UBM Tech

# EDN®

MAY 2013
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Issue 5





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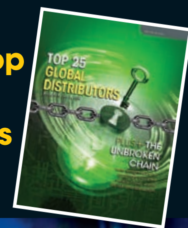
**SPECIAL REPORT: Top 25 global distributors**
After page 46





## ACE AWARDS

# CELEBRATING THE ART OF ENGINEERING

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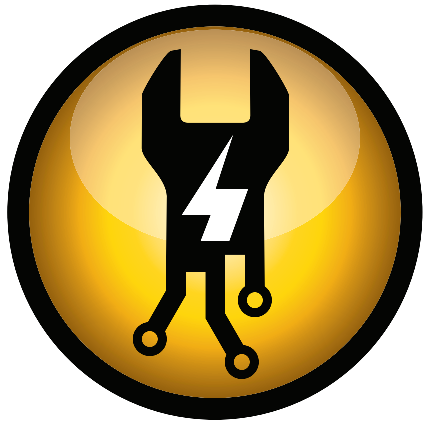
# EDN contents

May 2013


## ACE Awards: Celebrating the art of engineering





## Special report: Top 25 global distributors

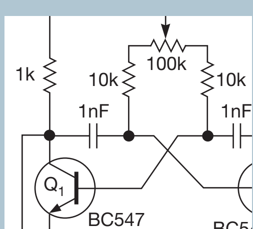


## Design for manufacturing and yield



COVER IMAGE: TRISH TUNNEY

## DESIGNIDEAS






▶ Find out how to submit your own Design Idea: www.edn.com/4394666.

# contents May 2013

## pulse



## DEPARTMENTS & COLUMNS



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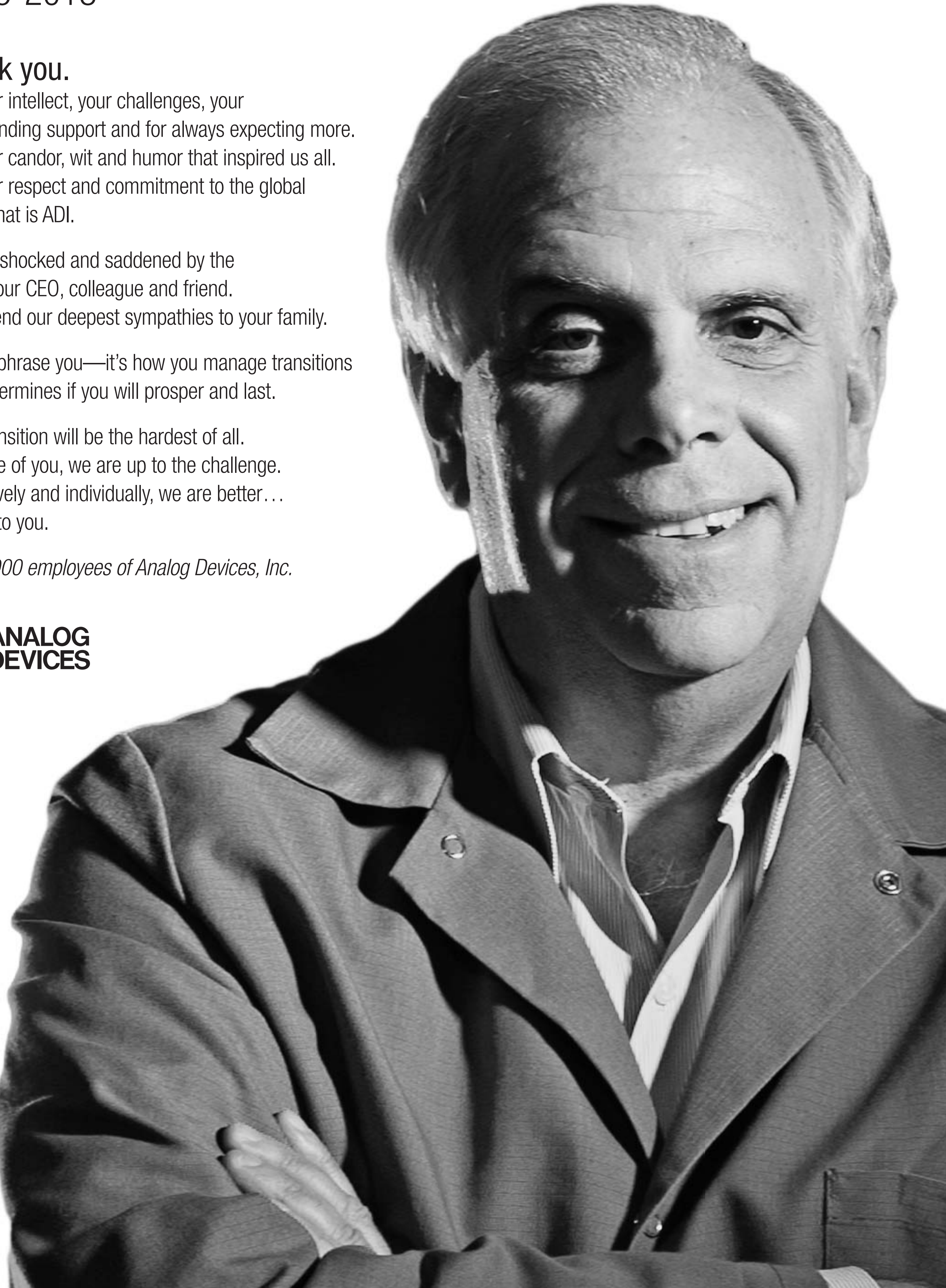
*Volume 58, Number 5 (Printed in USA).*

# Jerry Fishman

## 1945-2013



### Thank you.

For your intellect, your challenges, your
never-ending support and for always expecting more.
For your candor, wit and humor that inspired us all.
For your respect and commitment to the global
family that is ADI.

We are shocked and saddened by the
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We extend our deepest sympathies to your family.

To paraphrase you—it's how you manage transitions
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This transition will be the hardest of all.
Because of you, we are up to the challenge.
Collectively and individually, we are better…
thanks to you.

*The 9,000 employees of Analog Devices, Inc.*

ANALOG DEVICES

# EDN online

## JOIN THE CONVERSATION

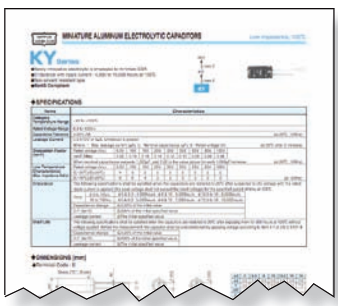
Comments, thoughts, and opinions shared by *EDN*'s community

**In response to "Audiophile heaven," a post in the HackWire blog at www.edn.com/4412053, jimfordbroadcom commented:**

*"Wow, another cool project that I wish I had time for. Last time I messed with vacuum tubes was back in the dark ages BK (before kids). It was a Paia plate-starved (45V IIRC) 12AX7 preamp that I was attempting to use as a distortion box for my guitar. When I upped the grid drive, it went into clipping, and tube clipping sounds just as bad as solid-state clipping. Something blew up while I was probing around inside the Bud Box I had it in, and I never got around to fixing it. I always wanted to add a variable plate bias up to 250V or so but never got around to that, either. Retirement, maybe? Only 15 to 20 more years to go!"*

**In response to reader comments on "Ensure long lifetimes from electrolytic capacitors: a case study in LED light bulbs," posted at www.edn.com/4411475, Mark Fortunato, the article's author, said:**

*"It is unfortunate the poor circuit design and component selection have led to many bad LED light bulb designs. People thus believe that the technology itself is unreliable. Proper design, including selection of adequate components, is needed to get the full capability out of the technology. Unfortunately, negative public perception is based on those earlier, bad designs!"*


MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

KY Series

SPECIFICATIONS

DIMENSIONS

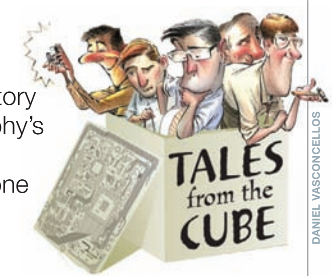
**EDN *invites all of its readers to constructively and creatively comment on our content. You'll find the opportunity to do so at the bottom of each article and blog post.***

## CONTENT

Can't-miss content on EDN.com

### THE PRODUCT THAT MADE ME DOWNRIGHT CERTIFIABLE

Here's an online-only Tales from the Cube story about Murphy's law as it applies to one engineer's first agency certification.




DANIEL VASCONCELLOS

**www.edn.com/4412240**

### TESTING A POWER SUPPLY

Part one of this three-part series describes how to properly test a dc/dc power supply, and ensure that it works reliably over various operating conditions.

**www.edn.com/4411146**


## ENGINEERING COMMUNITY

Opportunities to get involved and show your smarts

### Share and inspire

In this issue of *EDN*, you'll read about the 2013 ACE Awards Contributor of the Year, an award honoring the spirit of Jim Williams and his willingness to share knowledge and inspire others. If you have insight to share and inspire others with, consider contributing a Design Idea, technical article, blog, or Tales from the Cube story to *EDN*. We'll promote it through our various newsletters and social media, helping extend the reach of your work. Find out how to contribute to *EDN* on our About Us page: **www.edn.com/aboutus**.

**Jim Williams**

BY PATRICK MANNION, BRAND DIRECTOR

# Our ever-evolving *EDN*

It's probably appropriate that I am writing about the last issue of *EDN* print during DESIGN West 2013 here in San Jose, CA, and toward the end of what's looking to be the best month ever for the relaunched *EDN* community site. That all three "events" are happening at the same time is pure coincidence, but their relationship isn't.

Let's start with the closure of our print operations with the June installment. For many of you, this news will come as a shock and a disappointment. For others, it'll be a genuine sense of "losing a dear friend," coupled with a recognition that the means by which we consume and interact with the people, information, and technologies required to do our jobs are changing rapidly. And as with any vital, live organism, adapting to the environment is a natural part of evolution.

For you, the designer, that evolution comes in response to blindingly fast—and accelerating—design cycles. It's also driven by a more, ahem, "fluid" job environment in which satisfying your curiosity and learning new skills have gone way beyond what you like to do and turned into absolute necessities. This is especially the case as you take on new roles and immerse yourself in areas of design that perhaps you last touched upon in college. Or maybe you're just out of college and are realizing—rightfully so—that college was only the beginning of your education.

To get this ongoing education, it's no longer enough to simply read an article in print. A good article will answer a lot of questions, but it will also raise just as many as you synthesize the information and start to apply it in your own context. One of the ways to do this is to jump to the online version and ask the author and the other engineers who read that same piece what to do in your particular circumstances. There are many engineers there with lots of insights, and they are more than willing to share them. We recently started to feature their comments as a live stream on EDN.com's home page, and the feedback hasn't stopped: thousands of comments and questions—all day, every day.

That's good, and from there you can connect with peers, contributors, and others in your area of interest and share ideas, debate, and, sure, sometimes argue (politely and with a sense of fun, of course). Feel free to showcase your own skills, let people know who you are and what you're about, and keep learning as you engage with what are the smartest, most professional, helpful, and darn-well nicest group of people you're ever likely to "meet."

So what then? It turns out that forming that connection and getting that real-time online interaction and learning experience compose but a first step. At DesignCon in January and now DESIGN West here in April, many of our community members either planned to meet or met accidentally, and cemented the connection. Speakers met with their fans. And there were lots of fans.

If you've gotten this far, then you're probably seeing where I'm going with this. *EDN* is part UBM Tech, a group within UBM that is taking the lead on the full symbiosis of online and events. The goal is to allow you to go online and learn *what* you need to, *when* you need to. (Stay tuned for more on the new *EDN* School of Real-Time Learning.) You can then stick around to ask and answer some questions, identify like-minded engineers, form virtual connections, follow people you like, and then even meet them face to face at your nearest event.

How is this working out so far? Pretty well, to be honest. Last night at the speakers' party for DESIGN West, I had the pleasure of connecting two contributors to two different UBM Tech sites. These individuals realized they had much in common and are now going to connect and work together on contributions via *All Programmable Planet* and *EDN*. A perfect match!

**As with any vital, live organism, adapting to the environment is a natural part of evolution.**

I then bumped into instructor Bill Gatliff, hot off his Android training course. Bill is a classic engineer: focused, head-down, get the job done, and no time for frivolity. Since he started teaching the Android course at DESIGN West and began blogging for Embedded.com, however, Bill's realized that it's been a mutually beneficial relationship. He's gained as much as he's given—probably even more so—and is now preparing a series for *EDN* on the application of Android for systems beyond smartphones. You'll enjoy his work.

Bill's experience sums up what we're about: connecting those who *do* know with those who *want* to know—online and face to face—and helping form what we hope will be lifelong relationships that will carry you forward not just to the conclusion of this design cycle, but the next, and the next one after that. Dare I say it? Think of us as "EEHarmony." **EDN**

*Contact me at patrick.mannion@ubm.com.*

# pulse

INNOVATIONS & INNOVATORS

## Quantum refrigerator cools to extreme temps

A prototype solid-state refrigerator developed by researchers at the National Institute of Standards and Technology (NIST) uses quantum physics to cool a much larger object to extremely low temperatures. Measuring a few inches in outside dimensions, its cooling power is said to be equivalent to that of a window-mounted air-conditioner cooling a building the size of the Lincoln Memorial in Washington, DC.

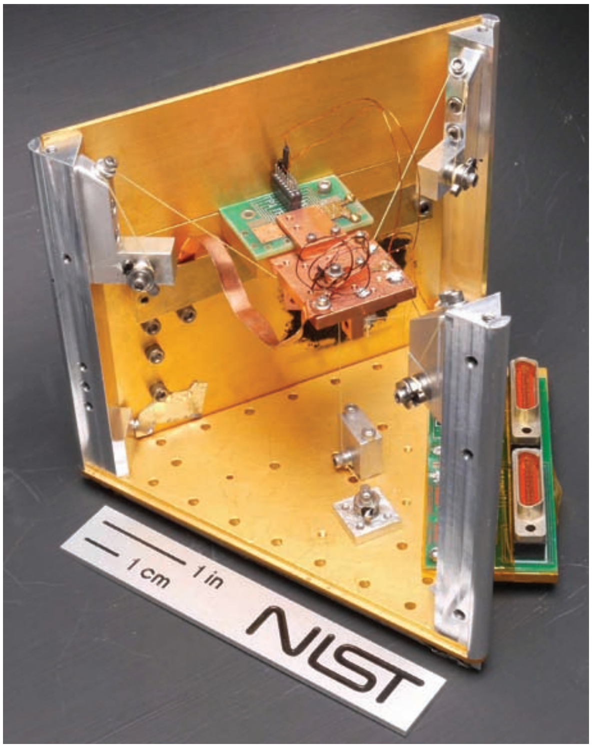
Just like with a normal refrigerator, suitable objects can be placed in the unit's cooling zone and later removed and replaced. The refrigerator's cooling elements comprise 48 tiny sandwiches consisting of a normal metal, a 1-nm-thick insulating layer, and a superconducting metal. When voltage is applied, electrons tunnel from the normal metal through the insulator to the superconductor, resulting in a dramatic reduction in temperature in the normal metal and draining energy from the object being cooled.

In the demonstration, researchers cooled a block of copper that was about a million times heavier than the unit's refrigerating elements. The cooling process took about 18 hours.

This technology may offer a compact way to cool advanced sensors to below standard cryogenic temperatures—300 milliKelvins—improving their performance in such applications as quantum information systems, telescope cameras, and searches for dark matter and dark energy. Currently such a degree of cooling requires complex, large, and costly equipment.

For more, see the related paper, "Macroscale refrigeration by nanoscale electron transport," published by *Applied Physics Letters* (http://bit.ly/109G2iJ). **—by Rich Pell**

▷**National Institute of Standards and Technology,** www.nist.gov




A prototype solid-state refrigerator uses quantum physics in the square chip mounted on the green circuit board to cool the much larger copper platform (in the middle of the photo) to below standard cryogenic temperatures.

### TALKBACK

**"How does the manufacturer perform verification? Surely, its staff must work from a document that specifies a sequential checklist procedure? Deciding that it's 'too much trouble' to put these notes in the data sheets and user manuals is unconscionable."**

—Commenter vapats, in response to Jon Titus's blog post "Why are some data sheets so unhelpful?" at www.edn.com/4411964. Join the conversation and add your own comment.

# Tektronix releases first power analyzer

Marking its entrance into the power-analyzer market, Tektronix debuted the PA4000 power analyzer. Based on intellectual property (IP) gained from Tek's agreement with Voltech, the new power analyzer features a proprietary Spiral Shunt design, which includes dual internal spiral shunts in each module for stable measurements from microamps to high-current motor drives.

Basic voltage and current accuracy is specified at 0.04%, with crest factors up to 10. The PA4000 offers a voltage input range up to 1000V RMS, 2000V peak. Its dual internal current shunts include a 20A RMS shunt for current up to 30A RMS, 200A peak. For low-current devices, each channel also includes a 1A RMS shunt. The shunts help keep voltage and current phase aligned during measurements. Sensing current accurately is challenging, and the IP in the instrument as well as high-resolution 14-bit ADCs make this possible. The unit measures up to the 100th harmonic.

Available with one to four inputs, the power analyzer is modular, so it can be configured in multiple ways. For instance, designers working on single-phase devices might order the PA4000 with two modules. Those working on three-phase devices would likely want all four channels.

In terms of analysis, the unit is equipped with USB, LAN, and RS-232 interfaces standard. (GPIB is optional.) PWRVIEW PC software is included. Application-specific built-in automatic test modes include PWM motor drive mode (which sets filters and timing for testing pulse-width modulated motor drive outputs), standby current test (which configures measurement timing to perform standby current measurements), electronic ballast test (which synchronizes measurements for highly modulated electronic ballast waveforms), and integrator mode (which sets the analyzer for energy-consumption measurements). In addition, designers can log their measurement data to a flash drive using a front-panel USB port. PC software for data download, analysis, and application-specific testing is available as a free download. For current measurements above 30A RMS, Tektronix recommends the CT-S, CT-M, or CL series of current transducers.

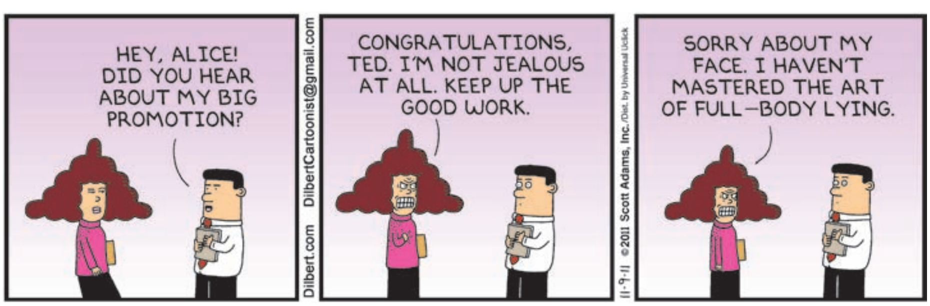
Pricing for a one-channel PA4000 is $10,500; two-, three-, and four-channel versions are priced at $13,400, $16,200, and $18,900, respectively. Most features are standard, but there are two options: the GPIB interface and an internal 15V power supply (for sensors above 30A). The unit comes with a three-year warranty. The power analyzers are available now worldwide.

**—by Janine Love**

▷**Tektronix**, www.tek.com

The PA4000 power analyzer from Tektronix is equipped with four channels.

## DILBERT By Scott Adams




05.13

## IC PROVIDES REAL-TIME INDOOR-LOCATION INFORMATION

**Targeting real-time location systems and wireless sensor networks, BlinkSight's single-chip transceiver employs ultralow-power impulse-radio technology developed by Imec and the Holst Centre to provide real-time 3-D location information that is accurate to within 10 cm. The device is capable of operating over both the 3.1- to 4.8-GHz and 6- to 10-GHz bands and can be integrated into tags, wireless sensors, base stations, and mobile devices.**

**The chip is fabricated in standard 90-nm RF-CMOS, combining digital processing elements and analog radio functionality in a small form factor. It operates from a single supply ranging from 1.5 to 3.6V, which makes it suitable for battery-powered applications. An embedded software-programmable 128-bit vector DSP consumes less than 16 picojoules/cycle. The device also has a line-of-sight range of greater than 60m and no-line-of-sight range of greater than 20m.**

**—Susan Nordyk**

▶**BlinkSight,** www.blinksight.com

▶**Imec,** www.imec.be

BlinkSight has released the first single-chip "indoor GPS" solution for RTLS and wireless sensor network applications.

# Econais rolls out Wi-Fi audio-streaming reference design

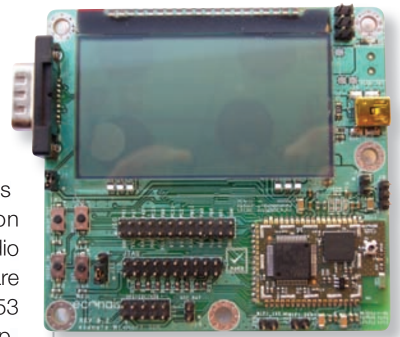
Based on the company's WiSmart EC32S13 Wi-Fi module, Econais now offers the WisAudio reference design for streaming raw uncompressed (WAV) and compressed (MP3, FLAC, AAC) audio over Wi-Fi. In addition, DLNA 1.5 support makes it compatible with DLNA-capable smartphones, smart TVs, game consoles, and PCs.

WisAudio performs on-the-fly audio decoding, which requires less bandwidth than the conventional WAV approach, while retaining the ability to play WAV audio. Econais reports that the reference design delivers high sound quality for WAV and FLAC streams, yet consumes minimal power when using encoded audio. The design is compact and can fit into a headset or speaker.

The reference design's onboard EC32S13 module with embedded MCU runs the TCP/IP stack, as well as the authentication and security protocols. Audio decoding and processing are performed by a VLSI VS1053 audio codec to natively support WAV, OGG, MP3, AAC, WMA, FLAC, and MIDI formats with on-the-fly audio decoding. The evaluation board also includes an embedded chip antenna with a range of up to 400m in open space. Optionally, an external antenna can be mounted on the board.

View a demo video at http://bit.ly/17KiHca to learn more about the WisAudio reference design. **—by Susan Nordyk**

▷**Econais**, www.econais.com



The WisAudio reference design from Econais allows users to stream raw compressed and uncompressed audio over Wi-Fi.

# Microcontrollers with ultralow power and USB target emerging mobile healthcare, smart homes, and the Internet of Things



**Renesas Electronics has introduced the first in its RX100 Series of ultralow-power, 32-bit microcontrollers. The RX111 Group is produced on an ultralow-power zero-wait-state flash process supporting market-leading 32-bit power-consumption/performance levels as well as fast wake-up. It has a wide range of standard peripherals and multiple safety functions, as well as an integrated USB 2.0 peripheral supporting host, device, and on-the-go (OTG) functionality.**

**This new device group brings the ultralow-power features of the Renesas 8/16-bit RL78 MCU Series to the 32-bit RX product lineup, offering a greater range of device scalability and functionality. The RX111 devices are designed to support a broad range of low-end 32-bit embedded applications, including mobile healthcare, smart meters, sensors/detectors, and industrial and building automation.**

**The company's True Low-Power capability offers designers the lowest possible power consumption across a range of temperatures and voltages, including all peripherals and flash memory, while also providing maximum flexibility with multiple operational and sleep modes. This setup allows for the lowest possible power consumption for the user's application environment.**

**The new RX111 devices feature 32-MHz operating speeds and 1.56 Dhrystone MIPS (DMIPS)/MHz throughput, with power consumption as low as 64 µA/DMIPS. The MCUs also achieve 3.08 CoreMark/MHz and 14.9 CoreMark/mA.**

**The new devices support multiple communications peripherals, including USB 2.0 host/function and battery charging, OTG, $I^2C$, and SPI protocols. Analog functions include a 12-bit ADC with internal voltage reference, an 8-bit DAC, and a temperature sensor.**

**The Renesas Starter Kit (RSK) provides sample drivers (mass storage class, communication class, and HID class), applications of high-speed charging by USB, and various middleware alongside the evaluation board and development environment required for MCU evaluation and first installation.**

**The RX111 Group of MCUs is software compatible with the RX600 and RX200 Series, providing greater flexibility and an easy migration path to higher-performance MCUs. The RX111 MCUs are available in low pin counts ranging from 36 to 64 pins and 16 kbytes to 128 kbytes of embedded flash memory. As part of the RX family, the new MCUs also feature a compatible instruction set, hardware and software tool set, peripherals, and hardware safety features to comply with several safety standards.**

**Renesas provides a comprehensive development ecosystem for the RX series, including an Eclipse-based IDE, as well as compilers, debugger emulators, code generation, and flash programmers. The RX111 devices are supported by IAR Systems' EWRX tool chain compiler and IDE. IAR Systems will provide the 64-kbyte free version of its EWRX tools to support all RX devices, including the new RX111 MCUs.**

**Samples of the RX111 devices are expected to be available in July. Mass production is scheduled to begin in September.**

**—by Nick Flaherty**

▶Renesas Electronics Corp, am.renesas.com

# Analog Devices, MathWorks offer engineering students low-cost learning platform

Analog Devices has introduced a low-cost hardware-software solution focusing on circuit testing and designed for the engineering education market. The solution combines MathWorks' MATLAB software and Analog Devices' Digilent Analog Discovery design kits, enabling students to experiment quickly and easily with advanced technologies and build, test, and analyze real-world, functional analog design circuits anytime, anywhere, for the price of a textbook.

"The combination of MATLAB and the Analog Devices Digilent design kits provides a very flexible, powerful learning solution," says Kathleen Meehan, associate professor in the Bradley Department of Electrical and Computer Engineering at Virginia Tech (Blacksburg, VA). "I don't need to maintain a traditional large lab for my engineering students. Instead, students complete experiments after class, where and when they want, with the analog design kit and analyze the data and write lab reports with MATLAB."

MATLAB and the Data Acquisition Toolbox Support Package for Analog Discovery hardware allow students to acquire signals directly from the Analog Discovery as well as filter and analyze data. This integration allows students to develop a deeper understanding of the circuits they are building and reinforces MATLAB skills they are already learning in other classes.

Each Analog Discovery is the size of a deck of cards and features two oscilloscopes, two waveform generators, two power supplies, and a logic analyzer. The Analog Discovery is manufactured by Digilent Inc and powered by Analog Devices components. The Analog Discovery design kit costs $99. Students can access MATLAB by purchasing a MATLAB Student Version license or through a site license that may be available from their university. **—by Paul Buckley**

▷**Analog Devices**, www.analog.com
▷**MathWorks**, www.mathworks.com
▷**Digilent Inc**, www.digilentinc.com


The Digilent Analog Discovery design kit, developed in conjunction with Analog Devices, is designed to enable engineering students to quickly and easily experiment with advanced technologies and build and test real-world, functional analog design circuits right on their PCs.

# Make an IMPACT

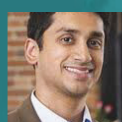
A whole new way of doing business is emerging – one where businesses of all sizes can make a difference and have an impact. Business4Better (B4B) Conference and Nonprofit Expo will bring together midsized business, large corporations, and nonprofits to truly define mutually beneficial partnerships and the impact they can have on societal causes.

Explore the benefits of business-integrated social responsibility programs and powerful partnerships. Join leading companies, innovative nonprofits, and individuals inspired to take action and transform business impact on social change.



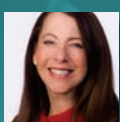

## Check out the lineup of speakers:

**Neil Bush**
Chairman
Points of Light



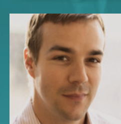
**Premal Shah**
President
Kiva

**Chris Jarvis**
Co-Founder & Partner
Realized Worth



**Carol Cone**
Global Practice Chair
Edelman Business +
Social Purpose

**Jeff Hoffman**
President
Jeff Hoffman & Associates



**Chad Bolick**
Associate Director of
Partnerships
FSG

**Dev Patnaik**
CEO
Jump Associates & Author
"Wired to Care"

**Bea Boccalandro**
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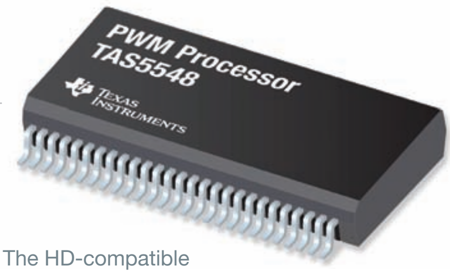
# TI introduces first eight-channel PWM audio processor with dual asynchronous SRCs




The HD-compatible TAS5548 from TI allows home and pro audio designers to seamlessly mix two audio sources, providing design flexibility and cost savings compared with competitive solutions that require two chips.

