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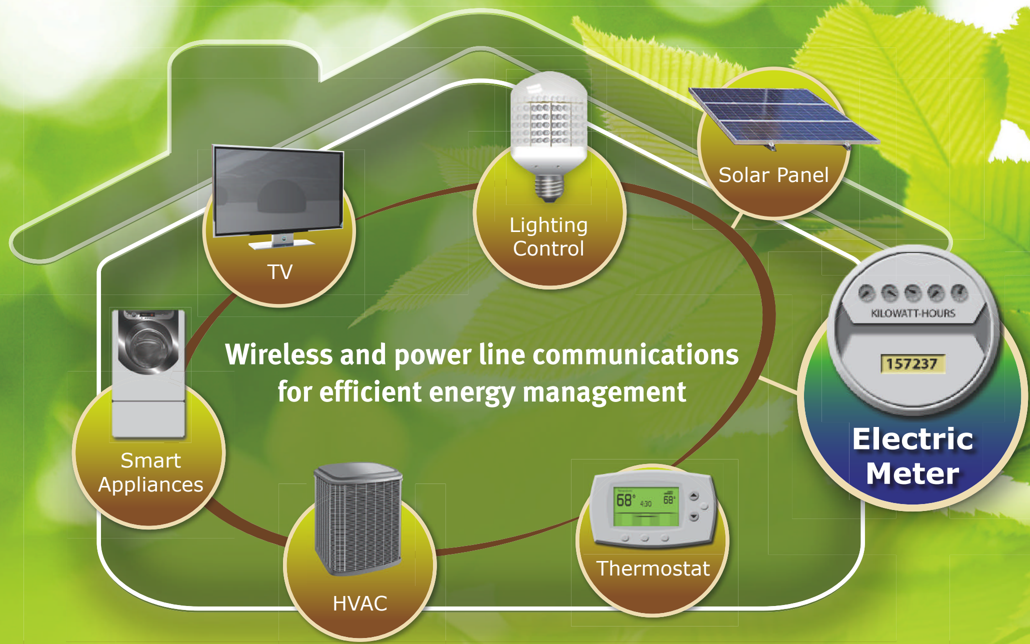

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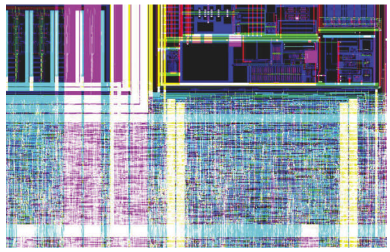

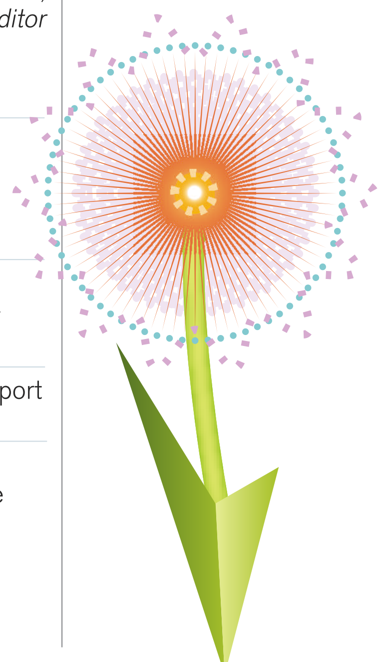

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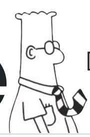

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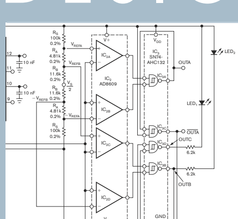

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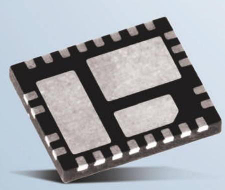

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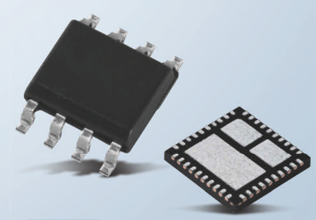

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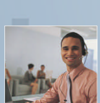

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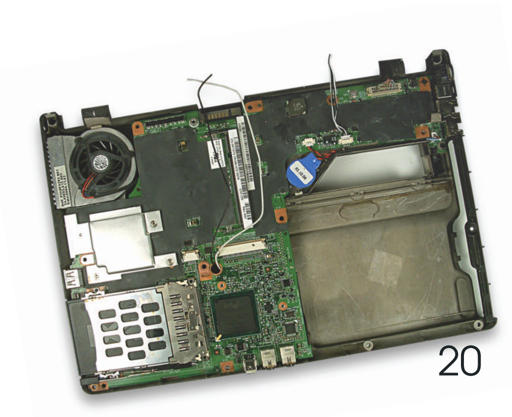

DEPARTMENTS & COLUMNS

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INNOVATION VOTE NOW!

Take a look at pg 35 in this issue to see a list of the innovative engineers and products our editors selected as finalists in the 20th annual *EDN* Innovation Awards. After perusing the candidates, head to the Web to view a write-up of each finalist and help us honor electronic innovation by using the easy electronic ballot to make your voice heard.
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FROM *EDN*'S BLOGS

Cadence Encounter Digital Implementation System 9.1: avoiding incorrect by construction
from Practical Chip Design, by Ron Wilson

One of the most serious problems with design flows for 32- and 28-nm designs, aside from the sheer complexity involved, is what you might think of as a mismatch between the flow and the process.
→www.edn.com/100218toca

Competitive design challenges
from Embedded Processing, by Robert Cravotta

NXP just opened the doors on a competitive design challenge based on its LPC1100 Cortex-M0 processor. The challenge takes place over three phases covering concept, hardware, and prototype.
→www.edn.com/100218tocb

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BY RICK NELSON, EDITOR-IN-CHIEF

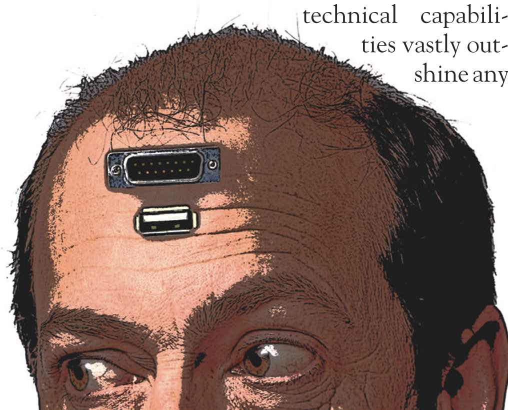
McGwire, Pistorius, Montag, and you

So, what do you think about Mark McGwire's finally coming clean and admitting to steroid use? What about Oscar Pistorius, a double-amputee sprinter with carbon-fiber prosthetic feet: Should he have been denied a chance to compete in the Olympics? What about Heidi Montag? Is it exemplary that she has undergone 10 plastic surgeries in one day in an effort to excel at her profession as an entertainer? And what about you? Are you going to have the augmentation it will take to compete in the 21st-century job market?

You might be wondering what McGwire, Pistorius, and Montag have to do with you. Perhaps McGwire and Pistorius don't have much to do with you, assuming that you aren't into hitting home runs or sprinting competitively. So maybe you can forgo the chemical steroids and mechanical prosthetic limbs. What about Montag, though? Various studies suggest that supposedly attractive people are more successful in their careers, even though they don't aspire to be stars of the screen or stage.

Here is some advice from the Institute of Cosmetic Surgery (**Reference 1**): "In today's extremely competitive business world, men wear their résumés on their faces. Being qualified isn't enough anymore. You have to look qualified, too."

Perhaps you believe that your technical capabilities vastly outshine any shortcomings on how qualified you might superficially look. Various drugs that alleviate the need for sleep have long been available, however. Suppose that a prospective employer required that you, as a condition of employment, take such medications and work 80 hours or more per week.



Such examples only scratch the surface of the forthcoming age of augmentation, according to futurist Scott Klososky, speaking at the annual Automated Imaging Association Business Conference last month in Orlando, FL. Klososky traced the history of technology's augmentation of human capabilities from mechanical cash registers' handling of basic arithmetic to the Internet's support of sharing data. He eschewed the term "artificial intelligence," saying it implied fake intelligence, in favor of the term "augmented intelligence." Augmented intelligence, Klososky said, captures rules-based systems from the human brain and implements them in code that, for example, supports the self-learning text-processing system that the Apple iPhone uses. He outlined applications for augmented intelligence in which, for example, an augmented-intelligence system could interview a psychiatric patient by phone and detect symptoms of depression.

Klososky said that augmented reality will follow. In this scenario, heads-up visor displays will augment what you are seeing with additional information—perhaps the forgotten name of a person you have met. He described the layered Internet as a "paraverse" in which an individual's avatar participates in various parallel universes. He also described virtual meeting rooms populated by such avatars, who don't sit stone-faced but rather acquire attributes that indicate their agreement or disagreement with various points that arose during the meeting.

What we really need, Klososky said, is an updated human-to-machine interface. The QWERTY keyboard originating with the typewriter is hopelessly outdated, despite efforts to deploy laser projections of its layout. He suggested that a true brain-to-computer interface will replace the keyboard and that this neuroaugmentation will work at the speed of thought.

Are you ready for an implanted USB-like port that allows you to move beyond the keyboard and instantaneously download into your brain French 3.0 or the latest academic papers and competitive information related to your job? Klososky suggested that the first question at your next job interview might be, "What augmentation do you have?" If you answer, "Nothing, I'm natural," the interviewer will most likely say, "Next!" EDN

REFERENCE

1 Tarshis, Lorne M, MD, "Male Cosmetic Surgery/Cosmetic Surgery for Men," www.cosmeticscanada.com/male-cosmetic-surgery.html.

+ Go to www.edn.com/100218ed and click on Feedback Loop to post a comment on this column.

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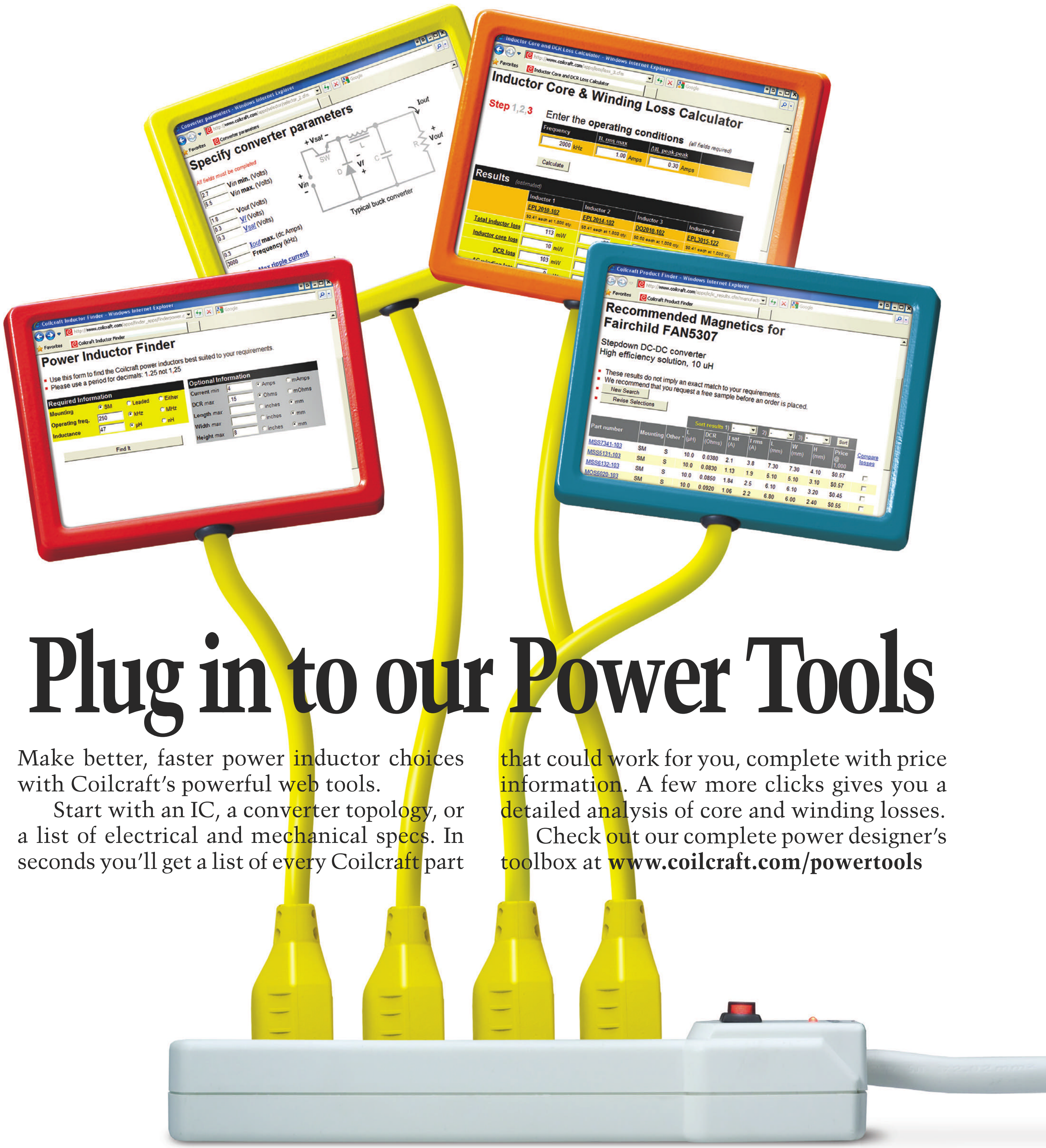
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Reed Electronics Group

Accurate, handheld, 4- and 6-GHz, two-port VNAs integrate calibration

Agilent Technologies' new N9923A FieldFox 2-MHz to 4- and 6-GHz RF VNAs (vector network analyzers) have 0.01-dB/°C measurement stability, the industry's best, according to the manufacturer. The instruments also integrate the QuickCal VNA-calibration capability, which enables consistent measurement results, providing confidence in the data and eliminating the need to carry a calibration kit into the field.

The units expand the manufacturer's handheld-instrument portfolio and aim at factory and field engineers who characterize or troubleshoot RF components for mission-critical applications in aerospace, defense, and network-equipment manufacturing. As full two-port network analyzers, the instruments allow operators to simultaneously measure and display all four S (scattering) parameters. The instruments provide more network-analysis capability than that of the previously announced N9912A FieldFox RF analyzer, which addresses requirements in wireless-system installation and maintenance. Each instrument weighs less than 6.2 lbs.

Calibration is critical in any VNA. Traditional methods can be problematic, especially in the field, because calibration protocols require kits and hardware accessories that users must not only carry into the field but also maintain. QuickCal addresses these annoyances by replacing the external items with internal components. Operators can perform calibration in seconds, quickly and easily eliminating measurement errors.

Another challenge with many portable instruments is measurement stability over temperature. Although not an issue in temperature-controlled office environments, stability can pose problems in the large temperature variations that are common outside. The rugged, weather-resistant units have no fans or vents and are, according to Agilent, the only handheld network analyzers that meet or exceed military performance 28800F Class 2.

Additional features include a dynamic range of 100 dB, which enables accurate measurements of high-rejection filters; cable and antenna test for distance to fault, return loss, and voltage-standing-wave ratio; one- and two-channel vector voltmeters; power-meter measurements to 24 GHz with a USB (Universal Serial Bus) power sensor; and a bright, wide-angle display. US prices start at $12,000.

—by Dan Strassberg

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

Weighing less than 6.2 lbs, the FieldFox 4- and 6-GHz, two-port VNAs boast a novel internal calibration system and 0.01-dB/°C measurement stability.

FEEDBACK LOOP

"I can stop thinking about periodic round trips to the charger and simply focus on building the robot."

—Programmer Meredith Poor, in *EDN*'s Feedback Loop, at www.edn.com/article/CA6715767. Add your comments.

Novel e-paper personalizes electronic devices

Philips' technology allows users to build different colors of ink into one layer and to control each color separately.

