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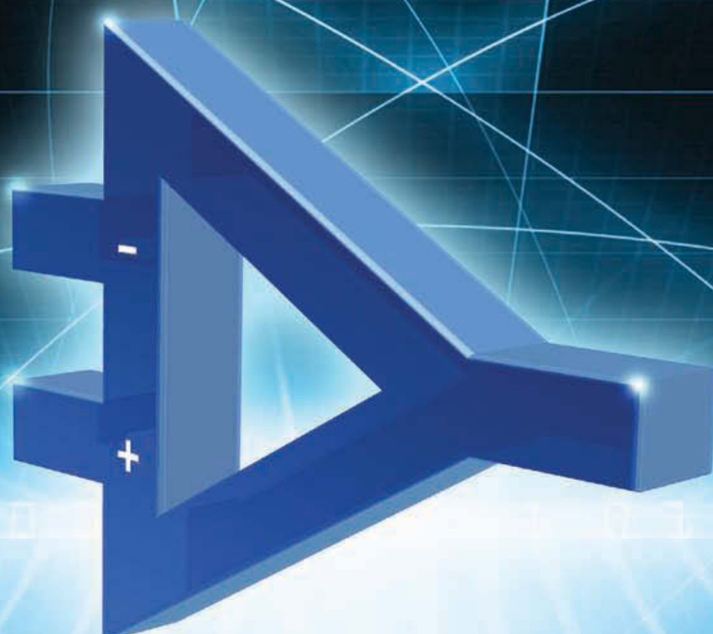

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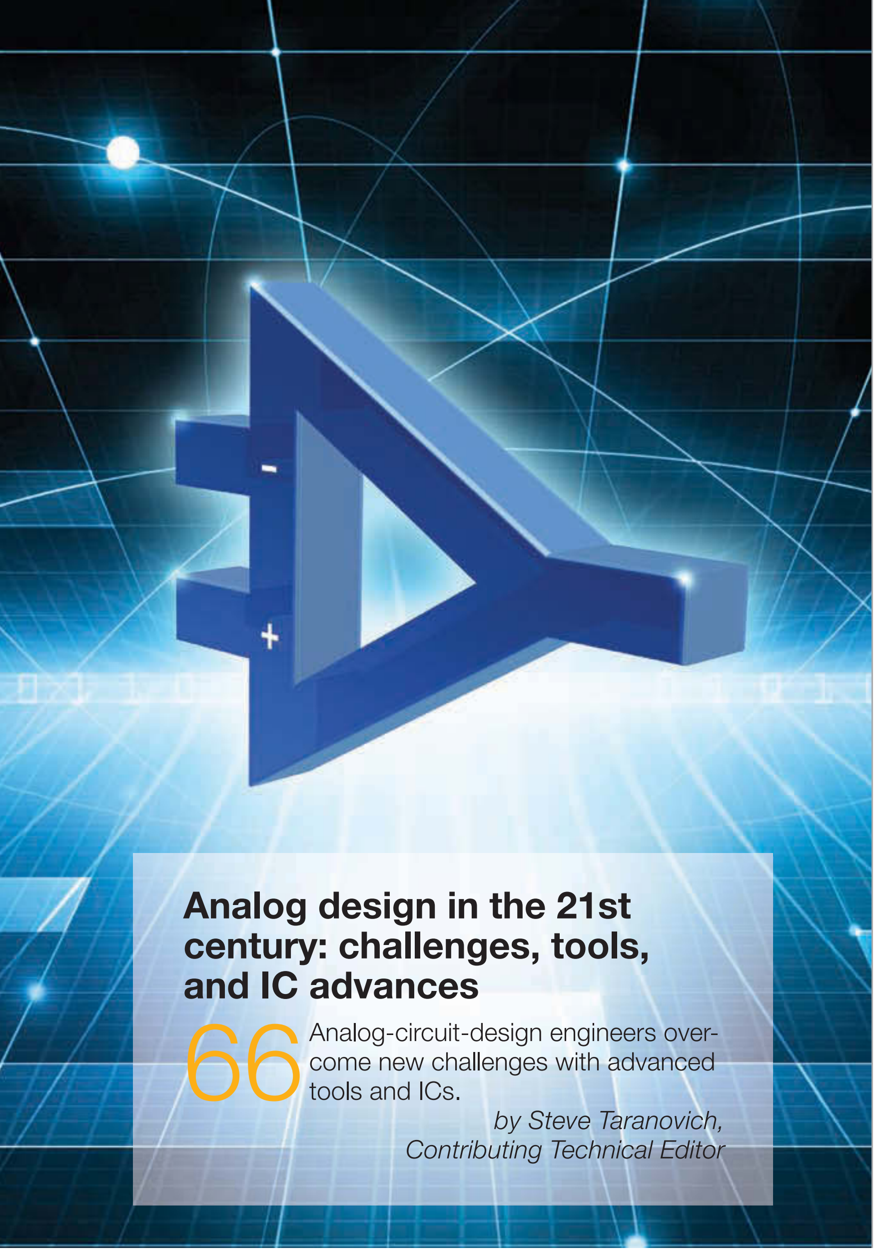

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2012 global electronics distribution special

COVER IMAGE: SHUTTERSTOCK/YOSHI HOHOKABE

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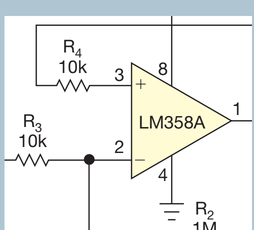

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EDN online

JOIN THE CONVERSATION

Comments, thoughts, and opinions shared by *EDN*'s community

In response to "Get off the sidelines," an editorial by Suzanne Deffree, http://bit.ly/sO0XUF, that was shared via social media on *EDN*'s Facebook wall, http://on.fb.me/EDNFacebook, SpecTECHEDU commented:

"Best line of the day: 'Progress: It's what engineers do.' We think progress is what engineers do best."

In response to "Peering inside a portable, $200 cancer detector," by Jim MacArthur, Electronic Instrument Design Laboratory, Harvard University, http://bit.ly/xELhdN, Pop Mircea, a physics researcher, commented:

"It's quite a nice accomplishment. It's quite a quest to tame such electronic devices, specific to NMR [nuclear-magnetic-resonance] instrumentation, in order to make them so (relatively) simple and ergonomic. I've seen some articles about NMR digital-processing units using FPGAs. I would still vote for FPGAs (maybe along with an additional DSP core) since these devices can be completely 'reordered' by reprogramming. It seems to me that the RF and acquisition part is much more expensive than the processing part."

In response to Margery Conner's "What's inside a smart meter?" http://bit.ly/A8TSIh, Jack Haesly commented:

"I have heard these smart meters can and do spy on the individual user in that they can and do report most aspects of energy use in the installation. … If true, what's up with that? Just how detailed is the report, and to whom does the utility company sell the available data? When energy companies install these systems, they do not, in my opinion, divulge all aspects of what the meters actually are capable of transmitting or who they are targeting."

***EDN* invites all of its readers to constructively and creatively comment on our content. You'll find the opportunity to do so at the bottom of each article and blog post. To review current comment threads on EDN.com, visit http://bit.ly/EDN_Talkback.**

CONTENT

Can't-miss content on EDN.com

READERS' CHOICE 2011: PEASE AND WILLIAMS, LEDs, MEDICAL ELECTRONICS, MORE …

Take a look back at 2011 and what the year brought for engineers with this collection of popular *EDN* content on electric vehicles, LEDs, ham radio, medical electronics, and more.

http://bit.ly/zusvZ7

CIRCUIT-PROTECTION BASICS: ISSUES AND DESIGN SOLUTIONS

The inconsistency of the power grid places the reliability and efficiency of electronic equipment in constant jeopardy.

http://bit.ly/wmH2V0

ENGINEERING COMMUNITY

Opportunities to get involved and show your smarts

DESIGNCON 2012

More than 100 tutorials and technical-paper sessions in 14 conference tracks focused on the pervasive nature of signal integrity at all levels of electronic design—chip, package, board, and system—make DesignCon 2012 the place where chipheads connect. Running Jan 30 through Feb 2 at the Santa Clara Convention Center in Santa Clara, CA, DesignCon offers numerous educational and networking opportunities. Find more information and register to attend at **http://designcon.com**.

BY PATRICK MANNION, DIRECTOR OF CONTENT

CES is over; it's time to start designing

At press time, I was preparing to fly to Las Vegas for the 2012 CES (Consumer Electronics Show), where I am looking forward to unearthing and presenting for evaluation some truly innovative, exciting, and useful technology and devices from among the thousands of gizmos and gadgets that will inevitably catch my curious eye. By the time you read this, however, CES will be behind us; you will have already determined the good, the bad, and the ugly; and either you will be looking forward to getting your hands on the coolest gadget or, more likely for an *EDN* reader, you'll have already poked holes in the designs shown at CES 2012 and are now well on the way toward imagining how you or your design team can do better, possibly even before CES 2013!

With that thought in mind, I would like to invite you, on behalf of UBM Electronics and Barry Sullivan, IEC director and technical-program chair, to DesignCon 2012, Jan 30 to Feb 2, in Santa Clara, CA. It may be no coincidence that this conference so quickly follows CES, the biggest display of electronic designers' wizardry. DesignCon focuses on both inspiration and deep-dive exploration of the technologies and techniques designers can apply toward forging the next generation of electronic devices and systems.

This year's conference is jam-packed with something for everyone looking to get the right signal from Point A to Point B intact—or at least in a decipherable form—as efficiently and elegantly as possible, from die, through packaging, to board and system. So it's safe to say that "everyone" includes just about every engineer out there involved in design and test.

Toward that end, we have panels, technical tracks, teardowns, awards (DesignVision and *Test & Measurement World*'s Best in Test), tutorials, focused educational tracks, breakout sessions, and, of course, happy-hour opportunities to mix with your peers and digest the information while visiting a packed exhibit floor. Even at this stage, we're still trying to squeeze in more, so keep up to date at www.designcon.com.

To set the tone for each day, we'll have keynote speeches from industry visionaries, starting on Monday, Jan 30, with Joe Macri, corporate vice president and chief technology officer of AMD's client division. Macri is also chairman of the JEDEC JC42.3 DRAM Committee and vice chair at large of the JEDEC board of directors. His areas of expertise are in CPU, memory, and graphic design, with more than 20 patents pending or granted. Go to http://bit.ly/z0W24o for an overview of what's happening at DesignCon with respect to high-speed memory design.

Ilan Spillinger, corporate vice president for hardware architecture at Microsoft, will kick off the day on Tuesday. His group leads the Xbox 360 and Kinect architecture and verification, silicon design, hardware incubation, and business-development efforts for Microsoft's interactive-entertainment-business-hardware division. I'll be looking forward to catching up with Spillinger after his keynote speech to get more information on his vision of gaming, underlying architectures, and the future of sensor-based user interfaces. Finally, on Wednesday, Prith Banerjee, senior vice president of research at Hewlett-Packard and director of HP Labs, the epicenter of the company's R&D, will give us his take on where the opportunities lie and what HP may be doing about it. Banerjee's own research interests include VLSI computer-aided design, parallel computing, and compilers. He is the author of about 300 research papers in these areas, so his thoughts will be worth tapping into.

The technical tracks focus on signal integrity, as usual, but there's a clear emphasis on 3-D packaging, high-speed interfaces (28 Gbps, for example), FPGAs, analog design and verification, and PCB layout. For test, it's not news that high-speed serial buses are causing concern for designers, so to help provide some hands-on help, Agilent has agreed to step you through the challenges and the testing tools available in high-speed serial-design workflow, from design and simulation through turn-on, debugging, and system and compliance testing. Don't miss the session "Design and Test Challenges in Next Generation High-Speed Serial Standards."

Elsewhere at the conference, I'll be leading a panel discussion with four of the brightest minds in test to see where the challenges are for you, the designer, and what test companies are doing about them. Among several teardown sessions, iFixit's Kyle Wiens will be comparing Amazon's Kindle Fire with Barnes & Noble's latest Nook, and I'll be tearing down the Vizio and gTablet tablets and a Cisco Linksys E3200 router. Read more about the Vizio tablet on page 24 of this issue and at http://bit.ly/zKZT42. If you'd like to participate in the discussion on tablet design and the state of Wi-Fi design, let me know. I'll be sure to include you. I look forward to seeing you there! **EDN**

Contact me at patrick.mannion@ubm.com.

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pulse

INNOVATIONS & INNOVATORS

BLDC-fan motor driver employs sensorless sinusoidal architecture

The PC fan may be less glamorous than active components are, but managing it and minimizing its power usage are critical to the overall system design, cooling, and runtime. Addressing these issues, Microchip Technology's MTD6505 stand-alone, resistor-programmable fan motor driver enables the selection of multiple BEMF (back-electromotive-force) coefficient ranges. This feature allows engineers to design in one device to match a variety of three-phase BLDC-fan characteristics. The driver comes in a 0.5-mm-thick, 3×3-mm, 10-pin UDFN package suiting space-constrained applications, such as thin laptops and tiny BLDC fans.

For high energy efficiency and quiet operation with low acoustic noise and mechanical vibration, the MTD6505 includes a 180° sinusoidal drive. As a sensorless driver, the MTD6505 eliminates the need for an external Hall-effect sensor, reducing both cost and board space. It also includes on-chip-protection features to preserve the motor's life and avoid harmful operating conditions, including thermal shutdown, overcurrent limiting, and lockup protection.

The $59.99 MTD6505 demonstration board will be available this month. It comes with a three-phase BLDC fan and three MTD6505 plug-in modules. A free, downloadable GUI is also available. It simplifies fan monitoring and control with an onboard PIC microcontroller. The MTD6505 motor driver is available for sampling and sells for 57 cents (5000).—**by Bill Schweber**

▷**Microchip Technology**, www.microchip.com.

The MTD6505 fan motor driver from Microchip Technology uses a resistor-programmable, sensorless sinusoidal architecture so that you can tailor it to many fan models.

TALKBACK

"Intensity of purpose is not conferred along with a degree, and just because a student is good at math and science, it does not follow that he/she will be a good engineer."

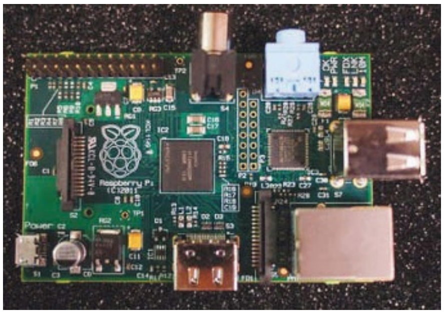
—Professional Engineer and *EDN* reader Gordon Young, in *EDN*'s Talkback section, at http://bit.ly/AA4p36. Add your comments.

Foundation readies $25 PC for launch

British not-for-profit foundation Raspberry Pi claims that its credit-card-sized, $25 PCs will become available for sale next month, once the units emerge from final beta testing. The company developed the computer, which recently won an award at ARM TechCon in Santa Clara, CA, for use in teaching computer programming and for educational use in the developing world.

The small PCB can connect to a TV or a screen through a USB 2.0 interface or an HDMI. It sports a 700-MHz ARM11 processor from Broadcom with 128 Mbytes of RAM, an SD/multimedia-card/SDIO memory-card slot, and OpenGL ES 2.0. It runs a Linux-based operating system, and video demos show that the diminutive computer can run computationally intensive video games, such as *Quake*, as well as 1080p high-definition video. The device also comes with the option of an additional USB hub and a 10/100-Gbps GbE controller.

Eben Upton, the foundation's executive director, who also works as an SOC architect at Broadcom, says that the company's aim was to build a computer that was inexpensive enough to hand out to children, as schools currently hand out textbooks. "Children are enormously illiterate now, but … they know how to … use computers," Upton said in a recent interview (**Reference 1**). "They see them as bits [of] functional magic and have no idea how they work. That [concept is] fine for Facebook and browsing, but, if you want a career of this stuff or to create something that's high value, you have to understand how the thing works."



The $25 Raspberry Pi targets use in teaching computer programming and for educational use in the developing world.

Upton called the initiative "almost nationalist," saying that the idea arose out of concern over Cambridge University's inability to attract sufficient numbers of qualified students and Britain's difficulty in producing engineering graduates. Lately, however, the foundation has also been seeing interest from people in developing countries, such as Brazil and Russia, as well as from adult hobbyists looking to build home-made robots and media centers.

"It won't set the world on fire with its desktop performance," he added, "but it has a lot of multimedia performance," explaining how the plug-and-play computer could turn any TV into a workable productivity computer.

As a registered not-for-profit organization, the foundation will funnel any money it generates from the sale of its Pi boards back into the business in the hope that copycat companies would spring up and start developing their own brands of inexpensive chips. "We can't make any money out of this [idea]; we have no incentive to keep the design of the device secret," Upton said. "We would like nothing more than [to see] some company in China make a million of these [computers]. It would be perfect; we would achieve our goal, which is ubiquitous presence of cheap computers."

> The $25 Raspberry Pi could well mean a slice of affordable computing pie for many who would otherwise be unable to afford a full-priced system.

Meanwhile, Raspberry Pi has enough parts for about 10,000 devices, and the foundation plans to commit a manufacturing run for that number. Once the devices are ready for sale, the foundation will offer them in a Web store. "I suspect it's going to take an hour to sell through it at that point," Upton said, noting that the foundation will hold a few hundred in reserve for developers to whom the company had already committed devices.

The organization plans to introduce a fresh batch of devices slightly more than once a month, although doing so will require careful planning of capital requirements. If the foundation manages to keep a balanced budget, it could well mean a slice of affordable computing pie for many who would otherwise be unable to afford a full-priced system.

—by Sylvie Barak

▷**Raspberry Pi**, www.raspberrypi.org.

REFERENCE

1 Lynley, Matt, "INSIDE THE RASPBERRY PI: How This $25 Computer (Yes, Computer!) Could Change The World," *Business Insider*, Dec 28, 2011, http://read.bi/y02JPc.

DILBERT By Scott Adams

RAQ's

Rarely Asked Questions

Strange stories from the call logs of Analog Devices

Contributing Writer John Ardizzoni is a Technical Product Manager at Analog Devices in the High Speed Linear group. John joined Analog Devices in 2002, he received his BSEE from Merrimack College in N. Andover, MA and has over 30 years experience in the electronics industry.

Beware of big claims and large numbers… they don't always add up

Q: Are wide bandwidth and fast slew rate the best way to benchmark an amplifier?

A: Not necessarily; op amps typically specify 30 or more individual parameters. The task you're trying to accomplish will dictate which of these specifications are most important to you (and your circuit). When evaluating amplifiers, or any component, it is important to make sure you understand the specifications, the test conditions, how test data is collected, and how it is presented, as different manufacturers sometimes present the same parameters in different ways. Knowing both the test conditions and your circuit needs is imperative when comparing parts.

Since you brought up bandwidth and slew rate, let's have a look at those specifications.

Some people think, "the larger the bandwidth, the better," but the savvy analog engineer knows that having just enough bandwidth is better than having hugely excessive bandwidth. The best way to evaluate any parameter is to read the data sheet and look at the plots, as they tell the real story of how the amplifier will behave. Is there excess peaking in the bandwidth plot? Some manufacturers will spin this as a larger –3-dB bandwidth, but it may also indicate that the part has stability issues. Even though the –3-dB bandwidth may appear large, the amplifier's gain flatness may be decreased because of the peaking. Therefore, address bandwidth on just how much you need, noting that wider bandwidth amplifiers require more attention to stability and PCB layout.

Slew rate (SR) is the rate of change at an amplifier output due to a sudden change at the amplifier input. It is typically measured in volts per microsecond (V/µs). The maximum large-signal operating frequency can be determined by using the equation $F=SR/(2\pi Vp)$, where Vp is the peak voltage. Some amplifiers feature very large slew rates, trying to wow engineers with large numbers, but they are not always needed, because the maximum operating frequency will be limited by distortion. The easiest way to check this is to look at the distortion plots for your frequency of interest. Is the distortion level acceptable for your application? Again, knowing your system requirements is paramount. Then, plug this frequency into the slew rate equation and see exactly how much slew rate is needed.

In some cases, big numbers don't add up to better performance. Know your circuit and what you need to get the job done. Add a little more for margin and look at the plots… they tell the real story.

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ANALOG DEVICES

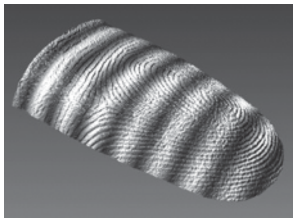
SLI eliminates the need for touch in MEMS applications

The next promising frontier in emerging ubiquitous MEMS applications, SLI (structured-light illumination), may revolutionize metrology applications by removing the need for touch with MEMS. The technology is both smaller and more precise than conventional approaches. Texas Instruments, with its million-mirror DLPs (digital-light processors), is a pioneer in this segment.

SLI works by projecting moving stripes of light onto objects and then measuring the deformity of the reflected patterns using algorithms to reconstruct their 3-D shapes. So far, TI's biggest customers are OEMs manufacturing touch-free fingerprint scanners, which can identify people without the traditional ink-blotter protocol. Besides revolutionizing biometric, facial, dental, and medical scanning, SLI is also opening new frontiers in DLP applications—from industrial inspection systems to scientific instrumentation.

TI previously has supplied OEM development kits that bundled its DLPs with algorithm libraries that can recognize 3-D shapes, surfaces, contours, roughness, and discontinuities, enabling fast, accurate, noncontact 3-D scanning and recognition systems that operate with light sources ranging from ultraviolet to nearly infrared. At this year's CES (Consumer Electronics Show) in Las Vegas this month, TI planned to show its new DLP LightCrafter development platform, which uses almost 500,000 micromirrors to simultaneously illuminate almost anything with structured light, allowing almost-instant characterization and recognition of 3-D objects without touching them.

According to TI customer Mike Troy, chief executive officer of FlashScan3D, DLP technology allows FlashScan3D to capture greater detail in fingerprints with higher accuracy than with other SLI approaches, thus reducing the possibilities of technician error and fraud. "The new DLP LightCrafter development module can scan faster; store data internally versus on a laptop or a separate storage device; and, because of its size,



SLI works by projecting moving stripes of light onto objects and then measuring the deformity of the reflected patterns using algorithms to reconstruct their 3-D shapes.

enable even smaller, more portable SLI applications," says Troy.

YoungOptics, which manufactures TI's DLP optical engine for OEMs building projection TVs, also manufactures the LightCrafter plug-and-play module. Using TI's DLP 0.3 WVGA chip set, OEMs can use the LightCrafter for R&D, but it can also serve as the main subsystem in finished end-user products. The LightCrafter includes a 415,872-micromirror DLP chip as a second custom controller ASIC; a DaVinci digital video processor with its own 128 Mbytes of NAND-flash memory for pattern storage; and a configurable I/O trigger for integrating cameras, sensors, and the other peripherals for SLI.

Developers can also add an optional FPGA to accelerate displayed SLI patterns to as fast as 4000/sec. An integrated LED array for red, green, and blue completes the LightCrafter by enabling it to output as much as 20 lumens of light. OEMs use embedded Linux to develop their software for the DaVinci processor in the LightCrafter, which will cost $600 when it becomes available after this month's SPIE (International Society for Optics and Photonics Engineering) West, in San Francisco.

—by R Colin Johnson

▷**Texas Instruments**, www.ti.com.

Tiny dc/dc-power modules target rugged industrial and avionics environments

Since researching power modules for a recent article (**Reference 1**), I've developed a healthy respect for this product niche. Although they're more expensive than roll-your-own power converters, their perfectly matched internal components and layout solve most high-density-power-conversion headaches.

Addressing that niche, Linear Technology recently introduced a couple of 1.5W dc/dc modules with 725V-dc galvanic isolation in a 9×11.25×4.92-mm BGA package. The module targets applications such as industrial, avionics, and instrumentation equipment. The enclosed BGA package houses all components, including the transformer, the control circuitry, and the power switches, for interconnect reliability in high-vibration applications.

The 1.5W LTM8047 and LTM8048 dc/dc power modules have 725V-dc galvanic isolation and come in a 9×11.25×4.92-mm BGA package.

Both devices take an input voltage of 3.1 to 32V and deliver a regulated output voltage adjustable from 2.5 to 12V for the LTM8047 and from 1.2 to 12V for the LTM8048. The LTM8048 includes a low-noise linear postregulator that reduces the output-ripple noise to 20 μV rms at 300 mA.

The devices are available in temperature grades E and I, which operate at a junction temperature of –40 to +125°C, and MP, which operates at –55 to +125°C. Prices start at $8.25 and $8.75 (1000) for the LTM8047 and LTM8048, respectively.

—by Margery Conner

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

REFERENCE

1 Conner, Margery, "IC-like modules simplify system dc/dc-power designs," *EDN*, July 28, 2011, pg 29, http://bit.ly/vKwfmN.


New AV Series
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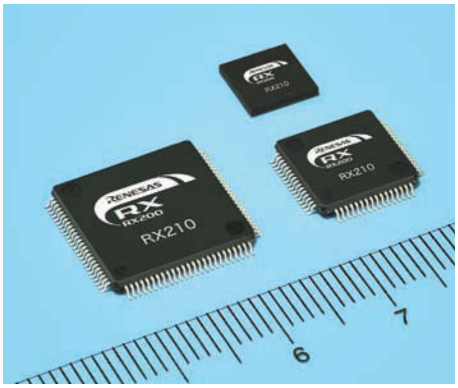
Microcontrollers target smart metering

The compatible RX630, RX63N, and RX210 microcontroller families, targeting smart-metering applications, use the vendor's 32-bit RX core and advanced MONOS flash processors. The RX210 provides flash operation as fast as 50 MHz at 3.3V and 20 MHz at voltages as low as 1.62V, including flash programming and erasure. These features ease the design of applications requiring battery backup and read performance during power-off.



The RX210, RX63N, and RX630 microcontrollers target use in smart-metering applications.

The RX210 integrates as much as 512 kbytes of on-chip flash memory and 8 kbytes of on-chip data flash, supporting 100,000 write/erase cycles and programming and erasing in the background. The RX630 offers 100-MHz flash memory and supports 64- to 176-pin packages, as much as 2 Mbytes of flash memory, 32 kbytes of data-flash memory, and 128 kbytes of SRAM. It includes as many as 13 serial interfaces, an I²C interface, SPI, a real-time clock, and a 12-bit ADC.

