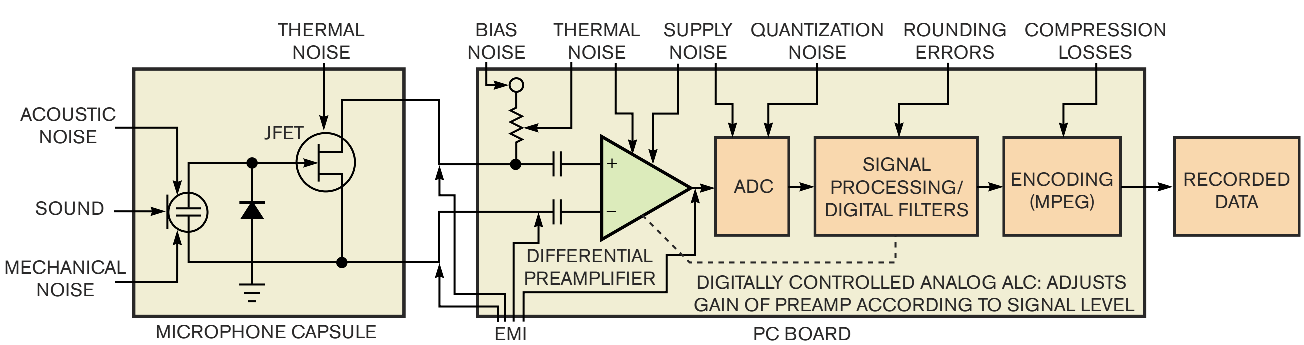

Figure 1 The cleverness that produces the high-quality audio is not immediately apparent from examining a typical portable camera's audio-signal chain.

generated in the FET buffer. To avoid filling up periods of silence with loud, white noise (a phenomenon known as noise pumping), designers should use ALC in conjunction with noise gating, which cuts off the signal when its amplitude drops close to the noise floor. If possible, designers should also tailor ALC timing to the type of signal; speech usually sounds best with shorter hold and decay times than those that are appropriate for music, whose volume changes are often intentional.

ACOUSTIC NOISE

By a common definition, "acoustic noise" refers to any unwanted sound that enters the microphone, such as voices, music, or traffic noise. These noise sources usually originate off-axis; the sound does not come from where the camera lens is pointing. Highly directional, shotgun-type microphones pick up far less off-axis noise but are equally insensitive to all off-axis sound. For capturing background sounds, a cardioid or omnidirectional microphone is more appropriate. Video professionals have a set of microphones to choose from. For more modest amateur requirements, a zoom microphone is a good compromise. Such a microphone is actually an arrangement of two microphones with different directionality, or a pair of back-to-back-mounted membranes, whose signals are mixed in varying proportions depending on the optical zoom. In wide-angle scenes, the combined response is omnidirectional but gets progressively narrower as the lens zooms in.

Air blowing directly into the microphone generates wind noise. It is mostly random in nature and occupies the low audio frequencies. Foam windscreens effectively suppress wind noise, but designers should supplement them with electronic highpass filtering in windy conditions. Second-order filters with cutoff frequencies near 200 Hz have worked well in practice. Because such filters also remove bass from the signal, you should enable them only when you need to. You can conveniently implement them in the digital domain and incorporate them into an audio IC (**Figure 2**).

Another type of acoustic noise occurs when someone breathes a plosive, such as a p, b, or t sound, directly into the microphone capsule. Most of such sounds' energy concentrates near the low end of the audio range, with amplitudes much greater than those of other speech. As a result, unlike wind noise, designers cannot remove plosive sounds in the digital domain; the large-signal peak would drive the ADC into saturation, resulting in a brief silence in the digitized audio until the signal returned within the ADC's range. Although an analog peak limiter or ALC with a short attack time mitigates this problem, the best cure is free. The microphone's source impedance, the preamplifier's input impedance, and the coupling capacitor between them form a first-order highpass filter whose cutoff frequency depends on the capacitance. This capacitor need not be any larger than necessary to maintain the overall bass response, which the microphone usually limits. Reducing the capacitance to just the right value suppresses many types of low-frequency noise at no extra cost.

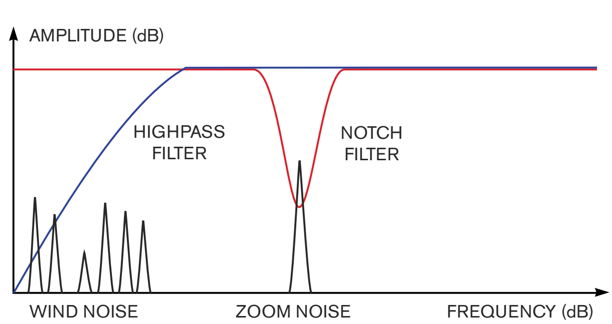

Figure 2 Digital filtering can suppress noise that is limited to one part of the audio spectrum, such as low-frequency wind noise and narrowband zoom noise.

MECHANICAL NOISE

The microphone membrane reacts to mechanical vibrations and shocks just as much as it does to sound waves. In handheld cameras, this sensitivity leads to problems in handling noise. First, internal microphones often pick up the rattling of moving parts, such as pushbuttons or loose cables within the camera enclosure. You should prevent any such parts from moving when the camera shakes. Second, the mechanical action of fingers and palms on the camera enclosure generates large peaks in the bass and infrasonic regions.

Because effective shock mounting is impractical in consumer cameras, the only option is filtering. As with plosive noise, a smaller microphone-coupling capacitance blocks the worst mechanical-noise peaks. If necessary, you can supplement this measure with additional highpass filtering in the digital domain. However, for higher frequency components of handling noise (fingernails tapping against the enclosure, for example), the cutoff frequency would be well within the audible range. Therefore, it is preferable to rely on the user's more gentle handling of the equipment, rather than indiscriminately suppressing the entire bass range.

ELECTRICAL NOISE

Transients in dc/dc converters and digital signals generate EMI (electromagnetic interference) that nearby pc-board tracks pick up. The connection from the microphone to the preamplifier is particularly sensitive to EMI because the signal amplitude is relatively low in relation to the induced spikes. EMI covers a wide bandwidth, and, thus, filtering cannot remove it. However, a differential microphone preamplifier can suppress EMI spikes that appear in both the microphone signal and the microphone ground. To use this approach, you must treat the microphone ground as a signal in its own right and route it next to the microphone-signal track. The differential amplifier then subtracts the ground voltage from the signal, canceling out the EMI and leaving the desired signal.

This remedy is imperfect, though. In a real-world pc-board layout, one of the two tracks is slightly longer or closer to the noise source, making the EMI spikes larger in one track than in the other. Moreover, differential amplifiers' finite CMRR (common-mode rejection ratio) results in attenuation—rather than complete cancellation—of even perfectly identical signals. You should therefore design the board to reduce EMI pickup. First, make the microphone connection as short as possible. If you use a cable, shield it. You can produce a shielding effect on

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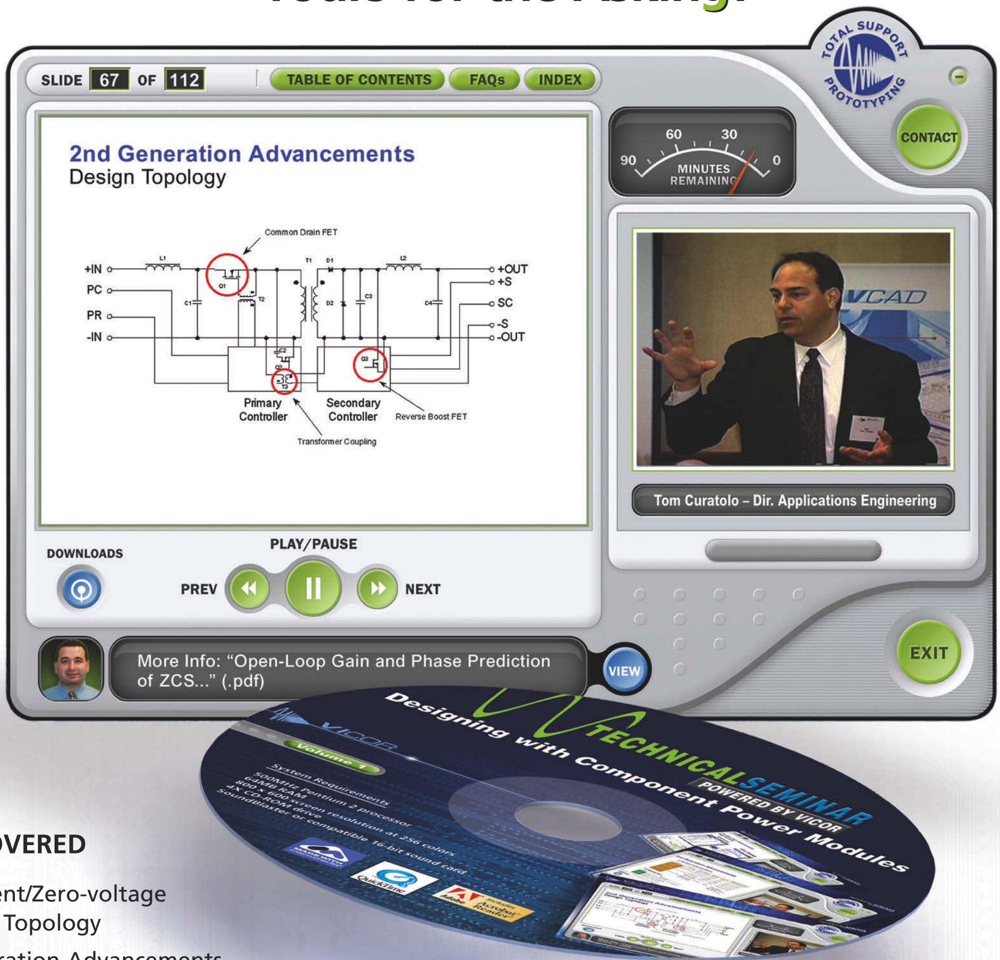

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the board itself by placing grounded lands on both sides of the signal track and creating ground planes on adjacent copper layers. The next step is to maximize the physical distance between the EMI source and the analog audio circuitry. Finally, wherever possible, minimize the EMI that digital and power-switching circuits emit within the camera.