Texas Instruments has introduced the industry's first eight-channel PWM audio processor with dual asynchronous sample-rate converters (SRCs) integrated on a single chip. The HD-compatible TAS5548 allows home and pro audio designers to seamlessly mix two audio sources, providing design flexibility and cost savings compared with competitive solutions that require two chips. It accepts sample rates from 8 to 192 kHz and converts them to a fixed rate of 96 or 192 kHz, eliminating the need to create, store, and change coefficients. This simplifies the design of digital multichannel products, such as Blu-ray home-theater-in-a-box (HTiB), A/V receivers, mini/micro combos, and soundbars.

The TAS5548's 40-kHz audio bandwidth is compatible with Dolby True HD and DTS-HD. Designers can optimize their products with rich audio processing capabilities, such as seven-band parametric equalization, bass and treble tone control, volume and loudness control, dynamic range compression, and input and output mixing.

Two integrated four-channel ASRC cores allow audio system designers to switch sample rates without changing coefficients, while native processing at 96 kHz for eight-channel output enables ultralow out-of-band noise and jitter suppression. An extra microphone and $I^2S$ input combines with the ASRC's ability to mix two different sample-rate sources. This feature provides the flexibility to mix a microphone with up to eight karaoke tracks.

An integrated smart energy manager also delivers more efficient operation. The manager can limit the audio system's peak power by interrupting the host processor if the power threshold is reached. For high-end audio systems, a power-supply volume control enables energy-efficient high-power performance.

The TAS5548EVM evaluation module can be purchased today for a suggested retail price of $99. This evaluation module is provided with the easy-to-use ControlConsole graphical development suite to simplify the evaluation, configuration, and debug of audio products. The ControlConsole's GUI enables quick evaluation of all TAS5548 functions, including DRC, programmable EQ, and energy management.

The TAS5548 is available now in a 56-pin TSSOP package for a suggested retail price of $3.68 in 1,000-unit quantities.

**—by Nick Flaherty**

▷**Texas Instruments**, www.ti.com

BY HOWARD JOHNSON, PhD

# Why reflections happen

Throw a rubber ball hard against a concrete wall. The ball bounces. You have just experienced a reflection. Reflections happen in propagating systems at those points where the conditions of propagation change.

The best way to understand reflections is to track the movement of energy. When the ball reaches the wall, it cannot continue on its original course. Neither can the ball simply stop, because the energy associated with its incoming path cannot just disappear; it must go somewhere.

Nature solves this problem by dividing the incoming energy among the available outgoing modes of propagation. Those modes include the ball's retreating along its incoming direction, an acoustic wave (bonk!) generated in the air, a slight movement of the concrete wall, and a residual thermal agitation of both rubber and concrete.

The proportions of energy contained in each outgoing mode are determined by the law of conservation of momentum in combination with the various properties, called boundary conditions, of each individual outgoing mode. The reflecting-ball problem is tricky, because the ball can arrive at any incident angle, it can carry spin, and there are multiple avenues for energy dissipation.

A transmission line supports only two modes of operation: A signal either goes straight down the line in one direction or comes back in the other. That's it. In a typical digital application, no other modes of operation are possible. When a traveling wave encounters a load at the end of a transmission structure, only three entities are involved: the incoming power, the fraction of that power that is dissipated in the load, and the remaining power, all of which reflects back toward the source.

The solution to the problem of allocating power among those three modes is the highly vaunted "reflection coefficient" formula, which is used to predict the size of a reflected signal:

$$\frac{V_R}{V_I}=\frac{Z_L-Z_C}{Z_L+Z_C}.$$

The reflection formula expresses the ratio of reflected voltage to incident voltage, as observed at the end of a transmission line, computed as a function of the load impedance at the end, $Z_L$, and the characteristic impedance of the transmission line, $Z_C$.

If the end of a transmission structure is left open-circuited, making an infinite load impedance, that load draws no current and therefore dissipates zero power. In that case, 100% of the incident power reflects, creating a reflected signal just as large as the incident waveform. If you imagine electrical current as being loosely analogous to physical velocity in the rubber-ball example, the concrete wall did the same thing. When struck, the wall hardly moved, absorbing very little energy, and thereby reflecting almost perfectly.

If you reduce the endpoint load impedance to successively lower values, the load begins to draw more current, dissipating more power and creating a progressively weaker reflected signal. In the physical world, you can test that idea by throwing your ball at three things: a wooden fence, a wall of hay bales, and a wet sheet hanging out to dry. When the mechanical impedance of the wall best matches the physical properties of the ball, the ball reflects least strongly.

Electrically, a load impedance that completely absorbs all incoming power creates zero reflection. That is the ideal arrangement for an end terminator. That particular impedance, if you can find it, is defined as the characteristic impedance of the transmission structure. There is no other definition. All formulas for characteristic impedance are merely approximations of this ultimate meaning. EDN

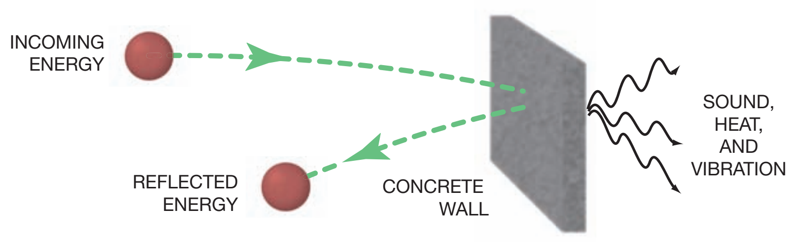
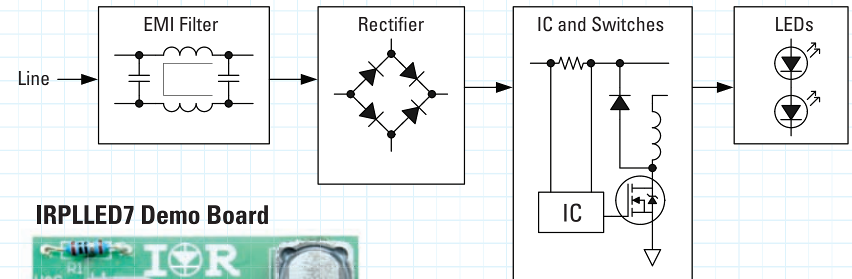


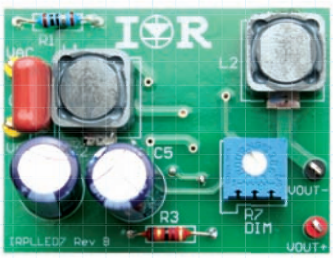

Figure 1 The wall converts a portion of the incoming energy into sound, heat, and vibration.

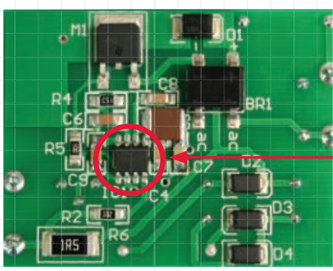
*Howard Johnson, PhD, of Signal Consulting, frequently conducts technical workshops for digital engineers at Oxford University and other sites worldwide. Visit his Web site at www.sigcon.com, or e-mail him at howie03@sigcon.com.*


# High-Voltage Buck Control ICs for Constant LED Current Regulation



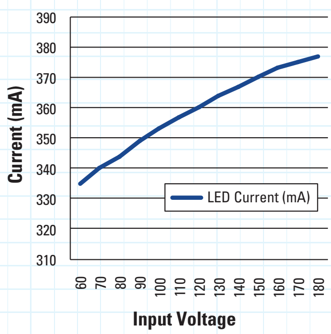

### IRPLLED7 Demo Board





LEDrivIR™
IRS2980

### IRPLLED7 Demo Board LED Current vs Input Voltage




### IRS2980 Features

- Internal high voltage regulator
- Hysteretic current control
- High side current sensing
- PWM dimming with analog or PWM control input
- Free running frequency with maximum limiting (150kHz)

### IRS2980 Benefits

- Low component count
- Off-line operation
- Very simple design
- Inherent stability
- Inherent short circuit protection

### Demo Board Specifications

- Input Voltage 70V to 250V (AC)
- Output Voltage 0V to 50V (DC)
- Regulated Output Current: 350mA
- Power Factor > 0.9
- Low component count
- Dimmable 0 to 100%
- Non-isolated Buck regulator

| Part Number | Package | Voltage | Gate Drive Current | Startup Current | Frequency |
|---|---|---|---|---|---|
| IRS2980S | SO-8 | 450V | +180 / -260 mA | <250 µA | <150 kHz |
| IRS25401S | SO-8 | 200V | +500 / -700 mA | <500 µA | <500 kHz |
| IRS25411S | SO-8 | 600V | +500 / -700 mA | <500 µA | <500 kHz |

WANT MORE?

Read more of the WD NAS-drive Teardown at www.edn.com/4412821.

Go to www.edn.com/learning/teardowns for more Teardowns.

# Disposable 1-Tbyte NAS drives: How'd that happen?

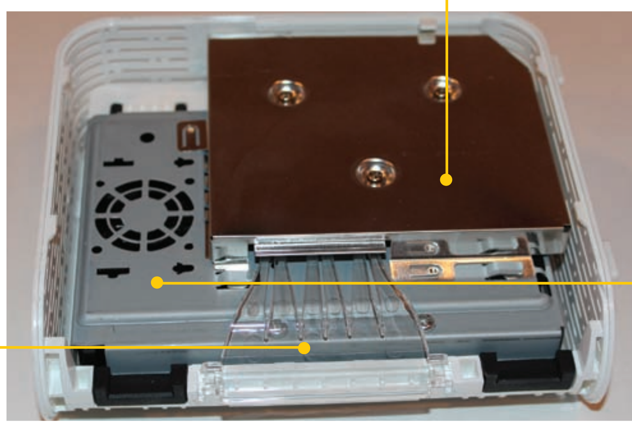
Here's a tip: Don't start cleaning the area around your external network-attached storage (NAS) drive when it's backing up. Odds are that you're going to smack it. I did, and so a perfectly functioning 1-Tbyte drive, with my whole life stored on it, almost became a perfectly functioning doorstop.

The NAS drive in question is a 1-Tbyte Western Digital My Book World Edition, which I used for backing up multiple computers and for music streaming using a Sonos audio network via the shared router. While the device itself was dead, it was not a problem to recover the data from my other external hard drive and back it up to the shiny new 3-Tbyte drive.

I realized when holding the drive just how nuts it was that a little over 20 years ago I was excited by a 40-Mbyte hard drive, and now here I was holding a 1-Tbyte drive that I just replaced with a 3-Tbyte drive for a scant $170. How did that happen? And why do we take it so much for granted? I had to go inside.

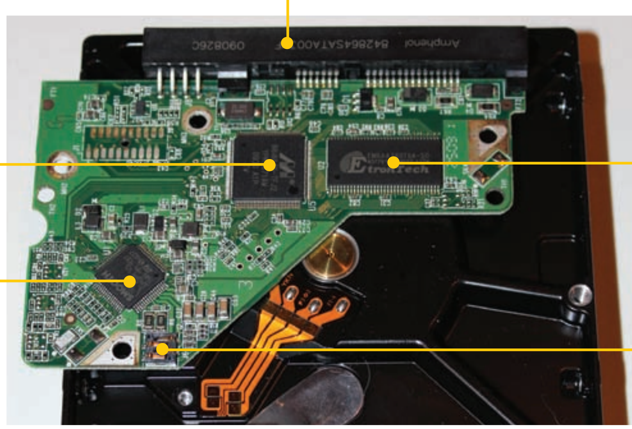
The main controller board enclosure houses the I/O, power, reset, and control electronics.

Taking the cover off exposed the plastic light pipe that was the source of that rather cool, Kit-like (Any Knight Rider fans out there?) up-down light movement on the front of the drive. It channeled the light from a bank of six LEDs housed on the main control board. Oddly, I think it was the first time I'd uncovered a light pipe in situ.



The control board itself was encased in metal shielding and attached to the hard drive via a right-angle edge connector. The entire drive was coupled to the main chassis using four rubber "shock absorbing" holders, which I wish had done a better job of, well, absorbing shock.

Amphenol 842864SATA003HF 90-degree connecter to main WD NAS control and interface board

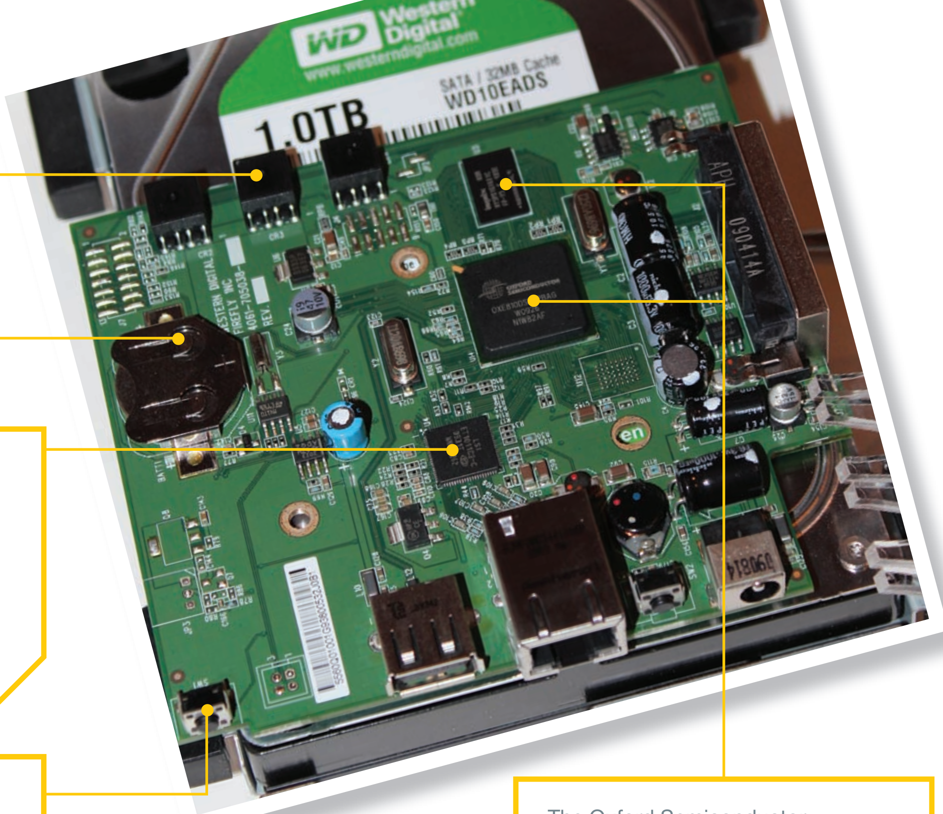


Marvell 88i8846 system-control processor

Etron Tech EM6AA160TSA-5G, 256 Mbits of DDR SDRAM

STMicroelectronics SMOOTH L7251 3.1 motor control and driver IC

Four-pin interface to hard-drive platter motor; beats ribbon cable, but requires tight, well-defined placement




Three banks of plastic housings contain two LEDs each, with light guided to the front of the drive.

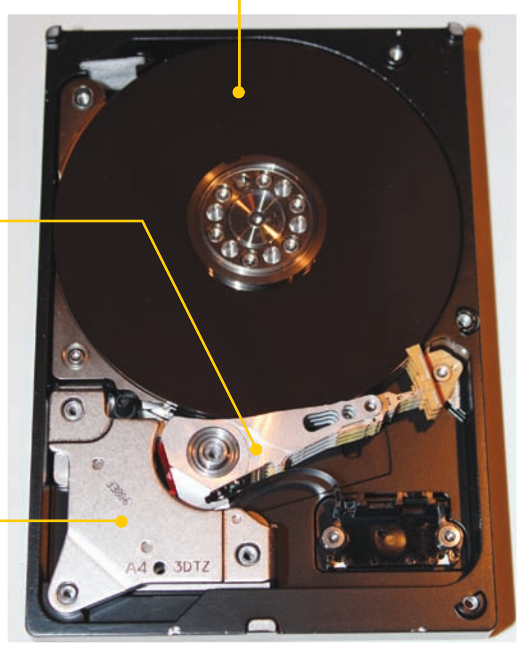
Battery backup

The LSI TruePHY ET1011C2-C Gigabit Ethernet transceiver debuted in 2008. It's built on 0.13-μm technology and is fully compliant with IEEE 802.3, 802.3u, and 802.3ab standards. Its main claim to fame is its use of an oversampling architecture to improve equalization.

Power-on button on rear, followed down the back by USB, Ethernet, reset, and power in

The Oxford Semiconductor OXE810DSE (now the PLX810, since PLX Tech acquired Oxford) is a Gigabit Ethernet to dual SATA controller. It is the main interface IC, with 802.11 support via Mini PCI. It has since been discontinued and replaced by the NAS 7821. Brian Dipert spent some time on the PLX chip in his teardown of an older WD NAS drive back in 2010 (www.edn.com/4312333). Also shown: 1 Gbyte of DDR2 memory (Hynix HY5PS1G1631C)

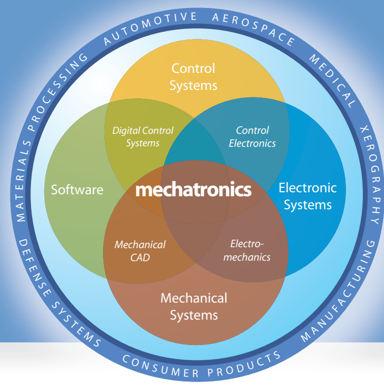
Three storage platters (These, and the read heads, have come a long way in the past 20 years. For more on modern storage techniques, including giant magnetoresistance all the way up to spintronics and quantum bits, take a look at this summary: http://bit.ly/Zg7yiW.)



Read-head armature in rest position (The armature is driven by the voice coil actuator on the left, housed between nickel-plated neodymium magnets, the most powerful permanent magnets available today.)

Coil and neodymium magnet housing (Coil is held between an upper and lower magnet with a four-wire interface to/from the SMOOTH L7251 to control read/write head position and acquire data.)

Over the years, fundamental research into electromagnets, quantum principles, materials, channel equalization, and motor-control and -positioning algorithms has been embodied within these drives. It's more than can even be touched on in a short teardown piece, yet we can take these drives so much for granted. As always, I'll be holding onto the parts, much like I do a good book. So much thought, research, and ingenuity have gone into realizing the product that throwing it out is actually hard to do, though I can only hoard so much until my wife gives me "that look."




# Frequency response: the gold standard

Engineers predict real-world response and identify model parameters.

*By Kevin C Craig, PhD*

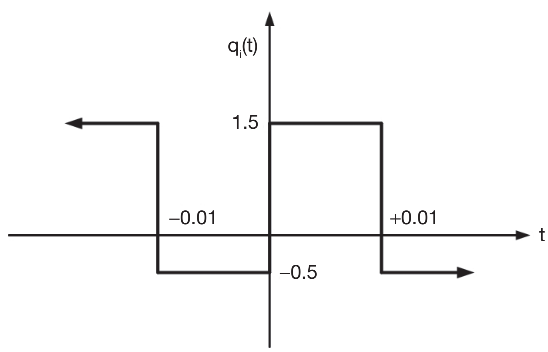
What do engineers "see" when they look at a real system or conceive a new design? They will look past the hardware and visualize the flow of energy, where it is stored, and where it is dissipated. They will identify the kinetic energy of moving fluids and solid masses; the potential energy of compressible fluids, elastic hoses and tanks, and deformable solids; the energy stored in electric and magnetic fields; and the energy lost through friction generating heat. But they will also "see" how the system might respond to real-world inputs by understanding the frequency response of the system and the frequency spectrum of the probable inputs.

A real system often can be modeled, over some range of motion and time duration, as stable, linear, and time invariant. If the input to this system is a sine wave, the steady-state output (after the transients have died out) is also a sine wave with the same frequency, but with an amplitude and phase angle that are both frequency dependent. Plots of the input-output amplitude ratio versus frequency and the phase angle versus frequency are called Bode plots.

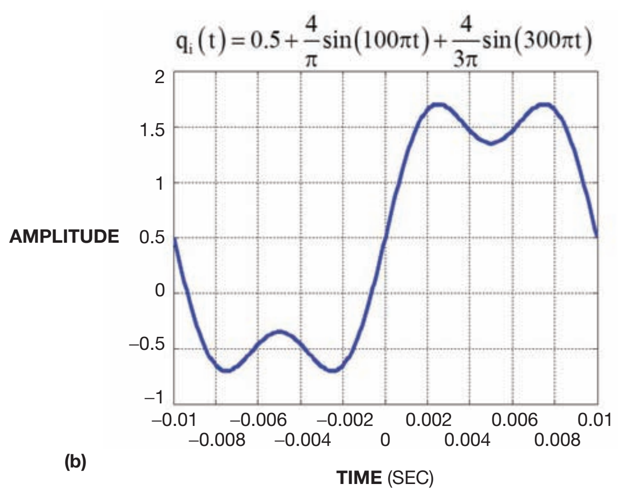
If the system being excited were nonlinear or time varying, the output might contain frequencies other than the input frequency, and the amplitude ratio might be dependent on the input magnitude. Any real-world device or process will need to function properly for only a certain range of frequencies; outside this range, we don't care what happens. When one has the frequency-response curves for any system and is given a specific sinusoidal input, it is easy to calculate the sinusoidal output. What is not obvious, but extremely important, is that the frequency-response curves are really a complete description of the system's dynamic behavior and allow one to compute the response for any input, not just sine waves.

Two hundred years ago, Jean Baptiste Fourier showed that any periodic waveform that exists in nature can be generated by adding up sine waves. By picking the amplitudes, frequencies, and phases of these sine waves, one can generate a waveform identical to the desired signal. A periodic function, $q_i(t)$, can be represented by an infinite series of terms called a Fourier series. **Figure 1** shows a square wave and a plot of the first few terms of the Fourier series. The more terms used in the series, the better the fit.

Using the principle of superposition for linear systems, we can combine the frequency spectrum of a real-world signal with the system's frequency response and calculate the time response. A dynamic signal analyzer is the device used to experimentally determine a system's frequency response. Many excellent application notes on its use are available. EDN




(a)




(b)

Figure 1 A periodic function, $q_i(t)$, can be represented by an infinite series of terms called a Fourier series; shown are a square wave (a) and a plot of the first few terms of the Fourier series (b).

# DESIGN FOR MANUFACTURING & YIELD

**WITHOUT INCREASINGLY SOPHISTICATED SOFTWARE, MANUFACTURING AT 28 NM HAS BECOME HIGHLY PROBLEMATIC AND YIELDS UNECONOMICALLY LOW. WHAT CAN BE DONE TO ENABLE THIS AND SMALLER NODES TO REACH THE DESIRED YIELDS?**

BRIAN BAILEY • CONTRIBUTING TECHNICAL EDITOR

As designs move to the 28-nm and smaller nodes, the likelihood of a design being manufactured without defects trends toward zero unless a rapidly growing set of rules is adhered to. Those rules are increasing in number and complexity. The absence of extreme ultraviolet light sources means that double patterning has become essential and new devices, such as 3-D transistors, are being adopted. But it does not stop with just manufacturability. Lithographic features affect functionality and performance in such a way that yield has also become a primary concern.

Here we examine the problems and the ways in which increasingly sophisticated software can be used to overcome the limitations of technology. Representatives from five different companies discuss, from their own perspectives, these issues as well as solutions.

IMAGE: SHUTTERSTOCK

## WHY HAS IT BECOME SUCH AN IMPORTANT TOPIC?

**Shrikrishna Mehetre,** *Director of Engineering, Open-Silicon*

Major contributors to yield loss are:

- Geometric variations during the manufacturing process may result in performance variations that can push the device out of the allowed 3-Sigma variation, causing parametric yield loss.
- Specific patterns on the die may not get manufactured as desired because of diffractions that happen during the lithography process, causing catastrophic failures on the dies.
- Random defects may induce shorts or opens on the wafer, resulting in yield loss.
- The wafer goes through chemical mechanical pol-

ishing (CMP) after every interconnect and dielectric layer is deposited. Metal-density variations result in the thickness variations during the CMP process, which can accumulate errors and alter interconnect parasitics, causing yield loss.

Engineers can take precautions during the design process that would help reduce these effects. Logic designers can add either redundant logic or memory cells. These can be used to repair faults, which will increase yield even though the die is partly defective. There are tools and techniques used in the diagnosis of failures seen on silicon to ascertain the cause of the failures. This information can be used to correct layouts to improve the yield.

Additional steps are required in the physical and logic design flow. Logic designers can add additional test or diagnosis logic and implement redundancy for sensitive circuits, such as memory bit cells. Physical design engineers can ensure planarity of metals, litho-friendly design, redundant vias, and wire spreading to reduce failures on the die. Parametric yield loss can be addressed by using additional on-chip variation guard banding.

As the steps are added to the ASIC design flow for DFM/DFY, cost increases. The additional cost comes from the additional time required to plan, execute, and correct for these issues.

### AT A GLANCE

- Identifying a manufacturable design within the bounds of performance, reliability, and cost requirements is becoming ever more challenging.
- Logic designers can add additional test or diagnosis logic and implement redundancy for sensitive circuits.
- At 20 nm, double-patterning technology adds yet another dimension to the impact of silicon printability and connectivity.
- To derive the underlying root causes, you need to apply machine learning and design statistics.

There are additional EDA tools necessary to perform logical and physical checks for the design. It is important to see the ROI of such investments for a product. If the cost advantage from the increased yield is not significant compared with the investment done to achieve better yield, it is not worth spending those additional efforts. If 5% yield improvement can be obtained on a 28-nm design by implementing such DFM techniques, the investment may be worthwhile.

Another approach that can be considered is to do partial fixes. Addressing effects that affect yield the most, such as memory redundancy, redundant vias, litho-friendly routing, and pattern corrections, may have a greater impact compared with other DFM solutions. Designers can choose to selectively fix

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To comment on this article, go to www.edn.com/4412868.

the DFM issues that provide the highest gains.

## THE ROLE OF PACKAGE MODELING IN DFM OF ELECTRONIC DEVICES

**Siva P Gurrum and Manu Prakuzhy,** *Design for Manufacturing, Semiconductor Packaging, Texas Instruments*

Semiconductor packaging is evolving from an enabling role to a differentiator in today's electronic devices. Identifying a manufacturable design within the bounds of performance, reliability, and cost requirements is becoming ever more challenging. Advances in package modeling are providing means to predict a multitude of parameters related to performance, reliability, and cost.

Predictions from package modeling can be broadly categorized into performance and reliability. The cost of a packaging solution is typically derived from the design specification and manufacturing process flow. Performance parameters include thermal, such as thermal resistance values, and electrical, such as parasitics. In reliability, predictions typically cover risks and trends for the identified fail modes in a package family or package lifetime based on some of the fail modes. Predictions of both performance and reliability require correlations between model values and physical evaluations (**Figure 1**).

Modeling correlations are typically empirical relations between output parameters resulting from a model and physical parameters. Examples include: (a) the relationship between a model evaluation of the fatigue damage in solder joint and the physical number of temperature cycles to electrical failure, and (b) the relationship between electrical model prediction for the current density profile in a trace and the electromigration lifetime from physical tests. In some cases, physical parameters are directly predicted by a model, such as the junction-to-air thermal resistance of the package, or bond wire electrical parasitics. In these instances, correlations serve as a validation of the chosen approach for derivative designs.