The RX630, with 384 kbytes of flash and 64 kbytes of RAM, comes in an 80-pin LQFP and sells for $4.70 (10,000). The RX63N, with 2 Mbytes of flash and 128 kbytes of RAM, comes in a 176-pin LQFP and sells for $10.30, and the RX210, with 512 kbytes of flash and 64 kbytes of RAM, comes in a 64-pin LQFP and sells for $4.50.—**by Fran Granville**

▷**Renesas Electronics**, www.renesas.com.

Intel rolls out 32-nm Atom, preps 22-nm Ivy Bridge

Intel Corp rolled out Cedar Trail, its 32-nm Atom chip for netbooks and embedded systems, and Taiwanese newspaper *Digitimes* claims that it has uncovered details about the company's plans to release its 22-nm Ivy Bridge notebook and desktop CPUs. Intel plans to release 25 Ivy Bridge processors in early April. The company made the processors in its 22-nm technology, according to a report in *Digitimes*, which states that 17 desktop-bound chips will range in price from $184 to $332 and eight notebook CPUs will range in price from $40 to $1096—a likely inaccurate range.

Since approximately 2008, Intel has rolled out its next-generation desktop and notebook CPUs at the CES (Consumer Electronics Show) in January. This year is an exception to the trend, sparking one analyst to suggest that Intel delayed the Ivy Bridge chips by at least a quarter. An Intel spokesman denies that claim, however.

Intel did formally unveil its latest Cedar Trail Atom chip set, which includes two new dual-core Atom processors for netbooks—the 1.6-GHz N2600 with 400-MHz embedded graphics dissipating approximately 3.5W and the 1.86-GHz N2800 with 640-MHz graphics consuming 6.5W. The chips support faster graphics cores and DRAM interfaces—as fast as 1066 MHz for DDR3—and consume less power than Intel's previous-generation Oak Trail parts.

Intel pairs the chips with the NM10, an I/O hub that supports PCIe, USB, Ethernet, SATA, and audio interfaces. Acer, Asus, Hewlett-Packard, Lenovo, Samsung, and Toshiba will ship netbooks using the chips as early as this month, according to Intel, which claims that the systems can sport battery life as long as 10 hours and start at prices as low as $199. Intel also introduced D2500 and D2700 Atom processors for entry-level desktops and embedded systems. The chips support data rates as high as 2.1 GHz and consume as much as 10W.

—**by Rick Merritt**

▷**Intel Corp**, www.intel.com.

> “Acer, Hewlett-Packard, Samsung, and Toshiba will ship netbooks using the chips as early as this month.

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SMALL MEMS MODULES BOOST CONSUMER-DEVICE SENSITIVITY

STMicroelectronics' new LSM330D multisensory MEMS module for consumer- and portable-system applications integrates three-axis sensing of linear and angular motion in a 3×5.5×1-mm package. The iNEMO module with 6° of freedom is almost 20% smaller than competing devices, according to the company.

The module combines a user-selectable full-scale acceleration range of 2 to 16g with angular-rate detection of 250 to 2000 dps along the pitch, roll, and yaw axes. It includes power-down and sleep modes in two embedded FIFO-memory blocks—one for each sensor. It can operate with a supply voltage of 2.4 to 3.6V. The device is compatible with the company's three-axis accelerometers and gyroscopes. Price is $2.75 (1000).

—by Fran Granville

▶**STMicroelectronics**, www.st.com.

The LSM330D multisensory MEMS module for consumer- and portable-system applications integrates three-axis sensing of linear and angular motion in a 3×5.5×1-mm package.

CAN transceiver isolates signals to 5 kV rms, handles temperatures to 125°C

Signal isolation—for those who know what it is—is a wide-ranging, often-mandatory problem-solver; for those who don't, it's a magical function, which, they hope, can somehow save their design. Either camp will be able to use the ADM3054 digital CAN (controller-area-network) transceiver from Analog Devices. It provides isolation for digital signals as high as 5 kV rms and operates at temperatures of –40 to +125°C. Target applications are automotive and industrial designs requiring isolation for either user safety or signal integrity, including ground loops and floating signals.

As a signal-only isolation device, the ADM3054 finds use in applications in which power is available through an isolated rail or through a transformer pick-off winding. A single 3.3 or 5V supply powers the device's logic on the V_{DD1} output, and the bus side uses a 5V supply on the V_{DD2} output.

This physical-layer transceiver fully complies with the ISO 11898 CAN standard and uses Analog Devices' iCoupler digital-isolator technology; it can operate at data rates as high as 1 Mbps. The ADM3054 combines a three-channel digital isolator with a CAN transceiver in a 10×10-mm, single-surface-mount, 16-lead, wide-body-SOIC package, which the vendor claims yields a reduction of as much as 70% in BOM component count and 61% in PCB footprint.

The transceiver integrates ±36V fault protection on the CAN-bus pins to guard against short circuits to power and ground in 12 and 24V systems. The device also has current-limiting and thermal-shutdown features that protect against output short circuits and situations in which the bus might short-circuit to ground or power terminals. The ADM3054 sells for $2.10 (1000).

—by Bill Schweber

▷**Analog Devices Inc**, www.analog.com.

The ADM3054 digital CAN transceiver from Analog Devices tackles industrial- and automotive-interface problems.

Differential op amp tackles common-mode voltage as high as ±275V

Op amps, those versatile building blocks of the analog world, come in thousands of varieties. Yet there's still a need for more and better, in which "better" means units with more desired attributes but not at the expense of others. One such amplifier is Texas Instruments' INA149 differential amplifier. With common-mode voltage as high as ±275V and 100-dB CMRR, the device finds use in high-voltage current sensing; battery-cell-voltage monitoring in photovoltaic, telecom, and electric-vehicle applications; alternative-energy applications; power-supply-current monitoring; and motor control.

The vendor claims that the device's CMRR, along with a specified minimum CMRR of more than 90 dB throughout the industrial temperature range of –40 to +125°C, provides two-times better overall measurement accuracy than that of its closest competitor. An extended input-common-mode voltage of –275 to +275V enables accurate monitoring of signals riding in high common-mode voltages, eliminating the need for multiple supply sources and analog isolation components to interface to an ADC. The unit also offers twice the slew rate and full-power bandwidth of its closest competitor for applications requiring the monitoring and quick correction of abrupt changes, such as short-circuit conditions. The faster response and wider large-signal bandwidth of 500 kHz increase system performance. The INA149's maximum initial gain error of 0.02% provides accuracy, especially in applications with low common-mode-voltage signals.

TI offers a variety of tools and support, including the $49 INA149EVM (evaluation module) and a Tina-TI Spice model to simulate device performance. The INA149 comes in a 4.9×6-mm SOIC package and sells for $2.70 (1000).—by Bill Schweber

▶**Texas Instruments**, www.ti.com/ina149-pr.

VOICES

Mark Mitchell: An early interest in computers leads to lifelong ambition

Mark Mitchell, director of embedded tools for Mentor Graphics' embedded-software division, was previously the founder and chief "sourcerer" of CodeSourcery. He has worked on C/C++ software-development tools since 1994, has been involved in Free Software Foundation's GCC (GNU compiler collection), and, since 2001, has been an active member of the GCC Steering Committee. Mitchell holds degrees in computer science from Harvard University (Cambridge, MA) and Stanford University (Stanford, CA). The software guru recently spoke with *EDN* about how he initially became interested in engineering, what today's engineering students need to know, and the biggest challenges currently facing the software community.

How did you get interested in engineering?

A When I was in elementary school, they still had budget for various enrichment programs. They had a woman—Vivian Wills—teaching accelerated math and computers. I give her tremendous credit because, especially at that time, … there were not a lot of women in computers. The school had managed to get its hands on a grand total of two Commodore PETs. I think we had one 8-kbyte model, and we might have had a 16-kbyte model that had an extra bank of RAM in it; they had tape drives. In about the second grade, I got curious about these things and would start going in during recess even before I was old enough to take the classes and started learning a little bit about how to use them. Like kids today, I wanted to play games on them. ... Of course, the games weren't really sophisticated. She could tell I was interested in computers, so I started even ahead of the coursework learning to program them in Basic and, then, a bit later, by the time I got to the end of elementary school I managed—by working odd jobs—to get my hands on a Commodore 64. I programmed that thing both in Basic and in assembly language.

What advice would you give to engineering students?

A There are a few things that I think students don't get much visibility into that are really important. One is the difference between computer science and software engineering. A lot of what gets taught is computer science, so they learn about algorithms and data structures—and all those sorts of things are very important—but the discipline of software engineering is a really collaborative thing. That [distinction] is the key difference.

The other thing is—and I don't know whether this [subject] is teachable—but when you come to a piece of software, you look at it, and your thought is, "Oh my goodness, this is an ugly, hairy mess. I can't believe they put it together like this, and we need to just take this [thing], throw it out, and start from scratch. I know better. I've studied the latest techniques, and I know how to build this [thing] from the ground up so that it's way better." You're going to have that instinct a hundred times, and you're going to be right about one out of a hundred times. [The attitude] is incredibly pervasive. It's one of these things that every young software engineer [has]: You look at some horrible pile of code, and what is really hard is to tease out what parts of that [code] are, despite maybe some ugliness in the structure of it, essential complexity that has to be there for the thing to do what it does.

What has open source done for the software-engineering community?

A Open source really makes sense to engineers at that level, but it certainly changed the discipline and practice of things because now one of the common engineering activities is actually integration and customization of open-source software. So, as you're going off to build, for example, a system for navigation, a CD player, and the stuff that sits in the front of the car up under the dashboard that you can play with while you're driving, now that system very well may be running on Linux. The exercise then for the people building that system is to get a lot of open-source technology and then try to customize it, manipulate it, [and] add things on top of it to make it into that system.

The open-source solution … means that you can move much faster, and it's much cheaper because you're using all this stuff that already exists. It's just code from somewhere that you got somehow, and you have to work with it. Even more of the discipline is about comprehending other people's work and building on it as much as it is creating from scratch.

What is the biggest challenge the embedded-software industry is facing?

A The biggest challenge we have as an industry is in these really large systems. We need them to be reliable, we need them to be secure, and we need them to perform well. We're hitting the limits of our ability to scale not in a technical sense but in a process sense. We don't understand the systems well enough to make them perform well, and we don't have time to make them perform well. The techniques and tools we have aren't sufficient. That's our big hill to climb.

—interview conducted and edited by Ann Steffora Mutschler

BY BONNIE BAKER

Designing with temperature sensors, part five: IC temperature sensors

My previous four columns examine thermistors, RTDs (resistance-temperature detectors), and thermocouple temperature sensors (**references 1** through **4**). The integrated temperature sensors on the market can also solve your temperature woes (**Figure 1**). These sensors operate over a temperature range of only −55 to +200°C. However, they are easy to install on your PCB, and they have a user-friendly output format. It is difficult to categorize the various types of IC sensors, but the following paragraphs take a stab at describing the generalities of the inputs, insides, and outputs of these silicon chips.

IC temperature sensors have a variety of input and output options. For instance, you can select an IC temperature sensor that has the actual temperature sensor within the silicon chip. This sensor reports the temperature at the sensor's location. In contrast, you can connect many IC temperature sensors to remote diodes and IR sensors. Remote diodes come in handy when you want an inexpensive way to remotely sense the temperature of your electronics or when you want to interface with the available microcontroller or processor internal diode.

As you acquire the temperature information at the output terminal of these chips, you will see many interfaces, including voltage and current analog output, digital SPI, digital I²C, and PWM. The analog voltage- and current-output IC sensors let you keep the signals in the analog domain. For die-hard digital-minded people, however, the temperature information is available in the standard SPI or three-wire formats and in the two-wire I²C and SMBus (system-management-bus) formats. These digital interfaces provide noise immunity with easy PCB-routing alternatives. With these types of digital signals, you can acquire resolution as high as 16 bits and temperature accuracies as high as ±0.5°C over a limited temperature range, with ±2.5°C over the full temperature range.

Designers exploit the process technology of these silicon-based ICs to everyone's advantage. For instance, some of these chips offer overtemperature signal notifications. If the IC sensor can connect to remote diodes, it may also include compensation features for beta, resistance, and eta factor.

These temperature sensors have some limitations. For instance, you must use RTD or thermocouple temperature sensors to sense temperatures lower than −55°C or higher than 200°C. If your design requires high repeatability and accuracy, an RTD is your best option. The IC temperature sensor's responsiveness to temperature changes depends on the device's package size; smaller packages respond more quickly. RTDs, thermocouples, and thermistors typically respond in 1 to 10 sec. IC temperature sensors respond in approximately 4 to 60 sec.

IC temperature sensors are attractive because they include on-chip signal-conditioning circuitry. System designers need not worry about linearization, cold-junction compensation, comparators, additional ADCs, or voltage references. This low-cost approach may be exactly what you need to protect your systems in the field. EDN

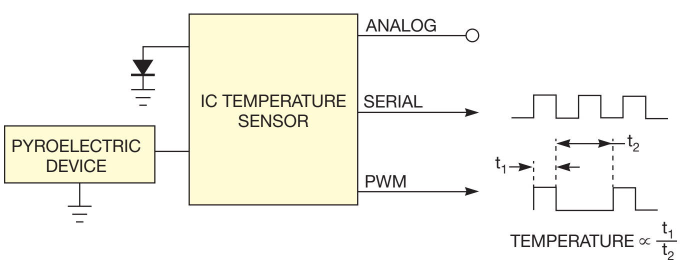

Figure 1 Integrated temperature sensors operate over a temperature range of only −55 to +200°C; however, they are easy to install on your PCB, and they have a user-friendly output format.

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Bonnie Baker is a senior applications engineer at Texas Instruments.

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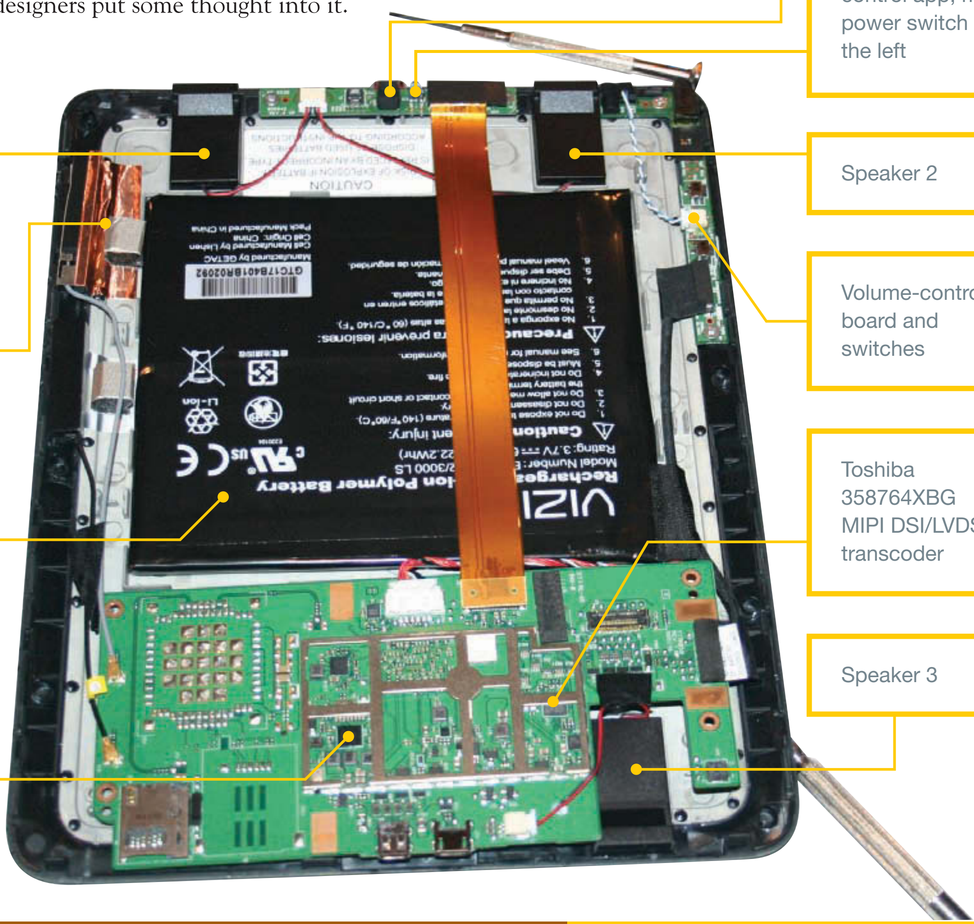
- For more on the Vizio, see the full teardown at http://bit.ly/zKZT42.
- Join us for a full-tablet-teardown panel and wireless discussion at DesignCon 2012, www.designcon.com.

Vizio VTAB1008 tablet: symbiosis of man and machine

There's just something about the 8-in. Vizio VTAB1008 Android tablet: You take it out of the box, turn it on, start using it, and immediately get attached to it. I did, and so did my family, to the point that they're asking for a new one now that this one is shredded. Few designs generate that natural symbiosis of user and system, but all designers know how hard it is to achieve it. In the case of the Vizio, which is not a design house but instead a provider of generic, reasonably priced, midrange consumer devices, it came about through close collaboration between the application engineers at Marvell, whose 1-GHz, dual-core ARM Version 7 Armada 610 processor is at the heart of the device, and contract manufacturer Foxconn.

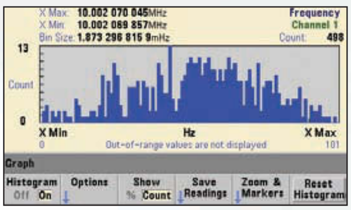
The basics: Vizio introduced the VTAB1008 in August 2011 at $329, but the price quickly dropped to $269, and you can now nab one for about $150. For that price, you get a 1024×768-pixel LED display, a 1-GHz processor, GPS, 802.11n, and Bluetooth wireless. The device has a capacitive, multitouch panel; a 1.3M-pixel, 30-frame/sec front-facing camera; and 4 Gbytes of storage, though only 2 Gbytes are available to the user. That said, storage is expandable to 32 Gbytes through an external memory card.

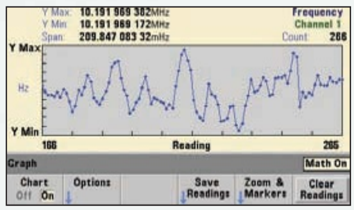
The device fluidly performs the basics and adds an IR emitter, which, with a universal remote-control app, controls your entire home-entertainment system. It also features HDCP compliance, to allow streaming of secured HD content from Netflix, Hulu, or other sources to your TV, and a three-speaker system that allows multiaxis stereo sound using SRS TruMedia. You just know that its designers put some thought into it.



“I never expected a frequency counter to do so much, so fast.”

Speed, resolution and accuracy are just the beginning.





Especially today, every investment you make has to earn its keep, and RF/ Universal Frequency Counters are no exception. The new Agilent 53200A Series boasts greater performance than anything in its class, along with important extras that may surprise you. Like a large color display for built-in analysis, unprecedented connectivity and new measurement capabilities. You get more than higher performance. You get insight. That’s Agilent.

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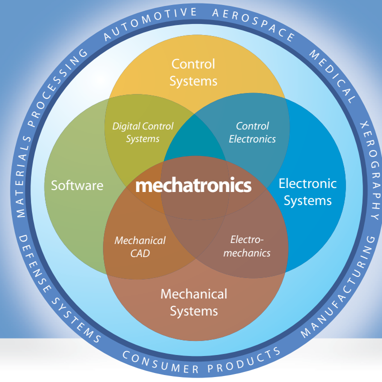

Theory and practice

We all know about the gap; let's do something about it.

The theory-practice gap has existed for decades, and each of us must bridge this gap in all we do. Control is an essential element in all multidisciplinary systems, so let's start there and begin to bridge the gap that exists between the theory of control and its digital implementation. The following points provide an overview of control theory for the practitioner.

First, remember that feedback control is a pervasive, powerful, and enabling technology. At first sight, it looks simple and straightforward, but it is amazingly subtle and intricate in both theory and practice. Also remember that you cannot instantaneously effect changes in a dynamic system, so applying an otherwise-correct control decision at the wrong time could result in catastrophe. Further, nonlinearities, including backlash, coulomb friction, saturation, hysteresis, quantization, deadband, and kinematic nonlinearities, are always present. You can use a linearized model to approximate a nonlinear system near an operating point.

When working with dynamic systems, keep in mind that they must have guaranteed stability. Closed-loop systems become unstable because of an imbalance between the strength of corrective action and the system's dynamic lags. Stable systems must have adequate stability margins to work after you have built them. Stable systems also have a frequency response. If you apply a sinusoidal input to a stable linear system, then the steady-state output will be a sinusoid of the same frequency. The amplitude ratio and phase difference of the two sinusoids are frequency-dependent, however.

Once you have a stable, closed-loop system, the main reasons for using feedback control are command following, disturbance rejection, insensitivity to modeling errors, and insensitivity to unmodeled high-frequency dynamics and noise.

Keep in mind that the open-loop transfer function is the product of all the transfer functions in the loop, including the controller, the actuator, the plant, and the sensor. The open-loop transfer function is much less complex than the closed-loop system-transfer function. The Nyquist criterion, a graphical technique for determining the stability of a system, and the root-locus procedure, which allows adjustment of the system poles by changing the feedback system's static gain, allow you to use the open-loop transfer function to predict closed-loop system performance.

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Once you have a stable, closed-loop system, the main reasons for using feedback control are command following, disturbance rejection, insensitivity to modeling errors, and insensitivity to unmodeled high-frequency dynamics and noise. Time delays can be deadly, however. Always conserve phase, the equivalent of time delay. Integral control adds 90° of phase lag at every frequency, and digital control adds time delay primarily due to digital-to-analog conversion. Imagine trying to make decisions using old information.

High control gain yields good command tracking and good disturbance rejection. However, areas of concern include roll-off, saturation, and noise. Even the most insignificant detail of control engineering may prove important. Real control systems must be reliable, especially if people's lives depend on them.

Maybe you know all of this information, but it is worth repeating. Let's put some of this theory into practice. A case study at www.designnews.com bridges the theory-practice gap regarding something you all must be able to do: implement speed control of a motor with an attached incremental optical-encoder sensor using a microcontroller with a PWM output to drive an H bridge. This exercise uncovers gaps that many of us are aware of. The case study uses the popular, inexpensive Arduino microcontroller, a 12V Pitman brushed-dc motor, a three-channel optical encoder with 500 counts per revolution, the L298 H bridge, and MatLab/Simulink real-time code generation. I resolve to continue bridging the theory-practice gap with articles and Web-site case studies. Happy New Year. EDN

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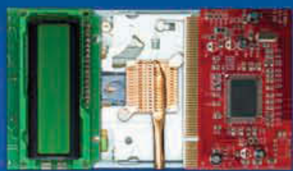
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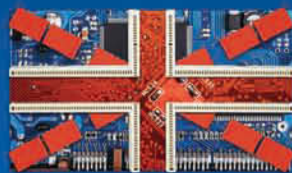
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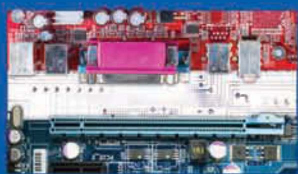
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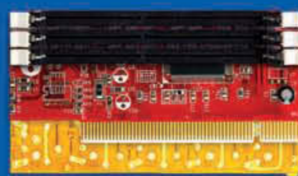
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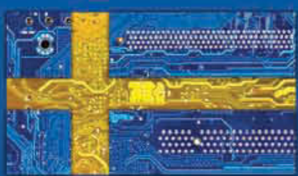
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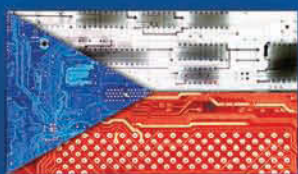
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An industry in transition

By Bolaji Ojo

INSIDE

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Nobody has come up with a catchy alternative yet, but it is becoming increasingly clear that the term “electronics distributor”— harking back to the group’s origin as middlemen that linked component vendors with customers worldwide—has outlived its usefulness. The misnomer does little justice to the range of services that the sector’s diverse participants perform nowadays, and it might be time to dump it altogether.

A look at Avnet Electronics’ latest annual filing with the U.S. Securities and Exchange Commission bolsters that argument. The filing states that Avnet “provides engineering design, materials management and logistics services, system integration and configuration, and supply chain services that can be customized to meet the requirements of both customers and suppliers.” Of course, the company still functions as an “industrial distributor of electronic components, enterprise computer and storage products, and embedded systems,” but it is no mere middleman. Rather, it is “a vital link in the technology supply chain.”

Distributors have added design, inventory management, logistics, subassembly and other services. How much deeper into the electronics design and supply chains are they willing to extend themselves?

The description is not hyperbole. And it applies not only to distribution giants like Avnet, Arrow, World Peace Group, Future, Digi-Key, Mouser and Element14, but also, increasingly, to midsize and niche players. This editorial package, a joint project among the publications of UBM Electronics, provides ample evidence that in all segments of the electronics industry, the companies we know today as distributors are increasingly critical resources for design and related value-added services. In short, today’s distributors have taken on many more responsibilities than tradition has assigned them.

The expansion of distribution’s role raises key questions not just about distributors, but also about the fundamental changes occurring in the industry and in society at large. As distributors add design functions to their slate of offerings,

what is the effect on their relationship with their various constituencies—component makers, the OEMs that have traditionally handled design, the outsourcing community on which equipment vendors rely for production, and the customers who rely on their services? How many more OEM and vendor functions can distributors absorb? What are the implications of this brand extension for the design and supply chain? Who benefits most from the new twists in relationships among suppliers, distributors and their customers? And how do the players get reimbursed for their services in an environment where goods and ideas crisscross national and corporate boundaries?

The lines of demarcation are being erased across all industry segments

The articles in this special editorial package examine those questions and provide perspective on how the industry can best manage its evolving web of interrelated business models.

The discussion is only just beginning. As technology innovations have accelerated, so has the complexity of the industry's relationships. The lines of demarcation are being erased not just between OEMs and their EMS providers, but across all industry segments.

Indeed, even the definition of OEM is changing rapidly.