Philips Research claims to have developed a color-e-paper technology that allows for personalization of electronic devices and has the potential for use in future large "e-wallpapers," allowing users to adjust the color of a wall or smart window. According to Philips, its technology allows users to build colors of ink into one layer with separate control of each color. This approach allows a layer to be transparent, the same color as any one of the inks, or a mixture of multiple colors. Users can accurately control the saturation of each color in its e-paper so that they can produce any shade. Philips uses this technique to create "e-skin," a less complicated and less expensive technology than paper that uses ambient light for energy efficiency and for application in portable devices.

"The first applications using the technology could be e-skins for small devices, such as MP3 players or cell phones," says Kars-Michiel Lenssen, principal scientist at Philips Research. "However, the technology is highly scalable. In the future, it will be possible to use e-skins to bring new color and a new aura or 'vibe' to much larger equipment." A large e-skin could make the concept useful for MRI (magnetic-resonance-imaging) or CT (computer-tomography) scanners, potentially putting patients at ease, he adds. In ambience-creation applications, reflective e-skins complement the emissive ambience-creation technologies that use LEDs (light-emitting diodes) and OLEDs (organic LEDs) to create colorful light. "You could use LEDs or OLEDs when you want a theatrical look and e-skins when you want something more subtle and more natural-looking that uses less energy," Lenssen says.

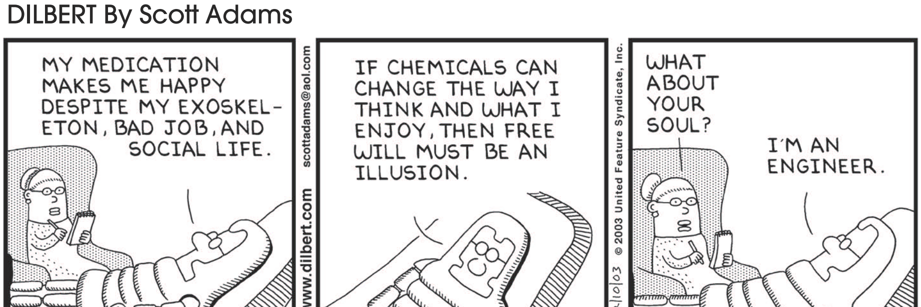
Philips based its e-skin technology on its previous work with e-paper. Because the particles in suspension carry a surface charge, you can control their motion using an electric field, or electrophoresis. When you create a pixel with colored particles in a clear suspension, applying an electric field perpendicular to the surface makes the particles migrate to the top of the pixel, turning it dark and serving as the basis of the monochrome e-paper that e-book readers use. The e-skin technology features a gradient of gray levels from a highly transparent optical state to full black to allow future applications, such as smart windows.

To go from monochrome to polychrome, Philips uses in-plane electrophoresis, which applies the field parallel to the surface. This approach causes the colored particles to spread across the pixel, again turning it dark. When you reset the pixel, the colored particles hide behind a mask, so the pixel is completely transparent. Philips builds a gate electrode into each pixel, which provides control over how many colored particles spread across the pixel and the saturation or shade of each color. Philips is open to licensing its technology to other parties in other applications, such as e-paper displays.

—by Suzanne Deffree

▷**Philips Research**, www.research.philips.com.

DILBERT By Scott Adams



Studio Suite 2010 addresses EM, mechanical, and thermal problems

With the introduction of CST (Computer Simulation Technology) Studio Suite 2010, CST aims to help engineers and researchers solve EM (electromagnetic), mechanical, and thermal problems within an integrated design environment. The new version offers an extended range of solvers within one design environment, enabling you to analyze a variety of applications without leaving the familiar CST interface. It features a new asymptotic solver, which the company based on the shooting-bouncing-ray method, an extension of physical optics, and can tackle simulations with an electric size of many thousands of wavelengths, thereby addressing applications such as radar-cross-section analysis.

The CST MWS (Microwave Studio) frequency-domain solver, which featured true geometry adaptation with Version 2009, now includes third- and mixed-order elements to further increase simulation efficiency and speed. The frequency-domain solver is also the first solver to feature CST's new sensitivity-analysis approach.

The new version also includes the flagship CST MWS time-domain solver, which incorporates functional enhancements, such as arbitrary-order dispersive-material modeling and domain decomposition, in support of cluster, distributed, and GPU (graphics-processing-unit) computing. The CST Microstripes 3-D EM-simulation tool serves engineers working on EMC (electromagnetic compatibility). The integration provides features valuable in EMC simulations. For more on Studio Suite 2010, go to www.edn.com/100218pa.**—by Rick Nelson**

▷**CST**, www.cst.com.

PROGRAMMABLE DIFFERENTIAL ATTENUATOR FINDS USE IN AUDIO PREAMPLIFIERS

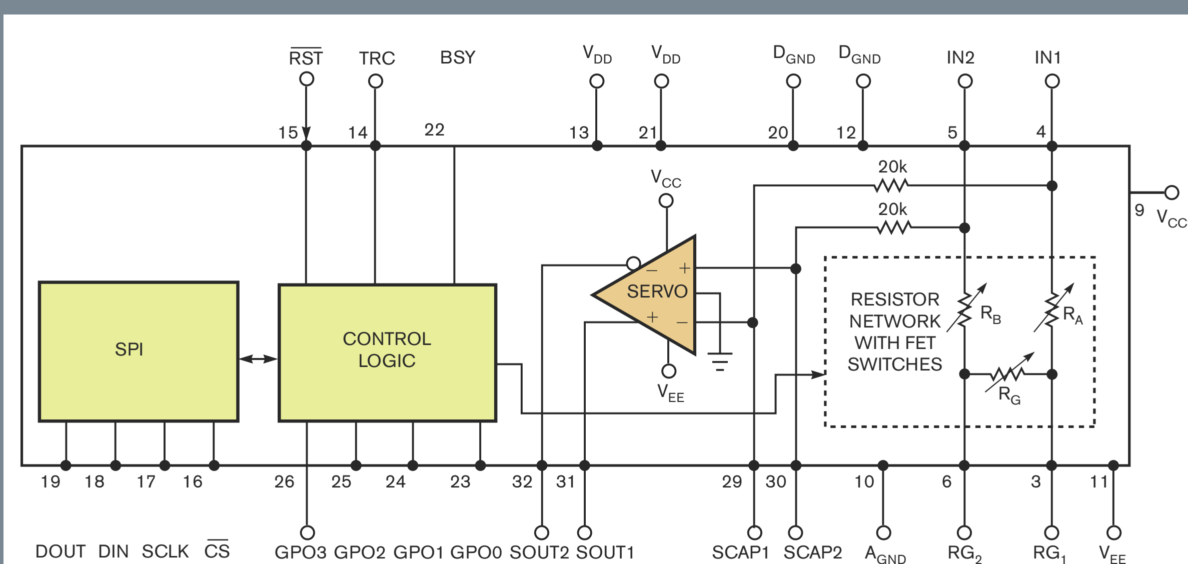
That Corp recently announced the That5171 SPI (serial-peripheral-interface)-controlled digital attenuator. The fully differential device serves as part of a differential audio-signal path. You can set gain in 1-dB steps. The part is compatible with the 1570 current-feedback, differential audio preamplifier.

The IC operates from ±5 to ±17V supplies. It supports input-signal levels as high as 22 dBu (decibels unloaded). That guarantees the gain error at a maximum of ±0.5 dB. To reduce "zipper noise," the sound from digital stepping of gain, the 5171 has a zero-crossing detector that prevents the part from changing gain until the signal is within 5% of 0V. The product also features a differential servo amplifier that you can set up as an integrator to reduce dc offsets to less than 1.5 mV.

You control the 5171 using an addressable SPI port and use the four general-purpose, 3.3V digital outputs to control input pads, analog switches, mute circuits, and LEDs. The SPI bus supports read-back so that your host software can verify proper operation.

Applications include microphone preamplifiers, digitally controlled instrumentation amplifiers, digitally controlled differential amplifiers, and digitally controlled audio instrumentation. The 5171 comes in a 7×7-mm QFN package, sells for $6.70 (1000), and operates in the −40 to +85°C range.—by Paul Rako

▶**That Corp, www.thatcorp.com.**



You can use the That5171 differential attenuator in high-performance microphone-preamplifier signal paths.

High-speed synchronous N-channel-MOSFET driver has powerful gate drive

Linear Technology's new high-speed LTC4449 synchronous MOSFET driver drives upper and lower power N-channel MOSFETs in a synchronous rectified-converter topology. This driver combines with a Linear Technology dc/dc controller and a power FET to form a complete high-efficiency synchronous regulator that can serve as a step-down or step-up dc/dc converter.

The LTC4449 drives MOSFET gates over a range of 4 to 6.5V and operates from a supply voltage as high as 38V. The driver sinks as much as 4.5A and sources as much as 3.2A, making it ideal for driving high-gate-capacitance and high-current MOSFETs. It can also drive multiple MOSFETs in parallel for higher-current applications.

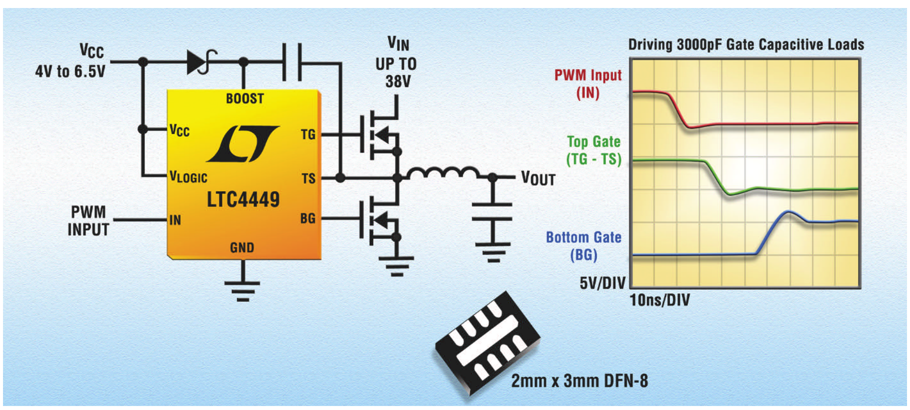
The top MOSFET has rise and fall times of 8 and 7 nsec, respectively, and the bottom MOSFET has rise and fall times of 7 and 4 nsec, respectively, when driving a 3000-pF load, minimizing switching losses. The driver integrates adaptive shoot-through protection to prevent the upper and lower MOSFETs from conducting simultaneously and to minimize dead time.

The LTC4449 features a three-state PWM (pulse-width-modulation) input for power-stage control and shutdown that is compatible with all multiphase controllers employing a three-state-output feature. The device has a separate supply for the input logic to match the signal swing of the controller IC, as well as an undervoltage-lockout circuit on both the driver and the logic supplies.

The LTC4449EDCB is available in a 2×3-mm DFN-8 package for prices starting at $1.25 (1000). The industrial-grade version, LTC4449IDCB, operates over a −40 to +125°C operating junction-temperature range and sells for $1.39 (1000).

—by Fran Granville

▷**Linear Technology Corp**, www.linear.com.



The LTC4449 MOSFET driver gates over a range of 4 to 6.5V and operates from a supply voltage as high as 38V.

MENTOR ADDS SYSTEMC SUPPORT TO CATAPULT C

Mentor Graphics has continued to expand the reach of its product with its core Catapult C synthesis engine. In December, the company added support for control-logic synthesis and some level of power management. The company has now taken another step, adding a preprocessor that makes SystemC code into a form that the Catapult C engine can use.

For some people, SystemC is a way to document and explore systems at the transaction level. For some, it is a cycle-accurate tool for creating test benches. For still others, it's the first stage in synthesizing an actual design. Each of these users employs a different subset of the language and uses code in a different way. In an attempt to please almost all of these users, the tool handles abstract, untimed C++ code, TLM (transaction-level-modeling) 2.0-compliant SystemC, and cycle-accurate SystemC, employing, for example, the wait construct, according to Shawn McCloud, product-line director at the company.

Mentor is emphasizing the accurate representation and synthesis of complex bus interfaces and, in some instances, on-chip interconnect. The ability to generate production-quality RTL (register-transfer-level) logic from SystemC representations of these structures combines with Catapult C's ability to generate useful RTL logic for functional blocks to bring the tool closer to the goal of digital full-chip synthesis.

Accordingly, Mentor provides SystemC creation and simulation in Vista, including lint, coverage, and runtime-checking tools. After synthesis, Catapult generates insertions into your RTL to assist in Questa RTL debugging. You can also synthesize much of your SystemC test bench and reuse it at RTL.

HLL (high-level-language)-synthesis tools are increasingly addressing the full range of needs of a design team at both the block and the full-chip levels. But even as HLL tools improve, the design community continues to increase its reliance on IP (intellectual-property) blocks and IP-integration methods. The long-term importance of these tools may lie in their ability to describe, model, and refine an assembly of IP rather than their ability to create a chip from a sheet of paper.—by Ron Wilson

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

02.18.10

Rarely Asked Questions

Strange stories from the call logs of Analog Devices

Don't be Mean - be Root Mean Square!

Q. How do you measure a varying signal?

A. Very carefully! Archimedes had to measure gold in a crown; measuring arbitrary waveforms is even tougher.

The simplest measure of a varying signal is its mean or average value over some time interval, but this can be misleading. Suppose that we have a square wave with a 1:1 mark-space ratio and 1 V peak-to-peak amplitude. What is its mean value?

With a positive peak of +1 V and a negative peak of 0 V, the mean value is 0.5 V. With a positive peak of 0.5 V and a negative peak of –0.5 V, the mean is 0V. If this signal were applied to a resistor, however, it would get warm; this would not happen with a steady 0-V signal.

So perhaps we should disregard the polarity for power purposes? If, in the second case above, we removed the sign or polarity before taking the mean, then the "mean absolute" value would be 0.5 V just like the first case. But if we applied these two signals to the same resistor, it will get much warmer with the first signal than with the second, so the mean value of a varying voltage or current does not tell us enough about its heating effects. DC, sine waves, square waves, sawtooths, and gaussian noise with the same mean voltage have very different heating effects.

This is because the power in a resistive load is proportional to the square of the applied voltage. In fact, the measure we need is the Root Mean Square or rms value of the varying signal. This is the square root of the mean value of the square of the signal. We could get very mathematical here, but there is no need. Although it is possible to use analog-to-digital conversion and high-speed digital signal processing (DSP) to obtain the rms value of a varying signal, the same job can be done more accurately with a simple analog circuit using multipliers and op-amps—easily built but even more easily (and cheaply) bought as an IC.

Such rms-to-dc converter ICs are a convincing example of signal processing that is still more effective with analog rather than digital technology. Analog rms-to-dc converters use less power and board space than their DSP counterparts, and are available for use at LF or at RF up to almost 10 GHz, where DSP cannot yet work at all. Their architectures and performance are described in the linked articles.

To Learn More About Measuring Varying Signals
http://designnews.hotims.com/27736-101

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

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

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Mansour Izadinia: spreading analog expertise

IDT (Integrated Device Technology) recently hired Mansour Izadinia as senior vice president of the analog and power group, signaling the company's growing emphasis on analog and mixed-signal products. He has seven patents in the analog field and has authored several articles on the subject. *EDN* recently interviewed him. A portion of that discussion follows. To read more, go to www.edn.com/100218pb.

How do you think product definition should work in an analog semiconductor company?

A You didn't really need an equipment expert 20 years ago. An op amp is so general-purpose that it would compete on parameters and specs. As systems got more complex and integration took hold, we needed to have people who exactly understand the end-customer system. Sometimes, our customers don't understand their own subsystems. Many companies don't have power-management experts, yet power management is critical to the performance of their end products. There lies an opportunity for us to bring that expertise and use it to come up with differentiated products. We alleviate our customers' headaches. In the future, customers won't really care what an IC does as long as it solves their entire problem.