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The power supply provides another point for noise entry into analog circuits. As digital and power-management circuits pollute their supply rails with switching noise, the microphone preamplifier and the analog part of the ADC need a separate, low-noise supply. Carefully separate digital and analog grounds. Finally, good decoupling of all of the supply voltages short-circuits supply noise before it can spread around the system.

Zoom noise is an issue peculiar to cameras. Originating from the stepper motor attached to the zoom lens, it can spread acoustically, mechanically, or electrically—through the supply, or as EMI—through the alternating magnetic field that the motor windings emit. Zoom noise is periodic and falls into a narrow band around the motor's step frequency, usually within the audio range; harmonics and mechanical gears can add peaks at other frequencies. Digital notch filtering can remove this type of noise but also suppresses genuine audio signals within the same frequency band. To minimize such collateral damage, the notch filter should be highly selective with a narrow stopband, and you should disable it whenever the lens motor is inactive.

You can use the same approach to guard against narrowband noise from motors in hard-disk drives or other electromechanical components.

AUDIO PLAYBACK

Although cameras are primarily recording devices, audio-playback quality is also an important part of a user's experience. The options for playback are headphones, built-in loudspeakers, and line-out connections to a home high-fidelity system. The line-out connection is the most demanding in signal purity and requires a low-noise, low-distortion DAC and an output buffer. In practice, headphone outputs can often double as line outputs, because their THD is much lower with a high-impedance line load than with 16 or 32Ω headphones. Higher signal amplitudes make the playback signal chain less noise-sensitive than the recording side. Nevertheless, the usual precautions for mixed-signal circuits apply: Separate analog from digital, provide clean analog supplies, and protect analog signals from EMI.

If the signal is good enough for a line-out connection, it's good enough for headphones, too; the transducer rather than the electronics usually limits overall performance. However, producing sufficient volume with built-in loudspeakers can be difficult. Small magnets and membrane diameters limit their energy efficiency, and cranking up the signal level only causes distortion and even more quickly depletes the battery.

DSP techniques can boost perceived loudness without increasing the peak signal level that the loudspeaker and the analog-signal path see. One option is dynamic compression, which applies extra gain when the signal amplitude is low. This technique squeezes the signal's dynamic range into a narrower region near full-scale.

Another technique is peak limiting, which amplifies the signal beyond full-scale and instantaneously ramps down the gain during signal peaks to prevent clipping (**Figure 3**). In effect, the method compresses the top part of the original signal's dynamic range and amplifies the lower part. Both methods reduce the signal's dynamic range, and you should employ them when you use headphones or a line-out connection.

An additional problem with small loudspeakers is their poor bass response. Bass-boost circuits can help mitigate this issue; alternatively, equalizers offer a more complete approach that can also iron out other kinks in the speaker's frequency response. Although obtaining flat response to 20 Hz remains elusive with subminiature speakers, bass boost and equalization deliver drastic improvements. You should use both in conjunction with peak limiting to prevent signal clipping when you apply a large gain to one or more frequency bands. You can relatively inexpensively implement dynamic compression, peak limiting, bass boost, and equalization inside an audio chip. As with other signal-processing functions, a dedicated-hardware or DSP approach invariably uses less power than does a software algorithm running on a general-purpose processor. EDN

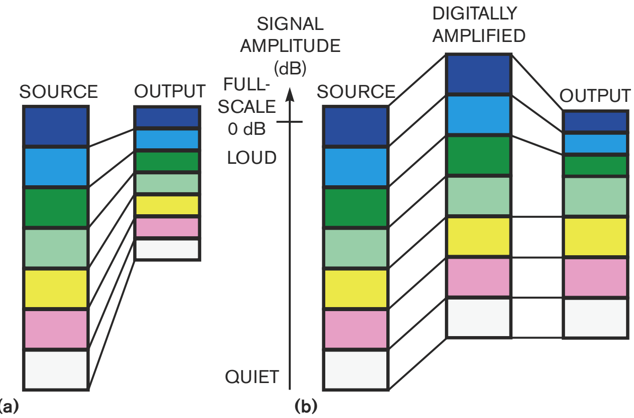

Figure 3 Using dynamic compression (a) or peak limiting (b) coaxes more volume from small speakers.

AUTHOR'S BIOGRAPHY

Yan Goh is a product-marketing engineer at Wolfson Microelectronics (www.wolfson.co.uk) with responsibility for portable products. Before joining Wolfson in 2004, he worked at NewLogic Technologies for four years in sales and marketing in the United States and Austria. He has also held IC-design positions at Infineon and Tritech Microelectronics. He holds a bachelor's degree with honors in electrical and electronic engineering from the University of Edinburgh (Scotland) and a diploma in electronics and communication engineering from Singapore Polytechnic.

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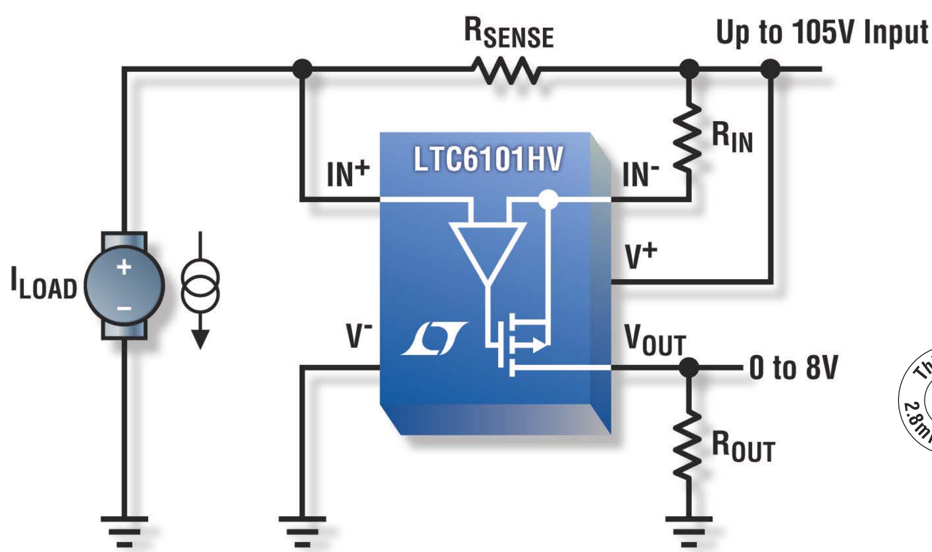

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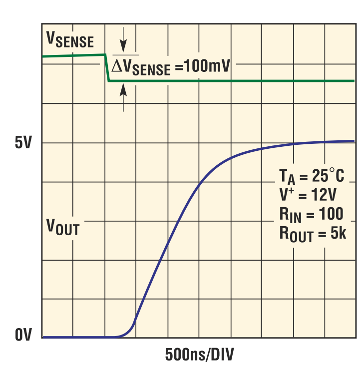

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Temperature-to-period circuit provides linearization of thermistor response

S Kaliyugavaradan, Anna University,
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Designers often use thermistors rather than other temperature sensors because thermistors offer high sensitivity, compactness, low cost, and small time constants. But most thermistors' resistance-versus-temperature characteristics are highly nonlinear and need correction for applications that require a linear response. Using a thermistor as a sensor, the simple circuit in **Figure 1** provides a time period varying linearly with temperature with a nonlinearity error of less than 0.1K over a range as high as 30K. You can use a frequency counter to convert the period into a digital output. An approximation derived from Bosson's Law for thermistor resistance, R_T, as a function of temperature, θ, comprises $R_T=AB^{-\theta}$ (see **sidebar** "Exploring Bosson's Law and its equation" on the Web version of this article at www.edn.com/051110di1). This relationship closely represents an actual thermistor's behavior over a narrow temperature range.