The OEM ranks thinned out during the recessionary Y2K period but have expanded fast since then to accommodate some players that bear little resemblance to the typical OEM of 2000. In addition to "traditional" companies like Microsoft and Apple, industry participants now include bookseller and Nook e-reader vendor Barnes & Noble; online retail titan, Kindle creator and, if speculation proves correct, aspiring smartphone market participant Amazon; and Google Inc., which leveraged its high value in search engine optimization to launch Android and purchase a traditional OEM (Motorola Mobility).

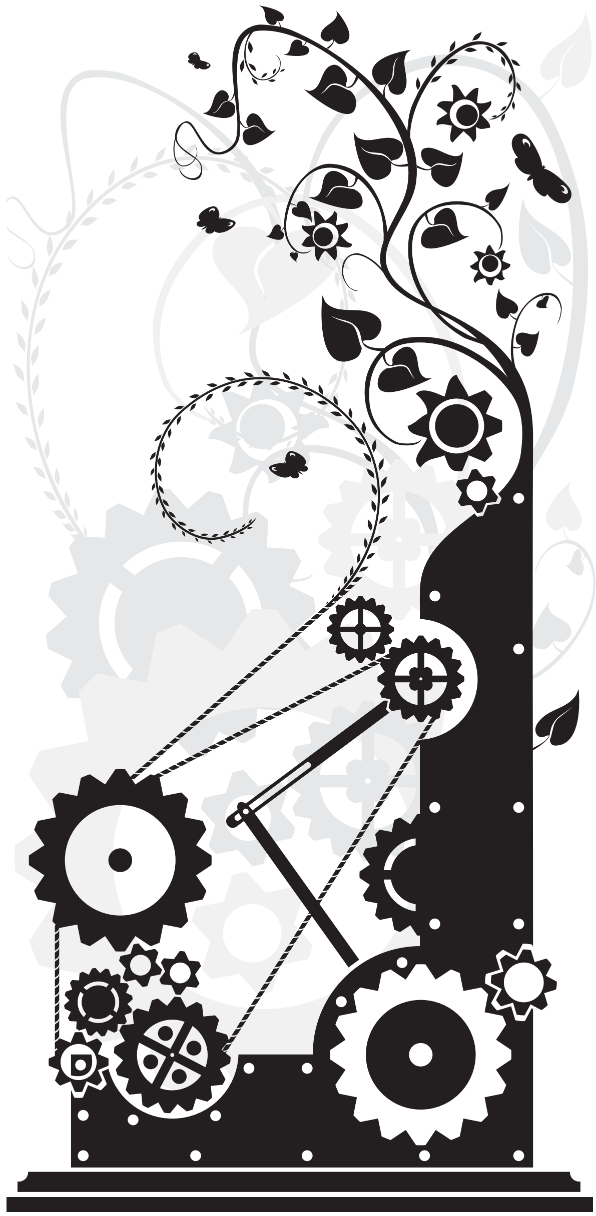
I suspect distributors will somehow find new ways to serve everyone in the industry, whatever direction they pursue. That's because they've changed faster than any other segment over the past 20 years and have a depth of offerings and market penetration that few can match. Avnet alone says its roster of customers includes "more than 100,000" OEMs, EMS providers, ODMs and VARs, in addition to hundreds of component makers.

Such companies can rightly still be called distributors only in the context of how extensively their distributed services touch all segments of the industry. ■

Bolaji Ojo (*bolaji.ojo@ubm.com*) **is editor in chief of** ***EBN*****.**

Keeping the channel relevant in an ever-changing world

By Barbara Jorgensen



Electronics distributors have seen wrenching changes in the industry over the past two decades and have had to adjust rapidly to the demands of their customers. The channel's traditional model of order fulfillment has evolved to include design services and engineering support. Meeting the needs of both the engineering and procurement departments isn't always easy, and distributors are resolving this dilemma in a number of ways.

Until fairly recently, distributors' main focus was on purchasing—securing large-volume orders to be shipped to manufacturing sites around the world. Engineers either interfaced directly with component suppliers or worked with catalog distributors.

A number of factors have changed that. First, suppliers are cutting back on their technical support to all but their major customers. Second, the global regulatory environment has made the supply chain increasingly complex. Distributors, which interface extensively with both their suppliers and their customers, have seen an opportunity to fill in some gaps by expanding their role in the supply chain.

As component suppliers have cut back on their support, customers have been turning to distribution for design assistance. As extensions of their suppliers' sales forces, distributors are trained in many technologies. Since most distributors carry a wide variety of suppliers—some in the hundreds—the channel has a bird's-eye view of how these technologies interact.

Distributors are in a unique position to assist designers in selecting the best mix of components for their end products.

That has required a change in the way distributors interact with suppliers and customers. In the past, distributors would typically push a supplier's product—a Texas Instruments or Intel part, for example—as the mainstay on a customer's pc board. Now, instead of focusing on a single product, distributors focus on solutions.

This approach takes a combination of products, directs them toward an application, test drives the solutions and offers them to the market. Intel and TI products may be on the board, but so are the capacitors, resistors and connectors that complete the solution. Even longtime competitors appear side by side on the same board.

Some distributors are taking design assistance a step further and are guiding customers to design tools as well as components. Catalog distributor Element14, for example, has created an interactive site hosting component data, EDA tools, design-related content, pc board prototyping services, an engineering community and a components store.

Interactive communities like the Knode are 'a gateway into ... design solutions'
— Jeff Jussel, Premier Farnell

For now the community, called The Knode, targets the pc board design and embedded systems markets, but there are plans to expand into other design areas, such as FPGAs, according to Jeff Jussel, senior director of global technology for Element14 parent company Premier Farnell plc.

"We see this as a gateway into engineering design solutions," Jussel told *EBN*. "We now provide solutions beyond component development kits and hardware tools: We can help engineers with the design, their component selection, their pc board services and their prototyping needs, and contain it all in one 'room.'

"The concept is to present these solutions to engineers and let them do their work faster, with less risk, and in a way that makes sense to them."

All this engineering assistance comes at a cost, however. Distribution is first and foremost a sales-driven business model. High-salaried engineers are a fixed cost in these organizations and have to be deployed toward distributors' most profitable opportunities. Distributors are trying to scale their design services toward a highly segmented customer base.

While distributors can spread the expense of hiring engineers over a customer base that numbers in the tens of thousands, they are also turning to their suppliers for support. Global distributors Arrow Electronics Inc. and Avnet Inc., for example, host several programs every year that include suppliers and customers. Events such as Avnet's X-Fest and its SpeedWay and On-Ramp programs offer intensive hands-on training sessions that bring suppliers and customers face-to-face.

On the fulfillment side of the business, distributors face many of the same challenges as OEMs. Electronics companies are under increasing pressure to become better global citizens. Manufacturers are being asked to provide information on the materials they use, where those materials are sourced and to whom their products are being shipped. Distributors are frequently conduits of such information.

For example, environmental mandates such as the European Union's RoHS directive require manufacturers to document their compliance. Most OEM systems aren't set up to track and sort millions of components, but distributors' systems are. So OEMs rely on distributors to stay on top of a variety of environmental laws.

Only a decade ago, the Internet threatened to render the distribution channel irrelevant. That hasn't happened, but distributors realize they have to keep evolving to keep customers engaged. The channel has moved from the parts-fulfillment business into the design realm and still has room to grow.

"We've moved from selling parts to making complexity seem simple," Arrow CEO Michael Long said at a recent industry conference. "But innovation is the cost of entry." ■

Barbara Jorgensen (*barbara.jorgensen@ubm.com*) is community editor at *EBN*.

Need design guidance? Ask a distributor

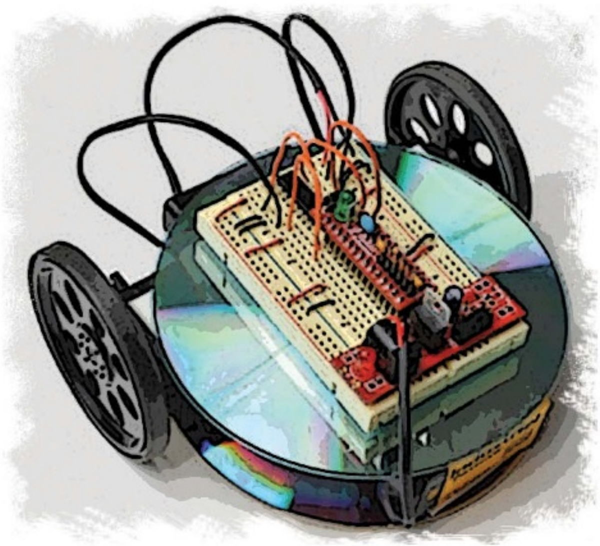
By Paul Rako

Component vendors and resources like *EDN* are go-to sources for design guidance, but electronics distributors can also help you get your designs off the ground.

Many distributors have their own teams of application engineers. Companies such as Newark offer libraries of application notes and white papers, as well as training and design tools.

In addition, distributors like Avnet Inc. have long championed reference designs as a way to help OEMs speed product evaluations. Sometimes component vendors do these reference designs, but distributors have also stepped up to the challenge of creating their own. If enough customers request a design, many distribution companies have the engineering talent on hand to supply it. So even if you don't see the reference design you need, be sure to ask your distributor if it can come up with the required reference platform.

Distributors also partner with other vendors to provide design services. For example, Avnet's Technology Solutions group partners with Palo Alto Networks to help with firewall solutions, and it teams with Lincor Solutions to handle clinical assessment and entertainment systems. Avnet's Electronic Marketing division conducts technical seminars and workshops on such topics as designing with USB or ARM. There's a Design with Avnet section on the company's Web site, and there's even a technology museum at Avnet's Phoenix headquarters. And Avnet Express is UBM Electronics' partner in the Drive for Innovation, a program in which Brian Fuller of *EDN* sister publication *EE Times* has been driving a Chevy Volt around the country and meeting with engineers.



The One-Hour CoasterBot, built with a handful of parts and unreadable CD castoffs (derisively nicknamed coasters), is one of the fun—and instructive—DIYs featured on Jameco's Web site.

Photo credit: Jameco

Digi-Key has long helped design engineers get the job done. If you need information on the on-resistance of a 200-volt p-channel FET, you could go to five or more component vendor Web sites and look up the parts. But it's far easier to conduct a search on *digikey.com* and filter for your desired specs, such as the lowest on-resistance available from the vendors that distribute through Digi-Key.

The distributor also offers product training modules and videos to help customers understand their design challenges and trade-offs, and it has reference designs on hand and application engineers on staff to help designers get started.

Perhaps Digi-Key's most valuable design-related service is its TechXchange forum, where designers can share information and pick the brains of Digi-Key's application engineers. A recent discussion centered on how to power an LCD through a microcontroller output pin. Alec, a Digi-Key engineer, was monitoring the forum and responded: "I asked one of the other engineers here at Digi-Key, and he says he has used small LCDs with that level of current draw and powered them directly from an MSP430 GPIO pin without any problems."

Digi-Key also partners with National Instruments, NXP, Screaming Circuits and Sunstone in what the participants call a circuit design ECOsystem. The capitalized ECO riffs on the engineering change order, but the use of "ecosystem" reminds designers they need distribution, board fabrication, simulation and testing, as well as an IC vendor, to get a design working and ready for production. The ECOsystem helps them move from parts research to circuit design, fabrication and assembly, and validation and test.

Mouser is another distributor that does more than just stock parts. Its Product Knowledge Center has information on more than 1,700 topics to help engineers strategize and refine designs. The company also offers a search accelerator that can be added to a browser to expedite part searches, an often frustrating part of the design process. And Mouser's project sharing system lets designers share projects with coworkers.

Even smaller distributors, such as Jameco, offer design assistance. Electronics guru Forrest M. Mims III describes his favorite designs on Jameco's Web site. The site also offers a DIY section that offers fun projects, such as the One-Hour CoasterBot kit. Such diversions might not solve an immediate design problem, but they let engineers get hands-on experience in areas such as robotics and analog design.

Be sure to consider the resources and talents of distributors as you plan your next design project. They have the tools and expertise to help you get a jump on the competition. ■

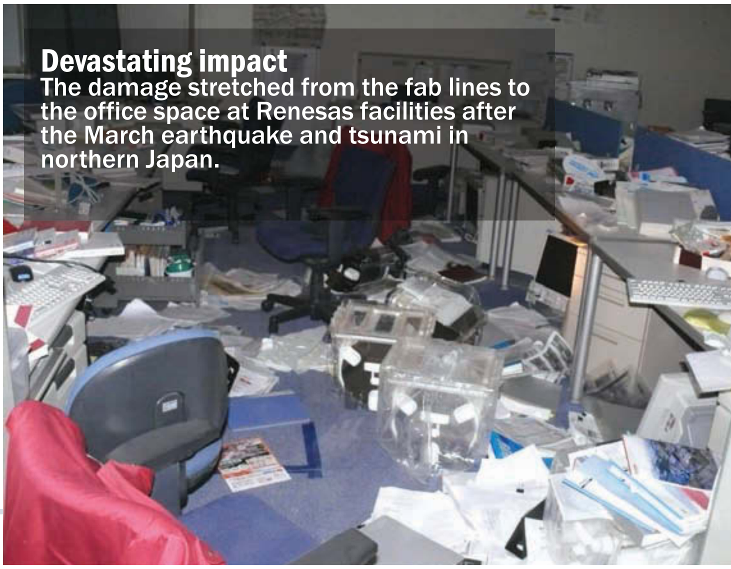
Paul Rako is a former *EDN* technical editor.

Disasters, shortages, counterfeits: For industry, 2011 was a year of wakeup calls

By Junko Yoshida

The electronics industry got a rude awakening—or a series of them—in 2011. It was a year in which any hiccup in the supply chain posed the threat of profound disruption for OEM businesses ranging from automaking to light bulb manufacture.

Supply chain issues that plagued the industry last year included the great earthquake and tsunami that hit Japan in March; the increasing rarity of rare-earth materials; and an alarming uptick in chip counterfeiting, which has brought new national-security headaches.



Devastating impact
The damage stretched from the fab lines to the office space at Renesas facilities after the March earthquake and tsunami in northern Japan.

Their finest hour
Dan Mahoney, president and CEO of Renesas Electronics America, characterizes the rebuilding period as his colleagues' finest hour. Part of the process, once the crisis was over and manufacturing capability was restored, was to draft a 'fab network' plan that would get the company through the next disruptive event.

Before and after
Although there was damage to equipment inside clean rooms like this one, shown before and after the repairs, the buildings themselves held up well, having been engineered and constructed to withstand seismic activity.

Everyone in the industry knows their business lives or dies by the supply chain, but nobody fully appreciates its centrality until a catastrophe serves as a reminder. Then, at least for a time, folks get serious about devising plans to cope with the next distribution crisis.

The problem is, every supply chain problem is unique in terms of its cause, its impact and its appropriate solution.

Often, distribution ruptures cannot be repaired by distributors alone. It takes serious collaboration all along the supply chain—component suppliers, distributors and OEMs included.

To complicate matters, the supply chain itself has become increasingly fragmented. The rise of Internet trading, the increased use of electronics manufacturing service providers in diverse locations, and system vendors' giving in to the temptation of faster and cheaper solutions have all compromised supply chain visibility. That, in turn, has created new entry points for counterfeit chips, as the industry and government discovered last year.

Topping the list of 2011 events in terms of damage to the supply chain was the March 11 earthquake and tsunami. The catastrophe's repercussions were spread broadly among the materials, components and equipment segments of the supply chain. A shortage of MCUs from Renesas—hardest hit among the Japanese chip companies slammed by the quake—sent shock waves of production-line disruptions through tier-one automotive manufacturers like Nissan and Honda, as well as through second- and third-tier-automotive subsystem suppliers.

Thanks to the combined efforts of the IC vendors themselves and their suppliers, customers and competitors, even the most damaged chip vendors resumed full production before the end of the third quarter. But a robust redundancy program to stave off the next supply crisis is still in the works.

In an interview with *EE Times* last fall, Yasushi Akao, CEO of Renesas, laid out his vision for a "fab network" of production lines operated both inside and outside Renesas fabs. During a crisis, the fab network would allow the company the flexibility to change, on the fly, the volume and mix of products run on the various fab lines.

Renesas' three-pronged plan for the

redundancy program involves securing multiple production lines, asking customers to evaluate and qualify production lines at different fabs in advance, and requiring each fab to maintain an inventory of "semi-finished" products. Renesas aims to restore production at any given fab—no matter what happens—"within a month," said Akao. "That's our endgame."

But, of course, no supply chain issue can be sorted out just by one party.

The fab network won't function properly if Renesas and its customers fail to disclose and share information on specifics such as available capacity at fabs, product road maps and qualification processes. Further, they must agree on how to share the cost of building the needed redundancy into the model.

At a time when many leading integrated device manufacturers have been busy downsizing in-house production capacity and going fab-lite, Japan's earthquake was a shock to even the best-laid fab plans. The question semiconductor companies need to answer is no longer whether they should maintain their own fabs, but how they can build a network of production lines on which they can reliably depend.

Artificial scarcity

Along with reliable access to fab capacity, reliability of materials supply was an issue last year as China tightened restrictions on production of the rare earths used in electronics manufacture. The problem originated with a tiff between Japan and China in 2009 and quickly escalated beyond those traditional rivals. By last summer, China had cut already-short export supplies by a third. The unsurprising upshot has been skyrocketing prices for the vital materials.

Australia, Canada and the United States all have programs under way to open or reopen rare-earth mines outside China, including new mines in Malaysia and Russia. But the added mine capacity isn't expected to reduce the shortfall appreciably for at least three years.

Rare earths are used in slurries for mechanical planarization of everything from glass to semiconductor wafers. Chip makers are resorting to silicates and other minerals to substitute for rare earths, but manufacturers of phosphors for such products as fluorescent bulbs and white LEDs are having a hard time finding alternatives.

For some, moving production to China—the source of the needed materials—addresses the problem, albeit by sidestepping it. Meanwhile, phosphor manufacturers' research and engineering teams are working to develop alternative phosphors in the United States.

Ultimately, regardless of how the rare-earths shortage is addressed, the lesson that should linger well after last year's wakeup call on materials supply is that relying on a single source for anything is never a good idea.

Crackdown on counterfeits

Nothing reveals the complexity of today's supply chain issues more plainly than the counterfeit chips that have crept, with growing sophistication, into the electronics pipeline in recent decades.

Last May, customs officials at the Port of Long Beach, Calif., intercepted a shipment of almost $1 million worth of fake SanDisk memory chips stashed inside nearly 2,000 karaoke machines, shipped in a container from China.

In a U.S. Dept. of Commerce survey of original component manufacturers conducted in 2010, China topped the list of suspected sources of counterfeits by country. In the same survey, "brokers," "independent distributors" and "Internet-exclusive sources" were identified as the three worst offenders by supply chain segment.

As the electronics industry and law enforcement step up their efforts to ferret out the fakes, counterfeiters are becoming even more devious. Some are using dice harvested from decapped scrap ICs and repackaging them.

The best defense against counterfeit parts is prevention. For OEMs and EMS providers, traceability to the source—knowing where every part comes from—is the obvious first step. But equally important are heavy-handed diplomacy—particularly with China—and legislative oversight to combat the flood of counterfeit electronics parts coming into the defense supply system.

In today's interconnected world, design engineers cannot afford to ignore politics—just as they dare not disregard natural disasters, manmade shortages and chips of questionable pedigree. If past is prelude, however, they probably will—until the next rude awakening. ■

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Stemming the counterfeit tide

By Bruce Rayner

Counterfeit components have been a thorn in the side of the electronics industry for decades. And every year the incidents seem to grow more common—and more costly.

One estimate suggests that counterfeit parts account for more than $5 billion, or about 2 percent, of the total available market for semiconductors worldwide. The Semiconductor Industry Association claims counterfeiting costs U.S.-based semiconductor companies more than $7.5 billion each year.

Law enforcement and government agencies are collaborating to catch fakes before they enter the supply chain. Between 2007 and 2010, the U.S. Immigration and Customs Enforcement agency (ICE) worked with U.S. Customs and Border Patrol on more than 1,300 seizures involving 5.6 million counterfeit semiconductors. The confiscated counterfeits bore the trademarks of 87 North American, Asian and European semiconductor companies.

A 2010 government case against chip broker VisionTech Components of Clearwater, Fla., charged two company officials with knowingly importing more than 3,200 shipments of counterfeit semiconductors into the United States, marketing some of the products as "military grade" and selling them to the U.S. Navy, defense contractors and others. The case involved the coordination of multiple government agencies, including the Department of Justice Task Force on Intellectual Property, the Naval Criminal Investigative Service (NCIS) and ICE.

VisionTech "set a ticking time bomb of incalculable damage and harm to the U.S. military, U.S. servicemen and -women, the government, all of the industries to which VisionTech sold goods, and consumers," the U.S. attorney who prosecuted the case wrote in the government's sentencing memo.

New efforts to keep fakes out of the military supply chain have made headway, but are they enough to protect against tomorrow's threats?

Congressional response

In 2011, electronics counterfeiting caught the attention of the Senate Armed Services Committee. A series of hearings explored the extent and severity of the counterfeit problem within the military and government sectors, and a congressional investigation documented more than 1,800 instances of counterfeit electronic parts in the defense supply chain. Some of those parts had wound up in military equipment operating in the field.

One case involved suspect counterfeit parts in forward-looking infrared radar (FLIR) units supplied to the U.S. Navy by Raytheon Co. Some of the FLIR units had been installed on helicopters deployed to the Pacific Fleet. In another case, suspect counterfeit parts were used in color multipurpose display units (CMDUs) that L3 Communications had installed on U.S. Air Force C-27J aircraft. Two of the C-27Js had been deployed in Afghanistan.


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More

In the case of the CMDUs, the counterfeit parts were traced back to a company in China that had sold them to a U.S. independent distributor. The U.S. company in turn had sold the parts to L-3 Communications, according to an Oct. 31 letter to Michael Donley, secretary of the Air Force, from Senate Armed Services Committee Chairman Carl Levin and Ranking Minority Leader John McCain. "More than 500 of those [CMDUs] were sold to both L-3 Communications Integrated Systems, the prime contractor on the C-27J, and Lockheed Martin, the prime contractor to the C-130J," Levin and McCain wrote.

HIGHLIGHTS OF THE LEVIN-McCAIN AMENDMENT TO THE FY 2012 NDAA

- Prohibits contractors from charging the DOD for the cost of fixing the problem when counterfeit parts are discovered.
- Requires the department and its contractors whenever possible to buy electronic parts from original component manufacturers and their authorized dealers, or from trusted suppliers that meet established standards for detecting and avoiding counterfeit parts.
- Requires contractors and military officials who learn of counterfeit parts in the supply chain to provide written notification to the contracting officer, the DOD inspector general and the Government-Industry Data Exchange Program.
- Requires the secretary of Homeland Security to establish a methodology for the enhanced inspection of electronic parts after consulting with the secretary of Defense as to the sources of counterfeit parts in the defense supply chain.
- Mandates that large defense contractors establish systems for detecting and avoiding counterfeit parts, and authorizes reductions in contract payments to contractors that fail to do so.
- Requires the DOD to adopt policies and procedures for detecting and avoiding counterfeit parts in its direct purchases, and for assessing and acting on reports of counterfeits.
- Adopts provisions of a bill sponsored by Sen. Sheldon Whitehouse, D-R.I., to toughen criminal sentences for counterfeiting of military goods or services.
- Requires the DOD to define "counterfeit part" and to include in that definition previously used parts that have been misrepresented as new.

SOURCES: OFFICE OF SEN. CARL LEVIN; TITLE VIII, SUBTITLE C, SECTION 848 OF THE NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 2012

The investigation culminated last month in an amendment to the National Defense Authorization Act (NDAA) for Fiscal Year 2012 co-sponsored by Levin and McCain that would "bolster the detection and avoidance of counterfeit electronic parts." The amendment, which was signed into law on Dec. 31, puts the responsibility squarely on the shoulders of contractors such as Raytheon and L-3 to ensure that counterfeits never make it into equipment deployed to the field.

The Levin-McCain amendment requires the contractor to absorb the cost for any equipment rework or refurbishment resulting from counterfeits. It also calls for a fine of up to $5 million and 20 years in prison for individuals convicted of selling counterfeits to the U.S. government that are used in critical infrastructure or national security applications. Guilty companies could be fined up to $15 million.

The amendment further requires contractors to obtain electronic parts from original manufacturers, their authorized dealers or other "trusted suppliers." Those trusted suppliers can include independent distributors as long as they have adequate policies and procedures in place to detect counterfeits.

Because military systems are often deployed for decades, replacement parts are typically out of production and often not available from either the original component manufacturer (OCM) or a franchised distributor. A few franchised distributors, such as Rochester Electronics, specialize in obsolete parts for defense systems. But when those sources don't have the parts—or, more precisely, don't have them when the customer needs them—the only recourse for defense contractors is to buy from independents and brokers on the open market.

While the vast majority of independents are aboveboard, most do not have the systems in place to catch counterfeits. In fact, some independent distributors have estimated their incoming inventory to be as high as 35 percent counterfeit, according to Leon Hamiter of Components Technology Institute Inc. (Huntsville, Ala.).

Catching the fakes is expensive. Outlays for the equipment needed for physical inspection and test can run into the hundreds of thousands of dollars. The instrument roster includes high-powered laboratory-grade microscopes, X-ray fluorescence equipment, scanning electron and acoustic microscopes, and decapsulation test equipment. In addition to

absorbing the capital costs, companies must invest to hire and train staff for both physical and electrical testing.

Contractors and defense agencies are reviewing their relationships with independent distributors and brokers in light of the Levin-McCain amendment. “Many are cutting their approved vendor lists to just three or four independents,” said Tom Sharpe, vice president of independent distributor SMT Corp. (Sandy Hook, Conn.).

Sharpe hopes SMT will be one of the few independents that make the cut, though a few years ago it would not have been considered a standout. In 2005 and 2006, SMT unknowingly sold counterfeit parts to a defense contractor. The contractor discovered the fakes during a stock sweep and in early 2007 filed two Government Industry Data Exchange Program (GIDEP) reports against SMT.

Appearing in the GIDEP database amounts to being blacklisted by the defense community. But “that event was the best thing that ever happened to SMT,” Sharpe said. “It made us reassess our capabilities and develop a mitigation strategy.”