Apple shows this approach. If you buy an iPhone, it takes you 10 minutes to know how to use it. It's exactly the same with chips and ICs. If you handed a 300-page data sheet to a customer, they don't have the time and sometimes not even the expertise to be able to read it. Ease of use also applies to ICs. To do that, we need to have elegance in product definition. We need product definition that's targeted, that's specific, and that solves the problem with the least amount of headache.

When a customer calls us and wants to use our product, we need to have experts in product definition who can go in and solve the problem in the shortest amount of time. That service is what differentiates our products. Ted [Tewksbury, IDT's president and chief executive officer] has put an emphasis on this issue. We've been bringing that end-equipment expertise into IDT.

Some companies call [this person] a product definer. Some companies call him a system architect. Some companies call him a marketing person. Some companies call him a field-application engineer. It doesn't matter what title you give that person. You've got to have a person who has the system knowledge of your customer and who can bring a value to your customer. No customer ever wants to talk to a salesman or a field-application engineer

who doesn't understand his problems.

So, do you view your customers' jobs as opportunities?

A Absolutely. We have to bring value to a meeting. We want to solve this problem that you have. We want to exactly understand that problem. That differentiates companies and drives sales. It's not just an IC design anymore. It used to be that you would execute on a product specification. If you came up with a lower offset voltage on an op amp, you would win the business. It's not that way anymore. The world has become so complex and systems have become so complex. The end equipment may have one or two ICs inside. The whole thing is integrated. That guy who understands how to apply that IC is the one who wins the business.

Smartphones have lots of analog and power-management content. Is that the kind of business you want to do?

A At IDT, we have a diverse set of technologies that apply not just to smartphones but also to e-books and display applications. We have a whole bag of technologies available to us. I think mobile computing is important. I can't speculate on whether it's smartphones, e-books, or other audio and video handheld devices.

Your knowledge of process seems to play well serving an entire system. Can you comment on that aspect?

A We're going to be looking at all these system pieces at IDT. In the front end, we look to provide RF devices. On the back end, we are looking at providing the power-amplifier devices. It's not an issue of whether we need to have analog, digital, or DSP capabilities. It's an issue of providing tools for a complete system. I don't think that any company has a choice in being an analog supplier or a mixed-signal supplier or a digital supplier. You have to have this bag of tricks.

What is your attitude about fabless versus captive-fab operation?

A We need certain technologies to be differentiated from our competition and to provide special value to a customer. We don't need to have a fab to have those differentiated technologies. So, whether or not you own a fabrication facility, I think it's immaterial. We can develop specialized process technologies within any of the captive foundries.

Could you comment on IDT's broad spectrum of part types?

A Ted has a vision that you've got to have these foundations—these pillars that we put in place now to invest for the future. Touch technology is going to be a must. Audio is going to be a must. If you look at what IDT has been doing, we've been putting in place all these technologies that we think are needed for the next 10 years. **—interview conducted and edited by Paul Rako**

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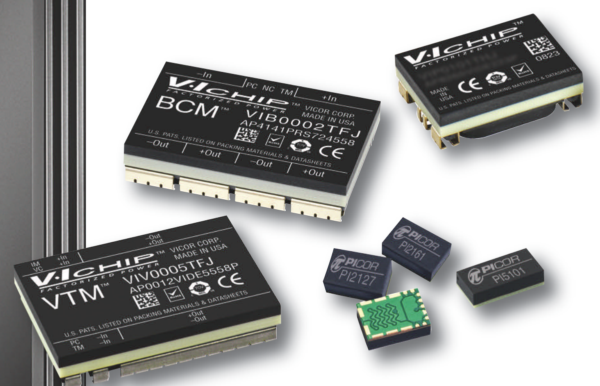

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BY BONNIE BAKER

From high to low frequencies with IBIS

One challenge that high-speed-digital-system designers have is tackling overshoot, undershoot, mismatched-impedance ringing, jitter distribution, and crosstalk problems on their PCBs (printed-circuit boards). These problems fall into the category of signal integrity. Many high-speed-system designers use the IBIS (input/output-buffer-information-specification) modeling language to anticipate and solve signal-integrity problems. This modeling language has been around since the early 1990s and has evolved into a formal standard: EIA-ANSI 656-B (www.eigroup.org/ibis). This standard is alive and well, and the IBIS consortium released Version 5 in August 2008. IBIS uses I-V (current-to-voltage) and V-t (voltage-to-time) data tables to describe a device's I/O-pin characteristics. Manufacturers generate these tables by simulating or measuring their devices' I/O cells.

This type of simulation tool is necessary for high-speed designs that are now stretching up to clock rates of 20 Gbps. The simulation times for IBIS are considerably shorter than those of Spice, and the results are equally accurate. It takes days or weeks for a large PCB system to complete a transistor-level Spice simulation, whereas an IBIS simulation takes minutes or hours to execute. From an IBIS simulation, you can generate transmission-line responses and eye diagrams.

Customers are now asking for IBIS support with lower-frequency devices, with clocks that operate at frequencies lower than 40 MHz. Even at the lower frequencies, digital-signal edge rates cause signal-integrity issues. These fast edge rates can be responsible for clock signals that ring, causing a misinterpretation of a command or even an unexpected gain of two from an ADC. IC manufacturers have sophisticated analog Spice macro models for precision devices, but they are just catching up with the IBIS digital-I/O-model library. **Figure 1** illustrates an example in which an IBIS-model simulation would be useful.

In this circuit, the designer has not paid attention to line impedances. The **figure** shows the measured results at an ADC in the system. The ADC and processor reside on their respective boards, and the designer simply connected the two boards together through 1m Category 5 twisted-pair cables. The frequency of the clock signal from the processor is 2.25 MHz (CH3). The ADC uses this signal to synchronize the transmission of data back to the processor (CH2).

Initially, the designer thought that the low clock speed between these two devices would not cause termination problems. However, the termination used in this circuit creates signals that exceed high and low thresholds, causing ringing and degraded eye diagrams. IBIS simulations to the rescue! Save time and reduce costs. Identify problem digital circuits before turning your circuit into hardware. EDN

Figure 1 An IBIS simulation would be useful in this example, in which the clock- and data-signal-termination method creates signals that exceed specified high- and low-level thresholds. See the online version of this article at www.edn.com/100218bb for a block diagram of the system.

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

For a list of references, go to www.edn.com/100218bb.


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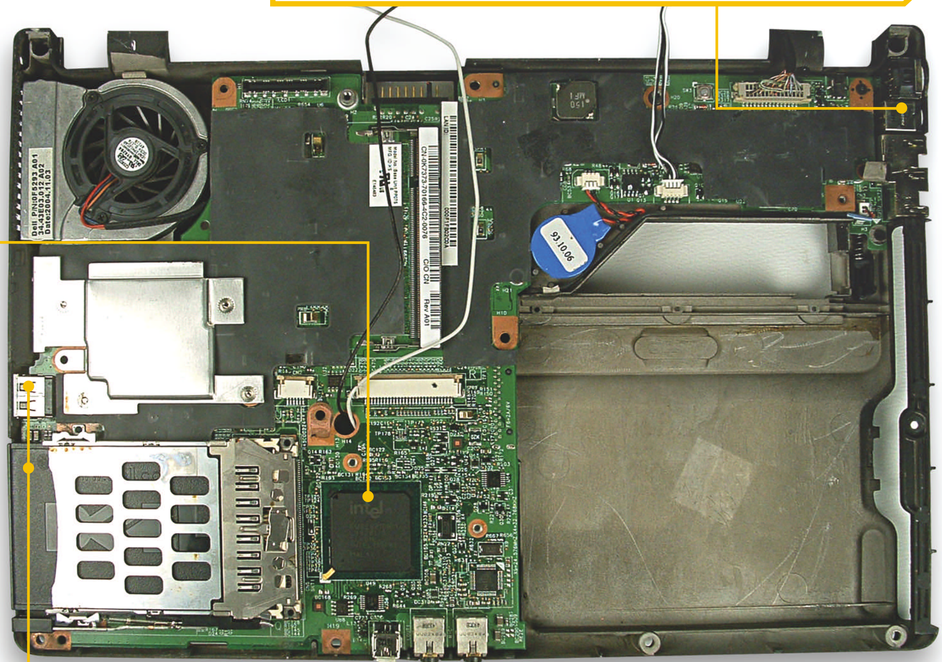
Prying—not crying—out the wine

Take one no-longer-manufactured but still perfectly good laptop. Add one dog chasing one cat. Top it all off with one half-filled glass of Merlot. What do you have? My latest Prying Eyes project (see "Felines, fluids, and laptops: a potent fusion," www.edn.com/blog/400000040/post/1950031395.html). How did Dell squeeze such an abundant number of functions, including an optical drive, into a svelte, 12.1-in., wide-screen-LCD form factor that is only 1.5 in. thick and weighs a shade more than 4 lbs?

A mini-PCI (peripheral-component-interconnect) connector provides the means by which Wi-Fi support appends to the Inspiron 700m. This system configuration employs a Broadcom BCM94318 transceiver; Dell also optionally shipped the Inspiron 700m with Intel-sourced 80.11g connectivity. Broadcom's BCM440x IC supports 10/100-Mbps wired-Ethernet services. The system even includes a rarely seen nowadays 56-kbps analog modem. For external-display connectivity, Dell supplies VGA and S-Video-connector options.

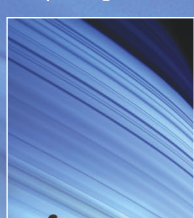
A second-generation, 1.6-GHz Pentium M 725 Dothan processor, which Intel fabricated on a 90-nm lithography process, powers this Inspiron 700m. The processor has a 2-Mbyte L2 cache and mates to the first-generation 855GME core-logic chip set. The Pentium M CPU was a much-needed mobile success story for Intel after its mostly underwhelming NetBurst predecessor, and the Pentium M's power-optimized microarchitecture influence subsequently spread throughout the company's product line.



The Inspiron 700m does not embed Bluetooth capabilities; dual USB (Universal Serial Bus) 2 ports provide one means of augmentation, and industrious hackers have also figured out how to internally embed this feature by tapping into USB. The system also supports IEEE 1394, or Firewire, along with module-based peripheral expansion through PC Card and SD (secure-digital) Card slots. ExpressCard slots now supersede PC cards.

Dual SODIMM (small-outline dual inline-memory-module) slots—one under the keyboard and the other on the bottom of the system—each accept as much as 1 Gbyte of DDR333 PC2700 SDRAM. The 2 Gbytes of aggregate maximum system memory is sufficient for Windows XP and Linux, but Windows Vista and Windows 7 would find it lacking.

The Inspiron 700m employs the now-obsolete PATA (parallel-advanced-technology-attachment) interface for both the hard-disk drive and rewritable-DVD drive. The performance gap between PATA and more modern SATA (serial ATA) is largely evident only when doing burst transfers into and out of the drives' RAM buffers. Nonetheless, the simplified cabling topology that SATA's few-wire interface incurs is particularly attractive in cramped-quarters designs. Although its Merlot bath caused the system to fail, its hard drive was intact, and, by removing it and installing it in a USB2 enclosure, I was subsequently able to recover all of its data.

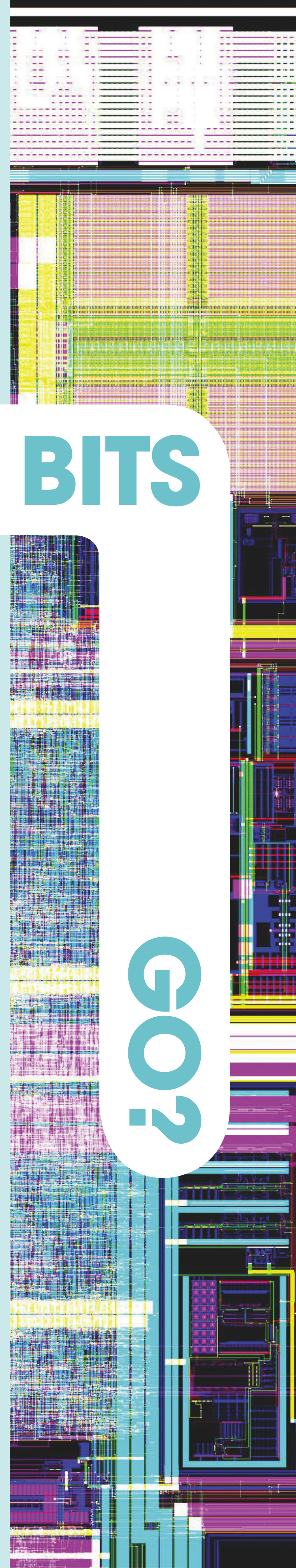


Saturn's northern latitudes and the moon Mimas. Image from the Cassini-Huygens mission.

AS 32-BIT PROCESSORS APPROACH PRICE PARITY WITH 8-BIT PROCESSORS, WILL THAT PARITY CHANGE THE MARKET FOR 8-BIT PROCESSORS?

BY ROBERT CRAVOTTA • TECHNICAL EDITOR

HOW LOW CAN 32 BITS GO?



Moore's Law observes that the number of transistors doubles for the same area every two years. The relentless fulfillment of this observation has been the rallying point for those who predict that 32-bit processors will replace 8-bit processors. The argument starts with the fact that the relative size difference between an 8- and a 32-bit-processor core approaches zero compared with the other resources on the chip as the transistor geometry continues to shrink (**Figure 1**). As the difference in the silicon area of 8- and 32-bit cores shrinks to nothing, 8-bit processors lose the price advantage that they once enjoyed.

In 2004, 32-bit processors hit a pricing milestone when Philips, now NXP, and Atmel offered ARM7 processors with 8-bit features, such as atomic bit manipulation and brownout-detection circuits, for as little as $3. However, providing a low-cost processor does not change the evaluation process; other considerations also matter in a designer's choice of processor. Although this price point brought 32-bit processors into consideration for a new set of applications, it did not spell the end of the market for 8-bit processors (**Reference 1**).

In 2006, Luminary Micro, now Texas Instruments, opened its doors for business with a 32-bit ARM Cortex-M3 microcontroller that sold for less than $1. At this price, 16-bit processors would surely feel some pressure. Once again, price is only one advantage that the smaller processors have. Like 8-bit processors, 16-bit processors have a class of applications to which they deliver just enough performance at the best price and power-consumption level, making it difficult for general-purpose 32-bit architectures to compete (**Reference 2**).

In late 2009, NXP rolled out an ARM Cortex-M0 processor that sells for 65 cents. This price places this device squarely in pricing competition with 8-bit processors. The lowest public pricing information puts 8-bit processors at 45 cents to $10 per device (**Reference 3**). As people predicted, the difference in pricing between 32- and 8-bit processors is trending toward zero.

A few other things make this new pricing milestone with the Cortex-M0 a little more interesting, however, and worthy of a deeper look. The Cortex-M0 has replaced the Cortex-

M3 as ARM's smallest, lowest-power, and most energy-efficient 32-bit-processor core to date, whereas the M3 is the clear migration target from the M0. Designers can implement the M0 core in as few as 12,000 gates. As a result, the M0 implements a substantially smaller subset of the 16-bit Thumb2 instruction-set architecture that the M3 fully supports (**Figure 2**). ARM based the subset on the statistical frequency of the most commonly used Thumb2 instructions. The loss of function of the constrained instruction set is that the system must use multiple instructions to perform what a single instruction in the full Thumb2 instruction set could do.

NXP claims that the code density of its M0 processor is better than the code density of the 8- and 16-bit processors on the market. Code density can be a loose proxy for processing performance; smaller code for the same function might correlate with fewer memory fetches and faster execution for the same task. There might also be a loose correlation to a lower energy budget for systems that switch between sleep and active modes. The faster system might consume more power, but it may also require less energy to perform the same task as the slower system because the faster processor can go back to sleep sooner. So there are some technical issues that bear investigation with regard to M0 and smaller processors.

AT A GLANCE

- More processor vendors than ever before are straddling 8-, 16-, and 32-bit-processor offerings.
- The expansion of low-end 32-bit-processor offerings may indicate an inflection point in the embedded-processing market.
- Even when a benchmark tries to cover differences in architecture sizes, you need to understand the target to make sure your benchmark tests are appropriate.
- The 8- and 16-bit processors can meet price and energy thresholds years before 32-bit processors can meet those same thresholds.

