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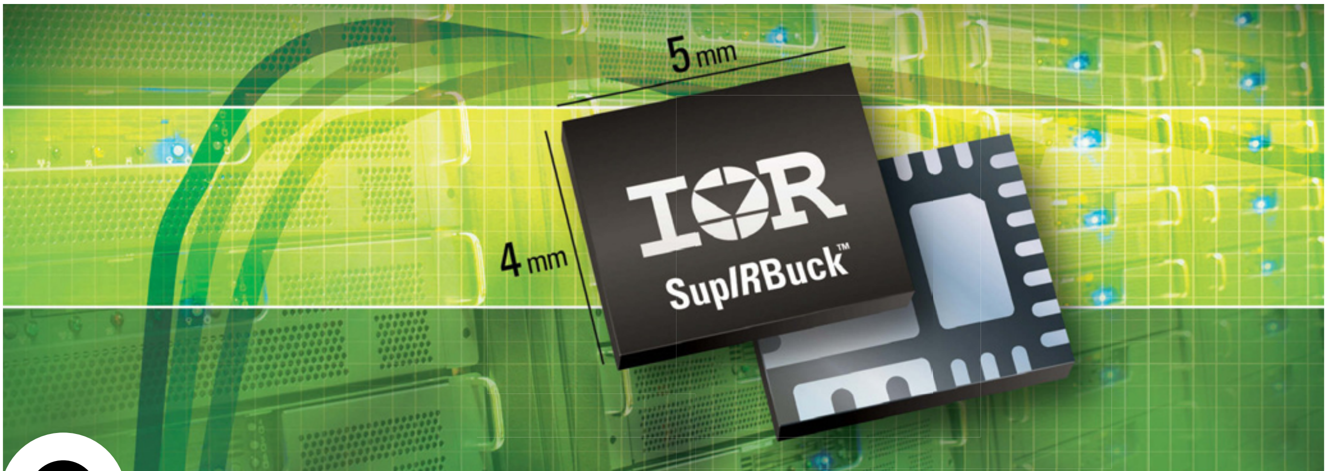

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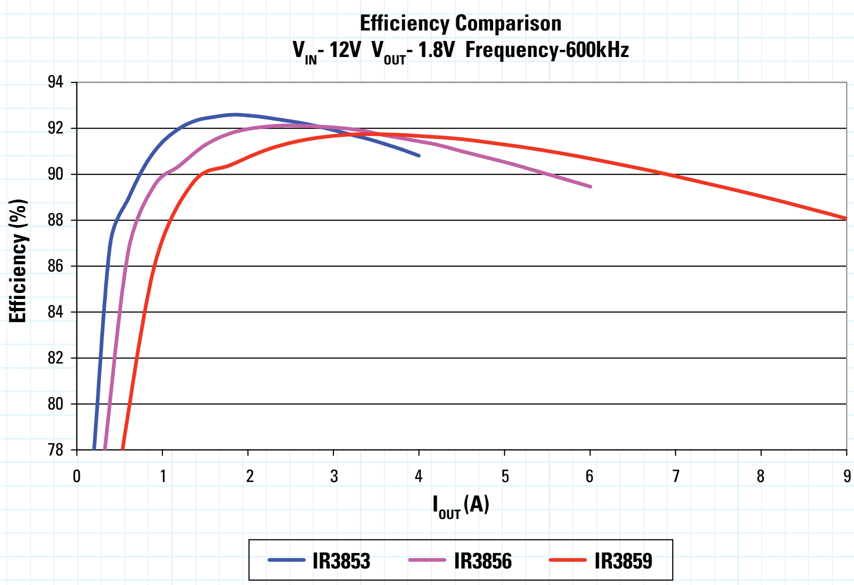

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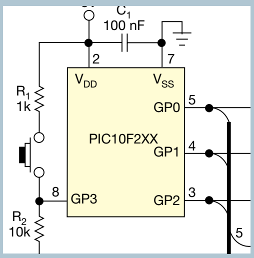

contents 5.26.11

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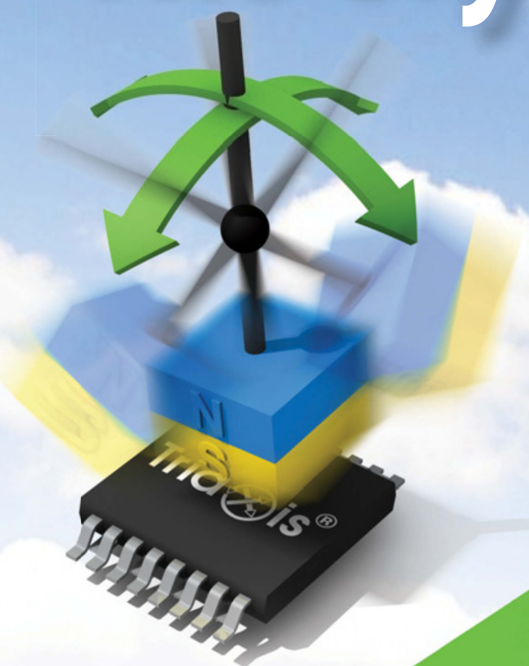

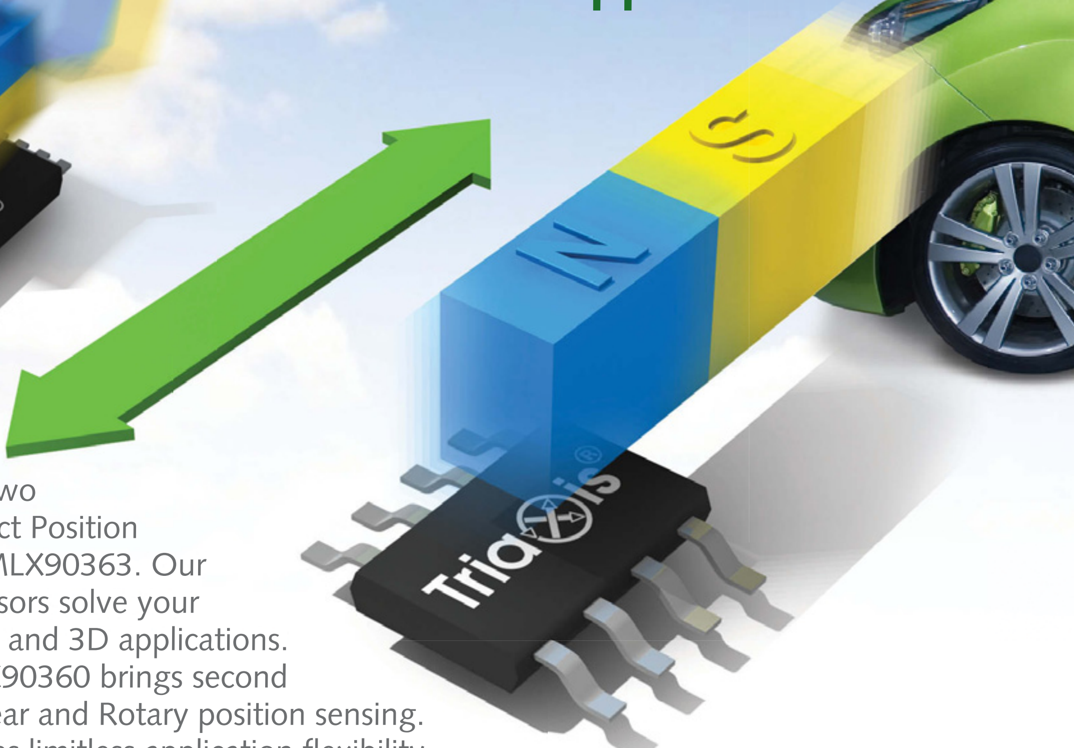

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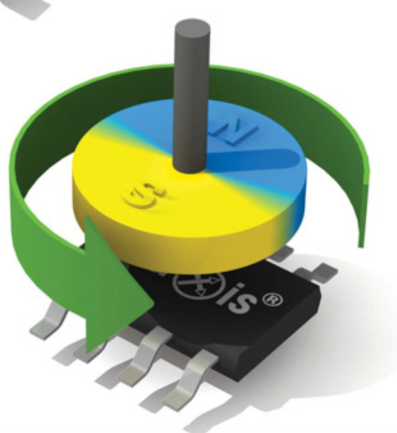

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BY RON WILSON, EDITORIAL DIRECTOR

Nebulosity and The Cloud

An interesting story recently flickered across the business pages of news sites before fading into the vast forgetfulness that is the Web. Amazon.com, the "dreadnaught" of online retailers, had experienced a problem in one of its massive server colonies. Ordinarily, this situation would not have even sparked any interest across the news screens. Servers occasionally have problems. This incident, however, was news because this server glitch disrupted "The Cloud."

As you may know, Amazon has many aspects. In addition to retailing, the Web giant hosts a number of shared virtual resources that we call clouds, portions of *The* Cloud. Such a plan can be handy for a heavy user of servers. Amazon, for example, can build its server colonies to support not the average but the peak loads from its highly seasonal retail business. Instead of just eating the cost of those additional servers for the non-holiday-season portion of the year, Amazon can sell the unused capacity to others under defined-service contracts. Smaller companies need not make capital investments in large numbers of underused servers, Amazon receives payment for keeping a reserve against peak demand, and everyone comes out happy—until something goes wrong.

In this case, Amazon's glitch caused a portion of The Cloud to evaporate, leaving a number of high-profile Web sites without computing capacity. The problem probably also shut down a lot of less-public undertakings, but you are unlikely ever to hear about those endeavors. The disruption leaked fuel onto one of the major debates about cloud computing—guaranteed quality of service. And that debate makes this little news story relevant to many of you because The Cloud intersects your practice of electronics design, and it introduces new risks at each point of intersection. For example, design teams may use The Cloud to store design data. A disruption that renders data unavailable for a day or two could affect a schedule. A glitch or a malicious attack could cause outright loss of data.

Similarly, many design teams are thinking about hosting tools in The Cloud, saving license fees and server investments. The idea is appealing to teams outside the IC-design world, many of which go into terminal sticker shock when they see the pricing on system-modeling software. What do they think when they see The Cloud simply go away for a day or two?

There is a deeper problem, too. Some embedded designs today use The Cloud in the design itself, as a place for their systems to log data or as a site for postprocessing to extract cost, billing, or failure-prediction information. Some designers also even discuss implementing functional algorithms with hard real-time deadlines in The Cloud, saving the cost and power consumption of heavy-duty computing hardware in an embedded design. Things get interesting during that step.

Does your system halt gracefully? Does it throw a tantrum and damage those around it? Your answers had better be concrete.

Access to The Cloud necessarily invokes the uncertainties of the Internet. Both latency and delivery are unpredictable. Once your message reaches The Cloud, the physical memory and computing resources you get depend on many factors beyond your control. And, as Amazon has demonstrated, The Cloud may simply be momentarily absent.

Such uncertainties call for a new style of design. You must assume variable latencies—as long as, apparently, several days—and understand how your system will behave when such delays occur. Does your system halt gracefully? Does it throw a tantrum and damage those around it, or—and here is the real challenge—can you design the system to degrade gracefully and to resume smoothly once access to The Cloud returns? The Cloud may be nebulous, but your answers had better be concrete. **EDN**

Contact me at ron.wilson@ubm.com.

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EDITED BY FRAN GRANVILLE

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INNOVATIONS & INNOVATORS

Floating-point-DSP family adds processors and software

Texas Instruments has added the single-core TMS320C6671 to its TMS320C66x family of floating-point DSPs. The device increases clock speed to 1.25 GHz and is pin- and software-compatible with other members of the TMS320C66x family, providing an upgrade path from single-core configurations to two-, four-, and eight-core configurations.

The company also has added features to the communications-centric TMS320C6670 SOC (system on chip). These features include a multistandard BCP (bit-rate coprocessor) and accelerators for PHY (physical)-layer processing in LTE (long-term-evolution), WCDMA (wideband-code-division-multiple-access), TDSCDMA (time-division/synchronous-code-division-multiple-access), and WiMax (worldwide-interoperability-for-microwave-access) applications. The 1.2-GHz, quad-core C6670 SOC targets use in SDRs (software-defined radios) in applications such as public safety and military radios, which require support for fewer users than cellular-radio base stations. The floating-point DSP also supports emerging applications for processing surveillance video in security and defense applications.

TI also recently updated its MCSDK (multicore-software-development kit). The kit of software libraries provides Linux kernel support for the C66x DSP generation and the OpenMP API (application-programming interface) with a C66x compiler and runtime software for the KeyStone multicore architecture. The MCSDK integrates a software-development platform that includes multicore communication layers for intercore and interchip communication, validated and optimized drivers with TI's Sys/BIOS real-time operating system, and Linux support with appropriate demonstration examples. TI also plans this year to add to its DSPLIBs (DSP libraries) and IMGLIBs (image-processing libraries) for the C66x DSP instruction-set architecture with additional kernels and libraries for vision analysis, cryptography, voice, and fax applications.

Texas Instruments offers the TMDXEVM6670L and TMDXEVM6678L evaluation modules for the DSP family. The kits sell for $399 each and include a free MCSDK, a Code Composer Studio IDE (integrated development environment), and a suite of application and demo codes. The C6671 DSP, C6670 radio SOC, and evaluation modules are now available. The MCSDK is available as a free download. Prices for the C6671 DSP start at $79 (1000).—**by Mike Demler**

▷**Texas Instruments**, www.ti.com.

The single-core TMS320C6671 floating-point DSP increases clock speed to 1.25 GHz and is pin- and software-compatible with other members of the TMS320C66x family, providing an upgrade path from single-core configurations to two-, four-, and eight-core configurations.

TALKBACK

"We replaced many IBM 1401 computers in those days of platform shoes, wide ties, loud sports jackets, and bell-bottom pants! I even had hair on top of my head back then. Today, I design entire microsystems that sit in the real estate that used to occupy a single flip-flop in a U1005 computer!"

—Engineer and self-described "migrant worker" Al Sledge, in *EDN*'s Talkback section, at http://bit.ly/mG8Mjd. Add your comments.


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Job Title
Associate Professor of Mechanical Engineering, Virginia Tech
Area of Expertise
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NI LabVIEW
LabVIEW makes me better because
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Researchers claim extremely sensitive sensor based on Raman scattering

Researchers at Princeton University claim to have developed the extremely sensitive D2PA (disk-coupled dots-on-pillar antenna-array) sensor employing Raman scattering, a phenomenon that physicist Chandrasekhara Raman discovered in the 1920s. Raman found that light reflecting off an object carries a signature of its molecular composition and structure. The researchers say that the sensor opens new ways of detecting a range of substances—from those that indicate telltale signs of cancer to those that detect hidden explosives. The researchers are touting the sensor as a major advance in the long search to identify materials using the phenomenon. Placing material—as small as one molecule—on a scattering of light enables the sensor to boost faint signals, allowing the identification of various substances depending on the color of light they reflect.

"Raman scattering has enormous potential in biological and chemical sensing and could have many applications in industry, medicine, the military, and other fields," says Stephen Y Chou, professor of electrical engineering at Princeton, who led the research team. "But current Raman sensors are so weak that their use has been very limited outside of research. We've developed a way to significantly enhance the signal over the entire sensor, and that [technique] could change the landscape of how Raman scattering can be used."

In Raman scattering, a beam of pure one-color light focuses on a target. The reflected light from the object contains two extra colors of light. The frequency of these extra colors is unique to the molecular makeup of the substance, providing a potentially powerful method of determining the identity of the substance. For many materials, according to the researchers, even the most sophisticated laboratory equipment cannot see the extra colors of reflected light.

Czechoslovakian electrochemist Martin Fleischmann and fellow researchers in 1974 discovered that the Raman signals became stronger if the team placed the substance it wanted to identify on a rough metal surface or on tiny particles of gold or silver. The technique, SERS (surface-enhanced Raman scattering), has proved difficult to put to practical use.

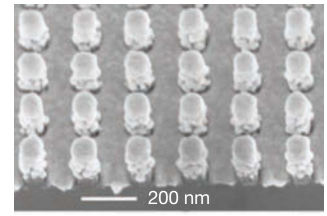
According to the researchers, the small particles and gaps significantly boost the Raman signal. The cavities serve as antennas, trapping light from the laser so that it passes the plasmonic nanodots multiple times rather than only once to generate the Raman signal. The cavities also enhance the outgoing Raman signal. The sensor is a billion times more sensitive than is possible without SERS boosting the Raman signals and is uniformly sensitive, making it more reliable for use in sensing devices. The researchers claim that the technology would be cost-effective to produce using nanoimprint self-assembly techniques. Chou's team produces the sensors on 4-in. wafers and can scale the fabrication to much larger wafers.

"This is a powerful method to identify molecules," says Chou. "The combination of a sensor that enhances signals far beyond what was previously possible, that's uniform in its sensitivity, and that's easy to mass-produce could change the landscape of sensor technology and what's possible with sensing."

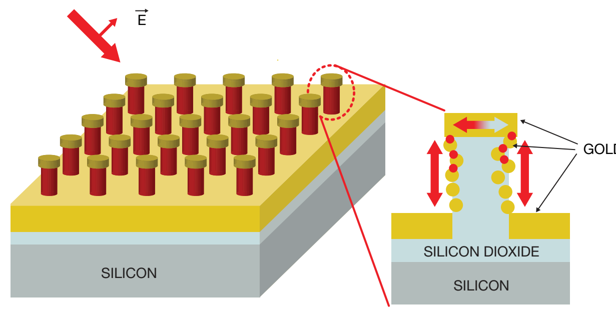
Electrical engineering graduate students Wen-Di Li and Fei Ding, postdoctoral fellow Jonathan Hu, and Chou published a paper on this technology (**Reference 1**). The researchers received funding from the Defense Advanced Research Projects Agency.

–by Suzanne Deffree

▷**Princeton University**, www.princeton.edu.



Princeton researchers developed this sensor for sensing Raman scattering (courtesy Stephen Y Chou).



Researchers at Princeton University claim to have developed the extremely sensitive D2PA (disk-coupled dots-on-pillar antenna-array) sensor employing Raman scattering (courtesy Stephen Y Chou).