SMT took a year off from selling to the military to enhance its ability to identify counterfeits. It invested more than $1 million in test and inspection equipment, earned certification to three industry quality standards, trained and certified its quality-control lab staff, and built new capacity and processes.

The company reentered the defense market in July 2008 and has since gained a reputation as a leader in authenticating semiconductors, according to a number of industry sources.

SMT has contributed to the industry’s understanding of counterfeit practices by documenting some of the more advanced methods used to resurface and remark semiconductor packages. In 2009, it identified a surface recoating material that is immune to acetone surface permanency testing. And last year, it uncovered two new processes used by counterfeiters: one for removing part markings without requiring surface recoating, and the other to remove and recondition the surfaces of ceramic components.

“There’s no college degree in detecting counterfeit parts,” said Sharpe. “You need to be looking at parts and work with the stuff every day.”

The counterfeiting problem is hardly confined to the public sector. About 98 percent of all semiconductors are sold to commercial customers in all market segments—including the automotive, industrial and medical sectors, in which safety and quality standards are rigorous. And there are plenty of cases in all of these sectors of counterfeits’ causing system failure.

The recommendations made in Levin-McCain are as valid for commercial applications as they are for the military. All companies should source only from OCMs or their franchised distributors whenever possible. And if there’s no alternative to the open market, they should source only from “trusted sources” that have robust test capabilities.

Still, there’s no telling how long today’s test regimes will protect the electronics supply chain, as counterfeiters are constantly refining their capabilities. As soon as companies identify a counterfeiting technique, counterfeiters respond with even more sophisticated approaches.

One of the most serious new threats is the “clone” component—a part manufactured to look and function exactly like the OCM’s product. Typically, clones pass both physical and electrical testing. Taking the concept a bit further is “malicious insertion,” whereby malware is embedded in a piece of industrial equipment with the intent of causing a malfunction or to gather intelligence. Targets include commercial companies, the military and the government.

One suspected example of malicious insertion, reported roughly a year ago, involved software embedded in a piece of industrial equipment manufactured by Siemens. The software contained a sophisticated worm known as Stuxnet that was allegedly responsible for causing malfunctions of nuclear centrifuges at an Iranian nuclear enrichment plant. Israel has been implicated in that attack, according to *The New York Times*.

A November report by the Office of the National Counterintelligence Executive titled “Foreign Spies Stealing U.S. Economic Secrets in Cyberspace” argued that the pace of industrial espionage against U.S. corporations and government agencies is accelerating. While the report did not mention clone components specifically, it did address the increased incidence of malware.

Don’t let your guard down. ■

Bruce Rayner (*bruce@afitplanet.com*) is a contributing editor to *EE Times*.

Five regulations to watch in 2012

By Suzanne Deffree

Messy, confusing, expensive and often limiting to design, government regulations and legislation are ever changing—and always influential.

Like it or not, the task of understanding and complying with these directives is a necessary evil of the electronics supply chain. Quality distributors stay on top of the directives to usher designers and manufacturers through challenging processes, even going so far as to keep an eye on product end-of-life for the consumer. But every link in the chain needs to be aware of current regulations and legislation.

As we move into 2012, here are five regulations, directives and laws across the globe that will affect the electronics supply chain—the manufacturers, distributors, design engineers and, ultimately, users of electronics.

1. RoHS recast

If you thought you were done with the European Union's Restriction of Hazardous Substances (RoHS) directive, think again. A "recast" or reimplementation of RoHS was written into the original directive's documentation. Its subsequent changes became law in the summer of 2011.

The changes include new product categories under RoHS and a coming analysis of additional substances, as well as new challenges in terms of meeting requirements for the CE mark, a mandatory conformity mark for products placed on the market in the European Economic Area.

"The requirements of the CE mark included in the recast will prove a massive burden on industry," said Gary Nevison, head of legislation at Newark/Element14. "There will be a massive data collection exercise required, including a new 'declaration of conformity' document. There is already widespread concern in industry around the CE requirements … this can impact manufacturers, importers and distributors."

As to other changes brought by the recast, Nevison noted, "Manufacturers of products in categories 8 (medical devices) and 9 (monitoring and control instruments) will need to have RoHS-compliant products from 2014 onward. Those ready 'early' could gain market share."

2. China RoHS

The term "China RoHS" has been used in the electronics supply chain for more than five years, yet its meaning remains a mystery to many. China RoHS, officially known as Measures for Administration of the Pollution Control of Electronic Information Products, is a Chinese Ministry of Information

Industry regulation that aims to control certain materials, such as lead, that have been used in electronics and are considered to have negative environmental or health effects.

Because of the long road this regulation has taken, the measure seems to have fallen off many watch lists. To be sure, however, so-called China RoHS is alive and strong. Its "Standard Product Catalog for the Pollution Control of Electrical and Electronic Products" was published in July; in November, the first "voluntary certification" measures took effect for some parts, materials and components used in computers, household electronics and telecommunications products.

3. Eco-design of Energy-related Products directive

Until recently, the EU Eco-design of Energy-related Products (ErP) directive's focus had been on increasing energy efficiency, particularly during the use phase of a product's life. Now looking at the electronics supply chain from start to finish, the directive aims to improve the environmental performance of products throughout their life cycle, from mining of the raw material through recycling at end-of-life.

By definition, this is a framework directive, meaning that while it defines the legal context for "implementing measures" for specific target groups of products, it does not itself impose any obligations on industry. Nonetheless, the European Commission (EC) reports that 12 Eco-design regulations, two amendments and five energy labeling regulations came into force between 2008 and 2011.

At press time, an EC Consultation Forum on the Eco-design directive working plan and the new methodology was slated for Jan. 20, 2012. It was expected to address a working plan for 2012 through 2014 and to include a review of the directive's methodology. It was also expected to address the need for additional guidance and clarity in producing a uniform method for implementation of regulations.

Element14 reports that 2012 is expected to be a big year for the Eco-design directive, with more regulations due to be implemented. Adoption of the revised Eco-design directive is due by March 2012.

4. U.S. e-cycling

About half of the states in the United States—including tech centers like California, New York and Texas—have passed electronics recycling (e-cycling) laws to varying degrees. Under the New York law, which took effect in April and so far is the most comprehensive in terms of covered products, manufacturers must provide an electronic waste acceptance program at no cost to consumers. Such state e-cycling laws are expected to continue to pass and go into effect in 2012, with Pennsylvania's law being the first to go into force this year, on Jan. 1.

Several federal bills have been presented that would affect e-cycling. Bill S.1397 was just one such effort to go beyond e-waste dumping and call for "sustainable design" of electronic equipment, as well as funding for research and development of more sustainable designs.

While Bill S.1397 did not become law, similar legislation is expected to continue to be presented. Such efforts, as

More information on legislation can be found via these sources and links:

European Commission's information page on the recast of the RoHS directive
http://bit.ly/uuUZ90

China Ministry of Commerce English translation of Measures for Administration of the Pollution Control of Electronic Information Products
http://bit.ly/tWHoJR

Element14's legislation information page
http://bit.ly/i886Qu

Export.gov information page on Eco-design of Energy-related Products directive
http://1.usa.gov/sinoj1

National Center for Electronics Recycling
http://www.electronicsrecycling.org

Dodd-Frank Wall Street Reform and Consumer Protection Act
http://1.usa.gov/dohxqC

IPC's conflict minerals information page
http://bit.ly/u5fRIN

well as the various state e-cycling laws, will affect the supply chain.

5. Dodd-Frank Wall Street Reform and Consumer Protection Act

Dodd-Frank is largely focused on financial supervision. But 838 pages into this act, which became law in the summer of 2010, information on regulating so-called conflict minerals is presented. A provision requires public companies trading on a major U.S. exchange to determine whether their products use any gold, tantalum, tin or tungsten from the Democratic Republic of Congo or surrounding countries, described as conflict areas.

The law's conflict minerals provision aims to deter what the United Nations describes as genocide in the area, as it is believed that terrorist activity is being financed through the illegal sale of minerals from the region's mines.

The task of determining the origination of such minerals and then reporting it to the SEC is enormous but is necessary to comply with the law. Various electronics industry organizations and groups have begun addressing the requirement. For example, the IPC, the Electronic Industry Citizenship Coalition and the Global e-Sustainability Initiative have a standard in the works to assist companies in demonstrating compliance.

In September, the IPC separately announced that it had agreed to participate in a pilot evaluation program to review and refine the Organization for Economic Cooperation and Development's due-diligence guidance for conflict minerals. And in mid-October, the IPC's Solder Products Value Council began urging tin smelters to use conflict-free minerals and recommended the Electronic Industry Citizenship Coalition/Global e-Sustainability Initiative Conflict-Free Smelter program. ■

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Niche suppliers point to hardware democratization

By Margery Conner

One not-so-obvious side benefit of the miniaturization of electronics is that folks far removed from the engineering realm become comfortable with small electronic devices and think, "Wouldn't it be neat if I had a gadget that did … ?"

Back when computers were called "workstations," their inner workings seemed mysterious, complex and expensive. Few consumers thought about how they could exploit the computational power. But now that the equivalent of a workstation fits into a smartphone, complete with a rechargeable power source and a high-definition screen, software creation has become more appealing to a nontechnical audience. There's an app for seemingly everything, and even 10-year-olds are creating them.

Similarly, hardware itself is becoming more open. A decade ago, distributors like Avnet and Arrow began to create their own corps of application engineers to intermediate between manufacturers' new, increasingly complex products and customers who wanted to solve design problems without necessarily becoming experts in a highly specialized IC. Fast-forward to the present, and a new breed of electronics supplier is emerging to facilitate the "democratization of hardware"—that is, the use of hardware in new designs by nontechnical people.

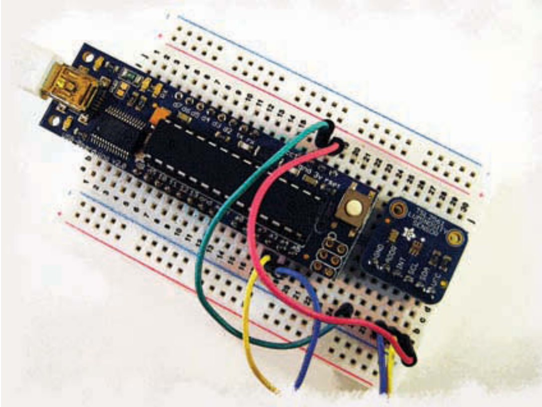
One leader in this niche is SparkFun Electronics, started by Nathan Seidle, a newly minted EE from the University of Colorado. Seidle had been looking for a source of small quantities of sometimes-obscure electronic parts and began offering them himself. Shortly thereafter, he began receiving questions from customers on how to use them, and he started posting tutorials. That made for a virtuous circle: The tutorials served as link bait to draw in new, often nontechnical customers who found the company through Google.

Seidle contrasts the thinking of professionally trained engineers and nontechies: "I've seen a lot of senior projects in the university EE department, and they are all very good and very technical. And they all have to do with some kind of solar tracker or a digital music player or a power supply. But in the digital media classes, [the art students] are doing the most amazing, ridiculous, beautiful things with the same electronics. It's important to show creative people that they can achieve a grand project—and, yes, it has some current and voltage, but don't worry about that. We'll teach you that part." It's the opposite of a traditional EE educational approach, which is: We'll give you the technical background, and after a couple of years you can implement your grand ideas—if you remember what they were.

Adafruit Industries has a similar story of how it got into the parts/kit business with detailed tutorials that include step-by-step instructions and photographs to lead newbies through the basics of Ohm's Law and soldering, and on to programming the open-source hardware Arduino platform.

Whereas traditional electronics distributors often have application engineers on staff, the Adafruit site effectively crowdsources its application engineering support through its forums and FAQ pages on the kits and parts. This reliance on the knowledge of the site's fans is part of a well-thought-out business plan: Adafruit's founder, Limor Fried, detailed the company philosophy in the *EDN* article, "15 steps to starting your own electronic-kit business" (*http://bit.ly/sIFA7f*).

Individual parts offered by Adafruit benefit from the company's excellent documentation and tutorials. I speak from personal experience. A couple of years ago, I bought a TLS 2561 light-to-digital converter from TAOS Semiconductor (now part of Austriamicrosystems). It seemed like a handy component for getting a quick, objective measurement of LEDs. However, although documentation existed for the part, its outputs were hard to interpret, and it was not easy to hook it up to a computer for data logging. I quickly gave up and forgot about it.



This combination of an Arduino microcontroller platform on the left and a TSL 2561 light-to-digital converter simplifies the detection and measurement of light.

Then Adafruit fielded the part premounted on a small pc board with a couple of chip resistors and some headers, along with a tutorial as well as a software library for the open-source Arduino platform. As the Adafruit tutorial says, "To use this sensor and calculate Lux, there's a lot of very hairy and unpleasant math. You can check out the math in the data sheet, but really, it's not intuitive or educational—it's just how the sensor works. So, we took care of all the math and wrapped it up into a nice Arduino library" (*http://bit.ly/rNMbL7*).

My sentiments exactly; I just wanted to start using the sensor. Adafruit took a part that sells competitively for about $2 each, added a couple of passive components and a well-thought-out online tutorial, and sold it for $12. It was worth every penny.

Digi-Key Corp. had a similar start back in 1972, selling its Digi-Keyer Kit to ham radio enthusiasts. Today it's a $1 billion company. History could repeat itself with a whole new generation of parts and kits providers. ■

Margery Conner (*margery.conner@ubm.com*) is a technical editor at *EDN*.

Web, economy shift distrib models for automation/control products

By Ann R. Thryft

Selling automation and control products through distribution has traditionally been the domain of local and regional resellers that serve customers in their own geographic markets. Because products in this market are niche-oriented and designs are highly customized, the smaller operations that serve it function more like system integrators than traditional broadline electronics distributors. They provide specialized hardware and software design services, often targeting only one or two main control platforms.

But other models for selling these products have emerged, partly as a result of the economic downturns of the past decade and the shift to the Web for research and e-commerce.

In particular, the recessions of 2001-2002 and 2008-2009 were hard on smaller distributors and smaller manufacturers. Many were forced to reduce inventory when their access to capital all but dried up, said Scott McLendon, vice president of product management and marketing for Allied Electronics.

"They also typically aren't quite as strong logistically as some larger distributors, nor do they have the full breadth of product solutions available for many customers," said McLendon.

Consequently, some larger distributors, including Allied, have been able to build rapidly growing business in this sector. Just last year, Allied's growth in automation and control exceeded 50 percent.

Channel strategy and the selling process for electronics are quite different from those for automation/control or mechanical products, said Chris Beeson, vice president of global sales and business development for Digi-Key. "An automation design is typically characterized by a higher mix and lower volume," Beeson said. "Some of these products are a one-time sale and might be capital expenditures, vs. selling less-expensive components to an OEM on a repeat basis."

B&R Industrial Automation's compact, high-performance ACOPOSmulti drive system reflects the trend toward greater integration in control systems.

SOURCE: B&R INDUSTRIAL AUTOMATION

For larger distributors whose model is based on moving large numbers of parts, these differences can be especially challenging. On top of that, consolidation among the large semiconductor distributors means that mindshare becomes even more important to automation and control suppliers. "Smaller suppliers are competing with very large companies under the same umbrella," said Beeson. "How does the supplier know they are getting share of mind through the large distributor?"

While price is always important, other critical considerations in the automation and control sector include whether a product will be applied in a finished system or an OEM application, whether it will target domestic or global use, and the harshness of the operating environment.

"In today's business climate, buyers are looking for a better price on the brands they already know and trust, but they are not necessarily looking to sacrifice quality or performance in the process of getting a lower product price," said Allied's McLendon. Making those sacrifices on the front end could potentially require much more on the back end in warranty and repair, as well as in downtime costs.

Therefore, Allied approaches the mix/volume issue more strategically. "Within a given technology, we try to offer the customer 'good,' 'better' and 'best' options," McLendon said. A "good" product "may do the job, but it might not last as long or be as accurate, or it might have fewer features," compared with the alternatives.

Specialist AutomationDirect takes an altogether different tack from the traditional reseller model by relying primarily on e-commerce and phone sales. "We don't have sales reps who visit customer sites to demo products, take orders or take the customer out to lunch," said Tina Gable, focused image team advertising manager at AutomationDirect. "We don't provide full assistance with designing a solution or with programming. We do have qualified internal support, plus external support through system integrators and VARs [value-added resellers] that are fully acclimated to our products and solutions."

The Phoenix RAD-ICM-900 integrated radio and I/O module eliminates cable and conduit for one 4- to 20-mA current loop and two digital signals in harsh industrial environments.

SOURCE: ALLIED ELECTRONICS

The distributor also provides free online tutorials, videos and other training assistance tools. "AutomationDirect is like the Walmart of automation, with a business model similar to that of Dell," Gable said. "If you phone us, someone knowledgeable answers immediately. All our products are stocked in a gigantic warehouse and are available for same-day shipping."

One of the biggest changes in how the sector operates has been customers' use of the Web. "There's been a wider adoption of Web-based everything in users' lives: tools, social media, user sites and user groups," said Gable. "Therefore, it's become many people's whole mechanism for researching products and services. And they are researching vendors and sources, too, not just products and tools."

As machine builders and OEMs increasingly look to the Web for research, they are more open to ordering products online, Gable said. "In a down economy, with price more important than it has been, if you are a low-price leader you can procure opportunities you did not have before. In the past, some people may have not considered us, because they were buying from the sources they were most familiar with. But now, more are coming to us because often we are the price leader [and offer] immediate product availability. Those buyers often become our best customers."

Said McLendon: "I think people are doing more comparative shopping today, and the Web makes that a lot easier. Buyers in this sector are definitely shifting more to e-commerce. Over the last four years, we've seen the online percentage of our revenue increase from 10 percent to over 40 percent, while our overall business has grown dramatically in that time frame, so the increase in online is substantial. Last year, we grew our online sales by more than 80 percent."

Some users conduct research online first before talking to the local distributor, said Beeson. "The small niche distributor or rep may have a Web site, but their customers may not be using it, since the rep is always in front of their customers anyway. The niche-oriented suppliers to this segment can really get into a tier-one company and get into the details of design. We fit more of the long-tail equation—that is, working with tier-two, -three or -four customers who may have similar design requirements but may not need the same degree of support from us."

That's why Web-based solutions and tactics work for Digi-Key, which is somewhat new to this sector: The one-to-many equation yields economies of scale and builds on the distributor's origins as a cataloger with an engineering orientation. "Many of our customers in this sector can now be self-serviced," Beeson said. "The few customers that need additional support can rely on the supplier and/or their manufacturers' reps for followup."

Worker checks inventory for fulfilling an order in AutomationDirect's warehouse.

SOURCE: AUTOMATIONDIRECT

AutomationDirect is evaluating social networking's role in marketing, said Gable. "Is it a trend yet in automation? We don't know," she said. "Most of the engineers who buy from us now don't use it, at least not in their work lives. They might be more open to user groups, like technical forums. But the next generation of engineers will be open to social networking."

One supplier, B&R Industrial Automation, combines a highly technical distributor network with direct sales and engineering staff in regional offices. The privately owned Austrian company, which has done business in the United States and Canada since 1987, uses distribution as the main push of its sales strategy, said Nathan Massey, sales channel manager. "In addition to its sales staff, each regional office and distributor has in-house, local engineering resources, something that's a big part of our regional strategy but not common among our competition. Our regional engineers provide design assistance and support our customers throughout the whole development process."

Some customers take complete ownership of their designs, said Massey. "We help them with training and the initial design, but they do 100 percent of the programming." Others contract for a B&R engineer or one of its distributors' engineers to develop the entire system. Most fall somewhere in between: They want training and support with the first product line, but when expanding to other machines and product lines they take all design functions in-house.

Products get more integrated

Automation and control products are becoming more interconnected via open communications standards, more dependent on software, and more integrated. These changes can pose challenges for distributors.

"Today, through open-source software and open standards, manufacturers are developing products that are more plug-and-play and that communicate with each other wirelessly, or, if wired, via open protocols like Ethernet," said McLendon. "Not only communication among devices, but also interoperability among vendors, has proliferated over the last few years."

For B&R, programming support is more important as software becomes a key factor in differentiating customers' machines through increased performance, faster time-to-market and ease of maintenance, said Massey. Many distributors the company encounters don't have such engineering resources in-house, and are strictly hardware-oriented.

B&R was among the first automation companies to release an all-in-one control solution, said Massey. Now, customers are quickly migrating to integrated control. "In the past, a control system [might include] an HMI, a PLC, a motion controller and a safety relay, all from different suppliers and requiring different software, multiple communication links, individual training and separate troubleshooting. Integrated control solutions combine these into a single, efficient package with a single, integrated development environment."

Open communications and connectivity-oriented networking standards are also becoming more important, visible in the rapid growth in demand for real-time Industrial Ethernet protocols. As a result, OEMs can select products from multiple sources, instead of choosing a single vendor with older, proprietary protocols.

In a related trend, machine builders' customers are increasingly removing the control system brand from their machine specifications and are concentrating on a machine's performance and capability. "This allows the machine builder to focus on their core competencies and not remain handcuffed to aging, limited technology," said Massey. "This encourages automation suppliers to innovate in order to stay competitive."

Overall, there's been a lot of demystifying in the control world, making it easier for design engineers to compare products, spec them in or out of a design, or specify multiples within the control system. "Today, you rarely see only one brand of controls in a system," said McLendon. "The challenge, or opportunity, that arises for distributors is: How do you support a customer who is using multiple platforms and multiple products? How do you provide the service they require?" ■

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Parts 'ownership' questions defy easy solutions

By Barbara Jorgensen

As the supply chain moves closer to JIT, distribution still manages upside and downside demand

Until the twin natural disasters that shook Japan in mid-March, the supply chain seemed to have gotten its inventory management practices down pat. The old habit of purchasing inventory well in advance of demand has shifted to just-in-time (JIT), relieving most companies of the burden of financing inventory they aren't sure they are going to need.

Most companies, that is, except distributors.

Distributors have become the de facto warehouses for the entire supply chain, storing enough inventory for customers' upside forecasts or inventory that is consigned by EMS companies or OEMs. Under most JIT, build-to-order (BTO) and consignment practices, distributors own inventory, and its attendant risks, until customers consume it.

Such programs make sense for suppliers and customers who don't want to carry inventory on the balance sheet. Although inventory is considered an asset, explains Charlie Barnhart, principal of consultancy Charlie Barnhart & Associates, certain supply chain practices—such as buying inventory on credit—make it look like a liability. OEM customers don't want unused components or work-in-progress on their books when quarterly earnings periods come around.

But distributors are likewise beholden to Wall Street and to shareholders, so the channel is always in the middle of some kind of inventory adjustment. How do distributors maintain enough inventory for customers without bogging themselves down?

Lessons of 2001

Memories of the inventory glut of 2001 still sting, yet it has taken a decade for the supply chain to even come close to a JIT inventory model. The first hurdle was convincing partners to share demand forecast data in a timely manner; the next was interpreting that data in a meaningful way. Distributors, as the link between component suppliers and manufacturing customers, have become the clearinghouse not just for inventory, but for the information used to manage the supply chain.

Before 2001, customers had little incentive not to over-order; the market was so hot that excess inventory was invariably gobbled up. It was only when demand slammed on the brakes that anyone questioned who was responsible for all the stock in the supply chain: Was it the customer who ordered it, the distributor that delivered it or the supplier that made it?

Facing huge write-downs on devalued parts, customers tried to return inventory to distributors, which, in turn, pressed suppliers to take it back. The supply chain wrote off an estimated $13 billion worth of components.

Ten years later, the distribution channel has become so big that it can push back a bit on OEM and EMS customers. Distributors now require more frequent forecasts from their partners. They compare the data to historic buying patterns, flag major upside/downside trends and follow up to rectify discrepancies.

But distribution has to deal with component makers as well as OEMs. Component manufacturers rely on distribution information to manage their own production schedules. The better the information coming from the distributor, the better manufacturing can be managed.

All of this requires closer partnerships. Indeed, over the past decade, trust has built up among the partners, and upside/downside forecasts work themselves out pretty quickly.

Globalization, meanwhile, has been a plus for inventory management. Global distributors manage pockets of inventory in all major regions, so a global distributor can internally move inventory out of, say, the Pacific Rim to the Americas if demand in Mexico suddenly spikes. The channel can also position inventory based on geographic demand cycles, accommodating seasonal shifts in ordering for the yearend holidays in the Americas, the August vacations in Europe or the Chinese New Year in the Pacific Rim .

But the natural disasters of 2011 have some in the industry rethinking the Lean supply chain. Coupling inventory management so closely to forecasts leaves little maneuvering room for upside demand.

Late last year, for example, the flooding in Thailand, a manufacturing hub for hard drives, forced many companies to suspend production. Although demand for the Christmas season had been met before the disaster, future orders were expected to be delayed. Such uncertainty drives some companies to pad inventory for orders that may or may not materialize.

Distributors manage their way through inventory imbalances by selling to a diverse customer base: If one customer orders too many widgets, others can take up the slack. The same should hold true for EMS companies, but industry watchers say that isn't the case.

"Inventory in many cases makes up the largest asset on the balance sheets of global EMS providers," IHS iSuppli EMS/ODM analyst Thomas Dinges wrote for *EBN* (*http://bit.ly/sIBcir*). "The latest results from several of the largest global EMS providers show, in fact, that nearly one-third of their tangible asset base is tied up in inventory."

While EMS companies serve many customers, their base isn't as broad as the channel's. Selling off excess EMS inventory usually has meant selling to the gray market. Anecdotally, however, distributors say EMS providers are turning increasingly toward authorized distribution to manage their inventory imbalances. Given the lingering market uncertainty, that's a sound move.

So as long as the electronics supply chain operates on a demand forecasting model—which it still does, despite JIT, BTO and Lean—the channel will play a leading role in global inventory management. Whether the electronics market is in an up-cycle or down-cycle, Barnhart says, "We are always in the middle of some kind of inventory question." ■

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Is your supplier's distrib deal good news for you?

By Patrick Mannion

For manufacturers, the question is almost as old as engineers' make-or-buy dilemma: use in-house support or commit to a distributor? The latter is attractive in a time when global reach and rapid turnaround are necessary in order to compete and grow, but there are implications for both the manufacturers and the designers using the product in terms of reputation, intellectual property protection, design support and trust.