For good modeling correlation, it is essential to incorporate the best modeling tools and techniques, accurate properties from material characterization, and the wealth of data from physical evaluations. Analysis tools are maturing, with customized tools now available for thermal and electrical, whereas the majority of mechanical tools are more general purpose, with longer cycle times. Material characterization must include bulk properties as well as properties sensitive to the physical structure and assembly of a package, such as the interfacial thermal resistance of a die attach material or the adhesion strength between interfaces. Also important is package characterization to bound manufacturing tolerances on critical parameters. An example is the die attach bond line thickness in a leadframe package, which critically affects delamination risk. Physical evaluations needed to complete a correlation include thermal resistance measurements, electrical testing on evaluation boards, and reliability testing according to standard specifications.

Some examples of design for manufacturing in packaging are:

- Bond wire pattern to eliminate shorts during mold flow for high wire density molded packages
- Lead finger design to minimize

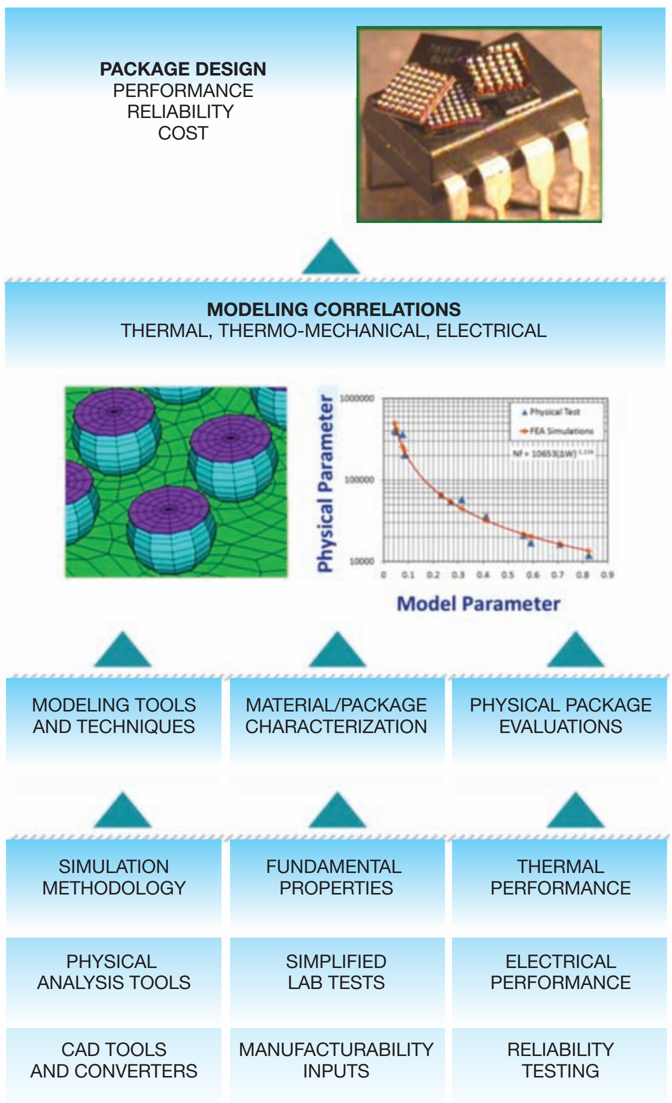


Figure 1 Building blocks of modeling correlations enable package design for manufacturing.

warpage and stress concentration near the bond wire stitch

- Layout of silicon chips on a die pad in a multichip module to minimize delamination stresses
- Thick metal content to reduce wafer warpage, which affects handling in assembly
- Metal content balancing in a substrate to reduce warpage, which affects assembly to PCBs

The role of modeling will grow to influence design, materials, and processes used in packaging.

## DFM AT ADVANCED NODES AND ITS IMPACT ON DESIGN FLOWS: A REALITY CHECK

**Manoj Chacko,** *Product Marketing Director, Custom IC and Sign Off, Cadence Design Systems*

Manufacturing improvements via novel materials, processes, and new technologies aren't keeping up with the market demand for ever-shrinking feature dimensions, increasing performance, and low-power requirements. Software is now, and will remain, the new key enabler, as long as there's a growing gap between design and manufacturing.

At 28 nm, the impact of manufacturing variability on performance, power consumption, and yield has become disproportionately larger and more complex. Software analysis is critical for effectively quantifying and mitigating the impact on both the physical integrity and parametric performance of the designs.

Physical DFM checks are the final step after DRC, especially lithography process check analysis. Litho analysis can be run on blocks, post route in a design flow, and as the final step after DRC. The value of litho checks is clearly evident at the beginning of a process technology ramp-up. At 28 nm, for better predictability of physical and parametric yield, the lithography complexity has moved upstream to parasitic extraction with changes in the multi orders effects range, and in physical verification in the form of recommended DFM rules or litho yield detractor patterns in the design rule manuals (**Figure 2**). At 20 nm, double-patterning technology adds yet another dimension to the impact of silicon printability and connectivity.

The increase in design density and use of third-party IP bring additional challenges associated with CMP-induced metal thickness variation. For example, model-based, rather than rule-based, CMP analysis is key to identifying thickness variations of the complete metal stack set. Also, as more design teams integrate third-party IP, the metal fill thickness variations around the border of the IP are increasing. The IP designer follows the design rules and the density requirements. However, making blocks that are easily integrated into different SoC environments without iterations to address CMP density issues is ineffective.

The impact of layout-dependent effects (LDE) variability on the design is well acknowledged. LDE variability comes primarily from manufacturing challenges, lithography effects, CMP, and stress, which significantly affect device behavior. Varying methods are used to mitigate the LDE issues because of the inability to qualify and quantify variability impact at the specific transistors. LDE cannot be analyzed by considering devices in isolation. A common method is to over-margin the transistors with dummies to minimize the impact of context problems on device performance. Designers need software to help quantify delay and leakage due to LDE, improve their traditional methods, and locally optimize the devices deviating from the specifications (**Figure 3**). Timing and power variability are becoming more significant at each new process node,



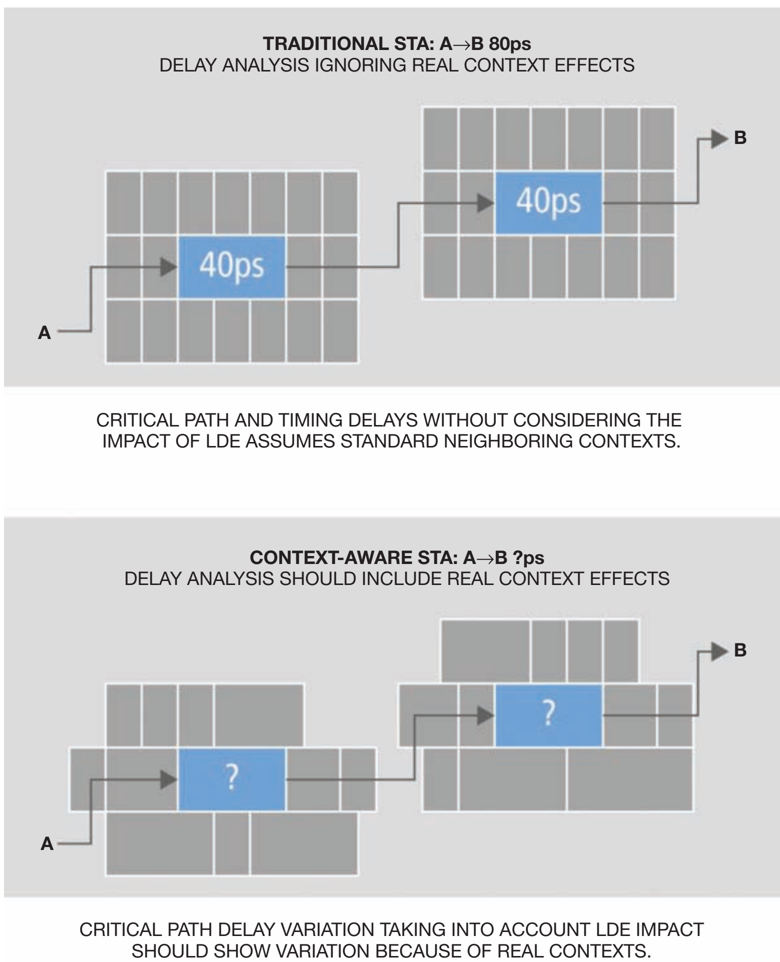


Figure 2 Lithography complexity has moved upstream to parasitic extraction.

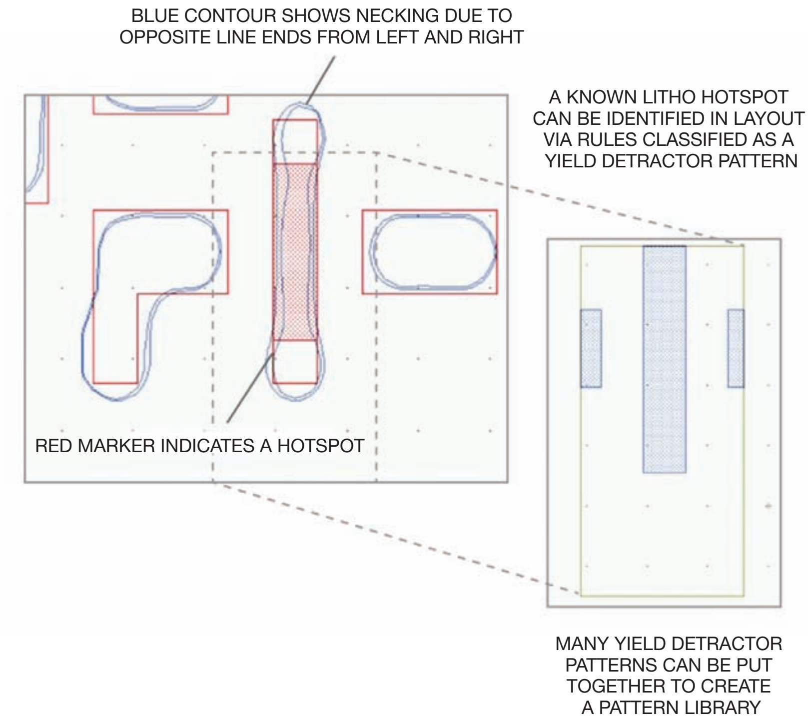


Figure 3 Software helps quantify problems due to LDE and to locally optimize the devices deviating from the specifications.

affecting margins, silicon utilization, silicon failure, and timing closure.

Consequently, advanced-node designers must optimize chip manufacturability along with area, speed, and power. This trend will increase exponentially as technology advances to 14 nm.

## IDENTIFY CRITICAL DESIGN FEATURES USING DIAGNOSIS-DRIVEN YIELD ANALYSIS

**Geir Eide,** *Product Marketing Manager, Silicon Test Solutions Group, Mentor Graphics*

During the transition to the 28-nm node, several leading semiconductor companies struggled with supply: They couldn't ship enough of their products. Part of the problem was lower-than-expected yield. This situation illustrates how traditional yield learning methods are running out of steam, largely because of the dramatic increase in the number and complexity of design-sensitive defects and longer failure analysis cycle times. These factors have forced fabless semiconductor companies to arm themselves with new technologies such as diagnosis-driven yield analysis (DDYA), which can rapidly identify the root cause of yield loss and effectively separate design- and process-oriented yield loss.

Software-based diagnosis of test failures is an established method for localizing defects during failure analysis for digital semiconductor devices. Diagnosis software determines the defect type and location for each failing device based on the design description, scan test patterns, and tester fail data. Using statistical analysis, diagnosis results from a number of failing devices can be used to effectively determine the underlying root causes.

The primary challenge for yield analysis is dealing with the ambiguity in the results. For example, more than one location could explain the defective behavior, and each suspect location often has multiple possible root causes associated with it. To better derive the underlying root causes represented in a population of failing devices from test data alone, you need to apply machine learning and design statistics, such as tested critical area for each layer and total number of gates tested of any given type[1].

Another way to expand the scope of DDYA is to include data from DFM analysis (**Figure 4**). One key motivation behind this approach is to be able to prove that a defect found in failure analysis is a systematic critical feature, and then to learn what about that feature relates to the defect's rate of occurrence. Without a DDYA methodology that can automatically incorporate DFM information, you would need a team of experts and a lot of experimentation to accomplish this. However, by first identifying all locations in a design with a suspected feature through DFM analysis, any diagnosis results (that is, actual silicon defects) that overlap these locations can easily be identified and analyzed to determine whether this correlation also presents causation. A second motivation behind this approach is to determine whether a potential design fix could cure the problem. By identifying design locations that contain the planned fix, a similar correlation can be performed before actually implementing the fix, and the failure rates can be combined[2].

Diagnosis-driven yield analysis appears particularly promising for the 20- and 16-nm nodes in spite of the inherent limitations of immersion lithography.

## SPICE SIMULATION CHALLENGES FOR DFY APPLICATIONS

**Dr Bruce W McGaughy,**
*Chief Technology Officer and Senior Vice President of Engineering, ProPlus Design Solutions*

Process variations, especially local random variations, are making DFY a must-have methodology for sub-65-nm design. A DFY methodology comprises three critical components: statistical transistor model extraction, yield prediction and analysis, and a powerful statistical simulation engine. An integrated solution with all three components provides added efficiency and consistency.

The heart and soul of DFY is the simulation engine. Until recently, most simulators have not been well suited as

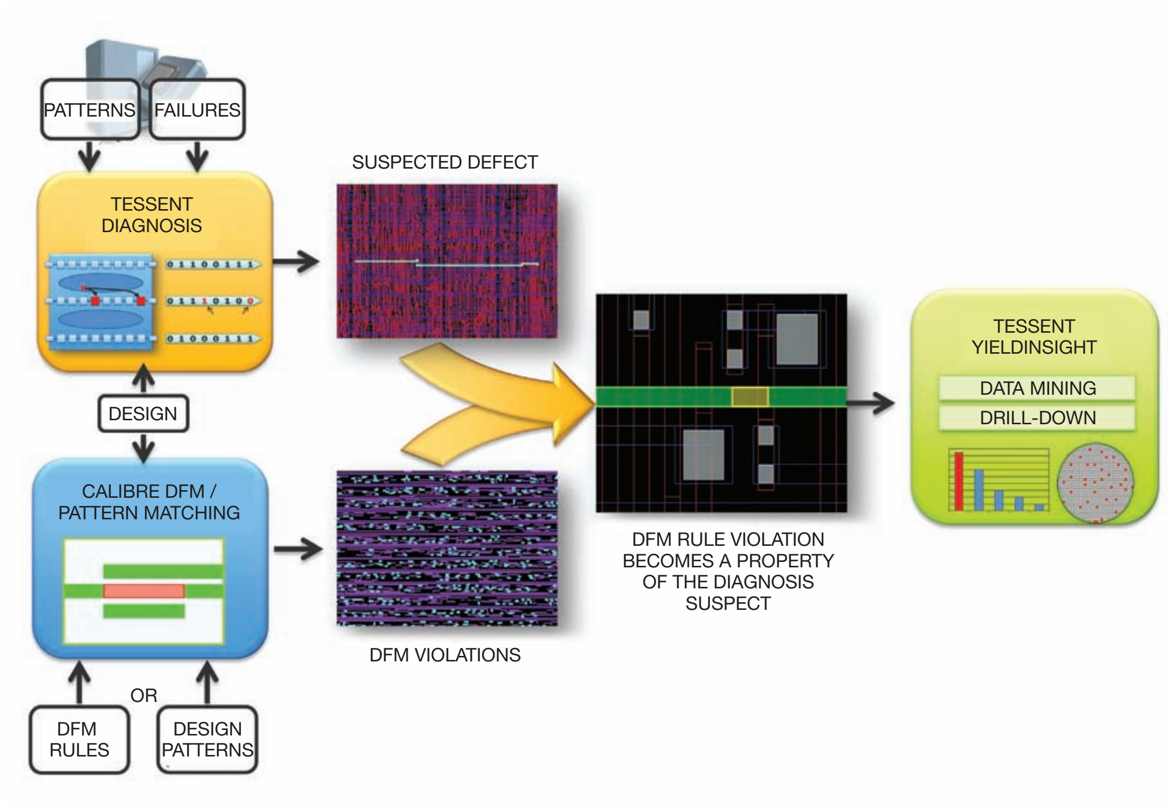


Figure 4 DFM analysis meets diagnosis-driven yield analysis in new methodologies and software tools such as these from Mentor Graphics.

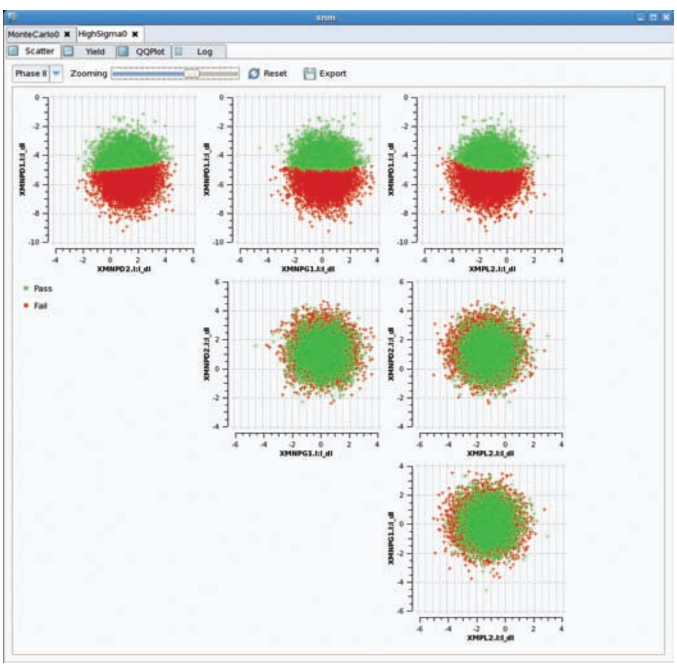


Figure 5 DFY analysis places tremendous computational demands on the simulator.

the core engine of a DFY solution. First, it needs to be built from the ground up with specially designed data structures and algorithms for statistical analysis and simulation. Second, the simulator needs to have tight integration into a yield-prediction tool with the ability to massively parallelize simulations on server farms. Third, the simulator needs to have full compatibility with foundry model libraries and consistency with the extraction process from silicon measurement.

Given the tremendous computational demands of DFY analysis (**Figure 5**), the simulator needs to have high accuracy, capacity, and performance.

Designers have had to choose between two types of circuit simulators. Either they can choose high accuracy and good usability available in SPICE simulators, but sacrifice performance and capacity, or designers can choose FastSPICE with high performance and capacity but with poor accuracy and usability. Neither is suitable as a DFY simulation engine.

FastSPICE simulators employ aggressive partitioning, event-driven multirate schemes, transistor table models, hierarchical array reduction, and the like. All of these techniques are "tuned" for typical circuit types and operating conditions and, in most cases, require further "tuning" with special options by the designer.

With yield prediction, designers track circuit behavior at the margins of the design and process space where built-in tuning may not apply, leading to accuracy problems. Furthermore, the designer cannot manually tune the options for marginal operating conditions during statistical simulation. Finally, techniques such as table models and hierarchical array reduction will not work when every transistor in the circuit has a different variation.

The ideal solution would be to extend the capabilities of SPICE to cover the performance and capacity provided with FastSPICE. Parallel SPICE simulators have taken over some of the space covered by FastSPICE with 10× or more speedup over traditional SPICE.

Advancement for giga-scale simulators is coming from highly optimized data structures and core algorithms built for high-performance parallelization and capacity. Giga-scale SPICE is the principle behind ProPlus's NanoSpice, the simulation engine of its DFY solution built around NanoYield, yield prediction and improvement, and BSIMProPlus, statistical model extraction. EDN

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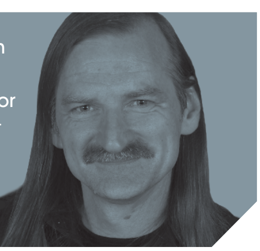


# ACE AWARDS

BY *EDN* STAFF

It's hard to believe it's been a whole year, but here we are: Welcome to the *EDN/EE Times* Annual Creativity in Electronics (ACE) Awards, our yearly homage to those who have most inspired all of us in the engineering community through their engineering prowess, leadership, innovation, and, of course, creativity.

By the time you read this, the awards will have been given out with much ceremony at a special event during DESIGN West, held April 22 to 25 in San Jose, CA. The winners will have celebrated, wiped off the confetti, popped their balloons, and, by now, gone quietly back to doing what they do so well: creating the next generation of technological innovations, or inspiring the next generation of engineers. Please allow us one last shout-out to the people who keep us all up at night, wondering how we ourselves can do better.

On the following pages, you'll read about why Kathryn Kranen, president and CEO of Jasper Design Automation, received the Lifetime Achievement Award; why Steve Hageman is our second Jim Williams Memorial Contributor of the Year Award winner; why a certain team at Maxim was named Design Team of the Year; and why TI's Yogesh Ramadass is Innovator of the Year. Those are some of this year's highlights, so read on to see the products, companies, and executives who stood out in 2012, and join us in congratulating them online at www.edn.com/4412659, where you can add your own thoughts and even possible suggestions for next year; it's coming fast!

## LIFETIME ACHIEVEMENT AWARD: KATHRYN KRANEN

**Brian Bailey,** *Contributing Technical Editor*

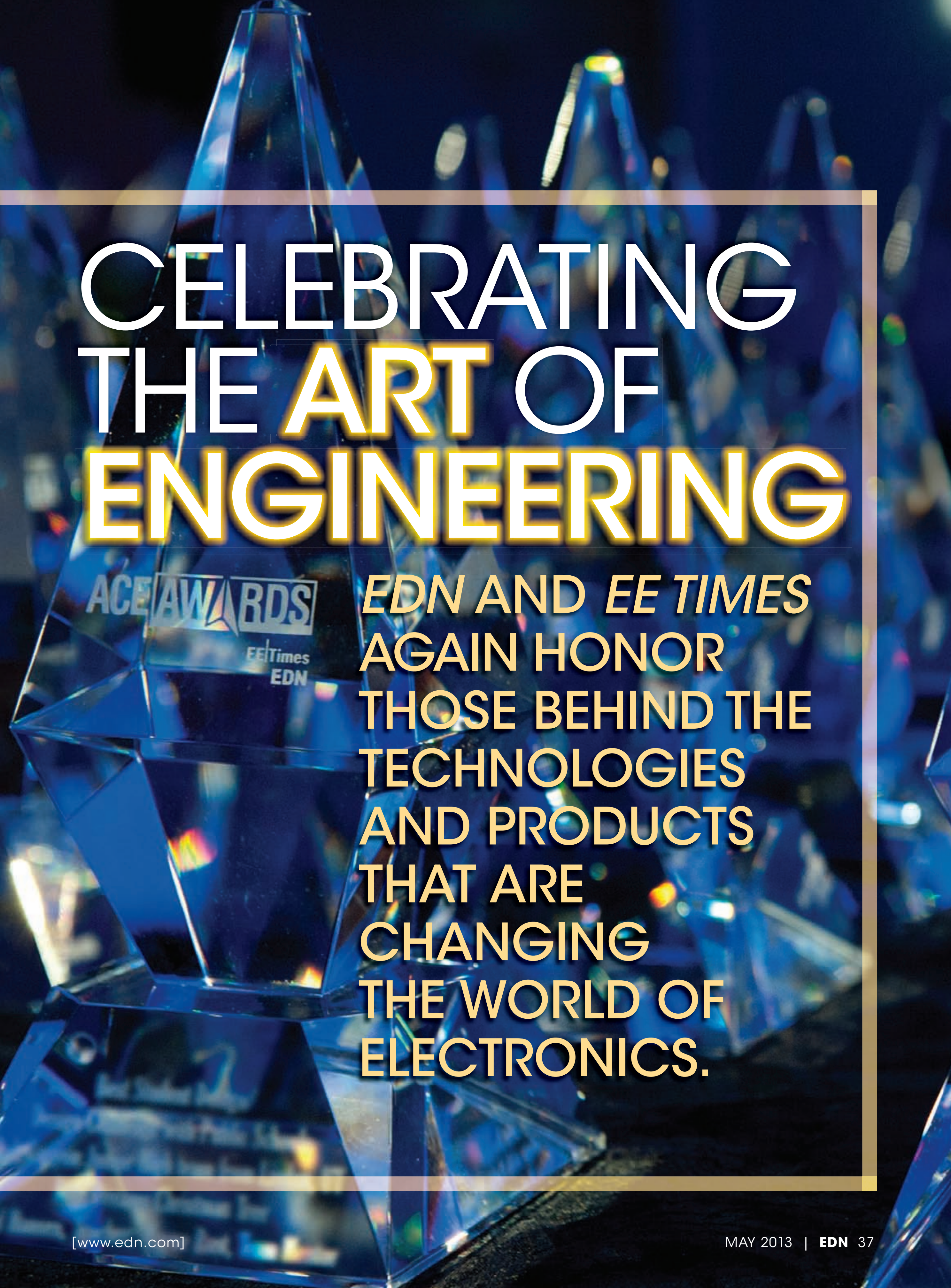
They say that the EDA industry gets no respect, but UBM Tech has just changed that by awarding an EDA veteran with the 2013 ACE Lifetime Achievement Award. The award is meant to honor the people and companies behind the technologies and products that are changing the world of electronics. That is a common theme when you look at past recipients, which include Gordon Moore, Wilf Corrigan, and Morris Chang. Kathryn Kranen has changed the industry not just once, but twice over. She has led two start-ups to success, and in each case she has transformed an emerging technology into a mainstream one. She first succeeded in doing that with Verisity Design Inc, an early verification automation company, and quickly grew it from being an interesting idea to the primary verification strategy in use by top semiconductor companies. Kranen has done that again at Jasper Design Automation by turning formal verification from a technology that

Kathryn Kranen has changed the EDA industry not once but twice.

AWARD IMAGE: TRISH TUNNEY

# CELEBRATING THE ART OF ENGINEERING

## *EDN* AND *EE TIMES* AGAIN HONOR THOSE BEHIND THE TECHNOLOGIES AND PRODUCTS THAT ARE CHANGING THE WORLD OF ELECTRONICS.



required a PhD to understand into something available to the masses.

There are many adjectives that come to mind when thinking about Kranen, but perhaps the ones that most people would think of are focused, determined, and energetic. She has never been scared to be a lone voice. While most people in the industry would advise entrepreneurs to stay lean and build technology rather than a channel, Kranen told me in a recent interview that "to tackle big problems, and get big revenue, you have to spend to succeed." She conceded that if you aren't going to win big, you had better not raise too much money, but for Kranen, "there are those of us that passionately want to conquer something harder." She will use techniques scorned by others. She understands both technology and business issues, and she ensures that the company and customer are both successful when entering into an agreement. She does not see it as a sale, but as a partnership.

You would think that would keep her busy, but Kranen has almost limitless energy and drive. She has been very active in the advancement of women in the industry and was awarded the Marie R Pistilli Women in EDA Achievement Award in 2005. She is chairman of the board of directors of the EDA Consortium (EDAC), an EDA vendor trade group that promotes the health of the EDA industry.

While others in the industry like to complain about the state of the business, Kranen has always remained forthright in her belief that "every company needs to use its assets to compete the best it can. A company has to figure out how to differentiate and be relevant." This is something that she has managed to do consistently. Kranen's advice for entrepreneurs: "Start-ups must make sure that what they're doing is relevant, differentiated, and that they have a credible plan for success."

## JIM WILLIAMS MEMORIAL CONTRIBUTOR OF THE YEAR: STEVE HAGEMAN

**Suzanne Deffree,** *Executive Editor, Community*

Good Karma. Pay it forward. Passing on the gift. Insert your favorite good-will description here, and it will describe this year's Jim Williams Memorial Contributor of the Year Award winner, Steve Hageman.

Hageman, as can be common, wandered into engineering as a child. "It all started about the fifth grade for some reason, like a lot of engineers my age," he says. "Something about the magic of pulling radio waves out of the air. I got the bug to build radios and started trying to find schematics and things to look at."

That search led him to the local library and its magazine subscription to *Popular Electronics*. "I used to devour those," he recalls. "Writing really came out of that as payback. I thought it was something you had to do to pay back all those fun hours you spent reading about other people's projects."