INFLECTION POINT?

Another reason to explore how low 32-bit processors can go is that ARM claims that the Cortex-M0 has the fastest adoption rate of any of the company's processor cores. ARM also claims that half of its M0 licensees are new to ARM, with a strong implication that those vendors were traditionally serving the 8- and 16-bit-application areas. The public list of licensees lists only NXP, Triad Semiconductor, and Melfas from a list of at least 15 licensees, so it is hard to draw any conclusions. However, considering ARM's statements, the Cortex-M0 may have crossed a key threshold, and its adoption by so many new licensees may signal an inflection point in the market serving 8-, 16-, and low-end 32-bit applications.

In addition to processor vendors' rolling out smaller and lower-priced 32-bit processors, some traditional 8- and 16-bit-processor vendors have rolled out their own 32-bit products. Microchip in 2007 added the 32-bit, MIPS-based PIC32 processor to its line of more than 650 PIC processors. The PIC32 uses the same development tool set as the 8- and 16-bit devices, and the Explorer 16 platform hosts the processor because the platform maintains the software, peripheral, and pin compatibility that the 16-bit processors supported on that same platform.

In 2009, Cypress Semiconductor rolled out the 32-bit Cortex-M3-based PSoC5 (programmable system on chip) alongside the single-cycle, 8051-based PSoC3. The 32-bit PSoC5 roll-out is not a big surprise. The 8051-based PSoC3 is a surprise, however, because the company had for years offered a proprietary 8-bit PSoC1 product. The PSoC Creator software tool set supports development for both new processor families, and PSoC Designer supports the PSoC1. PSoC Creator also makes it easier for developers to migrate from or between 8- and 32-bit designs.

In 2007, Freescale took the 8- and 32-bit common tools a step further with the Flexis line of processors. These processors share pin, tool, and common peripheral IP (intellectual property). In each of these cases, the companies provide not just a silicon migration path between their 8- and 32-bit-processor options but also a common tool set and common peripheral API (application-programming interface) to reduce the pain of an architectural migration.

The 8- and 32-bit-processor markets continue to approach pricing parity, but part of the basis of that pricing parity is

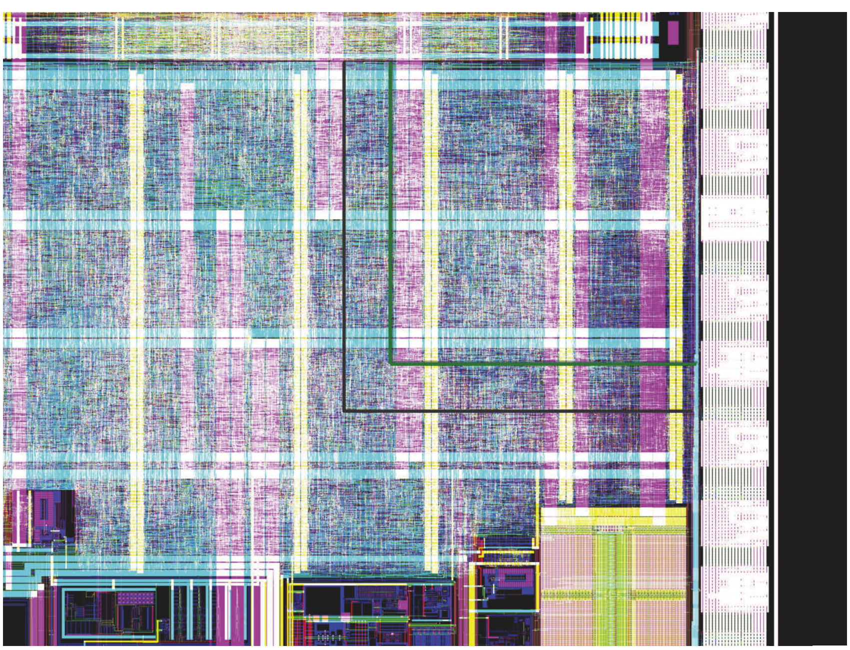


Figure 1 The relative area of different processor architectures becomes a smaller portion of the overall device package as transistor size continues to get smaller. The area of the M0 core (black outline) encompasses approximately 16,000 gates. The green outline denotes the area of a two-clock 8051 core that contains debugging in approximately 11,000 gates. The M0 includes debugging and a similar interrupt controller. The process is a 0.14-nm node (courtesy NXP).

the fact that 8-bit processors rely on older, fully depreciated, process geometries and the fact that 32-bit processors rely on advanced process geometries to approach matching that pricing. The assumption in the market seems to be that 8-bit processors will not continue to move down the process curve. Until recently, however, little price competition existed to drive the need to make that move. So pricing parity alone is probably not sufficient to replace the 8-bit-processor market.

BENCHMARKS

At this point, NXP's code-density claim for the M0 becomes more important. However, measuring code density and processing performance is tricky at best, especially when the processing architectures differ significantly and aim at different problems. In the case of NXP's claim, the company was comparing the code density and processing performance of the CoreMark benchmark. CoreMark's developers introduced it in 2009, and it focuses exclusively on the processor core rather than the memory architecture's ability to hide latency. It comprises several core functions that try to exercise 8-, 16-, and 32-bit operation in roughly equal amounts. A state-machine component, which is basically an 8-bit implementation, covers 8-bit operation, and 8-bit processors are strong in this task.

A DOUBLE-LINK LIST IS A PROCESSING SWEET SPOT FOR 16-BIT ARCHITECTURES.

A double-link list is another component of the benchmark that is a processing sweet spot for 16-bit architectures; however, the benchmark sizes the link list to be appropriate for 8-bit architectures because the list contains only 14 elements. This detail is important because the designers of the benchmark considered the implications of using the benchmark on different-sized architectures. When running the benchmarks, however, you must understand these types of trade-offs to ensure that the compiler is generating code with the appropriate assumptions.

In the case of the double-link list, it is a reasonable assumption that a compiler will specify 32-bit pointers for a 32-bit processor and 16-bit pointers for a 16-bit processor. However, what size pointers should the compiler use for an 8-bit processor? Remember that the benchmark should exercise a task that would be reasonable for the target processor to perform; otherwise, the exercise will produce noise.

Unfortunately, when you are compiling code like this, you probably need to explicitly tell the compiler to use 8-bit pointers. Implementing 16- or 32-bit pointers on an 8-bit processor in this way grossly overstates the needed code and data memory for a data structure that you would never use on such a small machine. Rather than occupying 3 bytes per data element, the structure

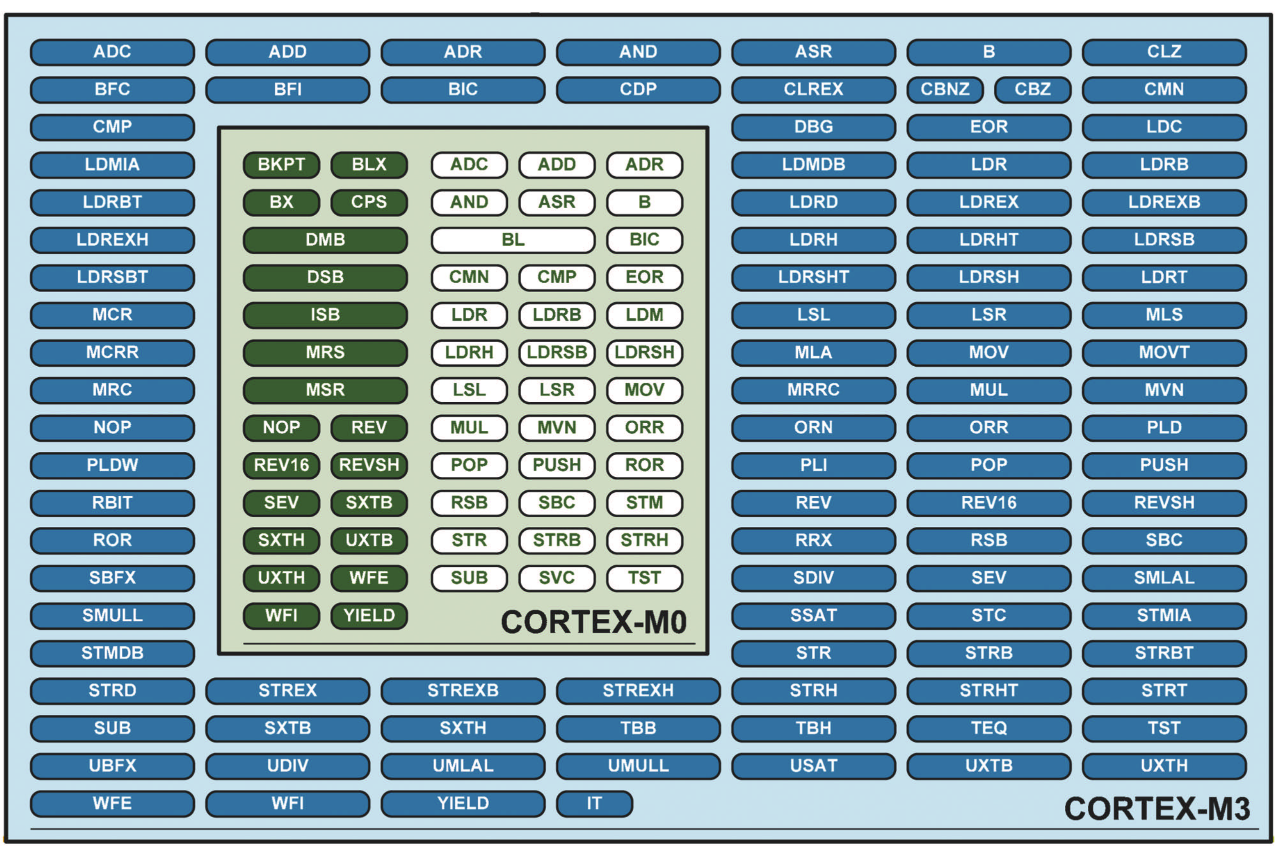


Figure 2 The Cortex-M0 implements a subset of the Cortex-M3 Thumb2 instruction-set architecture (courtesy NXP).

would occupy 5 or 7 bytes per data element. Additionally, the code would require additional instructions to load the 16- or 32-bit addresses.

On an 8-bit processor, a double-link list would reasonably use 8-bit data with two 8-bit pointers. Using 8-bit pointers in this data structure might necessitate the use of a base or an index pointer, and it would place a hard limit on the size of the list so that the entire data structure would fit within the 8-bit address. In this case, the list is 14 elements long—far short of the approximately 80-element maximum for implementing 8-bit pointers with this type of data structure.

Another component of the benchmark is matrix manipulations. This component favors those architectures that can implement looping optimizations and comprises 16- and 32-bit operations that favor architectures with 32-bit math units or other features, such as SIMD (single-instruction/multiple-data) extensions. The final component of the CoreMark benchmark is a 16-bit CRC (cyclic redundancy check) that acts as a verification task and helps balance the 16-bit operations with the 8- and 32-bit operations. However, just because an operation is a 16- or 32-bit operation does not mean that an 8-bit processor is completely inappropriate for the task. Infineon's 8-bit XC878 core has 16- and 32-bit extended, semiautonomous peripherals that allow the system to perform these extended tasks without overburdening the processor core (**Figure 3**). These extended peripherals are appropriate for an application-specific processor with a well-known set of tasks and constraints to meet tight cost and power targets.

THE 8- AND 16-BIT PROCESSORS OFTEN HAVE AN ADVANTAGE OVER 32-BIT PROCESSORS IN SYSTEM-LEVEL ENERGY.

Unfortunately, when comparing 8- and 32-bit architectures, you cannot completely separate out the performance of the components in the CoreMark benchmark so that you examine only those that are relevant to your target. As with the Infineon processor, however, you can in a sometimes economically feasible way make a specialized part that further complicates apples-to-apples comparisons without a deep understanding of the problem and target processors. Code density is a tough measurement to compare because, as you expand for the double-link list, each processor size becomes appropriate for analogous implementations of different types and sizes of data sets.

POWER AND ENERGY

The 8- and 16-bit processors also often have an advantage over 32-bit processors in power consumption or, more important, system-level energy. When comparing processors, you must measure the energy the system consumes while asleep, the energy it wastes when it wakes up, and the energy it consumes to actively perform these tasks. The energy the system loses while the processor wakes up from sleep is a function of system settling times during which the clock-signal-propagation time is in the range for proper processor operation. How often the system has to wake up compared with how much energy it consumes performing active processing determines the impact of this requirement on the system.

Other than for pricing reasons, 8- and 16-bit processors use older process

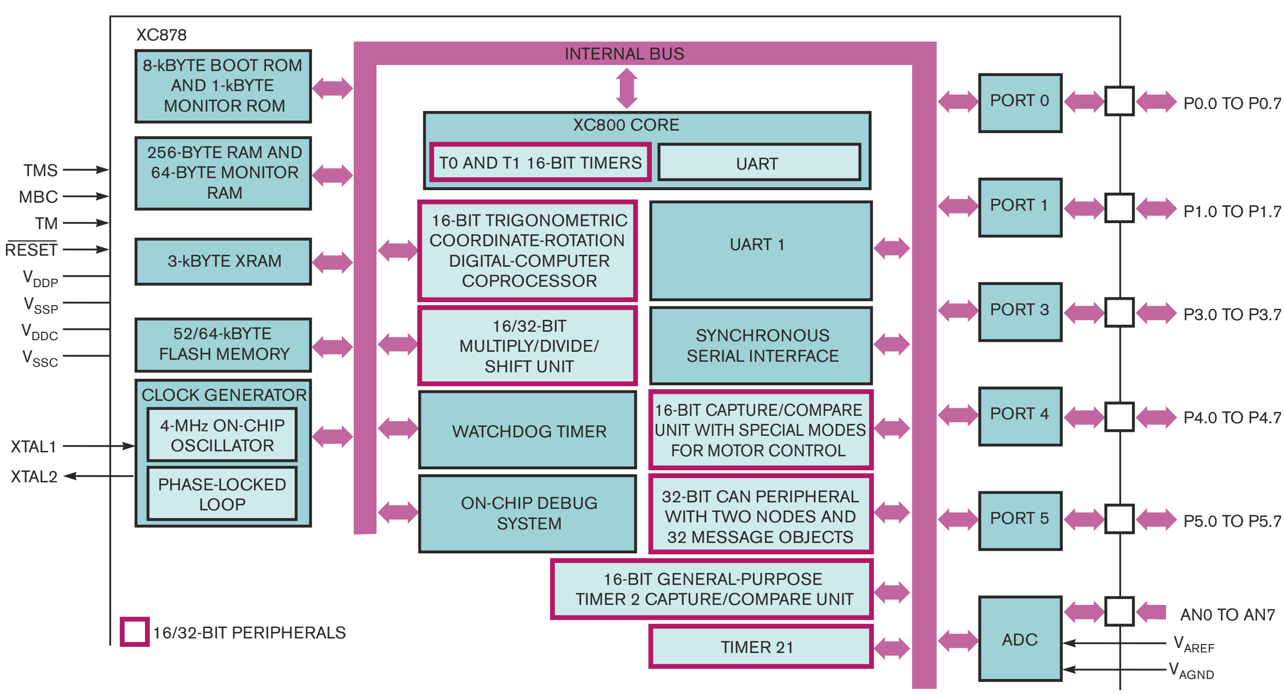


Figure 3 Semiautonomous peripherals allow a smaller system to perform extended tasks without overburdening the processor core (courtesy Infineon).

geometries because the larger geometries allow a much lower leakage current than do more advanced processes. This fact is especially important for systems that sleep most of the time. However, choosing a process geometry that yields a lower sleep or leakage current is a trade-off because it also means that the system has a higher active current when the system is awake. As a result, the energy consumption represents a trade-off of the ratio of sleep and active processing the system will experience. Smaller and larger processors can take significantly different amounts of time to finish a task, further complicating the trade-off. A 32-bit processor's ability to complete active processing more quickly than an 8-bit processor can offset the 32-bit device's higher power consumption because it can spend even more time in sleep mode and yield a net savings in system energy dissipation.