You can connect a parallel resistance, R_P, of appropriate value across the thermistor and obtain an effective resistance that tracks fairly close to $AB^{-\theta}\simeq$ 30K. In **Figure 1**, the network connected between terminals A and B provides an effective resistance of $R_{AB}\simeq AB^{-\theta}$. JFET Q_1 and resistance R_S form a current regulator that supplies a constant current sink, I_S, between terminals D and E.

Through buffer-amplifier IC_1, the voltage across R_4 excites the RC circuit comprising R_1 and C_1 in series, producing an exponentially decaying voltage across R_1 when R_2 is greater than R_{AB}. At the instant when the decaying voltage across R_1 falls below the voltage across thermistor R_T, the output of comparator IC_2 changes its state. The circuit oscillates, producing the voltage waveforms in **Figure 2** at IC_2's output. The period of oscillation, T, is $T=2R_1C_1\ln(R_2/R_{AB})\simeq 2R_1C_1[\ln(R_2/A)+\theta\ln B]$. This equation indicates that T varies linearly with thermistor temperature θ.

You can easily vary the conversion sensitivity, ΔT/Δθ, by varying resistor R_1's value. The current source comprising Q_1 and R_1 renders the output period, T, largely insensitive to variations in supply voltage and output load. You can vary the period, T, without affecting conversion sensitivity by

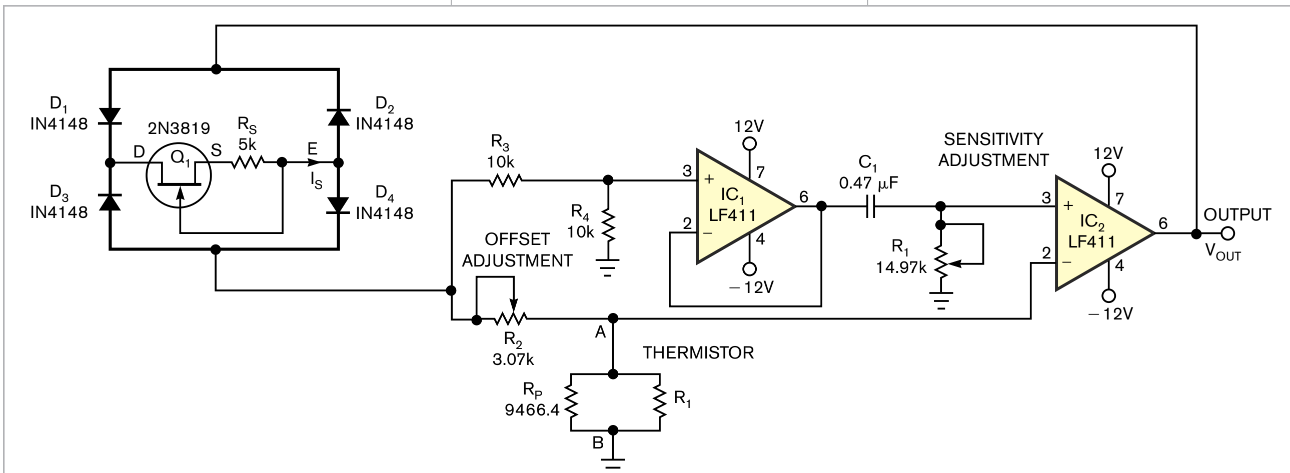

Figure 1 This simple circuit linearizes a thermistor's response and produces an output period that's proportional to temperature.

varying R_2. For a given temperature range, θ_L to θ_H, and conversion sensitivity, S_C, you can design the circuit as follows: Let θ_C represent the center temperature of the range. Measure the thermistor's resistance at temperatures θ_L, θ_C, and θ_H. Using the three resistance values R_L, R_C, and R_H, determine R_P, for which R_{AB} at θ_C represents the geometric mean of R_{AB} at θ_L and θ_H. For this value of R_P, you get R_{AB} exactly equal to $AB^{-\theta}$ at the three temperatures, θ_L, θ_C, and θ_H.

At other temperatures in the range, R_{AB} deviates from $AB^{-\theta}$, causing a nonlinearity error that is appreciably less than 0.1K for most thermistors when the temperature range is 30K or less. You can easily compute R_P using: $R_P=R_C[R_C(R_L+R_H)-2R_LR_H]/(R_LR_H-R_C^2)$. Because temperature-to-period-conversion sensitivity, S_C, is $2R_1C_1\ln b$, you can choose R_1 and C_1 such that $R_1C_1=S_C[\theta_H-\theta_C]/\ln(R_{AB}\text{ at }\theta_L/R_{AB}\text{ at }\theta_H)$ to obtain the required value of S_C. To get a specific output period, T_L, for the low temperature, θ_L, R_2 should equal $(R_{AB}\text{ at }\theta_L)e^Y$, in which Y represents $(T_L/2R_1C_1)$. In practice, use a lower value for R_2 because the nonzero response delay of IC_2 causes an increase in the output period.

Next, set potentiometers R_1 and R_2 close to their calculated values. After you adjust R_1 for the correct S_C, adjust R_2 until T equals T_L for temperature θ_L. The two voltage-divider resistances, R_3 and R_4, should be equal in value and of close tolerances. As a practical example, use a standard thermistor, such as a Yellow Springs Instruments 46004, to convert a temperature span of 20 to 50°C into periods of 5 to 20 msec. This thermistor exhibits resistances for R_L, R_C, and R_H of 2814, 1471, and 811.3Ω, respectively, at the low, midpoint, and high temperatures. Other parameters for the design include S_C=0.5 msec/K, θ_L=20°C, θ_H=50°C, θ_C=35°C, and T_L=5 msec.

Because only a fraction of current I_S is through the thermistor, I_S should be low to avoid self-heating effects. This design uses an I_S of approximately 0.48 mA, which introduces a self-heating error of less than 0.03K for a thermistor's dissipation constant of 10 mW/K. **Figure 1** illustrates the values of the components in the example. All resistors are of 1% tolerance and 0.25W rating; use a polycarbonate-dielectric capacitor for C_1.

Simulating various temperatures from 20 to 50°C by replacing the thermistor with standard, 2814 to 811.3Ω, 0.01%-tolerance resistors produces T values of 5 to 20 msec with a maximum deviation from correct readings of less than 32 μsec, which corresponds to a maximum temperature error of less than 0.07K. Using an actual thermistor produces a maximum error of less than 0.1K for a thermistor dissipation constant of 10 mW/K or less.EDN

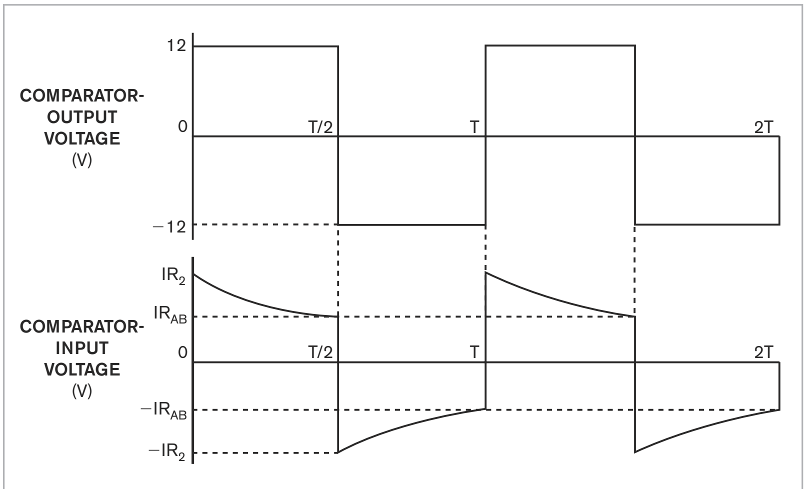

Figure 2 Waveforms show input to comparator IC_2 (lower trace) and its output (upper trace). In the lower trace, IR_2 represents the voltage across R_2.

Two wires control SPI high-speed ADC

Dan Meeks, Texas Instruments Inc, Austin, TX

Most current microprocessors, DSPs, and field-programmable gate arrays integrate hardware and software resources that support either or both of two common interface standards—SPI (serial-peripheral interface) and I²C (inter-IC)/SMBus. Both two-wire-interface standards suffer from a few crucial disadvantages. For example, I²C's throughput rates are 100 kbps, 400 kbps, or 3.4 Mbps in standard-, fast-, and high-speed modes, respectively, and can thus restrain a fast peripheral data converter's sample rate. Excluding framing and overhead bits, a 100k-sample/sec, 12-bit ADC must transfer at least 1.2 Mbps over the interface, a rate that only I²C's high-speed mode supports. Many processors and controllers currently offer no I²C high-speed mode and thus would be unable to support a fast data converter.