DILBERT By Scott Adams

REFERENCE

1 Li, Wen-Di; Fei Ding; Jonathan Hu; and Stephen Y Chou, "Three-dimensional cavity nanoantenna coupled plasmonic nanodots for ultrahigh and uniform surface-enhanced Raman scattering over large area," *Optics Express*, Feb 28, 2011, pg 3925, http://bit.ly/iCM2yi.

Researchers claim replacement for rare material indium-tin oxide

Researchers at Eindhoven University of Technology (Eindhoven, Netherlands) claim to have discovered a replacement for ITO (indium-tin oxide), a material that finds use in electronics displays and solar cells (**Reference 1**). The transparent conducting oxide has electrical conductivity and optical transparency that engineers can deposit as a thin film. Indium is a rare material, and industry participants expect the depletion of available supplies within as little as 10 years.

The team of researchers produces the transparent, conducting film-replacement material in water and bases it on electrically conducting carbon nanotubes and plastic nanoparticles. The researchers combine low concentrations of carbon nanotubes and conducting latex in a low-cost polystyrene film. The nanotubes and the latex account for less than 1% of the weight of the conducting film. A high concentration of carbon nanotubes makes the film black and opaque, so the concentration must be as low as possible to achieve transparency.

Cor Koning (left) and Paul van der Schoot (right) developed a four-point conductivity measurement of a transparent conducting film. The black pot contains a dispersion of carbon nanotubes in water, and the white pot contains the conducting latex.

The researchers use standard, commonly available nanotubes, which they dissolve in water. They then add conducting latex—polymer beads in water—with a binder in the form of polystyrene beads. When the mixture is heated, the polystyrene beads fuse together to form the film, which contains a conducting network of nanotubes and beads from the conducting latex. Using freeze-drying techniques, the researchers remove the water, which serves as a dispersing agent in production.

The researchers claim that the conductivity of the transparent film is still 100 times lower than that of ITO but expect that they can quickly close that gap. "We used standard carbon nanotubes—a mixture of metallic conducting and semiconducting tubes," says Cor Koning, a polymer chemist on the research team. "As soon as you start to use 100% metallic tubes, the conductivity increases greatly."

The researchers have discovered that manufacturers have recently developed production technology for 100%-metallic tubes and expect the price to fall rapidly. The conductivity of the film is good enough for use as an antistatic layer for displays, for EMI (electromagnetic-interference) shielding to protect devices and their surroundings, and for flexible displays.

—by Suzanne Deffree

▷**Eindhoven University of Technology**, www.tue.nl.

REFERENCE

1. Kyrylyuk, Andriy V; Marie Claire Hermant; Tanja Schilling; Bert Klumperman; Cor E Koning; and Paul van der Schoot, "Controlling electrical percolation in multicomponent carbon nanotube dispersions," *Nature Nanotechnology*, April 10, 2011, http://bit.ly/hcLtHK.

TI, National pairing: a bright idea for LED lighting

What might Texas Instruments' purchase of National Semiconductor (www.national.com) mean for the world of LED lighting? IMS Research (www.imsresearch.com) puts TI and National at numbers 1 and 2, respectively, in the LED-IC-driver market, with TI accounting for 19% and National for 7% of what IMS terms a $1 billion market. However, that $1 billion represents the whole LED-IC-driver market, including backlighting; you can bet that IC drivers for solid-state illumination are a much smaller piece of the pie. I've found National Semiconductor drivers in the high-volume, relatively low-cost EcoSmart brand that Home Depot (www.homedepot.com) carries, but I've found none from TI. National is now most likely the stronger player in this market.

TI's acquisition of National Semiconductor is interesting because the future of LED lighting is decidedly digital, and National Semiconductor hasn't done well in the digital arena, but TI has excelled at it. In power management, digital has two applications: the control of the PWM (pulse-width-modulation) loop in power conversion and regulation and the communication path between the power-conversion/regulation controller and the overall system. Both of these pieces will become dominant in solid-state lighting as the market moves beyond thinking about replacement bulbs for incandescent lights to lighting as an integral part of building and environment management. TI is one of the key players in digital-power control, whereas National Semiconductor's LED drivers are currently all analog. With control networks, TI is a long-time market leader, but it also brings a portfolio of energy-harvesting and ultra-low-power design chops, both of which will be keys in lighting applications. Imagine TI's MSP430 microcontroller in every bulb or luminaire; that's the future of lighting.

Solid-state lighting is now just a tiny piece of the electronics road map, and TI didn't buy National Semiconductor just for its LED-driver smarts, but the market will become significant, and these two companies make a beautiful pairing.—by Margery Conner

▶**Texas Instruments**, www.ti.com.

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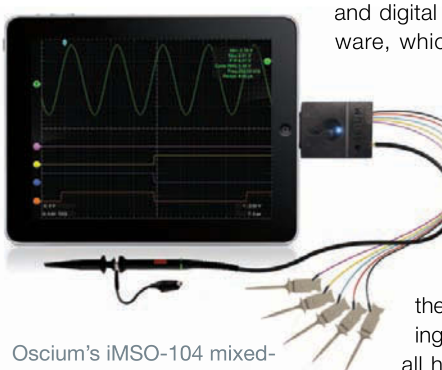
Apple iOS-based oscilloscope has features galore but seems pricey

Oscium's $297.99 iOS (iPhone-operating-system)-based MSO (mixed-signal oscilloscope)-104 for Apple's (www.apple.com) iOS-based handheld devices includes one analog channel and four digital channels, touts 5-MHz analog bandwidth, and samples at 12M samples/sec. A dock connector-based adapter contains a Cypress (www.cypress.com) PSOC (programmable-system-on-chip) 3 IC, which manages two-way communication between the oscilloscope and any iOS device using Apple's proprietary dock connector and processes the incoming analog and digital signals. Free software, which you can download from the Apple store, runs in demo mode without hardware attached. It requires only Version 3.1.3 of the iOS, thereby making it compatible with all hardware iterations of the iPad, iPhone, and iPod touch.



Oscium's iMSO-104 mixed-signal oscilloscope for Apple's iOS-based handheld devices includes one analog channel and four digital channels, touts 5-MHz analog bandwidth, and samples at 12M samples/sec.

I recently received the unit and, after testing it for a few days, passed it along to *EDN* Technical Editor Paul Rako. I figured that, as an "analog guy," he would likely be able to give it a more thorough evaluation than I could. He and his friends own both first- and second-generation iPads, so together they'd also be able to assess whether the iPad 2's more advanced CPU and GPU (graphics-processing unit) and two-times-larger system DRAM allocation would translate into a performance advantage.

Paul and his friends deemed the unit handy for embedded-system projects in which you are troubleshooting a small microcontroller as well as some analog. They hooked it to an iPhone and got it working. However, the unit's almost-$300 price tag proved a deterrent. "You can get a half-decent 50-MHz lunchbox-sized scope for $400, as well as other hobby units for $68 and $89," Paul says.

In short, although it has surprisingly many robust features, the iMSO-104 seems expensive considering its specs and interface count. I'm sure that the vendor hopes that would-be users will like its portability versus the need to drag along an entire stand-alone oscilloscope. The iPad also enables large-screen capability; price out a competitive display-real-estate-equipped stand-alone oscilloscope, and you might experience serious sticker shock, although these units also tout more features than a handheld unit can.

Oscium is perhaps hoping to snag early-adopter enthusiasts now, with a subsequent price drop in parallel with the production volume ramp-up and consequent BOM (bill-of-materials) cost decrease. Oscium is now shipping the hardware along with a new release of the software that includes "minor bug fixes as well as the added ability to save configurations," according to Bryan Lee, the company's president.

—by Brian Dipert

▷**Oscium**, www.oscium.com.

USB 3.0 controller embeds microcontroller for customized applications

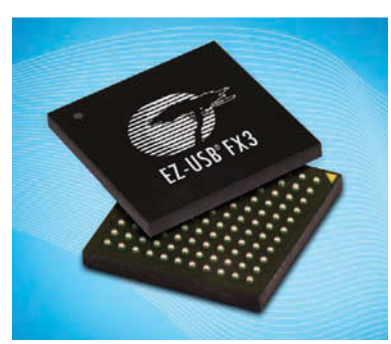
Cypress Semiconductor's new EZ-USB (Universal Serial Bus) FX3 for USB 3.0 applications combines a flexible peripheral controller with a USB 3.0 PHY (physical)-layer interface that provides a data pipeline as fast as 5 Gbps. Designers can use the 32-bit, 100-MHz parallel GPIF (general programmable interface) II to program the controller through a state machine for master or slave; synchronous or asynchronous; and 8-, 16-, 24-, or 32-bit configurations.

You can customize the FX3 with an embedded 32-bit, 200-MHz ARM926EJS processor core for the needs of end markets. The ARM9 core is fully accessible for use as an independent microcontroller and includes 512 kbytes of memory. You can program the device with Cypress tools or standard ARM tools.

The FX3 provides a variety of serial interfaces, including I^2C (inter-integrated circuit) for the boot EEPROM, SPI (serial-peripheral interface), UART (universal asynchronous receiver/transmitter), and I^2S (inter-IC sound). According to the company, you can configure most unused I/Os as general-purpose I/Os.

The controller is now available for sampling. An alpha development kit, beta SDK (software-development kit), and associated programmers' manual are also available. Cypress plans to release full production quantities in September for less than $10. The company is packaging the FX3 in a 121-ball, 10×10-mm BGA package and is specifying the device for industrial-temperature-grade operation. **—by Mike Demler**

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



The EZ-USB FX3 combines a flexible peripheral controller with a USB 3.0 PHY.

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VOICES

Digi-Key's Mark Larson: Go big, go global, go online

Digi-Key Corp (www.digikey.com) President and Chief Operating Officer Mark Larson recently discussed the company's posted sales growth of 64% in 2010—more than twice the sales growth of the semiconductor industry; the pros and cons of doing business in China; and the company's decision to end its print catalog, a fairly new notion for component distribution. Excerpts of Larson's interview with *EDN* follow.

How did Digi-Key manage to hit a $1.5 billion sales milestone in 2010?

A We added almost $600 million in additional sales, over and above what we accomplished in 2009. And in 2009, although it was a rougher market, our decline was a fraction of that of the greater market; 2010 was a great year that exceeded our expectations. We see it not only as additional sales, which we were pleased to get, but also as a validation of our business model.

Why did Digi-Key recently decide to end its print catalog, making the all-digital move and becoming an Internet-based distributor?

A We saw that 85 to 88% of our orders were coming in through the Internet. We had strong reason to believe that the remaining orders were almost all coming as a result of orders that were built on the Internet, but maybe the customer needed slightly more information so they placed the order in the form of a call. We coupled this [idea] with the tremendous amount of feedback over the last several years that's been escalating to where customers are saying they don't want or need the catalog. At a lot of international sites, customers pay to dispose of paper. Given the extreme way that our customers have embraced the Web and the extremely negative [way they view some aspects] of the catalog, and couple all of that with a general want to be "green," [and we made the move]. Our initial thought was that maybe there would be some customers who would still want the catalog. [We've had] very little negative feedback. I'm comfortable we made the right decision.

What region do most of Digi-Key's sales come from?

A Just a little less than 60% of our sales are coming from North America. Then, of the remaining 40%, EMEA [Europe, the Middle East, and Africa] and Asia/Pacific are pretty much dividing the difference.

What are you seeing in China?

A Last year, our sales in China increased about 240%. So far this year [early April], we are up approximately 85%. Total sales in

China I would expect will be in the range of $80 million this year. If we were to talk about Greater China, our sales would be well over $100 million. Our base is still small, but the potential is huge. The ability to realize that potential is increasing in a way almost daily. It's a process and takes some patience, but not too much patience if you can grow 240% and then turn around and grow 85%. After a few years of that [growth], we will have truly significant sales.

What was behind Digi-Key's recent move to help found the China Electronics Distributor Alliance?

A We believe there is a real need and value proposition for the organization and for Digi-Key to participate in the organization. A significant problem in China and in the world is counterfeiting. One of this organization's goals will be to promote franchise distribution, meaning that the product the distributor sells comes directly from the manufacturer. When there's that type of purchasing, the possibility of counterfeiting is driven down to a near-zero potential.

Do you have any concerns about the rare-earth-materials shortages and China's restrictions of their exports?

A There's obviously concern. In speaking with our suppliers that rely on a lot of these materials, I do think that there has been a certain upward price pressure on families of components that rely on some of these rare-earth materials, but it's not a situation that is out of control at this point. I'm not uncomfortable at this point that it will have an extremely negative effect. I think it's something that is being worked through, and, in some cases, there are alternative sources. We have not used these sources because it has not been cost-effective, but, as price pressure increases, some of these alternatives become viable options because it is economic once again to access these materials. I think it's like so many areas in which we have precious metals. These markets have a certain volatility that becomes part of life, and we somehow all seem to adjust to them.

Does it look like inventory supply and demand in the electronics supply chain are coming back into balance?

A It really does. In fact, in the short run, the disaster in Japan created a certain amount of panic, but, by and large, since almost the beginning of this year, we've seen supply and demand be fairly balanced. We stock about 600,000 components, and at any given time, our target is to be 95 to 96% in stock. We're right in that range now. It's a strong indication that supply and demand are well-balanced. If we were to look at that figure in 2010, there were times it was significantly lower. Our ability to pull off the shelf was impaired at certain times in 2010. Now we are where we want to be.

—interview conducted and edited by Suzanne Deffree

Rarely Asked Questions

Strange stories from the call logs of Analog Devices

Considerations on High-Speed Converter PCB Design, Part 3: The E-Pad Low Down

Q. What are some important PCB layout rules when using a high-speed converter?

A. Part 1 discussed why splitting AGND and DGND is not necessary unless circumstances within the design force that choice. Part 2 discussed the power delivery system (PDS), and how squeezing the power and ground planes together provides additional capacitance. Part 3 discusses the exposed pad (E Pad), another overlooked item that is essential for getting the best performance and most heat out of your PCB design.

The E-Pad (pin 0), is the paddle found underneath most modern high-speed ICs. An important connection, it ties all internal grounds from the die to a central point under the device. The E-Pad is responsible for the lack of ground pins in many converters and amplifiers. The key is to solder this pad to the PCB, making a robust electrical and thermal connection. If not, havoc can occur in your system.

Three steps help to achieve the best electrical and thermal connection to the E-Pad. First, if possible, replicate the E-Pad on each PCB layer. This creates a thick thermal connection to all grounds, allowing heat to dissipate quickly, and is especially important for high-power parts. Electrically, this gives a nice equal connection to all the ground layers. Replicating the E-Pad on the bottom layer allows it to serve as a ground point for decoupling and a place to attach a heat sink or thermal relief.

Second, partition the E-Pad into equal segments. A checkerboard pattern works best, and can be implemented by a silkscreen crosshatch or solder mask. There is no guarantee as to how solder paste will flow to connect the device to the PCB during the reflow assembly process, so the connection might be present but not evenly distributed or, worse yet, it might be small and positioned in a corner. Dicing the E-Pad into smaller partitions places a connection point in each separate area, ensuring a robust, even connection between the device and the PCB.

Finally, make sure that each partition has via connections to ground. The partition is usually big enough so that several vias can be placed. Make sure each of these vias are filled with solder paste or epoxy before assembly. This important step will ensure that the E-Pad solder paste won't reflow into the via voids, which would otherwise lower the chance of obtaining a proper connection.

To Learn More About High-Speed Layout
http://dn.hotims.com/34932-100

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

Have a question involving a perplexing or unusual analog problem? Submit your question to: www.analog.com/askrob

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BY BONNIE BAKER

Beyond the data sheet with IBIS

Have you ever found that a product improvement or upgrade turns out to be not what you need? For instance, imagine that you are trying to purchase a vehicle in Arizona. The sales representative tells you that the car will do anything and everything. After all, it is new and improved. You would expect the car to have a standard air-conditioning unit because Arizona is extremely hot, right? But what if it doesn't?

You can compare this situation to studying a new product's data sheet. You may think that the product offers everything you want, but the nuances in the specs may come back to bite you. As you begin your project and attempt to design a PCB (printed-circuit board), for example, you may find that the data sheet omits some of the information you need. You can tackle this problem by either asking the manufacturer for the information or augmenting the data sheet with the product's simulation model.

As you begin to tackle your PCB design, you must address signal-integrity issues with your digital pins. You will need basic signal-integrity elements, such as the input and output capacitance of the digital ports. The product's data sheet may not list this small detail. If it doesn't, you can measure a product sample. Better yet, you can look into the IBIS (input/output-buffer-information-specification) model.

In an IBIS model, the pin capacitance comprises the C_pin package capacitance plus the C_comp buffer capacitance (**figures 1** and **2**). The [Pin] keyword relates to a package, and the component, manufacturer, and package keywords above the [Pin] keyword describe the selected package. You will find the package capacitance in the [Pin] keyword table as it relates to your pin of interest. The remainder of this article uses the tsc2020.ibs model, which you can access online at www.edn.com/110526bonnie.

If you add the C_pin value to the C_comp value, you can derive this buffer's input capacitance in a tristate configuration. In this example, the total input capacitance of the TSC2020 SDA pin is 0.17059 pF plus 2.7972710 pF, or approximately 2.97 pF.

If the manufacturer of the product that you are considering is touting that product as new and improved, there may be more information on that product than meets the eye in your first evaluation. If you are frustrated about information missing from the standard product data sheet, take a look at the tools that surround that product. EDN

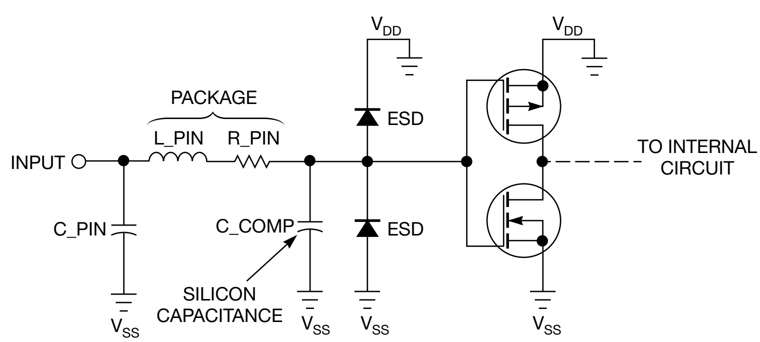

Figure 1 An input buffer for an IBIS model includes the package parasitics, electrostatic-discharge cells, and input gate.

