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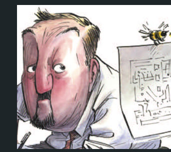

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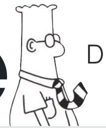

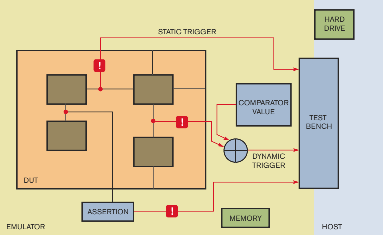

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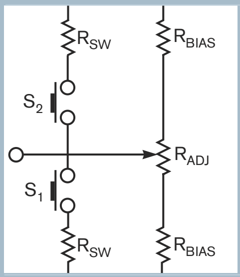

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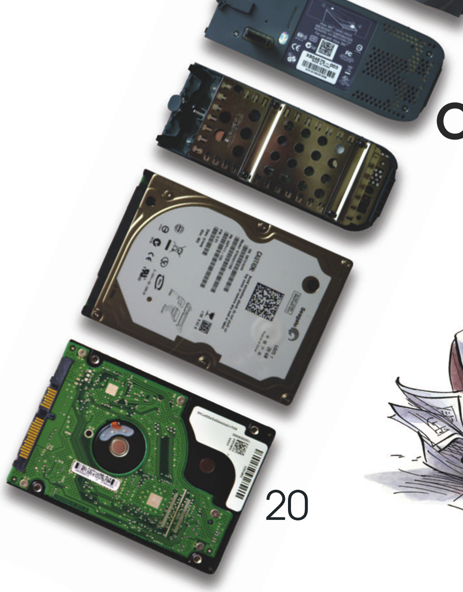

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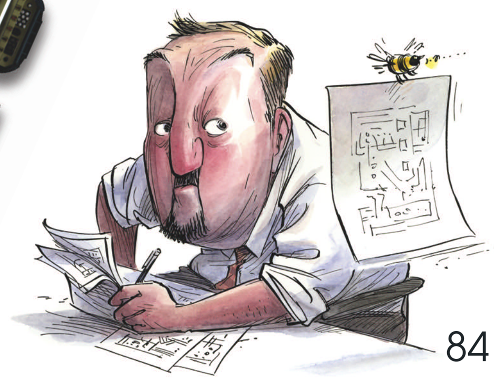

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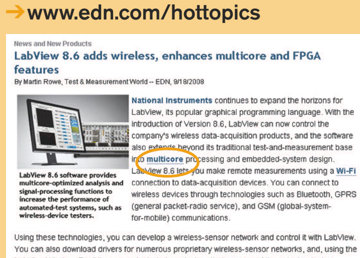

News and New Products

LabView 8.6 adds wireless, enhances multicore and FPGA features

By Martin Rowe, Test & Measurement World -- EDN, 9/18/2008

LabView 8.6 software provides multicore-optimized analysis and signal-processing functions to increase the performance of automated-test systems, such as wireless-device testers.

National Instruments continues to expand the horizons for LabView, its popular graphical programming language. With the introduction of Version 8.6, LabView can now control the company's wireless data-acquisition products, and the software also extends beyond its traditional test-and-measurement base into multicore processing and embedded-system design. LabView 8.6 lets you make remote measurements using a Wi-Fi connection to data-acquisition devices. You can connect to wireless devices through technologies such as Bluetooth, GPRS (general packet-radio service), and GSM (global-system-for-mobile) communications.

Using these technologies, you can develop a wireless-sensor network and control it with LabView. You can also download drivers for numerous proprietary wireless-sensor networks, and, using the LabView Wireless Toolkit, you can test wireless devices that use any of these technologies.

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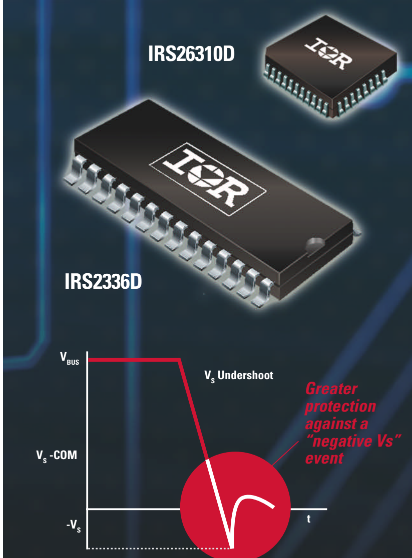

BY RICK NELSON, EDITOR-IN-CHIEF

March Madness

March Madness. Was that about a series of college basketball games last month or the hype leading up to the April 3 launch of Apple's iPad? As I write this on April 4 on a conventional laptop computer, I still don't know which team will triumph in college basketball's national-championship tournament, but the iPad did hit the streets on April 3, as Apple planned.

IMAGE COURTESY OF APPLE

Hopes are high for the success of the device. "Market researchers at iSuppli Corp believe the long-awaited tablet device has the potential for impressive demand, now and in the future," writes *EDN* Contributing Editor Ann Steffora Mutschler.

According to research-and-advisory-firm iSuppli, the tablet's "attractive design, compelling applications, and multitouch capability will help to offset the initial omission of Adobe Flash from the device." The company expects worldwide iPad sales to reach 7.1 million units this year, doubling to 14.4 million next year and nearly tripling to 20.1 million in 2012. The company also notes this forecast is conservative and that "feature enhancements along with Flash support could boost sales beyond its preliminary expectations."

I'll grant the device's attractive design, even though, as I've said before, it's not for me. I need the full capabilities of a laptop when I'm on the road, and I have no desire to drag an iPad along with my laptop, iPod, cell phone, and digital camera. Nevertheless, I'm as interested as anyone else to see what's under the hood.

Fortunately, Senior Technical Editor Brian Dipert's companions at iFixit were among the mad crowds waiting in line overnight, and they secured an iPad and promptly took it apart to see what's inside. You'll find Brian's comments along with pictures and links to more information on iFixit's site at the Brian's Brain blog at www.edn.com/blog/400000040/post/1230053723.html.

The folks at Chipworks, the reverse-engineering and patent-infringement-analysis firm that writes *EDN*'s online "IC Insider" articles, were also able to secure an iPad. By noon on April 4, Chipworks had surmised that Apple focused on industrial design and usability and employed conservative, low-cost technology under the hood.

Chipworks found that Apple is using not the Texas Instruments do-all touchscreen controller that it used in the iPhone 3G but instead a three-chip approach that the iPhone 2G employs. Two 8-Gbyte Samsung K96CG08U1M MLC (multilevel-cell) NAND-flash-memory chips provide 16 Gbytes of memory. The Apple A4 processor, like Apple's iPhone processors, uses package-on-package technology with two 128-Mbyte Samsung DRAM dice and an STMicroelectronics accelerometer.

The iPad seems to be a big iPod instead of a little laptop. "Essentially, the iPad is an iPod Touch with an enhanced display and much increased battery life," says Dick James, senior technology analyst for Chipworks. "The iPhone 2G-style touchscreen architecture perhaps reflects the date of design start, and we will likely see Texas Instruments get the design win in the next-generation iPad, especially as we have seen the same chip in the latest iPhone, iPod Touch, and Magic Mouse."

So, I reiterate my position that an iPad is not a laptop killer. I don't see myself writing a 5000-word article on an iPad, just as I don't see myself jogging while listening to tunes on an iPad. Nevertheless, a sizable number of people don't need frequent access to the full power of a laptop, and the iPad might be well-positioned to make significant inroads among the netbook crowd, for example. It will be interesting to see whether iPad sales meet iSuppli's projections—and among what demographics. From an engineering perspective, it will be even more interesting to see what technologies Apple incorporates in future versions.**EDN**

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EDITED BY FRAN GRANVILLE

pulse

INNOVATIONS & INNOVATORS

4.2G-sample/sec AWG achieves both high resolution and high bandwidth

Agilent Technologies has announced the 81180A AWG (arbitrary-waveform generator, a new generation of instrument that the company calls the first to offer both high bandwidth and high resolution. Until now, when selecting an AWG, you had to choose between bandwidth and signal quality. However, many of today's applications, such as those in aerospace and defense, demand both high bandwidth and high signal quality. For example, to ensure measurement repeatability in such applications, wide bandwidth is not sufficient; your generator must also offer excellent dynamic range. Transferring large volumes of digital data at high speed also requires broadband modulation with wide dynamic range. With an output-rate range of 10M to 4.2G samples/sec, the 81180A achieves both 12-bit vertical resolution and bandwidth as great as 1.5 GHz.

Three levels of sequencing combine with a 64M-point memory to allow you to synthesize complex signals. The dynamic-control connector lets real-time applications control the waveform and allows external selection of sequences. The 81180A works with Agilent's Performance vector signal generator for in-phase- and quadrature-system applications; provides maximum bandwidth and flatness for direct-RF applications to bandwidths as high as 1.5 GHz; and works in the time domain to provide waveforms that exhibit low overshoot and jitter despite rise and fall times as short as 600 psec, measured from 10 to 90% of the signal swing.

The unit features versatile signal generation, with broad, flat frequency response, low overshoot, and the signal quality necessary for testing complex devices. It also offers high-bandwidth signal generation with low harmonic distortion and flat response to ensure reliable measurements. It integrates with Agilent's Signal Studio, The MathWorks' (www.mathworks.com) Matlab, and National Instruments' (www.ni.com) LabView software to provide a complete signal-generation approach and easy integration into the user's environment. US prices for the Agilent 81180A AWG start at $46,500.

–by Dan Strassberg

Agilent Technologies, www.agilent.com/find/81180.

FEEDBACK LOOP

"You can think much faster on 'speed,' but then you die. So the trade-off there is fairly harsh."

—Engineer William Ketel, in *EDN*'s Feedback Loop, at www.edn.com/article/CA6718485. Add your comments.

The compact 81180A AWG includes a front-panel graphics display that provides a scopelike view of the wideband high-resolution waveforms the instrument synthesizes.

Hynix, Innovative Silicon show floating-body DRAM on bulk silicon

DRAM giant Hynix and IP (intellectual-property) vendor Innovative Silicon recently announced work that offers an alternative future for the DRAM industry beyond the 30-nm half-pitch. Using 3-D transistors similar to FinFETs, the two companies have demonstrated behavior similar to the floating-body effect in SOI (silicon-on-insulator) planar transistors.

Innovative Silicon claims that the effect is strong enough and has the right characteristics to implement a capacitorless, one-transistor DRAM that can meet DDR3 voltage, power, and performance specifications both at and beyond the 50-nm half-pitch. By 30-nm, according to Jeff Lewis, the company's senior vice president of marketing and business development, the floating-body memory will have a significant cost advantage over conventional stacked-capacitor DRAM.

Today's floating-body memory, which the company calls Z (zero-capacitor)-RAM, depends upon a retained charge in the electrically isolated region between the channel and the insulating substrate of a planar SOI transistor. When the transistor conducts in a high-voltage mode, charge accumulates in this region, altering the transistor's threshold voltage. Because there is no path for the charge to escape, the threshold voltage remains altered until a resetting current removes the charge. A small read voltage can sense the state of the threshold. Thus, a single transistor serves as a bit cell, with one pair of voltages for set/reset and a lower voltage for sensing.

Z-RAM requires SOI wafers, whose initial cost is higher than the cost of bulk wafers. Another cost-related issue is that Z-RAM uses a relatively high voltage for writing, necessitating on-chip charge pumps and increased power consumption. A third issue is that the planar SOI cell is subject to gradual disturbance from activity in nearby cells, limiting the time the cell can retain data between refreshes—the so-called dynamic retention time.

The new cell design addresses all of these issues. The current path, Lewis says, is vertical between two N+ regions. He does not go into further detail about the operation of the device, but it appears that the transistor reads in partial-depletion mode, with channels forming just at the dielectric interface on either side of the fin. This approach would allow charge to accumulate and become trapped by the low mobility of the lightly doped material in the undepleted center of the fin, where it would act as a floating body to alter the device's threshold voltage. Presumably, a relatively small increase in gate voltage during conduction would be sufficient to extend the depletion regions and sweep away the trapped charge.

> "The effect has the right characteristics to implement a capacitorless, one-transistor DRAM.

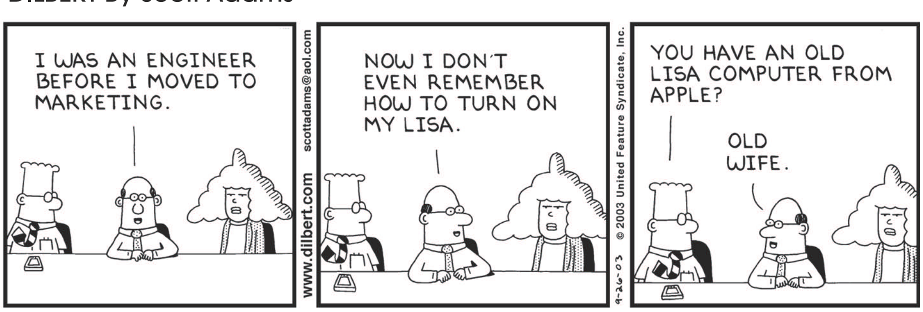
Because the bottom N+ region forms an isolating junction with the intrinsic bulk silicon beneath it, there is no need to fabricate the transistor on an insulating layer. Hence, the process could use bulk-silicon wafers, Lewis explains. For more on this technology, go to www.edn.com/100422pa.