Armed with a BSEE and EECS from Santa Clara University, Hageman went on to focus on analog/RF/embedded. His resume includes experience earned at companies including Agilent, CALEX, Hewlett-Packard, and Keithley Instruments. He started his own brand, Analog Home, in 2003, and describes it on his LinkedIn profile as "You provide the idea—I provide the Electronic Glue to make your product a reality."

As demonstrated in his popular EDN.com blog, The Practicing Instrumentation Engineer (www.edn.com/4374099) and the comments he posts across the Web site's various content using the screen name "LostInSpace2010," Hageman approaches his work with enthusiasm and an eagerness to share knowledge, much like the award's namesake, Jim Williams (www.edn.com/4374116).

Williams, an engineer's engineer and analog great who passed away in June 2011, contributed to many electronics publications, including *EDN*, willing to teach anyone who wanted to learn. In 2012, UBM Tech, *EDN*'s parent company, renamed the annual ACE contributor of the year award after Williams to honor his legacy and his willingness to inspire.

Steve Hageman is humbled and honored to receive an award named after the late Jim Williams.

Says a humble Hageman of winning the Jim Williams Memorial award:

"It's a huge, huge honor. Jim did everything in analog. A lot of us had the same loves for the same things, like Tektronix oscilloscopes. The first time you got a Tektronix oscilloscope—the first time you managed to talk the boss into buying you a nice Tektronix oscilloscope—we all still remember. Getting a service manual or going through the old HP journals, I know Jim did those things, too. In fact, I still have all those journals and go through them periodically, finding interesting things. Just that love of circuits that Jim had, to a certain extent I have that, too, and I know there are other engineers I work with that have the same love of those things."

Declining to look at it as "work,"

### OTHER ACE AWARD WINNERS INCLUDE:

- **Company of the Year:** ARM
- **Executive of the Year:** Haruo Matsuno, President and CEO of Advantest Corp
- **Energy Technology Award:** STMicroelectronics for its FD-SOI technology


IF WE help people with
a damaged skeleton,
could they walk again?
A robotic skeleton – a dream
our software could bring to life.
Innovative thinkers everywhere use the 3DEXPERIENCE software platform from Dassault Systèmes to explore the true impact of their ideas. Insights from the virtual world help companies combine electronic, mechanical and software technologies to design innovative solutions that overcome human limitations. How long before bionic humans are real life, not science fiction?
3DEXPERIENCE
It takes a special kind of compass to understand the present and navigate the future.
Discover our Industry Solution Experience:
HT body
3DS.COM/HIGHTECH
DASSAULT SYSTEMES
IF WE ask the right questions
we can change the world.

Hageman seems to get as much out of the action of contributing and commenting as a member of the engineering community as those who read his work and interact with him online do.

"It's a hobby. I get enjoyment out of it. It also helps me to learn," he says. "I'm not one of those guys who can just see something and remember it forever. Thinking about it and writing it down forces you to think about it sequentially and get all the steps in. It also helps to ingrain it in my mind, so I learn from the process of writing, too."

Hageman, now an established engineer, still approaches engineering with the same curiosity he found as a kid in the library.

"It's the same thing since fifth grade. I just get interested in something, like a little project. Whether it comes to fruition or not, I think about the design process and what you have to know and how to put it together. That brings you down an alley and then down several other alleys before you get to the end," he says. "And somewhere along the way, you've collected quite a bit of information. It's like training, constantly training. Certainly you have to keep knowing skills and throwing away skills."

SOMETHING ABOUT THE MAGIC OF PULLING RADIO WAVES OUT OF THE AIR. I GOT THE BUG TO BUILD RADIOS.

As to why Hageman has not gotten comfortable, settling in with the extensive knowledge he's amassed in his career thus far, and instead continually seeks new ways to grow, share, and learn through various avenues, including making contributions to technical Web sites and communities, he sums it up nicely: "You get bored, otherwise."

*EDN and UBM Tech congratulate Steve Hageman, 2013 Jim Williams Memorial Contributor of the Year Award winner.*

Shown are the Hillsboro, OR, design team, one of three geographically separated design groups that together formed a 21-member team—scattered from Silicon Valley, to Hillsboro, to Bristol, England—that won Design Team of the Year for realizing the MAX2173 digital audio broadcast tuner.

## DESIGN TEAM OF THE YEAR: MAXIM INTEGRATED'S MAX2173

**Patrick Mannion,** *Brand Director*

The Tao of Design should state officially somewhere that the smaller and easier to use an IC, the bigger and more complex the thought and energy are that went into its design. Such was the case with the MAX2173 direct-conversion digital audio broadcast (DAB) tuner, and the energy, skill, and design expertise of the 21-member design team that brought it to life.

Spread out between Hillsboro, OR; San Jose, CA; and Bristol, England, the MAX2173 design team overcame several tough challenges. Not only were they developing a cutting-edge RF product with demanding sensitivity and blocking performance requirements, but they also needed to do so while meeting demanding automotive-grade ESD and temperature standards and managing power consumption and die size—all while collaborating across multiple regions.

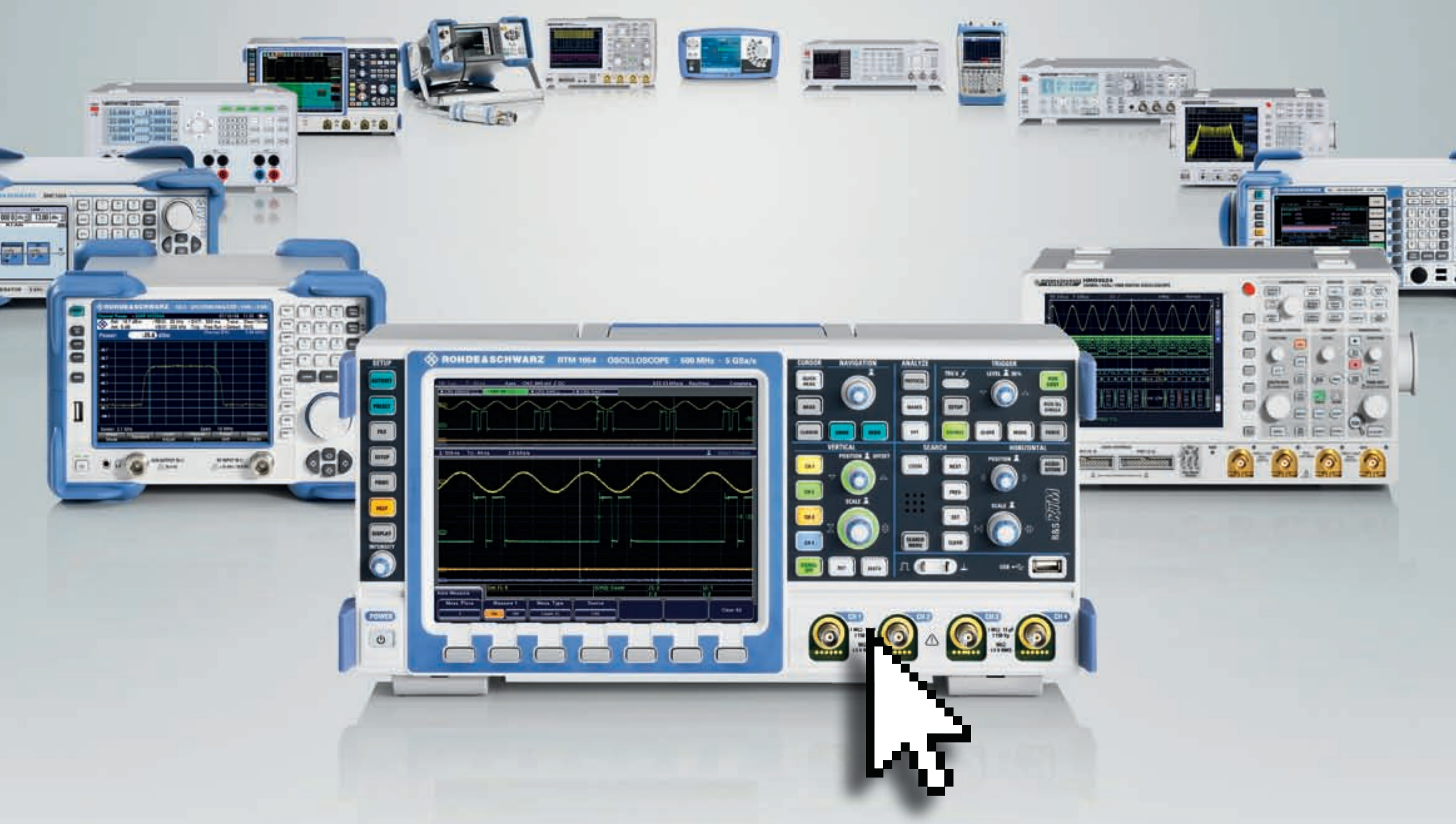
To deal with the geographic issue, each of the three design teams developed blocks in the overall design, but for any product to work, each team had to ensure that its block fit into the design seamlessly, without any mistakes, which could add costly delays requiring redesign and time-consuming tape-out cycles. This demanded constant communication between team members.

However, communication didn't end with the design team. The production test team needed to be aware of the production schedule. Inspired by this communication challenge, the team leader ensured excellent, open communication to keep everyone well informed of the specifics of each block and design schedule. The team pulled from their design know-how, available infrastructure, and proper forethought to align with the production test team efficiently. Along with strong design protocols, this communication among the team resulted in the production of high-quality product samples on the first pass.

The team delivered samples approximately one year after receiving the product definition. The product was ready for production approximately one year following the delivery of the first samples.

Of course, a relatively small die size had to be achieved in concert with the 6×6-mm TQFN package. As many designers are aware, suppliers of automotive electronics are under constant pressure to reduce size and power consumption. To overcome this challenge, the team creatively shrunk the baseband filter, a key component in the design, and combined that with excellent layout planning.

The resulting device is the first RF-to-bits DAB tuner on the market. It simplifies design and reduces design time, allows the DSP to support additional features, and reduces the cost and count of external components. The integrated ADCs reduce footprint, lower power consumption, and reduce cost. Digital filtering eliminates the need for filtering in the DSP while providing a programmable FIR, thereby saving MIPS in DSP and allowing support for other features or services. An integrated DCXO can digitally trim out crystal error, saving the cost of a TCXO or more expensive crystal. On-chip LDOs save space and reduce cost.



## INNOVATOR OF THE YEAR: YOGESH RAMADASS

**Rick Merritt,** EE Times *Editor at Large*

Yogesh Ramadass was named Innovator of the Year at the 2013 ACE Awards ceremony for his pioneering work in energy-harvesting circuits. The Texas Instruments lead design engineer helped craft the TPS62736, an ultralow-power converter that manages microwatts generated from solar, thermoelectric, magnetic, and vibration energy.


Yogesh Ramadass is helping pioneer the young but promising field of energy harvesting.

The device is actually a second-generation design that evolved out of graduate work at MIT as part of a five-person team assisted by Anantha Chandrakasan, the head of electrical engineering and computer science there. The group developed a 0.3V energy-harvesting part that was presented in a 2008 paper at the International Solid-State Circuits Conference (ISSCC) (www.edn.com/4325471). It ultimately saw the light of day as a TI product, the bq25504.

The MIT work was funded in part by a grant from the US Defense Advanced Research Projects Agency. DARPA sees potential for energy-harvesting devices to power tiny, self-contained sensor networks that could be dispersed in a battlefield.

Others believe energy-harvesting circuits will drive implantable medical devices, using the body's own heat or movement to provide power. In addition, researchers say the technology could be suitable for use in body area networks and RFID and other wireless terminals.

"Energy harvesting is still a relatively new field," Ramadass said in a recent article for TI's internal Web site. "It's exciting going from research to productization and creating a market," he added.

Ramadass is already at work on a next-generation energy-harvesting chip at TI. He also participates in developing high-power wired and wireless mobile-phone charger systems.

The TI engineer has co-authored dozens of technical papers, at least 10 of which have been cited dozens of times in related works. He was a co-recipient of the Jack Kilby best student paper award at ISSCC 2009 and the Beatrice Winner award for editorial excellence at ISSCC 2007. He serves on the technical program committee for ISSCC and also served as the chair of the analog, MEMS, mixed-signal, and imaging electronics committee for another technical conference.

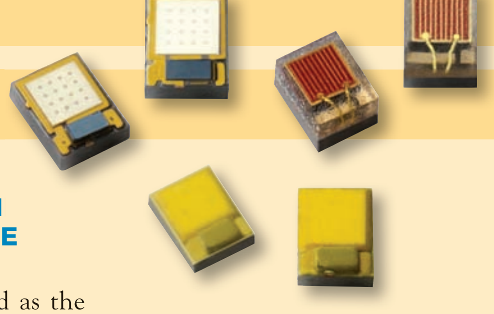


## ULTIMATE PRODUCTS

**Rich Pell,** *Executive and Chief Technical Editor*

The 2013 ACE Awards showcase the best in today's electronics industry, including the hottest new products and technologies that have made a difference in the electronics industry in the last year. Spanning a range of applications and technologies, this year's Ultimate Products reflect that more than ever.

Not surprisingly, some are from the always-hot communications sector, reflecting technologies such as 5G Wi-Fi, Bluetooth sensor iPhone app development, and high-performance networks and servers, as well as emerging communications. Others are focused on the ever-important power sector, and in particular automotive battery management in electric vehicles. Another addresses performance improvements and design simplification in the medical market. Rounding out the represented applications are areas as diverse as lightning sensing, custom LED lighting, and IP/system-centric design.



**ANALOG ICs: AD9670/71 OCTAL ULTRASOUND AFE**
(ANALOG DEVICES)

The AD9670 was introduced as the industry's first octal (eight-channel) ultrasound receiver with on-chip digital I/Q demodulation and decimation filtering. Because of the embedded demodulation and decimation feature, it is the first ultrasound receiver able to condition eight channels of data from RF to a baseband frequency, reducing the processing load on the system FPGA by at least 50% compared with other receivers.

By incorporating a 5-Gbit/sec JESD204B interface, the AD9671 reduces ultrasound system I/O data routing by as much as 80% compared with other data interface standards. The AD9670 and AD9671 also integrate a low-noise amplifier, variable-gain amplifier, anti-aliasing filter, and 14-bit ADC with a 125M-sample/sec sample rate and an SNR performance of 75 dB for enhanced ultrasound image quality. The extended anti-aliasing filter frequency range and a high ADC sample rate are also designed to help medical and industrial ultrasound equipment manufacturers meet the trend toward higher-frequency probes and superior image quality.

**DEVELOPMENT KITS/ EVALUATION BOARDS: BLUETOOTH LOW ENERGY SENSORTAG KIT**
(TEXAS INSTRUMENTS)

The goal of the SensorTag development kit is to make possible a Bluetooth low-energy device with the maximum number of sensors while achieving years of battery life on a single coin-cell battery. At the same time, it's designed to shorten the design time for Bluetooth app development from months to hours.

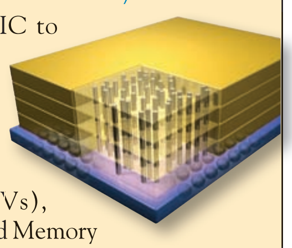
With a free downloadable SensorTag app from the App Store and no required hardware or software expertise, the kit makes it easy for smartphone app developers to take advantage of the growing number of Bluetooth low-energy-enabled smartphones and tablets. It's offered as the first Bluetooth low-energy development kit focusing on wireless sensor applications and the only development kit targeting smartphone app developers.

**LEDs & LIGHTING: LUXEON Z LEDs** (PHILIPS LUMILEDS)

Designed as the smallest and most flexible high-power light source, LUXEON Z LEDs are offered as a step toward simplifying luminaire design and inspiring the imagination of the lighting designer while improving system luminance and miniaturizing light sources, enabling the next generation of uniform and efficient light sources. Their micro source size of 1.7×1.33 mm or 2.2 $mm^2$ is 80% smaller and delivers higher performance than standard LEDs.

With LUXEON Z, designers can build their own custom 1×4, 2×2, 3×3, 4×4, and other arrays based on end luminaire design. The un-domed architecture of LUXEON Z is unique to LEDs in illumination and allows designers precise optical control, leading to more uniform and tighter beam patterns desired in directional and high-end applications. Configurations are virtually limitless, and with the ability to mount as many as 250 of the high-lumen LUXEON Z in one square inch, designers can reach new levels in lumen densities.

**LOGIC/INTERFACE/MEMORY: HYBRID MEMORY CUBE**
(MICRON TECHNOLOGY)



The first 3-D IC to be successfully manufactured in volume with advanced through-silicon vias (TSVs), Micron's Hybrid Memory Cube uses a logic device as its base, with high-performance DRAM vertically stacked above it using TSV connections. Initial volume production of the Hybrid Memory Cube, with its combination of high performance, low power, next-generation features, and competitive cost, heralds 2013 as the turning point for 3-D ICs designed to enable high-performance networks and servers today and destined for markets ranging from industrial to consumer.

The HMC concept completely rearchitects and redistributes normal DRAM functions while delivering:

- Scalable system architectures: Flexible topologies (expandability)
- Performance: Higher DRAM bandwidth
- Energy (power-efficient architectures): Lower DRAM energy per useful unit of work done
- Dependability (RAS): In-field repair capability

The result is bandwidth and efficiencies that are a leap beyond current device capabilities. HMC prototypes, for example, clock in with bandwidth of 128 Gbytes/sec compared with state-of-the-art module form factors that deliver 12.8 Gbytes/sec.

### PASSIVES, INTERCONNECTS, AND ELECTROMECHANICAL: LPS1100 THICK-FILM RESISTOR (VISHAY INTERTECHNOLOGY)


The LPS1100 thick-film power resistor is offered as the industry's first resistor in the compact 57×60-mm package to offer a power rating of 1100W at a heat-sink temperature of +25°C. With its high power capabilities and high dielectric strength to 12 kV RMS, the LPS1100 is intended for power supply, inverter, converter, HEV-EV battery management, and snubber, chopper, pre-charge, discharge, and filtering resistor applications.

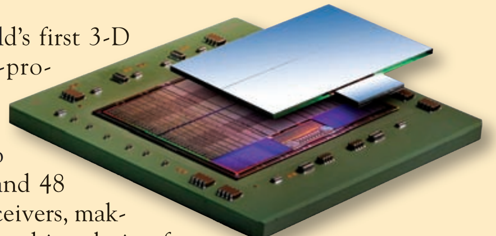
The LPS1100 thick-film resistor is non-inductive (less than 0.1 microhenry) and provides a resistance range from 1Ω to 1.3 kΩ. Designed for easy mounting to a heat sink, the device's compact footprint, low 25-mm profile, and low weight of 79 grams allow designers to reduce the size of their end products.

### POWER: LTC6804 MULTICELL BATTERY MONITOR (LINEAR TECHNOLOGY)

Addressing automotive battery management, the LTC6804 high-voltage battery monitor for hybrid electric and electric vehicles and other high-voltage stacked-battery systems measures up to 12 series-connected battery cells with a total measurement error of less than 1.2 mV. The cell measurement range of 0V to 5V makes the LTC6804 suitable for most battery chemistries. All 12 cells can be measured in 290 μsec, and lower data acquisition rates can be selected for high noise reduction.

Multiple LTC6804 devices can be connected in series, permitting simultaneous cell monitoring of long, high-voltage battery strings. Each LTC6804 has an isoSPI interface for high-speed, RF-immune, local area communications. Using the LTC6804-1, multiple devices are connected in a daisy-chain with one host processor connection for all devices. Using the LTC6804-2, multiple devices are connected in parallel to the host processor, with each device individually addressed.

### PROCESSORS (FPGAs, MCUs, MICROPROCESSORS): VIRTEX-7 H580T FPGA (XILINX)



Offered as the world's first 3-D heterogeneous all-programmable product, the Virtex-7 H580T FPGA features up to eight 28-Gbit/sec and 48 13.1-Gbit/sec transceivers, making it the only single-chip solution for addressing key N×100G line card applications and functions. The architecture is called heterogeneous because the GTZ 25-28G SerDes are on a separate and different die from the FPGA slices, allowing a mix of 25- to 28-Gbit/sec ("GTZ") SerDes (transceivers), fabric, BRAM, and 13.1G ("GTH") SerDes to meet the needs of the market in advanced traditional products.

The heterogeneous implementation of the H580T device also allows independent technology choices for the core FPGA and 28-Gbit/sec transceiver die, which enables the right technology choices for the right function. This enables optimized power and performance and avoids big trade-offs, which often burden other aspects of a product. The inherent flexibility of the all-programmable technology, beyond hardware to software, digital to analog, and single to multiple die in 3-D ICs, is offered as addressing the communication market's ultimate need to reduce design costs while increasing performance.

### SENSORS: AS3935 FRANKLIN LIGHTNING SENSOR (ams-TAOS USA)

A unique device, the AS3935 programmable lightning sensor IC detects the presence and approach of potentially hazardous lightning activity in the vicinity. It detects intra-cloud activity as well as cloud-to-ground flashes, often enabling risk to be evaluated for approaching storms. In addition, it identifies and rejects interference signals from common man-made sources, such as fluorescent lighting, microwave ovens, and switches.

Configurability allows the part to work both indoors and outdoors. Portable devices, such as GPS, watches, cell phones, and handhelds, can monitor the environment to warn of potential lightning strikes. Devices such as weather stations, clocks, and pool equipment can warn of approaching lightning strikes in the area, with relative confidence. Devices protecting equipment, such as UPS for telecom, medical equipment, televisions, and computers, can switch to battery-backed or generator power when strikes threaten the integrity of power supply and quality.

### SOFTWARE: VIVADO DESIGN SUITE (XILINX)

The Vivado Design Suite is offered as the industry's first SoC-strength design environment consisting of a highly integrated IP and system-centric design platform for 28 nm, 20 nm, and future generations of all programmable devices. It is designed to help address design integration and implementation bottlenecks faced by FPGA users.

Vivado speeds the design of programmable logic and I/O as well as accelerates programmable systems integration and implementation into devices incorporating 3-D stacked silicon interconnect technology, ARM processing systems, analog mixed signal, and IP cores. To address implementation, Vivado includes a hierarchical design flow, logic synthesis with support for SystemVerilog, and a 4× faster, more deterministic place-and-route engine that uses analytics to minimize "cost" functions of multiple variables, including timing, wire length, and routing congestion. Last-minute design changes and ECOs are addressed with incremental flows that allow for small changes to be quickly processed, making iterations faster after each change.

**TEST & MEASUREMENT SYSTEMS AND BOARDS: INFINIIUM 90000 Q-SERIES OSCILLOSCOPE**
(AGILENT TECHNOLOGIES)

The Infiniium 90000 Q-Series oscilloscopes, offering bandwidths from 20 to 63 GHz, were the first real-time oscilloscopes over 60 GHz to ship to customers. Their bandwidth and low noise/jitter have enabled measurements that were previously impossible on a real-time oscilloscope.

Scientists and engineers are using the 90000 Q-Series to look at high-speed designs, enabling advances in technologies such as 56-Gbyte/sec SerDes. In addition, the 90000 Q-Series also features 2 Gpts of data, allowing it to measure jitter on long patterns, a key component in emerging technologies.

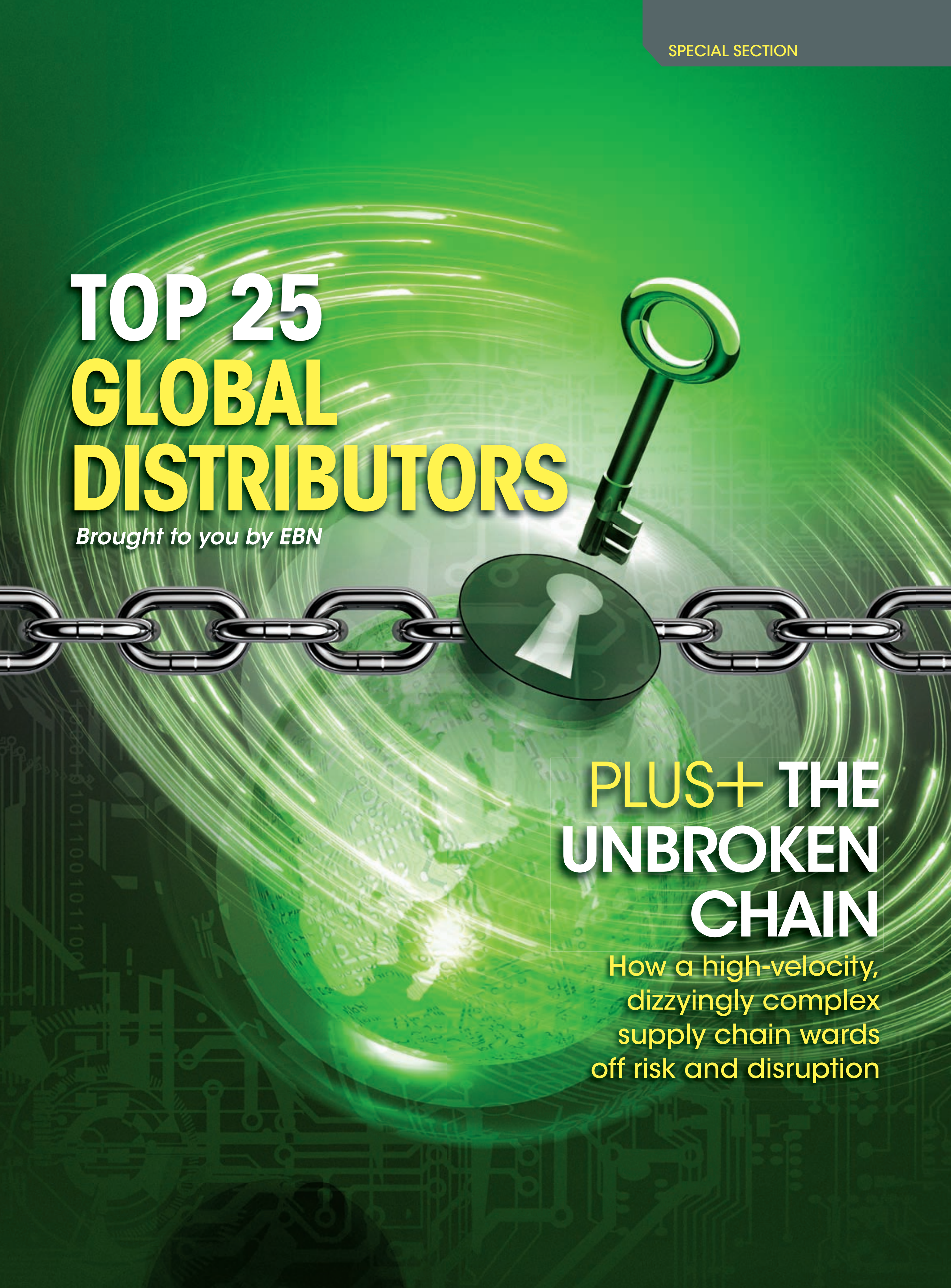
**WIRELESS/RF: BCM4335 5G Wi-Fi COMBO CHIP**
(BROADCOM)

The BCM4335 is offered as the industry's first complete 5G Wi-Fi combo chip for smartphones, tablets, ultrabooks, and other mobile devices. 5G Wi-Fi is a major evolutionary step from the existing 802.11a/b/g/n networks, and dramatically improves the wireless range in the home, allowing consumers to watch HD-quality video from more devices, in more places, simultaneously.

The BCM4335 integrates a complete, single-stream 5G Wi-Fi system—including MAC, PHY, and RF—with BT 4.0, FM radio, and software on a single silicon die. It is platform agnostic, and integration of the MAC, PHY, and RF allows it to be added to any smartphone or tablet regardless of application processor. Other features include wireless coexistence algorithms that mitigate radio interference, advanced "sleep modes" that extend battery life, and processing capabilities that off-load power-intensive tasks from the host processor.