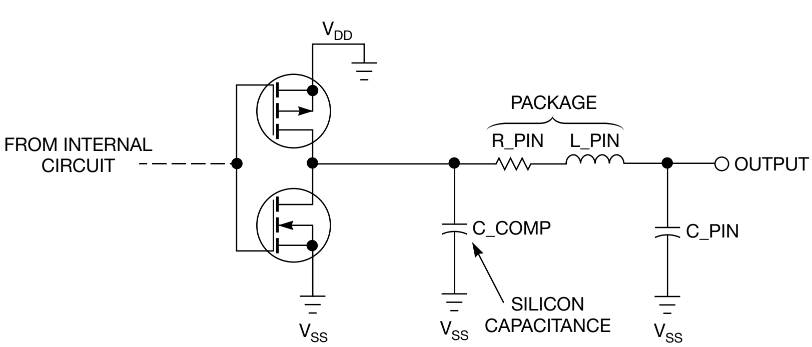

Figure 2 An output buffer for an IBIS model has the package parasitics and output gate.

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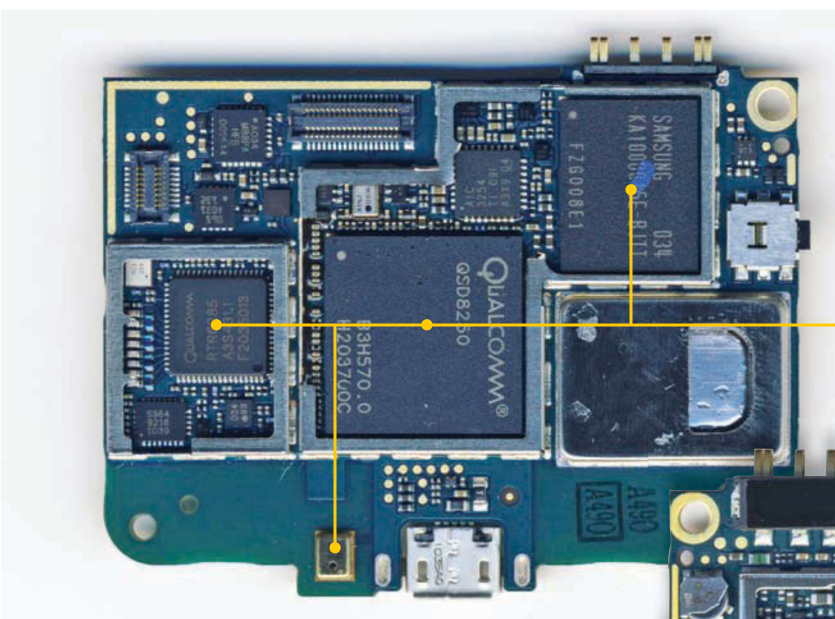
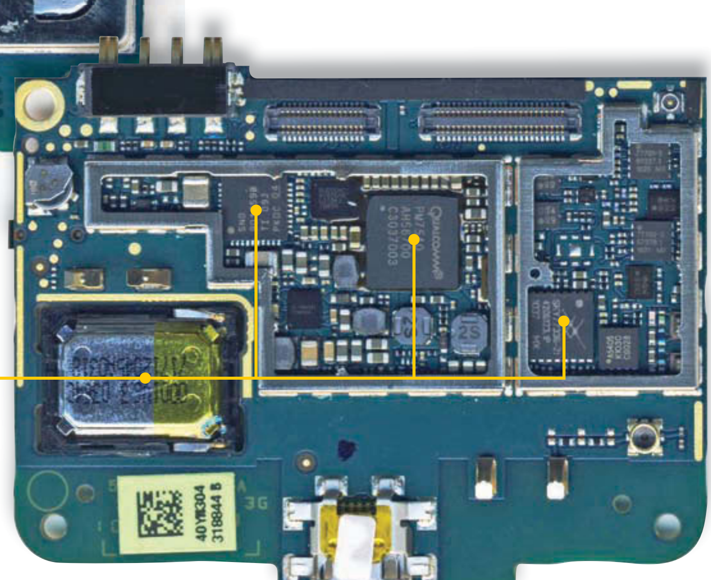
The HTC Surround: achieving differentiation through enhanced sound

Trumpeting its resurrection in mobile operating systems, Microsoft introduced the Windows Phone 7 operating system at the 2010 Mobile World Congress show. The company followed up with supporting hardware in October 2010. Although Windows Phone 7 uptake has so far been slow, Nokia in February 2011 announced its plans to anoint Microsoft's operating system as the successor to both Nokia's Symbian and the Nokia/Intel MeeGo, which should notably accelerate market-share growth. In partnership with iFixit, *EDN* takes a look at a first-generation WP7 handset, the HTC Surround, to assess both current platform status and future potential enhancements (see "HTC Surround Teardown," iFixit, http://bit.ly/e2YSpI).

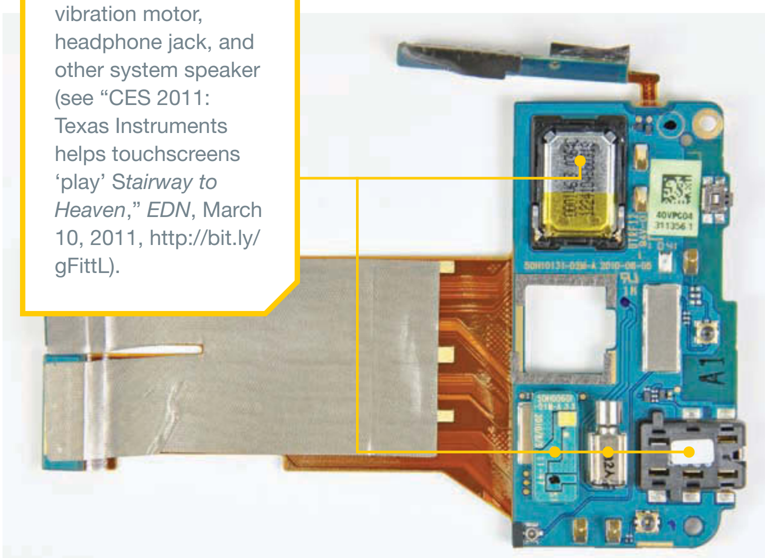


After a cursory inspection of the front side of the lower PCB, you may think you're rereading an earlier *EDN* article (see "The Nexus One: Google hits a smartphone home run," *EDN*, Feb 17, 2011, pg 24, http://bit.ly/hm4KTo). Like the HTC-designed Google Nexus One, the HTC Surround includes Qualcomm's RTR6285 multiband UMTS (Universal Mobile Telecommunications System)/EGPRS (enhanced general-packet-radio-service) transceiver with integrated GPS capability, along with the company's 1-GHz, ARM Cortex-A9-based QSD8250 Snapdragon SOC (system on chip) (see "ARM versus Intel: a successful stratagem for RISC or grist for CISC's tricks?" *EDN*, April 7, 2011, pg 24, http://bit.ly/hQwGEu). The phone also includes Samsung's two-die, single-package memory "sandwich," 4 Gbits each of NAND-flash memory and SDRAM. Like the Nexus One, the HTC Surround employs a dual-microphone array for ambient-noise suppression; the lower microphone mounts on this PCB.



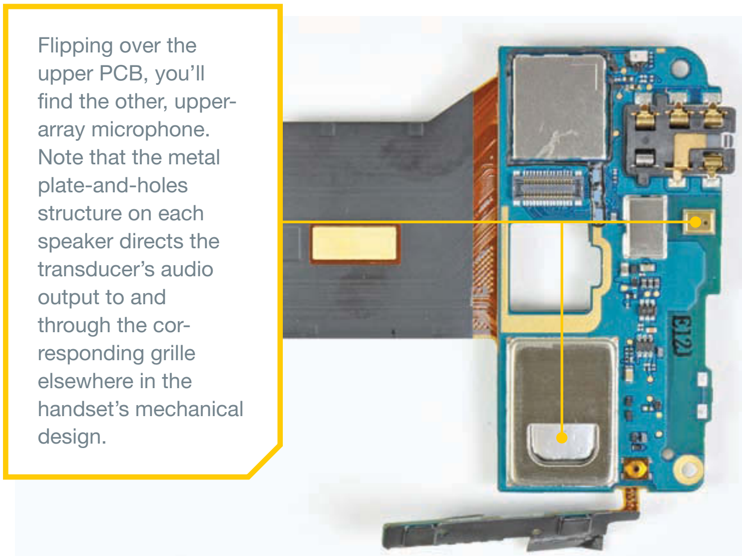
The HTC Surround contains a ribbon-cable-interconnected two-PCB stack. On the back side of the lower PCB, an Audience A1026 audio processor manages the two-microphone setup, as was the case with the Google Nexus One. Additional semiconductor content common with the Nexus One includes Qualcomm's PM7540 power-management IC and a Skyworks SKY77336 power-amplifier module. The HTC Surround integrates two speakers, one of which is visible here, for "stereo" audio playback.

The upper PCB's front exposes the camera's LED flash, vibration motor, headphone jack, and other system speaker (see "CES 2011: Texas Instruments helps touchscreens 'play' *Stairway to Heaven*," *EDN*, March 10, 2011, http://bit.ly/gFittL).

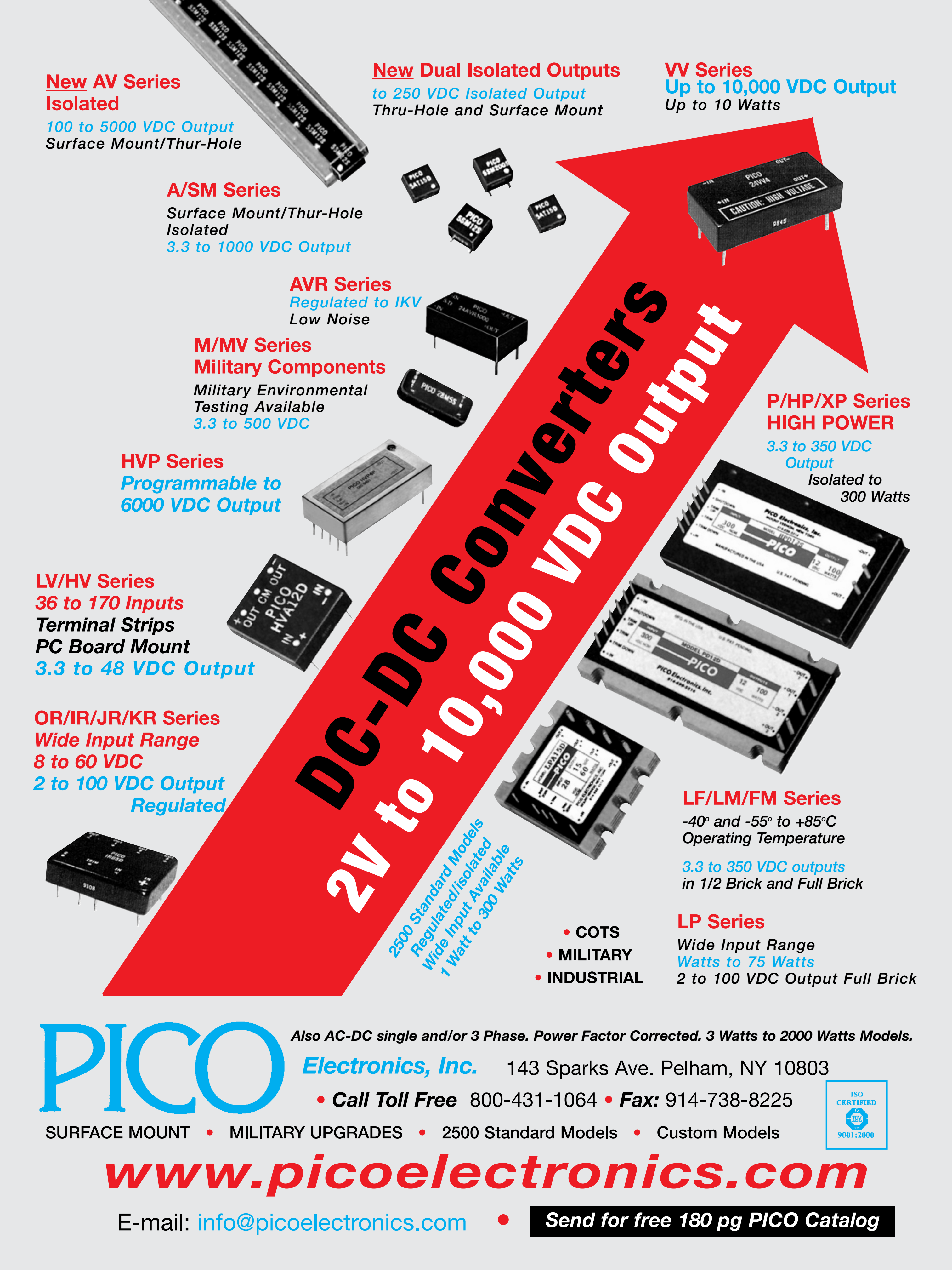


Handsets typically use a hinge-slider mechanism to stow a physical keyboard behind the LCD or OLED (organic light-emitting diode)—as with Google's T-Mobile G1 Android smartphone (see "T Mobile's G1: Google's Android OS emerges," *EDN*, Sept 22, 2009, pg 22, http://bit.ly/eW8h3q). With the HTC Surround, however, the slider exposes dual speaker grilles, which combine with a back-side stand to transform the smartphone into an audio/video playback nexus. Support for Dolby Mobile, SRS Wow HD virtual surround, and other audio-enhancement algorithms further ups the multimedia ante, but multiple reviewers' reports indicate that the speakers still sound tinny or are otherwise acoustically deficient.

Flipping over the upper PCB, you'll find the other, upper-array microphone. Note that the metal plate-and-holes structure on each speaker directs the transducer's audio output to and through the corresponding grille elsewhere in the handset's mechanical design.



This teardown does not show one key difference between this handset and the Nexus One—the touchscreen controller—because it's embedded within the display, and tearing down to that level would have damaged the handset beyond repair. The Nexus One uses a Synaptics controller, whereas HTC Surround uses Cypress' TrueTouch technology (see "Cypress TrueTouch Solution Drives Touchscreens for HTC's Hot New HTC 7 Surround And HTC 7 Mozart Phones," Cypress Semiconductor, Dec 7, 2010, http://bit.ly/ec4UPT).



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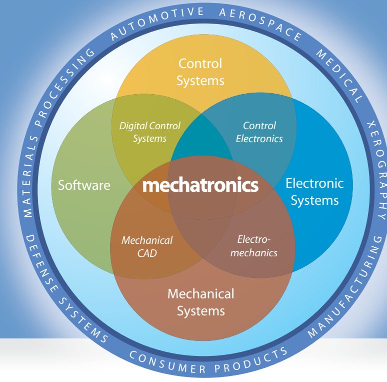

So, you want to build an H-bot?

The H-bot is conceptually simple, but the design of the controls makes it amazing.

Designers of modern robotics based their systems on modularity. Instead of using one six-axis robot for all applications, mechatronics engineers design a robot for each application. This approach places more emphasis on model-based design and system integration.

The H-bot, so-named because it resembles the letter H, is an example of such a robot. This 2-D robot, a planar mechanism for positioning an object in XY space, such as a plane, finds use in many industrial applications, such as pick-and-place, sorting, gluing, and inspection systems. It is easy to manufacture because it comprises two motors, a timing belt, and two perpendicularly mounted rails (**Figure 1**). Despite its dynamic simplicity, friction, backlash, and compliance throughout the mechanism are impediments to accurate positioning and represent system-design challenges.

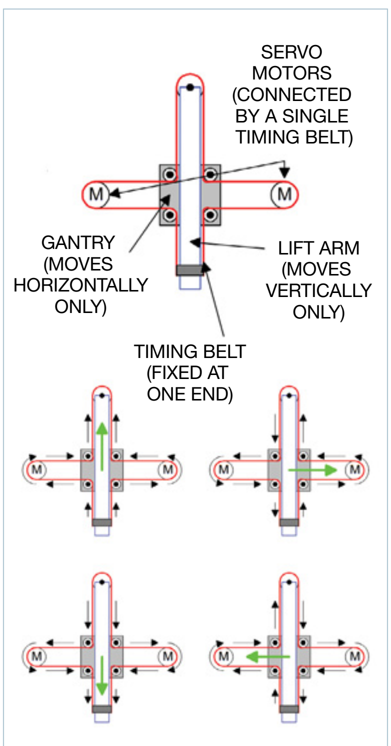

Figure 1 The 2-D H-bot robot comprises two motors, a timing belt, and two perpendicularly mounted rails.

As in any coordinated-motion system, the computation of the position command to each motor of the H-bot is just as important as the control scheme you employ to control the robot. The successful combination of these two aspects will lead to accurate positioning, but that concept means different things depending on the application. In point-to-point-system applications, such as a pick-and-place system, accurately moving to the target position is the main concern, whereas tracking applications, such as a gluing system, require a low number of position-following errors.

Motion applications typically use a cascade-control system that comprises position, velocity, and current loops, all typically proportional integral. Additional features, such as velocity feedforward to reduce position-following error and acceleration feedforward to reduce velocity-following error, are also usually part of the control architecture.

Many mechatronics engineers lack a thorough understanding of the position-command computation. Its complexity depends on the shape of the path the robot must follow. Paths with sharp corners, such as a square, are challenging to accurately reproduce with a machine. The challenge resides in accurately following sharp corners. Poor implementation of the calculation of the position command causes an overshoot on the corner, yielding imperfections in the product.

One approach to mitigating this effect produces perfect corners for a square shape with an H-bot. In this approach, each side of the square becomes a segment on the motion profile, which is defined by the geometry of a square projected on X and Y axes. Thus, you obtain the profile X and Y axes in the Cartesian space. You then employ the inverse kinematics of the robot to obtain the position profile at the motor shafts. Use a master axis to obtain synchronization between axes. The motion profile of this master axis plays a key role in creating perfect corners. Four segments that start and end at each corner of the square shape define this profile. To reduce machine vibration, wear, and noise, use a smooth profile, such as a fifth-order polynomial profile, to define the motion of the master axis from corner to corner.