Contemporary processors are implementing ever-more-sophisticated power-management techniques. These innovative approaches go beyond the process-geometry issues to the heart of resource allocation and sizing. A small example, such as NXP and Texas Instruments are using, is the use of ROM to house system drivers and libraries that represent the final integration of a function as a hardware block and a firmware block. Using ROM in this way provides stability to targeted low-level functions, and it may reduce the amount of program flash a design might otherwise need if the designer left those functions as software for the end developer. The need for smaller flash can in a small way affect the total silicon cost and energy requirements for the system. By itself, this savings is not large, but combining many of these small types of savings can result in real and measurable cost and energy savings.

CRYSTAL BALL

Although 32-bit processors can approach cost and energy parity with 8-bit processors, contemporary discussion about low-end 32-bit processors often overlooks an analogous relationship between FPGAs and ASSPs (application-specific standard products) at the high end of the processing market. The processing sweet spot for FPGAs is a task that can leverage arbitrarily wide signal-processing algorithms that designers implement as hardware-acceleration blocks. FPGAs have an advantage over DSPs when the signal-processing algorithm is specialized or wide enough to benefit from using more parallel execution units than a hardened processor architecture has.

Designers base the number of execution units they implement in a DSP or a microprocessor on a trade-off between silicon cost, energy consumption, and the ability of the target applications to keep all of the implemented execution units busy enough to justify their inclusion in the device. Texas Instruments and Freescale offer the C6472 and MSC8156 DSPs, respectively, which have six cores. Both companies explored the choice of eight-core configurations, but the six-core configurations struck the best balance of cost, power, and resource usage for the range of targeted wireless applications. An FPGA need not balance the execution units across multiple application designs as an ASSP does because each design can independently implement the optimum number and type of execution resources for each design.

However, as algorithms and application mature, patterns emerge. Architects of ASSPs can take advantage of these patterns to provide systems that are better than FPGAs from cost and energy perspectives in high-volume applications. DSP vendors, such as Texas Instruments and Freescale, have integrated into their processor architectures the Turbo and Viterbi decoding algorithms as hardware accelerators. An FPGA has a tough time competing with these types of processors with hardware accelerators when they provide a perfect match with the processing requirements of a design.

Does this relationship mean the eventual end of FPGAs, or does it mean that a key value of FPGAs is that designers can feasibly, technically, and economically implement innovative designs with an FPGA years before ASSPs can competitively support those same designs? In a similar fashion, 8- and 16-bit processors will be able to reach lower price and energy thresholds years before 32-bit processors can feasibly support those same thresholds.

At the low end of the embedded-design market, the key constraint is not the amount of processing performance you can cram into a unit of time but rather what kind of processing you can perform with ambient energy. Energy-scavenging-based designs and low-speed, cascading, or feedback-based-processing mesh designs are potentially huge emerging applications that smaller processors will be able to enable years before 32-bit processors feasibly can. However, these types of applications have an additional significant hurdle to overcome before they can explode onto the scene because the programming paradigm of the past few decades has directed programming languages, development tools, and processor architectures to focus on optimizing processing capability over a unit of time rather than how to extract processing value in a variable and energy-starved environment. **EDN**

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HIGH-BRIGHTNESS LEDs FOR SOLID-STATE LIGHTING CAN LAST 50,000 HOURS OR MORE, BUT THE COMPONENTS SURROUNDING THEM GENERATE HEAT THAT CAN CAUSE EARLY FAILURES. PROPER SELECTION OF CAPACITORS AND OTHER COMPONENTS, ALONG WITH THERMAL MANAGEMENT, CAN HELP YOU SAVE YOUR LEDs FROM AN EARLY DEMISE.

BY MARGERY CONNER • TECHNICAL EDITOR

The trendy nature of consumer electronics and the rapid advances in IC features and capacity have led to a culture of products that need not outlast the next wave of devices: When an iPod or a cell phone fails after a year or two, many consumers are willing to dispose of it and buy the next version with its cool new features (**Reference 1**). However, electronics are finding their way into not only solid-state lighting but also automobiles, home appliances, and energy management and monitoring, and for these applications customers expect lifetimes of 10 years and beyond. Not all electronic components are unreliable. It's difficult to think that a microprocessor would simply wear out, for example. Nevertheless, a designer's poor choice or poor layout of the other components that surround a microprocessor, including capacitors and the PCB (printed-circuit board), can cause these components to overheat and ultimately fail.

Lighting products have historically been reliable, but as electronics-rich CFLs (compact fluorescent lights) began to replace incandescent bulbs, consumers began seeing the products' early failures. In some cases, these failures resulted from poor product selections. CFLs are not a good choice for lights that users frequently turn on and off, such as those in a closet. CFLs also require proper airflow, which they may not get in a downward-facing light fixture. Other failures are due to low-quality lights in the product design, the components in the design, or the units' assembly methods. The electronics components surrounding the fluorescent tubes rather than the tubes themselves are often the culprits that cause these failures. As residential, commercial, and industrial lighting begins to incorporate HB-LED (high-brightness-light-emitting-diode)-based SSL (solid-state lighting), will SSL be similarly prone to short lifetimes and reliability problems?

Product lifetime and product reliability are different things. "Lifetime" refers to the length of time an end user can expect a product to work, whereas "reliability" refers to how many products per thousand a user can expect to fail in normal use during their expected lifetime. HB-LED-device manufacturers often quote lifetimes of 50,000 hours or more for the devices (**Reference 2**). However, specifying lifetimes for HB-LED-based lights is more complicated than using the lifetime for an HB LED because the lighting unit comprises an LED driver—a power supply whose lifetime and reliability vary based on its internal components. Capacitors usually have shorter specified lifetimes than the other components in the driver circuit.


OUT

"People see capacitors as being the Achilles' heel of SSL," says Geof Potter, a power technologist at Texas Instruments. "But a nonsolid electrolytic capacitor can have the same lifetime as the components it's supporting if the designer chooses the right capacitor." According to Potter, the most important factor affecting the lifetime of electronic products in general and capacitors specifically is heat, including both the temperature extremes the product will experience during its life and the device's operating temperature.

An HB LED and its driver determine the lifetime of an SSL. HB LEDs have two wear-out mechanisms: the encapsulant, which begins to discolor over time and the application of heat, and the current through the LED. After a certain amount of current goes through any diode, the diode becomes less able to convert electrons to photons, causing the LED to grow dimmer rather than simply burn out. Lumen maintenance is a number that defines end of life for an LED and generally is L70, which means that the LED is emitting 70% of the light it did at its maximum output when it was new.

The main wear-out mechanisms for drivers are the aging of the electrolytic, the solder joints, and the optional optoisolator. The electrolytic in the electrolytic capacitor ages due to the chemical reaction that takes place as the capacitor charges and discharges. This aging accelerates with heat; however, it's a misconception that electrolytic capacitors dry out, which would happen only if you opened the capacitor's vent. Although the chemical reaction in a driver differs from that of a battery, their aging processes are similar.

Electrolytic capacitors, which in LED drivers are usually nonsolid aluminum electrolytic capacitors, don't have fixed lifetimes. Spec sheets for aluminum elec-

AT A GLANCE

- Properly chosen capacitors can support the long life and reliability that SSL (solid-state-lighting) products require.
- Heat is the main culprit in decreasing capacitor life.
- Aluminum electrolytic, ceramic, and film capacitors all have their place in HB-LED (high-brightness-light-emitting-diode)-driver designs.

LED-ARRAY SIZE DETERMINES DRIVERS' OUTPUT VOLTAGE

HB LEDs (high-brightness light-emitting diodes) usually have a forward-voltage drop of approximately 3.5V, so the number of LEDs in series determines the LED driver's voltage, according to Geof Potter, power technologist for Texas Instruments. The simplest way to drive multiple LEDs is to put them in one long string and have one power supply drive the string. However, bright outdoor lamps, such as streetlights, may have 100 or more HB LEDs, requiring a dc output driver with more than 350V and an output-filter capacitor with a voltage of 800V, which is usually impractical.

An alternative arrangement has an array of 10 strings of 10 HB LEDs, requiring a main power supply that provides 35V dc of regulated voltage (Figure A). The 35V-dc power probably doesn't reside on the aluminum panel that supports the LEDs and does double duty as a heat sink. Each 10-LED string has its own constant-current supply that can probably use a lower-voltage ceramic capacitor on the input to the LED string.

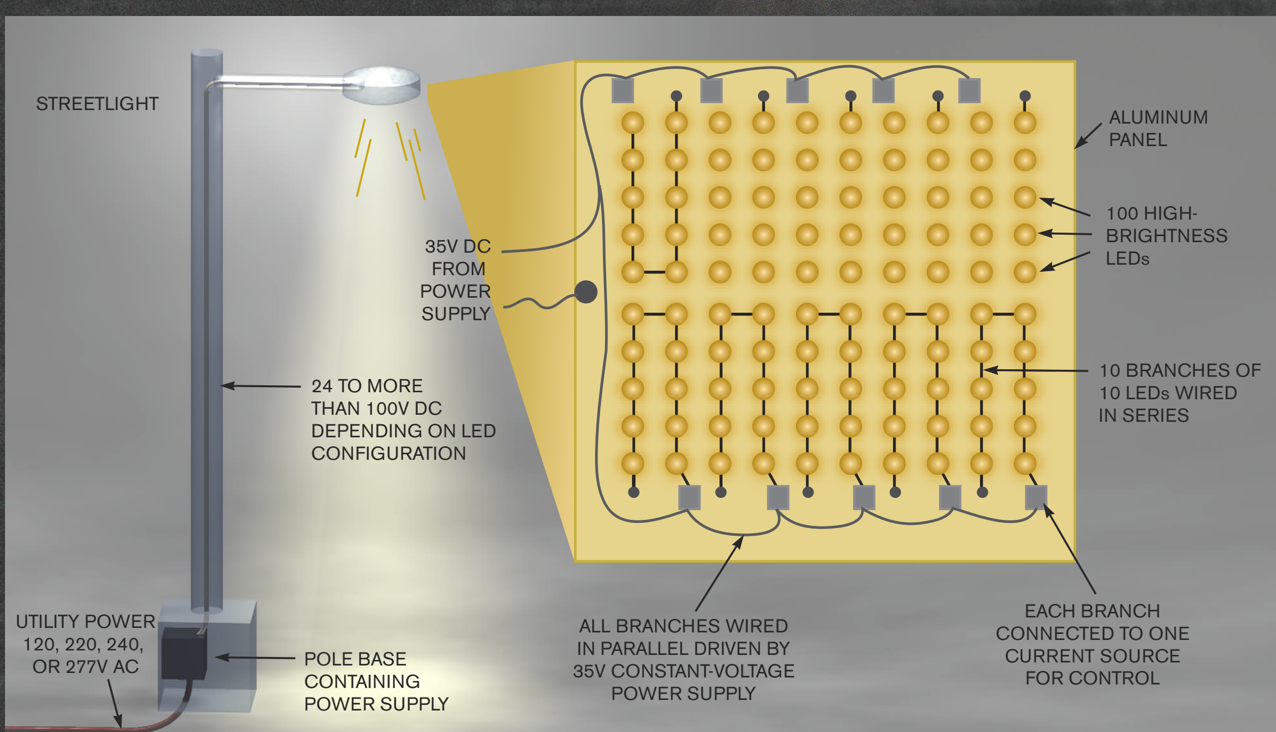
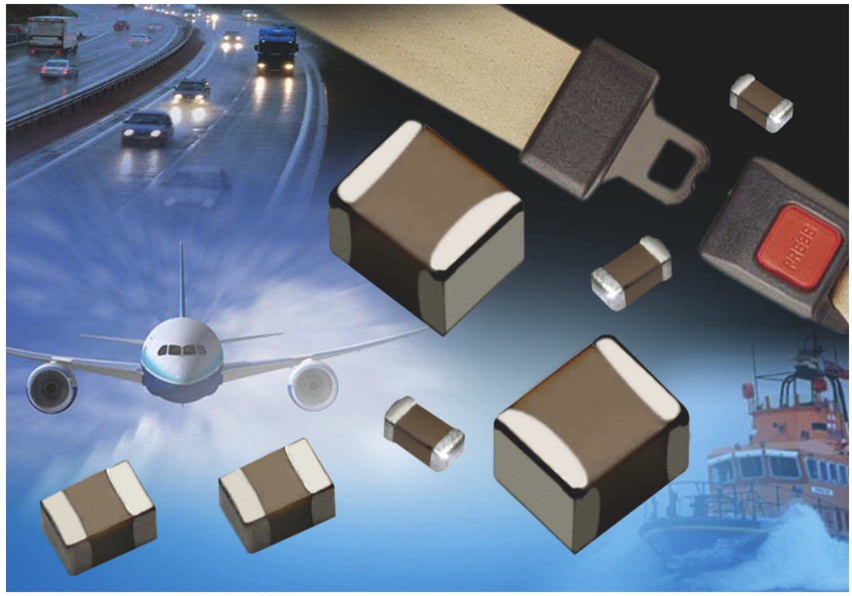


Figure A This streetlight has an array of 10 strings of 10 HB LEDs.



MLCCs (multilayer ceramic capacitors) can fail due to the mechanical stresses of handling and soldering. These 0805 and 0603 FlexiTerm MLCCs from AVX have a tin-finished termination with a conductive-epoxy sublayer that is compliant with some degree of mechanical stress.

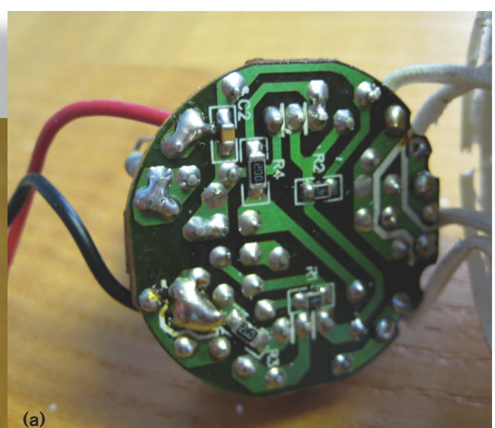
trolytic capacitors typically quote temperatures of, for example, 85, 105, and 125°C. However, electrolytic capacitors experience internal heat that you must also factor in when selecting their temperature range. Ambient temperature and internal power dissipation cause internal heating in aluminum electrolytic. The heat from the application's environment and radiated heat from the other components surrounding the capacitor affect ambient temperature. Ripple current causes internal power dissipation, according to the **equation** $P_D=I_R^2\times ESR$ (equivalent series resistance), where P_D is dissipated power and I_R is the ripple current. Ripple current contributes to the temperature rise in the capacitor's core. The size of the capacitor and inductor on the output of the LED driver determines the ripple current. Make sure that the capacitor can support the ripple current and still maintain its rated internal temperature.

Cost is also a factor in selecting the temperature range for aluminum electrolytics. Although 85°C is a standard temperature, it can't support a long life for SSLs in any but the most benign temperature applications, such as small indoor lamps with sizable heat sinks. Devices that can withstand temperatures of 100 and 125°C are usually necessary for outdoor applications, such as streetlights.

Aluminum electrolytics' high CV (capacitance-voltage) number usually dictates the choice of aluminum electrolytic capacitors rather than, say, ceramic or film capacitors. Electrolytic devices are often the best choice for designs that need high capacitance and high voltage. Ceramic capacitors are making progress, however, due to recently increased voltage ratings. As a result, some ceramic units can work in LED-lighting designs. Note that you must derate the voltage by half with these units. If the highest voltage you anticipate is 50V, use at least a 100V capacitor. Many SSL applications require high-voltage capacitors, and most ac/dc drivers require an aluminum electrolytic capacitor on the input ac side. For example, parking-lot lighting and streetlights usually run at higher voltages, such as three-phase 308V ac or single-phase 240V ac, requiring 400 to 600V capacitors. However, ceramic capacitors sometimes work well on the output side of the driver, in which the number of LEDs in series in an array determines the output (see **sidebar** "LED-array size determines drivers' output voltage").