One of I²C's major benefits reduces the number of host-to-target interconnections. Using only two wires plus ground, the host controller can address the target device and exchange data, whereas SPI requires three wires—data, clock, and chip-selection—plus ground. Multiple SPI-target devices can share data and clock lines, but each device requires its own

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Given the perpetual demand for higher sample rates and resolution, I^2C's limited speed may restrict its use in some applications and instead force designers to select SPI. However, SPI requires an additional I/O pin on the host controller. In situations in which extra pins are unavailable but the application requires a fast SPI-bus converter, you can apply the technique in **Figure 1**.

For example, Texas Instruments' ADS7816 comprises a 200k-sample/sec, 12-bit-sampling ADC that requires a bit rate of 3M samples/sec to sample continuously at a 200k-sample/sec rate (**Reference 1**). Selecting the ADS7816's active-low $\overline{CS}$ (chip-select) pin initiates a conversion cycle. After toggling and holding $\overline{CS}$ low during the data transfer, $\overline{CS}$ returns high after transferring the data completes the process.

When the clock line initially goes low, it also asserts $\overline{CS}$ to a low state. The time constant of the peak detector comprising D_1, R_1, and C_1 ensures that $\overline{CS}$ does not go high until the clock line remains high for more than one clock cycle (**Figure 2**). Although the clock line toggles and retrieves data from IC_2, $\overline{CS}$ remains asserted low, and, upon completion of retrieval, the clock line goes high, and $\overline{CS}$ follows, readying the circuit for another conversion cycle.

Because C_1 must discharge at the end of a conversion cycle, the controller should delay the start of the next conversion cycle until C_1 fully discharges. Careful choice of R_1 and C_1 minimizes the delay to a minimum of three clock cycles. In addition, the voltage across C_1 must not fall below inverter IC_{1B}'s input threshold before the next clock pulse arrives to refresh the capacitor's voltage. Inverter IC_{1A}'s output voltage and current capabilities affect C_1's recharge time, and R_1 and IC_{1B}'s input impedance affect the discharge time. To ensure a robust design, include components' tolerances and temperature coefficients along with variations of logic-input and -output thresholds. EDN

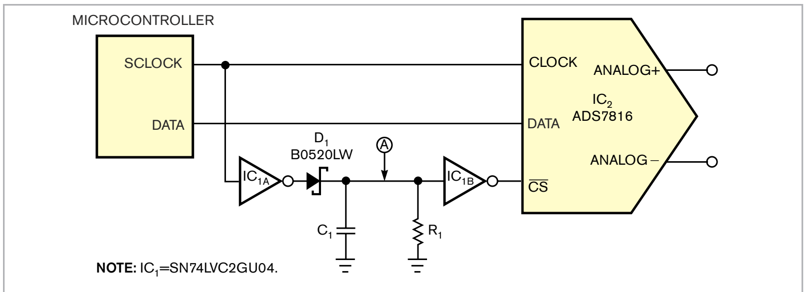

Figure 1 Two inverters and a few components can substitute for an SPI ADC's chip-select line.

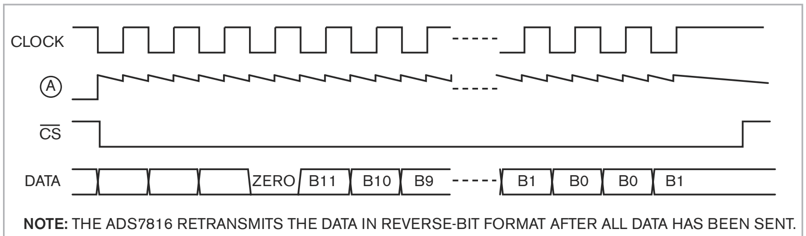

Figure 2 An SPI-clock waveform (top trace) evokes data (bottom trace), and peak detection of the clock (the waveform at Point A in Figure 1) yields a signal (next-to-bottom trace) that mimics the chip-selection line's behavior.

REFERENCE

1. ADS7816 data sheet, http://focus.ti.com/docs/prod/folders/print/ads7816.html, Texas Instruments.

Volume-unit meter spans 60-dB dynamic range

Jon Munson, Linear Technology Corp, Sunnyvale, CA

An audio volume-unit meter displays peak-related audio amplitudes to aid in accurately setting recording levels or for displaying an amplifier's operating conditions. A simple diode and capacitor network provides a classic volume-unit meter's peak-weighted response, but the circuit typically limits response to about 23 dB of displayable dynamic range, and the meter suffers from errors that its pointer's inertia and mechanical "ballistics" introduce. Contemporary displays eliminate the inertia problem by using arrays of lighted elements to form bar graphs, but any shortcomings in response and accuracy characteristics now shift to the signal-processing domain. You can use DSP techniques and applied mathematics to replicate a meter's functions in firmware, but this approach gets relatively expensive if the device doesn't already include DSP functions to spare.

An inexpensive analog meter's weakness remains its peak-hold element, a capacitor that must charge quickly to accommodate large signals and accurately for small signals—two mutually exclusive goals. In addition, the nonideal characteristics of the diodes for

(continued on pg 88)

LINEAR TECHNOLOGY DESIGN NOTES

LT5528 WCDMA ACPR and AltCPR Measurements – Design Note 375

Doug Stuetzle

Introduction

ACPR (adjacent channel power ratio) and AltCPR (alternate channel power ratio) are important measures of spectral regrowth for digital communication systems that use, for example, WCDMA (wideband code division multiple access) modulation. Both ACPR and AltCPR quantify the ratio of regrowth in a nearby channel to the power in the transmitted channel.

To measure ACPR and AltCPR, refer to the test setup shown in Figure 2. The DUT (device under test) is the LT5528, which is a high linearity direct I/Q modulator. It accepts complex modulation signals at its baseband inputs and generates a modulated RF signal at the RF output. An accurate measurement of the spectral regrowth of a highly linear device such as the LT5528 is difficult because its dynamic range may rival that of the measurement equipment. Because of this, it is important to account for the noise of the measurement system; i.e., the spectrum analyzer. Refer to Figure 3. Some spectrum

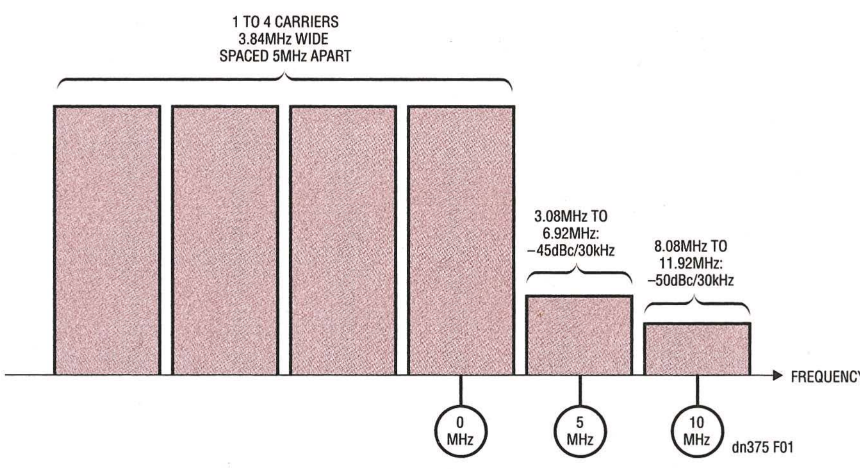

Figure 1. WCDMA ACPR Limits, Per 3GPP TS 25.104, Section 6.6.2.2.1

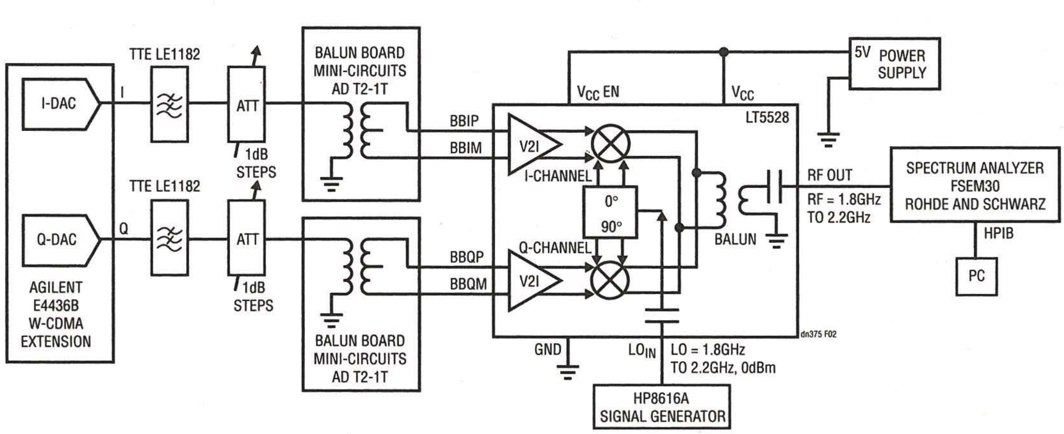

Figure 2. ACPR Measurement Setup

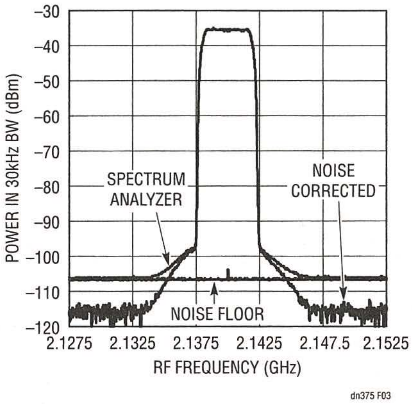

Figure 3. ACPR Spectrum for a Single Carrier WCDMA Signal

analyzers offer an ACPR measurement utility. This utility will not, however, give accurate results for highly linear devices, as it does not compensate for the system noise floor.