You can find details on the design and construction of an H-bot, including modeling, analysis, control design, and experimental validation, at www.multimechatronics.com. EDN

Kevin C Craig, PhD, is the Robert C Greenheck chair in engineering design and a professor of mechanical engineering, College of Engineering, Marquette University.

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IMPLEMENTING AN SLVS TRANSCEIVER

SLVS PROVIDES AN IMPORTANT NEW ALTERNATIVE TO LVDS FOR HIGH-SPEED SIGNALING, BUT IT PLACES HEAVY DEMANDS ON I/O CIRCUITRY, ESPECIALLY IN FPGAs. YOU MUST WATCH THE DETAILS.

BY FENG CHEN • LATTICE SEMICONDUCTOR CORP

Over the past two decades, the explosive growth in demand for data bandwidth has led to a variety of data-transmission standards. Lower implementation costs and the ability to transfer more data bits with less power consumption are the primary goals of any data-transmission standard. Since National Semiconductor's (www.national.com) introduction of LVDS (low-voltage differential signaling) in 1994, it has become the most widely adopted data-transceiver standard in the industry for delivering gigabit performance levels at milliwatt power levels.

Although the company crafted the technology for easy implementation in the equipment of a previous decade, it has its limitations. Addressing the limitations of LVDS as a generic standard, several variations have evolved to meet application-specific requirements. In October 2001, the JEDEC (Joint Electron Device Engineering Council) Solid State Technology Association published the SLVS (scalable-low-voltage-signaling) standard for 400-mV operation. SLVS inherits from LVDS low noise susceptibility. It also boasts a scaled-down 400-mV signal swing—versus the 700-mV swing of LVDS—and includes a ground reference. This combination results in lower power consumption for transmission. The interface normally requires a 0.8V power rail, which is commonly available in submicron silicon devices. Designers can achieve a data rate as high as 3 Gbps or beyond over a range that is compatible with the size of a typical PCB (printed-circuit board). This combination of features makes SLVS appropriate for use in high-speed, low-power transmission for interdevice data links on a PCB.

This utility also makes SLVS important in the FPGA world. Designers often use FPGA devices, due to their feature-rich I/O ports, for datapath interfacing and protocol bridging. With the increasing popularity of SLVS in data-channel design, designers hope to achieve economic and robust FPGA design for SLVS-transceiver applications. Most FPGAs support the traditional LVDS interface. However, designers cannot program all modern FPGA-I/O structures to drive current at SLVS requirements for output, and not all provide a built-in differential termination to receive SLVS input with few external components. To determine the abilities of an FPGA-I/O design to support SLVS, you must look deeper into both the standard and the I/O structures that today's programmable devices use.

LVDS/SLVS OVERVIEW

The LVDS data-transmission standard is a mature technology and has become the most common transceiver interface in applications such as video, storage, and data communications, which require transmission of large amounts of data. In a point-to-point LVDS link,

IMAGE: GETTY IMAGES

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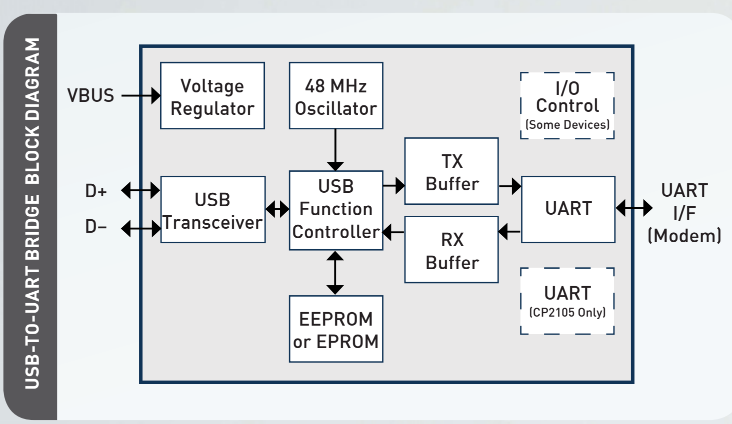

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AT A GLANCE

- SLVS (scalable low-voltage signaling) offers significant power savings over LVDS (low-voltage differential signaling).
- SLVS reduces both signal-swing and common-mode voltages.
- Some FPGAs can implement SLVS I/Os.

a current source in the transmitter toggles polarity as the signal changes state, driving the wire loop (**Figure 1**). Most of the drive current flows through the receiver-side termination resistor, assuming high impedance at the op amp's input for dc current. The voltage drop across the termination resistor is proportional to the drive current; when the transmitter toggles, the receiver's op amp detects the change in polarity, recognizing the change in signal state at the transmitter's input.

LVDS offers high noise tolerance because it uses a pair of differential traces to provide common-mode rejection. Both the speed of data transmission and the power dissipation closely relate to the voltage swing across the termination resistor, which is 350 mV, or 700 mV p-p nominal, over a 100Ω resistor for a typical LVDS loop.

LVDS channels have a low susceptibility to external noise because distant noise sources tend to add the same amount of voltage to both lines, so the difference between the voltages remains the same. The low common-mode voltage is the average of the voltages on the two traces—approximately 1.25V. The transmitter sets the common-mode voltage as an offset voltage from ground. The 350-mV differential voltage causes the LVDS to consume static power in the LVDS load resistor, depending on the 1.25V offset voltage and 350-mV differential-voltage swing.

The JEDEC JESD8-13 SLVS-400 standard defines a point-to-point signaling method. SLVS uses smaller voltage swings and a lower common-mode voltage than LVDS. The 200-mV, or 400-mV-p-p, SLVS swing contributes to a reduction in power and is common in RSDS (reduced-swing-differential-signaling) standards. The RSDS standard reduces the swing from 350 mV to 200 mV with the same 1.25V common-mode offset of the LVDS standard. SLVS goes further and also reduces the common-mode voltage. The SLVS nominal common-mode voltage of 200 mV provides a considerable decrease in quiescent power. The combination of a smaller signal swing and low common-mode voltage produces much lower power consumption.

To illustrate this point, consider that a 6-Gbps LVDS SERDES (serializer/deserializer) link consumes approximately 250 mW. A typical SLVS pair running at 800 Mbps consumes approximately 15 mW. Even eight 800-Mbps SLVS links running in parallel for a combined speed of 6.4 Gbps consume only about 120 mW—less than half the power consumption of the LVDS implementation.

FPGA DESIGN FOR SLVS

To build an SLVS-compatible interface, a designer must consider whether the target FPGA device provides sufficient hardware resources and flexibility at its I/O ports for both receiver and transmitter implementation. Embedded differential termination is preferable in an SLVS receiver to minimize the number of onboard components that directly connect to its transmitter peer. More important, many FPGA receivers target use in LVDS, so designers should ensure that the FPGA receiver's differential and common-mode range covers the entire SLVS output specification. The FPGA's differential output port also must be able to source the drive current for the proper SLVS level with an external coupling-resistor network.

Like LVDS, SLVS requires a load termination at the receiver but does not specify whether the termination is inside or outside the receiver. Most FPGA devices typically use both built-in and board resources to build an SLVS interface to industry-standard devices. To achieve cleaner board interconnections and robust system performance, an FPGA device that contains built-in differential termination in the receiver implementation has an advantage (**Figure 2**).

The programmability of the output current source is critical for an SLVS transmitter. You must program the differential driver current to a value that emulates SLVS requirements. The design typically uses an onboard resistor network to adjust the swing and common-mode voltages that the SLVS receiver requires. To compensate for the power consumption of the onboard resistor network, the current-source

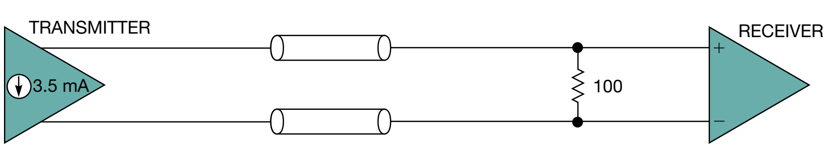

Figure 1 The LVDS transmitter drives the line from an internal current loop.

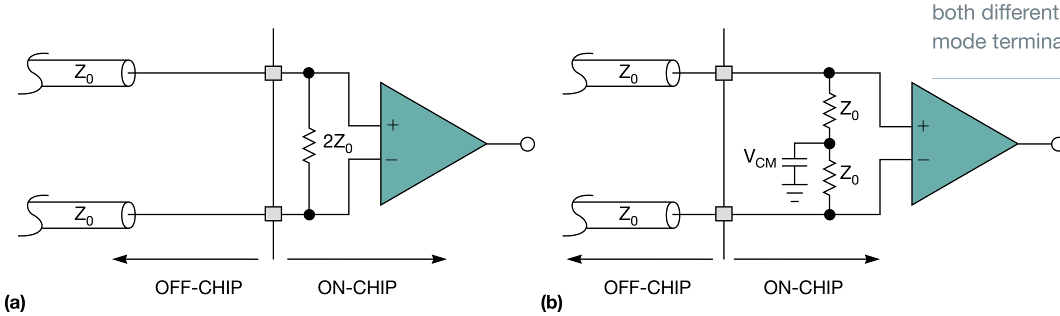

Figure 2 FPGAs can use differential termination (a) but should use both differential and common-mode termination (b) for SLVS.

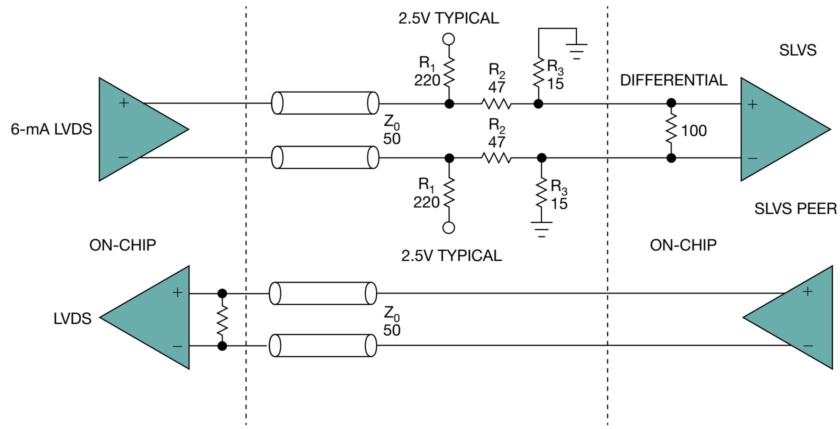

Figure 3 An FPGA with internal termination offers a simple connection to an SLVS peer device.

driver buffer typically must inject more than the LVDS-nominal 3.5 mA of current into the off-chip differential traces. A current-driver buffer meeting this requirement is not commonly available with a traditional LVDS-compatible FPGA-I/O port.

One SLVS-interface implementation uses an FPGA in which the features of the LVDS inputs conform to the signaling requirements to directly connect to SLVS transmitters (**Figure 3**). The internal differential terminations are available for inputs on all sides of the device. Common-mode- and differential-voltage ranges sufficiently cover the SLVS output spec, enabling the inputs to receive data streams as fast as 2 Gbps without any additional board components. The FPGA also provides programmability of differential-current output at 2, 3.5, 4, and 6 mA. This example uses a 6-mA driver current with the off-chip termination circuitry to emulate the SLVS requirements. **Table 1** details SLVS-specification conformance for this example.

SLVS APPLICATIONS

The SLVS interface finds application in, for example, data communications and video/image displays requiring high-speed and low-power data channels. An FPGA device with SLVS-compatible transceivers plays an important role in bridging the SLVS I/O on a standard IC product to other data protocols. The recent design-in of a Lattice (www.latticesemi.com) SC/M FPGA with a Broadcom (www.broadcom.com) VDSL2 (very-high-bit-rate-digital-subscriber-line) reference line card demonstrates how the FPGA provides SLVS interfacing and XAUI (10-Gbps-attachment-unit-interface) PHY (physical)-layer bridging functions.

On the VDSL2 reference design, the FPGA implements six SLVS links (**Figure 4**). The FPGA device functions as a bridge between the SLVS

TABLE 1 SLVS INPUT- AND OUTPUT-SPECIFICATION CONFORMANCE

Characteristic	Device LVDS input (mV)	SLVS output (mV)
Minimum common-mode voltage	50	150
Maximum common-mode voltage	2350	250
Minimum differential voltage	100	140
Maximum differential voltage	2400	270
Characteristic	**Output with resistor network (mV)**	**SLVS input (mV)**
Minimum common-mode voltage	150	70
Maximum common-mode voltage	280	330
Minimum differential voltage	180	140
Maximum differential voltage	280	450

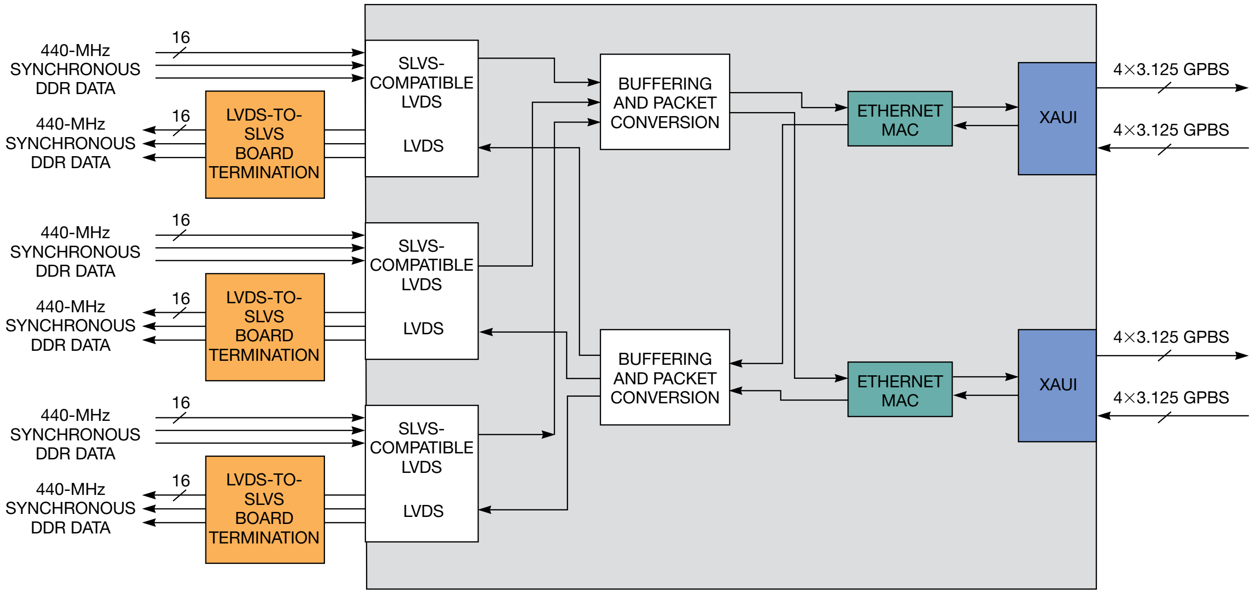

Figure 4 An FPGA bridges between an SOC with SLVS I/O and a set of XAUI ports.

data stream and the XAUI packets. The VDSL2 device transmits three links and receives three links. Each link contains an 18-bit bus, connecting to the standard SLVS ports from Broadcom's DSL (digital-subscriber-line)-termination ICs to the FPGA. The FPGA can steer and multiplex the SLVS buses from any of the three receiver links to any of the three transmitter links, so the Broadcom devices all interconnect. At the other side of the FPGA, eight 3.125-Gbps SERDES channels can form two interfaces for Ethernet-switch connections. This configuration constructs a typical 48-line VDSL2 terminal in a 10-Gbps backhaul connection.

The differential I/Os on the FPGA support a data-transmission speed of 884 Mbps. Along with built-in LVDS transceivers and XAUI-sublayer logic, the FPGA internally implements two buffering and packet-conversion function blocks and two Ethernet MAC (media-access-control) blocks. All four of these blocks consume less than 15,000 look-up tables. This relatively high ratio of SERDES-to-look-up-table resource requirements is characteristic of many implementations of high-speed SLVS bridging in DSLAM (digital-subscriber-line-access-multiplexer) applications. Along with adequate I/O flexibility to implement robust SLVS ports, it is useful for the FPGA family to have members that emphasize high-speed-I/O-pin count rather than logic-cell count.

A number of features, including low differential-mode signal swing and low common-mode voltage, provide lower power dissipation for SLVS ports than that of LVDS ports. This advantage is leading to wide use of SLVS within the communications/networking community, especially on the latest generation of SOCs (systems on chips). FPGAs provide a flexible and economical implementation for a data-transmission interface and for protocol bridging, so it is important for designers to understand how to implement an SLVS interface in an FPGA. Design engineers should carefully consider an FPGA's I/O features and select the right device from commonly available LVDS-compatible systems to implement the lower-power SLVS interface. Features such as wide input common-mode range, built-in differential-termination load, programmable SLVS drive-current output, and high SERDES-to-logic ratios can have a substantial effect on board-level implementation of SLVS links. **EDN**

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AUTHOR'S BIOGRAPHY

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AUTOMOBILE SENSORS **MAY USHER IN** SELF-DRIVING CARS

BY MARGERY CONNER • TECHNICAL EDITOR

Google last year demonstrated the results of its research-and-development efforts to create an autonomous vehicle. The small fleet of specially equipped cars—six Toyota Priuses and one Audi TT—has logged more than 140,000 miles of daytime and nighttime driving in California, including traversing San Francisco's famously crooked Lombard Street and the Los Angeles freeways (Figure 1). In all cases, an engineer was in the driver's seat, monitoring each car's performance and ready to take over if necessary.

A robocar of the future would be so intelligent that its driver would be able to read, play, or work rather than piloting the car. The benefits would include safety, freeing up the driver for other tasks or recreation, and the more effective use of the traffic infrastructure due to more efficient traffic regulation and fuel efficiency.