–by Ron Wilson

▷**Hynix**, www.hynix.com.

▷**Innovative Silicon**, www.innovativesilicon.com.

DILBERT By Scott Adams



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RESEARCH INTO PLASMONICS MAY BOOST SOLAR-CELL EFFICIENCY

European research consortium IMEC (Interuniversity MicroElectronics Center) has announced the Prima partnership, whose goal is to improve solar-cell efficiency through metallic nanostructures. The metallic nanostructures absorb and intensify light at wavelengths due to the incoming light, creating "plasmonics," a collective oscillation of the electrons at the metal's surface.

According to the researchers, metallic nanostructures in solar cells can boost the absorption of light into the cell's photoactive material. With enhanced light absorption, it is possible to produce cells with less base material, thus yielding thinner and cheaper cells. Metal nanostructures can improve the absorption in various types of cells, including crystalline-silicon cells, those employing high-performance semiconductors, and organic and dye-sensitized solar cells.

Prima includes Imperial College (London), Chalmers University of Technology (Sweden), Photovoltech (Belgium), Quantasol (United Kingdom), and Australian National University (Australia).

–by Margery Conner

▶**Interuniversity MicroElectronics Center, www.imec.be.**

FPGA/DSP-development kit features RTL and model-based support

The Avnet Electronics Marketing operating group of Avnet Inc is now accepting orders for its $1995 Xilinx (www.xilinx.com) Spartan-6 FPGA/DSP-development kit. The kit includes a device-locked version of Xilinx's ISE (integrated software environment) Design Suite System Edition 11.4. Each Spartan-6 FPGA achieves as many as 45 billion MAC (multiply/accumulate) operations/sec to serve computationally intensive applications that demand high digital-signal-processing performance at low cost. The new kit represents a DSP-domain-specific extension of Avnet's Spartan-6 FPGA evaluation and development kits that the company introduced last fall.

"With the introduction of the Spartan-6 FPGA DSP kit, Avnet is offering its first DSP-development platform for customers who need greater performance and low cost," says Jim Beneke, vice president for global technical marketing at Avnet Electronics Marketing. "This kit will help our customers quickly learn the tool flows and design techniques involved in creating DSP-centric designs with Spartan-6 FPGA."

The development kit combines a scalable development board, DSP IP (intellectual property), DSP-development tools, and a preconfigured and fully validated Spartan-6-DSP-targeted reference design. This design serves as a basis for illustrating DSP techniques and design flows for the Spartan-6 class of signal-processing functions.

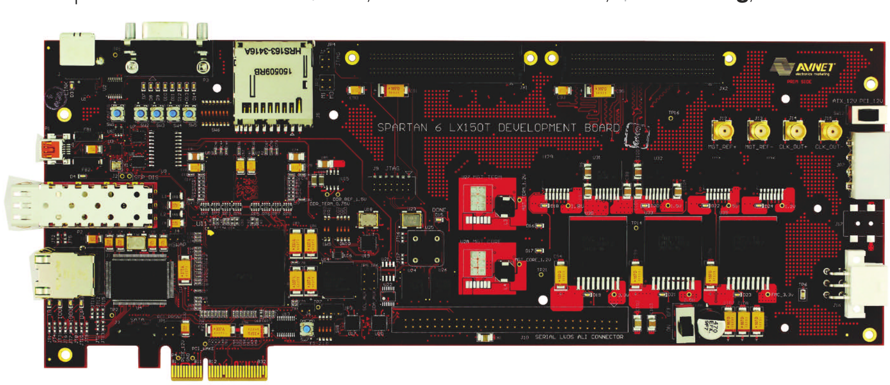
The kit includes both RTL (register-transfer-level) and model-based design support. Its model-based design flow uses The MathWorks' (www.mathworks.com) Matlab and Simulink to allow algorithm developers to create DSP-hardware designs using a familiar modeling environment without the need to learn RTL. For experienced RTL designers, the kit supports design techniques for creating efficient DSP hardware using ISE Design Suite and LogicCore DSP IP along with verification methods for comparing functional correctness against high-level algorithm models.

The reference design includes design-source files for RTL and Simulink, top-level system-integration RTL source files, a simulation environment, test benches, an implementation environment, place-and-route and timing-closure support, and tutorials highlighting recommended flows for design modification and integration.

> "The new kit represents a DSP-domain-specific extension of the Spartan-6 FPGA evaluation and development kits.

"Model-based design using Simulink eases the adoption of FPGAs and significantly accelerates FPGA implementation of signal-processing, computer-vision, and control-system applications," says Amnon Gai, a manager in The MathWorks' corporate-development and partner-programs group. "With Xilinx System Generator, it provides a turnkey rapid prototyping solution for engineers new to FPGAs without RTL design experience."**–by Rick Nelson**

▷**Avnet Electronics Marketing**, www.avnet.com.



The Spartan-6 FPGA/DSP-development kit includes a device-locked version of Xilinx's ISE Design Suite System Edition 11.4.

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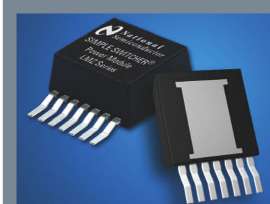
SWITCHER MODULES SIMPLIFY POWER-SUPPLY DESIGN

Devices in National Semiconductor's new LMZ series of Simple Switcher modules integrate a switching controller, power FETs, and an inductor into one package–a standard configuration with a die-attached paddle on the bottom, making soldering and assembly of the package more straightforward. The package achieves a thermal junction-to-ambient resistance of 20°/C/W when you mount the device on a 2.25×2.25-in. (5.8×5.8-cm), four-layer board, with 1-oz copper, 36 10-mil thermal vias, and no airflow.

The LMZ14203 supports maximum load currents of 3A with an input voltage of 6 to 42V. The parts operate over a −40 to +125°C range and come in a seven-lead, 10.16×13.77×4.57-mm TO-PMOD-7 package. The 5.5V-input LMZ10505TZ 5A costs $7.60; the 42V-input LMZ14203TZ costs $9.50 (500).–by Paul Rako

▶National Semiconductor, www.national.com.



National Semiconductor's new power modules use a standard IC package for simpler board layout and soldering.

IC allows remote voltage sensing without separate sense wires

Linear Technology Corp's new LT4180 virtual remote sense-controller IC detects losses in the wiring of remote power loads and adjusts a local voltage regulator to compensate for wiring losses. Because most remote loads have a storage capacitor, the IC takes advantage of the fact that the ac impedance of this capacitor is almost 0Ω.

The part multiplexes an ac signal that you set at 20 to 100 kHz onto the power lines to the load. The ac signal "sees" this remote storage capacitor as a short circuit, monitors the current of the ac signal into the load, and then calculates the dc impedance of the wires to the remote load. The device also compensates for changes in the ac impedance of the load, as long as the frequency of impedance change is sufficiently below the excitation frequency you set.

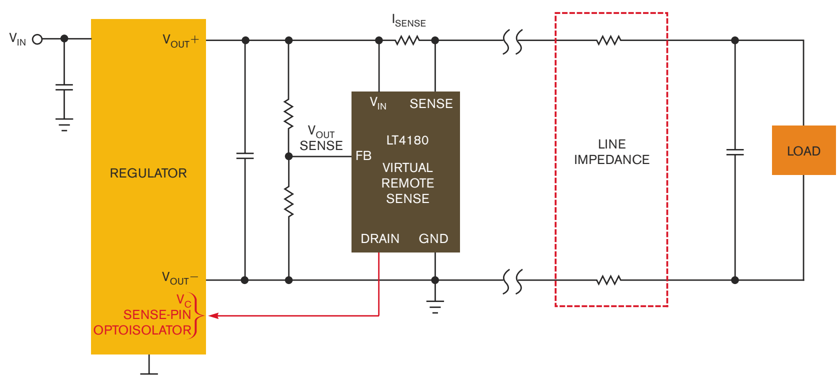
The IC works with any power-supply topology for both linear and switching regulators. Its 5-mA current sink drives an optoisolator to adjust the regulator when you use it in an isolated supply topology. You can use the IC's oscillator-output pin to synchronize a switching regulator or to drive an optocoupler for isolated-supply applications. By interfacing the part to the trim pin of power bricks, you can use it to replace the sense wires you would normally use with those modules.

The LT4180 works with 3 to 50V power-supply voltages and has soft-start and undervoltage and overvoltage-lockout features. You can modulate the excitation frequency in a spread-spectrum fashion to reduce EMI (electromagnetic interference). An internal voltage reference maintains ±1% accuracy over temperature.

The LT3092 comes in an SSOP-24 package. The LT4180MP version operates in the −55 to +125°C-junction-temperature range, and the LT4180E and LT4180I versions operate in the −40 to +125°C range. Prices range from $2.95 to $7.88 (1000).

–by Paul Rako

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



The LT4180 multiplexes a small ac signal onto the power lines so that it can calculate and compensate for voltage drops due to wiring resistance.

MODULAR LED-LIGHT SYSTEM TARGETS NEW INSTALLATIONS

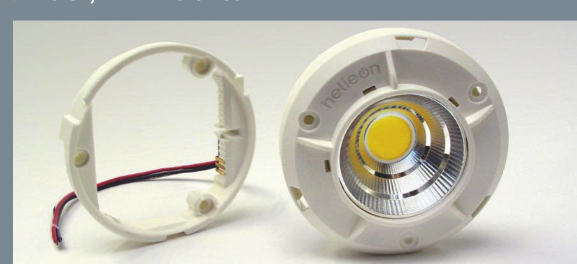
Retrofitting light systems with LEDs forces LEDs into the wiring networks and package configurations of another technology–typically, incandescent lighting. Triac dimmers and screw-in sockets are two examples of these retrofits. Although many LED-lighting companies are introducing retrofitted LED lights for the huge installed base of incandescents, Bridgelux and Molex have teamed up to introduce a new socket-and-module combination for new installations that don't require retrofits.

The companies' Helieon lighting-interconnect module includes a Bridgelux LED array, a lens, and an aluminum spreader on the back. The LED array can deliver 500 to 1500 lumens in 3000K warm white or 4100K neutral white, and the module's optics shape the light path to deliver narrow, medium, or wide flood-beam angles. You can change the white light unit's color temperature and beam focus by swapping out the LED module. The socket attaches the LED module to the ceiling or wall and delivers power to the fixture. OEM-lighting manufacturers will provide power-management components.

Prices start at $20 (high quantities) for the socket-and-module combination. Jason Posselt, vice president of sales at Bridgelux, estimates that a complete light fixture, including power-management components, could sell for $35 to $40, with that price dropping rapidly as the market matures and grows.–by Margery Conner

▶**Bridgelux, www.bridgelux.com.**

▶**Molex, www.molex.com.**



The Helieon modular LED-light system includes a Bridgelux LED array that can deliver 500 to 1500 lumens in 3000K warm white or 4100K neutral white.

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Takehiro Kamigama and Klaus Ziegler of TDK-EPC talk integration

TDK-EPC Corp, established in Japan in October 2009, combines TDK's components business with Epcos, a manufacturer of electronic components, modules, and systems. The combined company has 36,000 employees in 50 production plants plus a network of R&D facilities and sales offices around the world. *EDN* conducted an e-mail interview with Takehiro Kamigama (**photo**, left), president and chief executive officer, and Klaus Ziegler (**photo**, right), chairman.

What products will the combined organizations offer?

A (Kamigama) TDK is a manufacturer especially of commodity products, such as ceramic capacitors and inductive devices in the area of digital home appliances, IT equipment, and the automotive sector. Epcos provides tailor-made, customer-specific solutions based on components such as SAW (surface-acoustic-wave) filters, duplexers, RF modules, piezoelectric actuators, and aluminum electrolytic and film capacitors for telecommunications and automotive, industrial, and consumer electronics.

How will products from the combined organizations be branded?

A (Kamigama) The new company is now responsible for the combined components business of TDK and Epcos and will market its products under the well-established and unchanged product brands TDK and Epcos.

What is the status of the integration process?

A (Ziegler) The integration process is making good progress. The careful and simultaneously speedy continuation of the integration process is an indispensable prerequisite in being able to achieve our goals. Under their new corporate brand TDK-EPC, TDK and Epcos—outside Japan—still operate both product lines in parallel and process their businesses over the established sales channels. For the time being, order transactions, due to different processes and IT systems, also will be handled by the customer-service organizations of TDK or Epcos, respectively.

How will you handle sales?

A (Ziegler) The next step of the operative sales combination of both companies will be the definition of only one local salesperson in each case responsible for the product lines of TDK and Epcos. Sales are among those activities where the degree of integration must be increased both fast and continuously but with great care. The objectives are clear-cut: Increase the efficiency and implementation of the one-face-to-the-customer principle.