The spectrum analyzer must have a wide dynamic range. That means a high input 3rd order intercept point, and a low noise floor. The analyzer shown in Figure 2 meets both of these requirements.

Note that a free running RF generator provides the LO signal. This type of generator is used because of its superior noise performance. This is critical, as a noisy LO signal may corrupt the ACPR measurement. Its output operating frequency can drift slightly, so manual frequency correction is required.

Also, the baseband source can generate spectral regrowth and noise which may swamp the performance of the DUT. The lowpass filters shown at the baseband generator outputs reduce these impairments to a tolerable level. Filters suggested for this purpose are made by TTE Engineering and offer >20dB rejection at 10.4MHz and >80dB rejection at 13.08MHz.

To start, measure the noise floor of the spectrum analyzer with a 50Ω input termination. The input attenuation of the analyzer is set to minimize the noise figure of the measurement system. A 30kHz resolution bandwidth is used because the spectrum analyzer shown has the lowest noise figure (about 24dB) at that resolution bandwidth. The spectrum analyzer shown includes an RMS display detector mode, which is specifically designed to measure noise-like signals. For spectum analyzers that do not offer this mode, it is important to set the video bandwidth to at least 3 times the resolution bandwidth; in this case 100kHz. If the ratio of video to resolution bandwidth is too low, the power measurement will be inaccurate. Video averaging helps smooth the result; 100 averages gives good results. Once the settings are correct, use the channel power utility of the analyzer to find the total noise power within a 3.84MHz bandwidth.

Next measure the output spectrum of the DUT using the same settings. For ACPR/AltCPR, center the measurement band 5MHz/10MHz above the center of the highest carrier. To find the true spectral regrowth power, convert the measured spectral power levels to mW and subtract the spectrum analyzer noise floor from the measured DUT power. Reconvert to dBm to get the true spectral regrowth.

The ACPR/AltCPR is equal to the difference in dB between the signal power per carrier and the spectral regrowth.

ACPR and AltCPR vary with output signal level. Figure 4 shows the ACPR and AltCPR versus RF output level for a 4-carrier WCDMA signal centered at 2.14GHz. For low RF power levels, these are limited by the output noise floor of the DUT. At high RF output power levels, they are determined by the linearity of the DUT. The maximum ACPR/AltCPR are observed between these extremes, where the spectral regrowth equals the noise floor of the DUT.

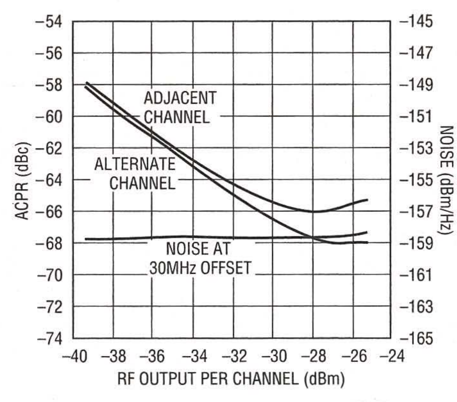

Figure 4. LT5528 4-Channel WCDMA Adjacent and Alternate CPR Measurement vs Channel Power

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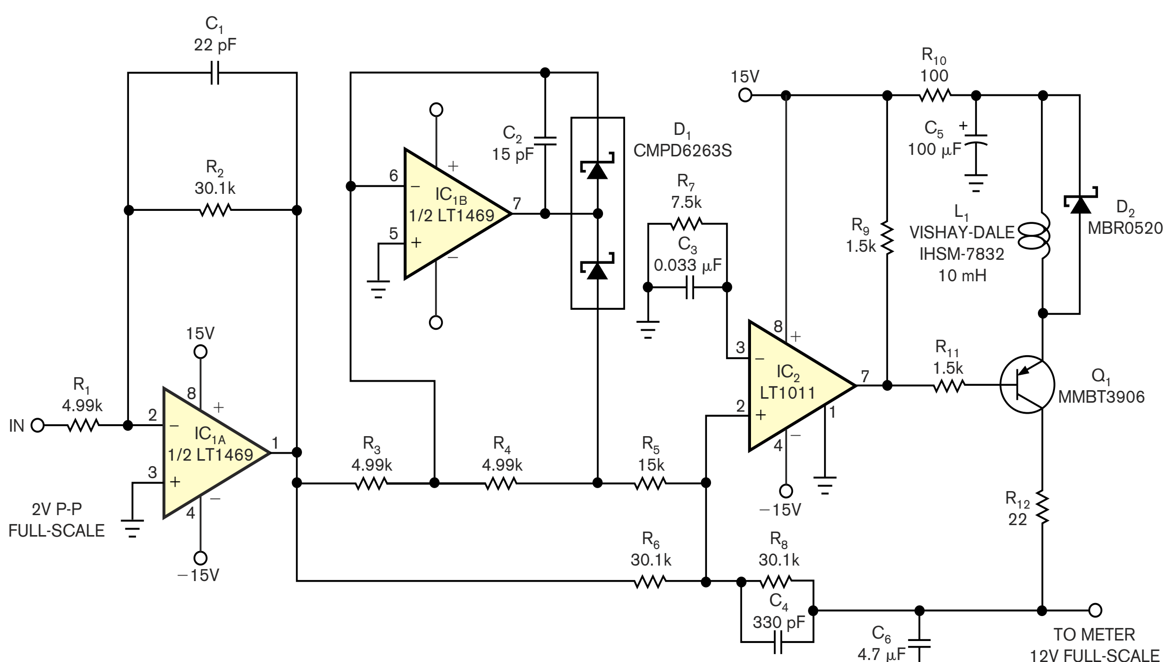
full-wave rectification and peak-hold functions also limit an analog volume-unit meter's dynamic range. Preserving 20 dB of display dynamics and monitoring signal levels that can vary over a 40-dB range, which is typical in consumer electronics, call for a circuit with a dynamic range on the order of 60 dB.

In most instances, traditional circuits fail to simultaneously provide the intended accuracy and slew rate, particularly at low signal levels over a wide dynamic range. The circuit in **Figure 1** offers a simple configuration that delivers high accuracy over a dynamic range that exceeds 60 dB and provides the rapid-attack/slow-decay characteristics that a high-quality display requires.

The heart of the circuit is a Linear Technology LT1011 comparator, IC_2, which monitors the difference between the incoming signal's amplitude and the peak-detected output. It also delivers charging current to a 4.7-μF hold capacitor, C_6, whenever the state of its charge is too low. Unfortunately, the input-to-output delay inherent in comparators and nonlinear amplifiers determines the minimum output-pulse width. If the hold capacitor charges quickly to track large input bursts, the minimum charge step must greatly exceed the level of small signals and thus limits the dynamic range.

Inductor L_1 solves the capacitor-response problem by providing an adaptively variable source of charging current. Adding a 10-mH inductor limits the maximum current rate when the comparator generates narrow pulses, thus reducing the minimum charging amplitude step to a smaller level of 1 mV or less. For wider charging pulses, the current automatically ramps up to higher levels to provide the desired high slewing rate. The minimum charge step is essentially proportional to the signal-step size, ensuring a constant relative accuracy of better than 1 dB over a 60-dB signal range. A signal level of −59 dB corresponds to a 13-mV input, and a meter-scale factor of 0 dB of 2V peak corresponds to the input level necessary for a typical gain-of-20 audio power amplifier to deliver 100W rms into an 8Ω load, or approximately 40V peak output.

The circuit also includes two operational-amplifier stages based on Linear Technology's high-accuracy LT1469 dual op amp. The first stage, IC_{1A}, provides gain of a factor of six in this example, so that a 2V input peak provides a 12V output. The second op-amp stage, IC_{1B}, forms a precision inverting half-wave rectifier. The outputs from IC_{1A} and IC_{1B} and the positive-peak-detected voltage across C_6 combine at IC_2's input to provide a zero-crossing threshold to the comparator. When its input falls below 0V, IC_2's output switches on Q_1 and delivers charge to C_6 until the voltage across C_6 reaches or slightly exceeds the amplified audio voltage. The feedback network comprising R_8 and C_4 provides an optimal volume-unit-metering discharge. **EDN**



NOTE: SCHEMATIC DOES NOT SHOW THE 0.033-μF BYPASS CAPACITORS AT EACH IC POWER LEAD.

Figure 1 This inductor-compensated voltage-unit meter displays a 60-dB dynamic range.