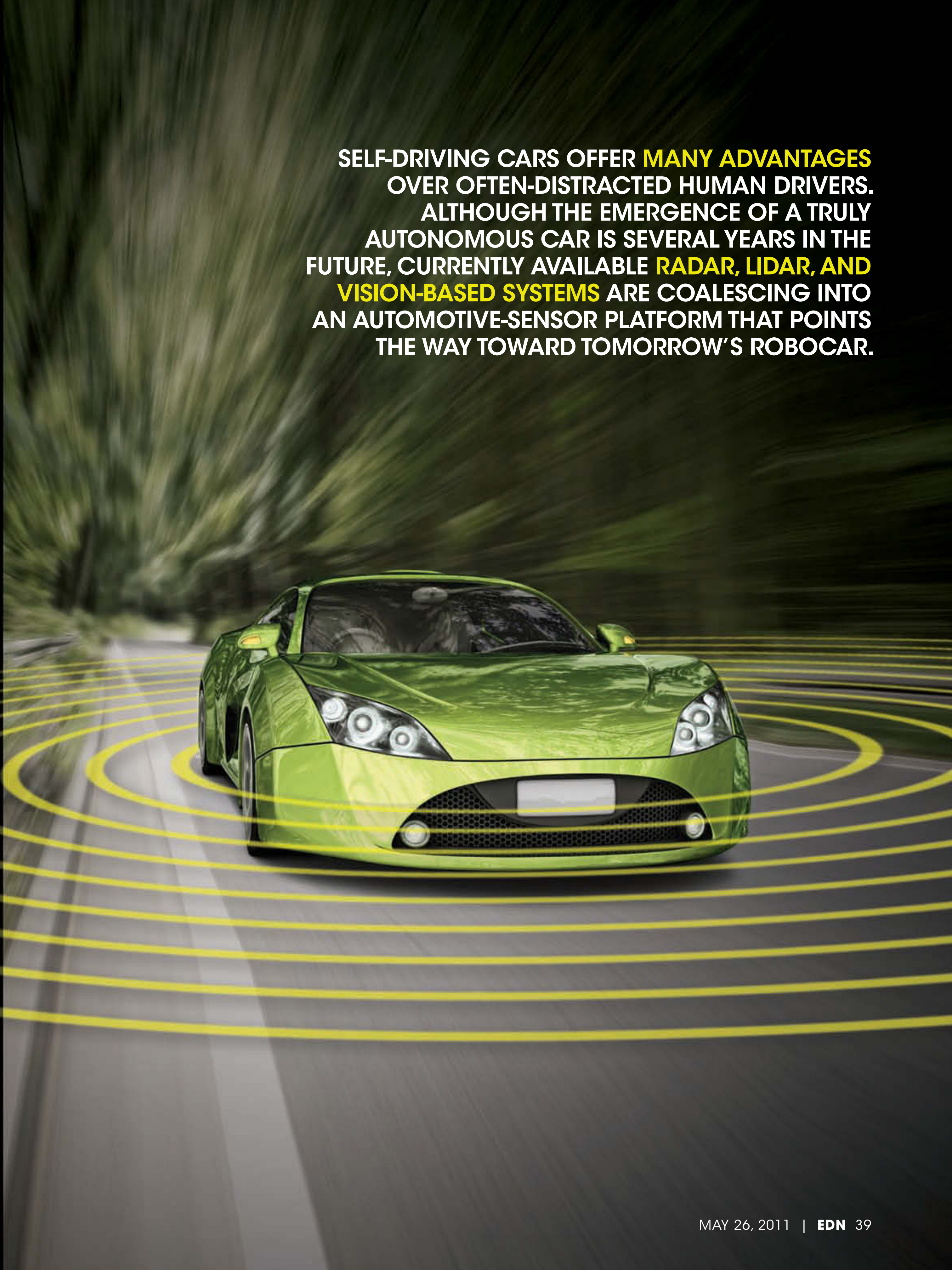
Motor-vehicle accidents are the leading cause of death of 13- to 29-year-olds in the United States. According to Sebastian Thrun, an engineer at Google and the director of the Stanford Artificial Intelligence Laboratory, which created the Google robocar, almost all of these accidents are the result of human error rather than machine error, and he believes that machines can prevent some of these accidents.

"We could change the capacity of highways by a factor of two or three if we didn't rely on human precision for staying in the lane and [instead] depended on robotic precision," says Thrun. "[We could] thereby drive a little bit closer together in a little bit narrower lanes and do away with all traffic jams on highways."

Doubling highway capacity by a factor of three with no added infrastructure costs and freeing an hour or two a day for productive or relaxing pursuits seem like worthy goals, but how close is the auto industry to achieving a practical self-driving car? Google is not in the car-production business and has no business plan for monetizing its research (Reference 1). In Google's approach, autonomous vehicles will not require a government mandate to become reality. The Google fleet uses LIDAR (light-detection-and-ranging) technology, such as that in a system

IMAGE: ISTOCK

SELF-DRIVING CARS OFFER MANY ADVANTAGES OVER OFTEN-DISTRACTED HUMAN DRIVERS. ALTHOUGH THE EMERGENCE OF A TRULY AUTONOMOUS CAR IS SEVERAL YEARS IN THE FUTURE, CURRENTLY AVAILABLE RADAR, LIDAR, AND VISION-BASED SYSTEMS ARE COALESCING INTO AN AUTOMOTIVE-SENSOR PLATFORM THAT POINTS THE WAY TOWARD TOMORROW'S ROBOCAR.



available from Velodyne's HDL (high-definition LIDAR)-64D laser-sensor system, which uses 64 spinning lasers and then gathers 1.3 million points/sec to create a virtual model of its surroundings. One reason to use LIDAR rather than radar is that the laser's higher-energy, shorter-wavelength laser light better reflects nonmetallic surfaces, such as humans and wooden power poles. Google combines the LIDAR system with vision cameras and algorithmic vision-processing systems to construct and react to a 3-D view of the world through which it is driving (**Reference 2**).

The enabling sensor hardware in the vehicles enables the cars to see everything around them and make decisions about every aspect of driving, according to Thrun. Although we are not close yet to a fully autonomous vehicle, the technology, including the sensor platform of radar, ultrasonic sensors, and cameras, is available in today's intelligent vehicle. It remains only to standardize the car's hardware platform and develop the software. Cars are approaching the point that smartphone platforms had reached just before the introduction of the Apple iPhone and the Motorola Android.

As sensors decrease in price and increase in integration, they will become ubiquitous in all cars. Once users accept them as normal parts of a car, then automotive-OEM companies can integrate more intelligence into them until they achieve the goal of an autonomous car. Today's intelligent automobile can perform many driver-assistance tasks, such as avoiding and preventing accidents and reducing the severity of accidents. To perform these tasks, the vehicles have passive safety systems, such as air bags and seat belts; active safety systems, such as electronic stability control, adaptive suspension, and yaw and roll control; and driver-assistance systems, including adaptive cruise control, blind-spot detection, lane-departure warning, drowsy-driver alert, and parking assistance. These systems require many of the same sensors that the autonomous car requires: ultrasonic sensors, radar, LIDAR systems, and vision-imaging cameras.

Cars now use ultrasonic sensors to provide proximity detection for low-speed events, such as parallel parking and low-speed collision avoidance. Ultrasonic detection works only at low speeds because it senses acoustic waves; when the car is moving faster than a person can walk, the ultrasonic sensor is blind.

Although ultrasonic-sensor technology is more mature and less expensive than radar, car designers who care about the aesthetics of the car's appearance are reluctant to have too many sensor apertures visible on the car's exterior. As a more powerful and more flexible technology, radar should begin to replace ultra-

AT A GLANCE

- Although self-driving cars are still five to 10 years in the future, they offer many benefits in traffic and fuel efficiency, safety, and time saving.
- Self-driving cars will require relatively few infrastructure changes, with cars relying on sensors and processors to "see" and react to their surroundings.
- Some of the key sensors will be radar or LIDAR (light-detection-and-ranging) and vision systems, such as visible light and IR (infrared) cameras.

Figure 1 Google's fleet of specially equipped cars has logged more than 140,000 miles of daytime and nighttime driving in California, including traversing San Francisco's famously crooked Lombard Street and the Los Angeles freeways.


Where power is hard to find,
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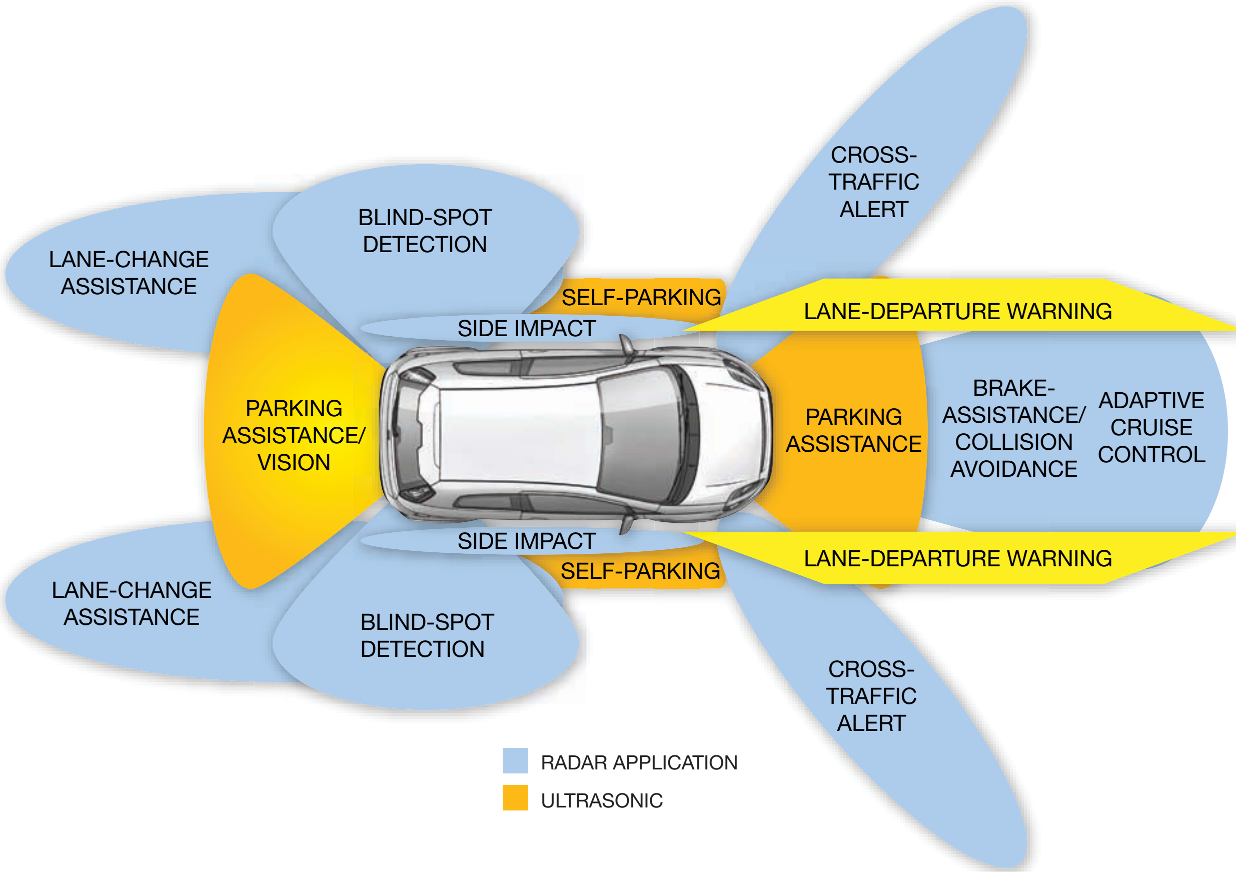


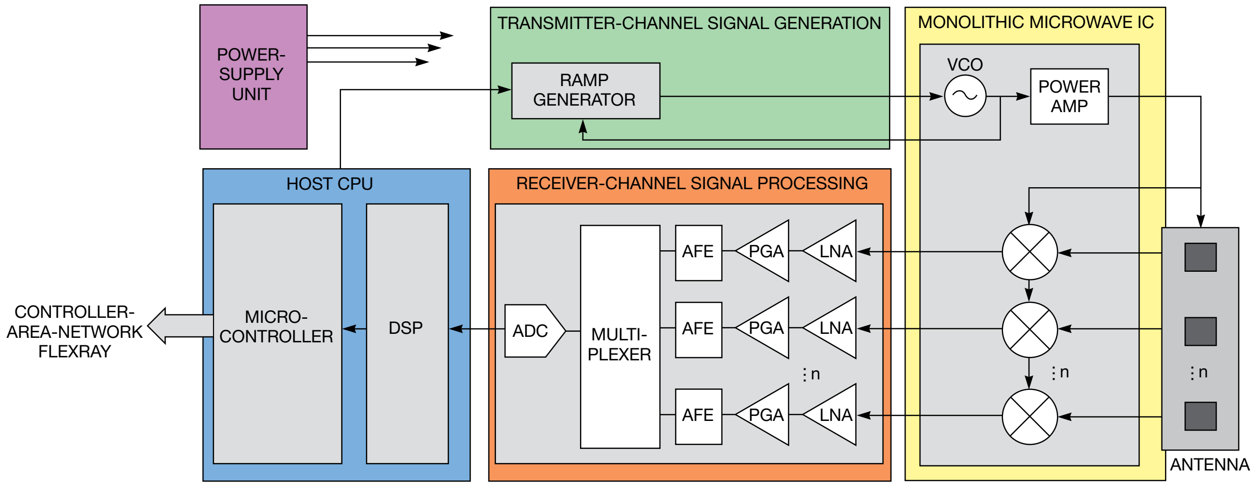
Figure 2 Several driver-assistance systems are currently using radar technology to provide blind-spot detection, parking assistance, collision avoidance, and other driver aids (courtesy Analog Devices).

sonic sensors in future designs (**Figure 2**).

Radar works in any type of weather and has short-, medium-, and long-range characteristics. For example, adaptive cruise control works in the long range, looking 200m in front of the car, tracking the car, and accelerating or braking the car to maintain a certain distance. Radar also provides blind-spot detection and lane-departure warning. Early versions of these systems audibly warned the driver of an impending problem, but some implementations now take control of the car to avoid the problem. For example, the 2011 Infiniti M56 has an optional blind-spot-warning/intervention system that relies on radar scans from the left and the right rear quadrant of a car. If the radar system detects a car in the driver's blind spot, a light comes on. If the driver activates the turn signal, an audible beep comes on. If the driver persists and starts to move into another lane, the car gently applies brakes on the opposite side of the car, moving the car back into the center of the lane (**Reference 3**).

Most automotive radar systems currently are not highly integrated, taking up significant space, and are costly. Analog Devices' recently introduced AD8283 integrated automotive-radar-receiver analog front end represents the increasing integration that decreases the size and cost of automotive radar (**Figure 3**). It will sell for about 50% less than a discrete design for an automotive analog front end and fits into a 10×10-mm package. "The market is moving toward putting radar into nonluxury vehicles—cars for the rest of us," says Sam Weinstein, product manager for the Precision Linear Group at Analog Devices. The sample price for a six-channel AD8283 is $12.44 (1000).

IR (infrared) LEDs and photosensors find use in automotive applications, such as rain sensing/wiper activation on



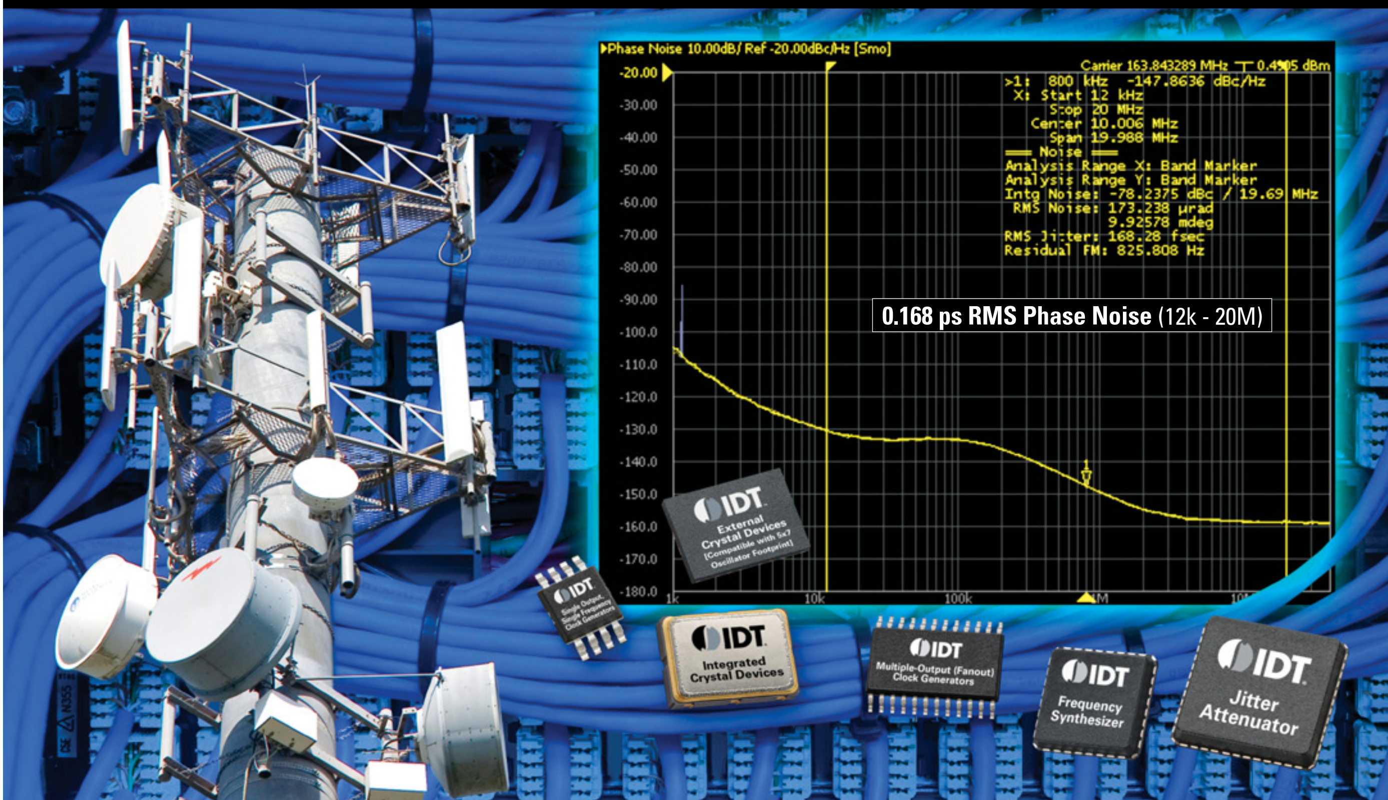
NOTES: AFE: ANALOG FRONT END
LNA: LOW-NOISE AMP
PGA: PROGRAMMABLE-GAIN AMP
VCO: VOLTAGE-CONTROLLED OSCILLATOR

Figure 3 The Analog Devices AD8283 radar analog front end comprises transmitter-channel-signal-generation, power-supply, host-CPU, receiver-channel-signal-processing, and monolithic-microwave-IC blocks.

the BMW 7 series and the Ford Edge. Sophisticated IR cameras enable safety applications, such as drowsy-driver sensing, which is also an option in the Mercedes E550 sedan. Drowsy-driver sensing uses an IR camera to watch the driver's eyelids to tell whether they are blinking rapidly, indicating that the driver is alert, or blinking slowly or even closing. The car emits an audible warning or vibrates the driver's seat.