A case in point: In June, Vicor (Andover, Mass.) committed to Future Electronics, making the Canadian company its global distributor for all of its power conversion devices. The phased rollout began in August. It was a big move for Vicor, which to date had been its own distributor within the United States while relying solely on smaller, specialty distributors, such as Craftec and ACAL Technology, elsewhere.

'We're going all-in with Future Electronics' – Rich Begen of Vicor

Vicor traditionally has been self-reliant, keeping all its intellectual property, as well as its manufacturing, in-house to maintain a tight inner circle and thereby avoid the risk of exposing its road maps to anyone who might take the knowledge elsewhere. Now, in a quick turnabout, it's "going all-in" with Future globally, said Rich Begen, vice president of distribution at Vicor.

Why now, and why Future?

To explain the "why now" part, Begen referred back to 2003, when Vicor introduced the Factorized Power Architecture. FPA was the invention of company founder and CEO Patrizio Vinciarelli—a true engineer's CEO.

The FPA could be called a solution to a solution. At the time of its arrival, the distributed power architecture (DPA), with power "bricks" that brought power to the point of load (POL), was widely deployed and had been in broad use since the 1980s. DPAs solved the problem of distribution losses, but multiple on-board voltage levels meant the number of DPA bricks also multiplied, sucking up board space and increasing cost. They also proved inadequate for the loads' increasing transient-response requirements.

FPA concepts were realized in ASICs that led to the development of V•I Chips, which divide voltages and multiply currents while keeping the voltage-current product (the "•" in V•I) constant. The chips, in turn, led to a popular series of power components that in the years since have garnered key design wins and solidified Vicor's position in the power market, most recently with the Picor line of semiconductors.

But the technology has matured, and it is with that in mind that Vicor now needs to broaden its reach and distribution capabilities to ramp up volume.

That's where Future comes in.

Given the distributor's size, it's not intuitively obvious that Future would be the best choice. In a UBM Electronics distributor customer evaluation study (May 2011;

http://tinyurl.com/brerw5s), Future was ranked eighth in overall patronage for all products. Digi-Key led the category, followed by Arrow, Mouser, Avnet, Element14, Allied and McMaster-Carr. Worse, Future placed tenth among the study's "most preferred" distributors. Digi-Key again sat securely at the top; Arrow and Avnet were a distant second and third.

Begen makes it clear that size doesn't matter; on the contrary, it can sometimes be a liability. "Arrow and Avnet are too encumbered with large engagements," such as Texas Instruments and Analog Devices, he said. "Future is better with niche suppliers; it's in their DNA."

Begen speaks with some authority on the matter. Until last June, he was a principal of LJ James LLC, a consulting business focused on sales and channel management strategy.

Some suppliers have abdicated their responsibility for tech support

Implications

For suppliers and designers, the implications of working through a distributor are manifold. First there's the issue of trust, as the supplier has to expose its road map, as well as train the field application engineers (FAEs) at the distributor. That's "secret sauce" information, but in general, NDAs cover exposure liability pretty well.

Then there's a concern that a distributor might push one supplier's line at the expense of another's, depending on which supplier's product has the higher margin or who's being the squeakiest wheel about how much product is moving. That's a trust issue not just for suppliers, but also for designers seeking reliable support from a distributor. Begen, however, said the distributor model has matured enough that neither suppliers nor designers need be worried.

Designers over the years have expressed concern about suppliers' overreliance on distributors to provide technical support; in some cases, suppliers have abdicated their responsibility and gutted their own tech support infrastructure.

That's not the case at Vicor, Begen said. He acknowledged that handing over support to a third party is a bit like trusting your baby to a stranger. With four months' training, the distributor FAEs come up to speed but can't completely replace in-house support. "An FAE or two may get to a supplier-level FAE, but they [generally] won't have the depth," and while they tend to be more available than the suppliers' own support staff, "it's the luck of the draw" in terms of quality.

"You have to ferret out the FAEs who can best serve [the designers'] needs," Began asserted. That said, the distributor FAE can always refer to the supplier for help.

Web-based support

Increasingly, before attempting to reach an FAE, designers refer to both suppliers' and distributors' Web sites for technical information, application tips and notes—and, in some cases, community knowledge. The Future Electronics Web site's reputation as a comprehensive information source—supported by the UBM study—belies the company's size.

In general, distributors have tended to be a good starting point for basic product search and selection, but that bright spot may be fading. Comments on a recent *EE Times* article (*http://bit.ly/tbKbje*) bemoan the lack of solidly tabulated and parameterized data on distributors' sites, and instead recommend using one of a number of paid product selection sites, such as Octopart, Partminer or SiliconExpert.

Thus, the answer to whether it's a good move for suppliers and their customers to work through distributors is, "It depends." It depends to what degree a supplier relies on the distributor, and to what degree the distributor's FAEs can be trusted. You may get them on the phone quicker, and you may get the part quicker—but is it the right part? ■

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See "Suppliers, distributors and the issue of trust" on *EDN* at *http://bit.ly/tkBD4J*.

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NOISE WARS: PROJECTED CAPACITANCE STRIKES BACK AGAINST INTERNAL NOISE

JOHN CAREY • CYPRESS SEMICONDUCTOR CORP

Today's users expect multitouch systems to perform with precision and still comply with demanding environmental standards. Designers face no small feat in meeting these requirements. With a rapidly changing internal environment in multitouch systems, the war for touchscreen dominance is effecting the emergence of new battlegrounds.

One current trend is the push toward thinner phones. Achieving this goal means direct lamination of capacitive-touch sensors to the display, moving the sensor inside the display, and overcoming many other challenges with antennas and ground loading. It is no longer acceptable to just throw a shield layer onto the sensor structure to block display noise. Such an approach adds too much cost and thickness.

Beyond displays, the prevalence of USB-charging connectors has made battery chargers into commodities, pulling every last cent from these devices. Capacitive-touchscreen ICs now sense picocoulombs of change in the presence of as much as 40V p-p ac noise. All of these factors add up to requirements for touchscreen ICs that are far more complex than what was required just last year. New innovations are needed, and so begin the noise wars.

CHARGER AND DISPLAY NOISE AFFECTS TOUCHSCREENS, BUT THERE ARE WAYS TO TACKLE THIS PROBLEM.

IMAGE: SHUTTERSTOCK

CHARGER NOISE

Charger noise physically couples into the sensor through the battery charger during the presence of touch. Its effects include degraded accuracy or linearity of touch, false or phantom touches, or even an unresponsive or erratic touchscreen. The culprit is typically an after-market, low-cost charger. Although OEM-supplied chargers typically have tight specifications for noise, the widespread adoption of USB connectors for charging circuits has created a massive after-market opportunity. Fighting to compete in this segment, after-market manufacturers are making these chargers as cheap as possible. These low-cost electronics yield chargers that charge your phone but may inject so much noise into your touchscreen that the phone becomes unusable.

Two common battery chargers are the ringing-choke converter and the flyback converter. Flyback-converter chargers typically use PWM circuits; low-cost, self-oscillating ringing-choke converters use a variant of the flyback design (**Figure 1**).

The ringing-choke converter has neither a microcontroller nor a capacitor, yielding a lack of PWM control, a lower-cost transformer, fewer diodes, and lower-capacitance polarized-input capacitors. These eliminations equate to cost savings for the manufacturer but a noisy system for the customer. Some ringing-choke-converter chargers are on the verge of becoming broadband noise generators because they emit as much as 40V p-p noise ranging from 1 to almost 100 kHz. Most have periodic-noise tendencies with many harmonics. A good example is the so-called zero charger, which has a noise output of 10 to 25V p-p (**Figure 2**). This charger's output depends on the battery state itself. To address this phenomenon, many OEMs banded together to create EN (European Norm) specifications that govern the maximum noise levels a charger should emit at any frequency. EN 62684-2010 and EN 301489-34v1.1.1 govern these noise levels (**Figure 3**).

AT A GLANCE

- Capacitive touchscreens are ubiquitous but prone to false and erratic response due to noise from the product in which they reside.
- Noise comes from both the internal dc/dc-converter subsystem and the display drivers.
- Whether dealing with noise from displays, chargers, antennas, or other sources, touchscreen ICs must perform with the same level of user experience.

From 1 to 100 kHz, a charger should output no more than 1V p-p noise, and the levels degrade exponentially from that level as the frequency increases. None of the after-markets, however, conform to this stringent specification. As a result, OEMs now expect touchscreen ICs to deal with much higher noise. Some specifications require 40V p-p from 1 to 400 kHz, with 95V-p-p immunity in the 50- to 60-Hz range. Fortunately, specialized algorithms and methods can meet stringent requirements and provide more than 95V-p-p noise immunity to battery chargers. They achieve these levels through a variety of mediums, such as nonlinear filtering, frequency hopping, and other hardware techniques.

DISPLAY NOISE

Displays offer many challenges for projected-capacitive touchscreen systems because they can generate a lot of noise that can conduct directly into the capacitive-touchscreen sensor. To make matters more difficult, OEMs are demanding thinner industrial designs for their phone models, which means moving the touchscreen sensor closer to or even inside

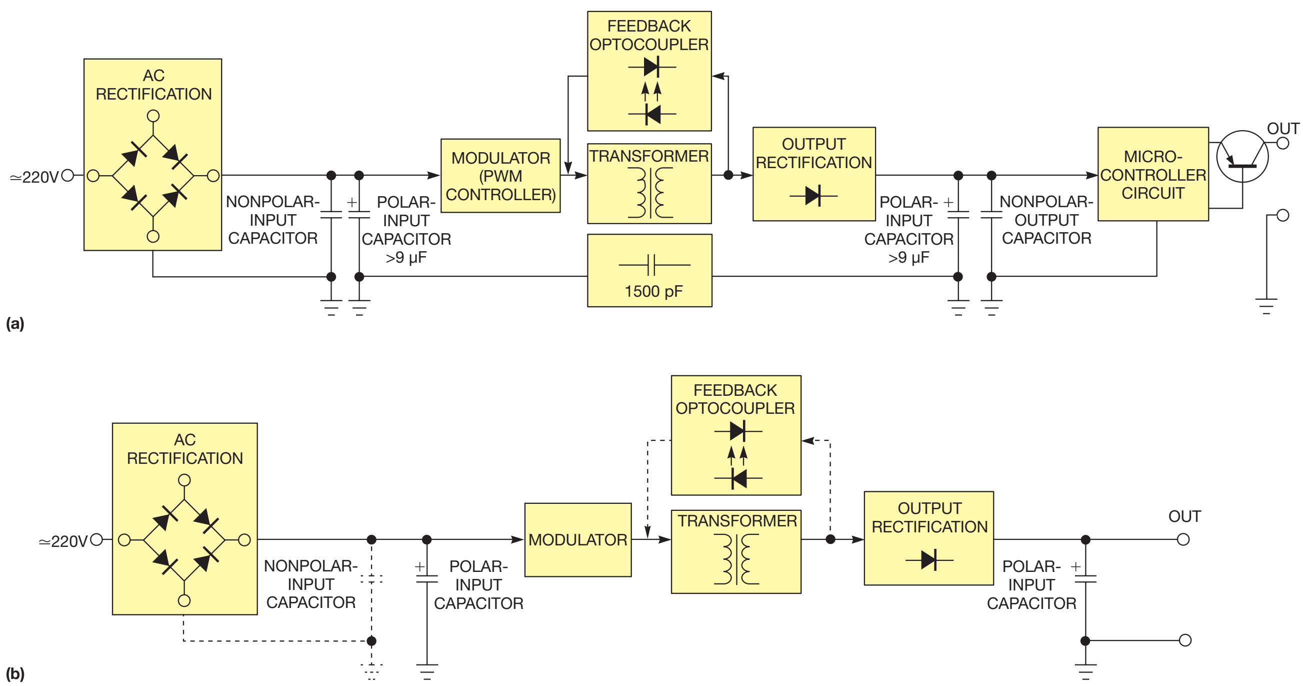

Figure 1 Flyback-converter chargers typically use PWM circuits (a), and low-cost, self-oscillating ringing-choke converters use a variant of the flyback design (b).

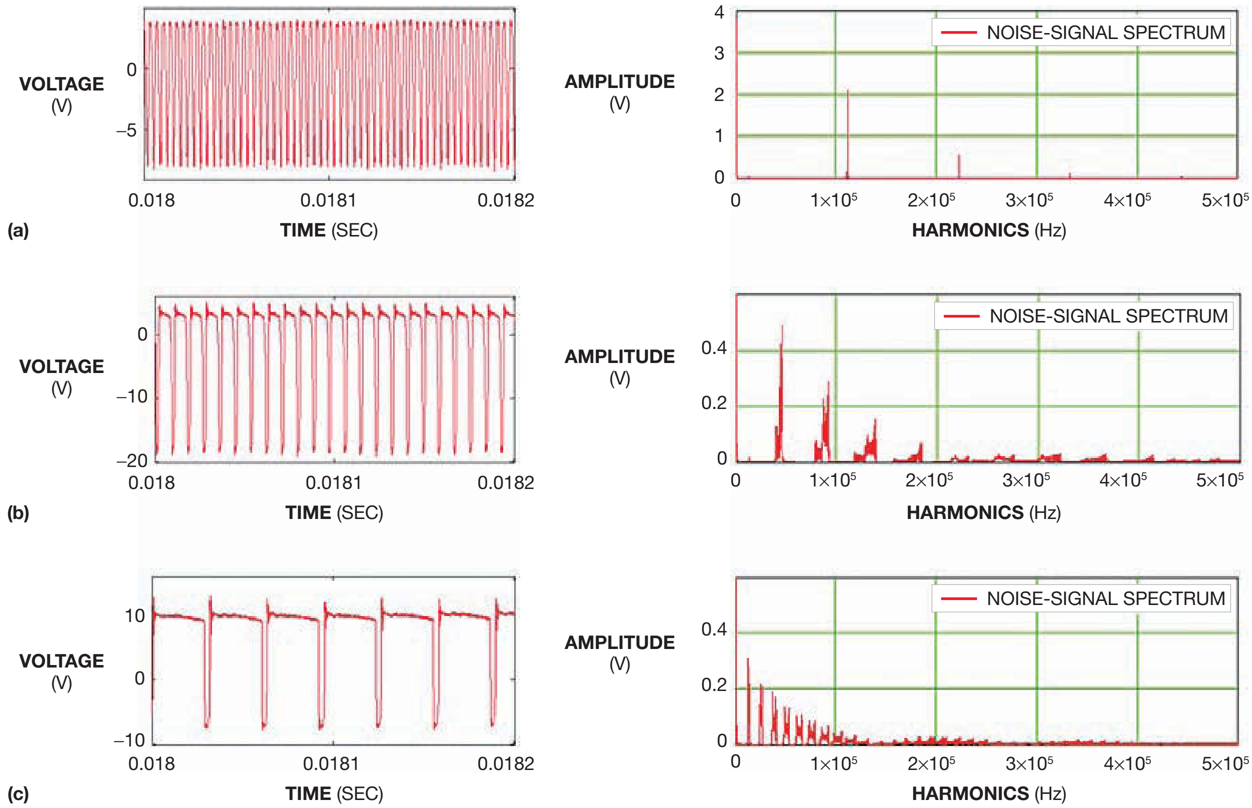

Figure 2 The noise of the "zero-charger" device differs at 0 (a), 50 (b), and 100% (c) loads.

the display. For years now, the industry has used a shield layer to protect the sensor from the noise that the display generates. This approach, though effective, adds both cost and thickness to a phone. The industry also uses a 0.3-mm-high air gap between the display and the sensor to allow the natural properties of air to dissipate the conducted noise from the display. However, as phones become thinner, neither of these options is appropriate for today's designs.

Fortunately, displays emit less noise than do chargers but are still difficult to handle. With a traditional TFT (thin-film-transistor) LCD, either a dc or an ac voltage drives the common electrode. An ac common-electrode layer typically lowers the operating voltage of the display driver and keeps a constant voltage across the liquid crystal. The ac common-electrode layer finds use in relatively low-cost displays, consumes more power, and has a noisier profile than do dc common-electrode layers (**Figure 4**).

Typical ac common-electrode displays have noise profiles of approxi-

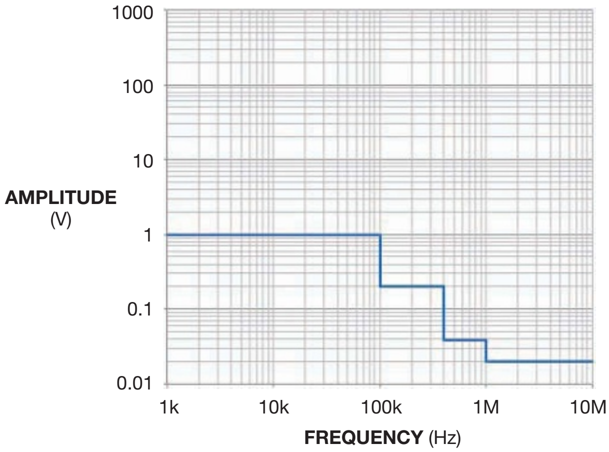

Figure 3 EN specifications govern the maximum noise levels a charger should emit at any frequency. EN 62684-2010 and EN 301489-34v1.1.1 govern these noise levels.

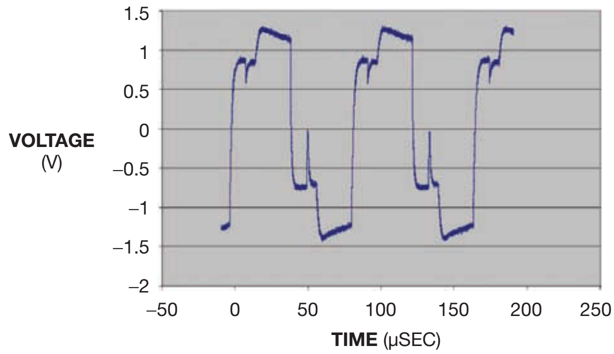

Figure 4 The ac electrode layer finds use in relatively low-cost displays, consumes more power, and has a noisier profile than do dc common-electrode layers.

mately 10 to 30 kHz and 500 mV to 3V p-p, whereas a dc common-electrode display is often quieter. You can measure noise from a display simply by connecting an oscilloscope to a bit of copper tape at the top of the display, connecting ground to the display's circuit ground, and running the display to catch the waveforms.

The use of AMOLED (active-matrix organic-light-emitting-diode) technology is gaining traction in mobile phones because it has a wide viewing angle, bright colors, and deep contrast. AMOLED displays are also quiet, although this feature comes with a price (**Figure 5**). The AMOLED display in the **figure** outputs peak spikes of 30 mV p-p—1% of the noise from an ac common-electrode display, greatly easing touchscreen design. Integrating the sensor in the physical display to create an on- or in-cell topology is also straightforward with this type of display. However, AMOLED displays are more expensive than are traditional LCDs.

On-cell designs typically deposit the sensor layer on the color-filter glass in the display, bringing it closer to the chemistry of the display because it is inside the stackup. Both the

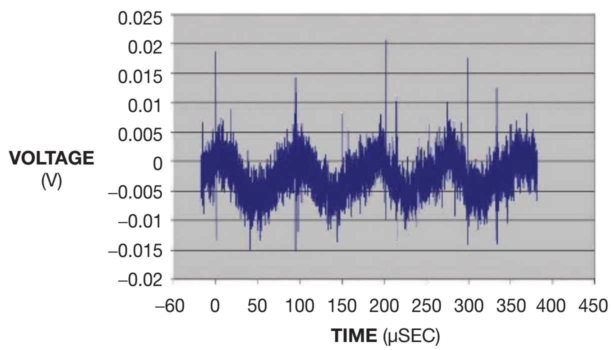

Figure 5 A typical AMOLED has a relatively small display-noise profile.

noise and the parasitic loading increase. However, AMOLED technology is inherently quiet and makes for a good platform for on- or in-cell sensors beneath the color-filter-glass design.

When designing sensors, a well-accepted sensor structure is to use a two-layer sensor, in which the transmitting lines are in the lower part of the sensor and the receiving lines are in the top. The receiving lines are sensitive to display noise, but the wide transmitting lines in the bottom of the sensor form a

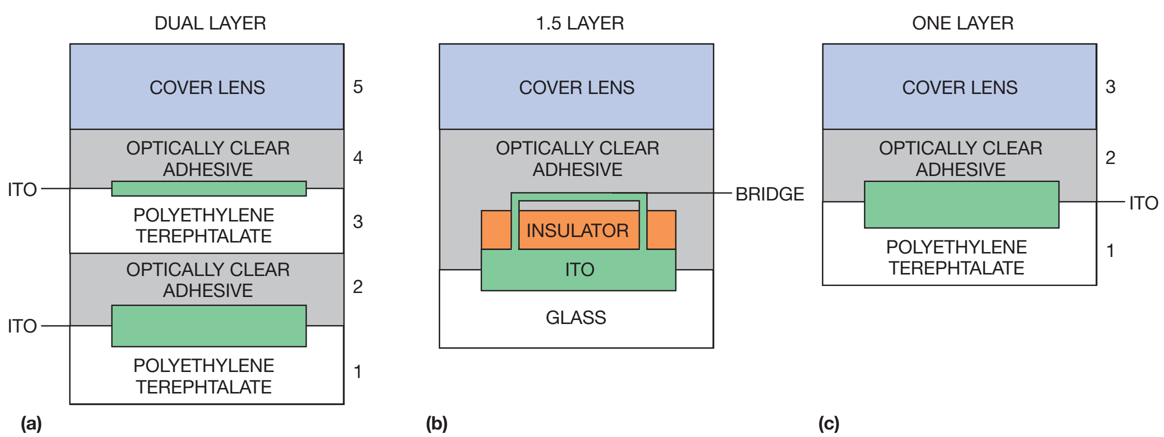

Figure 6 Touchscreen sensors using MH3 (a), diamonds (b), and proprietary technologies (c) use different stackups and materials.

barrier against the noise the display generates. This situation effectively builds a shield into the sensor pattern (**Figure 6**).

In an MH3 dual-layer stackup, the bottom layer of ITO (indium-tin oxide) acts as a shield to display noise. Unfortunately, glass-based sensors seldom use this approach, and it increases thickness and cost. The industry is pushing to build sensors on a single substrate layer with no shield. To enable true single-substrate-layer sensors without shielding requires the touchscreen IC to be resistant to display noise. This task is difficult because display noise can easily reach 3V p-p in ac and dc common-electrode displays.

You can mitigate display noise even in direct lamination—where the sensor structure is laminated to the top of the display with no air gap or shield—or display-integrated designs. An example is Cypress Semiconductor's Display Armor method to combat display noise. By integrating a built-in listening channel to the touchscreen device, touchscreen ICs can eliminate display noise by making advanced algorithmic decisions on what information is noise and what information is data. Detecting the noise source and latching onto the waveform allows you to make capacitive measurements during quiet times. These methods of reducing display noise result in advanced and thinner capacitive-touchscreen stackups at lower costs.

Aside from noisy displays and chargers, many other challenges face capacitive-touchscreen designers. For example, antennas are huge sources of noise challenges. With the increasing real-estate constraints within phones, components, such as antennas and touchscreen sensors, literally reside atop each other. Such design challenges can create issues in dealing with that portion of the touchscreen. Fortunately, the same innovations that are helping to reduce display and charger noise are also helping to reduce noise from other sources, such as antennas. Whether they use simple IIR (infinite-impulse-response) filters, advanced nonlinear-filtering methods, built-in noise-avoidance hardware, hopping capabilities, or any other methods, capacitive touchscreens enable some of the most advanced performance in embedded devices.

It is clear that noise immunity is one of the biggest concerns for designers. Whether dealing with noise from displays, chargers, antennas, or other sources, touchscreen ICs must perform with the same level of user experience. Innovation is happening daily in capacitive touch, and touchscreen ICs continue to wage the war against noise. **EDN**

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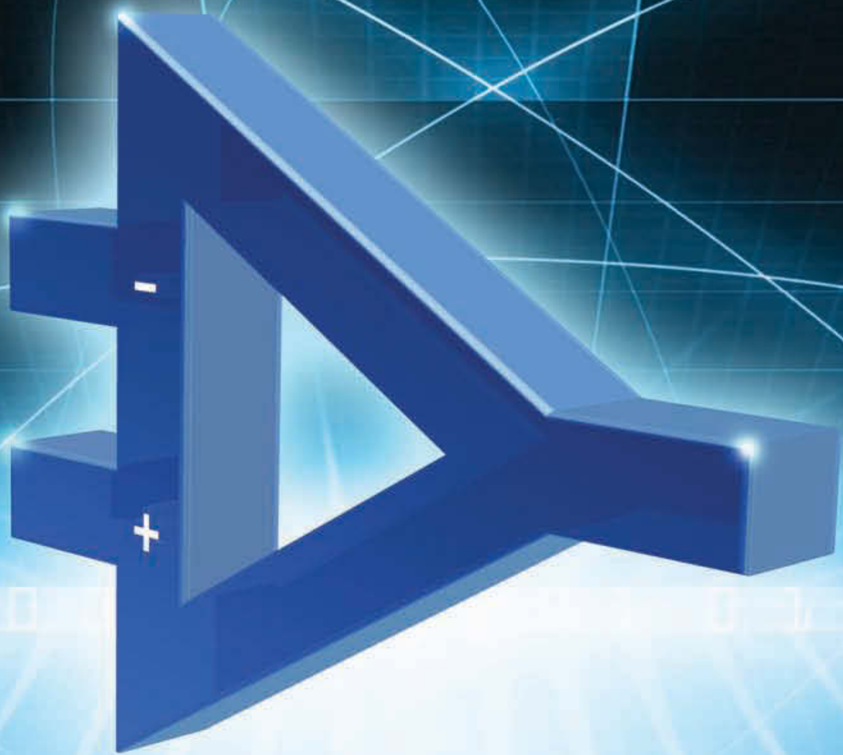
ANALOG DESIGN IN THE 21ST CENTURY: CHALLENGES, TOOLS, AND IC ADVANCES

BY STEVE TARANOVICH • CONTRIBUTING TECHNICAL EDITOR

We are now more than a decade into the 21st century, and on an ever-accelerating fast track to technological innovation in electronics. The transistor and progression into the IC, or microchip, lit the fuse leading to the explosion of innovations in electronics that is now taking place. Since the widespread introduction of the microchip in the early 1970s, more medical, mathematical, and scientific breakthroughs have occurred than during any other time, and big breakthroughs are happening more frequently. This surge is due in large part to the performance and computing power that the ever-shrinking but increasingly dense silicon wafer has brought.