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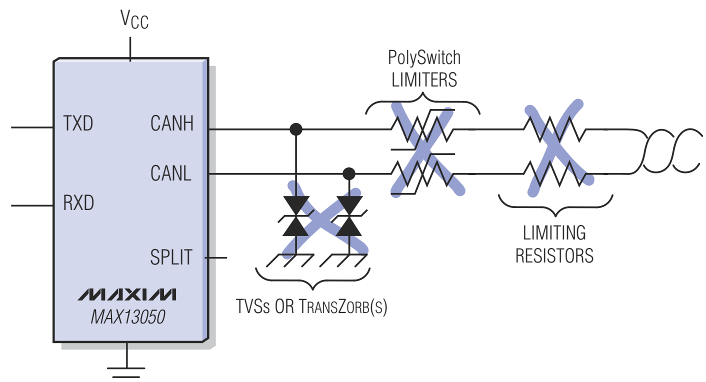

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Price† ($)	1.51	—	1.51	—	1.48	—	1.65	—

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Pacer clock saves subroutine calls

Enver Torlakovic, Willmot, New South Wales, Australia

This Design Idea outlines an easy-to-implement time-delay routine that requires no subroutine calls and thus avoids possible stack-overflow problems (**Listing 1**). This method also saves RAM space by requiring in most cases only two variables: the PACER_CLOCK as a free-running counter and another variable introduced at a particular instance (for example, TIME_VAR). The routine dedicates the microcontroller's Timer 0 to generate an interrupt-on-overflow instruction every 10 msec or at any other desired interval. You assign the Timer 0 interrupt a low priority in the initialization code and then enable the Timer 0 any convenient time. After assignment, do not alter the interval because many services likely depend on the pacer-clock routine. Note that the routine can achieve delays of as much as 255 times the Timer 0 overflow period.

Listing 1 is written for Microchip's PIC18F242 flash-memory controller, but porting the routine to another microcontroller should pose few problems. When copying the code to paste it into routines, note that you must change the labels—in this example, "wait_loop100"—at each application of the code between the rows of asterisks in the **listing**.EDN

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You can download the listing from the Web version of this Design Idea at www.edn.com/051110di2.

LISTING 1—TIME-DELAY ROUTINE

```
int_test_timer0

        btfss       INTCON,     TMR0IF          ; test if Timer0 IRQ was active
        goto        int_test_INT1                                     ;if not, check
next INT source
        bcf         INTCON,     TMR0IE                     ;disable Timer0 int.
        bcf         INTCON,     TMR0IF          ; clear Timer1 H/W flag

        ;Jobs to do here:       INC the PACER_CLOCK variable

        incf        PACER_CLOCK                 ;This variable is a free running
counter

        ;RELOAD TIMER0 now: (Timer0 set for 10 milliseconds pacer clock)
        ;Note: Rollover occurs after the Timer reaches 0xFFFF
        ;Required number of ticks is calculated as: 0xFFFF-(TMR0H:TMR0L)

        movlw       0x0D                                ; High byte
        movwf       TMR0H                       ; Reload Timer0 high
        movlw       0x61                                ; LOW byte
        movwf       TMR0L                       ; Reload Timer0 low.

        ;Note: for an internal clock period of 0.161002 microseconds, count 62111 clocks
        ;to make up  the 10 millisecond interval.

        bcf         INTCON,     TMR0IF          ; clear Timer1 H/W flag
        bsf         INTCON,     TMR0IE                     ;Re-enable the Timer0
interrupt
        bsf         T0CON,              TMR0ON             ; turn ON Timer0
module

int_test_INT1
        ;code for INT1 starts from here…
        .
        .
retfie          ;return from interrupt
```

```
Somewhere in the code:

                    ;******************
        movf                PACER_CLOCK, w          ;get the current Pacer_Clock
state
        addlw       D'10'                                          ; to
count up to 10  Timer0 overflow periods
        movwf       TIME_VAR                               ;load the time variable
with the contents of …

            ;…PACER_CLOCK plus 10
wait_loop100
        ;do some jobs here…
        ;….
        ;…
        movf                PACER_CLOCK, w
        xorwf               TIME_VAR, w                             ;check
if PACER_CLOCK was incremented 10 times
        tstfsz              WREG
        ;if zero, files are equal = Timed Out !
        goto                wait_loop100
        ;otherwise wait longer

            ;******************
```

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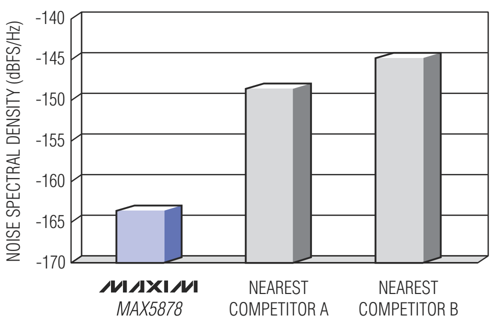

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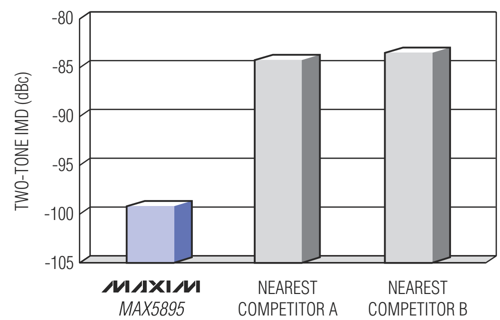

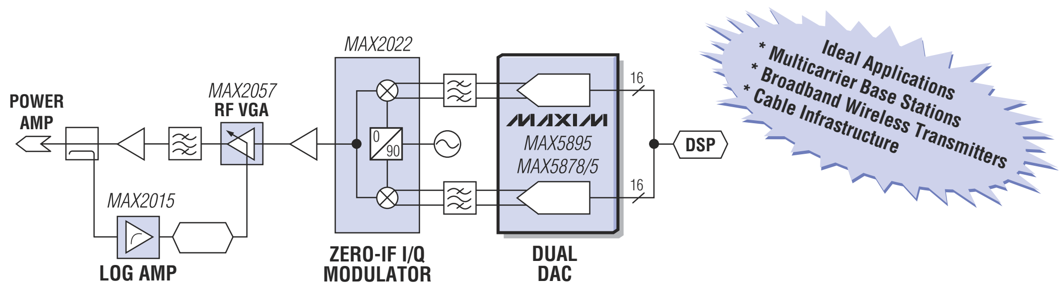

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MAX5875/MAX5874/MAX5873	16/14/12	200	—	—	CMOS

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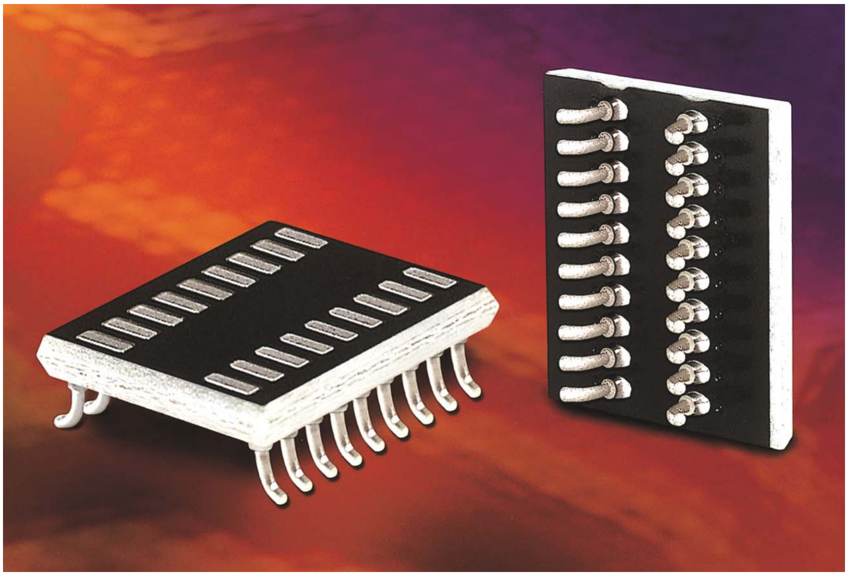

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1. Publication Title: EDN **2.** Publication No.: ISSN 0012-7515 **3.** Filing Date: October 1, 2005 **4.** Issue Frequency: Biweekly **5.** No. of Issues Published Annually: 26 **6.** Annual Subscription Price: U.S. $149.90 CAN $205.90 MEX $195.90 FOR $361.90 **7.** Complete Mailing Address of Known Office of Publication: Reed Business Information, 8878 S. Barrons Blvd., Highlands Ranch, CO 80129-2345 **8.** Complete Mailing Address of Headquarters or General Business Office of the Publisher: Reed Business Information, Division of Reed Elsevier, Inc., 360 Park Avenue South, New York, NY 10010 **9.** Full Names and Complete Mailing Addresses of Publisher, Editor and Managing Editor: Publisher, Stephen Moylan, Reed Business Information, 225 Wyman Street, Waltham, MA 02451; Editor, John Dodge, Reed Business Information, 225 Wyman Street, Waltham, MA 02451; Managing Editor, Kasey Clark, Reed Business Information, 225 Wyman Street, Waltham, MA 02451 **10.** Owner: Reed Business Information, Division of Reed Elsevier, Inc., 360 Park Avenue South, New York, NY 10010 **11.** Known bondholders, mortgagees and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages or other securities: none **12.** Tax Status: Has not changed during preceding 12 months. **13.** Publication Title: EDN **14.** Issue Date for Circulation Data Below: September 29, 2005