Out-of-position sensing similarly uses IR cameras. Today's passenger seats must have pressure sensors to determine the weight of the passenger and use the

Integrated Device Technology FemtoClock NG – When a Trillionth Of a Second is Just Too Long



The FemtoClock Next Generation (NG) clock synthesiser family allows engineers to generate almost any output frequency from a fixed frequency crystal, and to meet the challenges of the most demanding timing applications.

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With FemtoClock NG technology, IDT has eliminated the most challenging aspects of silicon-based clock design and introduced an unprecedented level of flexibility for clocking in high-performance applications.

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Figure 4 The Fraunhofer Institute expects to bring to market a camera as small as a grain of salt, which could replace side-view mirrors, reducing airflow drag.

information to deploy the passenger's air bags. The air bags deploy at different speeds, depending on the weight of the passenger. This sensor does not know, however, whether the passenger is leaning on the dashboard, reclining in the seat, or moving to the left or the right. The closer the passenger is to the deploying air bag, the greater the impact. The camera monitors the passenger's position, and, upon impact, deploys the air bag appropriately to the passenger's size and position.

These cameras use IR LEDs rather than those in the visible spectrum because they must be able to work at night. It would be distracting to illuminate the driver or the passenger with visible light for the camera to sense. The human eye detects light as visible at distances as great as approximately 700 nm, whereas IR cameras detect 850- to 900-nm-distant light.

IR imaging also has a place outside the car for crash avoidance, and these applications require IR illumination. According to Sevugan Nagappan, marketing manager of the infrared business unit at Osram Opto Semiconductors, IR cameras can help in collision avoidance by seeing beyond what the high beams illuminate. "IR-LED illumination allows you to see when you can't have your high beams on to see past your headlamps, for example, allowing the system to see beyond the headlights to see and avoid a deer entering the road," he says.

IR LEDs' primary use has so far been in remote controls. However, these inexpensive LEDs use 10 mW or less of power. Automotive applications require output power of greater than 1W to illuminate the subject. In addition, the IR LED must be small enough to fit next to the IR camera and be inconspicuous. Nagappan estimates that the camera needs to measure less than 10 mm^2, and illuminating the IR LED requires 5 mm^2. He says that manufacturers can make LEDs in small packages that can provide 3.5W and that these devices are enabling new applications. Osram's 3.5W SFH 4236 IR LED has an integral lens with a narrow beam angle to focus the IR light, increase the beam intensity, and focus the beam into the eye box to watch the driver's eyes.

Innovation is also driving down the cost of the cameras. The Fraunhofer Institute expects to bring to market a camera as small as a grain of salt and costing only a few euros. The resolution currently is 250×250 pixels. These cameras could replace side-view mirrors, reducing airflow drag (**Figure 4**). EDN

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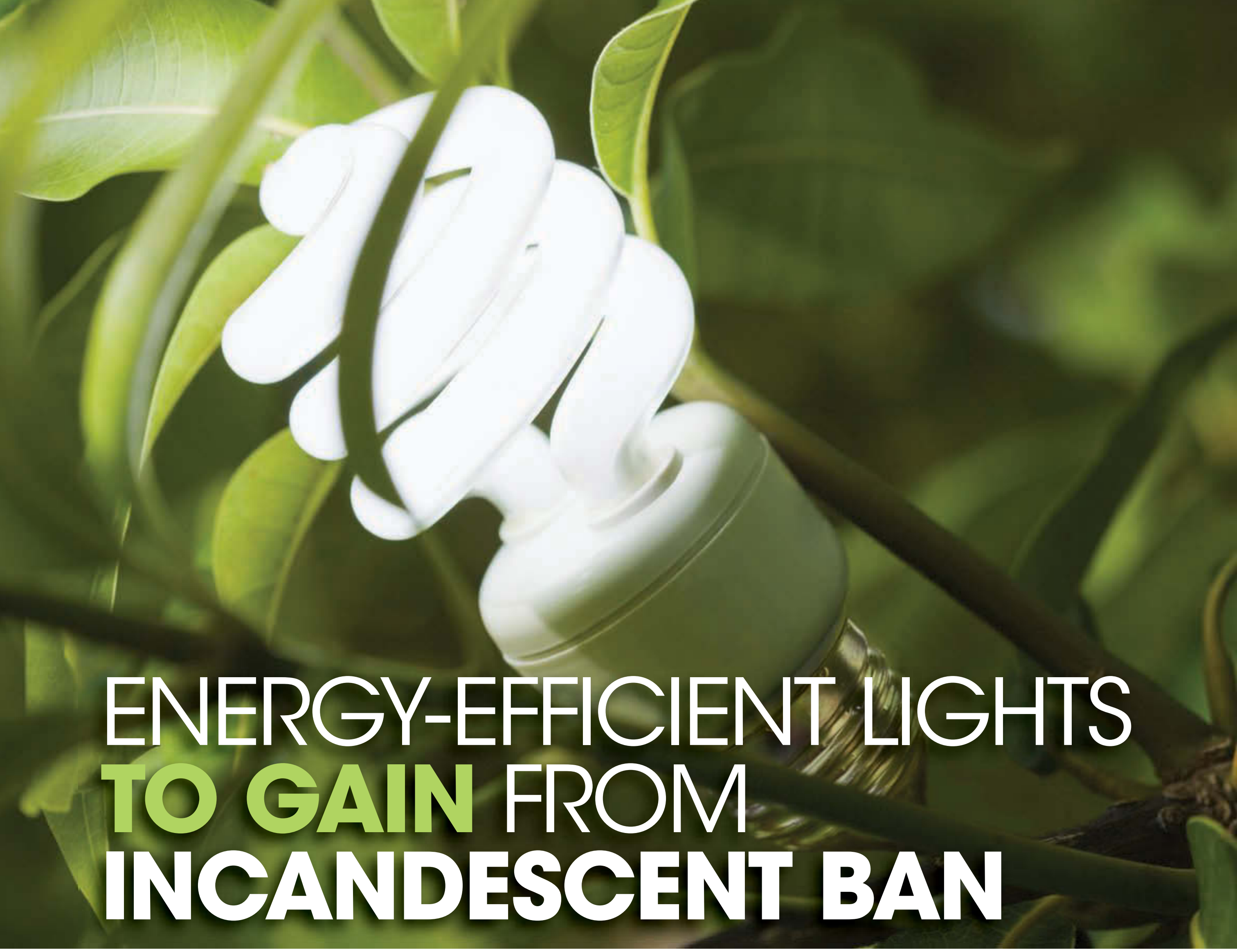

ENERGY-EFFICIENT LIGHTS **TO GAIN** FROM **INCANDESCENT BAN**

THE 100-YEAR-LONG REIGN OF THE INCANDESCENT LIGHT BULB IS ABOUT TO END. RATHER THAN BEMOANING ITS DEATH, LIGHTING-CIRCUIT DESIGNERS WOULD DO WELL TO SEE THE OPPORTUNITY IN OFFERING A LIGHT WITH INSTANT-ON, THAT DIMS WITHOUT FLICKER, AND THAT IS RELIABLE AND COST-EFFECTIVE.

BY MARGERY CONNER • TECHNICAL EDITOR

The Energy Independence and Security Act of 2007 dictates the phase-out of the incandescent light bulb starting in 2012 (**Reference 1**). The bill does not specifically ban incandescent lights: You will still be able to buy any incandescent light that can meet the act's efficacy specification of a 25% improvement in incandescent-light output. The lights are notoriously poor producers of usable light, however. They lose 96% of the power they use to heat; hence, Hasbro uses them as the heating element in the Easy-Bake toy oven. So far, no one has discovered a cost-effective way of coaxing more light and less heat from incandescent lights.

Nevertheless, both state and national governments, as well as consumers' preference for saving money in the face of rising energy costs, are signaling the end of the line for common incandescent light bulbs. Herein lies an opportunity for engineers in creating lights that not only replace incandescents but also enhance the home or commercial environment through automatic energy savings and create a pleasant lighting environment.

Lighting technologies such as LED, fluorescent, and halogen are vying to become the new ubiquitous light source.

IMAGE: THINKSTOCK

The challenge in the near future is to provide a lighting experience that matches consumers' expectations for how a light should work. Consumers don't necessarily want incandescent lights but rather lighting "experiences" that match their expectations—lights that come on instantly; work with currently installed light switches, including TRIAC (triode-alternating-current)-based dimmers; deliver a warm- to bright-white light; cost-effectively save energy, and have lifetimes of more than 10,000 hours.

As a recent *EDN* article notes, Avnet illumineer George Kelly believes that our preference for warm colors dates back to prehistoric times when firelight was the only option for light at night (**Reference 2**). Blue light is more prevalent during the day when the sun is high, whereas redder, warmer light is a signal that the day is winding down and it's time to relax. In other words, the goal of indoor lighting should be to as closely as possible match the black-body curve rather than simply to meet a color temperature or CRI (color-rendering index).

According to Wikipedia, German physicist Gustav Kirchoff introduced the term "black body" in 1862 to describe an idealized physical body that absorbs all incident electromagnetic radiation. Because of this perfect absorptivity at all wavelengths, a black body is also the best possible emitter of thermal radiation, which it radiates incandescently in a characteristic, continuous spectrum that depends on the body's temperature. At Earth-ambient temperatures, this emission is in the infrared region of the electromagnetic spectrum and is not visible. The object appears black because it neither reflects nor emits any visible light (**Figure 1** and **Reference 3**).

Another recent *EDN* article suggests that lighting can influence sleep (**Reference 4**). The circuit in the article uses one cyan LED and one royal-blue LED to vary the current between them to achieve 32 shades of blue. According to the article, "When coach cars of long-range trains comprised compartments for six to eight passengers, the passengers could choose either 'white' or deep-blue light. The blue light helped passengers sleep, even when they were not in full darkness."

This brief description is a bit hazy, but it implies that European trains once offered a blue light as a soothing nighttime color that would aid in sleep. Although the approach of using light to influence sleep is correct, the color is wrong. We now know that it's just the opposite: Blue light suppresses the production of melatonin, a hormone that helps induce sleep and, hence, drowsiness. Blue light of approximately 460 to 480 nm suppresses melatonin, an effect that increases with increased light intensity and length of exposure. Until recent history, humans in temperate climates were exposed to few hours of blue daylight in the winter; their fires produced predominantly yellow light (**Reference 5**). In addition, blue light also has a strong link to the setting of circadian rhythms, also necessary for healthful living (**Reference 6**).

A link between lighting and insomnia may also be possible. Seth Roberts, a psychology professor at the University of California—Berkeley, has explored the connection between lighting and insomnia, using himself as a guinea pig and referencing related research studies. He concludes that people who experience bright sunlight early in the day and no fluorescent lights just before bedtime have better sleep patterns (**Reference 7**).

Lighting technology has so far been developing along a drunkard's walk of innovation: We started out with the incandescent light bulb, which seemingly by chance uses a filament that mimics the yellow-red tones of white light and is a good stand-in for the burning embers of a prehistoric community fire. We then moved to fluorescent light, which in some instances has a distinct blue bias in its color temperature—one of the worst color choices for nighttime lighting if you're interested in sleeping shortly afterward.

One of the newest lighting tech-

AT A GLANCE

- The Energy Independence and Security Act of 2007 dictates phasing out incandescent light bulbs starting in 2012.
- To satisfy consumer demands, energy-efficient lights must also be instant-on, work with currently installed light switches, deliver a warm- to bright-white light, cost-effectively save energy, and have a lifetime of more than 10,000 hours.

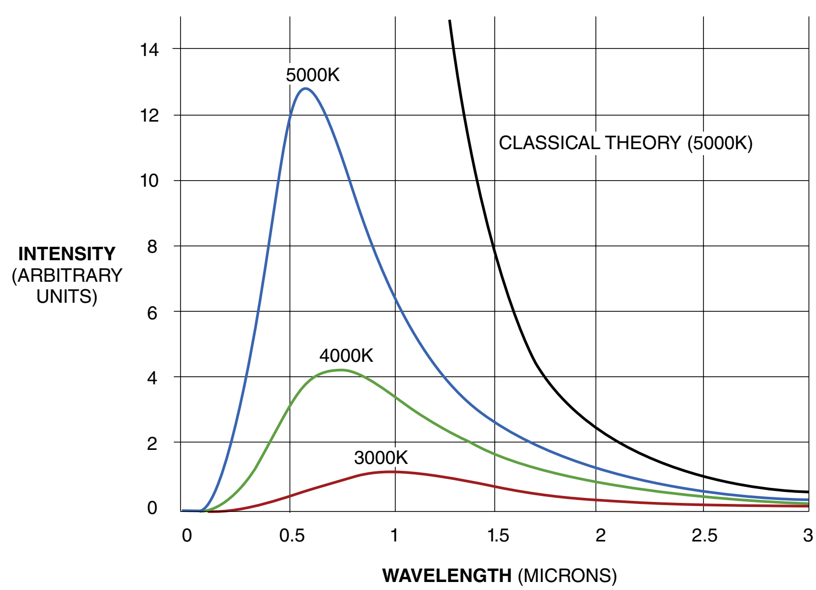

Figure 1 Black-body radiation has a frequency distribution with a characteristic frequency of maximum radiative power that shifts to higher frequencies with increasing temperature. As the temperature increases past a few hundred degrees Celsius, black bodies start to emit visible wavelengths, appearing red, orange, yellow, white, and blue. When an object is visually white, it is emitting a substantial fraction as ultraviolet radiation (courtesy Wikipedia).

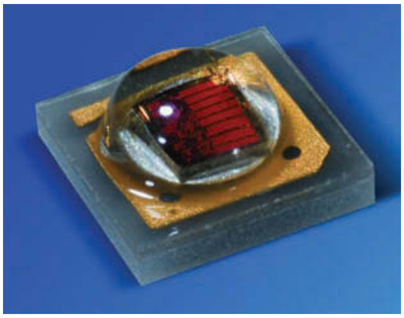

Figure 2 Osram's Oslon white diode in a 1W package uses the Brilliant Mix approach, which combines red and white LEDs to create a warmer white than possible with just blue LEDs and a phosphor to create a white light for general lighting.

nologies, LED-based solid-state lights have emerged as energy-efficient lighting that's easily controllable over a local network and lend themselves to intelligent-building environments that automatically adjust to a building's occupancy and use. However, the cheapest white LEDs, which commonly available LED lights currently use, have a blue hue. Designers of solid-state lights and lighting networks are learning about matching the right LED to the right use and can justify using the more expensive but also more congenially red-hued warm-white LEDs.

LED manufacturers are responding to the lighting requirement for warm lights through a variety of approaches. Cree's TrueWhite modular lighting adds two small red LEDs that kick in depending on the current to the white LEDs. A bulb from system manufacturer Pharox, on the other hand, uses a matrix of discrete LEDs that balances continuously on white and red LEDs.

LED manufacturer Osram takes another route with its Brilliant Mix approach to creating a white light for general lighting. Brilliant Mix technology adds red light from a red LED to a greenish-white LED, which comprises a blue LED exciting a green phosphor. Mixing the two yields a white with a color temperature of 2700K with high efficiency and improved CRI. Osram uses this scheme in its Oslon SSL (solid-state-lighting) diodes (**Figure 2**).

Most discrete white LEDs comprise a blue LED covered by a dollop of phosphor that emits white light when the blue LED's light strikes it. It's difficult to decipher the technology that many white LEDs use, and manufacturers are not always forthcoming about what's inside the seemingly discrete LED packages. One way to check out LEDs' warm-light performance is to look for peaks in the light-power-versus-frequency charts for a part. Avnet's Kelly points out, for example, that Seoul Semiconductor adds red LEDs to its warm-white Acriche A4 ac LEDs to achieve a high CRI; the spike at 620 nm in the A4's spectrum provides evidence of this approach (**Figure 3**).

Another technological hurdle to replacing the incandescent light is the requirement that replacement lights be compatible with the more than 150 million currently installed TRIAC-based dimming switches. Joel Spira, cofounder and former chairman of Lutron Electronics, invented the solid-state dimmer switch in 1959 (**Reference 8**). Now, at least 150 million dimmers are in use worldwide—most likely the reason for the Energy Star requirement that future CFLs (compact fluorescent lights) and LED lights must be compatible with the installed base of dimming switches. This compatibility requirement is difficult to meet because there is no universal specification for the performance characteristics of dimming switches. Therein lies the rub for LED-light designers. TRIAC dimmers are simple in their essence: They stop the ac line from reaching the load during part of the cycle. Less power means less light. This approach is fine when you're dealing with a purely resistive load, such as an incandescent light, but when you're dealing with an LED that expects constant current, handling the chopped line input from the dimmer can prove challenging. Two characteristics are their triggering voltage, or the minimum amount of line voltage it takes to cause the TRIAC to fire, and their holding current, which is the minimum current necessary to make the TRIAC remain on.

In addition, dimming switches require a load of 25 to 40W—not a problem for incandescent lights, but CFLs and LEDs typically require 7 to 13W. Thomas Shearer, design and development leader at Lutron, says that a common tactic for CFLs and LED lights is to incorporate active circuits to sense load variations and draw the current necessary to keep the TRIAC happy, even though this current does nothing to drive the light itself and is a source of inefficiency.