What are the implications for your international customers?

A (Ziegler) TDK has a very strong relationship with customers, especially in Japan and other countries in the Asian region. Epcos is very successful in its home market, Europe, but also complements TDK with a well-established presence in other countries, such as India and Brazil. Both partners have strong ties to leading North America-based customers. In all industries served and regional electronics markets, our combined business enjoys a stronger position than was the case previously for TDK and Epcos individually.

What technologies do TDK and Epcos bring to the organization?

A (Kamigama) TDK has an impressive track record in materials technology, in particular with regard to the development of ferrite and dielectric materials, and that is vital in process technology for bringing electronic components from the lab to the product stage. Epcos, on the other hand, excels in RF and module technology and applications expertise, all of which are vital for developing electronic-components solutions for a broad spectrum of applications.

What are your future plans?

A (Kamigama) Drawing on the synergies from these strengths, TDK-EPC aims not only to develop materials for a comprehensive range of electronic components, modules, and systems, but also to design device-manufacturing processes on the micron level and create the functions and form factors that are needed to make advanced end products a reality. TDK, for example, has accumulated expertise in thin-film-forming techniques for hard-disk-drive magnetic heads. This can be applied to further refine the range of SAW components and systems from Epcos. Conversely, the MEMS (microelectromechanical-systems) technology of Epcos is highly suited for TDK's development of electronic components. Ultimately, customers stand to benefit. The use of these synergies will improve our joint competitiveness.**—interview conducted and edited by Rick Nelson**

Rarely Asked Questions

Strange stories from the call logs of Analog Devices

Amplifier, Attenuator Or Both?

Q: Can I use an amplifier as an attenuator?

A: That's an interesting question. It seems counter intuitive on the surface, but there are actually some very good reasons why one might want to do this. One very useful feature of an op amp is impedance transformation. Using a passive attenuator in front of an op amp, or using the amplifier itself as an attenuator takes full advantage of this feature. A few precautions must be taken, however.

When using an amplifier as an attenuator, the amplifier has less than unity gain ($G < 1$). Therefore the assumption is the amplifier must be configured as an inverter. This is because the inverting gain equation is $G = –RF/RG$, while the noninverting gain equation is $G=(RF/RG)+1$. A quick inspection indicates that the only viable configuration for an amplifier/attenuator must be inverting. Well not necessarily; as mentioned previously a passive attenuator in front of a noninverting amplifier would work and provide a noninverted output. You could also use a differential amplifier or a difference amplifier; both use the gain equation $G = RF/RG$. So you can actually use both inverting and noninverting op amp configurations as attenuators … or as amplifiers.

I mentioned that some precautions must be considered when using amplifiers as attenuators. The first is when very large values of feedback resistance are used. This has several implications: more system noise, larger offset voltages and stability. Large feedback resistors, along with the amplifier's input and stray capacitance, can introduce a pole in the amplifiers feedback response, this causes additional phase shift, which reduces the amplifiers phase margin and can lead to instability.

A more important consideration is noise gain and how it relates to amplifier stability. Remember that it is the noise gain, not the signal gain that determines amplifier stability. The noise gain, which is the same for both inverting and noninverting amplifier configurations, is equal to the noninverting gain equation. For example if an inverting amplifier has a signal gain of -0.5, it still has a noise gain of 1.5. Once the noise gain is determined it can be transposed to the open loop gain and phase plot to check for phase margin and stability. If there is at least 45° of phase margin at the selected noise gain, the amplifier will work fine, if less than 45° you might have trouble. There are other ways of increasing noise gain while keeping signal gain low, but that will have to wait for another RAQ.

To Learn More About Amplifiers as Attenuators
http://designnews.hotims.com/27742-101

Contributing Writer John Ardizzoni is a Senior Application Engineer at Analog Devices in the High Speed Linear group. John joined Analog Devices in 2002, he received his BSEE from Merrimack College in N. Andover, MA and has over 29 years experience in the electronics industry.

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

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BY BONNIE BAKER

Comparing SAR and delta-sigma ADCs' throughput times

SAR (successive-approximation-register) ADCs combine with analog gain cells to yield a seemingly perfect fit for applications such as handheld meters, data loggers, automotive systems, and monitoring systems. In these systems, you can connect several types of sensing inputs as long as the analog gain is adjustable and has a front-end multiplexer. Try to think outside of this box. Many *EDN* readers claim that a delta-sigma converter can offer an alternative approach to these application problems.

Figure 1 shows an example of a SAR-ADC-based system. Evaluating the throughput time is the first challenge when comparing this system with a delta-sigma converter. The clock frequency for the SAR-ADC system depends on the device's system-clock requirements. The PGA (programmable-gain amplifier) requires a clock signal to program the appropriate gain and input channel. The ADC uses a clock signal to acquire and convert the data.

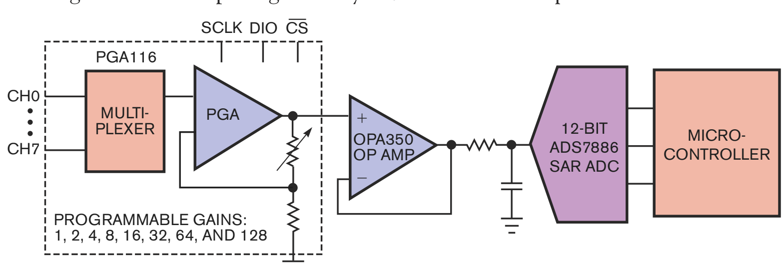

Figure 1 The PGA-SAR system has a multiplexer, an analog programmable-gain amplifier, a buffer, and a 12-bit SAR converter.

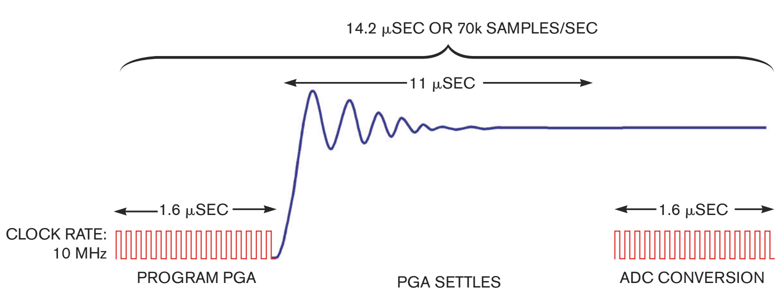

Figure 2 A clock rate of 10 MHz determines the PGA's programming time and the ADC's conversion/acquisition time.

Figure 2 shows the throughput-time diagram of **Figure 1**'s circuit. The PGA's output signal requires time to settle to 12 bits. Because this is a multiplexed system, assume that the input of the PGA's amplifier may see a full-scale step function. Finally, the operational amplifier settles fast enough that it is insignificant in this evaluation.

Assuming that the minimum clock speed is 10 MHz, programming the PGA and executing the ADC conversion require 16 clocks each, or 1.6 µsec. Combining these times with the PGA's settling time produces a data rate of 70k samples/sec.

Looking at the delta-sigma-converter option, you will find that multiplexed delta-sigma converters provide a fully settled signal at the end of one conversion. As a frame of reference, some multiplexed delta-sigma converters, such as Texas Instruments' ADS1258, produce fully settled signals at conversion rates higher than 23k samples/sec.

Which application system wins the timing race? The SAR-ADC system is a little faster, but the PGA's settling time does slow things down. The timing calculation of the delta-sigma-converter system is trivial because the manufacturer absorbs this issue within the device. If you are concerned only about speed, does a system speed of 70k samples/sec provide a greater advantage over one of 23k samples/sec? What do you think? Respond at ti_bonniebaker@list.ti.com. **EDN**

REFERENCE

1 Baker, Bonnie, "System or technology dictates ADC choice," *EDN*, March 18, 2010, pg 20, www.edn.com/article/CA6722366.

Bonnie Baker is a senior engineer at Texas Instruments.


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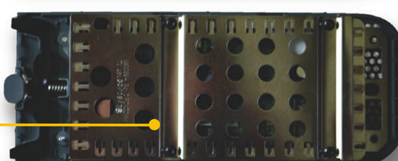
Taking a hard look at Microsoft's Xbox 360 hard drive

A 120-Gbyte, 2.5-in. hard-disk drive costs $44.99 at Newegg.com. So why did Microsoft charge $99.99 for the 20-Gbyte hard-disk-drive accessory to its Xbox 360 game console, and why did it sell the 120-Gbyte hard-disk-drive successor, which a 250-Gbyte replacement recently supplanted, for $129.99? A failed unit provides a tempting motivation to answer these questions.

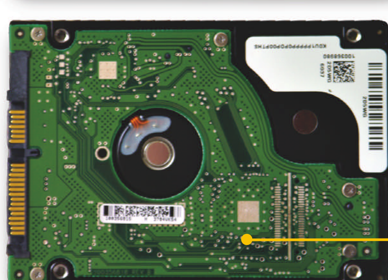
Measuring 8×3×1 in. and weighing less than 1 lb, the Xbox 360 hard drive clips onto one side of the console's enclosure.

The unit's back side contains the proprietary hard-drive-to-system connector, along with four screws, one of which lies underneath a Microsoft-labeled metallic sticker, that you must remove for disassembly.

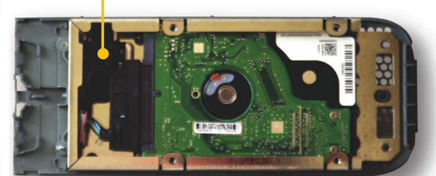
Removing four small Torx-head screws exposes the interiors of the two sides of the case. The top half is all plastic, whereas the bottom half contains the latch assembly and the hard drive.



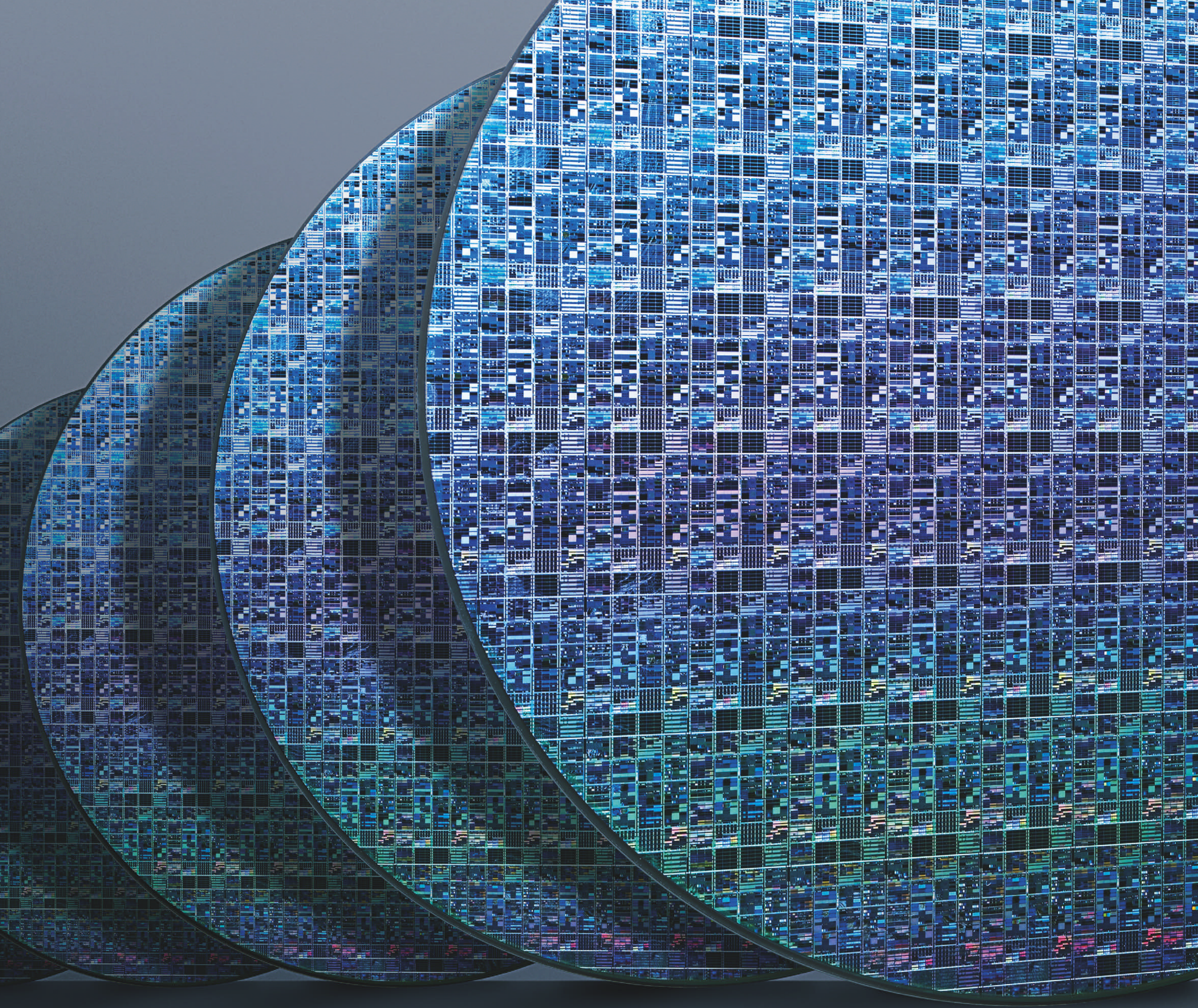
Removing the hard drive from the chassis reveals a seemingly conventional Seagate ST920217AS storage device with 5400-rpm rotation speed—better for both lower power consumption and less noise generation than its 7200-rpm counterparts—and 2-Mbyte integrated RAM cache. But as "modding"—that is, modifying—enthusiasts have discovered, they can neither access the Xbox 360 hard drive through their computers nor replace it with an off-the-shelf drive of similar or greater capacity.