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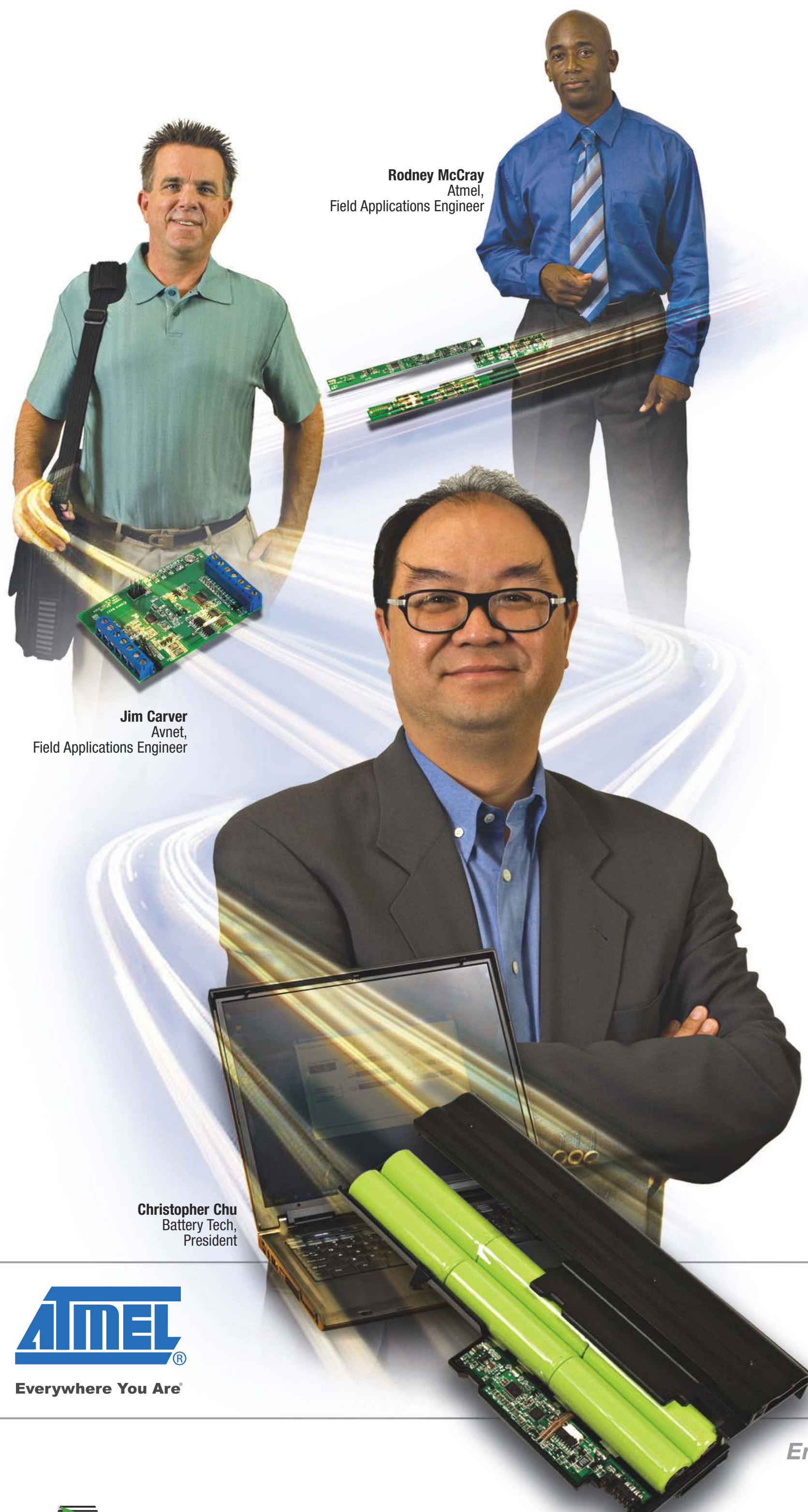

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Semflex Inc, www.semflex.com

Micropitch interfaces come in three submillimeter sizes

Targeting low-profile applications with a 2.31-mm mated height, these 0.5-mm-pitch interface systems are also available for 5-mm board spacing. Suiting applications requiring less density, the 0.635- and 0.8-mm-pitch systems are available with 300 and 240 I/Os, respectively. The micropitch interfaces cost 7 to 35 cents per mated line.
Samtec, www.samtec.com

High-density connector suits differential and single-ended systems

The 14-row version of the high-speed, high-density Ventura connector features 178 single-ended and 93 differential signals per inch. This design uses a standards-compliant, 110- or 12-mil via. Designers can use it in 6.25-Gbps, single-ended and 12-Gbps, differential systems. Crosstalk is less than 5%, and insertion loss is less than 2 dB at 6 GHz and 3 dB at 8 GHz. Differential insertion loss is less than 2 dB at 6 GHz and less than 3 dB at 10 GHz. The Ventura connector costs 18 to 24 cents per mated signal line.
Teradyne Inc, www.teradyne.com/tcs

Category 5e UTP cables find use in rugged environments

The 1304A and 1305A AES (Advanced Encryption Standard)/EBU (Enterprise Backup Utility)-compliant Brilliance CatSnake tactical field-deployable Category 5e UTP (unshielded-twisted-pair) cables feature bonded-pair UTPs. The 24-gauge-AWG, 7×32-stranded cables feature bare-copper conductors and polyolefin insulation. The 1304A has a heavy jacket wall for medium-duty use, and the 1305A has an upjacketed wall for heavy-duty applications. Both cables pass the −40°C bend test per the UL1381 standard.
Belden CDT Inc, www.belden.com

Cable assembly relocates connector jacks off the pc board

Targeting applications in need of higher density, the Octopus network-interface multiconnector cable assembly moves the network-facing connections on the box from full-size or M-BNC jacks on the pc board to a 100-mil center multipin pc-board connector. Each pc-board-mounted latching-ejector header handles 24 coax lines. A 24-cable assembly comes with standard BNC or M-BNC jacks and costs $400 for the 3m version.
Trompeter, www.trompeter.com

Digital megohmmeter combines analog and digital features

The 1860 megohmmeter features an enhanced LCD that presents measurements in digital and analog formats for instant test results and an RS-232C interface for serial-data collection. The device measures the insulation resistance of components and the leakage resistance on capacitors, and it performs resistivity tests on samples of insulating material. It features a 250-kΩ to 20-TΩ resistance-measurement range and a 50, 100, 250, 500, and 1000V-dc test voltage. Additional peripherals include a 2-mA charge current, programmable charging and measurement times, a comparison function with programmable low limits, and a go/no-go display indicator. The device costs $2995, including a NIST-traceable calibration certificate and lead set for connecting to the device under test.

QuadTech Inc, www.quadtech.com

Locking programmable oscillator generates a low-noise sine wave

Based on Analog Devices' AD-9858 1-GHz DDS (direct-digital synthesizer), the Model LPO400A locking programmable oscillator generates a noise sine wave of 200 kHz to 400 MHz and ECL-level clock outputs. The device features a user-programmable output frequency in 1-Hz steps, as well as the programmable phase of the output signal with a 14-bit resolution. With a 3.3V power supply and 2-ppm/year stability, the oscillator targets applications requiring programmable-frequency sources. The LPO400A features a 60×60-mm footprint and costs $395 (100).

Novatech Instruments Inc, www.novatech-instr.com

AWG family features 12-bit resolution

The PCI CompuGen family of ultrafast AWG (arbitrary-waveform-generator) cards has 12-bit resolution. The 11G member of the family features a 1 billion/sec conversion rate with a single channel, the 4300 has a 300 million/sec rate with four channels, and the 8150 has a 150 million/sec rate with eight channels. These waveform-generator and function-generator cards provide aperiodic analog waveforms by creating digital representations of the waveform in the onboard memory of the card. The PCI CompuGen family costs $4495.

Gage Applied Technologies, www.gage-applied.com

Set-top-box MPEG-2 decoders support dual-TV and -DVR applications

Implementing SVP (Secure Video Processor) technology, the STB-5524 and STB5525 set-top-box devices target the DVR (digital-video-reader) market; the 5525 also supports dual-TV and -DVR requirements in standard-definition set-top boxes. Both devices feature a glueless interface to the vendor's demodulator chips, a low-cost SATA interface, two 480-Mbps USB2 ports, and an integrated CPU with a 300-MHz ST231 core. The STB5524 and STB5525 cost $14 and $15 (10,000), respectively.