MLCCs (multilayer ceramic capacitors) have excellent high-frequency noise characteristics and do well on the output-dc filtering, in which they filter out the high-frequency PWM (pulse-width-modulated) noise. However, ceramic capacitors typically fail due to mechanical stress, according to Jerry Zheng, vice president of technology marketing at iWatt. "I tell customers not to go smaller than the 0805 [the package size of a surface-mount device]," he says. "The mechanical stress of a solder joint will easily cause damage. Most ceramic capacitors fail due to handling and soldering."

Several manufacturers in the capacitor industry have introduced compliant lead packages that resist cracking. Ron Demcko, application engineering man-



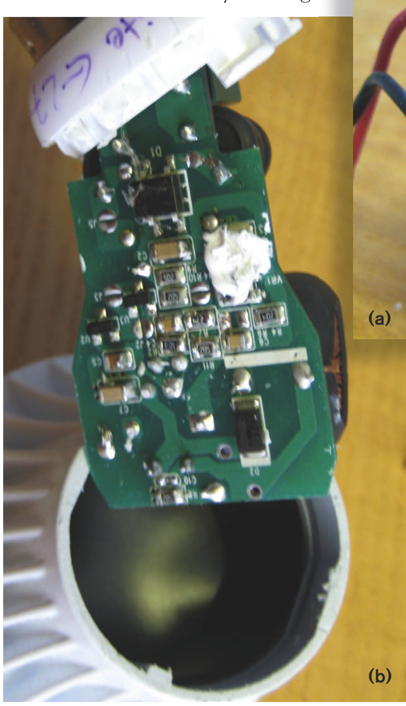


Figure 1 A PCB from a dead CFL shows the type of soldering you can expect in a high-volume, low-cost electronic product (a). If your design will be using such manufacturing, make sure to allow for the added stresses on solder joints that come from hand soldering. A PCB from an LED light targeting the replacement of an incandescent bulb is denser and has more machine soldering but also has a lot of manual assembly (b).

LED WORKSHOP COVERS LED RELIABILITY, DRIVER DESIGN

***EDN*'s second "Designing with LEDs" Workshop will take place in Santa Clara, CA, on Wednesday, March 17. Spend the day with *EDN* and learn how new HB-LED (high-brightness-light-emitting-diode) devices, packages, control electronics, and thermal devices combine to revolutionize lighting for consumer and medical devices and automotive, architectural, and signage applications.**

At the workshop, Geof Potter (photo, top), a power technologist at Texas Instruments, will present "The useful lifetime of HB LED lighting systems," and Jerry Zheng (photo, bottom), vice president of technology marketing at iWatt, will present "The top 3 design challenges for solid-state lights." A panel of speakers from Cree, Philips Lumileds, and Seoul Semiconductor will present their viewpoints on the challenges that can face the next generation of HB LEDs and what their companies are doing to overcome these challenges.

The workshop will also feature hands-on demos of HB-LED devices, drivers, and cooling devices. Cary Eskow, director of LightSpeed, the SSL (solid-state-lighting) and LED business unit of Avnet Electronics Marketing, will give the keynote presentation on the new products and environments that HB LEDs will enable. Register now for this free workshop at www.edn.com/ledworkshopsca.

ager at AVX, describes the package as a tin-finished termination with a sublayer comprising a conductive epoxy that allows for some degree of compressibility or compliance in thermal expansion or physical force. These parts cost about 10% more than those in other packages. No matter what size case you use, though, failure due to cracking always increases if you use hand-assembled parts.

Heat again is a culprit in decreasing lifetimes of solder joints, and the most common causes of their failure are heat excursions. TI's Potter says that HB-LED luminaires should contain as few solder joints as possible to maintain reliability and lengthen their lifetimes. Using fewer solder joints requires more integration of functions and components, and high-end, expensive luminaires often require this level of integration. However, for SSL to catch on in high volume, consumer-grade lighting, such as replacements for 60W incandescent bulbs, the lights must be inexpensive. The cost issue probably will require Chinese manufacturing. Chinese manufacturers produce most of today's incandescent and CFL bulbs, and they usually choose hand assembly, which produces lower-quality devices than the manufacturers can produce if they choose mechanized assembly (**Figure 1**).

LED drivers can also use film capacitors, which are expensive but reliable. Consumers have been complaining about EMI (electromagnetic interference) from CFLs, so designers must be vigilant about suppressing EMI noise in the PWM section of LED drivers. Film capacitors, with their excellent high-frequency response, are a good—albeit expensive—choice in high-frequency noise filters.

Optional optoisolators are other wear-out mechanisms. These components provide an economical form of isolation but are subject to aging, which heat accelerates. According to iWatt's Zheng, the US Department of Energy's Energy Star program does not mandate the use of either isolated or nonisolated LED drivers for offline LED lamps. However, LED-lamp manufacturers often use a metal heat sink for SSLs, which requires an isolated LED driver or an insulated heat sink to protect the user from coming into contact with the mains voltage through the heat sink. Adding insulation can reduce the effectiveness of the heat sink because the heat sink does not mate directly to the heat-generating LEDs. Moreover, if the heat sink is floating—that is, not electrically grounded—then it can radiate RF noise, resulting in high EMI. As such, nonisolated-LED-driver design can complicate safety and thermal management and EMI control.

One alternative to using an optoisolator is to perform the power conversion on the primary side so that there's no need for secondary-side feedback to the primary side. The heat sink can thermally mate to the LED's substrate on the low-voltage secondary side, and you can also ground it to reduce EMI. "Isolated LED drivers can in effect improve thermal efficiency, reduce EMI, and reduce the cost and complexity of LED-lamp designs that use heat sinks," says Zheng.

If you use a transformer to isolate the LED driver, then the heat sink can thermally mate to the LED's substrate on the low-voltage secondary side, and you can also ground it to reduce EMI. "Isolated LED drivers can in effect improve thermal efficiency, reduce EMI, and reduce the cost and complexity of LED-lamp designs that use heat sink," says Zheng (**Reference 4**).EDN

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AWARD FINALISTS: Spring is in the air

It's a bit early to start looking for the first crocus or daffodil buds, but lurking just beneath the still-wintry surface is an abundance of new growth, waiting patiently for its moment in the sun. We encourage you to honor the hope and innovator within by voting as part of *EDN*'s 20th annual Innovation Awards program for a fresh crop of engineers, technologies, and companies that truly embody engineering excellence.

Last year was a strong one for innovation, as evidenced by the huge response to *EDN*'s late-fall call for nominations. Over the past several weeks, our editors faced the difficult task of narrowing down an impressive field of contenders and finding the freshest, most inventive, and undeniably outstanding nominations that were worthy of being named finalists for *EDN*'s 2009 Innovation Awards.

Check out the list of finalists across many categories on these pages, including Innovator of the Year and Best Contributed Article. We even added a few new categories this time around to accommodate the high number of quality nominations.

Review complete write-ups of the finalists and cast your online ballot at www.edn.com/innovation. Your votes determine the Innovation Award winners, who will be honored along with all of the finalists at a reception held Monday, April 26, in San Jose, CA. If you'd like to join the festivities, you can also find event and ticket information at this link.

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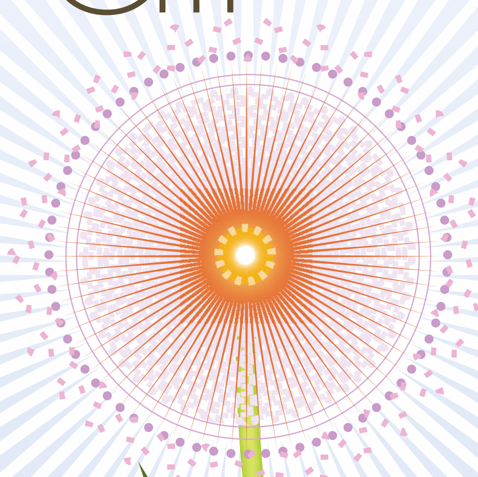

EDN 2009 INNOVATION

INNOVATOR OF THE YEAR

- **Intrinsity Cortex-A8 FastCore design team**
- **MontaVista Software fast-boot-dashboard-application design team**
- **Numonyx Alverstone phase-change-memory design team**
- **Synopsys DesignWare SuperSpeed USB 3.0 IP engineering team**
- **Xilinx Spartan-6/Virtex-6 FPGA design team**

ACCELEROMETERS

- **ADXL345 three-axis digital accelerometer,** Analog Devices
- **Digital MEMS accelerometer,** Hewlett-Packard
- **MMA7660FC three-axis digital accelerometer,** Freescale Semiconductor
- **RS9000 high-end MEMS accelerometer,** Colibrys

ANALOG: CONVERTERS

- **78M6612 power- and energy-measurement/monitoring SOC,** Teridian Semiconductor
- **AD9789 14-bit TxDAC,** Analog Devices
- **ADC16DV160 16-bit, 160M-sample/sec ADC,** National Semiconductor
- **ADS5400 12-bit, 1G-sample/sec ADC,** Texas Instruments

ANALOG: FRONT-END ICs

- **ADAS1128 current-to-digital converter,** Analog Devices
- **AS3910 RFID-reader IC,** austriamicrosystems
- **MAX2078 eight-channel ultrasound front end with CW doppler mixers,** Maxim Integrated Products
- **MC33812 small-engine analog IC,** Freescale Semiconductor

ANALOG: SIGNAL PATH

- **FSA800 USB accessory switch,** Fairchild Semiconductor
- **LT3092 200-mA, two-terminal current source,** Linear Technology
- **LTC6655 bandgap voltage reference,** Linear Technology
- **MCP651/2/55 operational amplifiers,** Microchip Technology

COMPONENTS

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- **Flared-pin-fin heat sinks,** Cool Innovations
- **IR1168 SmartRectifier,** International Rectifier
- **IS18WWC1W OLED rocker switch,** NKK Switches
- **WCM308 shaped-foil SMD/power inductors,** West Coast Magnetics

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- **Tessent YieldInsight yield-analysis tool,** Mentor Graphics
- **VeriStand 2009 open, configuration-based software environment,** National Instruments

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- **In-design DFM with Encounter Digital Implementation System,** Cadence Design Systems
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- **PowerPro MG memory-power optimizer,** Calypto Design Systems
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- **RootCause analyzer formal diagnosis tool,** OneSpin Solutions

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Use eight timers with PIC16Fxxx microcontrollers

Luis G Uribe C, Caracas, Venezuela

DIs Inside

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The need for timing in embedded programming often exceeds the small number of available hardware timers in microcontrollers. For example, the Microchip (www.microchip.com) PIC16F84A has one timer, but you can create as many as eight timers with the Timers8.inc assembly code, which you can download from the online version of this Design Idea at www.edn.com/100218dia.

Often, you need a timer while waiting for some expected lapse to expire, which blocks your program until that time has elapsed. To accomplish that task, you can use a simple routine, such as `Wait_on 2, .30`, meaning that Timer 2 counts 300 msec. The time value is .30 ticks of 10 msec each. In this way, you can debounce input data (**Listing 1**).

Using Microchip's MPLab assembler, you can't guess whether a parameter is a constant value or a variable, so you need two macros, one for each kind of circumstance. In the following explanation, use K if time is a constant and use V for variables, such as Wait_onK or Wait_onV. The same library for the TBM (timebase module) on the MCHC9S08GP32 microcontroller from Freescale Semiconductor (www.freescale.com) uses only one macro, Wait_on, under the CodeWarrior assembler. The function deals with both constants and variables.

The "tmr" always stands for a constant from zero to seven. It designates the number of the timer you apply to a situation. You must always multiply time by 10, so .1 is 10 msec. You can therefore use it with times from 10 to 2560 msec. Precision is plus or minus one tick. If you need to trigger an event with a 20-msec timer, you may end with 10 msec. So use 30 msec to be safe. At the high end of the scale, you will have 2560±1 msec, which is acceptable.

Timers8.inc programs the TMR0 on the PIC16F84A. You can extend beyond eight timers or use 16-bit variables, but remember that the PIC16F84A has only 68 bytes of RAM.

On some occasions, you need to start a timer but don't need to block your program to time-out; in this case, use the `Setimer 7, .20` macro. You start Timer 7 to last 200 msec; doing so does not block your program. Whenever you need to know the status of your timers, test them using the TimeOut macro, `TimeOut 2, Two_done`, meaning that, if Timer 2 has expired, you will go to the "Two_done" label. Any of your main code labels will fit. Otherwise, your program will continue executing the next instruction in sequence.

Setimer comes in two versions. `SetimerK 2, .20` sets Timer 2 to count 200 msec, using Constant `time .20`, and `SetimerV 5, var` sets Timer 5 to count, for example, 300 msec, using variable time var, which you should have previously loaded with .30.

You may need to employ timers in ISRs (interrupt-service routines)—for example, to debounce the interrupt pin. This situation is awkward because the routine to serve the external INT pin runs with general interrupts disabled, as usually happens in the PIC16F84A, but timer routines require you to enable interrupts. This microcontroller architecture makes it difficult to enable interrupts in ISRs. You may, however, use either `ISRWait_onK` or `ISRWait_onV` to accomplish your purpose, as in `ISRWait_onK 7, 3.`

This approach works in a similar way

LISTING 1 CODE FOR DEBOUNCING DATA

```
Loop1:
  btfss  PORTA, 0      ; Wait unitl PortA, Bit0, be equal to 1
  goto   Loop1         ; No? go to repeat test...
  Wait_onK 0, 3        ; Now, PortA, Bit0 = 1 so, set up Timer 0 for 30
                ; ..mSec to debounce it
  btfss  PORTA, 0      ; Time out! Re-test PortA, Bit0 input condition;
  goto   Loop1         ; ..if PortA, Bit0, = 0, discard it and go to Loop1
                ; ..to begin again
Cont:  ...             ; ..if PortA, Bit0, = 1 you are done
```

to its twin, the Wait_on macro, except that you can use the approach in any ISR—a nice added value for such an inexpensive microcontroller. Use it with care, however. Interrupt latency increases because you block the program in an ISR for several milliseconds with global interrupt disabled. If you choose to debounce your interrupt signal using programmed delays, you will probably encounter the same problem. If you use a specific timer number in the main program, don't use it in the ISR.

To use the Timers8.inc library, you must include the library file and define some variables outside the timer's code. To find the exact place to include the library and define variables, refer to the sample code. Look for <<< TMR0 <<<, which overemphasizes portions of the code. In particular, inspect the lines "CBLOCK" and "INCLUDE <timers8.inc>".

Follow this plan in your program: Use the macro Init8Timers to activate the hardware and set up the eight software timers. This macro defines eight variables, from Timer 0 to Timer 7, each using one unsigned byte. Each timer ticks once every 10 msec, covering a range of 10 to 2560 msec. You need not worry about these variables, though, because the macros will handle them. A 1-byte variable, TimerFlags, has bits that represent the ready state of timers zero through seven. You need not deal with this internal variable.

To initialize a timer from zero to seven, use the Setimer macro, as in `SetimerK 2, .20` (set Timer 2 to count 200 msec using a constant time of .20) or `SetimerV 5, var` (set Timer 5 to count 300 msec using a variable time of .30, which you previously stored in var). Setimer macros are not self-blocking; they initialize the software timers and continue. This feature comes in handy when you plan to loop, asking for several events to time out and do not need one of them to block you.

THE SOFTWARE IN THIS CODE AVOIDS TOUCHING OR UPDATING VARIABLES IF THE STATUS BIT IS 1.