A thin metal shield covers the hard drive, presumably to suppress EMI (electromagnetic interference). Removing four larger Torx-head screws exposes it and its mated standard SATA (serial-advanced-technology-attachment) data/power cabling for inspection.



Hard drives for the Xbox 360 contain custom firmware. Microsoft wants to prevent Xbox 360 hard-drive tethering to computers as a means of counteracting hacking attempts to manipulate game content on the drive, for example, or to circumvent DRM (digital-rights management) for rented or purchased music and video material. In addition, game consoles follow the well-known "razors-and-blades" marketing model: First sell the console at a loss and then make up the fiscal difference—and perhaps turn a profit—through subsequent sales of lucrative accessories (see "Got game? Living-room consoles grapple for consumers' eyes, wallets," *EDN*, Dec 16, 2005, pg 51, www.edn.com/article/CA6290451). Such accessories include not only games and other digital data but also hardware devices, such as controllers, cameras, flash-memory storage units, and … hard drives.



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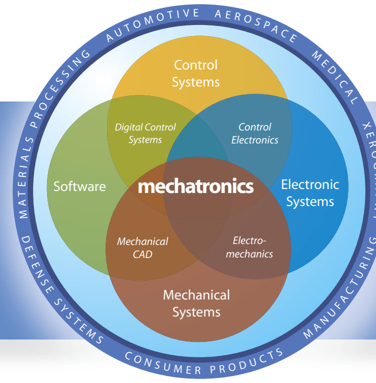
MECHATRONICS IN DESIGN

FRESH IDEAS ON INTEGRATING MECHANICAL SYSTEMS, ELECTRONICS, CONTROL SYSTEMS, AND SOFTWARE IN DESIGN



Friction fundamentals and accelerating cars

In elections it's always the economy; in engineering it's the fundamentals.

Friction may well be nature's most useful phenomenon. Without it, walking would be impossible and there would be no belt drives, no clutches, no wheels, and no brakes. However, in machinery in which it is not the driving force, friction is an undesirable parasitic effect, generating heat, causing wear, and wasting energy. So whether the goal is to reduce friction or enhance it, the proper combination of geometry, materials, and lubrication must be employed in a design—that is, a proper tribological approach. Tribology is the study of friction and wear, and it has been estimated that the correct application of tribology throughout US industry could save the country $500 billion annually.

We have all read about the problems with uncontrolled acceleration of automobiles due to faulty accelerator pedals. Friction has been identified as the likely culprit, and the proper combination of geometry, materials, and lubrication will likely lead to a solution. Why did this happen? It is too early to answer that question with any certainty, but I do know that most engineers, including mechanical engineers, do not fully understand the friction phenomenon. Failure to understand the fundamentals of such a pervasive physical effect is bound to lead to design failures, some of which might be catastrophic.

Stick-slip motion is a common behavior associated with friction. A typical stick-slip experiment is to attach one end of a spring to a block sitting on an unlubricated horizontal surface. The other end of the spring is moved horizontally with a constant velocity. How will the block move? Of course it is highly dependent on the physical system parameters, but one possible outcome is stick-slip motion, as shown in **Figure 1**. When the spring force exceeds F_{stick}, the mass accelerates, the spring elongates, and the mass comes to rest. The process then repeats, creating the stick-slip behavior. A model used to describe the friction phenomenon must be able to show this behavior. The automobile accelerator pedal relies on a balance between the return-spring force and sliding friction, which could vary over time due to wear and contamination, to perform effectively and safely.

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In the automobile electronic accelerator pedal assembly—electronic because when the gas pedal is depressed, a sensor tells the car to accelerate—it is essential to have a certain amount of friction to make it easier for the driver to maintain a steady throttle setting and also to reduce fatigue from pushing against the pedal return spring continuously. The designed-in friction is meant to simulate the intrinsic friction that is present in a traditional throttle cable as it passes through the cable housing. If the friction is excessive, the pedal return spring cannot return the pedal when the driver's foot is removed—the pedal sticks in the partially open position. Changing the friction characteristics will of course change the accelerator feel for the driver. In addition, if wear or contamination is allowed to occur and change the friction characteristics, the safe operation may change as well. View the original problem and proposed solution for a major manufacturer, Toyota, at www.designnews.com/article/455235-Friction_Fundamentals_and_Accelerating_Cars.php.

The Toyota pedal assembly includes a shoe that rubs against an adjoining surface during normal pedal operation. As discussed above, due to several causes these surfaces may, over time, begin to stick and slip instead of operating smoothly. In some cases, friction could increase to a point that the pedal is slow to return to the idle position or stick, leaving the throttle partially open. A solution is to insert a spacer that will reduce the friction between the friction shoe and the adjoining surface, thus eliminating the excess friction that can cause the pedal to stick.

In a mechanical design, a proper tribological approach must be taken to ensure safety, performance, and energy-efficient operation.EDN

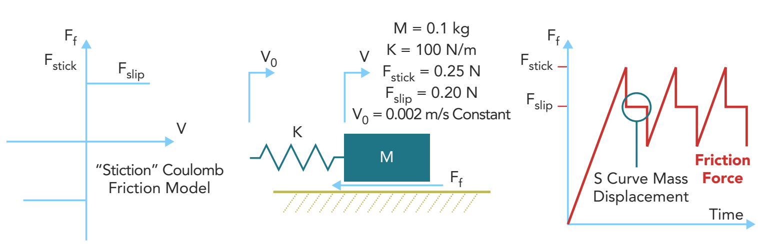

Figure 1 Stick-slip motion is a common behavior associated with friction.

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BY PAUL RAKO • TECHNICAL EDITOR

DIGITAL POWER WITHOUT THE HYPE

DIGITAL POWER IS A DECISION FOR THE CHIP COMPANY, NOT THE SYSTEM ENGINEER.

Well-meaning but overzealous marketing departments have recently been hyping digital power, which has lingered in academia for decades (**Figure 1**). Now that some of that hype is dying down, it is time to examine where digital power fits, how it works, its drawbacks, and its trade-offs (**Reference 1**). Despite the drawbacks, however, companies have developed and deployed parts that take advantage of the benefits of digital-control loops in situations in which these trade-offs don't matter.

Chip companies offer various definitions of digital power. Some companies consider digital power to comprise digital functions and communications links surrounding an analog PWM (pulse-width-modulation) loop. Others say that digital power is a state machine with a built-in chip featuring digital PWM. Still others state that it includes a general-purpose DSP running an algorithm that closes a control loop. True digital power, in the sense that academics have for the last decade used the term, has a digital PWM loop with either a state machine or a DSP. The mere existence of a serial bus on an analog PWM part does not provide digital power. Digital power, however, can be free, can eliminate the need for certain components, and can reduce costs.

You can add a FET-driver chip and some code to a DSP that controls the blade angles and the inverter in a wind turbine, essentially yielding free digital power. For example, Texas Instruments began more than 10 years ago to offer power libraries for its DSPs. The company now makes several lines of DSP-based power chips (**Figure 2**). In a move to reduce parts counts, CamSemi offers the 5W C2161PX2 ac/dc controller, which uses a sense winding on the flyback transformer rather than expensive optocouplers (**Reference 2** and **Figure 3**). The digital power senses the flyback waveform without diodes and blanks out the sense-winding feedback signal when it goes negative and when it does not represent the output voltage of the secondary. As for cost reduction, Exar makes the 16A XRP7740 digital-power chip to create multiple power rails in

AT A GLANCE

- Digital power can lower cost, simplify your design, and improve accuracy.
- Digital power is ideal for output margining and cycle-by-cycle loop compensation.
- Many system engineers don't want or need nonlinear control or adaptive compensation.
- Added efficiency claims for digital power often go unproven.
- Digital power can provide unique capabilities, but there are also trade-offs.

set-top boxes or data servers (**Figure 4**). Exar holds many patents on the chip involving the use of a small die area for a working control loop (**Reference 3**). Thus, Exar can price the chip to compete with analog chips.

Digital power can also perform cycle-by-cycle loop compensation. For example, Zilker Labs, Intersil's digital-power-management group, recently announced the ZL6105, which employs a state machine that performs autocompensation on a cycle-by-cycle basis (**Figure 5**). As another example, start-up Powervation uses a digital-power ASIC to perform cycle-by-cycle compensation of the power supply (**Figure 6**). This real-time loop compensation is a key benefit of digital chips over their analog counterparts. These digital-power controllers track the degradation of electrolytic capacitors as they age and dry out. If you design the part into a power brick, the digital controller senses the brick's input and output capacitance and compensates for it on every cycle. Other digital-power chips perform a one-time self-compensation cycle to help you create the digital-compensation-filter coefficients.

Digital power also provides margining—varying the power supply's output voltage over a range during testing, verifying that a system will function properly over its lifetime. For example, Infineon's Primarion group offers the PX7510, which performs margining and other operations over the PMBus (power-management bus). "Margining allows us to verify the system's electrical and thermal performance with the output voltage operating beyond its specified limits," says Bob Thomas, technical leader at Cisco Systems' DSSG (data center, switching, and services group).

DIGITAL-POWER HYPE

The hype of digital power harks back to the buzz over fuzzy logic a decade ago. Some people then believed that fuzzy logic would supplant the need for analog control. It turned out, however, that fuzzy logic works better than analog approaches in only a few applications, and, even in those applications, you can perform almost all of the functions with a PID (proportional/integral/differential) controller (**Reference 4**). Some marketers also claim that a digital-loop power supply can perform adaptive compensation—the ability to switch between fast transient response and low noise. This feature forces you to measure the noise and transient response, and then you must decide when to switch between them. Powervation has successfully accomplished this task, but it takes a lot of processing power.

Digital-power mavens also brag about "nonlinear"-control approaches, but these loops prevent you from connecting a network analyzer on digital-power chips. Nonlinear digital loops don't provide valid gain and phase response. Chip companies instead tell engineers to evaluate stability in the time domain, maintaining that they should apply a transient condition to the loop and ensure that the ringing dies down in a reasonable amount of time. Experienced control-system engineers don't like nonlinear control, however, preferring to work with familiar gain and phase plots.

Some companies claim that digital-power chips can maintain closer current matching between phases in a multiphase supply. Comparing an analog supply with a 30% mismatch is unrealistic, however, and no responsible engineer would release such a design to production.

Some chip companies also claim that digital power is more efficient than analog power, but that claim doesn't hold up. A chip's ability to turn off phases in multiphase controllers will represent an efficiency gain. This approach provides decent efficiency at light load, although a digital PWM loop is not responsible for this capability. Any analog chip can also perform this function. The major losses in a switching power supply are magnetic, switching, and copper losses, and a controller chip cannot affect these losses. A Linear Technology analog LTM4609 buck-boost-converter module attains 98% efficiency—better than with almost any digital chip.

Another efficiency claim is that digital chips provide better dead-time control. In other words, they can operate synchronous and power FETs so that there is no reverse current. Nevertheless, Linear Technology has a patent on an analog method to ensure that the synchronous FET never has reverse conduction, and National Semiconductor, Allegro, and Fairchild use analog

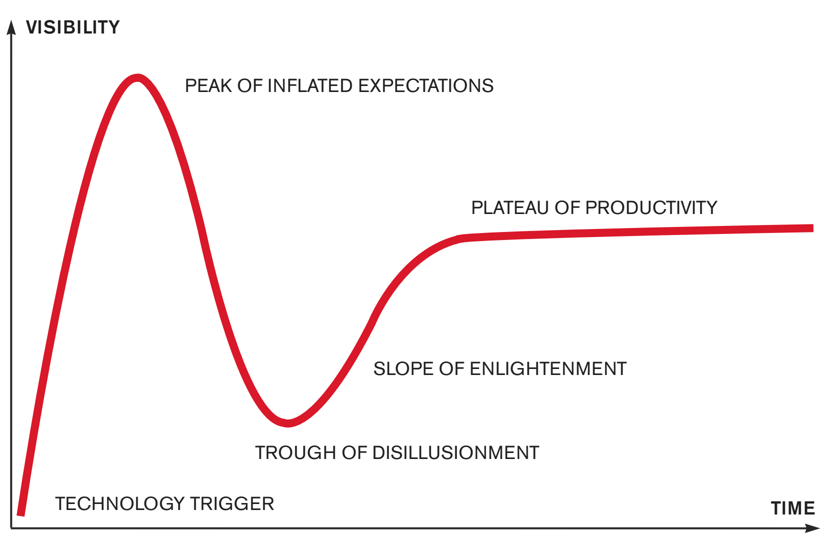


Figure 1 Digital power is finally reaching its plateau of productivity (courtesy Gartner Group).

valley-mode control in several chips to achieve the same effect. "There is no reason that digital control loops are more efficient," notes Bob Dobkin vice president of engineering and chief technical officer at Linear Technology. "You can do stage-shedding with analog. Shoot-through control has not been a problem, and some of our newer circuits have adaptive shoot-through control."