# TOP 25 GLOBAL DISTRIBUTORS

*Brought to you by EBN*



## PLUS+ THE UNBROKEN CHAIN

How a high-velocity, dizzyingly complex supply chain wards off risk and disruption

SPECIAL SECTION

# TOP 25 GLOBAL DISTRIBUTORS

SHUTTERSTOCK

A LETTER FROM THE EDITOR

# The wheel's **turning**

By **Brian Fuller,** *Editor-in-Chief,* EBN

Hello, and welcome back to another installment in the long-running Top 25 Distributors list, brought to you by *EBN* and hosted this year by our colleagues at *EDN*.

As you'll see from the annual list (page S-18), not too much changed amid the electronic components distribution landscape in 2012. Some companies lost revenue ground, and some gained—some significantly—but overall it was a flat year.

But the business itself—its internal challenges and opportunities—is wilder than ever, from shifting market and technology priorities, to regulatory and compliance challenges, to counterfeiting, to risk management, to crisis preparedness and management.

The stories inside this year's issue help illuminate that and more.

Our overview story (page S-4), which recalls Ulysses and the Sirens, delves into one of distribution's biggest challenges today: how much to embrace the high-volume, low-margin, and highly volatile consumer electronics business.

Tam Harbert wonders whether any lessons from the Japan earthquake and tsunami and Thailand floods sunk in at all (page S-8).

Longtime supply-chain editor and observer Barbara Jorgensen ties a neat thread between the two crucial halves of our world: the design chain and the supply chain (page S-12). What are the conflicts between the two, and how do we resolve them?

And Jennifer Baljko pens an in-depth look (page S-22) at the latest legislation, regulation, and strategy around anti-counterfeiting of components.

You can find these and more excellent supply-chain insights in this annual survey. And, every day, you can stay on top of the latest supply- and design-chain news and trends at EBNOnline.com.

Enjoy.

# Ulysses and the Sirens: Distributors eye consumer business longingly but warily

By **Brian Fuller**

In a world that lives by the quarter, 2012 was quite a ride for distributors. In short, it could have been worse, but it sure could have been better.

It was another year of go-go quarters followed by abrupt pauses. That led to some interesting numbers on the annual Top 25 Distributors survey, but little ranking change (see complete chart, page S-18).

Topping the list of the world's biggest electronics distributors were Avnet and Arrow, respectively, followed by WPG Holdings, Future Electronics, and WT Microelectronics. (WT wasn't included in the 2010 or 2011 top-distributors lists.)

Three of the top five (Avnet, Arrow, and Future) are western companies that saw revenues dip in 2012 anywhere from 4% to 6%.

Electrocomponents plc, Digi-Key Corp, Rutronik Electronics, and Mouser Electronics all fell one spot in the rankings from 2011 to 2012, while Premier Farnell fell two (from No. 6 to No. 8).

## Stability, slow growth

That stability in ranking and, largely, in revenue, reflects the theme for distribution in 2012: essentially flat (–1.1%) at about $78 billion in an overall semiconductor market of about $300 billion. That followed a torrid 2011, where the top four distributors enjoyed double-digit sales growth.

Like gazing into the bottom of a teacup, some executives look at the numbers and see traditional challenges magnified.

"I'm not sure the challenges have changed a lot," said Glenn Smith, CEO of Mouser, who celebrated his 40th anniversary at the company this spring. "The pressures are still there. We've got to have an efficient business. We've got to pull cost out of the supply chain. [The] challenge is we're all doing it globally, and the complexities are increasing."

But for other western distributors, the numbers reflect what could be a significant shift in business mix that has wide-ranging consequences for the channel. In short, the global adoption of and passion for mobile electronics such as smartphones and tablets are threatening the traditional distribution model.

Harley Feldberg, president of Avnet Electronics Marketing Global, puts it into perspective: "Two phenomena collided in the September and December quarters. Somewhere near 100% of the growth that has occurred in the electronic component supply chain is coming from select industries and select customers," he said in an interview.

Feldberg added that in a very short amount of time, tablets, phones, and other wireless mobile devices have experienced white-hot global demand. That's driving business for distributors, but it's largely high-volume, low-margin business.

**Brian Fuller**

## New dynamics

At the same time, "the broader industrial marketplaces are exhibiting little or negative growth, primarily due to macro-economic issues."

The shifting dynamic is affecting broadline distributors' results.

"Why? Because … those [consumer electronics] supply chains are quite different than our traditional business. I'm not sure a lot of people make money except for the [OEMs]. They're high-volume, low-margin businesses that can be attractive if you put a unique supply-chain solution around it," Feldberg said.

Mark Larson doesn't disagree, and indeed, as CEO of privately held Digi-Key, throws in a subtle needle or two to his huge public competitors.

"There's so much volume in the long runs of consumer production that it looks good if you're a public company to push your top line with huge sales," he said. "Much of it is fairly high risk. The consumer buyer tends to change features much more rapidly and much more quickly than in industrial products."

Larson added: "Large distributors have built the business on this longer-run business because that's where the volume is. They have to come under a fair amount of stress. Volume is nice, but it doesn't pay for the lights."

He noted that concentration exposure is a problem for the large distributors. Digi-Key services 300,000 businesses across a range of industries with electronics components.

"They've [larger distributors] got fewer customers," Larson said. "If they lose a customer, they may have to wear a black armband. If we lose a customer, we have to be careful we lose one we don't miss."

At Mouser, Glenn Smith is keenly focused on the higher-margin engineering services aspects of the distribution business as an antidote to end-market vulnerabilities.

"Our business model is primarily not high volume," Smith said. "It's to the industrial customer or the medical customer, who's building thousands of units but not millions of units. We're delivering information to engineers to help them in their design cycle."

## Tipping point

For Feldberg, at the moment, it's less about competitive positioning and more about an industry's potential tipping point in its history.

"Distribution's got a strategic question it has to answer now," Feldberg said. "If that's our future, if so much of component semiconductor consumption is going to come from digital consumer devices, how does that affect the role of distribution looking five to 10 years out?"

Feldberg said the consumer electronics part of the puzzle becomes almost a moot issue if growth returns to the traditional industrial sector of broadline distribution business.

"Will we see growth is the big question, and if so when?" Feldberg asked. "That's the $64,000 question today. If that growth does not occur and the West stays stagnant for two years, what does that mean for our model? What changes will we have to make?"

Distribution has had difficulty growing its share of the $300 billion global semiconductor market past $75 billion to $78 billion.

If the distributors can't grow that so-called DTAM, they need to come up with a model to tap into the remaining $225 billion direct semiconductor business.

"The direct business is a different model. It doesn't allow for FAEs or for local sales teams," Feldberg said. "The margin is very low."

## Outlook 2013

While Feldberg and others take a long view in a business that's usually focused on the next three months, there's the year to consider, as well. What's the business outlook? Electronics supply-chain professionals squirm if you ask them to look past the current quarter. (Indeed, Feldberg, who has been at Avnet for more than 30 years, instead says he's worked at the company for more than 120 quarters.)

Some markets are stagnant for the foreseeable future; others like mil-aero are surging, Feldberg said.

"It's early to tell," Digi-Key's Larson said. "There is more optimism in the business than there was last year. When it comes to hard, cold numbers, it's more elusive."

Calling himself an eternal optimist, Larson said, "I'm assuming market conditions are not going to change significantly to the end of the year. The growth that we'll drive and aspire to will be from gaining market share from some of our competitors. Market growth is too uncertain at this time. Our sales goal would be growth in the range of 8% to 10%."

As the year progresses, meanwhile, distributors will continue to hear the siren song of consumer electronics. Some may choose to sail closer to the sound; others may follow the path of Ulysses, who had himself lashed to the mast to ensure he didn't steer his boat toward the Sirens and sure death for him and his men. ●

# Did lessons from the **2011 tsunamis and floods** really sink in?

*By* **Tam Harbert**

You know the saying: "Those who fail to learn from history are doomed to repeat it." The natural disasters that buffeted the supply chain in 2011 are now history, albeit recent history. In March of that year, a massive earthquake, subsequent tsunami, and consequent nuclear disaster in northern Japan severely disrupted both the electronics and automotive supply chains. Then, in the fall, monsoons led to severe flooding in Thailand, swamping hundreds of factories—including several that made critical hard-disk-drive components.

The big question two years later: Has the industry learned its lessons? Would similar disasters today have such dramatic impacts? The year 2012 was mild, with a lower than usual number of dramatic weather events (with the notable exception of Superstorm Sandy in the United States), so it's easy to become complacent. But that's dangerous, if studies of climate change that claim increasing numbers and magnitude of violent weather events are accurate.

The truth is, only time will tell whether the supply chain is any better prepared today than in 2011. Some analysts say the events got industry's attention enough to initiate some changes. But at least one analyst thinks the electronics industry is doomed to repeat history.

After 2011, several of Technology Forecasters' clients—especially midsize OEMs and lower-tier contract manufacturers—"came to us and said, "We've had disaster preparedness on our to-do list for years; now we need to put it into place," says Pamela Gordon, president of the consultancy.

Bob Ferrari, managing director of Ferrari Consulting and Research Group and founder and executive editor of the blog Supply Chain Matters, also thinks the supply chain has learned from the 2011 disasters. "It was like our 9/11," Ferrari says. "Although supply-chain organizations used to talk about the implications of a major supply-chain disruption, we had never really seen one until 2011."

Consequently, companies are making some changes, according to Gordon and Ferrari. Specifically, at least some companies are doing the following:

**Looking beyond Tier 1 suppliers.** The Japanese tsunami, in particular, exposed real vulnerabilities in the lower tiers of the supply chain. OEMs initially were reassured when they learned that their first-tier suppliers weren't badly impacted, only to suffer later when they realized the disaster had wiped out some "40% of the silicon wafer supply," says Ferrari. Today, companies are looking deeper into their supply chains to identify the components and materials that are sole-sourced or where the supply is concentrated in a certain geographic region (such as disk-drive manufacturers in Thailand).

Emerging regulations and political pressures are already pushing companies to get "full material disclosures [FMDs]" from their suppliers, which identify the countries of origin of materials and components, says Gordon. Now companies are

seeing how useful these disclosures can be in a disaster. With FMDs, OEMs immediately know whether a given area is a key source of certain parts or materials, and can build alternative sources into their disaster planning, she explains.

**Improving communications plans.** The 2011 events exposed shortcomings in communication; it was more complex and took much longer than companies anticipated, says Gordon. Companies realized they needed better plans for how to communicate (if lines were down or power was out) and with whom they should be communicating, says Ferrari. It was the start of a new awareness "that social media can be a good alternative in communicating during a crisis," he notes. Since 2011, more companies have started to monitor media such as Facebook and Twitter to get alerts when disasters happen, to get the word out to employees or suppliers in harm's way, and to receive information from the affected area when other means of communication are unavailable.

Indeed, Ferrari monitors social media carefully himself. In late March, for example, he saw a surge of reports on Twitter that a major 6.1-magnitude earthquake had occurred in central Taiwan. "Knowing that this area is the epicenter for high tech and consumer electronics supply chains, we immediately re-tweeted this news with hopes that our readers would be on alert to both the event and the potential for disruption," he says. Among the companies in the area are TSMC (the world's largest semiconductor manufacturer), United Microelectronics, Innolux, and AU Optronics. Although two TSMC facilities were reportedly evacuated, it turned out that there was minimal damage. But it was a reminder of how vulnerable Taiwanese facilities are. "They are all in that earthquake zone," he says. "We dodged a bullet." (See **sidebar** on Asian high-risk areas.)

**Padding inventory, at least in critical areas.** Having been caught short in 2011, purchasers are more likely to be able to convince a CFO that they need to put aside safety stock or line up alternative suppliers, says Ferrari.

**Monitoring unstructured information.** Some forward-thinking companies are using data mining and analysis on e-mail communications and other types of unstructured data, which can serve as a "kind of early-warning system of supply-chain risk," says Ferrari. Such tools can help zero in on important information during a crisis, to monitor the situation in real time, and also to piece together data that may give a more complete and accurate assessment of the situation than can any one supplier. After all, "the natural human tendency is to hedge. Nobody's going tell their major customers, 'we really took a hit here and it may be a month before we get out of this,'" says Ferrari. "You're not going to get that right away."

Malcolm Penn, founder and CEO of Future Horizons, is less optimistic. He maintains that most companies have done nothing to become better prepared for natural disasters, despite all the damage inflicted by the calamities of 2011. "There was a lot of scurrying around, but I don't think anybody has changed structurally the way they do things," he says.

Although OEMs say they are looking beyond their Tier 1 suppliers and improving communications systems, Penn is skeptical. Have they really investigated how they would cope if a TSMC facility were destroyed in a Taiwanese earthquake, for example? "I can't think of a single customer that would go to TSMC and say, who are your wafer suppliers, and who are the suppliers of your wafer suppliers? Who supplies the slurry to grind the wafers down?" he says.

Even if they asked, he adds, "TSMC wouldn't tell them." ●

*Tam Harbert is a freelance journalist and* EBN *contributor.*

## THE ELECTRONICS SUPPLY CHAIN LIVES IN A DANGEROUS NEIGHBORHOOD

Asia comprises some of the riskiest areas in terms of the likelihood of natural disasters and the economic damage they can inflict, according to a recent report by Maplecroft, which analyzes risk of all kinds. The company compiles an index based on a country's economic exposure to the risk of natural disasters. Among the highest ranked (of 197 countries) are Japan (No. 2), China (No. 3), the Philippines (No. 4), Taiwan (No. 6), and Indonesia (No. 8), according to Helen Hodge, head of maps and indices at Maplecroft.

That means these countries have the most globally significant economic assets exposed to major natural hazards, particularly earthquakes and floods. "With the increasing global economic importance of these nations and their interconnectivity to global markets, a major event in one these financial centers increases the risk of economic contagion," says Hodge.



# Resolving design chain VS. supply chain conflicts

*By* **Barbara Jorgensen**

The modern supply chain could benefit from a 3-D simulation tool. The process is no longer linear: A better model might be the known galaxy, with a bunch of suppliers (planets) circling around a sun (the customer). But a supply-chain analysis has to start somewhere, and for the sake of the electronics supply chain, it starts with the design engineer.

*EBN* and *Velocity* have been examining steps and strategies to build an effective supply chain. "Effective" means different things to different constituents: For engineers, it's a wide choice of products, technical support, and fast prototyping; for buyers, it's quality, price, and dependability; for customers, it's all of these, plus aftermarket services. Each partner has a specific role to play and a wish list on how things could work better.

Design engineers traditionally haven't been a part of the classic supply chain. The process used to begin when a design was done and purchasing developed the BOM. But engineering responsibilities have expanded over the years. Designers now have to consider the price of the components they're using, the life cycle of these parts, compliance with environmental mandates such as RoHS, and a host of other issues. Engineers, like everybody else, are being asked to do more with less at a faster pace than ever. So what would make a designer's job more efficient?

A study conducted by Technology Forecasters Inc found that engineers visited 25 or more websites before even starting a design. Engineers are looking for new parts, the price and availability of these parts, potential end-of-life (EOL) issues, and environmental sustainability. In a perfect world, all of this information would be available upon visiting just a few sites. But it's not. Suppliers have their own websites with their parts; distributors host sites that feature their franchises; and some sites focus only on new products, while others focus on maintenance, repairs, and overhaul (MRO). Most sites now host the RoHS status of devices, but there are currently different RoHS standards for different countries.

Then there's the data itself. Engineers can find data sheets at suppliers' sites, distributor sites, and third-party sites. But not all data sheets are created equal. Some sites just aggregate suppliers' data, which may get out of date. Distributor sites are timelier—they get EOL notices from suppliers—but data may be organized by supplier, by technology, or by application. Suppliers may or may not provide tech support. Distributors usually do, but they may steer engineers toward a specific component. Worse, a sales rep might call on an engineer who was just making an inquiry.

Environmental compliance data is usually available through suppliers and distributors, and is also compiled at consultancy, government, and non-government-organization (NGO) sites. Some sites cross-reference compliance status with actual devices, while others provide general guidelines.

Engineering research could be made easier by compiling real-time component data at one master

**Barbara Jorgensen**

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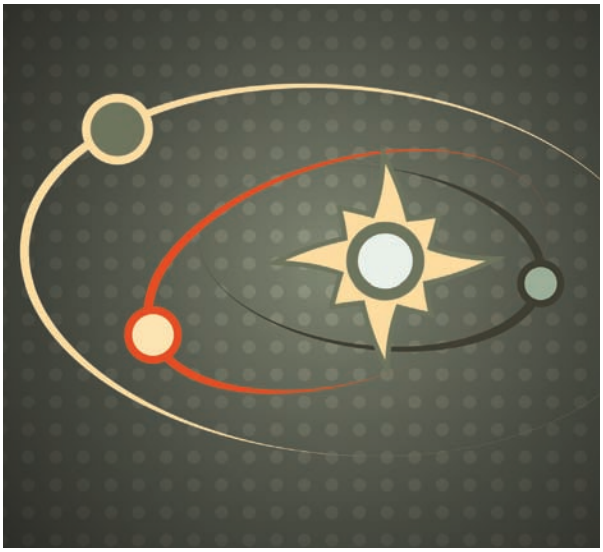
site. The site would cross-reference part numbers, suppliers, component specs, and applications. It would automatically flag a potential EOL or noncompliance issue. The perfect site would be agnostic (not tied to a sales or marketing strategy) and anonymous (engineers don't have to register).

Technology support is another factor that weighs in here heavily. But this, too, would be web-based, with the option of personal support. This site could be linked with a research site or standalone. Ideally, support staff would be available 24/7 by phone or by live chat. They'd speak or write in the engineers' language, and they wouldn't be tied to a supplier or distributor. Based on an engineer's questions, the technical staff would anticipate potential problems and help select supporting components. Then they'd tell designers where they could get samples of these components. This site could link to a third site or direct users back to a research page, where one-click purchasing is available. Parts would be delivered the next day.



If engineers were designing for their supply chain, they'd pick a widely available, low-priced part that could be sourced anywhere in the world. It wouldn't be a proprietary part, and it wouldn't have a lead time. This part would be in no danger of going EOL, and it would be automatically compliant with global environmental regulations. Somehow, though, the engineer would source this component only through a chosen supplier or a chosen distributor and not through a competitor. And even though the part is low-priced, there would be a healthy profit margin built into the sale.

**THE PROCESS IS NO LONGER LINEAR: A BETTER MODEL MIGHT BE THE KNOWN GALAXY, WITH A BUNCH OF SUPPLIERS (PLANETS) CIRCLING AROUND A SUN (THE CUSTOMER).**

But engineers don't design for the supply chain; they design for their customers. The needs of the supply chain and the design engineer aren't perfectly matched, but they can be better aligned. ●

*Barbara Jorgensen has more than 20 years of experience as a business journalist, working for leading electronics industry publications such as* Electronic Business, Electronic Buyers' News, EDN, *and* EBN.

# America's declared (and undeclared) cyberwar

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## The US government is employing several tactics to protect national interests from network attacks and data theft.

*By* **Bruce Gain**

President Barack Obama issued an executive order in mid-February to make it easier for "eligible critical infrastructure" companies and the US government to share information about network attacks.

As the international cyberwar heats up, the executive order represents one of several ways the US government is attempting to protect national interests from network attacks and data theft. It is also the latest development in the United States' reaction to increasingly common attacks that could have major implications on the world's supply chain.

The main goal of the executive order is to create more efficient best practices and policies for protection against "the cyber threat to critical infrastructure, which continues to grow and represents one of the most serious national security challenges we must confront."

The executive order follows an article published in the *The Washington Post* about a classified government report it obtained on international cyberattacks. Foreign governments, especially China, are directly or indirectly sponsoring "massive, sustained" cyberespionage campaigns that are putting US technology and development secrets at risk, according to the article.

### Same hack, different day

However, the claims are hardly new. The article in *The Washington Post* follows a report issued last year by the Office of the National Counterintelligence Executive, which monitors espionage against the United States. While attacks previously were largely limited to those against military and government networks, the National Counterintelligence Executive maintains that international cyberthieves are increasingly stealing US trade secrets from private firms and using them to gain an advantage in the undeclared economic war. Attacks originating from Russia, Israel, and France are also prevalent, but China is by far the worst culprit, according to the Office of the National Counterintelligence Executive.

The economic consequences in the United States from trade secret and other data theft by foreign parties are significant but difficult to quantify. The Office of the National Counterintelligence Executive said the attacks could cost the US economy up to $400 billion a year, but added that some estimates are substantially lower. However, speaking on a recent edition of *Face the Nation*, Bob Orr of CBS News cited estimates by House Intelligence Committee Chairman Mike Rogers who said cybertheft against US interests represents up to $400 billion in stolen intellectual property.

## No innocents?

But as the US government seeks to shore up its cyberdefenses, it is not necessarily a passive participant in this undeclared cyberwar. The US government, according to French media reports, was behind attacks on the French president's residence during the months leading up to the presidential elections last year. Both the United States and France would not comment on the reports, yet credible national French publications, including *L'Express* and *Le Télégramme*, confirmed that the attack took place. *Le Monde*, one of the most well-respected newspapers outside of the United States, cited a French diplomat who said he demanded an explanation from the US government about why it accessed then French President Nicolas Sarkozy's e-mails and other data.

AS THE US GOVERNMENT SEEKS TO SHORE UP ITS CYBERDEFENSES, IT IS NOT NECESSARILY A PASSIVE PARTICIPANT IN THIS UNDECLARED CYBERWAR.

The United States and Israel were unofficially behind the Stuxnet virus attack. Considered to be one of the most complex and lethal virus programs ever coded, the virus succeeded in crippling the supervisory control and data acquisition (SCADA) systems that Iranian scientists supposedly use to enrich uranium.

The French presidential and Stuxnet attacks are, of course, just two examples of attacks against foreign interests that supposedly originated in the United States. To the extent that the United States does apply its vast arsenal of defense spending to cybersurveillance and even cyberwarfare remains the stuff of chat-room discussions and information that will remain classified for decades from now, if it ever does become known.

## Technology theft

But as network attacks against US interests ramp up, the US government is also obviously worried about how illegally obtained technologies will shift beyond the shores of the United States. The theft potentially has huge implications in the technology industry, since stolen technologies developed in the United States, which spends the most in the world on research, could be marketed and produced elsewhere.

Citing China as the main culprit, Rogers noted during the *Meet the Press* episode how product blueprints and know-how are stolen by data theft and then used to produce specific products.

"I mean," said Rogers, "the Chinese basically are replicating these products about as fast as they can. And we're not doing very much about it. This is the first stage of what could be a very, very big problem if they turn this pillaging of wealth into attacking key systems."

However, the US government's more aggressive role in protecting intellectual property from cyberattacks should have at least some effect. The US government should also likely step up its more offensive actions in this covert cyberwar, although those actions will remain very covert.

Meanwhile, each skirmish and battle won could have a direct effect on which countries get to produce which technologies.

*Bruce Gain is a freelance writer based in France who got his start in the electronics world by hacking the family Commodore 64 in the early 1980s.*

# **Tips for design engineers:** tapping into online design tools

## Supporting the engineer from prototype to production

*By* **Brian German**

When it comes to product design, engineers have multiple goals: Design well, design within budget, and design fast. Companies trying to compete and move products to market faster are always looking for ways to decrease design time while improving quality and efficiency. These factors, combined with budget constraints and other complexities, mean today's engineers need all the help they can get to bring a new product to market, whether in the prototype or production design phases.

One resource designers can tap into for help is a collection of reference designs. These designs are proven solutions and act as a starting point for a specific product design, to be used as-is or modified as needed.

Some reference designs are a complete end-to-end product design solution, while others offer partial solutions designed to meet common engineering needs. Examples of full solutions would be DC/AC inverters, LED bulb drivers, or AC/DC wall converters, while partial solutions address such areas as DC/DC conversion, audio amplifiers, or motor drivers.

The main purpose of a reference design is to speed the development of new products using the latest technologies. Because engineers know they can start with a proven platform targeted for specific applications, they can shorten the design cycle, minimize errors, and get a product to market more quickly.

Manufacturers often provide reference designs, but it can be challenging to search across multiple suppliers and sites. A library that has consolidated designs from many suppliers can greatly decrease research time up front.

This type of cross-supplier library:

- Helps designers search for specific designs by category, supplier, and performance
- Provides access to detailed schematics with each design
- Eliminates extra steps in the design process, saving precious time
- Offers easy access to useful product ideas and design platforms/eval boards
- Offers BOM and Gerber files, when available

With engineers as its primary focus, Digi-Key knows how important it is for engineers to have easy access to two things: parts and information. But, with vast amounts of knowledge and many thousands of parts, the key is making it easy for the engineer to find useful content, proven designs, and the right parts quickly.

It can be frustrating to design a product only to discover that the parts required for prototype or production are not in stock. A good reference library should provide thorough supporting documentation, including BOM, schematics, and other materials, and ensure that the main ICs used

**Brian German**

in any design are normally in stock. For example, within the Digi-Key Reference Design Library, each design page offers a link to purchase the evaluation board that the design was based from, which can be delivered directly to the designer so he or she can test it at his or her desk, often within 24 hours.

Digi-Key utilized the strength of its part filter within the Reference Design Library to help engineers locate designs based on each reference design's performance and features.

Working with a distributor that offers personalized product designs can also decrease design time and improve design quality. The LED driver board (DKSB1003A/876-1003-ND) is an example of a modified reference design that Digi-Key's application engineers decided to make public in response to customer interest and demand. By tapping into the knowledge of application engineers, designers can create improved designs created by expert teams.