"Here's where we get into the con-

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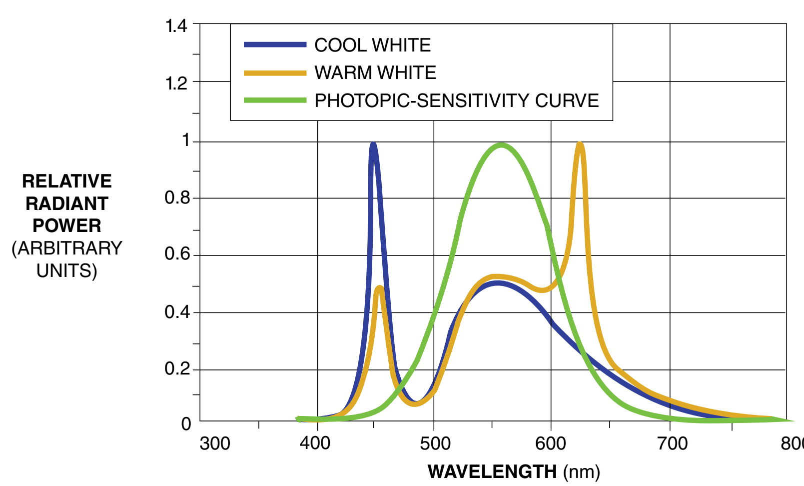

Figure 3 The sharp peak at 620 nm indicates that Seoul Semiconductor uses a red LED in its ac-powered Acriche SAWX4A0X. Both the color spectrum and the radiation pattern are at ambient temperatures of 25°C.

fluence of the product design and the requirements from the load," says Shearer. "For example, if you buy the cheapest possible dimmer, it will probably have a higher holding current. Keep in mind that you've got the latching or firing current, and you've got the holding current. So this cheaper dimmer will have a higher holding current of, say, 50 mA. At 50 mA, you've got 6W on a 120V line. Just to keep the TRIAC on, you're losing 6W." A more costly dimmer may have a substantially lower holding current, he adds.

Another way to solve the load problem is to decrease the LED light to only 10 or 20% of full intensity. If you don't go too low in light level, then the light itself still draws enough current to keep the TRIAC in a good state, Shearer explains. *EDN*'s LED-light tear-downs show that many LED lights dim to some fraction of the light and then abruptly shut off but still draw current from the line. EDN

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designideas

READERS SOLVE DESIGN PROBLEMS

Waveform generator minimizes amplitude dependency

Marián Štofka, Slovak University of Technology, Bratislava, Slovakia

DIs Inside

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Engineers have long used function-generator circuits employing analog integrators and high-hysteresis comparators. The outputs of these circuits often depend on variations in temperature, power-supply voltage, load, and parts. However, you can pump new life into the classic triangular/rectangular-waveform generator using the circuit in **Figure 1**. This circuit uses a precision reference-voltage source and the diode network comprising IC_1, IC_2, and IC_6; dual analog SPDT (single-pole/double-throw) switch IC_3; integrator IC_4; and comparator IC_5. The result is a ramp- and square-wave generator that holds its output stable in the face of those variations. Comparator IC_5 uses a switching technique to achieve its stable high hysteresis. **References 1** and **2** provide more details, including how the Schottky-barrier diodes of IC_6 suppress charge injection.

The output of IC_5, an ADCMP601 comparator, is initially low, forcing the ADG736 analog switch, IC_3, to connect a positive reference voltage, V_{REF+}, to IC_5's inverting input. Simultaneously, the S_2 switch connects a negative reference voltage, V_{REF-}, to the integrator's R_I resistor. As long as the comparator's output is low, the integrator's output, V_{INT}, increases linearly until it reaches V_{REF+}, the comparator's positive-threshold level. At that point, the output of the comparator changes to high, which turns on the B channels of both multiplexers as their A channels turn off.

When the switch positions change, the integrator integrates positive reference-voltage V_{REF+}, and V_{INT} decreases linearly until it reaches the negative threshold V_{REF-}, which the comparator sets. The cycle then repeats. A bipolar reference source comprising IC_1 and IC_2 creates V_{REF+} and V_{REF-}. This part

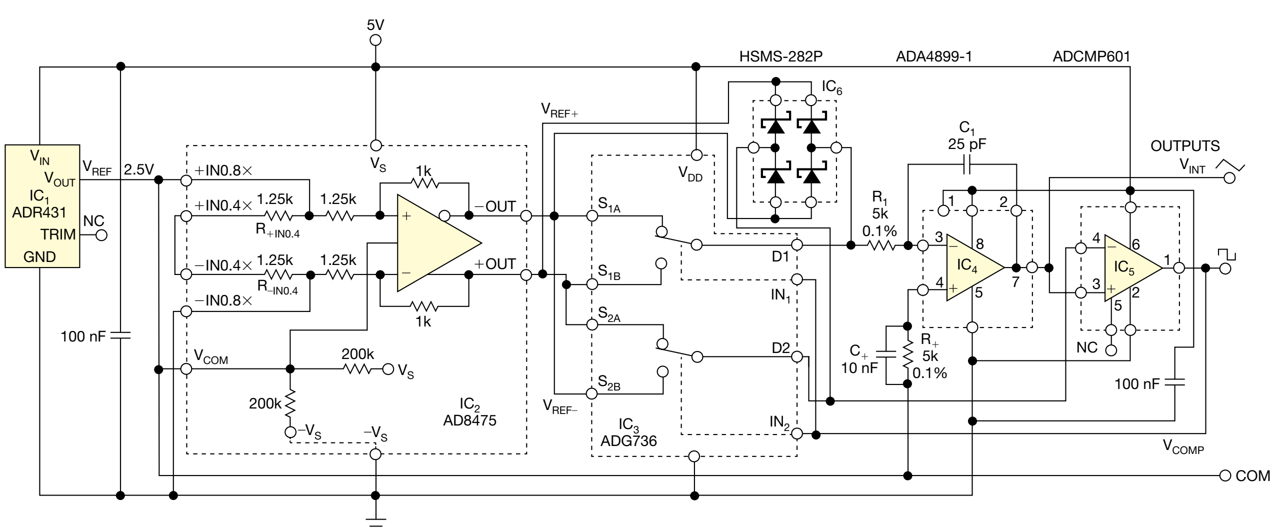

Figure 1 Creating hysteresis by switching precision reference voltages within the waveform generator ensures high insensitivity of the amplitude of triangular waveforms on supply-voltage variations.

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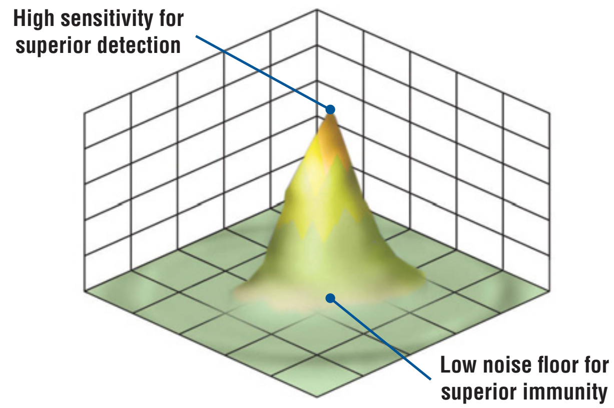

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of the circuit is a slight modification of the circuit in an earlier Design Idea (**Reference 3**).

As the ramp-up/ramp-down cycle repeats, the integrator produces a symmetrical, triangular waveform of V_{INT}, and a rectangular waveform, V_{COMP}, appears at the output of the comparator. The amplitude of V_{INT} is approximately $(V_{REF+}-V_{REF-})/2$. The duty cycle of the rectangular waveform is close to 50%. The thresholds of the comparator are independent of the output load, and you derive them from a precision source of reference voltages. Thus, the circuit has low sensitivity of the repetition frequency of its output to supply-voltage variations and to load variations. In a simplistic model of the generator, the amplitude of the triangular waveform at the output of the integrator no longer depends on variations of supply voltage.

Experimentally, increasing supply voltage V_S from 5.0365 to 5.437V increases the amplitude of the triangular waveform by 2.85 mV, representing 0.285% of full-scale. Under the same conditions, a classic triangular/rectangular-waveform generator typically shows an 8% increase in amplitude. Thus, this circuit reduces the dependence of amplitude on supply-voltage variation by a factor of about 28.

In testing this circuit, you can expect an output frequency of 1.366 MHz with a supply voltage of 5.0365V. When the supply voltage is 5.437V, the output frequency will be 1.368 MHz. The time constant sets the repetition rate. In this case, the repetition rate is one divided by four times the time constant for an ideal comparator and ideal switches. The comparator's propagation delay and the on/off times of the switches lower the repetition rate to lower than the ideal value.EDN

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Produce current from positive or negative high-voltage supplies

Kurt Nell, Sankt Pölten, Austria

You sometimes need a current source for supply voltages as high as 1000V or more. This current source can be useful for ripple-voltage reduction when the current source's high-impedance node feeds an electrolytic capacitor to effectively short the ripple voltage. The circuit in **Figure 1** does the job with a temperature-stable and exact-output current. The circuit uses N-channel MOSFET Q_1, which has a drain-to-source voltage of 1000V. Zener diode D_2, a ZR431LF01 shunt regulator, stabilizes and regulates the output current. The threshold voltage of Q_1 must be higher than D_2's 1.25V reference voltage.

R_1 and the voltage across it determine the output current. In this case, 1.25V/220Ω=5.6 mA. D_2 regulates the MOSFET's gate-to-source voltage until the voltage across R_1 equals D_2's reference voltage, which is temperature stable and accurate, making the current source stable and accurate, as well. Zener diode D_1 protects Q_1's gate and limits the gate-to-source voltage if no load connects to the current source.

You can use a similar circuit to get constant current from negative high-voltage supplies even if a P-channel MOSFET with a high drain-to-source voltage is unavailable. To make the circuit work with negative supplies with an N-channel MOSFET, you must modify the circuit in **Figure 1**. You can use the N-channel MOSFET by changing the source and drain connections of MOSFET Q_1 in **Figure 2** (pg 55). The function of the current regulation with zener diode D_2 is the same as for positive voltages.EDN

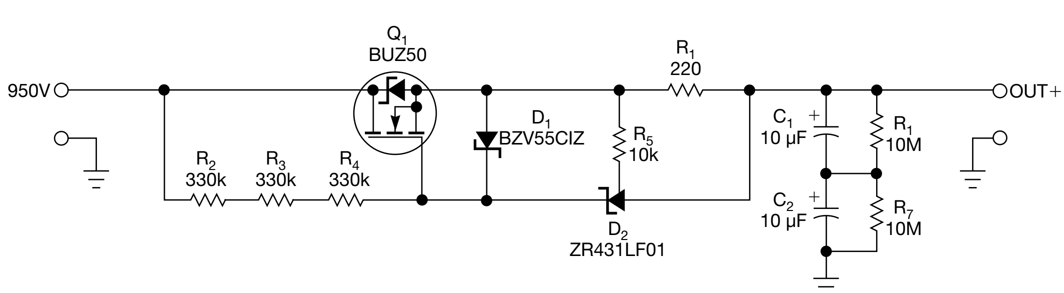

Figure 1 This circuit produces current using positive voltages.

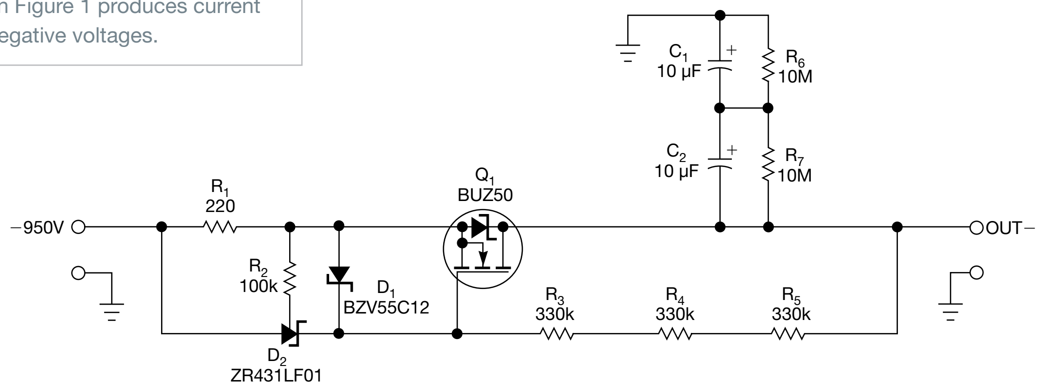

Figure 2 This modified version of the circuit in Figure 1 produces current using negative voltages.

Arrange LEDs as seven-segment displays

Charaf Laissoub, Valeo Engine and Electrical Systems, Créteil, France

When you need to drive three seven-segment LED displays, you typically need 10 I/O lines—and that's without a decimal point. You might think that you cannot accomplish that task without a binary-to-seven-segment decoder or a serial-to-parallel shift register (**Reference 1**). Many previous Design Ideas have shown how to maximize the number of LEDs you drive with a minimum number of I/O lines (**references 2** through **5**). This Design Idea shows how you can build a circuit that drives 21 LEDs, thus forming three pseudo-seven-segment displays.

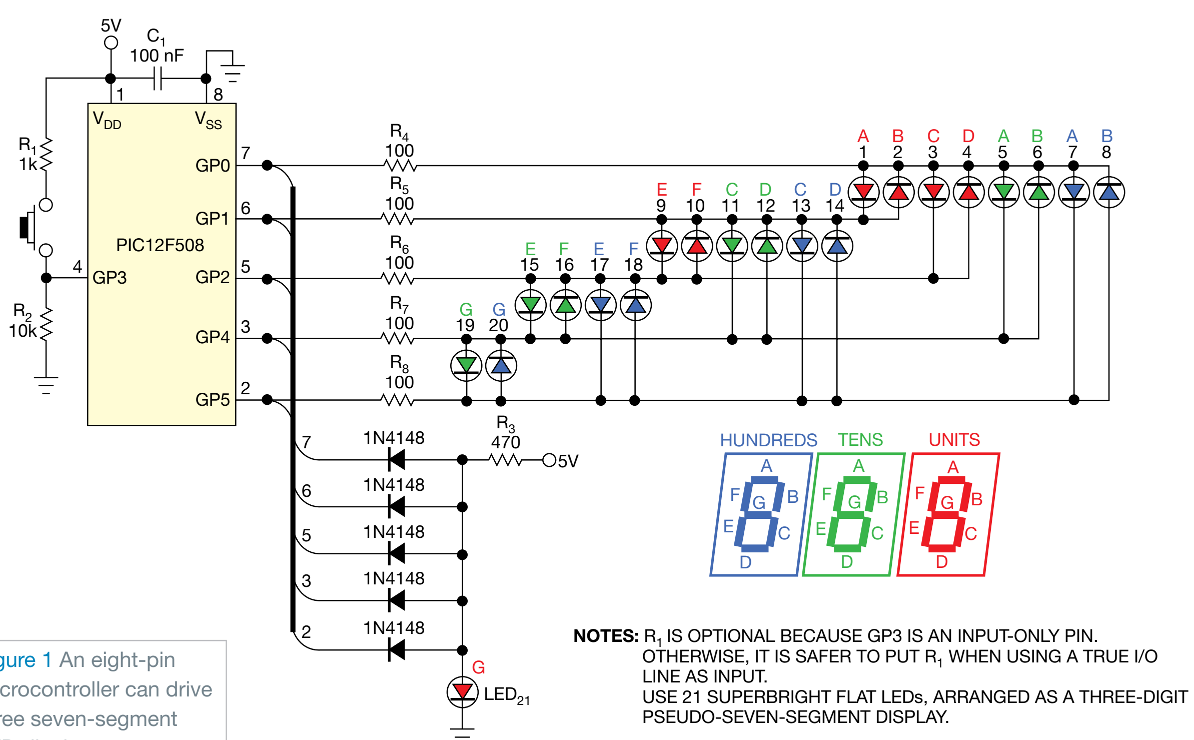

Figure 1 An eight-pin microcontroller can drive three seven-segment LED displays.

The circuit in **Figure 1** modifies the circuit in a previous Design Idea (**Reference 6**). It adds the 21st LED, but it modifies the assembler code to use just 98 words without the main routine. **Listing 1**, the assembler code, is available with the online version of this Design Idea at www.edn.com/110526dia. It can also suit any of a Microchip (www.microchip.com) baseline or midrange PIC microcontroller's eight pins.

THE CIRCUIT ADDS THE 21st LED, BUT IT MODIFIES THE ASSEMBLER CODE TO USE JUST 98 WORDS WITHOUT THE MAIN ROUTINE.

You can adapt this code for another type of microcontroller, such as those from Atmel (www.atmel.com) or STMicroelectronics (www.st.com), using the following steps:

1. Build a look-up table of 10 values for seven-segment coding (see **table** "Code7Segment" in **Listing 1**).
2. Build a look-up table of 3×7 values to store the successive configurations for I/O lines, each configuration containing only one high output and one low output to drive one LED at a time, for each digit (see **table** "Cfg2LinesOut" in **Listing 1**).
3. Build a look-up table of 3×7 values to store the successive high and low state for the I/O lines that are acting as outputs to light only one LED at a time for each digit (see **table** "Light1LED" in **Listing 1**).
4. The subroutine DispDigit rotates to the right seven times, through Carry flag, and the seven-segment code of a digit. It then calls the subroutine LEDon each time you set Carry.
5. The subroutine LEDon activates the LED related to the I/O configuration code, which you can extract from **table** "Cfg2LinesOut," and lights it according to the high or low state code, which you extract from **table** "Light1LED." The subroutine ends by a jump to a critical 1- to 3-msec delay subroutine. Increasing this delay increases the flicker effect, and decreasing this delay dims the LED.
6. Cycle digits of units, tens, and hundreds through steps 4 and 5.