INEVITABLE TRADE-OFFS

In reality, it doesn't matter whether a chip uses a digital or an analog control loop. You need to worry only about the trade-offs you make when you select a digital approach. For example, digital power consumes more quiescent current. Although Texas Instruments' DSPs provide high power efficiency and speed, they consume more power than a state-machine chip and far more than an analog chip. A discrete-time sampled-data PWM chip always draws more quiescent current than a low-power analog PWM chip. For this reason, Summit Microelectronics and other companies make "digitally managed" analog power. This approach surrounds the analog PWM section with the digital communications and control necessary for handheld electronics. Targeting use in battery-operated devices, these devices cannot have a high-speed ADC/DAC and a DSP that takes milliamperes of quiescent current. "If I went to one of our customers with a chip that drew more than 100 μA quiescent current, I would be laughed out of the building," says Abid Hussain, vice president of marketing and applications at Summit.

If you have the DSP anyway, it makes sense to add a software module to create a power rail. Be aware that DSPs must boot up, so, if there is a glitch, you may lose the digital-power rail until the part loads the boot code and starts running. Also, your DSP had better be deterministic. If it has so many loops and interrupts that it cannot service your digital-power code, the power-rail loop will not really close.

You can find analog parts that reduce parts count, as well. For example, Power Integrations offers low-cost offline analog parts that don't require an optocoupler, and Linear Technology makes the LTC4278 and other analog parts that use a sense winding rather than an optocoupler to provide voltage feedback. The devices provide these functions without digital power, so you don't need a digital PWM loop to blank the negative feedback voltage and use the proper part of the flyback waveform for feedback control. You shouldn't care whether the chip company uses an analog or a digital PWM loop, just whether the part can provide tight output regulation without an optocoupler.

Digital-power chips also require more expensive mask sets to make and have higher NRE (nonrecurring-engineering) costs. The Exar XRP7740 digital-

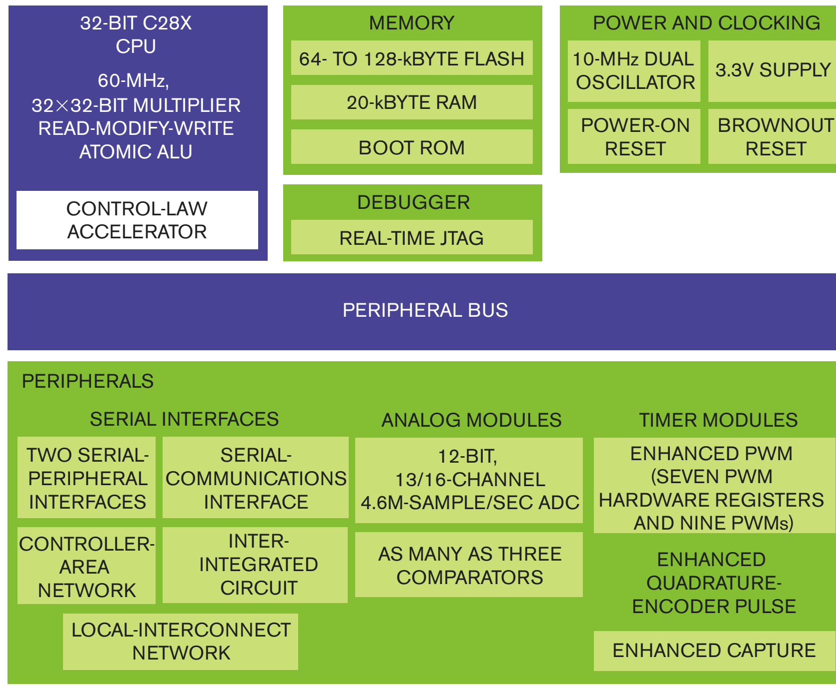


Figure 2 You can compile a digital-power library for any Texas Instruments DSP or use one of the company's specialized chips for digital-power systems. TI also makes state-machine-based digital-power chips.

Figure 3 CamSemi offers 5W switching power-supply-controller chips that combine with a bipolar transistor to replace a linear power supply. The switching design has better efficiency and uses much less copper wire, so it also reduces costs.

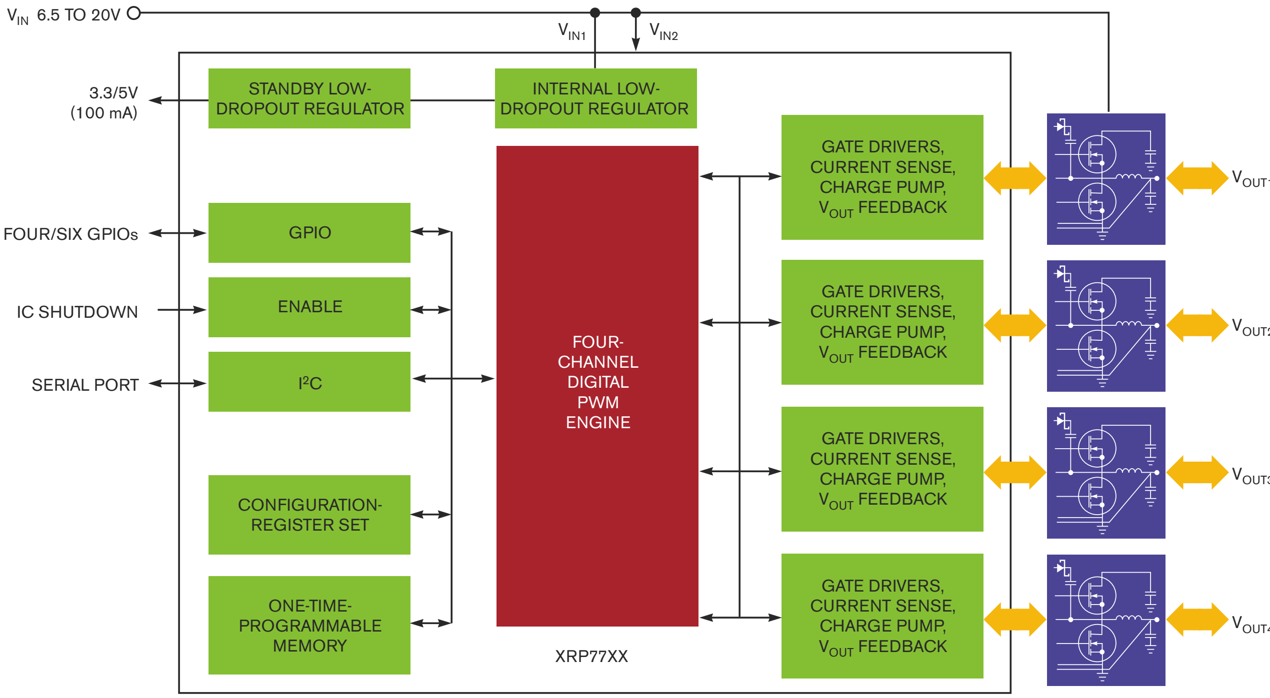
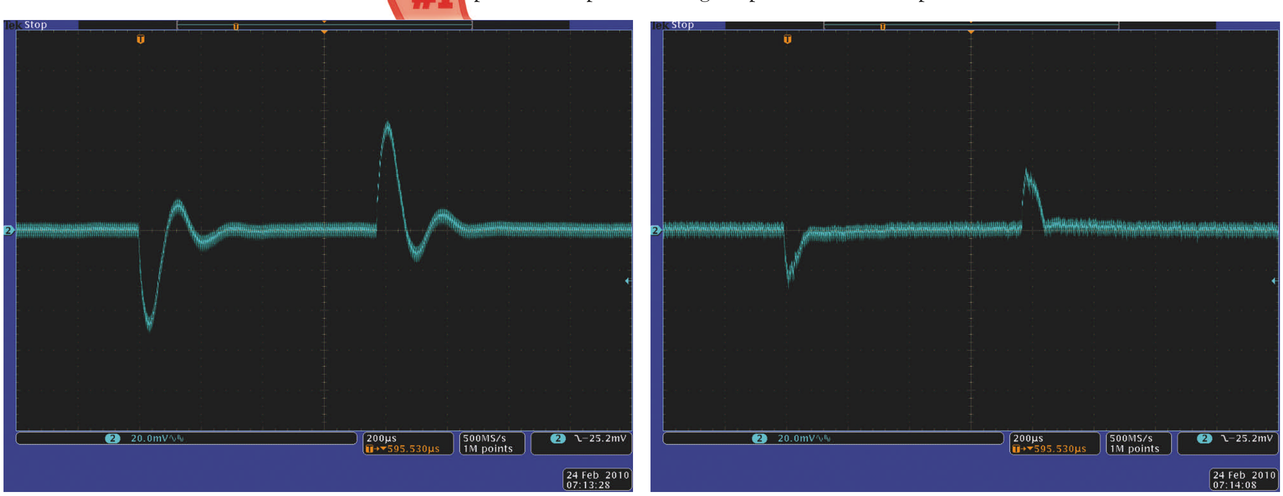


Figure 4 The Exar XRP7740 can supply 16A of output current on four channels. Clever IC design keeps the die small so that the company can offer the part at prices competitive with those of analog approaches.

power chip leverages the size of a digital PWM loop to provide low-cost chips that can compete in price with analog parts. The mask sets for these chips cost more, however, so companies selling these chips can't spin a minor variation, even if a customer orders millions of parts. The low cost of the die is a trade-off with the high cost of the fine-line CMOS mask set, so the manufacturer must target high-volume applications. "It comes down to techno-economics," says Tim Henricks, vice president of engineering services at Cadence. He points out that putting large output or driver transistors on fine-line CMOS is rarely a cost-effective approach. Using a less expensive CMOS process with larger lines is often beneficial (**Reference 5**). In addition, many power-supply chips must operate off voltages higher than those that fine- or wide-line CMOS can provide, so there will always be a place for bipolar analog chips.

Digital power shines in applications requiring cycle-by-cycle compensation, but many companies prefer to use a simple, robust analog design that has adequate compensation for the life of the part. Digital-power autocompensation is still a developing technology. "We had a legacy power rail with some parasitic resistance and inductance in the layout," says Cisco's Thomas. "A company expected that its chip could compensate it. When we evaluated the



(a) (b)

Figure 5 You can manually set the compensation of the Zilker Labs ZL6105 demo board, but doing so is not the ideal approach (a). When you turn on autocompensation, the transient response and stability of the design improve (b).

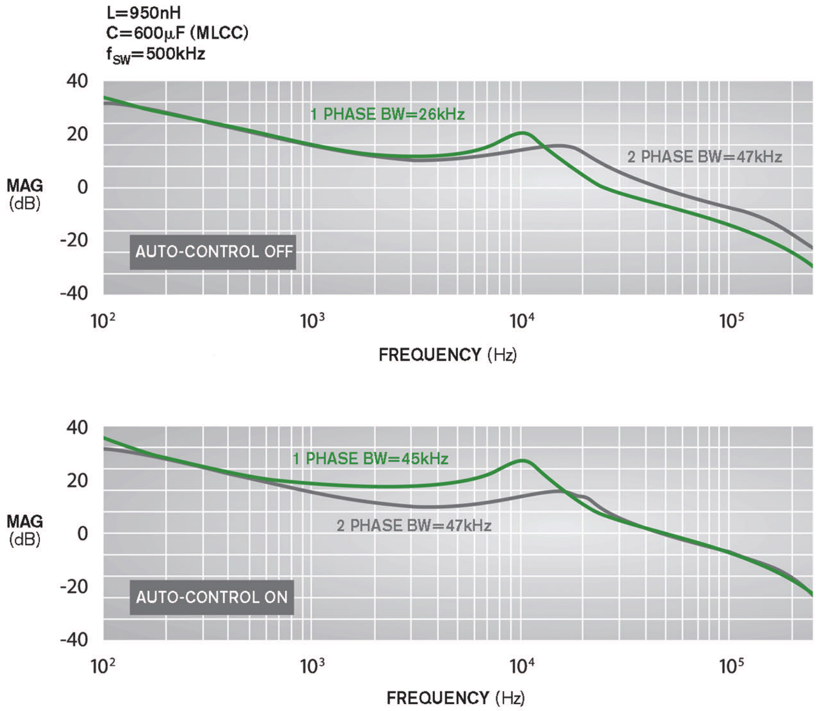


Figure 6 To improve efficiency at light loads, the Powervation digital-power chip can shed a phase. The autocompensation feature then maintains full loop bandwidth even with a single phase.

chip in this application, the customer concluded that its autotuning algorithm could not achieve reasonable margins." The analog chip in the design worked well, although the designer intentionally reduced its crossover frequency to compensate for a less-than-optimal layout due to mechanical constraints on the board.