By offering organized designs and personalized assistance, Digi-Key can support top-notch design that meets a company's need for speed to market, producing quality products. ●

*Brian German has been a technician with Digi-Key for 11 years, where his primary focus is the Reference Design Library. He graduated in 2001 from North Dakota State College of Science with an AAS in electronics.*

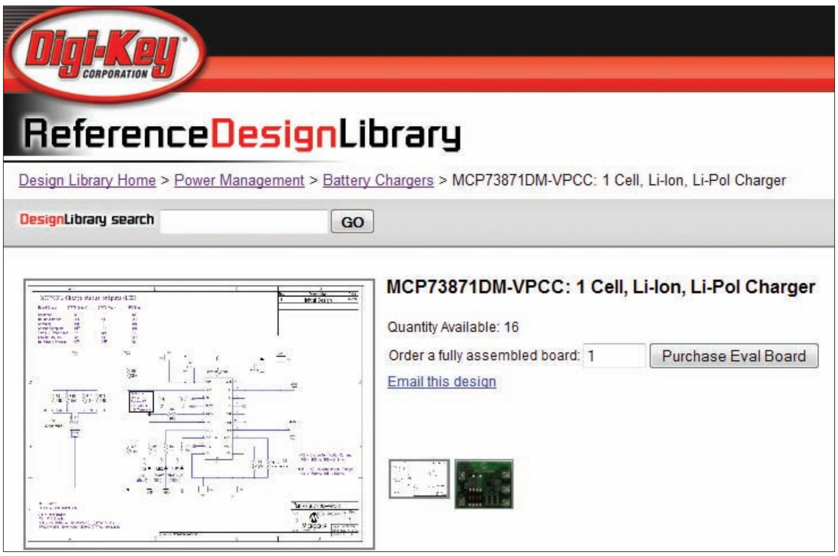


**Figure 1** *Example of a reference design from Microchip, an Li-Ion/ Li-Pol single-cell battery charger based on the MCP73871DM-VPCC eval board.*

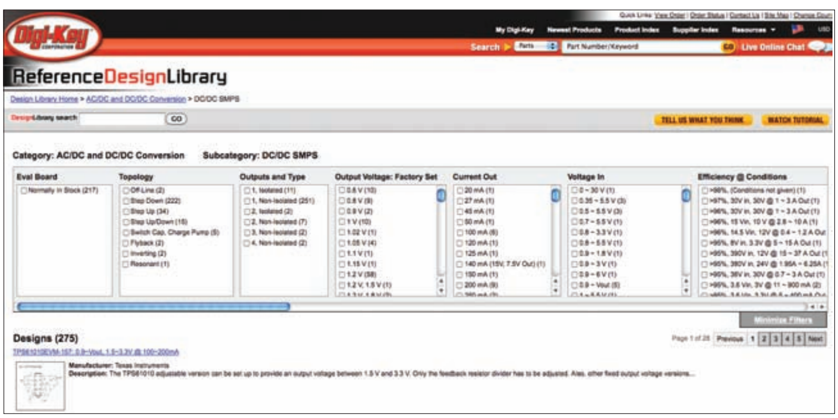


**Figure 2** *An example of filters in the subcategory DC/DC SMPS.*

# **TOP 25** Global Electronic Component

| 2012 rank | 2011 rank | Company | 2012 total global revenue | 2011 total global revenue | % change from 2011 | 2012 North American revenue | 2012 Asia/Pacific revenue | 2012 Europe/ Mideast/ROW revenue |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Avnet | 25,160.00 | 26,700.00 | -5.8% | 10,990.00 | 7,140.00 | 7,030.00 |
| 2 | 2 | Arrow Electronics | 20,405.13 | 21,390.26 | -4.6% | 10,641.90 | 3,836.00 | 5,927.20 |
| 3 | 3 | WPG Holdings | 12,397.80 | 11,111.90 | 11.6% | N/A | N/A | N/A |
| 4 | 4 | Future Electronics[1] | 4,831.00 | 5,107.00 | -5.4% | N/A | N/A | N/A |
| 5 | | WT Microelectronics | 2,800.69 | 2,365.65 | 18.4% | N/A | N/A | N/A |
| 6 | 5 | Electrocomponents PLC[3] | 2,028.98 | 1,902.39 | 6.7% | 444.00 | N/A | N/A |
| 7 | 7 | TTI Electronics[4] | 1,560.00 | 1,540.00 | 1.3% | 910.00 | 145.00 | 503.00 |
| 8 | 6 | Premier Farnell[2,5] | 1,544.60 | 1,574.44 | -1.9% | N/A | N/A | N/A |
| 9 | 8 | Digi-Key Corporation | 1,417.00 | 1,536.00 | -7.7% | 974.00 | 150.00 | 293.00 |
| 10 | 9 | Rutronik Electronics[1] | 1,100.75 | 1,026.82 | 7.2% | N/A | N/A | N/A |
| 11 | 10 | Mouser Electronics | 615.00 | 582.00 | 5.7% | 386.00 | 97.00 | 132.00 |
| 12 | 12 | Excelpoint Technology | 584.80 | 489.40 | 19.5% | 0.00 | 584.80 | 0.00 |
| 13 | 11 | DAC | 584.60 | 564.90 | 3.5% | 574.30 | 10.30 | 0.00 |
| 14 | 13 | Carlton-Bates[1,6] | 384.00 | 362.30 | 6.0% | N/A | N/A | N/A |
| 15 | 14 | Dependable Component Supply[1] | 334.50 | 327.00 | 2.3% | N/A | N/A | N/A |
| 16 | 16 | PEI Genesis[2] | 214.00 | 210.00 | 1.9% | N/A | N/A | N/A |
| 17 | 18 | Master Electronics | 163.00 | 156.20 | 4.4% | 147.00 | N/A | N/A |
| 18 | 17 | Richardson Electronics[2] | 149.44 | 161.03 | -7.2% | N/A | N/A | N/A |
| 19 | 19 | Powell Electronics | 120.00 | 120.00 | 0.0% | N/A | N/A | N/A |
| 20 | 20 | Bisco Industries | 116.30 | 103.20 | 12.7% | 111.80 | 2.20 | 2.30 |
| 21 | 21 | Flame Enterprises | 98.20 | 101.00 | -2.8% | 84.40 | 4.10 | 9.70 |
| 22 | 22 | Electro Sonic | 70.00 | 75.00 | -6.7% | 68.00 | 1.00 | 1.00 |
| 23 | 24 | Hughes-Peters | 63.00 | 59.00 | 6.8% | 63.00 | 0.00 | 0.00 |
| 24 | 25 | Steven Engineering | 51.00 | 49.00 | 4.1% | 45.30 | 3.00 | 2.70 |
| 25 | | Hammond Electronics | 35.90 | 37.90 | -5.3% | 35.9 | 0.00 | 0.00 |

All revenue figures expressed in US$ millions

[1] *EBN* estimate
[2] Fiscal year sales
[3] North American sales are based on figures at US subsidiary Allied Electronics Inc
[4] TTI acquired Sager Electronics in March 2012
[5] Premier Farnell includes Newark/element14 in North America
[6] Division of Wesco Distribution Inc

# Distributors

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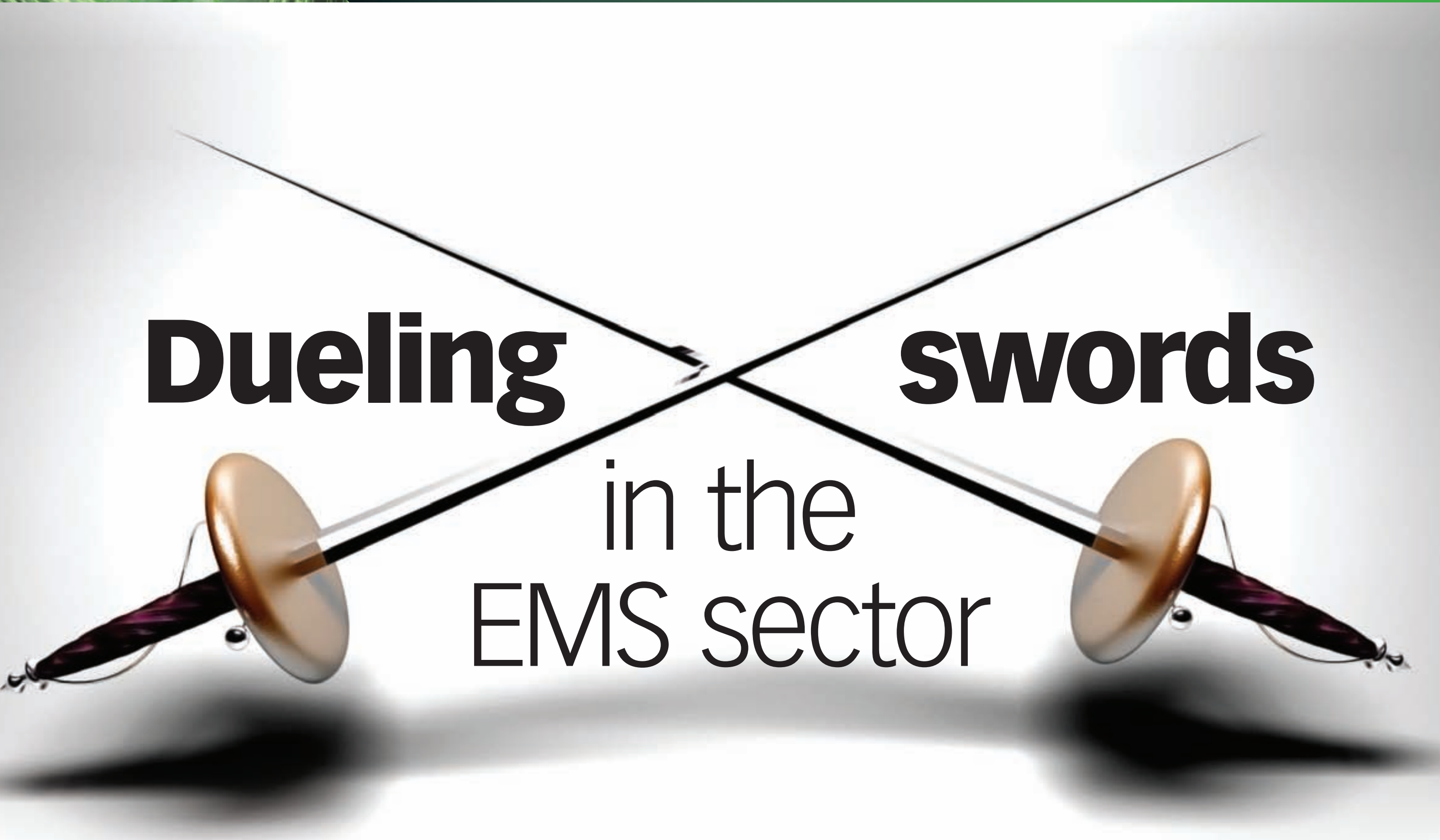

# Dueling swords in the EMS sector

## Electronics manufacturing services providers are experimenting with a revenue model that emphasizes quality instead of volume.

*By* **Bolaji Ojo**

**Bolaji Ojo**

The financial stats alone make it abundantly clear electronics manufacturing services (EMS) providers are among the most endangered species in the electronics industry. They are also among the industry's most adaptive enterprises, constantly tacking on new services and forever restructuring and readjusting operations to fit equally fast-changing revenue models.

EMS providers started out as junior partners to OEMs in a supply chain where players talk about partnerships, but which is governed in reality by how much power an enterprise has over its extended supplier base. With no natural base, restricted interactions with end customers—beyond what the OEM permits—and limited influence over component suppliers and distributors, EMS providers were not natural power brokers in the electronics industry.

That situation has changed little despite strong efforts on the part of senior executives to raise the profile of EMS companies. Even companies like Foxconn, the world's mega-EMS provider, are severely limited by what their equally mega-OEM customers, such as Apple, HP, and Dell, permit. Rather than butt heads with customers, but still conscious of the need to improve margins and profitability, EMS companies in more recent times have resorted

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to a strategy that's best described as "thrust and parry."

The thrust (offense) gets them involved in new business opportunities, while the parry is defensive. If you are a senior executive with an OEM that has an engagement with a contract manufacturer, then you should familiarize yourself quickly with the full range of the contractor's thrust and parry activities, as some of these will have an impact on your company's operations. In other words, add actions being taken by EMS providers to accelerate margin growth or exit lower-profit operations to your must-watch list.

Margins are so slim in the contract manufacturing industry that companies must constantly ensure they can justify the huge capital investments required. Like a malnourished child suffering an acute case of Kwashiorkor, EMS revenues can be bloated while everything else on the income statement is all bones and rags: The gross profit and operating margins are paltry, while net incomes—when they post a gain—are often so measly you wonder why anyone would want to be in the business at all.

## To the numbers

Let's take a look at numbers from a publicly traded EMS provider. Flextronics Corp, one of the largest in the industry—possibly second to Foxconn Electronics Inc—in the fiscal year ended March 31, 2012, posted sales of $29.4 billion and a gross profit margin of 5.2%, which represents about the average for the industry; 7% is considered great, while 9% is simply insanely fabulous.

Rivals Jabil Circuit, Plexus, and Sanmina are in some ways only slightly better positioned. Their sales are also much smaller; in this industry, companies are often forced to choose between higher revenue and fatter margins, an unpalatable option whichever way you cut it, since both choices are loaded with dangers. Market leader Foxconn, for example, has chosen higher sales but sweats bullets just to extract a fraction of the profits recorded by its biggest customer (Apple). The Taiwanese EMS provider, I predict, will eventually have to review and most likely change that strategy, but that's material for another discussion.

This is why change is a constant for the industry. After years of pandering to OEMs' desire to have "low cost" operations and competing with each other to drive down costs for customers, the EMS market is trying to move in a different direction. At the very least, these companies are experimenting with a revenue model that puts the emphasis on quality rather than volume. In doing so, they are also indirectly lending credence to the belief that Western countries still have a role in electronics design and manufacturing.

## Stepped-up investment

Two recent developments support this view. Flextronics announced in February that it would invest a total of $32 million in a new product innovation center in Milpitas, CA. This move backs up the company's long-term commitment to higher-end prototyping services in a western location. Jabil Circuit also has reported it would be partnering with UPS to offer "reverse logistics solutions for return and repair programs to high-tech original equipment manufacturers, service providers, and enterprises on a global scale."

That's the thrust. The parry comes when the EMS provider turns down that huge-volume, high-sales, but lower-margin business for lower revenue but healthier margin contracts.

*Bolaji Ojo, former editor-in-chief of* EBN*, has spent the last 25 years covering business issues on four continents, specializing over the last 11 years on the electronics industry supply chain.*

**METHODOLOGY FOR TOP 25 DISTRIBUTORS SURVEY (PAGE S-18):**

**The *EBN* Top 25 Distributors survey is conducted annually between March and April for publication online and in print. The listing ranks electronic component distributors by calendar-year sales; in the few cases where those numbers are unavailable, fiscal-year sales are used.**

**The data is collected via questionnaires that are e-mailed to private and public companies worldwide. The information provided is matched against public records; in cases where such records are unavailable, companies are asked to provide a signed letter confirming the numbers. *EBN* estimates the results for companies that do not complete the questions or that decline to offer letters confirming sales figures. Companies whose numbers cannot be independently verified are not ranked.**



# The anti-counterfeit movement: Is it really a movement yet?

Despite greater awareness and significant strides, the high-tech sector is only beginning to grasp what it means to deal with counterfeit part tracking and reporting.

*By* **Jennifer Baljko**

US legislation has compelled a stepped-up interest in preventing counterfeit electronic parts from slipping into the supply chain. It has also raised more questions than it has answered.

For many dealing with the enormity of tracking, reporting, and resolving issues associated with potential counterfeit parts, there is a collective hope that 2013 will bring clearer guidance on what needs to be done by whom and when.

Conversations today are already moving away from "What does the National Defense Authorization Act (NDAA) mean?" to "How is my company going to be impacted, and what am I doing about it?" This mental shift brings with it another set of challenges requiring increased collaboration, communication, trust, and thought leadership throughout the electronics industry, several industry watchers noted. A tall order, some acknowledged, because of the deep-rooted stigma and heightened concern about potential liability related to discovering counterfeits anywhere in a part's chain of custody.

Even so, if consensus is true, then the electronic industry's current dialog on this topic is a good start, but still largely perfunctory. Companies most affected by both the law and customers' updated risk-management requirements are doing what they can to be legally compliant, but an ongoing weak economic climate and a lack of specific governmental direction raise legitimate questions about whether the cost of an anti-counterfeiting program justifies the business case.

Cost considerations aside, progress depends on how willing industry, government, and academia are to work together to create cost-effective, long-term anti-counterfeiting solutions that outsmart the bad guys, reduce risks, and make the supply chain more secure.

"We have come a long way since these issues first surfaced," said Kristal Snider, vice president at ERAI Inc, Naples, FL. "But the supply chain cannot mature, improve, and keep up with this issue and develop effective solutions if it's not something everyone agrees on, at least to some extent."

"Everyone in the supply chain knows about NDAA," she added, noting some of the lag time between when the law was signed, when details about how different elements of the law will actually come together, and what the industry can do in the meantime. "But everyone is waiting for clearer instruction about what comes next. We're waiting for more information to flow down to the industry."

Until that happens, the industry's not standing still. Here's a snapshot of what's happening today and what else needs to be done to keep the anti-counterfeit movement moving ahead.

## NDAA's impact today

By now, any company touching the US defense and aerospace industry knows about the NDAA and its notorious Section 818. The law, brought into force in 2012 and updated this year, holds defense contractors accountable for detecting suspect or counterfeit electronic parts and paying for remediation and rework if suspect or counterfeit parts show up in their products. NDAA is the government's way of addressing the harm being done by worldwide counterfeiting and piracy, the magnitude of which—when calculated broadly and beyond electronics—is estimated to be "well over" $600 billion, according to the International Chamber of Commerce.

With the law in place, most companies in this supply-chain segment are likely already having deeper talks about risk mitigation, warranty contracts, and test and inspection processes ensuring part quality and authenticity. Since some OEM somewhere is going to be accountable to the Department of Defense, it's only a matter of time before they work through their approved supplier list and call up with questions about how parts are sourced, where they were procured, how long they have been in inventory, and how trustworthy is that source of supply.

> BY NOW, ANY COMPANY TOUCHING THE US DEFENSE AND AEROSPACE INDUSTRY KNOWS ABOUT THE NDAA'S SECTION 818.

The lead-up to the legislation's approval and the year since have also ushered in a new wave of industry conferences, training programs, working committees, and standards. Initially, these aimed to create awareness, but now the focus scopes more toward due diligence.

That push is keeping Carlo S Abesamis, quality engineer for the Procurement Quality Assurance group at NASA's Jet Propulsion Laboratory (JPL), busy. Abesamis, whose main responsibility is to audit the organization's electronics suppliers, also manages JPL's Counterfeit Awareness Training program, which started in 2008 before the mainstream was thinking about this and provides instruction to other NASA groups and external organizations such as the US Department of Justice and Customs and Border Protection (CBP).

"Shortly after I was hired, one of the tasks I was asked to work on was counterfeit parts training. Even back then, we have always had support from top management at headquarters to do this kind of outreach and awareness building," Abesamis said. "When we first started these programs, it was about creating awareness. Today people know about the problem, and now they want more in-depth information about it."

JPL uses a modular training approach, walking people through the basics and then going into topics such as risk-mitigation evaluations and establishing supplier requirements for obsolete parts. Another module being developed will focus on part inspection, from visual component inspection up to running parts through state-of-the-art test and X-ray equipment, he said.

Other companies—namely independent distributors that have taken the most heat so far because of their open-market procurement strategies and the perceived associated risk of bringing suspect parts to the supply chain—are also proactively trying to nip counterfeit issues in the bud, despite the high cost of doing so. The top-tier independent distributors, for instance, are investing in new test and X-ray machines, hiring and training more inspectors, undergoing rigorous standards-adoption measures, and doing all they can to prove due diligence, said Debra Eggeman, executive director of the Independent Distributors of Electronics Association in Buena Park, CA.

According to Eggeman, "Many of our members have been flushing out their risk-mitigation strategies and are in the process of adopting new standards," such as IDEA-QMS-9090 and SAE's AS5553 and AS6081, which address part quality and counterfeit-detection processes. "They are also constantly being challenged to upgrade equipment, and many independent distributors are making significant capital equipment investments. Some are installing their first X-ray machines; others are looking to buy new equipment with more sophisticated software algorithms that can better detect inconsistencies or process more parts. As they become more educated about this, they also recognize that they need more people to work on this. These aren't the kinds of people you can hire from Monster.com."

A harder task, though, isn't just detecting counterfeits as new parts arrive at the warehouse. It's knowing what's in inventory and deciding when and how to retest potentially millions of components to be compliant with NDAA, she added.

Enforcement is another layer of the equation, as well. While it's hard to pin down how much national law enforcement agencies are cracking down (the Department of Homeland Security is by its nature not a tell-the-world-everything kind of organization), a recent report suggests that counterfeit electronics parts are very much on the minds of those at the CBP and Immigration and Customs Enforcement (ICE) agencies.

> COUNTERFEITERS KNOW WHAT THE INDUSTRY IS DOING TO STOP THEM, AND ARE WORKING TO SIDESTEP EXISTING MEASURES.

The recent "Intellectual Property Rights Fiscal Year 2012 Seizure Statistics" report (http://1.usa.gov/ZvOJcE) notes that the organizations' expanded efforts "to seize infringing goods"—all products, not just electronics products—led to 691 arrests, 423 indictments, and 334 prosecutions. Electronics parts accounted for 15% of the total number of seizures. Additionally, initiatives under Operation Chain Reaction, an Intellectual Property Rights Coordination Center operation designed to prevent counterfeit items from entering US government supply chains, led to 24 arrests, 36 indictments, 26 convictions, and the seizure of more than $9.83 million in counterfeit electronics, currency, and vehicle parts, according to a CBP press release.

## What lies ahead

Not surprisingly, the more people talk about counterfeit-part prevention, the more there is to do about it, and the more the electronics industry will have to pull together to get things done.

Up high on the list are staying vigilant and thinking ahead. Counterfeiters know what the industry is doing to stop them, and the really good ones are building impressive networks to sidestep existing anti-counterfeit measures.

This is already evident. It used to be "easy" to identify fakes. There were scratches on the package or leads were damaged or some rudimentary technique was employed. Now, counterfeiters have moved onto more sophisticated techniques, such as cloning parts, which represents a serious issue for the entire industry, said Mohammad Tehranipoor, University of Connecticut's Castleman Associate Professor in Engineering Innovation and director of the university's Center for Hardware Assurance, Security, and Engineering (CHASE).

Developing cost-effective solutions that look beyond existing counterfeit issues and identify potential problems three, five, or 10 years from now will be critical. Tehranipoor expects that while the overall number of known counterfeit cases may drop in the next few years, it won't be because counterfeiting has stopped. Rather, counterfeiters will have gotten that much better and phony parts will be harder to identify.

Although equally sophisticated, industry-approved solutions are appearing in the market—such as Applied DNA Science's DNA signature marking for individual part packages, to name one—and academic institutions can help the industry develop longer-term solutions based on risk-based analytics, the electronics industry also has to be more innovative and eventually push anti-counterfeit strategies further down the line, back to the design level, Tehranipoor said.

"Companies and original component manufacturers have to design products with the whole life cycle in mind. They have to ask what happens when the components are thrown away or recycled, and what happens when they show up in other parts of the supply chain. People need to understand where the vulnerabilities are not just for today for the future," he said, adding that in the long run it's more cost-effective to deal with this in the design stage than try to efficiently manage one part at a time. "If you design-in anti-counterfeiting measures, you design once and can fabricate a million."

These high-level things, however, can be addressed only if the industry is willing to talk about them openly, and if safe-harbor assurances are built into the tracking, monitoring, and reporting processes.

A notable problem is that people are afraid to report counterfeit issues, because they are afraid either their company's brand reputation will be damaged if the news gets out or they'll be legally implicated and sued, said Snider. More effective communication could help lessen this fear, and that's why ERAI's conference in mid-April, which will highlight many of the supply-chain issues related to counterfeit part detection, will have a session on improving communications efforts between all involved parties.

"The missing piece for all this is communications. Right now, we have a broken-line communication," Snider added. "It's like building a high-speed train from the East Coast to the West Coast and skipping three states in the middle. We've already worked hard in laying the groundwork. We have to get the tracks fixed so we can go from point A to point B." ●

*Jennifer Baljko is a freelance journalist and contributor to* EBN.


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# Pocket white-LED torch is power efficient

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

This Design Idea describes a single white-LED torch, which can be housed in an empty glue-stick tube and has a long rechargeable-battery life. The circuit is constructed with just a few commonly available parts. This torch has proven to be highly durable; the prototype model constructed by the author has been in service for nearly five years and is still in good working condition.

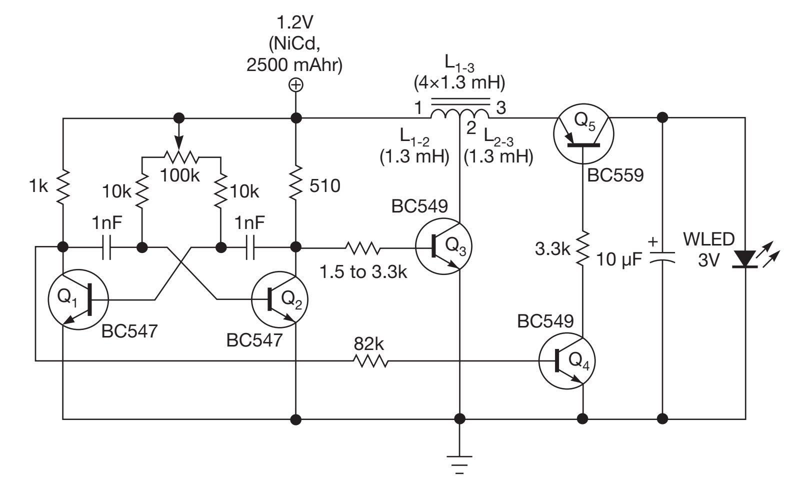



Figure 1 An inductive voltage booster powers the white LED.

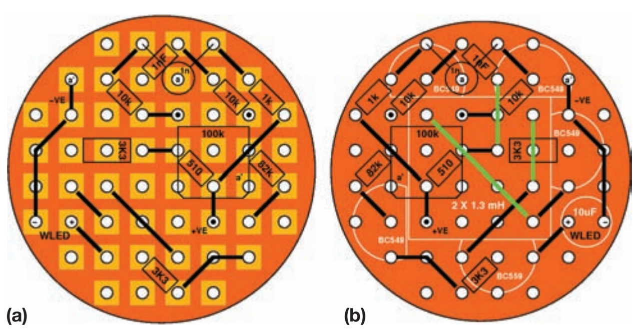



Figure 2 The circuit's components can be assembled onto the two sides of a circular general-purpose board: Connections on the lower surface have been mirrored (a); from the top, component placement is shown in white, and connections are shown in green (b).

## DIs Inside



▶To see and comment on all of *EDN*'s Design Ideas, visit www.edn.com/designideas.

A single 1.2V/2500-mAhr nickel-cadmium cell powers the torch (**Figure 1**). A simple transistorized boost switcher based on a tapped inductor is used to increase the voltage efficiently (up to approximately 80%) to the voltage needed for a typical white LED[1]—in this case, about 3V. $Q_1$ and $Q_2$ form an astable multivibrator producing rectangular waveforms at their collectors that are 180° out of phase.

Assume that at power-up, $Q_2$ is off and $Q_1$ is on. Under these conditions and with $Q_2$'s collector high, $Q_3$ is turned on via $Q_2$'s collector resistor. With $Q_3$ on, current flows through the first half of the inductor (from terminals 1 to 2).

At the end of this first half-cycle of operation, the multivibrator flips to the other state: $Q_2$ turns on and $Q_1$ turns off, and its collector goes high. $Q_3$ is switched off; $Q_4$ and $Q_5$ are switched on via $Q_1$'s collector resistor. The decaying inductor current now flows through terminals 1 and 3. Since $L_{1-2}$ is equal to $L_{2-3}$, and since they are on a common core, the inductance of $L_{1-3}$ is four times that of $L_{1-2}$ and $L_{2-3}$. This increased inductance (and the corresponding additional turns on the core) leads to a reduction in the magnitude of the current but an increase in voltage across the LED. During this phase, current flows

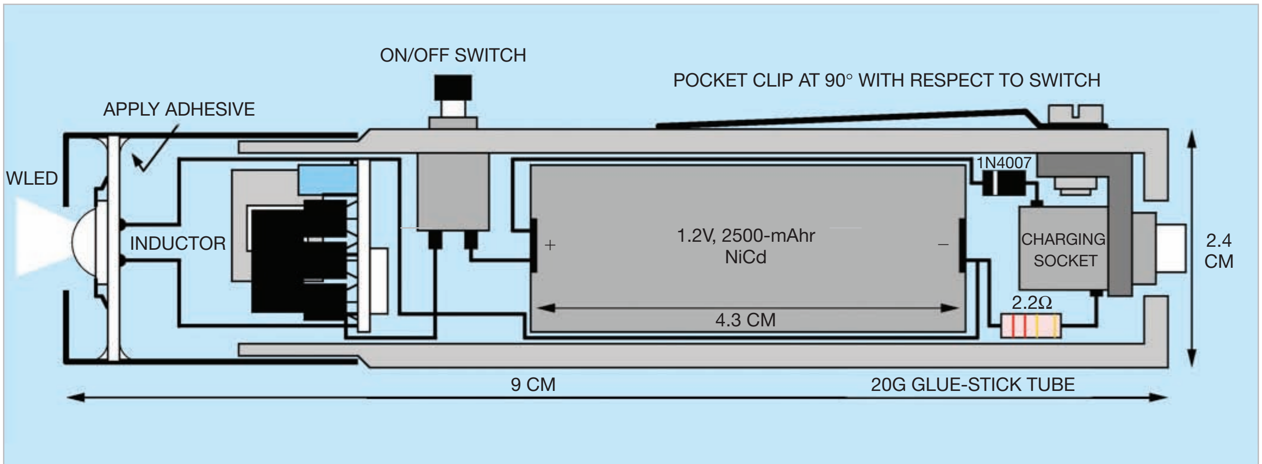



Figure 3 The white-LED torch can be assembled inside an empty glue-stick tube.

through the LED and, simultaneously, the 10-µF capacitor is charged. This phase lasts for a time period determined by the RC values in the astable circuit.

Once the RC time constant passes, the process repeats: $Q_1$ turns on, $Q_2$ turns off, and the other transistors switch as previously described. The current through terminals 1 and 2 of the coil again increases, storing energy from the battery in the inductor. During this phase, the 10-µF capacitor powers the LED.