To test whether one timer has expired, use the TimeOut macro after Setimer: `TimeOut 2, Two_on`. If Timer 2 has expired, go to Two_on; otherwise, execute the next instruction in the sequence. Wait_on combines these macros in one: `Wait_onK 2, .30`. Set Timer 2 to count 300 msec using a constant time of .30 and block until time-out. Alternatively, using `Wait_onK 5, var`, set Timer 5 to count 300 msec using a value of .30, which you previously stored in var. Wait_on macros are self-blocking; they initialize the software timers and wait until time elapses. You can use ISRWait_on in ISRs: `ISRWait_onK 6, .35`. Set Timer 6 to count 350 msec using a constant time of .35 and then block.

Alternatively, you can use `ISRWait_onV 5, var`. Set Timer 5 to count 2000 msec using a value of .200, which you previously stored in var. ISRWait_on macros are self-blocking. You can use them in ISRs to initialize the software timers and wait until time elapses. You must include an interrupt handler; see the IntHandler in **Listing 2**, which you can download from the online version of this Design Idea at www.edn.com/100218dia. The library also includes TMR0ISR, Timer 0's ISR, and the UpdTmr (update-timer) internal macro.

Each timer has a status bit, which helps when your variables have 16 bits, 24 bits, or more. When the driver detects that one multibyte timer variable reaches zero, it signals this situation by setting the timer's status bit. That action spares you several instructions when you need to later decide whether the timer is zero. You can also use these bits as semaphores. You may start a timer with Setimer, and the hardware may interrupt you in the middle of the start-up to update your data structures, causing lots of problems. The software in this code, however, avoids touching or updating variables if the status bit is 1. Setimer begins raising the status bit and then loads the variables. If Timer 0 interrupts, it does not interfere with your data because it skips the updating process if the status bit is on. When Setimer is done, it clears the status bit, and Timer 0's ISR will begin to update whenever a tick arrives.

This code doesn't stop a timer before a time-out because the need never arises. If Setimer uses zero as a value for the time, it lasts for 256 10-msec ticks. If you need a 1-msec tick, you can load Timer 0 with −0.125 instead of −0.39 and use a prescaler of 8 (b'00000010' in OPTION_REG) instead of 256 (b 00000111), which are the values this code uses. The exact time is $125\times8=1000$ µsec (1 msec). This approach provides a range of 1 to 256 msec.EDN

Tilt/fall detector has staggered thresholds

Marián Štofka, Slovak University of Technology, Bratislava, Slovakia

Measurement-and-control applications may require action based on two distinct voltage levels. Crossing a threshold can produce a warning indication, whereas reaching a higher threshold may initiate emergency action, such as a system shutdown. In a fall-detector application, an apparent decrease in gravity below a lower threshold might be a controlled displacement, but a further decrease below a second threshold might indicate an uncontrolled fall.

The circuit in **Figure 1** uses a voltage divider to generate two reference voltages. Comparators and Schmitt-trigger-input NAND gates let you create two digital signals based on using reference voltages V_{REFA} and V_{REFB}. The sample circuit drives two LEDs, but

you can use the digital signals to drive transistors or relays, as well.

The voltage divider comprising R_S, R_A, and R_B sets the voltages for comparing the Z-axis output of an Analog Devices (www.analog.com) ADXL335 accelerometer (**Reference 1**). The higher reference voltage, V_{REFA}, corresponds to the lower-threshold tilt angle, where $\alpha_{TA}=45°$. The lower reference, with respect to the midvoltage supply minus V_{REFB}, corresponds to the upper-threshold tilt angle, where $\alpha_{TB}=60°$. If you choose a value of 100 kΩ for R_S, then you can calculate R_A+R_B:

$$\frac{R_S}{R_A+R_B}=\frac{V_S/2}{V_{GZ}\times\cos\alpha_{TA}}-1.$$

The Z-axis voltage, V_{GZ}=300 mV, occurs when the accelerometer's Z axis is oriented vertically. From the obtained value of R_A+R_B, you can calculate R_B:

$$R_B=\frac{\cos\alpha_{TB}}{\cos\alpha_{TA}}\times(R_A+R_B).$$

Based on the chosen values of the tilt angles, $R_B=(R_A+R_B)/\sqrt{2}$. You can then solve for R_A from the known values of R_A+R_B as well as R_B.

The AD8609 op amp's input-bias current causes errors, but these errors are negligible because the input-bias current at room temperature is just 1 pA. The AD8609's input offset voltage, which is typically 50 μV, also causes errors, which are negligible as well (**Reference 2**). The signals at the outputs of comparators IC_{2A}, IC_{2B} and IC_{2C}, IC_{2D} are ORed in NAND gates IC_{3A} and IC_{3B}, respectively. NAND gate IC_{3C} serves as an inverter, and the output of IC_{3D} is the logic output of a window comparator in which logic low appears only when the Z-axis output voltage is between V_{REFA} and V_{REFB}, referenced to supply midvoltage $V_S/2$.

Grouping the comparators into IC_{3A}, IC_{3B} and IC_{3C}, IC_{3D} pairs ensures independent detection on whether the Z axis is 0 or 180° in the vertical orientation. LED_1 and LED_2 illuminate successively upon slowly tilting the Z axis by 45 and 60° (**Reference 3**). Similar action occurs when you orient the Z axis steadily vertically while moving downward. LED_1's brightness is turned on at an apparent decrease of gravity to $g/\sqrt{2}$. LED_1 dims, and LED_2 simultaneously illuminates when the vertical acceleration is equal to or lower than g/2. The operation of the detector is ratiometric and is therefore virtually insensitive to supply-voltage variations.**EDN**

REFERENCES

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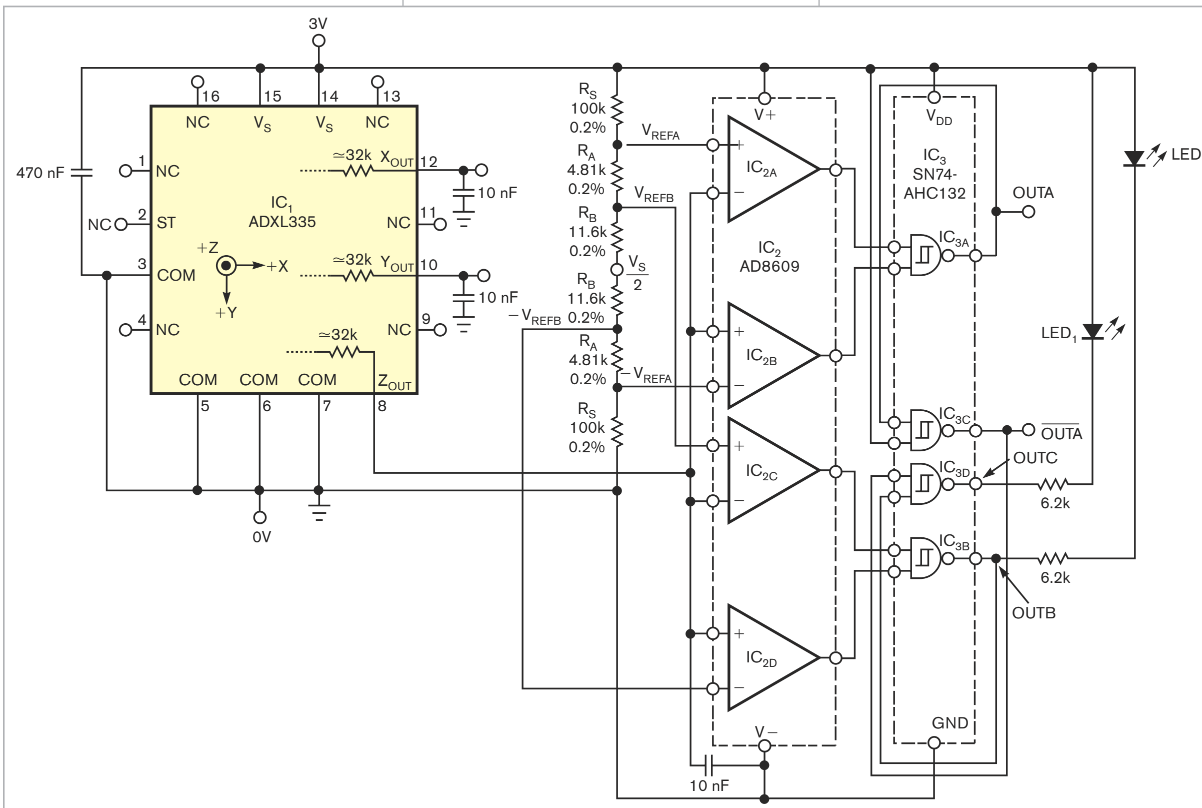

Figure 1 An accelerometer's Z-axis output, compared with two reference voltages, can generate two digital outputs.

High-frequency margining crystal oscillators ensure system robustness

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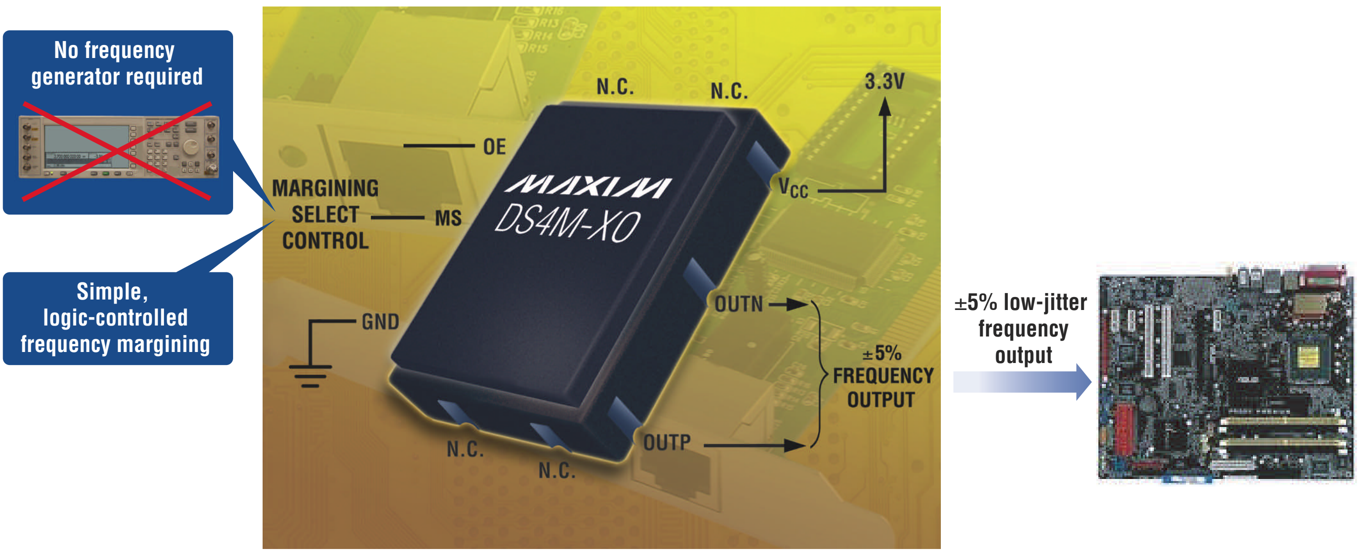

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Electronically generate rotating magnetic fields

F Ferrero, J Blanco, JC Campo, and M Valledor, University of Oviedo, Gijón, Spain

Many applications, such as medical therapies, magnetic stirrers, and induction heating, call for a rotating magnetic field, which you can generate by attaching multiple permanent magnets to a dc motor. This technique involves problems, including noise and the need to maintain the moving parts. This Design Idea describes how you can instead use a microcontroller and a full-bridge driver to generate variable magnetic fields without mechanical elements. The approach requires no maintenance, does not wear out, and provides high-precision speed control. It does, however, require large cores to achieve powerful magnetic excitation.

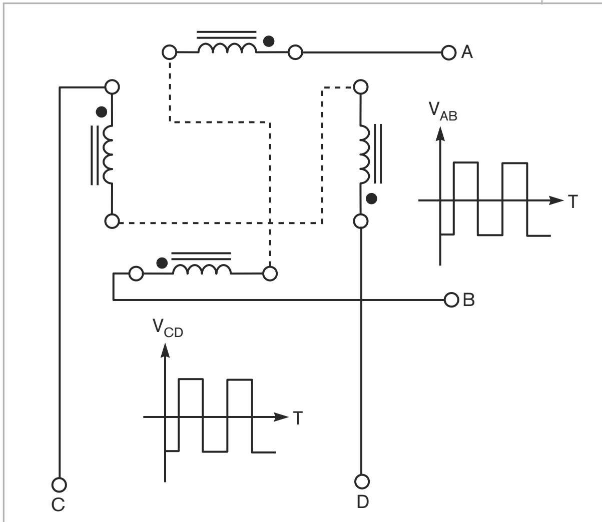

Figure 1 Two pairs of magnetic coils and their excitation waveforms show how to generate a rotating magnetic field.

You can excite a stationary magnetic coil with an ac current, which induces a north pole and a south pole that change at the frequency of the signal excitation. You can increase the number of poles by implementing a configuration with more magnetic coils. **Figure 1** shows a practical arrangement of the coils and the typical excitation waveforms. Note that the terminals of each pair of coils connect in series opposition to always obtain magnetic fields with different polarity.

Multiple ICs can drive inductive loads. This circuit uses an L6204 dual full-bridge driver from STMicroelectronics (www.st.com). Each bridge has four power-DMOS transistors with on-resistances of 1.2Ω. A PIC16F628 microcontroller from Microchip (www.microchip.com) controls the switches of the dual-bridge driver (**Figure 2**). Typical waveforms show how each circuit is excited (**Figure 3**).

To ensure the correct driving of high-side drivers, the circuit supplies a voltage higher than the supply voltage at IC$_2$'s Pin 20. External capacitors C$_1$ and C$_2$ and diodes D$_1$ and D$_2$ use a charge-pump method to produce this voltage. You can independently control the four half-bridges by means of the IN1, IN2, IN3, IN4, ENABLE1, and ENABLE2 inputs.

The microcontroller timer's interrupt generates the IN1 to IN4 waveforms with high precision. Using a 10-MHz oscillator crystal and fixing the postscaler to eight, the microcon-

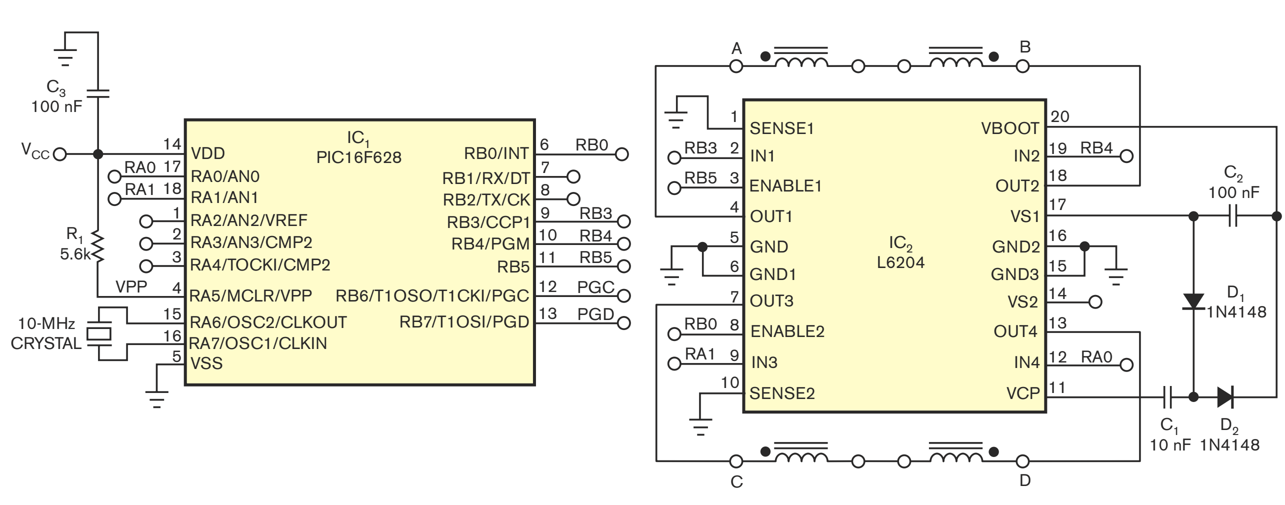

Figure 2 The circuit comprises a full-bridge driver and a microcontroller.