A chip that performs autocompensation may be vital to a company making power bricks with unknown input and output capacitance, but designers often develop power supplies for specific applications. Although it is nice to do a one-time tuning for the compensation of a digital-power part, an analog part doesn't require you to develop digital-filter coefficients. You just vary a compensation capacitor and resistor to tailor the loop response. "It is hard to beat the robustness and simplicity of an analog chip that has only a reference, a comparator, a switch, a single-pole filter, and some output circuitry," comments Cadence's Henricks. Note that perturbing the loop to do real-time compensation isn't exclusively the domain of digital power. Linear Technology has just announced the LT4180, a novel analog part that senses the output impedance of a power supply and adjusts the supply to compensate for ac and dc voltage drops.

Analog chips can also perform margining—a system function that does not depend on a digital PWM loop. The Maxim MAX16064 monitoring-and-control chip, for example, supervises four analog switching power converters (**Reference 6**), and the Linear Technology LTC2978 monitoring-and-control chip supervises eight analog power converters (**Reference 7**).

In short, digital power makes sense in some applications and no sense in others. It simply does not matter to a system engineer, who shouldn't care how the semiconductor company closes the loop. All system designers should care about is that the chip works and has features that they need. System engineers need price, availability, and a data sheet. Let the professors and the IC designers argue about digital and analog power. You need chips and functions that solve problems in the real world.

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Unless it does something you need it to, you should no more pay extra for digital power than you should pay more for laundry detergent that is labeled "new and improved." EDN

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BY ROBERT CRAVOTTA • TECHNICAL EDITOR

The 2010 DSP Directory

Scratching the surface

DIGITAL-SIGNAL PROCESSING IS FINDING ITS WAY INTO EVERYTHING. AS SUCH, IT IS DIFFICULT TO DO MORE THAN SCRATCH THE SURFACE OF WHAT IS AVAILABLE IN THIS CONSTANTLY EVOLVING MARKET.

Welcome to the 2010 Digital-Signal Processing Directory. The directory provides a snapshot each year of the companies, products, intellectual property, and software-development tools available as digital-signal-processing resources for embedded-system developers. The number of companies, devices, cores, and offerings in the directory continues to grow. Some product lines have dropped off the list only to have new ones replace them. We are constantly uncovering companies that previous editions of the directory did not list. If you notice that we omitted a company, please let the company and us know that you missed it and would like to see it in the next update of the directory.

This directory aims to provide designers and system architects enough visibility to dig into the processor options and quickly narrow the list of candidate processors for their project. This year's update of the DSP Directory covers the company summaries similar to the summaries in previous editions, but it does not include updates to the product detail pages and device tables that have become part of this directory over the past few years. You can still visit earlier editions of the directory at www.edn.com/dspdirectory, where you can still find the extended information. The directory lists the companies selling software-programmable processors, cores, and software-development resources, providing an overview of each and identifying the latest developments over the previous year at each company.

This directory lists companies that have experienced changes, such as dropping from the directory, with a "Where did they go?" sidebar to help you find companies that *EDN* no longer lists, whether because they closed their doors, changed their focus, were acquired, or were spun off. As always, the Web site duplicates and expands upon the material you find in the print version.

If this directory helps you find or choose a device or core, please let the vendor know how you found its part. Help us continue to improve the directory by visiting us at www.edn.com/dspdirectory or by sending your comments and feedback to edn.editor@reedbusiness.com.

Scratching the surface

ACTEL • WWW.ACTEL.COM

Actel offers single-chip, nonvolatile-FPGA technologies along with signal-processing capabilities, such as filtering and domain conversion. The company's DirectCore system-level IP (intellectual-property) blocks target use with its FPGAs, such as the RTAX-S and ProASIC3 device families. When you implement the flexible IP cores in Actel's flash- and antifuse-based FPGAs, they are immune to firm errors and tolerant of radiation. The company's devices support live-at-power-up capability, which allows them to target military, communication, aerospace, and medical applications that require no power-up delay.

ALTERA • WWW.ALTERA.COM

Altera's portfolio of FPGAs, structured ASICs, and CPLD products targets many electronics markets. The 65-nm Stratix III FPGAs incorporate features such as dedicated DSP blocks to combine high performance with the lowest possible static- and dynamic-power consumption. The devices improve performance by as much as 50% over previous-generation high-end FPGA devices. Stratix III FPGAs feature programmable power technology, selectable core voltage, process and circuit technologies, and support from the Quartus II PowerPlay power-analysis and -optimization technology. The 65-nm Cyclone III FPGAs with 288 embedded multipliers for DSP applications target high-volume applications requiring low power, high performance, and low cost. HardCopy II devices enable designers of volume-driven applications to seamlessly migrate their designs from a high-end Stratix series FPGA to a low-cost structured-ASIC product. The company offers a library of IP (intellectual-property) cores, including the Nios II embedded processor. The Quartus II design software supports all Altera products for FPGA, structured ASIC, and CPLD designs.

ANALOG DEVICES • WWW.ANALOG.COM

Analog Devices' Blackfin, SHARC, SigmaDSP, TigerSHARC, and ADSP-21xx processors and analog microcontrollers make up the company's embedded-processing and DSP portfolio, supporting high-speed, multi-DSP signal-processing, converged signal- and control-processing, fixed-function-processing, and microcontroller applications. Development tools for all of the company's processors include the VisualDSP++ integrated development and debugging environment, EZ-Kit Lite evaluation kits, EZ-Boards evaluation boards, and EZ-Extender daughtercards and emulators, as well as tools from SigmaStudio, and µClinux.

The Blackfin processor family combines a 32-bit RISC-like instruction set with 16-bit dual MAC (multiply/accumulate) units and targets convergent applications with audio-, video-, and data-processing requirements. The 32-bit floating/fixed-point SHARC processor family targets applications ranging from consumer, automotive, and professional audio to industrial, test-and-measurement, and medical equipment. Analog Devices' SigmaDSP audio processors provide a single-chip audio system with a 28/56-bit audio DSP, ADCs, DACs, and microcontroller-like control interfaces. Signal-processing elements include equalization, crossover, bass enhancement, multiband dynamics processing, delay compensation, speaker compensation, and stereo-image widening, which you can use to compensate for the real-world limitations of speakers, amplifiers, and listening environments.

The TigerSHARC processor family offers high floating-point- and fixed-point-performance with glueless multiprocessor scalability to target wireless-communications-infrastructure, medical-imaging, industrial-imaging, and military applications. Analog Devices' ADuC7xxx ARM7TDMI family integrates 12-, 16-, and 24-bit ADCs; 12-bit DACs with flash; SRAM; and digital peripherals for industrial, instrumentation, medical, communications, and automotive applications. The ADuC8xx series integrates true 12- to 24-bit analog precision, in-circuit reprogrammable flash/electrically erasable memory, and an on-chip 8052 core. ADSP-21xx processors are code- and pin-compatible DSPs that operate as fast as 160 MHz and consume as little as 184 µA of power. The ADSP-21xx family is ideal for speech processing and voice-band modems, as well as real-time-control applications.

ARM • WWW.ARM.COM

ARM licenses semiconductor IP (intellectual property), including processors, peripherals, interconnect, and physical libraries for the development of complex SOC (system-on-chip) devices. ARM processors target automotive, consumer-entertainment, imaging, networking, storage, security, and wireless applications, and ARM bases them on a common architecture that emphasizes performance, low power consumption, and reduced system cost. The company offers a range of processor cores, including the ARM7, ARM9, ARM10, and ARM11, as well as the Cortex family of processors featuring Thumb-2 technology and the SecurCore processor family. ARM's DSP-enhanced cores support products that require a mixture of DSP and control functions on a single core. ARM Neon technology provides powerful, flexible acceleration for media and DSP applications; ARM OptimoDE (data-engine) technology targets power-efficient, deeply embedded signal-processing applications; and the ARM9E processor family is well suited for products for microcontroller-DSP and Java applications.

ATMEL • WWW.ATMEL.COM

Atmel bases its DSCs (digital-signal controllers) on its proprietary AVR32-UC3 and AVR32-AP7 cores and ARM's ARM926EJ-S core. AVR32- and ARM-based DSCs use the same peripheral set, which includes DMA on all peripherals and Atmel's peripheral DMA controller, multilayer high-speed bus architecture, Ethernet MAC (media-access controller), USB (Universal Serial Bus) host/device, ADC, and serial-communication peripherals, as well as an optional external-bus interface. Atmel's Cap customizable microcontroller, which it based on the ARM processor, provides a large block of digital logic that application developers can customize to include a DSP coprocessor.

The company's Diopsis families of dual-core, VLIW (very-long-instruction-word), floating-point DSPs include its complex-domain, GFLOPS (billions-of-floating-point-operations-per-second) Magic core with ARM7- or ARM9-based microcontrollers. The MagicV DSP tool chain, including an IDE (integrated development environment), a C compiler, a linker, an archiver, and a graphical JTAG debugger, thanks to the C-oriented DSP architecture, fully exploits the parallelism of the processor resources. Moreover, a library of 200 C-callable DSP routines, implementing optimized DSP algorithms, including FFTs (fast Fourier transforms), filters, and matrix computations, is available.

Atmel Roma is an Atmel design center, whose mission is to develop the Diopsis family of audio-oriented SOCs (systems on chips) and the Magic DSP engine inside them. Atmel Roma also develops software tools and Diopsis-based reference designs.

AUSTRIAMICROSYSTEMS • WWW.AUSTRIAMICROSYSTEMS.COM

Austriamicrosystems bases its high-performance analog ICs on more than 25 years of analog design and system know-how with its own state-of-the-art manufacturing and test facilities. The company offers customized and standard analog products focusing on power management, sensors and sensor interfaces, and portable audio. The flexible, fully integrated AS3525 audio-processor system employs a 200-MIPS ARM9TDMI core; it can perform MP3 (Moving Picture Experts Group Layer 3), AAC (advanced audio coding), AAC+, WMA (Windows media audio), and Ogg, and it can support extensive user interfaces, motion graphics, and video playback. Large on-chip RAM leads to power consumption of 58 mW for a complete flash-based MP3 player.

CAMBRIDGE CONSULTANTS • WWW.CAMBRIDGECONSULTANTS.COM

Cambridge Consultants' expertise covers semiconductors, wireless communications, radar systems, advanced sensors, and control systems in automotive electronics, medical devices, and consumer goods. The company's IC-design capabilities include high-precision analog mixed-signal and RF products.

The company's portfolio of IP (intellectual property) and development tools includes an extensive library of analog, digital, mixed-signal, and wireless IP cores together with embedded software-development and debugging tools, protocol stacks, and design platforms for ASICs and FPGAs. Designers can tailor the portable, flexible IP cores to their specifications with flexible licensing contracts that can be royalty-free. Cambridge Consultants' silicon-IP offering includes 16- and 32-bit XAP processor cores and the APE2 configurable-datapath DSP.

CEVA • WWW.CEVA-DSP.COM

Ceva licenses a family of synthesizable, programmable DSP cores, DSP-based subsystems, and application-specific platforms, including video, multimedia, HD (high-definition) audio, VOIP (voice over Internet Protocol), Bluetooth, and SATA (serial advanced technology attachment). In 2009, Ceva introduced the Ceva-XC communication processor, a configurable DSP for 3.5G/4G (fourth-generation) mobile handsets and wireless infrastructure. The low-power, high-performance approach addresses the evolving needs of implementing LTE (long-term evolution)/4G, WiMax (worldwide-interoperability-for-microwave-access), and SDR (software-defined-radio)-based wireless-communications applications.

In early 2010, Ceva introduced the MM-3000, a multipurpose, programmable HD (high-definition) video- and image-processing platform for connected multimedia devices. The fully software-programmable, low-power platform uses scalable, configurable multicore architecture to support advanced video codecs and image-signal processing for portable multimedia and home-entertainment devices.

The Ceva-X and Ceva Teak DSP architectures form the foundation for a range of IP (intellectual-property) cores from Ceva that support features for advanced signal-processing requirements. Ceva hardware- and software-development tools support all of Ceva's DSP cores and system platforms, as do Cevanet-technology partners, which provide application software, RTOS implementations, simulation tools, and EDA tools.

CHIPWRIGHTS • WWW.CHIPWRIGHTS.COM

Chipwrights is a fabless semiconductor company that offers DSPs and SOCs (systems on chips) for audio-, video-, and image-processing applications. The Chipwrights processor family combines a 32-bit, RISC-like serial application processor with an array of 32-bit MAC (multiply/accumulate), ALU (arithmetic-logic-unit), and shift parallel processors. The products' parallel, scalable architecture enables them to process more data than conventional single- or dual-core devices with fewer cycles and lower power consumption.