**Figure 2** shows how the circuit's components can be assembled onto the two sides of a circular general-purpose board. **Figure 3** shows how the torch could be assembled inside the glue-stick tube. Once the torch is assembled and powered up, adjust the 100-kΩ potentiometer in the astable circuit for maximum brightness. Note that, if needed, an additional transistor can be used in parallel with $Q_3$ to boost the energy stored in the $L_{1\text{-}2}$ inductor. The need is dictated by how quickly and deeply $Q_3$ goes into saturation.

Photographs of the working circuit can be seen in the online version of this Design Idea at www.edn.com/4412618. An online appendix contains the quantitative aspects of the circuit. EDN


REFERENCE

1 "LT1932 constant-current DC/DC LED driver in ThinSOT," Linear Technology, http://bit.ly/17YVEdw.


# Gnat-power sawtooth oscillator works on low supply voltages

Bruce D Moore, Consulting Analog Engineer

This sawtooth-oscillator circuit, drawing less than 3.2 µA and working at under 1V, is a useful building block that fits the bill for extremely low-power consumption and operation to low supply voltages. It could be used as the basis for a PWM control loop, a timer, or a VCO, or as a capacitance-to-frequency converter. It's a nifty circuit for two reasons: It uses an open-drain comparator output to make an accurate switched current source, and it uses a latch function to make a simple comparator into a window comparator, while needing no extra components.

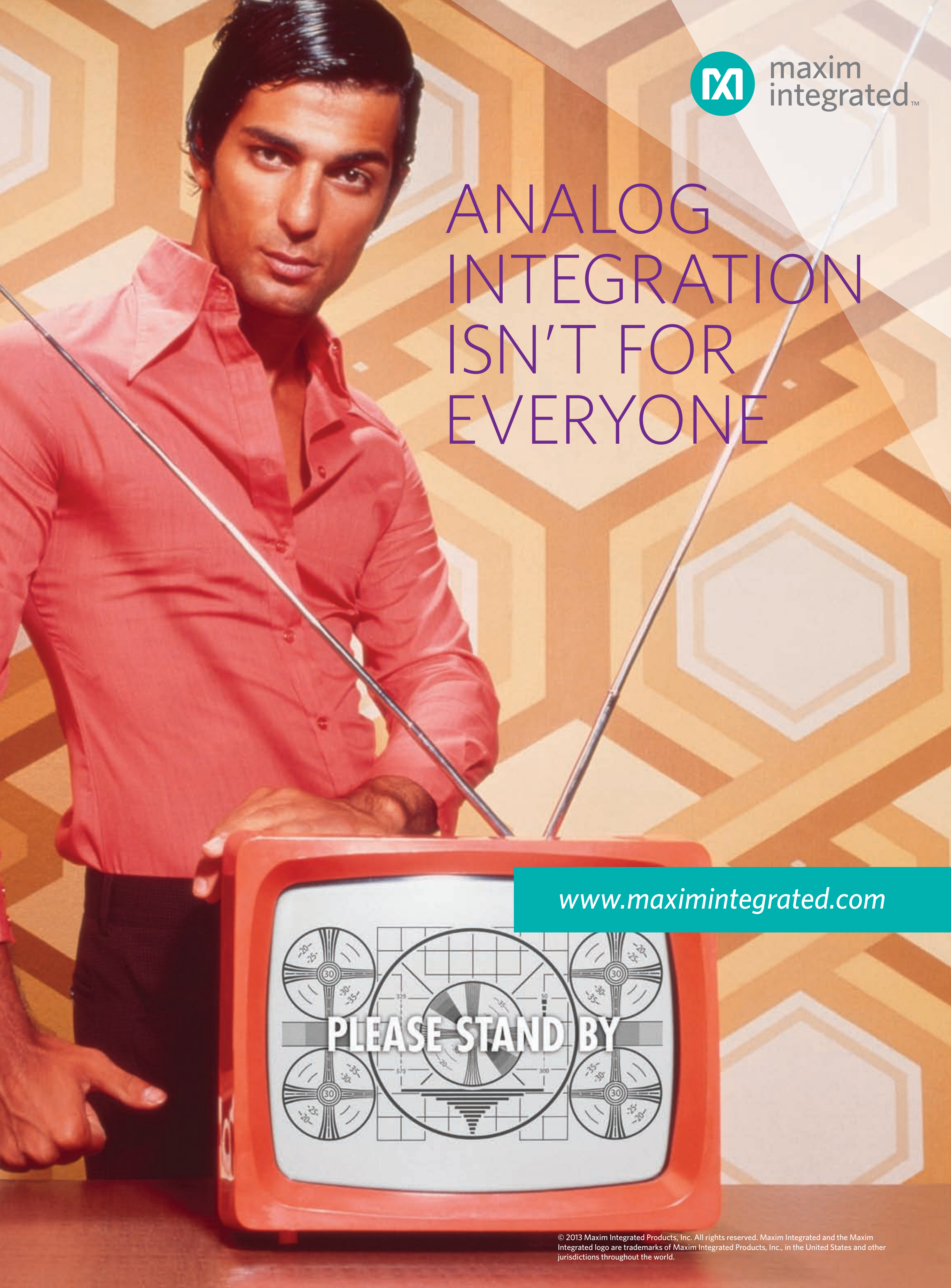
The appeal of this circuit is found in the combination of the tiny size, the ridiculously low number of external components, a low supply current, and the ability to maintain a constant amplitude and frequency despite the variable battery voltage. Unlike the classic op-amp astable multivibrator, this design features comparator thresholds that are set by precision reference voltages rather than the output swing of the op amp in combination with resistor feedback.

A ratiometric fixed-frequency design of this type usually results in a variable-amplitude sawtooth waveform, which is undesirable in PWM control loops because it can affect the loop gain. As a side benefit, the up/down ramps can be independently controlled by scaling $R_1$ and $R_2$.

Referring to **Figure 1**, there are only eight components in this circuit: two ICs, four resistors, a capacitor, and a power-supply-bypass capacitor. The key bits are two Touchstone Semiconductor analog building-block ICs in 4-mm$^2$ TDFN packages (the TS12011 and the TS12012), each containing an op amp, a comparator, and a reference. By leaning on their characteristics, the design can be kept terrifically tiny and simple.

THE APPEAL OF THIS CIRCUIT INCLUDES ITS SMALL SIZE AND LOW EXTERNAL-COMPONENT COUNT.

Here's how the circuit works: A summing integrator feeding a window comparator generates the sawtooth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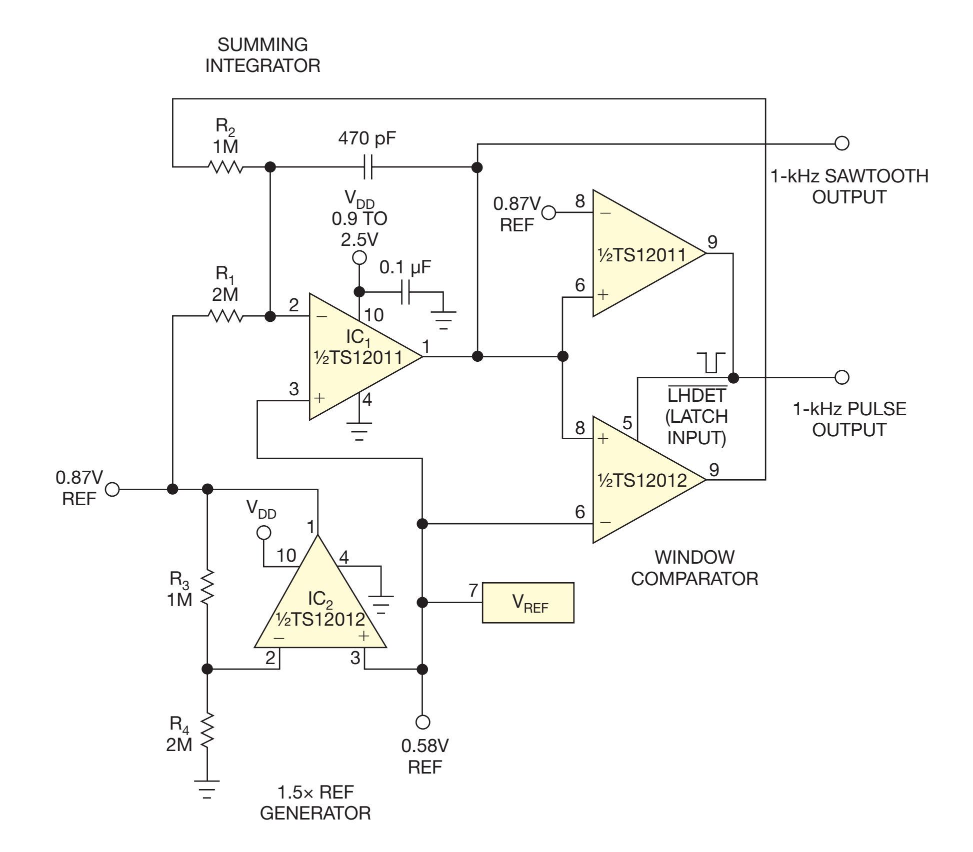


Figure 1 This low-voltage sawtooth generator uses only eight components and draws extremely low power.

wave. The integrator-summing node is held at $V_{REF}$ by the feedback action of the amplifier. Thus, a fixed positive reference current set by $R_1$ is balanced by a larger-amplitude switched negative current set by $R_2$. The lower comparator block has an open-drain output; when its output is low, current is pulled from the summing node via $R_2$: $I_{R1}=(0.87\times V_{REF}-0.58\times V_{REF})/R_1$ and $I_{R2}$ (switched)$=0.58\times V_{REF}/R_2$. If $I_{R2}$ is set to $2\times I_{R1}$, a symmetrical triangle wave results.

The frequency is set as follows:

$$f=\frac{1}{[1/I_{R1}+1/I_{R2}]\times C\times V},$$

where V is the difference between $0.87\times V_{REF}$ and $0.58\times V_{REF}$. Here, f=850 Hz.

**Figure 2** shows the waveforms at the sawtooth and pulse outputs.

The window comparator employs a built-in latch function of the TS12012 to provide hysteresis. The latch function has a sly feature: When $\overline{LHDET}$ is pulled low, the comparator inputs are still active and sensing the input state, until the inputs cross. The comparator in $IC_2$ gets set when the ramp crosses the lower threshold at $0.58\times V_{REF}$, and reset when the ramp crosses $0.87\times V_{REF}$. The reset pulse is momentary, but puts the latch in a state where the comparator inputs crossing cause it to set and latch again (which happens due to the switched reference current causing the integrator to ramp negative). The net result: No glue logic is needed.

The battery voltage ranges down to 0.9V with a miserly $V_{DD}$ current of 3.2 µA. Maximum operating frequency is limited by the op-amp slew rate and prop delays to about 3 kHz. Disconnecting $R_1$ and driving it with a voltage source greater than $0.58\times V_{REF}$ gives you a VCO function.

**Editor's note:** This Design Idea is courtesy of EDN.com's sister site, Planet Analog: http://bit.ly/11IkNeK. EDN

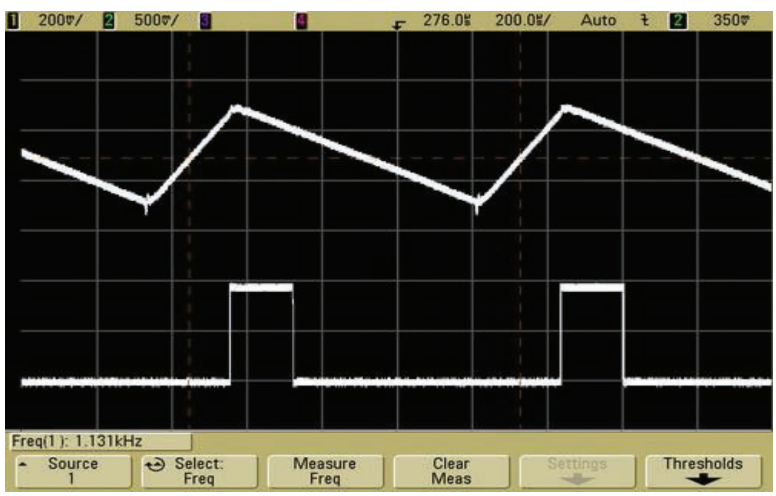


Figure 2 The waveforms at the sawtooth and pulse outputs are shown. The pulse train is used to reset the latching comparator.


INNOVATORS THINK STATUS-QUO
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# Connect a 4×3 matrix keyboard to a microcontroller using two I/O pins

Aruna Prabath Rubasinghe, University of Moratuwa, Moratuwa, Sri Lanka

Matrix keyboards are common as an input device in microcontroller-based projects. A conventional way of connecting a matrix keyboard to a microcontroller is to use multiple I/O pins of the MCU. The MCU then uses a scanning algorithm to identify which keys are pressed. A drawback of this method is that it requires a large number of the MCU's I/O pins to connect the keyboard. For example, to connect a 4×3 keyboard requires seven digital I/O pins. This becomes a problem when the project is based on a low-pin-count MCU or when the MCU being used does not have enough free I/O pins.

Two solutions for this issue are available: Use readily available I/O expanders, or assign a unique voltage to each key using a resistor network and then use an analog pin to read the voltage and determine which key is pressed. Each solution has its own disadvantages.

Since most of the time I/O expanders require a special communication protocol (I²C or SPI, for example) to read and write data, the MCU should have built-in communication modules, or the user has to implement the relevant communication-protocol software wisely, which adds significantly to the overhead of the MCU. On the

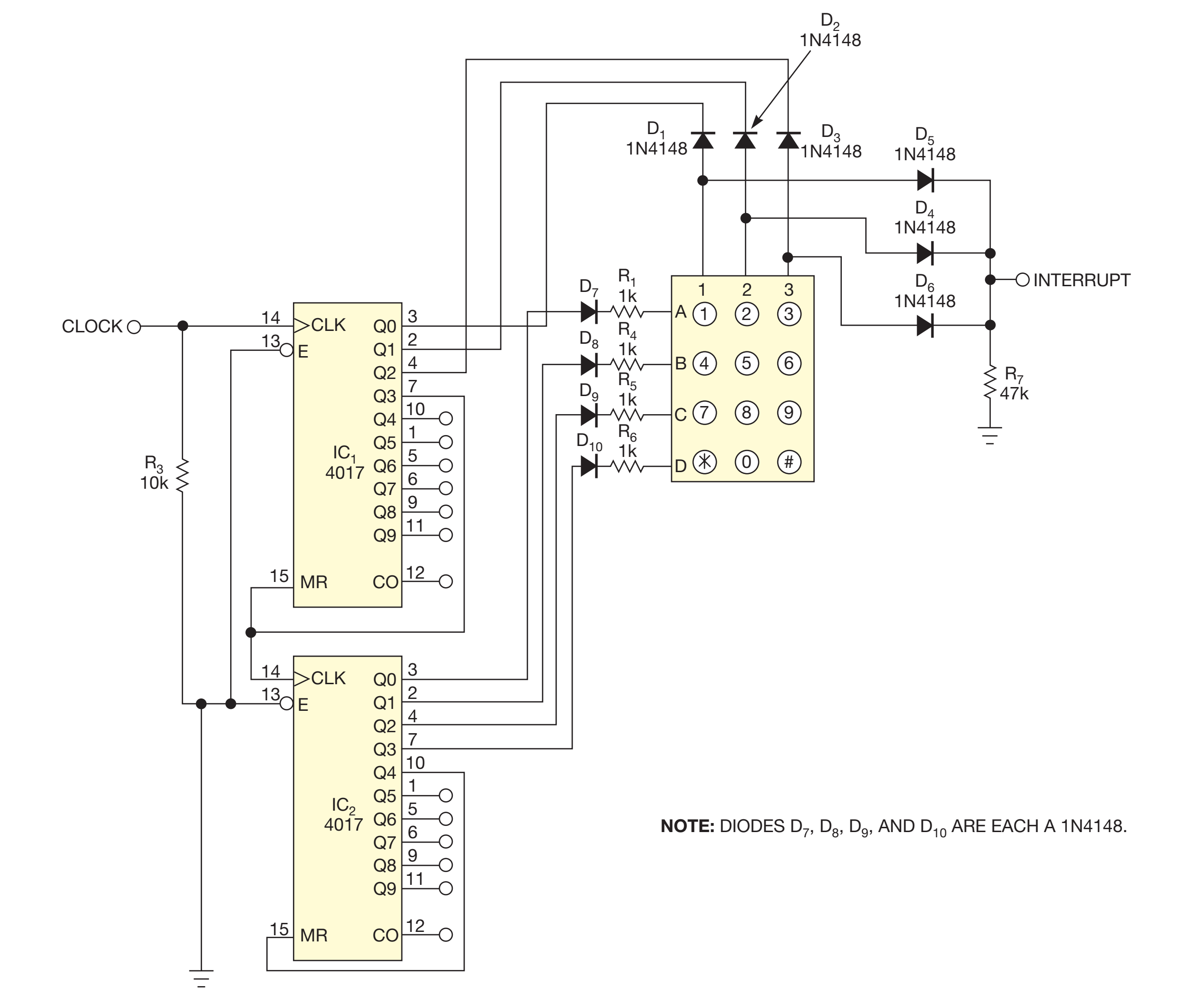


Figure 1 This circuit for a 4×3 keyboard shows a more efficient architecture using two CD4017 Johnson counters with only two I/O pins.

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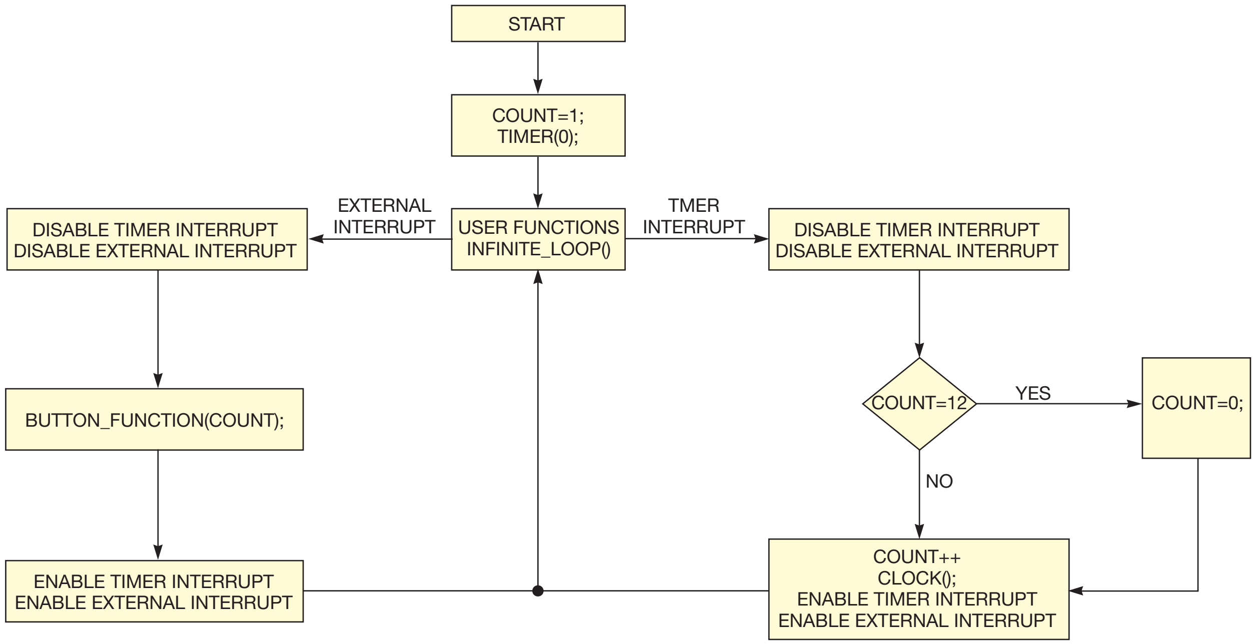


Figure 2 The clock count kept in the MCU increments as it generates clock pulses in intervals; this count is equal to the switch number focused at the moment.

other hand, assigning a unique voltage to each key using a resistor network becomes troublesome as the number of keys becomes high, which will lead to tight voltage margins. Then, as resistor values tend to change with temperature, the use of tight voltage margins can cause incorrect readings. Even switch bouncing can play a major role in producing incorrect voltages with this method. Another major drawback of this method is that it requires the presence in the MCU of an analog input pin.

The Design Idea described here addresses all of the above problems in an efficient manner and has several advantages: It requires only two I/O pins regardless of the number of switches connected; it does not require a special communication protocol; and it does not require an analog pin. The idea is based on two CD4017 Johnson counters, which are both common and inexpensive.

**Figure 1** shows the circuit for a 4×3 keyboard. $R_1$, $R_4$, $R_5$, and $R_6$ are used for current limiting; $R_7$, $D_4$, $D_5$, and $D_6$ form an OR gate.

The example described here shows how to implement this method to read a 4×3 matrix keyboard. One CD4017 is used to control the keyboard rows, while the other is used to control the columns.

The MCU generates a clock signal and feeds it to the counter IC controlling the columns. Initially, the 0th output of the column counter and row counter is at logic high, and the column counter increments as it receives clock pulses. At the fourth clock pulse, the column counter resets and simultaneously increments by one the counter controlling the rows. As the column controller resets, the row controller increments and the row controller resets with the fifth clock pulse from the column controller. As clock pulses generate, a count variable on the MCU should be incremented and should reset to one upon the fifth clock pulse to the row controller. The output of the keyboard is OR'ed and connected to an external interrupt pin of the MCU.

An interrupt occurs only if a button pressed when both the row and the column of the respective button are at the logic-high level. If either row or column of the button is logic zero, an interrupt will not occur.

When an interrupt occurs, the MCU reads the count value at the moment; that value is equal to the button just pressed.

The clock count kept in the MCU increments as it generates clock pulses in intervals; this count is equal to the switch number on the keypad that could generate an interrupt if pressed. The flow chart in **Figure 2** illustrates this scenario.

Note that even though this example shows a 4×3 keyboard, you can also read a 10×10 keyboard by using the remaining outputs of both 4017 counters. Furthermore, you can cascade additional 4017 ICs to expand the keyboard size as necessary. EDN

## REFERENCE

1 Rubasinghe, Aruna, "Read 10 or more switches using only two I/O pins of a microcontroller," *EDN*, Feb 28, 2013, www.edn.com/4408027.

# DESIGN NOTES

## A Robust 10MHz Reference Clock Input Protection Circuit and Distributor for RF Systems – Design Note 514

Michel Azarian

### Introduction

Designing the reference input circuit for an RF system can prove tricky. One challenge is maintaining the phase noise performance of the input clock while meeting the protection, buffering and distribution requirements for the clock. This article shows how to design a 10MHz reference input circuit and optimize its performance.

### Design Requirements

RF instruments and wireless transceivers often feature an input for an external reference clock, such as the ubiquitous 10MHz reference input port found on RF instruments. Many of these same systems include a provision to distribute the reference clock through the system. Figure 1 shows a common scheme, where the reference clock supplies the reference input to two distinct phase-locked loops (PLLs).

A well-designed, robust input would accept both sine and square wave signals over a wide range of amplitudes. It would maintain a constant signal level drive to the destination PLL inputs inside the system, even in the face of varied inputs. The exposed-to-the-world reference input port should have overvoltage/overpower protection. Most importantly, the inevitable degradation in the phase noise performance of the clock signal should be minimized.

### Design Implementation

The LTC®6957 is a very low additive phase noise (or jitter) dual-output clock buffer and logic translator. The input of the LTC6957 accepts a sine or a square wave over a wide range of amplitudes and drives loads at constant amplitude.

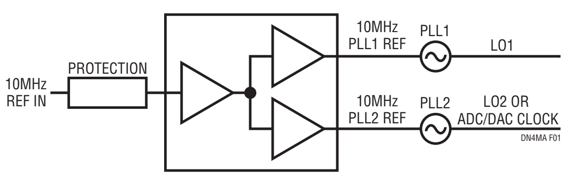


**Figure 1. Block Diagram of a Common Reference Input and Reference Distribution for an RF System**

The LTC6957 offers various output logic signal options: PECL, LVDS and CMOS (in-phase and complementary), allowing it to drive a wide range of loads. Figure 2 shows a 10MHz reference input circuit using the LTC6957-3, which produces two in-phase CMOS outputs.

The transformer shown in Figure 2 serves several functions. First, in conjunction with the Schottky diodes following it, it offers input overpower/overvoltage protection. The diodes limit the AC voltage seen by the LTC6957-3. The WBC16-1T can handle up to 0.25W power (3.5$V_{RMS}$ into 50Ω).

The transformer also isolates the connector ground—which is usually tied to the chassis of the RF system—from the internal analog ground of the system.

Furthermore, the transformer applies a voltage gain to the incoming signal, thus steepening the edges seen by the LTC6957-3. This helps reduce AM-to-PM noise conversion, which in turn limits phase noise degradation, especially with small input signals. The WBC16-1T has a voltage gain of four. It is possible to rely on the transformer's voltage gain of four, as opposed to its maximum and ideal power gain of one, because the LTC6957-3 presents a high impedance load to the transformer.

R1 and R2 can be adjusted in combination to match the input port to 50Ω. For small input signals, the diodes are off and the transformer sees a load of 804Ω in Figure 2. That load is reflected to the input as approximately 50Ω because of the transformer's primary-to-secondary impedance ratio of 16. For larger input signals, the Schottky diodes turn on, reducing the 604Ω resistance to nearly a short circuit. This degrades the reference input return loss—a problem that can be avoided by adjusting the values of R1 and R2, but there are trade-offs to doing so.

For large input signals, the input return loss can be improved by increasing R1's value, and reducing R2's

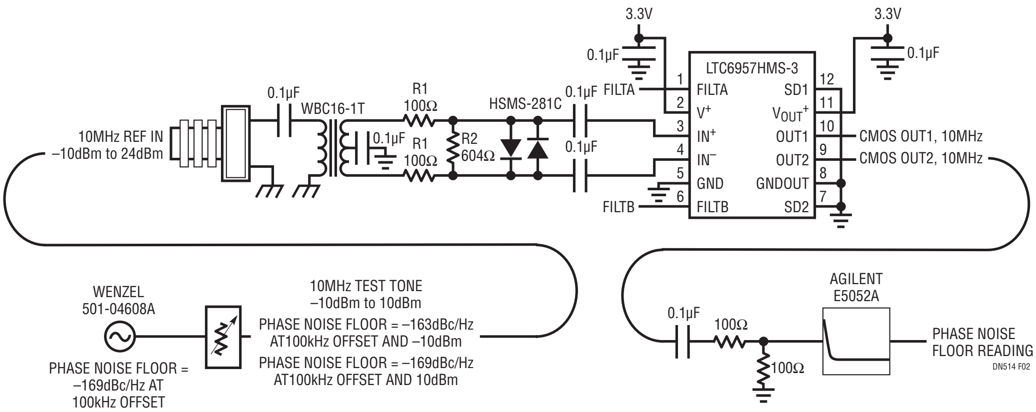


**Figure 2. 10MHz Reference Input Circuit Employing the LTC6957-3 with Front-End Protection, Shown with Test Signal and Phase Noise Measurement Set-Up**

value, such that their combined series resistance remains around 800Ω. However, since R1 appears in series with the signal, it adds noise to it. A larger R1 comes in combination with a smaller R2, resulting in a smaller portion of the signal appearing at the LTC6957-3's input, further degrading the phase noise performance. In other words, the designer can trade off phase noise performance for input return loss by playing with the values of R1 and R2. The values shown in Figure 2 strike an overall balance of these two performance metrics.

The AC-coupling capacitor separating the connector from the transformer in Figure 2 offers input protection from DC sources.

The LTC6957-3 has internal lowpass filters that can be selected via the FILTA and FILTB pins. This option strategically limits the bandwidth of the LTC6957's first amplifier stage, and hence, the additive phase noise of the circuit, especially when the input signal is weak as shown below.

## Performance

A 10MHz OCXO is connected to the input of the circuit via a step attenuator as shown in Figure 2. The reference input signal is varied between –10dBm and 10dBm while measuring the phase noise floor at the output of the LTC6957-3 with different input filter settings using the Agilent E5052A signal source analyzer. Figure 3 shows the phase noise floor of the 10MHz CMOS clock output of the LTC6957-3 measured at a 100kHz offset.