For the PIC10F2xx series, which contains only three I/O lines, **Figure 2** shows an example of driving one digit, and **Listing 2** shows the corresponding assembler code. You can access **Listing 2** from the Web version of this Design Idea at www.edn.com/110526dia. **EDN**

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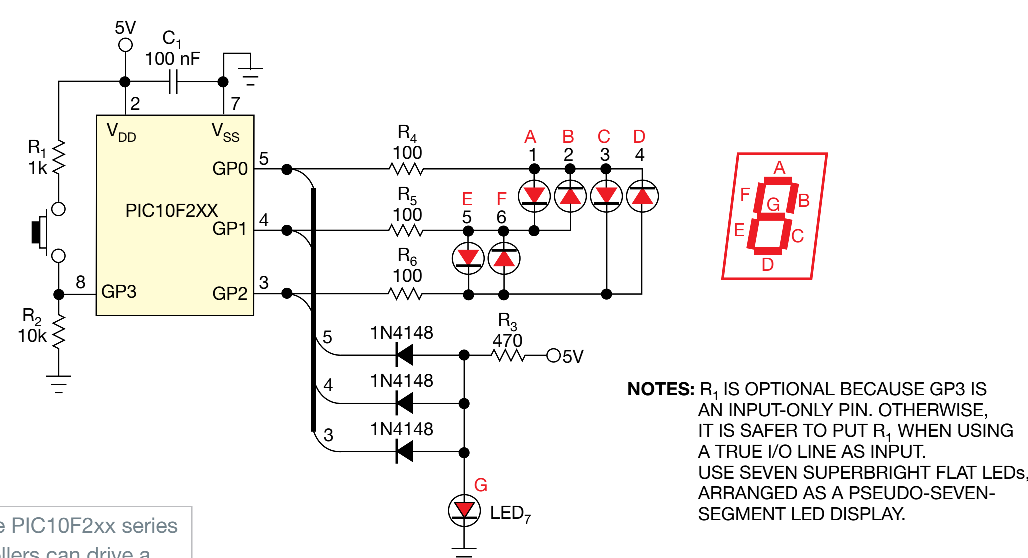


Figure 2 The PIC10F2xx series microcontrollers can drive a seven-segment display with three pins.

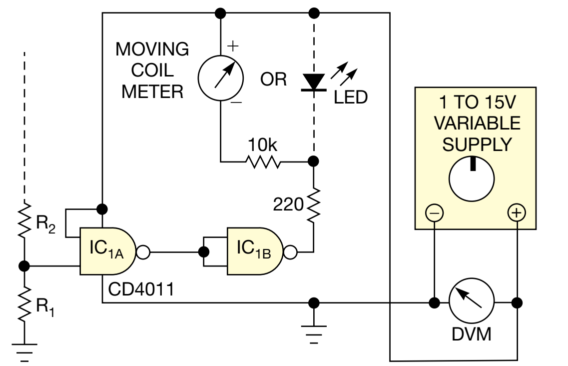
Logic gates form high-impedance voltmeter

Raju Baddi, Tata Institute of Fundamental Research, Maharashtra, India

You can use the circuit described in this Design Idea to estimate voltages across 10- to 100-MΩ resistances. It also works for reverse-biased diodes.

The common CMOS gates in **Figure 1** have an input threshold voltage in which the output swings from logic zero to logic one, and vice versa. The threshold voltage depends on the supply voltage (**Figure 2**). Because of each CMOS gate's high input impedance, input currents are approximately 0.01 nA. If you apply 5V to 100 MΩ, you get 50 nA. Thus, you can connect the gate input at a point at which it draws a negligible amount of current.

You can vary the CMOS gate's supply voltage to attain the desired threshold voltage for the gate input. If you apply the unknown voltage to one of the gate's inputs and then connect the other input to the positive-voltage supply, you can vary the supply voltage, V_S, until you reach a point at which the threshold voltage at the input becomes equal to the unknown voltage.



NOTE: R_1 AND R_2 ARE IN TENS OR HUNDREDS OF MEGOHMS.

Figure 1 Use CMOS gates and a variable power supply to find an unknown voltage.

At this point, the output of the sense gate, IC_{1A}, changes from logic zero to logic one. When this event happens, the threshold of the gate passes the unknown voltage. You can estimate the unknown voltage using a graph of threshold voltage versus supply voltage, such as the one in **Figure 2**. By fitting a parabola or a polynomial to the experimentally obtained points—say, some 20 points lying in the supply-voltage range of 2 to 15V—you can estimate the threshold voltage, V_T, for any supply voltage. This circuit has been built and tested. The online version of this Design Idea includes Octave/Matlab code that you can view at www.edn.com/110526dib.EDN

ESTIMATE THE UNKNOWN VOLTAGE USING A GRAPH OF THRESHOLD VERSUS SUPPLY VOLTAGE.

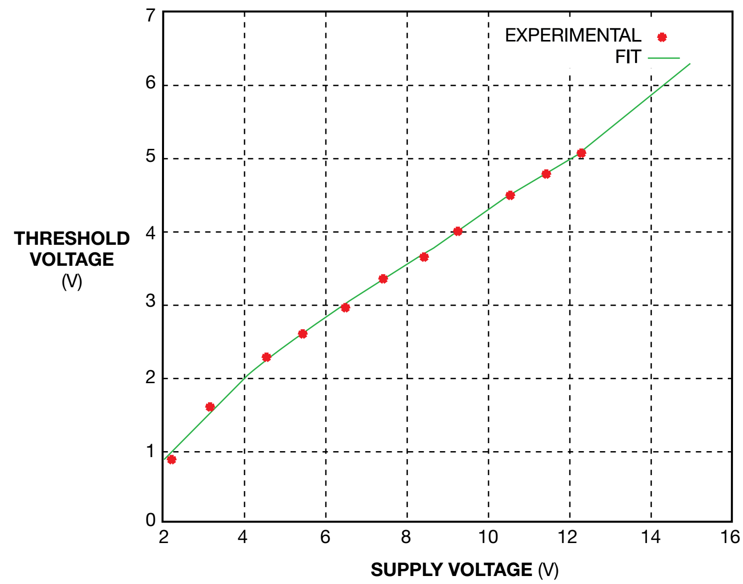


Figure 2 The gate's threshold voltage is nearly linear with respect to the power-supply voltage. You can download this plot at www.edn.com/110526dib.

Measure resistance and temperature with a sound card

Zoltan Gingl and Peter Kocsis, University of Szeged, Szeged, Hungary

Unless you add a measurement instrument to your computer, you have only the sound card as an analog I/O port. You can use the sound card to digitize ac analog voltages but only within a limited range. You can, however, add some signal processing and measure a wider variety of signals, even those that produce dc or low-frequency outputs. For example, you can directly connect a thermistor to make a sound-card thermometer to monitor or record the temperature on PCBs (printed-circuit boards), circuits, heat sinks, and more.

Thermistors are popular temperature sensors because they allow easy detection of changes in resistance. Once you measure a thermistor's resistance, you can apply the following **equation** to find the temperature:

$$T=\frac{1}{\frac{1}{T_O}+\frac{1}{\beta}\ln\left(\frac{R_T}{R_O}\right)},$$

where R_T is the thermistor resistance and T_O is the temperature in Kelvins at which the thermistor's resistance is R_O. You can find the value of β in a thermistor's data sheet.

Figure 1 shows the easiest way to interface a thermistor to a sound card. The microphone input has an internal bias resistor, R, with a typical value of 2 to 5 kΩ. A dc bias voltage drives this resistor. The bias resistor connects the thermistor between the line or the headphone output and the microphone input, which forms a voltage divider with the internal bias resistor. Those components are all the circuit needs. Note that some microphone inputs may have different internal connections, so check yours before use.

You also need a sinusoidal signal because the sound card's inputs are ac-coupled. The sound card's audio output can produce an ac voltage at the microphone input, whose amplitude is proportional to $R/(R+R_T)$. You can do a simple calibration to find the output signal's amplitude and the value of R by replacing R_T with known values, such as 0 and 10 kΩ.

A sound card's measurement accuracy is worse than what you could achieve using a commercial data-acquisition card, but this ratiometric arrangement and calibration keep errors to approximately 1% for resistor values of 1 to 100 kΩ. Even without

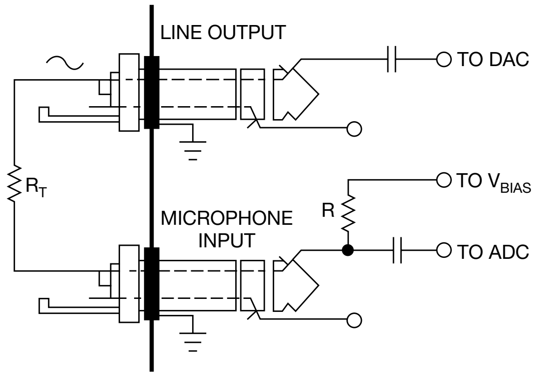


Figure 1 The internal microphone bias resistor and the externally connected thermistor form a voltage divider.

temperature calibration, you should get temperature errors of 1 to 2K with a 10-kΩ thermistor at room temperature. Accuracy degrades to 3 to 5K over the thermistor's operating temperature.

You can download simple, free, and open-source software in Java that you can use as a simple ohmmeter, thermometer, or chart recorder under Windows or Linux. You can download a Java executable or the Java source code (**Reference 1**).

You should consider adding protection to the sound card's audio I/O ports by inserting series resistors. Typically, a few kilohms is all the circuit needs. You can also use an inexpensive USB (Universal Serial Bus) sound card to spare and protect your PC sound card's inputs.

You can add second and third thermistors to your system by adding an external resistor divider (**Figure 2**). This approach lets you use both audio channels and a third thermistor at the microphone input. In addition to using thermistors, you can use the sound card with other resistive sensors, such as photoresistors or potentiometric displacement sensors. You can even connect capacitive sensors if you add some more components and signal processing (**Reference 2**).EDN

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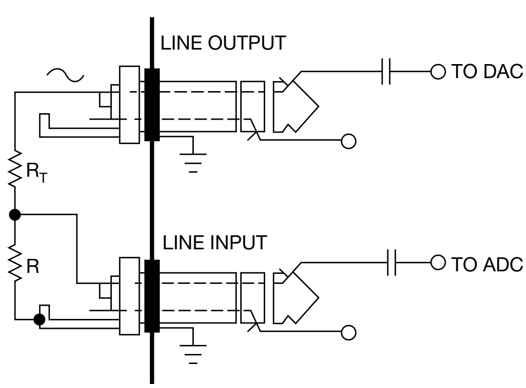

Figure 2 You can add second and third thermistors to your system by adding an external resistor divider.

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and instrumentation applications, including camera stability; antenna alignment; down-hole drilling; and GPS navigation in ships, aircraft, fleet vehicles, agricultural machinery, and factory robotics. The ADIS16135 gyroscope comes in a 36×44×14-mm module package and sells for $499, and the ADIS16385 IMU comes in a 36×47×39-mm module package and sells for $869 (1000).

Analog Devices, www.analog.com

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The Lifetime Power wireless-sensor system targets use in wireless environmental monitoring in HVAC control and building automation. Remote RF transmitters broadcast RF energy that perpetually powers the wireless-sensor nodes without batteries or wires. The first in the family, the WSN-1001 wireless temperature

and humidity sensor, is available now. Follow-on products will include sensors to measure carbon dioxide, pressure, light level, motion, and other conditions. In the wireless powering system, one transmitter or a network of transmitters powers multiple sensor devices. The sensor's nodes embed power-harvesting receivers that receive RF energy from as far as 60 to 80 feet away from the Powercaster transmitters, which broadcast radio waves at 915 MHz. The receivers then convert the RF energy into dc current to wirelessly power the sensors in a method that is similar to RFID but with greater range and performance. Broadcast RF energy can reach and power sensors through walls, above ceilings, and behind objects and provides a more reliable and predictable power source than do pure ambient-energy-harvesting technologies, such as indoor solar, thermal, or vibration. The fully installed Lifetime Power system, including sensors, transmitters, BAS (building-automation-system) gateway, and labor, costs approximately $300 per node for typical multinode deployments. A starter kit with two wireless temperature and humidity sensors, a transmitter, and a BAS gateway sells for $799.

Powercast, www.powercastco.com

Multiturn precision potentiometer has slip-clutch option

The 3547, 3548, and 3549 multiturn potentiometers offer an optional slip-clutch safety feature that helps prevent damage to the potentiometer in applications using full travel. The feature thus increases reliability and reduces service costs and system downtime. The devices find use in mechanized or machine-to-machine applications, such as linear actuators; cable transducers; and mechanical position sensors, in which the mechanical actuator may occasionally rotate the shaft beyond the mechanical stops or beyond the set number of turns. The three-turn Model 3547 and five-turn Model 3548 sell for $16.99 to $18.31. The 10-turn Model 3549 sells for $14.44 to $15.49 (1000).

Bourns Inc, www.bourns.com

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The Ex-scope-ist


DANIEL VASCONCELLOS

Many years ago, in my college days, I was an intern at a large computer manufacturer. I worked in a repair and refurbishing shop, where I analyzed and typically repaired electromechanical "business machines" and installed updates and engineering improvements. In the corner of this shop was the instrument-repair facility for the repair of service equipment, such as voltmeters, pulse generators, and—most important for the new all-electronic digital computers—oscilloscopes.

On occasion, I would help the instrument-repair technician tackle an unusually difficult repair. I had been an amateur radio operator since I was 11 years old, had worked for a TV-repair shop before I was old enough to drive the shop's truck, and was adept at fixing electronic equipment.

One day, the technician at the repair shop was exceedingly puzzled, and I asked whether I could help. He had just performed a complete calibration of a perfectly good operating oscilloscope and was ready to ship the unit back to the field. Inexplicably, however, it developed a constant offset of some 50 mV or so.

Those old vacuum-tube oscilloscopes had numerous dc-coupled stages of differential amplifiers to provide the several hundred volts to deflect the electron beam of the CRT. To have a ground potential that resulted in positioning the beam in the center of the screen, all the cascaded amplifiers had to have nearly 0V offset voltage. Some of the amplifiers had adjustments, and some required reasonably matched vacuum tubes.

Using another oscilloscope, the technician carefully probed the vertical amplifiers, working his way back from the deflection plates stage by stage, but he could not find the source of the constant offset. He then disconnected one stage from another and finally worked his way to the input stage, where he still detected an offset.

"There is nothing left," he lamented. "I have only the front-panel connector and the input attenuator in the circuit, and I still see an offset."

I immediately recognized the problem. "Your oscilloscope is possessed! It needs to be exorcised," I declared.

Ready to accept any explanation, he asked, "How can we exorcise it?"

"Put the scope on the cart and pull it away from the workbench," I replied. "We need to heat the scope to drive out the devil."

I grabbed the technician's heat gun and started to wave the hot air around the oscilloscope. "Oh wadda, oh wadda goo, oh wadda goo Siam," I chanted as I waved the heat gun around the sides and top of the oscilloscope, making sure to bathe the front panel with plenty of air. I then told the technician to power up the oscilloscope and see whether I had exorcised the evil spirit.

He powered the unit back up and, with a shriek of disbelief, remarked, "It's gone! There is no offset!" After a few minutes, he finally regained his senses. "How did you *really* do that?" he asked.

I replied with a question of my own: "What is the last thing you do before you ship a scope back to the field?"

"I clean it up and put it in a plastic bag," he replied.

"How do you clean it?" I asked.

"I use a spray cleaner and wipe it dry with a rag."

"Do you spray the front panel?" I asked.

"Yes," he replied.

"Do you cover the input connector to ensure that you don't get any cleaner in the connector?" I asked. I knew that, if he hadn't, he would have created a battery.

"Oh, I see," he said. "Two dissimilar metals, such as the inner conductor and the outer conductor of the input connector, would make a battery. I owe you lunch. Let's go." EDN

Albert Helfrick is a professor in the electrical and systems engineering department at Embry-Riddle Aeronautical University (Daytona Beach, FL).

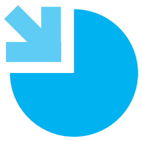
Making security the foundation of functionality.

> "AES-NI boosts AES encryption by 3x and decryption over 10x compared to pure software implementations of OpenSSL."
>
> *Praveen Mosur*
> *Network Security Architect*
> *Intel® Embedded and Communications Group*

CHALLENGE >>>

How to keep embedded devices secure without sacrificing performance?

From transportation to medical devices to automated factory systems, the number of embedded devices is growing exponentially. And so are the corresponding security threats. We now live in a world with a few billion smart, connected devices and over 60,000 new malware signatures identified each day.[1]



75 percent of enterprises surveyed by Symantec experienced some form of cyber attack in 2009.[2]

SOLUTION >>>

Move from a "known bad" to a "known good" model of security.

Instead of simply reacting to known bad signatures, wouldn't it be better to proactively shift embedded security to a "known good" model? One where you can trust the device you are communicating with? As the embedded universe continues to expand, achieving this new paradigm begins with three key elements.

Authentication

Quickly verifying a good signature instead of filtering bad ones means more resources can be devoted to focusing on the device's intended task. Which is why Intel created a true Random Number Generator that produces unpredictable random keys to help verify trusted connections.

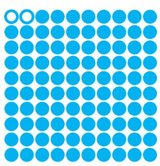
Device Integrity

If your hardware isn't secured, the solution on top of it can't be trusted. A combination of Intel® Virtualization Technology and Intel® Trusted Execution Technology enables a root of trust in hardware and secure isolation of critical code and data.

Data Protection

We need to ensure that data gets to its destination uncompromised. To make powerful encryption easier, we are adding AES new instructions (AES-NI) to our processors for up to 10-times faster crypto processing, without impacting application performance and functionality.

Intel believes that security goes hand-in-hand with functionality. Which is why we're continually working on new ways to provide you with proactive security building blocks that hit the performance, power, and cost targets you expect today, with the flexible scalability you'll need for tomorrow.



Threats to confidential information that incorporated remote access capabilities grew to 98 percent in 2009.[3]

Across embedded, new ideas and solutions to address security are continually emerging. From implementing secure end-to-end systems to protecting personal data to other security innovations, keep up with the critical information that is shaping the embedded landscape.

READ > WATCH > DISCUSS >>> **intel.com/embedded/innovation/security**

 [1] McAfee Threats Report, Third Quarter 2010. [2] Symantec State of Enterprise Security Report 2010. [3] Symantec Global Internet Security Threat Report 2010.

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LTC3109	Auto-polarity version of LTC3108	
LTC3588	Piezoelectric energy harvesting power supply	
LT®3652/HV	Power tracking 2A solar battery charger	
LTC4070	Nanoamp operating current shunt Li-Ion battery charger	

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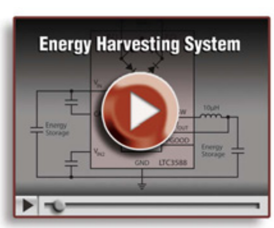

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