The company offers turnkey options for IPTV (Internet Protocol television) and IP cameras, including an evaluation board; system software; the Linux 2.6 operating system; the Eclipse IDE (integrated development environment); the FFMPEG (Motion Picture Experts Group); QT library; a Web-kit-based browser; and a comprehensive audio, video, and image library, including MPEG, JPEG (Joint Photographic Experts Group), REAL (remote electronics access for libraries), Win Media, dewarping, image filters, and color filters. Use the IPTV turnkey product to develop video-decoding applications, such as IP-Card for TV, PMPs (portable media players), navigation, and PDAs (personal digital assistants). The IP-Camera turnkey product is useful for developing any camera application, such as CCTV (closed-circuit-TV), Web, and conference-room cameras. In addition to turnkey products, the company offers a media-development kit for developing any audio/video application.

CIRRUS LOGIC • WWW.CIRRUS.COM

Cirrus Logic develops high-precision analog- and mixed-signal ICs for the consumer and energy markets. Cirrus Logic DSPs target audio applications and feature an extensive library of audio-processing algorithms for feature differentiation.

COREWORKS • WWW.COREWORKS-SA.COM

CoreWorks sells licensable silicon IP (intellectual property). SideWorks, a DSP technology targeting cost- and power-sensitive applications, such as multimedia and communications, enables the creation of DSP cores that are both configurable before fabrication and reconfigurable. The movement of data and some aspects of the execution unit's functions are programmable at runtime. SideWorks does not run as a stand-alone processor; it instead couples with a general-purpose host processor that manages program flow and data input/output. Therefore, CoreWorks also supplies FireWorks, a compact, 32-bit RISC CPU core. CoreWorks' initial business model is to license fully preconfigured standard IP modules employing the SideWorks architecture or creating SideWorks instances for customer-specific needs. A SideWorks mixed-radix FFT (fast-Fourier-transform) module is currently available, and modules targeting digital audio, including Dolby digital and AAC (advanced audio coding), are under development.

EVATRONIX SA • WWW.EVATRONIX.PL

Evatronix SA develops electronic virtual components comprising IP (intellectual-property) cores, along with complementary software and supporting development environ-

Where did they go?

ARC INTERNATIONAL

Virage Logic acquired ARC.

CRADLE TECHNOLOGIES • WWW.CRADLE.COM

Cradle Technologies has not been active in DSPs this year.

IMPROV SYSTEMS • WWW.IMPROVSYS.COM

Improv has been inactive in the DSP market this year.

ON DEMAND MICROELECTRONICS - WWW.ODM.AT

On Demand Microelectronics has been inactive in the DSP market this year.

RENESAS TECHNOLOGY • WWW.RENESAS.COM

Renesas merged with NEC Electronics to form Renesas Electronics.

STMICROELECTRONICS

STMicroelectronics no longer supports new designs with the ST240, and there are no new DSPs to promote.

ments. The company also provides electronic-design services. Product lines cover a range of products, from interface controllers and microprocessors to integrated SOC (system-on-chip)-development platforms. Evatronix offers the 16-bit C32025 family of programmable DSP cores that targets industrial, home, and consumer applications.

FREESCALE SEMICONDUCTOR • WWW.FREESCALE.COM

Freescale Semiconductor designs and manufactures embedded semiconductors for the automotive, consumer, industrial, and networking markets. Freescale offers programmable DSPs based on StarCore technology that target advanced communications and networking-infrastructure equipment. The company also offers advanced 16-bit DSCs (digital-signal controllers) that find use in factory automation; building and lighting control; and a range of motor-control applications, such as large appliances.

Freescale's flagship six-core MSC8156 DSP employs SC3850 StarCore DSP technology to advance the capabilities of wireless-broadband base-station equipment. The MSC8156 has been qualified on advanced 45-nm-process technology. Freescale last year introduced the MSC8154, a four-core version of the MSC8156. In February 2010, the company introduced the MSC8155, which is a higher-performance, cost-optimized version of the MSC8156. The MSC8155 includes next-generation acceleration and interconnect technologies that boost overall chip performance and further enhance the capabilities of broadband wireless-base-station equipment.

HYPERSTONE • WWW.HYPERSTONE.COM

Hyperstone's processors provide integrated RISC/DSP functions for applications requiring high-speed microprocessors and high-performance DSPs. These processors feature dual execution units in a pipelined architecture sharing the same registers. The system can mix RISC- and DSP-specific programming transparently to the programmer. RISC and DSP instructions execute with a high degree of parallelism, resulting in high throughput. Typical applications include telephony, VOIP (voice-over-Internet Protocol) telephony, video, digital cameras, and general signal processing.

Hyperstone builds its HyNet series of networking processors around its RISC/DSP core and adds integrated peripherals, including Ethernet, real-time Ethernet, serial, and ATM (asynchronous transfer mode), supporting high-speed communications, additional internal RAM, video interfacing, PCI (Peripheral Component Interconnect) support, DMA, and more. These processors target applications requiring high-speed signal processing, communications, or both, including real-time Ethernet. HyNet processors are ideal for any application requiring signal processing, along with industrial applications, such as real-time Ethernet and motor control, and wired/wireless communications.

INFINEON TECHNOLOGIES • WWW.INFINEON.COM

Infineon Technologies offers 8-, 16-, and 32-bit DSC (digital-signal-controller) and microcontroller families with DSP capabilities, targeting motor-control and transportation-power-train applications. In 2010, Infineon introduced the XC82x and XC83x families, adding 16-, 20-, and 24-pin package devices to its XC800 family, which uses a vector-computer coprocessor to enable low-cost, sensorless field-oriented control for less than $1 (1000) using an 8-bit device.

More challenging control schemes will benefit from the newly expanded XE16xN family. This 16-bit family offers a range of flash memories from 128 to 256 kbytes and performance as great as 40 MIPS. As with most XE16x devices, this family offers two independent ADCs, which you can synchronize. High-end servo-drive systems can benefit from the new TC11x7 devices, which offer as many as 48 ADC channels and memory of 1, 2, or 4 Mbytes. These tricore-based devices support a clock speed of 180 MHz and can perform as many as three instructions per clock cycle with a superscalar architecture.

The company has also introduced application kits, which are adaptable to a customer's motor. These kits are scalable from 12 to 230V, and their modular design allows for interchangeability between 8- and 16-bit processors to reach the best cost/performance ratio for specific applications.

LATTICE SEMICONDUCTOR • WWW.LATTICESEMI.COM

Lattice Semiconductor provides FPGAs, CPLDs, and programmable mixed-signal devices for clock and power management. Four of its FPGA families will be of interest to DSP designers. The nonvolatile LatticeXP2 FPGA family combines flash configuration memory, LUT (look-up-table) logic, and embedded memory and DSP blocks. Users can program the embedded DSP blocks to implement functions such as multiply, multiply/accumulate, and multiply/add/subtract. The LatticeXP2 devices provide as many as 40,000 LUTs, as many as 32 18×18-bit multipliers, and 885 kbits of embedded memory.

The low-cost LatticeECP2 and LatticeECP2M FPGA devices provide as many as 100,000 LUTs, 168 18×18-bit multipliers, 5.3 Mbits of block memory, embedded DSP blocks, and 16 channels of 3.125-Gbps SERDES (serializer/deserializer).

In February 2009, the company announced the LatticeECP3 FPGA family of low-power-consumption, low-cost SERDES-based FPGA devices. The LatticeECP3 family offers multiprotocol 3.2G SERDES with XAUI (10-Gbps-attachment-unit-interface) jitter compliance, DDR3-memory interfaces, as many as 320 multipliers, high-density on-chip memory, and as many as 149,000 LUTs.

Lattice provides many DSP-based IP (intellectual-property) cores, including DUC (digital upconverter), DDC (digital downconverter), an FFT (fast-Fourier-transform) compiler, a CIC (cascaded-integrator-comb) filter, a FIR (finite-impulse-response)-filter generator, Reed-Solomon encoders and decoders, convolution encoders, Viterbi decoders, and turbo-coding functions. Lattice includes all these IP cores in its Lattice IPexpress tool, which allows users to parameterize and generate IP on their desktops. Lattice also provides a block set for The MathWorks Matlab and Simulink. Lattice includes the IPexpress tool and Simulink block in its ispLever design-tool suite.

MICROCHIP TECHNOLOGY • WWW.MICROCHIP.COM/DSPIC

Microchip's dsPIC DSC (digital-signal controller), a 16-bit-data modified Harvard RISC machine, combines the control advantages of a high-performance, 16-bit microcontroller with the high computation speed of a fully implemented DSP to produce a tightly coupled, single-chip, single-instruction-stream option for embedded-system design. All of Microchip's 16-bit DSC and microcontroller families share the same core instructions; DSCs add DSP instructions. They also share peripherals and development tools and have compatible pinouts.

During 2009, Microchip introduced the first seven next-generation dsPIC33F GS series DSCs for common, multiloop SMPSs (switch-mode power supplies) and other power-conversion applications. These devices come in DSC packages as small as 6×6 mm for digital-power conversion and provide as much as twice the performance at a significantly lower price than Microchip's first SMPS family. They feature an intelligent power peripheral, which includes interconnected analog comparators, PWMs (pulse-width modulators), and ADCs for digital-power applications; designers can software-configure them to a variety of topologies.

Microchip introduced a series of reference designs employing the dsPIC33F GS DSCs, which demonstrate how digital-power techniques reduce component count, lower product cost, eliminate the need for oversized components, and incorporate topology flexibility. Reference designs included the pure-sine-wave UPS (uninterruptible-power supply), digital interleaved power-factor correction, and ac/dc reference designs.

New DSP-related development tools include Microchip's free, royalty-free high-performance-DSP library, which enables embedded-system designers to combine DSP and microcontroller control code with the 32-bit PIC32 microcontroller family. Microchip released additional tools supporting motor-control applications, including the dsPICDem MCHV (motor control/high voltage), which supports high-voltage, closed-loop motor-control applications using ac-induction motors, BLDC (brushless-dc) motors, or PMSMs (permanent-magnet synchronous motors). The cost-effective dsPICDem MCSM (motor-control/stepper-motor) development board allows the creation of unipolar and bipolar stepper-motor applications.

MIPS TECHNOLOGIES • WWW.MIPS.COM

MIPS Technologies offers a line of processor cores for DTV (digital-television), broadband-access, Wi-Fi (wireless-fidelity), cable-set-top-box, DVD (digital-video-disc)-recorder, HD (high-definition) DVDs, and VOIP (voice-over-Internet Protocol) applications. The fully synthesizable, 32-bit MIPS32 74K cores can achieve operating frequencies greater than 1 GHz in a 65-nm process. The MIPS DSP ASE (application-specific extensions) Revision 2 includes 74 built-in DSP instructions that can eliminate the need for a separate DSP core. Four 64-bit accumulator registers that provide fast local storage boost signal-processing performance. A robust suite of software-development tools, the MIPS DSP library, and a third-party DSP applications network support the 74K core family.

NXP SEMICONDUCTORS • WWW.NXP.COM

NXP creates semiconductors, systems, and software that target TVs, set-top boxes, identification applications, mobile phones, cars, and other electronic devices. Employing the TriMedia DSP technology, the PNX1005, PNX1002, PNX1700, and PNX1500 media-processor series target use in video and complex audio processing in security and surveillance, including CCTV (closed-circuit-television), videoconferencing, and professional-video applications. NXP has optimized the PNX1005 for h264 video codec, intelligent video analysis, and video enhancement. The company also offers the PNX1002 dedicated audio processor for 16-channel audio acoustic processing. Special versions for the automotive and industrial markets are also available.

The CoolFlux DSP is an ultra-low-power programmable core for portable-audio applications. It targets products including headsets, hearing devices, and portable audio players. This C-friendly audio-DSP core combines low gate count and good performance. NXP uses the CoolFlux DSP for custom-designed chips, and the DSP is part of a global technology-licensing program, resulting in a well-supported DSP platform and ecosystem. The CoolFlux BSP (baseband-signal processor) extends the classic CoolFlux DSP core with complex arithmetic, SIMD (single-instruction/multiple-data) parallelism, and Viterbi and FFT (fast-Fourier-transform) instructions.

OCTASIC • WWW.OCTASIC.COM

Octasic is a global provider of DSP silicon and software products for the converged-carrier, enterprise, and endpoint-communication-equipment markets. The company bases its DSP products on Opus, an asynchronous-DSP architecture. Octasic's Vocallo multicore media-gateway DSP product, the first Octasic product employing the Opus core, represents a new generation of multicore DSPs for media gateways.

ON SEMICONDUCTOR • WWW.ONSEMI.COM

On Semiconductor supplies power- and signal-management products. The company's BelaSigna product line of ultra-low-power audio-processing systems targets portable-system applications, such as mobile handsets and accessories, hands-free communication, industrial hearing protection, and ALDs (assistive-listening devices).