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troller's counter increments every 3.2 µsec: 1/((10 MHz/four instructions)/eight). Taking into account that the interruptions generate when the counter overflows and the maximum count is as high as 65,535, or 16 bits, you can program the interruptions at 3.2 µsec and 210 msec: 3.2×65,535.

From this wide range of interruptions, the firmware lets the user select the precharge within a small subrange of frequencies divided into 10 levels,

THE FIRMWARE LETS THE USER SELECT THE PRECHARGE WITHIN A SMALL SUBRANGE OF FREQUENCIES.

meaning that you must vary the interruption from 49.89 to 60.45 µsec, a good range for this application. The new frequency of the interruption has a simple calculation that includes the level; the maximum frequency; and the separation between levels, which is a constant value that the operations include. You can download **listings 1** and **2**, which have complete C source code, from the Web version of this Design Idea at www.edn.com/100218dib.EDN

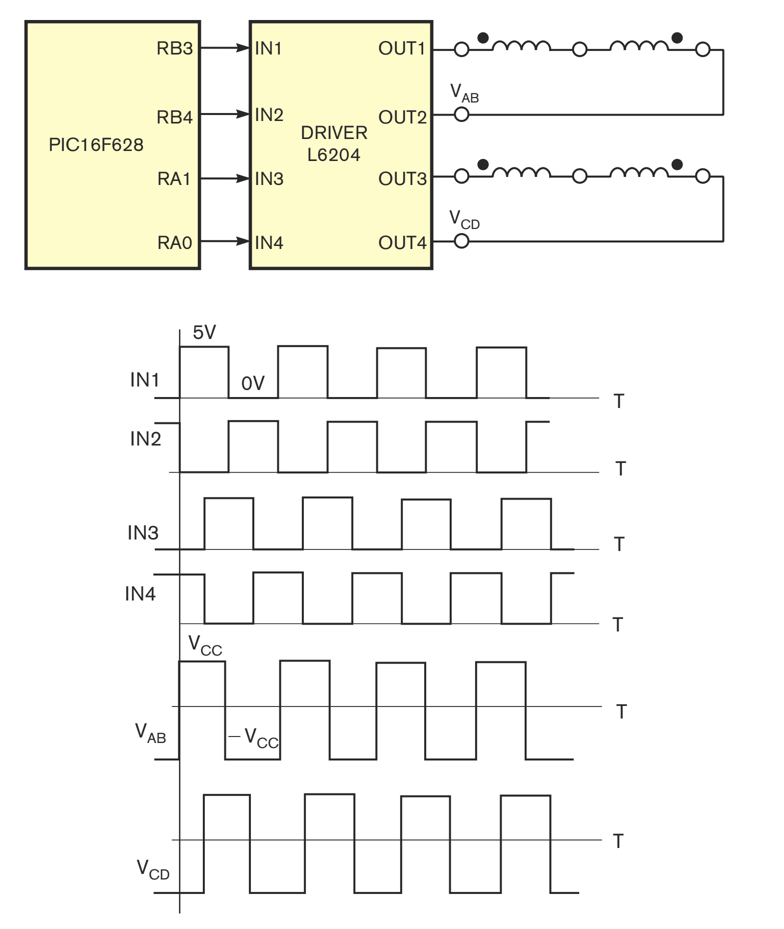

Figure 3 Waveforms show how each coil is excited.

Voltage reference stabilizes current sink

Suded Emmanuel, Emmanuel's Controls, Auckland, New Zealand

Analog circuits for long-term testing of passive components, such as 0.1%-tolerant resistors or high-intensity white LEDs, often require a constant current. Using two op amps and a voltage reference, you can develop a circuit that provides a constant-current sink with a variable setting of 0 mA to 0.99A. The circuit in **Figure 1** sinks a stable current through the load. The load current is insensitive to power-supply-voltage variations. IC_1 is a voltage reference that gives a stable 5V dc. It requires 500 µA of current from the power supply. IC_2 is a National Semiconductor (www.national.com) LM324 quad op-amp. Voltage follower IC_{2A} buffers the reference voltage from the rest of the circuit, which increases stability.

Resistor R_2 and potentiometer R_3 form a variable voltage divider that reduces the 5V reference voltage to a value between 0 and 3.26V. Unity-gain amplifier IC_{2D} drives the base of Q_1, a Darlington power transistor that has a current gain of 750, through R_4. R_4 and C_5 form a lowpass filter that prevents oscillation. You can drive Q_1 with a small base current. C_4 connects between the collector and the base of Q_1, adding further stability.

Operating as an emitter follower, Q_1 can drive an active or a passive load, such as a resistor or a high-brightness LED. Q_1's emitter connects to R_5, a 3.3Ω, 5W grounded power resistor. The voltage at IC_{2D}'s Pin 14 sets the voltage across R_5, which fixes Q_1's emitter current. Because of Q_1's high gain, the current in the load is effectively Q_1's emitter current.EDN

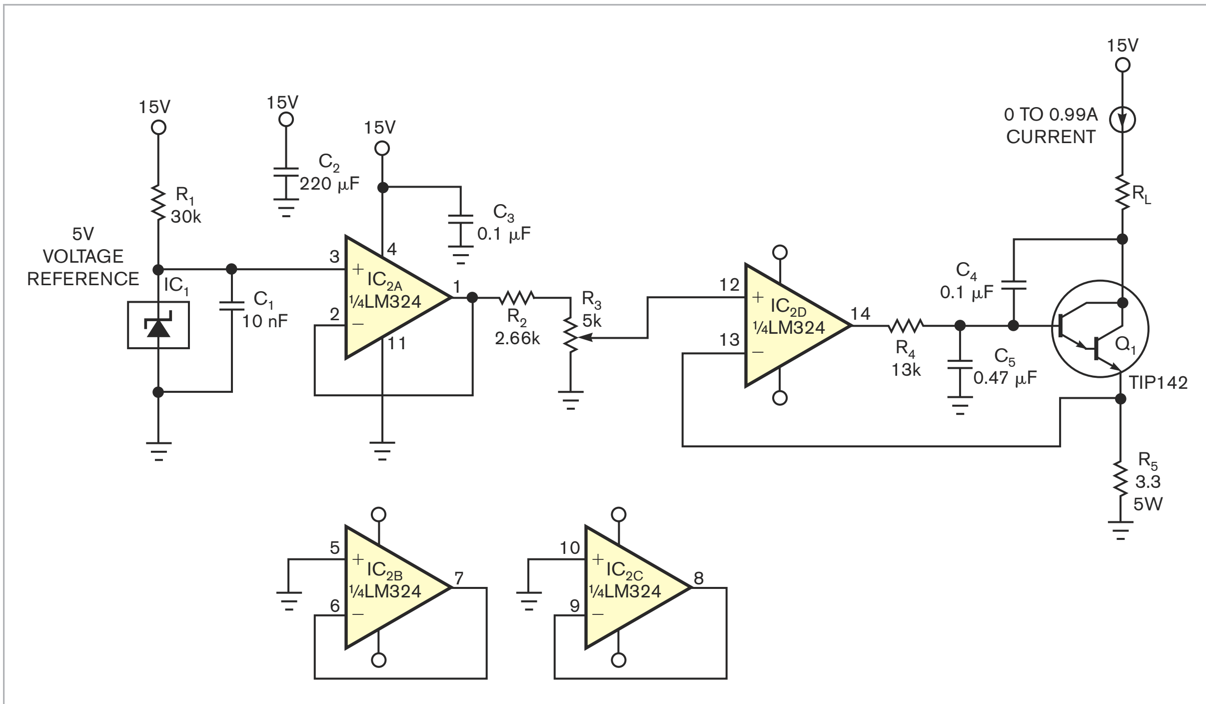

Figure 1 A voltage reference and two op amps provide a stable voltage to R_5, which provides a stable load current.

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SWITCHES AND RELAYS

Long-distance reflective switch aims at wind turbines for rpm sensing

The long-distance OPB732 infrared reflective-switch series targets 6-kW wind turbines for rpm sensing. The switches work internally at the turbine rotor to sense rotations per minute, transmitting data to a customer-accessible Web site over a GPRS. The reflective devices also suit use in assembly-line and machine-automation, equipment-security, door-sensor, machine-safety, end-of-travel-sensor, and non-contact-reflective-object-sensor applications. The switches have a reflective distance of more than 1 in., depending on circuitry. The configuration includes an infrared LED and a phototransistor and uses an opaque housing, reducing the sensor's ambient-light sensitivity. Features include an 850-nm wavelength and 100-mW power dissipation, 50-mA maximum forward current, and 1.8V maximum forward voltage at a 20-mA forward voltage. The device also provides 3V reverse-dc voltage with 100-mA reverse current and 2V reverse voltage. Devices in the OPB732 series cost $2.85 (1000) each.

Optek, www.optekinc.com

Illuminated pushbuttons have quiet actuation

The subminiature HB2 full-face-illuminated pushbutton switches have ultraquiet actuation at 0.4-VA 28V ac/dc maximum and suit use in telecommunications, medical-test, measurement, audio, and broadcast equipment. The switches have red/green or red/yellow LEDs; the red/yellow LEDs produce amber illumination. The SPST momentary devices feature tactile feedback and 1.8N nominal operating force. Options include laser etching, screen printing, film inserts, and pad printing. Custom legends and value-added assemblies are available from the vendor. Measuring 7.5×7.5×17 mm, the caps use a clear lens with a white diffuser. The HB2 subminiature pushbutton-switch series costs $3.41 (2500).

NKK Switches, www.nkkswitches.com

Integrated load switch has low on-resistance

Aiming at space-constrained, battery-powered applications, the TPS22924C integrated load switch provides 5.7-mΩ on-resistance at 3.6V. The device combines four parts into one, simplifying subsystem-load management. Features include a 0.75 to 3.6V input-voltage range, a 2A maximum continuous switch current, and a less-than-2-μA shutdown current. Available in a 1.4×0.9-mm CSP, the TPS22924C costs 55 cents (1000).

Texas Instruments, www.ti.com

USB accessory switch includes negative-swing capability

The FSA800 USB accessory switch integrates charger detection and 28V of overvoltage tolerance and negative-swing capability, thus requiring fewer external components. Targeting use in cell phones, PDAs, and MP3 players. The 28V overvoltage tolerance on the bus-voltage pin protects against high-voltage events, and the negative-swing capability enables audio signals to swing below ground, eliminating the need for coupling capacitors. Available in a 1.8×2.6×0.55-mm ULMP, the FSA800 USB accessory switch costs 70 cents (1000).

Fairchild Semiconductor, www.fairchildsemi.com

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Putting the brakes on Sparky


DANIEL VASCONCELLOS

In the early 1980s, while I was an electrical-design engineer for an automobile manufacturer, I had to diagnose and remedy a problem that surfaced during the development of a vehicle. The experimental-engineering garage called to tell me that one of the new development vehicles produced a strange, periodic snapping noise. Peering into the dark engine compartment, I saw that the noise was coming from a large arcing spark down low in the chamber. The arc was crossing between a small, metal inline oil-filter can and the vehicle's grounded chassis frame, which was some distance away from the filter. The spark was big, fat, and loud. It was at least 2 inches long, and occurred about once a second whenever the engine was running.

This vehicle incorporated an experimental hydraulically boosted power braking system in place of the conventional vacuum-boosted braking system. This new braking system required additional hydraulic plumbing from the engine-driven power-steering pump to the brake-booster system. The plumbing included an inline fluid filter to the rubber high-pressure feed hose from the pump. The filter housing was of a metal construction, and the insulated hose suspended the metal housing from the chassis frame.

I quickly concluded that a 2-inch-long spark equated to at least a couple hundred thousand volts. I wondered how you get that kind of voltage with a car's 12V system. This problem was especially confounding because the vehicle, which used a diesel engine, didn't even have a high-voltage ignition system!

I concluded that we had somehow inadvertently produced in this vehicle the "hydraulic" equivalent of a conventional mechanical Van de Graaff generator. A Van de Graaff generator consists of an insulated motor-driven electron-transport belt, a metal electron-collector brush that connects to the high-voltage metal dome at one end of the belt, and a source of electrons applied to the opposite end of the drive belt. In the conceptual equivalent of that system, the moving, nonconducting hydraulic fluid and insulated rubber hoses acted as the electron-transport mechanism. The metal filter can and its internal metal filter element served as the electron collector. The engine-driven hydraulic pump and drive belt were the sources of electrons to the fluid.

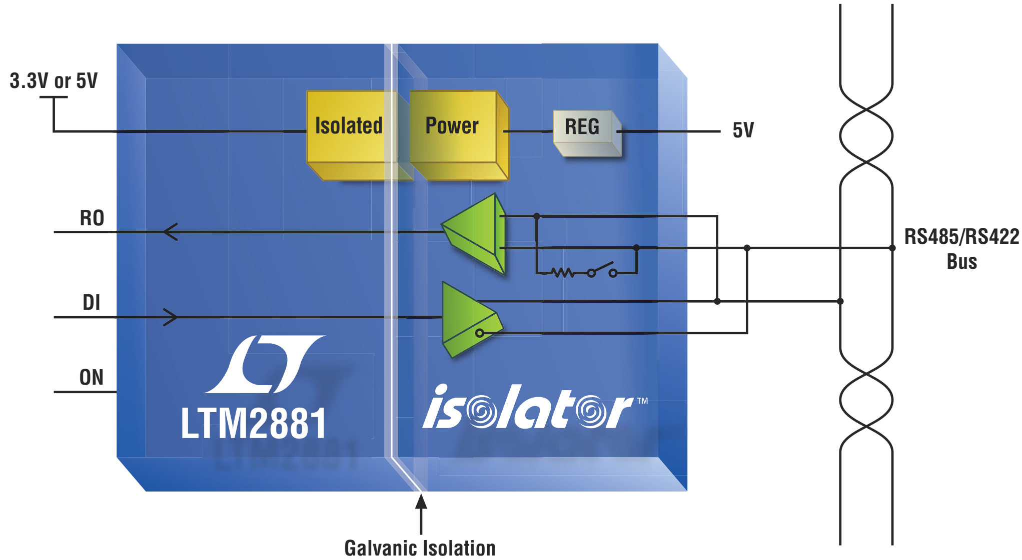
Because the engine-driven pump was of an all-metal construction and was grounded to the engine and the chassis frame, it was difficult at first to envision how the pump could be a source of electrons. However, attaching a grounded test lead to the pump by rubbing it against the pump's belt-driven pulley caused the arcing to stop. This result substantiated my suspicion that the pump was the electron source. When the engine stopped, a conductivity check confirmed that the pulley was grounded in this nonoperational state.

Upon further consideration, I concluded that the pump's spinning pulley and internal rotor assembly were electrically "floating" inside the grounded pump housing due to the hydrodynamic action of the bearings and rotor and the insulated seals inside the insulated hydraulic fluid. The actual electron source probably resulted from the triboelectric friction of the rubber drive belt on the pulley.

Grounding the filter-can housing to the vehicle frame eliminated the arcing symptoms. As I recall, this power-brake-booster configuration never made it into a production vehicle. Upon further reflection, grounding the filter can provided only a good sink for the electrons, and there was still a large circulation of those electrons in the hydraulic fluid. EDN

Electrical engineer Arthur Sundeen of Lansing, MI, holds 15 patents and runs his own electrical-OEM companies producing aircraft instruments and radio antennas of his own design.

Isolated RS485 + 1W Power



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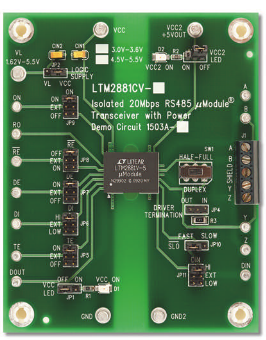
LTM2881 Demo Board



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