IMAGE: SHUTTERSTOCK/YOSHI HOHOKABE



ANALOG-CIRCUIT-DESIGN ENGINEERS OVERCOME NEW CHALLENGES WITH ADVANCED TOOLS AND ICs.

Let's take a look into the analog sector's crystal ball and see what's coming to the rescue of analog designers to help them in the scope of variables they must manage, the extreme sensitivities to circuit constraints, and the quality of results necessary to make analog design as much of an art form as it is a science (**Reference 1**).

ANALOG CHALLENGES

Beginning at the system level, you'll find that the silicon components embody much of the system (**Reference 2**). A good example of this trend is Intel's Huron River mobile platform, which includes the Sandy Bridge microprocessor and Cougar Point PCH (platform-controller hub). Signaling speeds of today's platforms can reach 1600 Mbps for single-ended DDR3 and 5 Gbps for differential PCIe Generation 2. The typical PCB material in systems has limitations that require advanced analog-design complexity to overcome limits. Analog designers often use interface chips, such as Texas Instruments' DS25BR204 LVDS (low-voltage-differential-signaling) repeater, which has built-in pre-emphasis on the transmitter side and equalization on the receiver side of a signal trace running on a PCB across a motherboard. The need to conserve power and silicon-die area is also challenging to analog-circuit designers.

Another factor affecting analog circuitry is in the mixed-signal domain, which you can observe primarily in the timing-convergence domain. As signal speeds increase, clock and timing budgets continue to shrink. This situation also fuels the risk of circuit bugs (**Reference 2**).

AT A GLANCE

- Critical decisions include where to place an IC on a board, the location and thickness of copper traces, where to locate components, and what other nearby circuits might affect performance.
- The analog software tools will reduce design time for analog-circuit architects.
- Analog-chip designers can use different approaches to improve energy efficiency, from selecting the optimum CMOS technology to clever system-level design.
- Analog controllers have a more difficult time than their digital counterparts in achieving the diverse and adaptive capability for power converters.

Despite its critical nature, especially in high-speed circuitry, PCB layout is often one of the last steps in the design process. As in real estate, location is everything. Critical decisions include where to place an IC on a board, the location and thickness of copper traces, where to locate components, and what other nearby circuits might affect performance. Many designers rely on IC suppliers' evaluation boards and data sheets to properly integrate a chip into a copper-clad, fiberglass PCB. Also check IC suppliers' white papers on the subject.

Figure 1 The National Semiconductor-developed Webench Designer tools include powerful software algorithms and visual interfaces that deliver on the promise of easy design for power, lighting, and sensing applications.

DESIGN TOOLS

The TI/National Semiconductor merger will enable more powerful analog designer tools. National's Webench Designer in seconds creates and presents all of the possible power, lighting, or sensing circuits that meet a design's requirements. This feature enables a user to make value-based comparisons at a system and supply-chain level before committing to a design. According to Phil Gibson, manager of Webench design at Texas Instruments, the goal is to make tools more visual, easier to use, and more intuitive. Webench brings analog designers from concept to selecting and ordering components for the breadboard. Stay tuned for more tools, which leverage the "cloud," from the combined expertise of both of these companies. TI and National will integrate the breadth of their combined portfolio into existing and new tools (**Figure 1**).

Precision sensing systems employing customized analog designs take weeks—or even months—to design. From IP (intellectual property) to prototype and test to writing system algorithms, designers have been unable to simplify the development and production cycle for critical development systems. The TI and National sensor analog-front-end system and ICs offer an integrated hardware- and software-development platform that allows circuit designers to quickly create a design online, configure it for their requirements, and rapidly prototype it.

A seemingly simple calculation of input-signal common-mode range with TI's INA-CMV-Calc (instrumentation-amplifier common-mode-voltage calculator) can save a designer valuable design time. You can avert many common instrumentation-amplifier design problems with this simple spreadsheet calculator.

Analog Devices has enhanced its Web site to support design engineers, with increasing emphasis on technical content. This support includes the Engineer Zone online technical-support community. The company also offers RF tools, such as ADIsimRF, an easy-to-use RF-signal-chain calculator for cascaded gain, noise figure, third-order intercept point, 1-dB gain compression, and total power consumption. Users can switch the calculator between transmitting and receiving modes, which present output-referred and input-referred calculations, respectively. The company's Circuits from the Lab lists proven reference designs so that designers can be confident in their performance.

On the amplifier side, Intersil offers the iSim active-lowpass-filter tool, which Michael Steffes, senior applications manager at the company, developed. Steffes recently updated the product to include a noninverting-design tool and design algorithms for inverting, both of which will be available shortly. These tools might seem simple. However, the inverting input capacitance in the models and in the device interacts with the resistance values, creating frequency-response issues, and this tool can help address these issues.

According to Steffes, companies can automate a range of ubiquitous application circuits for op amps into online tools. Although vendor and third-party tools apply textbook approaches to the external elements to achieve a design, emerging tools combine the features of a parametric search engine to home in on suitable devices and then execute the design algorithms, including device-specific features. Whereas earlier tools might do a design by looking at just the gain-bandwidth product for voltage-feedback-amplifier-based circuit blocks, newer tools might also consider slew rate, parasitic input capacitance, noise and flicker-noise corners, output-loading issues, and how these issues interact with the amplifier's frequency response.

These "expert system" approaches quickly and effectively narrow the range of device selections by considering both basic effects, such as supply-voltage range, and second-order effects. The new tools also enhance the design algorithms to reduce the required design margin in a device. This feature leads to lower-power and lower-cost devices by considering and compensating for the device's nonidealities in the initial design pass. For example, older tools might be looking for a 100-times greater bandwidth margin in a second-order Sallen-Key filter design, whereas new tools might reduce this margin into the 10-times region, greatly reducing the required design margin in the active device and leading to lower-cost and lower-power designs.

Starting from a few common circuit building blocks, these tools quickly deliver proposed devices; execute designs for the external elements; and, in some cases, port those designs into more general circuit simulators, in which the design can continue using a larger library of board-level components. The online tools thus incorporate accurate and more complete subcircuit models. They model key parasitics and device nonidealities, and designers then use these models in the design algorithms to anticipate and manage second-order issues.

The subsequent designer interface targets the desired outcome for a range of common applications circuits, along with system constraints, such as supply voltage. The tools combine this outcome with a parametric search and a weighting algorithm to eliminate unsuitable devices and then rank the remaining devices by closeness of fit. This weighting closely couples with the intended design algorithms for each of the common topologies. After selection of a device and target design, the tool then executes external element algorithms that are considering parasitic effects, leading to a proposed circuit block. After a circuit block is designed using these interactive tools, some tools can then port that block into a more general simulation platform in which design can continue, combining several of these blocks and inserting other required components.

These analog-circuit-design tools enhance engineers' capabilities and lead to a streamlined and rapid transition of a design idea to a realizable piece of circuit hardware that they can then tweak into a final, working design.

THESE TOOLS TRANSITION A DESIGN IDEA TO A REALIZABLE PIECE OF CIRCUIT HARDWARE THAT CAN BE TWEAKED INTO A FINAL DESIGN.

NANOSCALE CMOS

As CMOS processes move into the nanoscale—that is, less-than-100-nm—range, it becomes increasingly difficult to maintain the energy efficiency for medium- to high-accuracy analog circuits (**Reference 3**). Accuracies may decrease as the technology scales down. Analog-chip designers can improve energy efficiency using different approaches, from selecting the optimum CMOS technology to clever system-level design. Although these approaches can improve efficiencies, doing so is becoming increasingly challenging. Efficiency is essential to analog-circuit designers who are trying to pack 10 lbs of functions into a 5-lb bag. Proper transistor biasing and new clever circuit-level techniques can maintain or even improve energy efficiency in future analog CMOS circuits.

DATA CONVERTERS

Data-converter performance has been steadily increasing over the years.

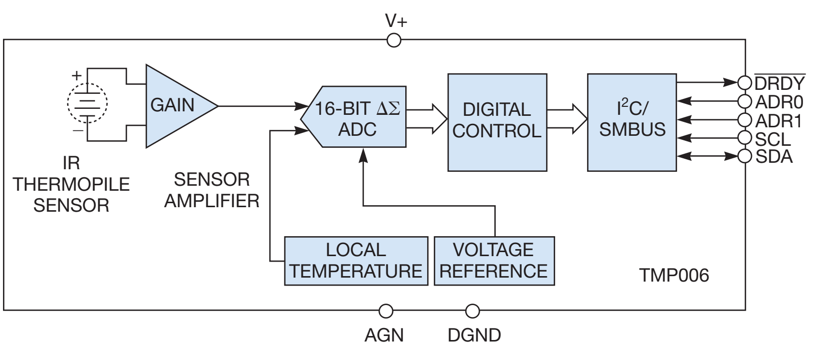


Figure 2 Texas Instruments' TMP006 infrared thermopile sensor integrates an IR MEMS temperature sensor, signal conditioning, and data conversion into a serial bus ready for seamless interface to a microcontroller.

Advancements in scaling and design techniques exploit the high density and speed of modern process technology. More intelligence is being put into data converters. Managing more system functions, converters will simplify programming software, shrink, and become less complex and more cost-effective with digital enhancement. Adaptive power management and sensor integration and enhancement are here, with more to come, eliminating the analog-circuit designer's messy task of signal conditioning the sensor and keeping the sensor, conditioning, and data-conversion chips as close as possible. Enter TI's TMP006 infrared thermopile sensor in an ultrasmall chip-scale package with integrated signal conditioning, an ADC, and a digital-signal output to a serial data bus (**Figure 2**).

Until recently, ADC converters employing a pipeline architecture were the most appropriate for processing wideband signals with the required resolution. Recent advances in oversampling-data-converter technology have enabled new alternatives for the definition of baseband analog front ends for wireless broadband communication systems. The technology for ADCs using oversampling sigma-delta architectures has evolved to the point that the devices can effectively convert signals with bandwidths of 10 MHz or more. This achievement is significant because it allows for the use of this ADC architecture in the receiver channel of broadband communication interfaces, such as LTE (long-term evolution), WiMax, or 802.11abg. They do not suit use for 802.11n, for which the required signal bandwidth is 20 MHz (**Reference 4**).

ADVANCEMENTS IN SCALING AND DESIGN TECHNIQUES EXPLOIT THE HIGH DENSITY AND SPEED OF MODERN PROCESS TECHNOLOGY.

Analog-circuit designers now have more choices in data converters, especially with the ability to integrate analog front ends in video, medical, and power-line-communication applications. These converters have lower-power, smaller-footprint, and lower-cost sigma-delta and pipeline architectures than ever before, allowing for implementation in new markets and applications that were previously off limits to such units. TI's ADS1298, targeting use in the medical arena, is a primary example of such a device.

With last year's advances in data converters and analog front ends, wideband oversampling sigma-delta ADCs will find use in handset systems that support both narrowband and broadband communications with signal bandwidths as high as 10 MHz. They will also find use in applications integrating the ADC together with the RF transceiver, such as fully integrated RF/broadband chips. Pipeline ADC converters, on the other hand, will find use in applications supporting broadband only, such as PC dongles and Pico cells, and applications, such as 802.11n, in which the baseband signal's bandwidth is wider than 10 MHz. They will also find use in applications in which the RFIC is an external device.

The wireless-communication market will be a key driver of data-conversion performance, power efficiency, and calculated integration. Emerging 4G cellular networks and the demand to keep pace with the exploding popularity of wireless video transmission will keep circuit designers busy. Meanwhile, data-converter manufacturers, such as Analog Devices, will develop products with faster sampling rates and more usable bandwidths at higher immediate

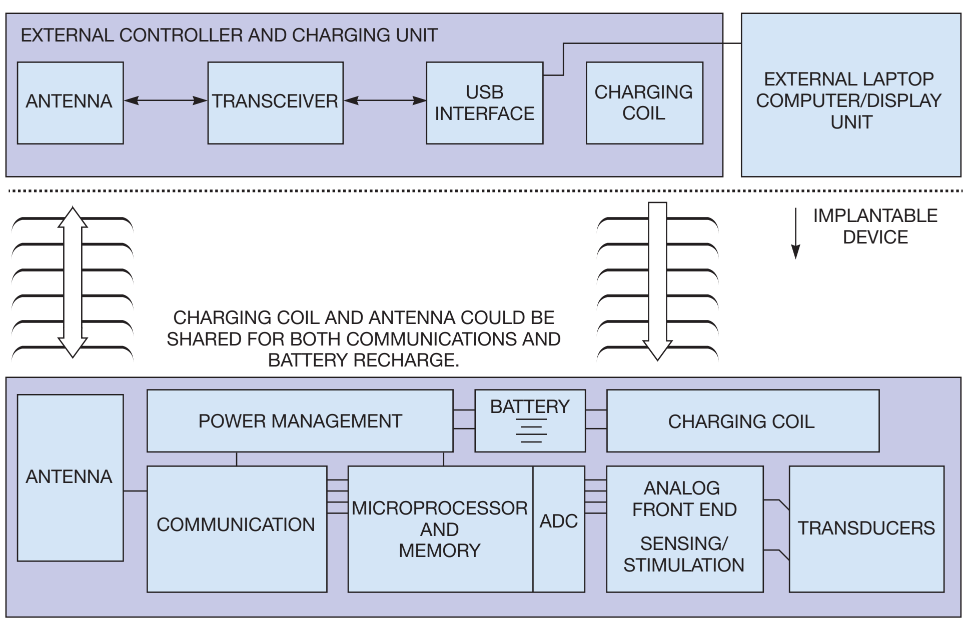


Figure 3 Cactus Semiconductor's high-integration, mixed-signal ICs brings new ideas to a circuit designer's bag of tricks.

frequencies, bringing the antenna closer to the data converter, thereby eliminating costly and complex microwave and RF components. This approach greatly simplifies the analog-circuit designer's task of developing new infrastructure to keep pace with consumer needs.

AMPLIFIERS

Vendors are developing amplifiers to complement the ever-increasing high speed and high bandwidth of ADCs. Intersil, for example, offers the ISL55210 SiGe amplifier with large dynamic range for high-end data acquisition. Another exotic new amplifier might be quiet enough for quantum computing (**Reference 3**). Quantum computers have the potential to solve seemingly intractable problems in no time flat. A big stumbling block on the path to practical quantum computing, however, is figuring out how to observe the tiny quantum signals that drive computation. In an advance that may ease that observation, a group at Aalto University in Finland has created a new kind of microwave amplifier. It uses a mechanical resonator—essentially, a nanometer-scale tuning fork.

MEMS

MEMS chips are ubiquitous. They tell Wii controllers that you're swinging your virtual tennis racket and iPhones that you're giving them a shake. Now, they're popping up in unexpected places, including ski goggles and surfboards (**Reference 5**). STMicroelectronics' MEMS group has entered the market with the three-axis L3G4200D digital gyroscope. Highly integrated products such as this one are easing the analog-circuit designer's burden of interfacing sensors on through to the serial bus.

ASICs AND ASSPs

Companies including Cactus Semiconductor have expertise in power-management and analog circuits that find value in products for the medical- and portable-system market. An analog-circuit designer's dream come true is the level of integration that such innovators make possible (**Figure 3**).

Touchstone Semiconductor, a 2010 start-up, is initially focusing on marketing parts as drop-in replacements for those from other manufacturers, such as Maxim Integrated Products and Linear

Technology. The company will eventually bring to market proprietary parts, which are already in development. Low-power and low-offset current-sense amplifiers are among the new developments, according to Brett Fox, chief executive officer at Touchstone. Targeting existing high-margin markets will enable the company to build revenue and credibility with customers, Fox says. Using TSMC (Taiwan Semiconductor Manufacturing Co) as a foundry allows Touchstone more flexibility and exceeds performance typically available in other semiconductor fabs with state-of-the-art processes. Touchstone now offers 15 analog ICs as part of its Maxim alternative-source product family. Engineers can use Touchstone's alternative-source parts with Maxim's products to ensure a constant supply, so companies can build products and meet shipping deadlines. Analog-circuit designers look to such innovative companies as Touchstone and Maxim for specialized, high-integration ASICs and ASSPs to ease their design task. The availability of multiple sources can be helpful when selecting an analog part for a design.

ADC INTERFACES

SOC technology requires smooth interfacing between peripherals and processors. Multichannel ADCs with high-speed and serial interfaces bring more challenges to analog designers for effectively interfacing these devices with the processor (**Reference 6**). For example, Analog Devices' AD9219 offers low cost, low power, a small footprint, and simple implementation for a VLSI design to pass the data from the ADC to the DSP. You can use asynchronous FIFO buffers with Gray-code synchronization to handle the synchronization issues that occur with two clock domains. This DSP-based ADC interface can be programmed as not only an ideal component to offload processing requirements but also as an analog-input signal preprocessor for the host.

DIGITALLY ENHANCED ANALOG

Implementing digital control in the design of power controllers allows analog-circuit designers to easily monitor multiple operational parameters of the power converter. These parameters include input and output voltage, output current, and temperature, which are only a few of the basic parameters of many critical parameters that you can measure. It is more difficult for analog controllers than their digital counterparts to achieve the diverse functions and adaptive capability that power converters require. Digital controllers more easily achieve these tasks because they can easily digitize data and make it readily available for an external device to read (**Reference 3**).

TI is the leader in digital power, providing flexible and configurable digital-power products for ac/dc and dc/dc designs. The company provides power designers with a broad portfolio of processors, controllers, and drivers, as well as modular approaches to any digital-power-system design challenge. Whether you are designing for isolated or nonisolated products from ac/dc to dc/dc POL (point-of-load) systems, TI's flexible, customizable, and intuitive digital-power portfolio enables a variety of designs.

Analog designers, take heart! More help is on the way as new designs demand smaller footprints, longer battery life, or energy-harvesting power and increased performance in all electronic devices, even in areas you never expected, such as newspapers. Within 10 years, you will see the e-Sheet, a virtually indestructible e-device that will be as thin and as rollable as a rubber placemat (**Reference 7**). The full-color, interactive device requires little power to operate because it charges using sunlight and ambient room light. However, it will be tough and will use only wireless connection ports, so you can leave it out overnight in the rain. You'll be able to wash or drop it without damaging the thin, highly flexible casing.

For more on this topic, see the companion feature "Analog design in the 21st century: semiconductor processes and design," which is available online at www.edn.com/120119cs. EDN

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BY THOMAS NEU • TEXAS INSTRUMENTS

Use a switching regulator to power a high-speed ADC

A PROPERLY DESIGNED SWITCHING REGULATOR CAN IMPROVE THE POWER EFFICIENCY OF LOW-POWER, HIGH-SPEED ADCs WITHOUT SIGNIFICANTLY SACRIFICING PERFORMANCE.

Power consumption is among the most important system-design parameters for designers choosing high-speed data converters. Power dissipation is critical whether in portable designs requiring longer battery life or for small products that dissipate less thermal energy. System designers traditionally power the data converter from a low-noise linear regulator, such as a low-dropout regulator, rather than a switching regulator because they worry that switching noise will feed into the output spectrum of the converter and significantly degrade ac performance.

However, newer-generation, noise-optimized switching regulators, for use in cell phones to minimize interference with nearby low-noise and power amplifiers, allow for a change in practice. They enable high-speed data converters to be powered directly from a dc/dc converter without significantly reducing ac performance. This design instantly improves power efficiency by 20 to 50%.

Modern high-speed converters reduce their power consumption by approximately 50% over previous generations, partly by lowering the power-supply voltage from 3.3V to 1.8V. As the supply rail goes lower in a low-dropout-regulator-based design, the regulator's dropout voltage and the available power rails become more critical for power efficiency. On the digital section of the board, many voltage rails typically service the various core and I/O voltages of FPGAs and processors. On the analog section, however, only a few "clean" options, such as 3.3 and 5V, may be available.

For a high-speed data converter, you can generate a 3.3V supply using a linear regulator from a common 5V rail. This 1.7V drop in the low-dropout regulator equates to a power loss of approximately 35%. When using a low-dropout regulator to derive the 1.8V supply of an ADC, such as the ADS4149 (**Reference 1**), from a 3.3V bus, the power loss in the linear regulator increases to approximately 45%, meaning that almost half the power dissipates in the low-dropout regulator. This example illustrates how easily inefficient power design can lose the 50% power reduction. The efficiency of a switching regulator is fairly independent of the input-supply rail and, therefore, offers a significant power savings. With careful design, you can minimize the effect on ac performance.

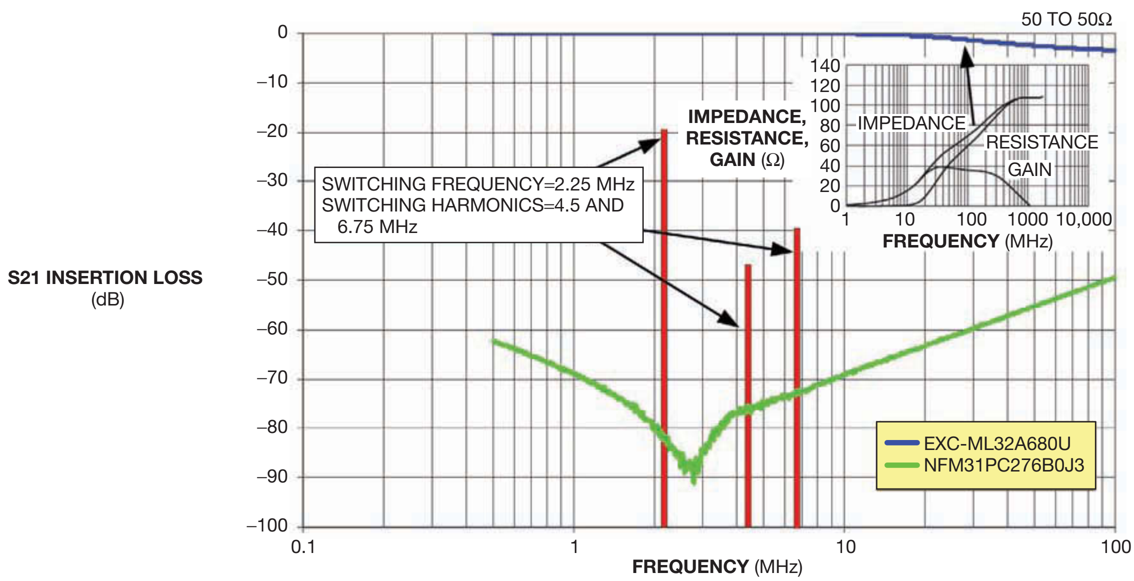

Figure 1 The NFM31PC276B0J3 EMI filter from Murata gives high impedance and low DCR versus a traditional ferrite bead with a resistance of 68Ω at 100 MHz.

POWER-SUPPLY FILTERING

A key component in isolating the switching noise from the ADC is the power-supply filter, which comprises a ferrite bead and the bypass capacitors. You should consider several critical characteristics when choosing a ferrite bead. First, the ferrite bead must have sufficient current rating for the data converter, and it must have a low DCR (direct-current resistance) to minimize the voltage drop across the bead itself. For example, a supply current of 200 mA through a bead with a DCR of 1Ω leads to a 200-mV drop of the supply voltage. This drop may push the voltage at the ADC close to the edge or even below recommended operating conditions when you factor in standard supply-voltage variations.

Second, the ferrite bead must have high impedance at the switching frequency and harmonics of the dc/dc converter to block the switching noise and switching spurs. Most available ferrite beads have an impedance of 100 MHz, whereas the switching frequencies of modern dc/dc converters typically are 500 kHz to 6 MHz. In our example, the ADS4149 evaluation module uses a TPS625290 switching regulator with a switching frequency of 2.25 MHz (**Reference 2**). Because dc/dc regulators have a square-wave output, you must also consider the higher-order harmonics. The NFM31PC276B0J3 EMI filter from Murata gives high impedance and low DCR in that frequency range.

Figure 1 compares the insertion loss of a traditional ferrite bead with a resistance of 68Ω at 100 MHz with the Murata EMI filter. Power-supply circuits have low impedance, and the insertion loss is measured in a 50Ω environment. Hence, the insertion-loss magnitude of the power-supply filter may differ slightly, although the resonant frequencies don't change.

The other components of the power-supply filter are the bypass capacitors. You should choose the values of these capacitors so that their resonant frequencies, which create a low-impedance path to ground, are close to the switching frequency. Thus, switching noise passing through the bead is shorted to ground. The insertion-loss comparison of the power-supply filter in **Figure 2** shows that proper bypass-capacitor values create a resonance close to the switching frequency, even when you combine it with a traditional ferrite bead, such as the EXC-ML32A680. However, at low frequencies, it does not differ much if you replace it with a 0Ω resistor. On the other hand, the Murata EMI filter provides approximately 20-dB extra attenuation around the switching frequency. The power-supply filter in **Figure 3** uses a 33-μF tantalum capacitor for broad frequency decoupling, and the 10-, 2.2-, and 0.1-μF ceramic capacitors have a narrower resonance frequency.

AC PERFORMANCE

Depending on the PSRR of the data converter, a certain amount of noise on the power rail still makes it into the ADC and degrades its ac performance. The SNR and SFDR (spurious-free-dynamic-range) sweeps in **Figure 4** compare a benchmark supply, such as a 1.8V, clean lab supply, with a low-dropout regulator and a dc/dc converter with different power-supply-filter options using the ADS4149 evaluation module.

Test results show SNR-performance degradation of approximately 0.3 dB when powered by a switching regulator compared with a low-noise low-dropout regulator at a 300-MHz intermediate frequency. The SFDR performance is also nearly identical between the setups. A closer look at the normalized FFT plot, which starts at the input signal and plots noise versus offset frequency, shows a slightly elevated noise floor across the Nyquist zone when using the suboptimal EXC ferrite bead but no evidence of any feedthrough of the switching frequency (**Figure 5**).