STMicroelectronics, **www.st.com**

DSP series supports 7.1 channels

The Aureus DA7xx DSPs support 7.1 channels, including AC3 or DTS decoding, Dolby ProLogic IIx or Neo:6 matrix decoding, bass management, and delay, using 22% of available performance of a DA710 processor. The 250-MHz TMS320DA708 comes in a TQFP-144 package and costs $13.52 (10,000); the 300-MHz TMS320DA710 comes in a BGA-256 package and costs $221.63 (10,000).

Texas Instruments, **www.ti.com**

Single-chip H.264 codec requires low power

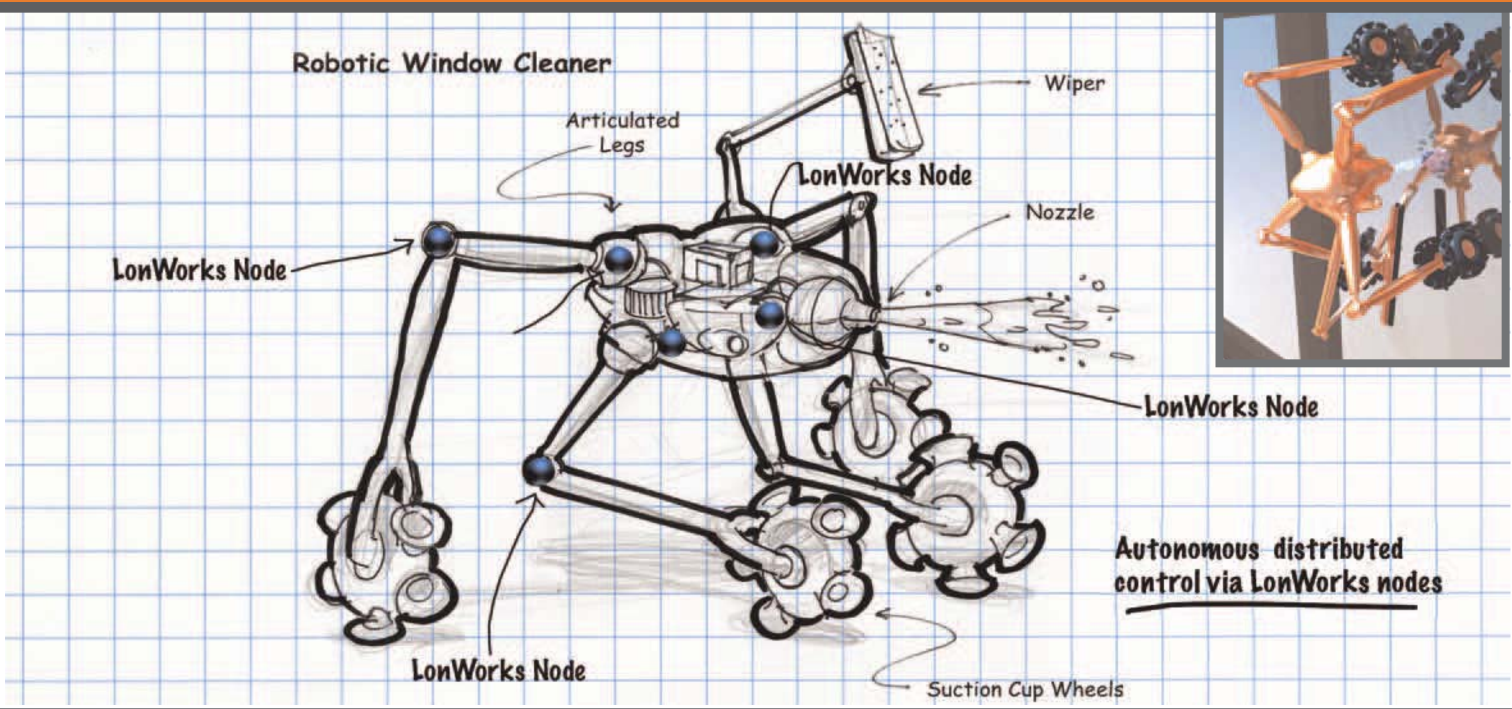
Requiring less than 185 mV of total chip power, the MG1264 single-chip VGA 30 fps H.264 video codec enables two-channel AAC audio encoding. The chip's EVE (enabling-video-everywhere) architecture uses dedicated hardware media-processing engines that are active only when data is processed, a multithread embedded microcontroller with single-cycle context switching, a video preprocessor, a video-processing oriented-memory controller, and a single 16-bit SDRAM. MG1264 samples are currently available and sell for $10.

Mobilygen, **www.mobilygen.com**

Physical-layer port-protection switch targets video systems

For use with the vendor's Hotlink-On-Demand family of video serializers/deserializers, the YLink SMPTE (Society of Motion Picture and Television Engineers) physical-layer port-protection switch provides HD-SDI and SD-SDI point-to-point-communication links. The switch automatically detects the system data rate and identifies protocols, including DVB-ASI. YLink transmitters and YLink-receiver protection switches each connect to a HotLink II transceiver. Available in a BGA-256, the product costs $100 (100).

Cypress Semiconductor Corp, **www.cypress.com**



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realitycheck

YESTERDAY'S HYPE MEETS TODAY'S REALITY

STATS Users at the end of the 90s: several hundred thousand / Remaining users in July 2005: 10,000

Wildfire ignites, then extinguishes

From 1990 through 1995, Massachusetts-based Wildfire Communications developed and marketed the Wildfire telephone-based "virtual assistant," which was the subject of a significant amount of media coverage and numerous favorable—even rave—reviews. Based on voice recognition of a few hundred key words, the device allowed subscribers to call in, ask for their messages, route and forward calls, manage contacts, send faxes, and more. It was a 24-hour-a-day, remotely accessible secretary—admittedly with fewer capabilities—costing $10 to $20 per month per user. By the end of the decade, the system boasted several hundred thousand active users, and the On PR public-relations agency was even taking some of the credit for its success (www.onpr.com/results/case_studies/HowTheEnterprise_Wildfire.asp).

The service was doing so well that, in April 2000, Orange plc (part of France Telecom) purchased Wildfire for €148 million and rolled out service to the United Kingdom, France, and Italy, operating though regional-phone-operating companies. But with the rise and accessibility of e-mail, the Web, cell phones, and other communications modes, Wildfire had just 10,000 remaining users by July 2005, and Orange pulled the plug on the product and service.—by Bill Schweber

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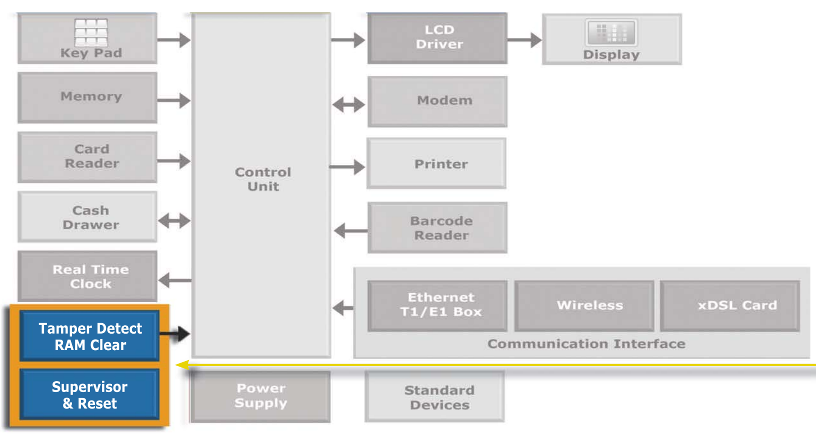

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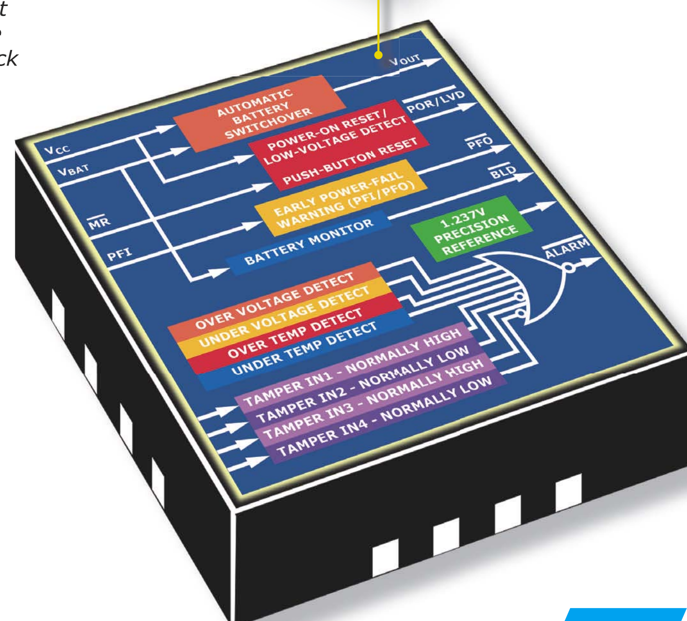

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