If the amplitude of the externally applied 10MHz reference signal is not known, pulling FILTA low and FILTB high yields good overall phase noise performance as shown in Figure 3. Nevertheless, performance can be optimized if the applied signal level at the input is measured and appropriate filter settings are applied.

The R1 and R2 values chosen in Figure 2 result in an input return loss of –9dB when the reference input's power is 0dBm into 50Ω. The return loss is better at lower input powers and worse at higher powers.

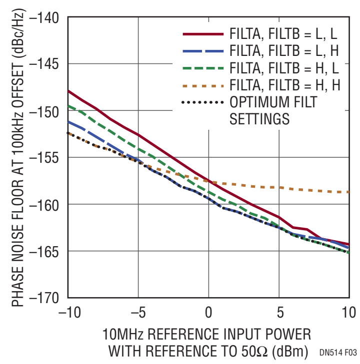


**Figure 3. 100kHz Offset Phase Noise Floor at the Output of the LTC6957-3 vs 10MHz Reference Input Power Level for Various LTC6957 Filter Settings**

## Conclusion

A robust, high performance 10MHz reference input circuit is built around the LTC6957-3. Features include a wide range of input signal type and level compatibility, protection and clock distribution with limited phase noise degradation. The circuit's phase noise and input return loss are evaluated and optimized. The LTC6957-3 simplifies the design process while achieving excellent overall performance.

**Data Sheet Download**

www.linear.com/LTC6957

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# Bender senses shocks

Don Sherman, Maxim Integrated Products, Sunnyvale, CA

With the aid of a simple mounting system and some soldered-on weights, a piezoelectric "bender" can detect mechanical shocks. The bender comprises a piezoelectric-ceramic element bonded to a thin brass disc. Such assemblies form the heart of many telephone annunciators and wrist-watch or panel-mounted alarms.

Depending on the mounting scheme, the bender can sense shocks in one axis (**Figure 1a**) or three axes (**Figure 1b**). For one-axis sensing, solder one edge of the bender to a mounting bolt. Opposite the mounting bolt, solder a weight to increase the bender's sensitivity. A small hook affixed to the mounting substrate limits motion so that the brittle piezoelectric element will not crack.

For three-axis sensitivity, solder one edge to a mounting bolt as before. At the other edge, solder a flat-head bolt that points away from the mounting substrate. Use a pair of jam nuts to increase the assembly's polar moment of inertia. The jam nuts' position determines the bender's sensitivity.

In both cases, apply your soldering iron as briefly as possible to the bender to avoid damaging the piezoelectric element's bond to the brass disc.

**Figure 2** shows a simple alarm circuit. Giving the bender a good smack will develop several volts across $R_1$, the 10-MΩ resistor. The dual-timer IC, $IC_1$, will then pulse the output alarm for one minute at a 1-Hz rate. The alarm has its own driver circuit and sounds a piercing 90-dB tone when energized.

The bender and alarm are both available from Projects Unlimited, Dayton, OH. EDN

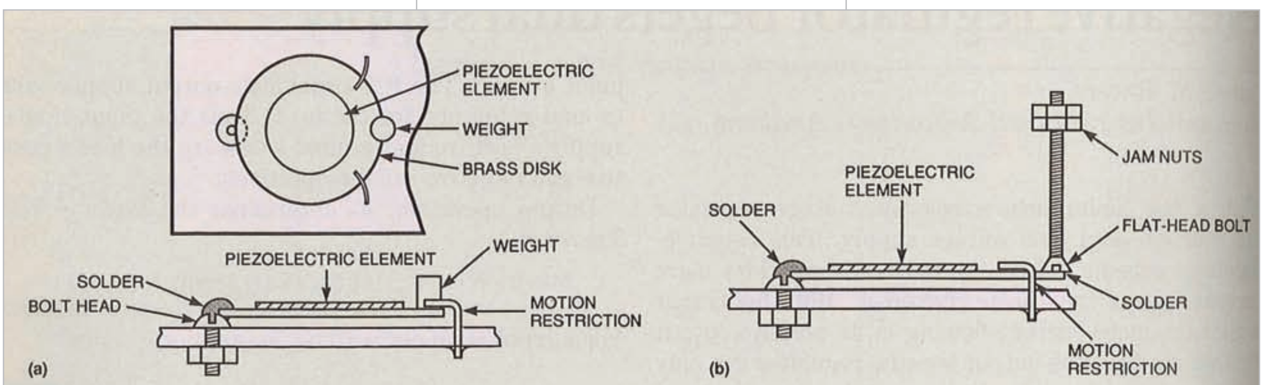


Figure 1 Solidly mounting one end of a piezoelectric "bender" and affixing a weight to the opposite edge transforms the bender into a shock sensor. Here, "a" is sensitive to vertical-axis shocks only; "b" senses shocks in all three axes.

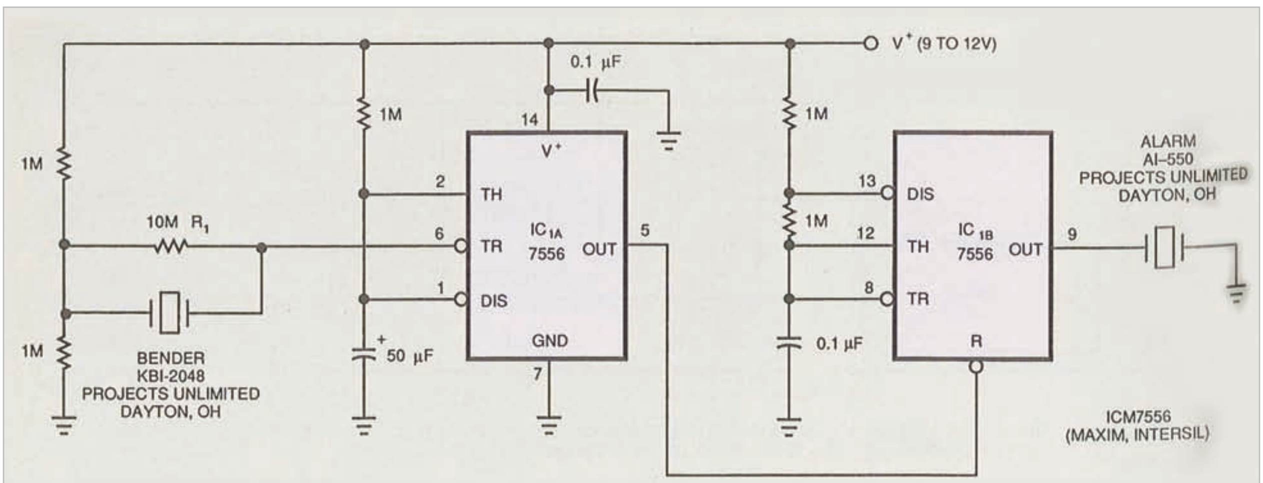


Figure 2 The circuit sounds a 1-sec alarm whenever you give the bender a good smack.

# supplychain

LINKING DESIGN AND RESOURCES

## Software supply chain's soft underbelly

With all the attention on counterfeit electronic components, it's easy to overlook the vulnerabilities of other supply chains in the computing industry. A recent Gartner report (http://gtnr.it/14hObdi) calls attention to the importance of investigating the supply chains of software, services, and even data. The report warns that the "IT supply chain" has become alarmingly insecure.

One example the report cites is the admission in May 2012 by Chinese mobile-phone maker ZTE that one model of its Android phone had a backdoor installed in its software. The backdoor, which was found only in smartphones shipped to the United States, allowed installation of arbitrary applications and full access to any data stored on the phone. There could be other smartphones with similar vulnerabilities, says the report.

To protect against such hacks, corporations need to institute a formal IT supply-chain risk-management program, including investigation into the robustness of software-update mechanisms, says the report. For smartphones, in particular, it recommends asking all hardware and software suppliers for specifics on how they update firmware and software.

The Gartner report notes that just because this happened in a ZTE phone doesn't necessarily mean that the company had a nefarious motive. Indeed, the backdoor could have been "developed and installed by a disgruntled or rogue employee, assuming he or she circumvented source-code control and deployment management systems."

Or maybe it didn't come from ZTE at all. *The Economist* reported recently that when an American telecommunications company investigated a Chinese company acquired by one of the American company's vendors, it found the Chinese company to be clean. It turned out, however, that the Chinese company was outsourcing software development to a firm that was a front for Russian intelligence (http://econ.st/110Fmif).

That's a perfect example of why today's convoluted IT supply chain is increasingly insecure. The Gartner report says software supply chains can be easy targets because of increased use of outsourced software development. Even if a company uses its own developers, many use third-party libraries and frameworks that include open-source software, which can be vulnerable. In addition, with the use of increasingly active code at many layers, the use of software-based platforms atop operating systems provides new opportunities to insert backdoors and vulnerabilities. Finally, content itself can be used to attack. Exploits against hidden application-layer vulnerabilities can change an innocent piece of code into an attack vector.

Are you doing what you should to ensure the integrity of your software supply chain?

**—by Tam Harbert**

*This story was originally posted by* EBN: *http://bit.ly/ZRkSFK.*

GREEN UPDATE

### THE FUTURE OF CLEAN MANUFACTURING IN THE UNITED STATES

**Improving supply-chain** and manufacturing methods, and educating consumers to demand greener electronics as well as less packaging, is a good start for any supply chain wishing to contribute responsibly to a cleaner environment while doing its business. I was pleased to learn that the US Department of Energy (DOE) on March 26 launched the Clean Energy Manufacturing Initiative (CEMI) (http://1.usa.gov/12RC2Ln). The initiative focuses on "growing American manufacturing of clean energy products and boosting US competitiveness across all sectors through major improvements in manufacturing energy productivity."

So, what does the CEMI mean for the supply chain? According to the Solar Foundation, roughly 30,000 jobs in the solar sector in the United States are in manufacturing. In addition, the US wind supply chain has grown in recent years. Nearly 70% of the component parts of wind installations in the United States are being sourced domestically. All of this effort translates into a means of reducing local and global air pollution. It also contributes to a 7.9% reduction in computers and electronics in the supply chain.

According to the DOE, with the recent opening to manufacturers of a $35 million, state-of-the-art Carbon Fiber Technology Facility (CFTF) in Oak Ridge, TN, clean-energy companies and researchers are provided with a test bed for the development of less expensive, better-performing carbon-fiber materials and manufacturing processes. The CFTF will help manufacturers lower the cost of producing their products, which, in turn, will reduce end-consumer prices.

The new facility represents a great potential in positioning the United States in the growing international carbon-fiber manufacturing sector. Finally, what is good for the environment is good for us. **—by Susan Fourtané**

*This story was originally posted by* EBN: *http://bit.ly/110Cmm2.*


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# SENSORS/TRANSDUCERS

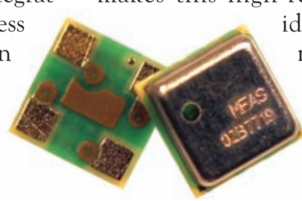

## Programmable Hall switch from Diodes Inc extends design flexibility

The AH1898 programmable omnipolar Hall effect switch enables designers to use the same contactless detection circuit in multiple applications or with different field strengths. It features a band-select pin, allowing device sensitivity to be changed to one of two predefined magnetic sensitivity ranges, and has been optimized for use across a 1.6 to 3.6V low-voltage supply range with a hibernating clocking system to minimize power consumption. The device helps extend portable battery-cell lifetime with an average supply current of 4.3 μA (typical) at 1.8V. The AH1898 has an 8 kV ESD rating on supply and output pins, and a chopper stabilized design that delivers temperature stability over the operating range of –40 to +85°C, absolute minimum switch point drift, and enhanced immunity to RF noise and physical stress. The switch is available in the miniature 0.8×0.8-mm CSP package, with a 4-pin footprint and integration of pull-up resistors that result in reduced external component counts and simplification of PCB layouts. Prices start at 20 cents (10,000).

**Diodes Inc,** www.diodes.com

## Measurement Specialties offers digital barometric sensor in a compact QFN package

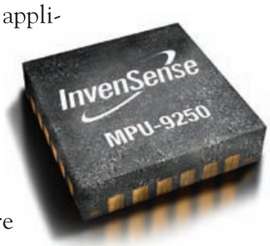
The MS5637 digital barometric pressure sensor uses an integrated 24-bit ADC to precisely process pressure and temperature values in as little as 0.5 msec. A low power draw of 0.6 μA combined with a compact footprint of 3×3×0.9 mm makes this high-resolution module ideal for handheld, mobile devices. The MS5637's high-resolution temperature output enables operation as an altimeter or thermometer, and a high-linearity pressure sensor provides an altitude resolution of 13 cm at sea level for accurate measurements. Standby power is less than 0.15 μA at 25°C, supply-voltage ranges from 1.5 to 3.6V, and the ADC interfaces with microcontrollers via an $I^2C$ interface. The sensor operates from 300 to 1200 mbar over an extended temperature range of –40 to +85°C, with a long-term stability of ±1 mbar per year. Pricing for the MS5637 is less than $1 (1 million). Delivery time is dependent upon quantity.



**Measurement Specialists,**
**www.meas-spec.com**

## Nine sensors included in contextual awareness kit from InvenSense

A contextual awareness system development kit (CA-SDK) combines nine sensors and software on a 1.71×1.46-in. PCB configured into a wearable watchband. Wearable sensor innovations enable applications and products to offer orientation tracking and activity recognition. It can also be used in sleep monitoring, posture detection, and immediate environment detection applications. The kit features the MPU-9250 nine-axis MotionTracking device and InvenSense's algorithms for MotionFusion. It incorporates temperature, humidity, UV light, proximity, pressure, and light sensors, and comes with an embedded motion-processing library, USB port, onboard memory, and Bluetooth module. The MPU-9250 will be available in the summer of 2013, and prices start at $5.50 (1000).

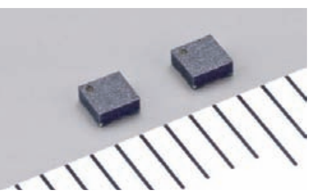



**InvenSense,** www.invensense.com

# productroundup

## Alps doubles dynamic range of geomagnetic sensor

Housed in a 1.6×1.6×0.7-mm LGA package, the HSCDTD008A geomagnetic sensor is 60% smaller than earlier HSCD series models, and delivers two times the dynamic range. The device is capable of measuring magnetic field strengths of ±2.4 mT on each of its three axes and provides an output resolution of 0.15 μT/LSB. Geomagnetic sensors in the HSCD series are intended for use in compact electronic equipment. The size reduction and wider range are the result of applying a thin-film process and magnetic simulation technology. Low noise and high resolution are achieved in the ASIC, which employs an Alps-developed algorithm that allows calibration with a natural user action. The sample price for the HSCDTD008A is 1000 yen, or about $10.



**Alps Electric, www.alps.com**

## USB power sensor covers dc to 110 GHz

The NRP-Z58 power sensor boasts a frequency range from dc to 110 GHz and a measurement speed of 300 readings/sec in buffered mode. It also provides a power measurement range of –35 to 20 dBm. For relative measurements, such as amplification and reflection, the NRP-Z58 achieves linearity of 0.007 dB (0.16%) up to 67 GHz and 0.010 dB (0.23%) between 67 and 110 GHz. The device connects directly to a PC via a USB port in order to analyze measurement results, and can be used in combination with the NRP2 base unit or with nearly any signal generator, signal and spectrum analyzer, or network analyzer from Rohde & Schwarz. The 1-mm coaxial plug screws securely onto the jack of the measuring instrument to provide high measurement reproducibility.

**Rohde & Schwarz, www.rohde-schwarz.com**

## Low-noise MEMS microphone from Analog Devices targets hearing aids

The ADMP801 MEMS electret condenser microphone measures 7.3 mm$^3$, produces a low EIN (equivalent input noise) of 27 dBa SPL (sound pressure level), and consumes just 17 μA with a 1V supply. The device is an analog-output, bottom-ported omnidirectional MEMS microphone designed specifically for hearing aids. Housed in a surface-mount LGA package that is 3.35×2.50×0.98 mm, the microphone is reflow-solderable with no sensitivity degradation. The ADMP801 is $10.78 (1000). An evaluation board, the EVAL-ADMP801Z-FLEX, sells for $95 each.

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

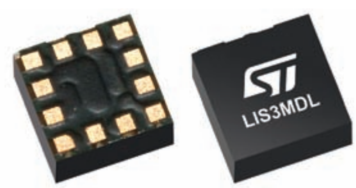
## Bourns Inc expands non-contacting rotary position sensor line

The AMS22U and AMM20B non-contacting rotary position sensors use magnetic Hall effect technology in such applications as patient platform position feedback, pneumatic control valve position feedback, actuator motor position feedback, life/shuttle suspension, and tilt control feedback. The AMS22U is a single-turn sensor that offers a rotational life of up to 100 million cycles. It features a 1/8-in. shaft supported by dual ball bearings and a factory-programmable electrical angle from 10 to 360 degrees. The AMM20B is a multi-turn model that features a rotational life of up to 50 million cycles, depending on the product and application. It has a slim-profile package, 12-bit resolution, and a factory-programmable electrical angle from 1080 to 3600 degrees. The sensors are available now in sample and production quantities. The AMS22U is priced at $35 each (1000), and the AMM20B is priced at $24 each (1000).

**Bourns Inc, www.bourns.com**

## ST launches single-chip magnetometer

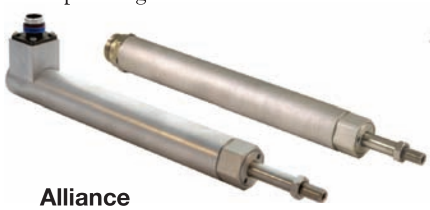
The LIS3MDL is a high-performance, standalone three-axis magnetometer that delivers flexibility for sensor-fusion designs. Housed in a 2×2×1-mm package, the sensor is used in mobile phones, tablets, and personal navigation devices and is suited to indoor navigation as it can calculate dead reckoning without satellite signals. The magnetometer can be combined with other discrete sensors, such as the three-axis MEMS accelerometer or the three-axis MEMS gyroscope, to build sensors with as many as nine degrees of freedom. Mass production is scheduled for Q2 2013, and unit pricing is 60 cents (1000).




**STMicroelectronics, www.st.com**

## Alliance Sensors introduces industrial LVDTs

The LA-25 series LVDTs are designed for harsh environments. The robust position sensor has a 1-in. OD aluminum housing with a wall that the company claims is five times as thick as competitive products. It is terminated with either a cable in a cord grip or a heavy-duty axial connector. The housing features a threaded end nose that can go through a 0.88-in. hole in a bulkhead or bracket up to 0.13-in. thick for single-hole mounting. It is available in full ranges from 3 to 15 in., and rated IP-67, so it can survive industrial wash-downs and equipment cleaning. Pricing for the LA-25 series varies depending on connector and stroke.



**Alliance Sensors Group,** **www.alliancesensors.com**

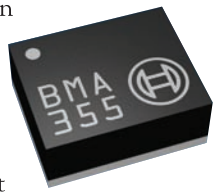
## Agilent Technologies' thermocouple power sensors are fast, accurate

The U8480 series of USB thermocouple-based power sensors delivers a measurement speed of 400 readings/sec, with the ability to measure down to dc. USB functionality enables the sensor to plug directly into a PC or USB-enabled instrument to allow power measurements without an external power meter or power supply. The U8480 series provides power linearity of less than 0.8%, a built-in trigger function to synchronize measurement capture, and an internal calibration function that reduces measurement uncertainty. The U8481A model covers frequency ranges of 10 MHz to 18 GHz, and the U8485A covers 10 MHz to 33 GHz, with the option to expand the frequency range from 10 MHz down to dc. The U8481A and U8485A thermocouple power sensors cost $2835 and $4028, respectively, while dc-coupled versions cost $3043 and $4236, respectively.

**Agilent Technologies,** **www.agilent.com**

## Bosch unveils consumer MEMS

The BMA355 three-axis accelerometer measures 1.2×1.5×0.8 mm$^3$ and provides ultralow-power performance while an integrated interrupt engine permits 12-bit resolution in small devices. For larger devices, the accelerometer includes on-chip motion detection, portrait-landscape orientation-switching, laying-flat detection, tap/double-tap sensing, shock detection, and free-fall protection. The BNO055 is the first member of a new Bosch Sensortec family of Application Specific Sensor Nodes, and implements a nine-axis sensor and sensor fusion in a single package. The 5×4.5-mm$^2$ system-in-package includes a 12-bit accelerometer, a triaxial 16-bit gyroscope, a triaxial geomagnetic sensor, and a 32-bit microcontroller running Bosch's FusionLib software.




**Bosch,** **www.bosch.com**

## Stackpole current-sense resistors keep their cool

The BR series of through-hole current-sense resistors elevate the resistive element off of the PCB to maximize cooling and minimize the amount of heat at the board level. Devices in the series offer power ratings of 1, 3, and 5W with a choice of ±1%,

±2%, and ±5% tolerances; resistance values from 5 to 100 mΩ; a temperature coefficient of resistance (TCR) of 20 ppm/°C; and current handling to 70 A. Prices vary depending on size, resistance value, and tolerance, and range from 16 to 38 cents (1000) for the most common values and sizes. Lead time is eight weeks, with popular values and sizes available from stock.

**Stackpole Electronics,** **www.seielect.com**

## TI sensor-to-processor chip reduces video system size

The SN65LVDS324 sensor-to-processor chip lowers BOM, reduces system power consumption, and shrinks package size, while providing full HD, 1080p60 image quality in a host of video capture applications and video recording equipment. As a dedicated bridge for video streams between HD image sensors and processors, the chip typically consumes less than 150 mW and supports a wide range of resolutions and frame rates, up to 1080p60 full-HD to maximize system performance. It is also optimized to work with a variety of processors, including TI's OMAP and DaVinci processors for video applications. The SN65LVDS324 is available in a 4.5×7-mm, 59-ball PBGA (ZQL) package, and costs $2.65 (1000).

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

## EDN ADVERTISER INDEX



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# Debugging with a LASER

DANIEL VASCONCELLOS

Counting the printers, media players, power-tool aiming devices, and laser pointers used to tease the cat, I have more than a dozen lasers in my house, and many more around my office. I certainly didn't foresee that happening at the time of my first encounter with laser technology 50 years ago. My first full-time job was as an electronics technician for a large military-electronics contractor. And among my first assignments was testing a remarkable new thing called a laser. The laser was so new that it was spelled in all caps like an acronym, sometimes even with periods between letters. An office joke was that "L.A.S.E.R." stood for *Latest Angle to Secure Expensive Resources*.

Another technician and I were put in a lab with a laser and left to test it day after day. The laser we were testing was quite something for its time—a 5W pulsed ruby laser with a flash-tube exciter. The ruby rod and a straight flash tube ran down the two foci of an elliptically bored-out aluminum cylinder, which itself was wrapped in cooling tubes. The laser, about the size of a 2-lb coffee can, looked like something straight out of a Buck Rogers movie.

Our job was to record data from about 10,000 laser test firings. Heat dissipation, then as now, was the limiting factor on laser power, and measurements from a dozen thermocouples were what we logged, by hand.

The testing took place during a toasty July. The air-conditioning at our lab couldn't keep up with the load, and open windows, fans, and T-shirts became the defenses against the weather. The open windows and heat seemed to bring out the flies. Nobody ever figured out the exact source of the flies, but they were everywhere. By early afternoon each day, dozens of large flies found their way to our side of the window screens.

In conditions made worse by the heat and the real bugs, the boredom got to us: Fire the laser, read the instruments, write down the data, wait for the flash-tube capacitors to recharge, swat the flies.

There was little break from the tedium, and our idle minds quickly turned to finding out what the laser could do. The output of the 5W laser was normally dumped onto a steel plate—safe but dull. We sought more exotic targets. We were disappointed that we could not make our laser drill a hole in a razor blade, the standard "wow" demonstration of laser power in the early days of the technology. The best we could do was create a pretty, blue-ish dot on a Gillette single-edge blade. But our laser could poke a clean hole through stacked sheets of paper. Twenty-seven sheets was our record.

## OUR IDLE MINDS TURNED TO FINDING OUT WHAT THE LASER COULD DO.

What I don't recall is which of us came up with the idea of the laser fly swatter. The laser turned out to be remarkably good at eliminating the pesky flies. Our technique was quite refined: We shut one of the big, double-hung windows, trapping the flies between the glass and the screen to restrict their movement. We aimed the laser at a fly, unconcerned in the days before OSHA about exactly where the laser beam traveled on its way out of the lab. Flash! Crack! One less fly.

About a week after the end of lab testing, however, we had to answer some tough questions from our boss. Did we have any idea, he asked, what might have caused the dozens of small holes that now peppered the window screens in that lab?

With experience I have become much more safety conscious, and I'm now careful to consider a full range of consequences—both intended and unintended—when testing new systems. EDN

*Richard Davis is a telecommunications engineer working in mobile-phone services, including E911 and location services.*


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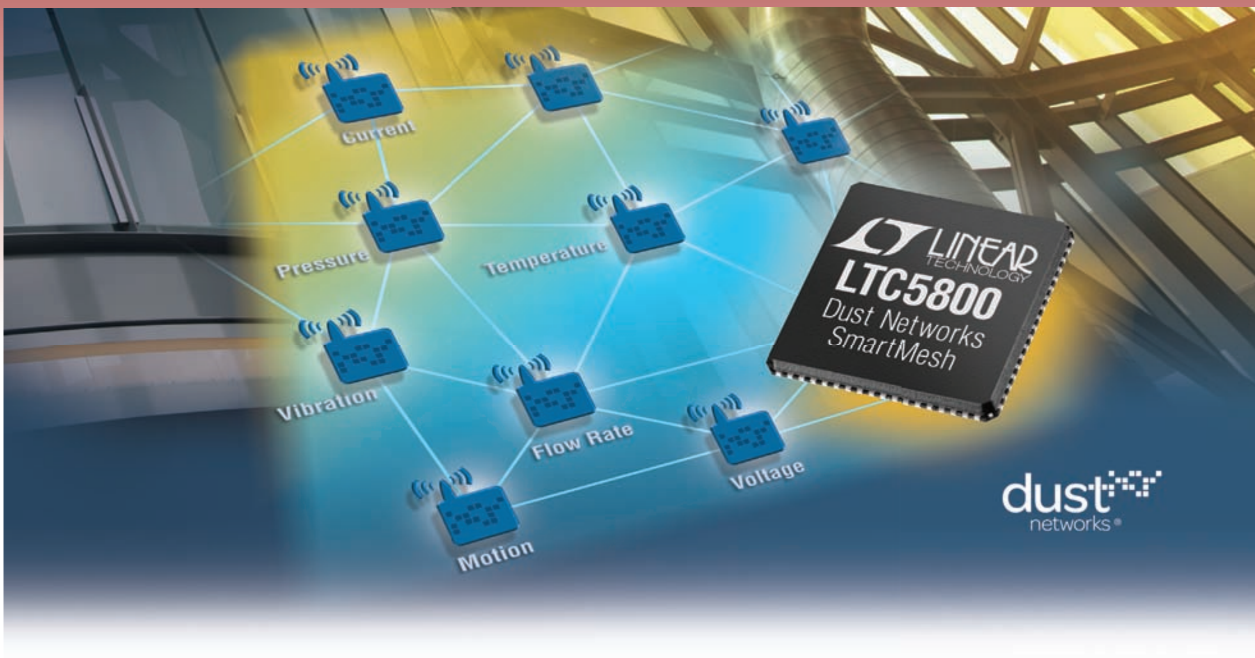


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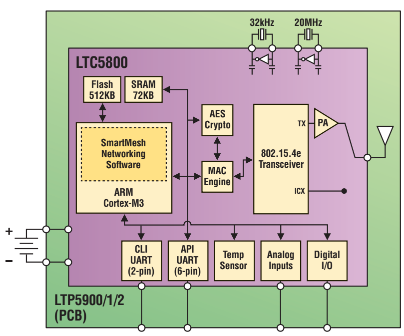


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