POWER EFFICIENCY

The main advantage of using a dc/dc converter instead of a

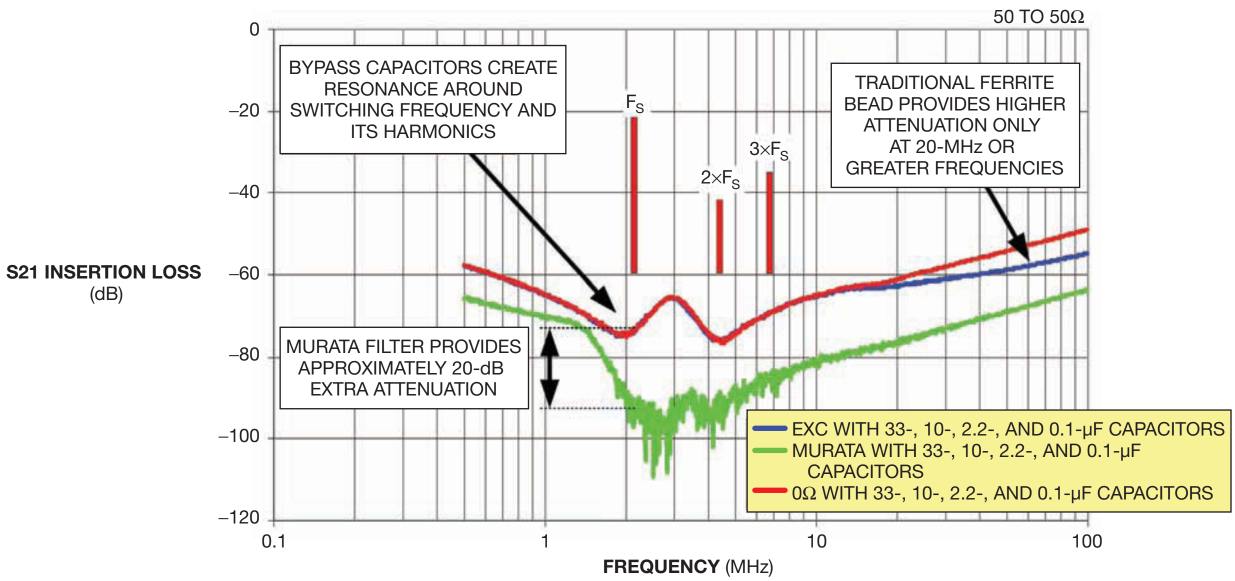

Figure 2 Proper bypass-capacitor values create a resonance close to F_S (switching frequency), even when you combine it with a traditional ferrite bead, such as the EXC-ML32A680.

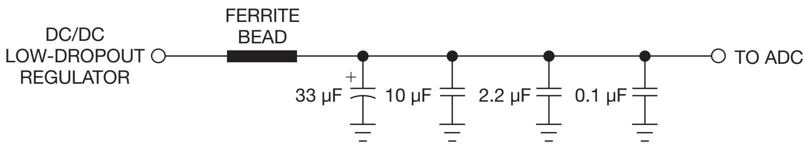

Figure 3 This power-supply filter uses a 33-μF tantalum capacitor for broad frequency decoupling, and the 10-, 2.2-, and 0.1-μF ceramic capacitors have narrower resonance frequency.

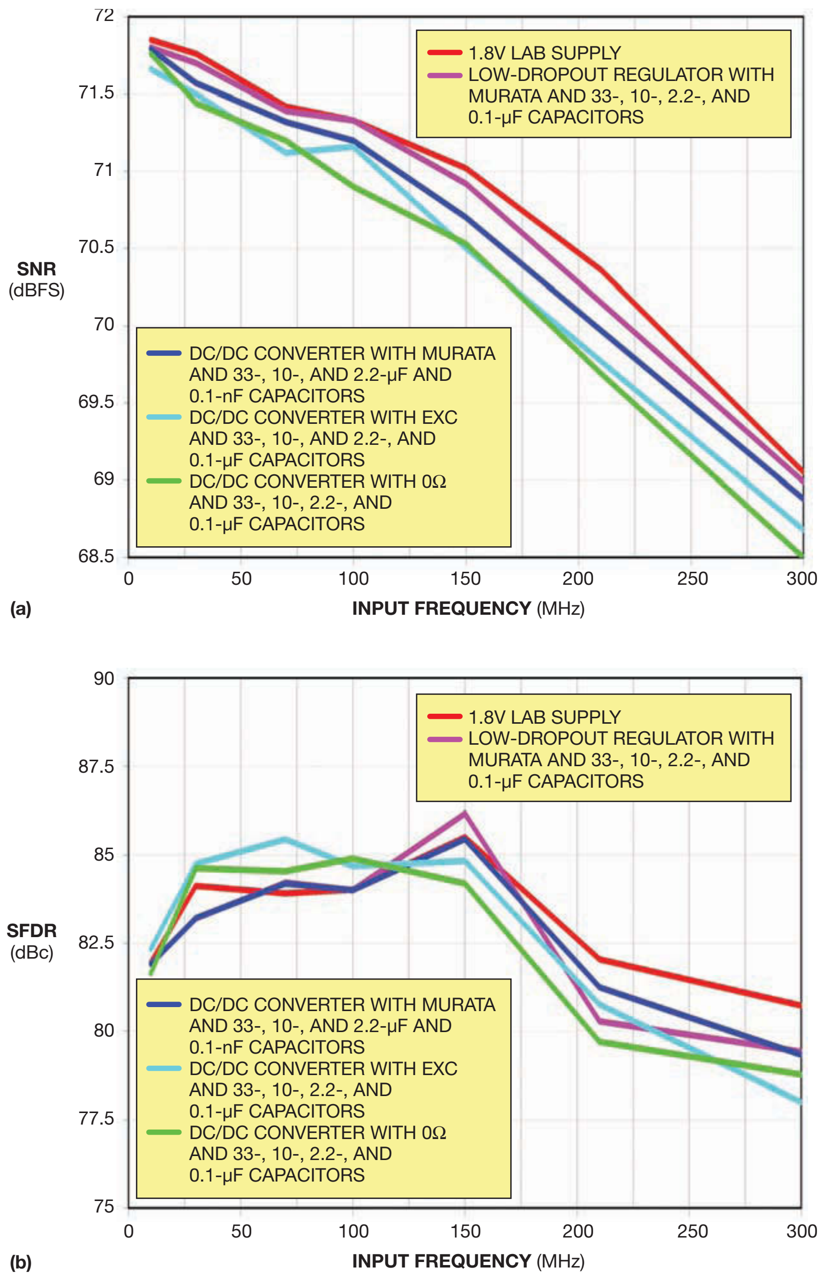

Figure 4 These SNR (a) and SFDR (b) sweeps compare a benchmark supply, such as a 1.8V, clean lab supply, with a low-dropout regulator and a dc/dc converter with different power-supply-filter options using the ADS4149 evaluation module.

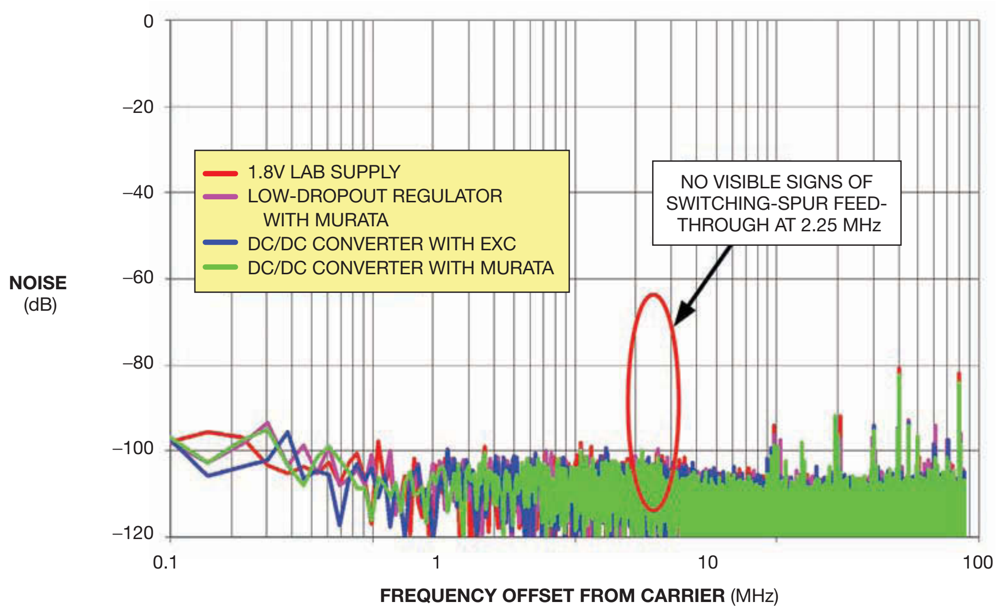

Figure 5 The normalized FFT plot starts at the input signal and plots noise versus offset frequency, showing a slightly elevated noise floor across the Nyquist zone when using the suboptimal EXC ferrite bead but no evidence of any feedthrough of the switching frequency.

TABLE 1 CONVERTER COMPARISON

Setup	Current from external supply (mA)	Power dissipation (mW)	Power efficiency (%)
1.8V lab supply	171 from 1.8V	308	100
Low-dropout regulator	173 from 3.3V	571	55.8
dc/dc converter	104 from 3.3V	343	90.9

linear regulator is power savings. In all of the experiments on the ADS4149 evaluation module, an external 3.3V supply, a common analog supply rail, powers both the low-dropout and the switching regulators. **Table 1** illustrates the measured power efficiencies and their respective quiescent currents. This comparison shows that the low-dropout regulator consumes almost as much power as does the ADC. The switching regulator dissipates only 32 mW more than an ideal approach, achieving an efficient power design. You could further improve the low-dropout regulator's efficiency by stepping down the input voltage—first from 3.3V to, for example, 2.5 or 2.2V—at the expense of increased system cost and size.

Despite having more external components than the low-dropout design, the footprint of a dc/dc-converter design overall may be smaller because newer dc/dc converters have higher switching frequencies that drastically reduce the inductor's size, making it, for example, approximately 2.2 μH for 2.25 MHz instead of 33 μH for 500 kHz.

Conversely, linear regulators may require less power-supply filtering, but they also have size constraints because they typically dissipate more power. From a cost perspective, a switching regulator may be slightly more expensive due to higher component count. Still, the increased efficiency can save cost in thermal-dissipation techniques and the system power budget (**references 3** and **4**).

As system designers push for more power-efficient components, changing the power architecture on a high-speed data-converter design to switching regulators can bring a large power saving. You can power a low-power, high-speed data converter directly from a switching regulator without significantly degrading its ac performance.EDN

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ACKNOWLEDGMENT

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AUTHOR'S BIOGRAPHY

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Make an asynchronous clock for VPX-based PCIe systems

Vadim Vaynerman, Bottom Line Technologies Inc, Westminster, MD

The VITA46 VPX standard defines a chassis that can accommodate all manner of cards with a common form factor (**Reference 1**). The cards plug into a common backplane. This design employs the VITA46.4 standard for PCIe to move data between peripheral cards and the host controller in a VPX system. It uses PCIe Revision 1, which runs at 2.5 Gbps. All VPX-compliant cards must use their own independent clocking, differing from other PCIe-compliant systems, such as PCs. VPX-peripheral cards must also create their own clock for PCIe transactions, meaning that the clock is not phase-coherent with the host single-board computer. Thus, the peripheral clock is asynchronous. The PCIe standard allows for this situation and imposes a tight jitter tolerance on all asynchronous PCIe clocks.

The peripheral card in this Design Idea uses an FPGA as the main digital-processing device. FPGA-vendor evaluation boards often feature PCIe interfaces but do not use asynchronous clocking on the board. To implement asynchronous clocking, you use a clock chip that you carefully match to a particular model of oscillator crystal (**Figure 1**). The clock-chip IC has requirements

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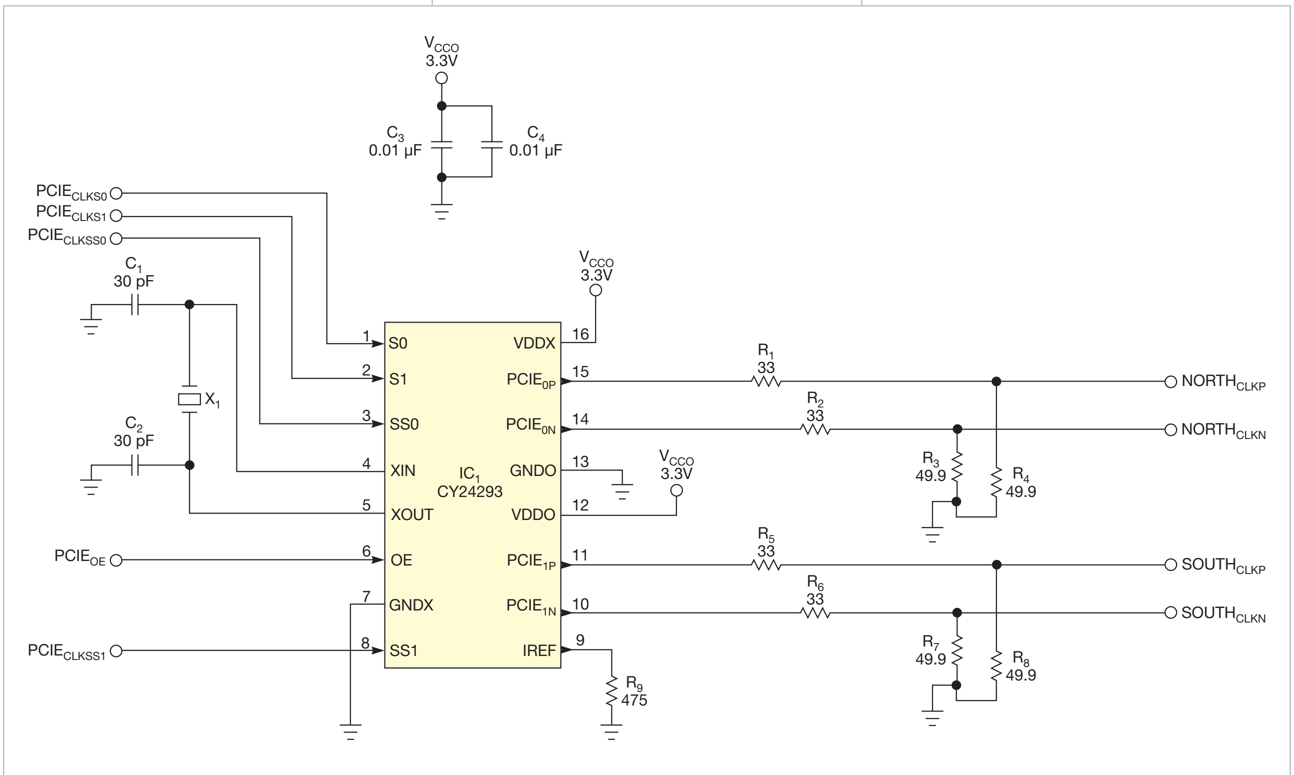

Figure 1 This circuit feeds a clock generator into an FPGA to make an asynchronous VPX clock.

for the crystal for jitter, aging, and impedance. The crystal should maintain these requirements over a –40 to +85°C temperature swing. You must calculate the crystal's loading-capacitor values using the formula in the CY24293's data sheet. Feed the clock from the CY24293 directly into the FPGA's high-speed-transceiver clock pins, yielding reliable PCIe packet transmission between the peripheral cards and the single-board computer. The CY24293 also has other component and layout requirements, as well. Specifically, it uses a PCIe-device-routing configuration, necessitating controlled impedance traces of specific length and series resistors of specific values. EDN

REFERENCE

1 http://en.wikipedia.org/wiki/VPX.

Use a photoelectric-FET optocoupler as a linear voltage-controlled potentiometer

Sajjad Haidar, University of British Columbia, Vancouver, BC, Canada

You can use a photoelectric FET as a variable resistor or a potentiometer in combination with a fixed resistor. The H11F3M photoelectric FET has an isolation voltage of 7.5 kV, enabling you to safely control high-voltage circuit parameters. The nonlinear-transfer characteristics of these devices are problematic, however (**Figure 1**). To correct the nonlinearity, using a simple feedback mechanism as a potentiometer yields a linear response (**Figure 2**). This circuit uses two photoelectric FETs—one for feedback and the other for applications requiring an isolated potentiometer. You connect the inputs of the two photoelectric FETs in series to ensure the same amount of current for the input LEDs.

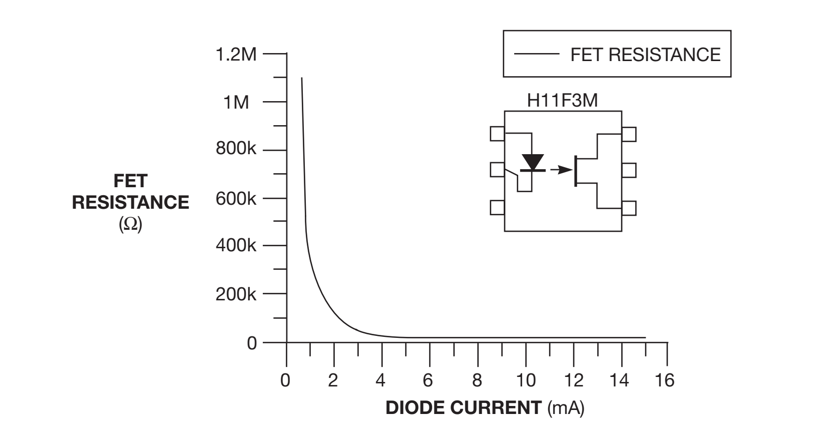

Figure 1 The output resistance of a photoelectric FET is nonlinear with respect to the input-LED current.

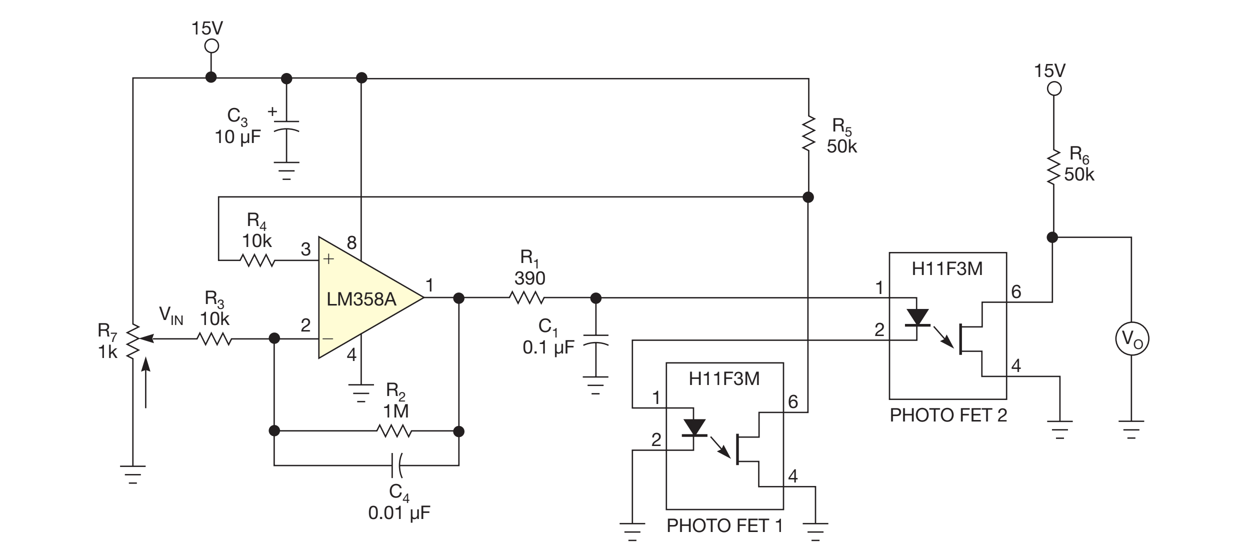

Figure 2 This circuit feeds back the response of an identical photoelectric FET to linearize the response.

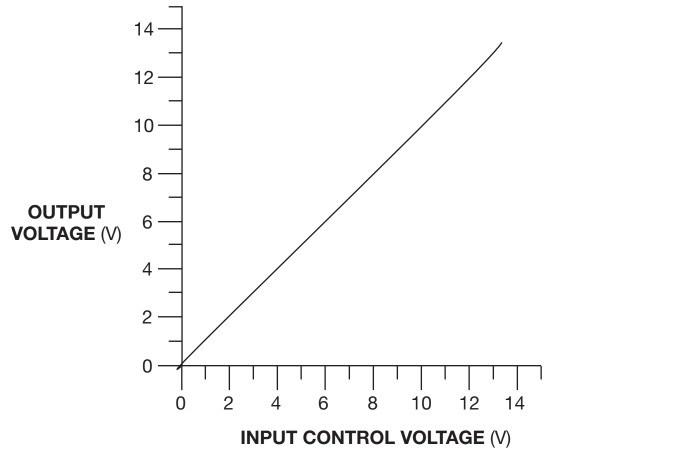

Figure 3 The feedback circuit greatly improves output linearity.

Place 50-kΩ resistors at the FET outputs to mimic the response of a potentiometer. The circuit amplifies the difference between the set input voltage, which you adjust using potentiometer R_7, and the feedback from photoelectric FET 1. The resulting output controls the current in the photoelectric-FET LEDs until the feedback voltage equals the input voltage. The output voltage follows linearly with the input voltage (**Figure 3**). You might think that photoelectric FETs bearing the same part number are identical, but small manufacturing discrepancies can be present. Five H11F3M parts have offsets within 3%. **EDN**

THE CIRCUIT AMPLIFIES THE DIFFERENCE BETWEEN THE SET INPUT VOLTAGE AND THE FEEDBACK FROM PHOTO FET 1.

Wireless temperature monitor has data-logging capabilities

Tom Au-Yeung and Wilson Tang, Maxim Integrated Products, Sunnyvale, CA

You can use a local temperature sensor and an ASK (amplitude-shift-keying) transmitter/receiver pair to design a simple wireless temperature-monitoring system with data-logging capabilities. A microcontroller processes and displays the temperature reading to the user. The microcontroller's onboard UART (universal asynchronous receiver/transmitter) also allows for data-logging applications.

Local-temperature sensor IC_1 detects the ambient temperature at the device (**Figure 1**). The output of IC_1 is a square wave with a frequency

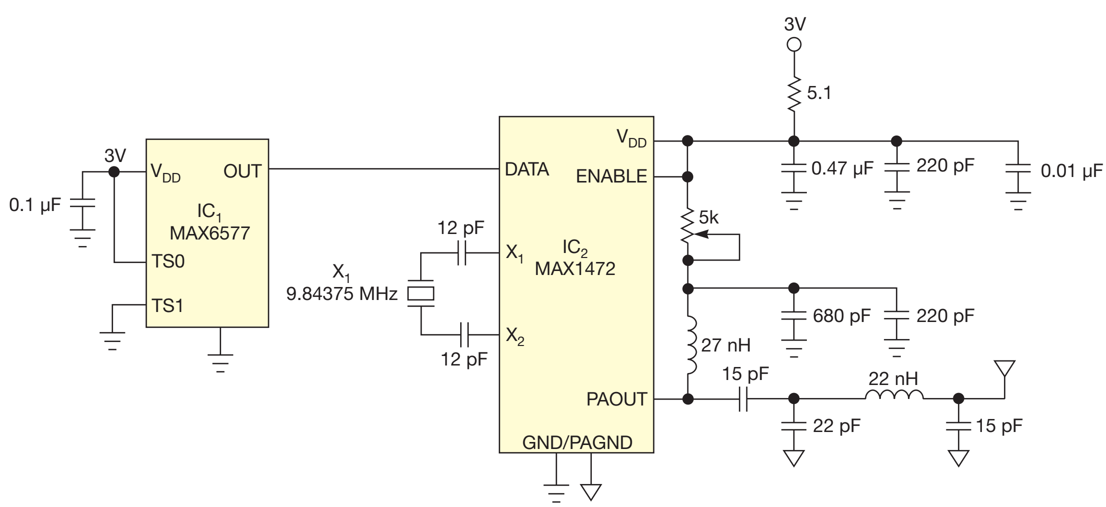

Figure 1 The MAX6577 temperature sensor and 315-MHz MAX1472 ASK transmitter form a wireless temperature-monitoring system.

proportional to temperature in kelvins. ASK transmitter IC_2 modulates the signal onto the carrier frequency of 315 MHz. You measure the output signal's frequency with a frequency counter. The configured scalar multiplier is 1K/Hz when the TS1 pin connects to ground and the TS0 pin connects to V_{DD}. This scalar multiplier is configurable with pins TS1 and TS0. ASK receiver IC_3 demodulates the signal at the corresponding carrier frequency (**Figure 2**).

Comparator IC_4 connects to IC_3's RSSI (received-signal-strength indicator) with an internal peak detector. The external RC follows the peak power of the received signal and compares it with a predetermined, resistor-voltage-divider-generated voltage level. Lab experiments show that a threshold of approximately 1.57V generates a valid output on the data-out pin without receiving false readings. Adjust this threshold to the proper level for optimal performance. The comparator's output is low when the received signal is weak or invalid and high when the received signal is adequate.

Microcontroller IC_5 then measures and displays the value of the signal frequency using its integrated timer/counters and LCD-driver peripherals. A counter tracks the number of rising-edge transitions on the input temperature signal, and a timer tracks the elapsed time. After the timer's 1-sec period elapses, an interrupt occurs. At that moment, the circuit reads the counter value, converts it to Celsius, and displays it on the LCD. The counter then resets to zero to restart the process. The timer automatically reloads once the timer interrupt occurs. UART0 also outputs the resulting temperature. A handheld frequency counter verifies the temperature reading.

The microcontroller monitors the signal power through P6.0, a general-purpose input pin. When the input is logic low, the LCD and UART output "no RF" to alert users of possible transmitter issues when the transmitter and receiver are too far apart from each other. The LCD connection follows the design in the IC's evaluation kit. Using a look-up table in the data segment of the assembly code enables you to preserve the internal mapping of the display's A through G segments. This preservation ensures that the display enables the correct segments. Using an RS-232 level converter, the UART output sends data to a data-logging device, such as a computer.

Use the MAX-IDE assembler software to program the device during assembly. The MAXQJTAG board operates with the MAX-IDE to load the code onto the device. You can download the project files at www.edn.com/120119dia. This design provides for a 1-sec temperature-refresh rate in 1°C increments, which is within the accuracy of IC_1. **EDN**

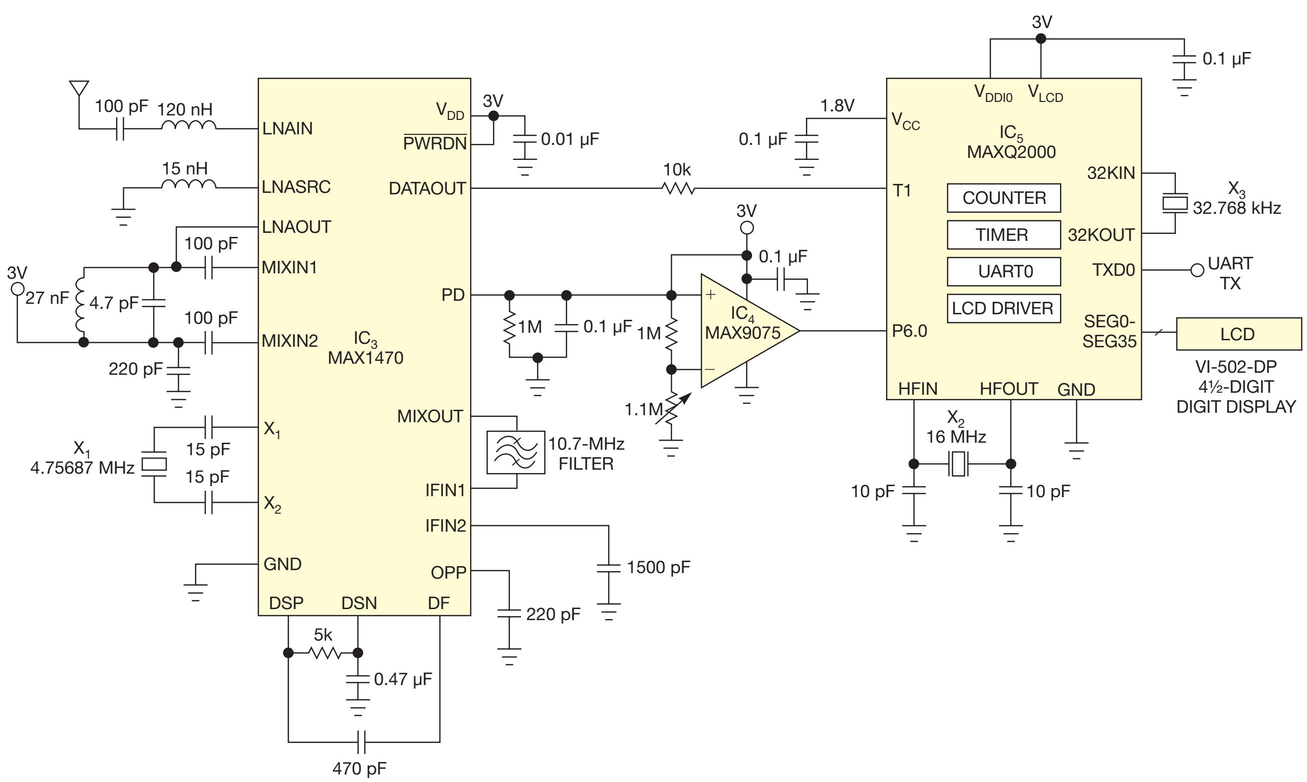

Figure 2 An ASK receiver with a microcontroller processes and displays temperature data.

designideas
CLASSICS

Originally published in the May 29, 1986, issue of *EDN*

Simple circuit tests twisted-pair cables

Mark D Braunstein, Contel Information Systems, Fairfax, VA

Using the system shown in **Fig 1**, you can quickly test a cable containing twisted-wire pairs and detect open or reversed pairs, shorted pairs, and shorts between unrelated pairs. The tester consists of an active test set that plugs into one end of the cable, and a passive terminator that plugs into the other end. (An RS-449 cable is used as an example.)

A battery or a dc supply delivers 15 to 24V to the test set. The voltage regulator (IC_1) is connected as a current regulator to supply a nominal 25 mA to the LED strings at each end of the cable. The cable in this example contains eight twisted pairs, and for a good cable, all eight LEDs in the test set (D_A through D_H, which are series-connected segments of a bar-graph display) and all eight LEDs in the terminator (D_1 through D_8) will light. If a twisted pair is open or reversed, the corresponding LED on the terminator will be extinguished; if a pair is shorted, corresponding LEDs at both ends will be extinguished; and if any two unrelated wires of different pairs are shorted, all intervening LEDs in the strings at both ends will be extinguished. For example, if pins 4 and 6 are shorted, LEDs D_A, D_B, D_1, and D_2 will not light.

You can add a heat sink to the IC_1 regulator as a safety precaution, but normal tester operation is well within the regulator's power-dissipation limits. Even with many shorted pairs, a dissipation of 700 mW would cause no more than 60°C junction temperature, and the IC is guaranteed to turn itself off at 160°C. The complete tester costs less than $50 to build. EDN

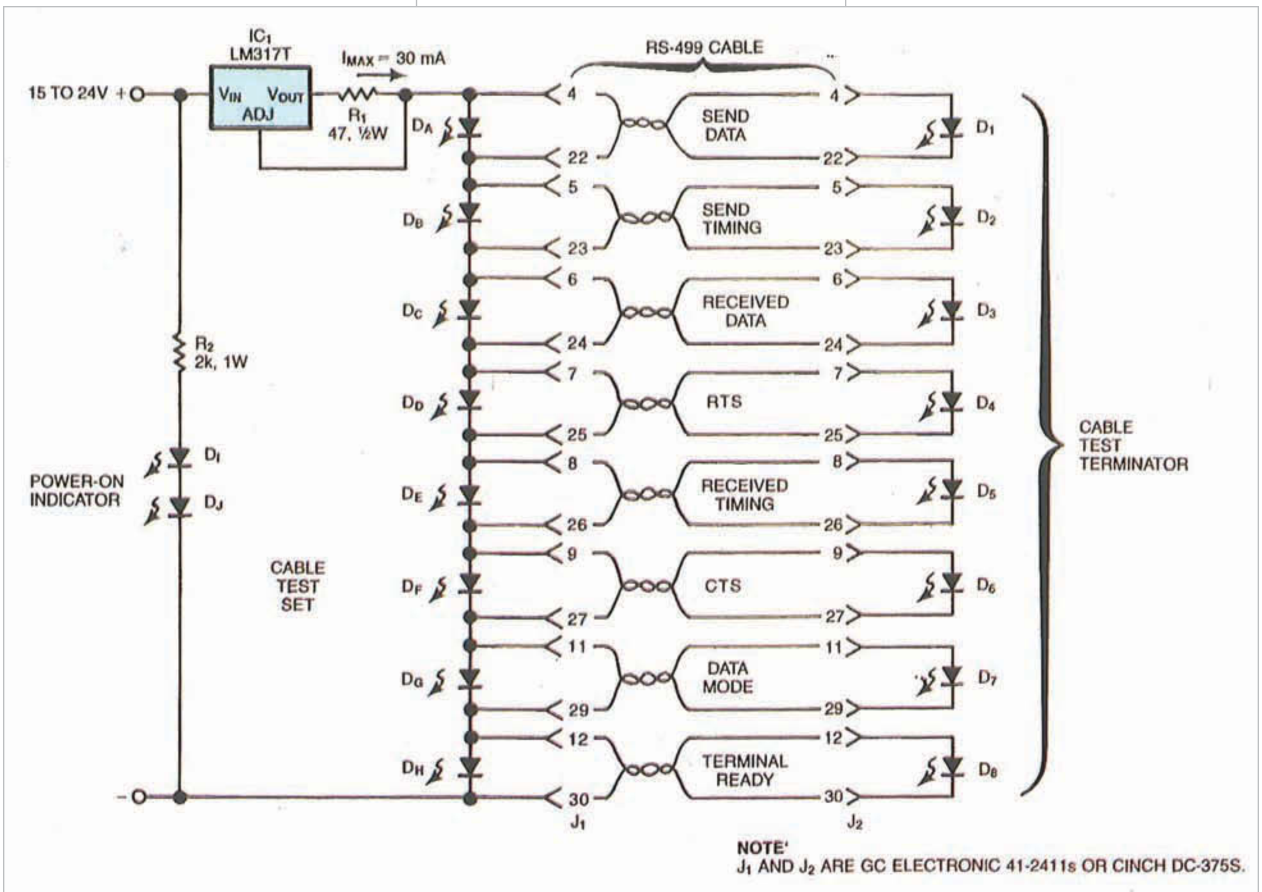

Figure 1 By driving two LED strings from a common current source, you can quickly check a cable of twisted-pair wires for short circuits, open circuits, and pair-to-pair shorts.

productroundup

OPTOELECTRONICS AND DISPLAYS

Toshiba's TLP700H and TLP701H miniature photocouplers drive IGBTs, MOSFETs

The TLP700H and TLP701H directly drive IGBTs and power MOSFETs without the need for external components. Applications include digital consumer products, test-and-measurement equipment, industrial-control systems, and induction heating. The TLP700H and TLP701H feature maximum peak output currents of ±2 and ±0.6A, respectively, and a minimum withstand voltage of 5000V rms. Other features include buffer-logic-type totem-pole outputs and internal noise shields to provide minimum guaranteed common-mode transient immunities of ±20 and ±15 kV/μsec, respectively. The devices have maximum supply currents of 3 and 2 mA, respectively. The TLP700H and TLP701H have power-supply input ranges of 15 to 30V and 10 to 30V, respectively. Maximum switching times are 500 and 700 nsec, respectively.

Toshiba Electronics Europe, www.toshiba-components.com

AndersDX Touch-dX multitouch monitor targets industrial, commercial user interfaces

The Touch-dX family of midsized monitors uses the vendor's ShadowSense technology, offering five touch points and compatibility with ELO Touchsystems' open-frame monitors. The Touch-dX monitors support finger, glove, and stylus input. The family includes a 19-in. unit with a 5-to-4 aspect ratio; a 17-in. unit with a 5-to-4 aspect ratio; and 19- and 22-in. units with a 16-to-10-aspect-ratio option. The devices' response time is 6 msec, and the units can detect objects as small as 2 mm. The devices require no periodic recalibration and come with a comprehensive programming and diagnostic utility that allows the vendor to fine-tune the sensitivity of the touch sensor to customers' application requirements.

AndersDX, www.andersdx.com

Sharp's Mega Zeni series LED modules replace 50W HID lamps

Targeting replacement of 50W HID lamps, the 50W Mega Zeni LED modules have a luminous efficiency of 3590 and 4770 lm, a light output as high as 100 lm/W in standard operating mode, and a service life of 40,000 hours at an operating temperature as high as 90°C. The devices have a forward voltage of 50V and a forward current of 950 mA but can also operate with a standard power source of 1050 mA. Other features include R9 values of more than 85 with CRI values of more than 90, MacAdam three-step Ellipse binning, and good color consistency and stability values over time under realistic operating conditions. The device's round, light-emitting surface comprises 160 LEDs, subdivided into 10 parallel-connected rows of 16. The device measures 24×20×1.8 mm.

Sharp Microelectronics Products, www.sharpleds.eu

Vishay's VO series packs phototransistor output in DIP packages

The DIP-4-packaged VO617A and VO618A optocouplers with a phototransistor output feature an isolation voltage of 5000V rms for switch-mode-power-supply applications. The devices achieve a 40 to 320% current-transfer ratio and an input drive current of 5 and 1 mA for the VO617A and VO618A, respectively. A creepage distance of 8 mm or more is available as an option. The SOP-4L-packaged VOL617A and VOL618A have an 8-mm or greater creepage distance and an isolation voltage of 5000V rms. Current-transfer ratio is 40

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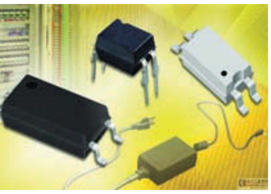


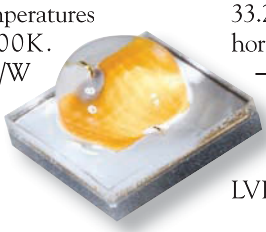
to 320% at an input drive current of 5 and 1 mA, respectively. The SSOP-4-packaged VOS618A and VOS628A have an isolation voltage of 3750V rms and a current-transfer ratio of 63 to 320% at an input drive current of 1 mA. The VO617A and VO618A sell for $0.072 (10,000); the VOS618A and VOS628A sell for 18 and 20 cents, respectively; and the VOL617A and VOL618A sell for 28 cents.

Vishay Intertechnology, www.vishay.com

Osram's Oslon Square lets the application determine the current

The Oslon Square LED family operates in applications ranging from cool designer luminaires to bright streetlights without requiring a change in the manufacturing process for the lamps. The Oslon Square measures 3×3 mm, has a thermal resistance of 4 to 3.8K/W, and comes in a robust package. The LED chip comes in a reflective package that reflects light emitted at the side or at the back so that this light is usable. The EC version targets indoor applications. With a color temperature of 3000K, it provides a warm-white light and offers high color stability over a viewing angle of 120°. The CRI is at least 80, and a "fine-bin" option is available. At an operating current of 700 mA, it achieves an efficiency greater than 90 lm/W and a luminous flux of 200 lm or greater. At a current of 350 mA, efficiency is greater than 100 lm/W. The PC and UW versions target use in outdoor applications, such as streetlights. They operate on currents of 200 mA to 1.5A and produce a neutral- to a cold-white light with color temperatures of 4000 to 6000K. Efficiency is 130 lm/W at 350 mA.

Osram Opto Semi, www.osram-os.com



PolymerVision's truly rollable display technology shows animated images

This truly rollable, 6-in. display technology can show animated images at a 10-Hz refresh rate. Potential applications include ITO replacement, printed TFTs, and printed emissive or reflective displays. These displays enable users to roll an unbreakable large screen from a tightly rolled scroll, plugging the market gap between higher-volume mobile screens and lower-volume laptop or desktop screens. A proprietary debonding process releases the 0.1-mm-thick, 7g display from the substrate without damage. A proven and mature organic TFT technology currently drives the displays. Mobility values range from 0.2 to 0.3 cm^2/V. Turn-on voltage is approximately 0V, resulting in low-voltage and low-power operation. The devices are encapsulated from the ambient environment to improve their stability during operation. The initial products have reflective electrophoretic displays, which minimize power consumption and are more tolerant of variations in the TFT-backplane process.

PolymerVision, www.polymervision.com

Optrex TFT LCDs deliver 1500 cd/m² for industrial applications

Five new superbright TFT LCDs work in outdoor environments, including direct sunlight and other high-ambient-light environments, such as briefly lit factory floors, in which the display must be readable at all times over a wide temperature range. The 19-in.-diagonal T-55699D190J-LW-A-AAN has a 1280×1024-pixel resolution, a brightness of 1500 cd/m^2, power consumption of 33.2W, a contrast ratio of 800 to 1, and horizontal and vertical viewing angles of −80 to +80°C. It also features an operating temperature range of −20 to +70°C, a white-LED backlight with 100,000-hour lifetime, and a standard LVDS interface. The 12-in.-diagonal super high bright T-55592D121J-LW-A-ABN TFT LCD has a 1280×800-pixel resolution, power consumption of 13.1W, a contrast ratio of 700 to 1, and horizontal and vertical viewing angles of −80 to +80°C and −60 to +80°C, respectively. It also features an operating temperature range of −30 to +80°C, and a white-LED backlight with a 100,000-hour lifetime. An LVDS interface is standard. The 9-in.-diagonal T-55562D090J-LW-A-ACN TFT LCD has 800×480-pixel resolution, power consumption of 6.4W, a contrast ratio of 800 to 1 and horizontal and vertical viewing angles of −80 to +80°C and −60 to +80°C, respectively.

Optrex, www.optrex.com

Sharp's LS series draws less power than conventional TFT LCDs

The 4.4-in. LS044Q7DH01, 1.17-in.-diagonal LS012B4DG01, and 1.28-in.-diagonal LS013B7DH03 ultra-low-power memory LCDs draw less than 1% of the power that conventional TFT LCDs require. The 4.4-in. unit has a QVGA resolution of 320×240 pixels, a 17.5% reflectivity, and a viewing angle of 120° in all directions. The device has a 0.25% transmissive portion, allowing readability in complete darkness. Power input without backlighting is 0.25 mW with static images and 0.65 mW with a frame rate of 1 Hz. The 1.28-in. unit measures 26.6×30.3×0.75 mm for a resolution of 128×128 pixels. Transmissivity is 0.2%, allowing for an optional backlight. The 1.17-in. unit has a resolution of 184×38 pixels and operates at temperatures of −10 to +70°C. The device's 52-mm-long ribbon cable enables the display to be flexibly positioned and allows its integration in the housings of power tools.

Sharp Microelectronics Products, www.sharpleds.eu

Mitsubishi LED-driver combo achieves high brightness

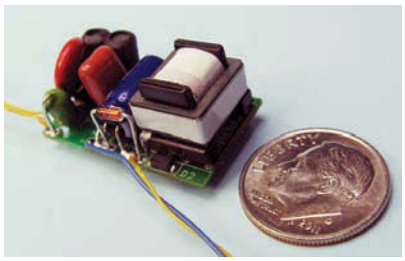
The 7-in. WVGA AA070MC01 and 10.6-in. WXGA AA106TA01 LCD modules for industrial applications feature integrated LED drivers, which achieve brightness of 1000 cd/m^2. The devices have a 170° horizontal and vertical viewing angle, making them suitable for marine applications. The TFT LCD modules feature a contrast ratio of 1000 to 1, and the units can operate without an inverter, making them suitable for compact designs. Operating life cycle for the LED background lighting is at least 100,000 hours at an ambient temperature of 25°C. Operating temperature range is −30 to +80°C, making the devices suitable for exterior applications in difficult climatic conditions.

Mitsubishi Electric,
www.global.mitsubishielectric.com

Power Integrations' LED-driver reference design adds efficiency

The DER-297 reference design uses the LinkSwitch-PL IC in PFC drivers for LEDs. The design describes a driver for B10, GU10, E17, and A19 LED light bulbs, such as Cree's new XLamp XT-E and XM-L LEDs. The design reaches 87% efficiency at 115V ac for a 4.3W LED driver and 86% efficiency at a 2.9W output. Power factor is greater than 0.9. The compact design has a BOM of only 20 components.

Power Integrations,
www.powerint.com/sites/default/files/PDFFiles/der297.pdf



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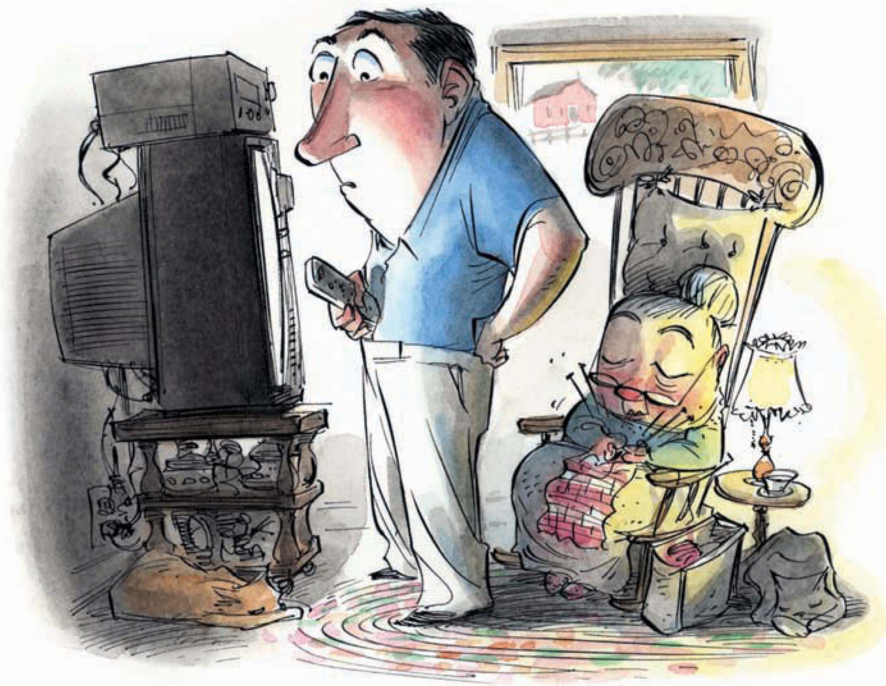
The silence of the circuit



For many years, I was an engineering troubleshooter for a large electronics company. Long ago, I had to solve some problems near my old neighborhood. It was a great opportunity to also visit my mother, whose birthday was coming up. She lived an old-fashioned life way out in the middle of nowhere. I decided to surprise her with her first VCR. She had never seen such a thing. I had to drive about two and a half hours to my out-of-town meeting, and had just enough time to make it. Before the trip, though, I stopped to buy a nice VCR. In a panic, I asked the young clerk whether he could recommend a video my mom would like. He enthusiastically handed me one. I bought it without even looking at it. I solved the work problems and then headed off to my mom's house.

A lot of friends and neighbors gathered, and everyone was ready to see this marvelous VCR. Well, it didn't work. The picture was hopelessly garbled.

At the time, I always carried my trusty portable scope. That instrument was like a Swiss Army knife to me; I used it for everything. I looked at the signals coming from the VCR and noticed lots of strange activity in the blanking interval. I didn't know it at the time, but that activity turned out to be Macrovision encoding on the tape, which prevents anyone from copying the video tape. The new VCR was doing fine with it, but Mom's old RCA TV just couldn't cope. Now everyone was looking at me, wondering why I couldn't get it working. I lost a lot of admiration points that day. Mom just kept right on knitting.

I told everyone to come back in a couple of hours, and I was sure I would have it going. I quickly designed a circuit on paper that would scrub the Macrovision signals, but it required far more parts than I had. I decided to scrounge transistors and other parts from an old hi-fi. I also had a few parts and vertical FETs in my toolbox, but still not enough components or time to put it all together.

So I went back to the drawing board. I developed some clever ways to use parts for more than one function and came up with a tricky but simple circuit that I could build quickly. I used a 9V battery for power. My circuit looked like a kludge but seemed to work properly. Finally, I had video just as everyone was filtering back. I was sweating bullets as I started the unknown video that I wasn't sure would even work. It worked great, but the video turned out to be probably the worst choice in the world for this old-fashioned country audience.

SOMEONE SHOWED UP WITH A TAPE OF *I LOVE LUCY*. IT WAS A HIT AND SAVED THE DAY.

Yikes! It was *The Silence of the Lambs*. Some people left; others stayed with confused looks on their faces. Mom just kept on knitting while watching occasionally over her glasses. I asked her if I should stop the movie. "No, just change the channel," she said.

"Well, Mom, a VCR has only one channel," I said. "If you want another one, you have to buy another tape."

Mom had no idea how clever I had to be to get this thing working at all. "Thanks for trying, son, but I like my programs," she said. "Why would I want to have only one?" As I hung my head in utter defeat, someone showed up with a tape of *I Love Lucy*. That program was a hit and saved the day. They must have played it 20 times. Mom loved the fact that she could stop, start, and even reverse it and that she could play it anytime she wanted.

For years, I've used a refined version of my Macrovision filter, and I'm still amazed how I could solve that complicated problem in the time it took my mom to knit me a sweater. Fixing that problem turned out to be more difficult than the one I was paid to solve. EDN

This Tale is a runner-up in *EDN*'s Tales from the Cube: Tell Us Your Tale Contest, sponsored by Tektronix. Read the other finalists' entries at http://bit.ly/Talesfinal_EDN.

DANIEL VASCONCELLOS

THE FUTURE IS ANALOG

For Three Decades We've Looked to the Future

Thirty years ago, at the dawn of the digital revolution, some questioned the wisdom of founding a company dedicated to delivering purely analog products. Since then, the worldwide analog market has grown twenty-fold. With this tailwind, Linear's growth as an industry leader is no mystery.

Innovation. Linear Technology wrote the book on analog innovation. From our power and Hot Swap™ devices to µModule® and energy harvesting products, we've provided our customers with enabling technology.

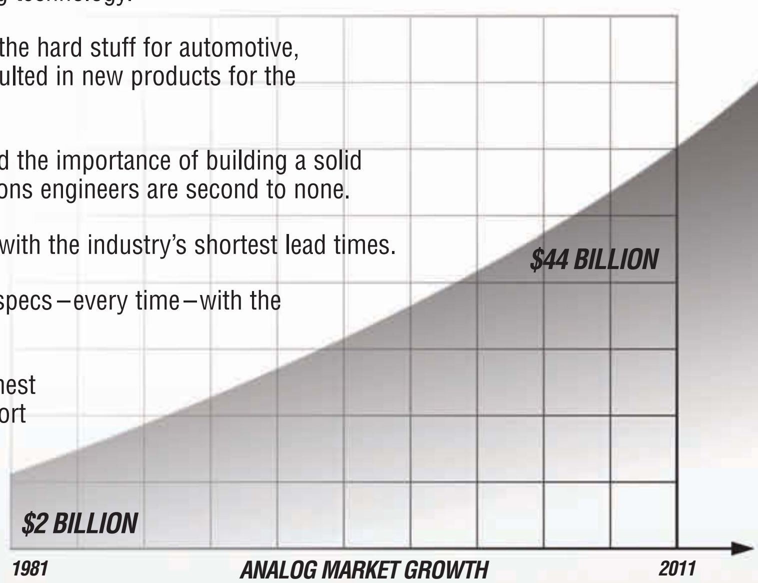
Focus. Our laser beam focus on designing the hard stuff for automotive, industrial and communications markets resulted in new products for the most demanding applications.

Technical Prowess. Early on, we recognized the importance of building a solid technical team. Our designers and applications engineers are second to none.

Support. Many say it; we deliver – on time, with the industry's shortest lead times.

Quality. Our products meet the data sheet specs – every time – with the industry's highest quality.

We're there for you, with the industry's highest performance analog products and the support you demand. Count on it.



Source: World Semiconductor Trade Statistics
*WSTS Analog Market Forecast, 2014

2011 30 YEARS
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View a video with CEO Lothar Maier and Co-founders Bob Swanson and Bob Dobkin at www.linear.com/30yearinterview

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