Innovations over the past year include the BelaSigna 300, an ultra-low-power, high-fidelity audio processor for portable communication devices, which delivers audio clarity without compromising size or battery life. With 24-bit precision computing, BelaSigna 300 eliminates noise and echo from communications channels and still has resources for additional audio-management features. Its dual-core architecture ensures an evenly balanced workload, optimizing processing efficiency and minimizing power consumption. As a small audio-processing system, the BelaSigna 300 WLCSP package can fit into PCB (printed-circuit-board) layouts with little or no impact on the size of the end product.

PICOCHIP • WWW.PICOCHIP.COM

PicoChip's family of high-performance multicore DSP processors includes 200 to 300 processors, each a 16-bit Harvard architecture that is programmable with ANSI C, to deliver total performance of 200 GIPS (billion instructions per second) and 30 GMACS (billion multiply/accumulate operations per second). Although these processors are usable for any high-performance-DSP application, the company primarily focuses on the wireless infrastructure. The processor finds use in base stations as common platforms for both WiMax (worldwide-interoperability-for-microwave-access) and LTE (long-term evolution). It also supports baseband for femtocells, small base stations for indoor coverage. The company released several new reference designs, including support for WiMax Wave 2 with MIMO (multiple input/multiple output), a WiMax femtocell, or access point, and a TD-SCDMA (time-division-synchronous-code-division-multiple-access) femtocell.

PIXELWORKS • WWW.PIXELWORKS.COM

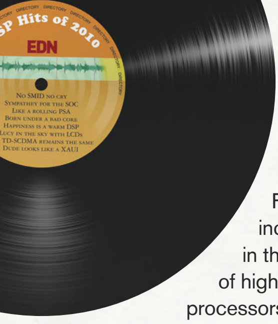
Pixelworks designs, develops, and markets semiconductors and software for the advanced-display industry, including advanced televisions, multimedia projectors, digital-streaming-media devices, and LCD panels. Pixelworks' line of programmable BSPs (broadband-signal processors) can handle multiple codecs for high-quality IPTV (Internet Protocol television) video and other digital-video applications. The company offers the DreamStream application-reference software for designers using the BSP chips. In addition to the BSP ICs, Pixelworks offers devices ranging from single-purpose, discrete ICs to SOCs (systems on chips) that can process and enhance the video signal throughout the entire path in the system.

RC MODULE • WWW.MODULE.RU

The RC (Research Center) Module provides IP (intellectual property) for VLIW/SIMD (very-long-instruction-word/single-instruction/multiple-data) processors with a flexible and high-performance vector-matrix engine. The architecture targets industrial video-image processing, navigation, multimedia, and telecommunications and provides scalable performance by employing a programmable operand width of 1 to 64 bits. This flexibility allows designers to trade precision for performance. The NeuroMatrix DSP family includes NM64xx chips and synthesizable NMC (NeuroMatrix core).

The new NM6405 processor is the third generation of NeuroMatrix DSP family. The architecture employs the 32/64-bit NMC3 with an eight-stage pipeline and an 8-kbyte cache that supports eight read/write memory operations per clock cycle and that an accelerated vector-unit operand loads. RC Module offers SOC (system-on-chip) design service that it bases on RC Module's NMC3 and ARM's ARM1176JZF-S core. Software- and hardware-development tools, as well as real-time signal- and video-image-processing systems, are available.

NEW RENESAS ELECTRONICS • WWW.RENESAS.COM



Scratching the surface

Renesas Electronics offers devices with built-in FPUs (floating-point units), including the SuperH devices in the SH-2A and SH-4A series of high-performance, 32-bit RISC processors. By combining both DSP and FPU capabilities into a single RISC CPU core, they save power and overall system cost.

Recent introductions in the SH-2A series include the SH7216, SH7262, and SH7264, which offer single- and double-precision FPUs. The SH7216 offers as much as 1 Mbyte of embedded flash and connectivity peripherals, such as Ethernet, USB (Universal Serial Bus), and CAN (controller-area network). The SH7262 and SH7264 offer as much as 1 Mbyte of on-chip SRAM for digital-audio systems and graphics-display applications. The new SH-4AL-DSP-based SH7366 processor provides multimedia support, including a VPU (video-processing unit) and USB. For portable multimedia systems, the 400-MHz SH7723 delivers 2.8 GFLOPS (billion floating-point operations per second) and supports a video-processing function, a 2-D graphics accelerator, and USB. A new audio-video-player-media reference platform employs Renesas' SH7264 microcontroller and Express Logic's ThreadX RTOS.

The 90-nm-based SH74504 and SH-74513 devices provide the performance and memory to target advanced driver-assistance safety systems. The 600-MHz SH77650 SOC (system on chip) targets use in vehicle image-recognition-processing applications, and the SH77721 SOC suits low-range to midrange car-navigation systems. With 1920-MIPS performance at 533 MHz, the dual-core SH7786 processor also incorporates a fast DDR3-SDRAM interface for data transfers as fast as 4.27 Gbytes/sec, making it suitable for multimedia systems and next-generation car-navigation systems.

RF ENGINES • WWW.RFENGINES.COM

RFEL (RF Engines Ltd) provides high-specification DSP products for FPGAs and digital receivers and products for the defense, government-services, communications, and instrumentation markets. Applications include communications base stations, satellite-communications systems, test-and-measurement instrumentation, and custom wideband receivers and transceivers. RFEL's cores and SOC (system-on-chip) designs primarily target Xilinx and Altera FPGAs.

RFEL's FPGA designs are available as firmware, COTS (commercial off-the-shelf) implementations, custom hardware, or finished products. At the high end of this specialist DSP area, standard EDA tools cannot provide designs that meet the main parameters of performance, power consumption, and speed. The standard range of cores includes the HyperSpeed cores for applications requiring as much as 6.4G-sample/sec performance. The HyperLength cores provide transforms with as many as 1 million points, typically running at complex sample rates as great as 200M samples/sec on Xilinx devices. The Matrix range includes different-length DFT (discrete-Fourier-transform) cores

Third-party software-development-tool providers

CMX SYSTEMS • WWW.CMX.COM

CMX Systems' core business is to develop real-time, multitasking operating systems; TCP/IP (Transmission Control Protocol/Internet Protocol) stacks; flash-file systems; USB (Universal Serial Bus) stacks; and the CAN (controller-area-network)-open stack for 8-, 16-, and 32-bit microcomputers, microprocessors, DSPs, and DSCs. CMX's RTOS supports more than 50 processor families and more than 30 C-compiler vendors. CMX also offers the tiny CMX-MicroNet, a TCP/IP stack that targets 8-, 16-, and 32-bit and DSP processors with limited ROM, RAM, or both. The company also offers CMX TCP/IP, a full-featured TCP/IP stack for 16-bit, 32-bit, and DSP processors. CMX also offers flash-file systems for memory management and CMX-USB to assist designers wishing to add USB connectivity to their products.

Over the previous year, the company expanded product support, including porting RTOS, TCP/IP stacks, and USB host/device/OTG (On-The-Go) stacks to the new ARM, Cortex-M3, and ColdFire processor families. The company added RTOS-kernel awareness for Keil Realview tools for ARM and completed RTOS ports to the Atmel Xmega, STMicroelectronics STM8, Renesas RX600, and Renesas SH-2A. All CMX products feature full source code, no royalties, and free technical support and updates with every purchase.

GREEN HILLS SOFTWARE • WWW.GHS.COM

Green Hills Software provides real-time operating systems; operating systems; certified software; hypervisor and virtualization software; security software; cryptographic algorithms; protocols and related software; hardware-debugging devices; networking software; static analysis; file systems; computer compiler programs; computer utility programs; and computer programs for writing, editing, analyzing, and debugging other computer programs. Green Hills products target 32- and 64-bit automotive, avionics, consumer, industrial, medical, telecommunications, and networking applications.

The TimeMachine debugging suite combines a familiar debugger interface that enables developers to step and run forward or backward through code. Standard debugging tools, such as execution and data breakpoints, are available. The TimeMachine suite includes PathAnalyzer, which enables developers to view an application's call stack over time to help identify bugs and inefficiencies in code. The EventAnalyzer displays a view of operating-system events over time and helps track down bad interactions, such as deadlocks and race conditions between tasks.

The feature-rich Multi development environment for C, C++, EC++, and Ada tightly couples with Green Hills Software's operating systems, compilers, and debugging probes. Multi's advanced cross referencing simplifies the search for references to any symbol or macro in a program by showing the location and role of any variable or procedure. Runtime error checking automatically pinpoints the source of a variety of runtime errors, eliminating the need to search for bugs in problem-free areas. The performance analyzer pinpoints where to focus optimization efforts by identifying which blocks of code are taking the longest to execute. The code-coverage utility improves product quality by identifying whether the system has executed areas of code. Code-coverage analysis allows developers to focus their efforts on creating tests to ensure 100% coverage and eliminate latent bugs. The project builder streamlines program configuration, allowing developers to get started quickly and to easily manage multiple configurations of their programs.

THE MATHWORKS • WWW.MATHWORKS.COM

Matlab, a high-level technical-computing language and interactive environment for algorithm development, data visualization, data analysis, and numeric computation, is applicable to a range of applications, including signal and image processing, communications, control design, test and measurement, financial modeling and analysis, and computational biology. Matlab provides a number of features for documenting and sharing work. Designers can also integrate Matlab code with other languages and applications to distribute Matlab algorithms and applications. Add-on toolboxes, separately available collections of special-purpose Matlab functions, extend the Matlab environment to that you can combine to configure FFTs (fast Fourier transforms) to match the number of points an application requires.

You can use ChannelCore64 for extracting as many as 64 narrowband channels from one or two wideband ADC inputs. RFEL bases the core on a novel channelization architecture that provides the flexibility you traditionally associate with DDC (digital-downconverter) cores and ASIC devices with greater silicon efficiency. The main features are 64 independent downconversion channels, support for two 16-bit ADC inputs reaching 220M samples/sec, alias-free channel bandwidths as wide as 687.5 kHz, independent tuning of channels' center frequencies with a resolution of less than 0.01 Hz, and a fractional resampler for setting output sample rates with a resolution of less than 0.01 Hz. You can reconfigure channels without affecting the operation of other channels. The core supports an end-to-end dynamic range of more than 80 dB as well as gain control.

Other techniques include the PFT (pipelined-frequency transform), which is relevant for real-time multichannel-filter-bank applications. You can also apply the polyphase DFT or WOLA (weighted overlap and add) when applications require a uniformly distributed multichannel-filter bank.

SENSORY • WWW.SENSORYINC.COM

Sensory's RSC family of devices performs recognition, speech synthesis, and general-purpose product control. The RSC line supports speaker-independent recognition, speaker-dependent recognition, speaker verification for voice biometric security, 2400-bps speech compression for speech playback, and music synthesis. The RSC-4x family provides on-chip integration of features, including a microphone preamplifier, twin DMA units, a vector accelerator, and a hardware multiplier, all of which allow a designer to build a system with little more than a battery, a speaker, a microphone, and a few resistors and capacitors. Multiple ROM options are available. Sensory's SC-6x series of DSPs offers multiple options for introducing speech- and music-synthesis abilities into consumer products. Members of the SC-6x line can store as much as 37 minutes of speech on-chip and include as many as 64 I/O pins for external interfacing.

SILICON HIVE • WWW.SILICONHIVE.COM

Silicon Hive, a supplier of semiconductor IP (intellectual property), designs, builds, and licenses application-specific products for communications and media processing, tuned processor cores, and program-development tools with application libraries. Silicon Hive processor cores target the requirements of application domains and are high-level-programmable from ANSI C.

The company's processor lineup includes the Avispa-CH1, a high-performance C-programmable data processor for communications-signal processing. The Avispa-IM2 is a general-purpose, C-programmable data processor. These two processors are scalable to a high level of operations per cycle, with multiple options for precision, I/O, and

solve domain-specific problems related to digital-signal processing.

Simulink, an environment for multidomain simulation and model-based design for dynamic and embedded systems, provides an interactive graphical environment and a customizable set of block libraries that let engineers design, simulate, implement, and test a variety of time-varying systems, including communications, controls, signal processing, video processing, and image processing.

Matlab integrates Simulink, providing access to a range of tools to develop algorithms; analyze and visualize simulations; create batch-processing scripts; customize the modeling environment; and define signal, parameter, and test data. Add-on products extend Simulink software to multiple modeling domains, and they provide tools for design, implementation, and verification and validation tasks.

MICRIUM • WWW.MICRIUM.COM

Micrium delivers to the embedded market a full portfolio of embedded-software components for automotive, avionics, consumer-electronics, medical-device, military and aerospace, networking, and SOC (system-on-chip) applications. The company's products include its µC/OS-II RTOS; a TCP/IP (Transmission Control Protocol/Internet Protocol) stack; a USB (Universal Serial Bus) device, host, and OTG (On-The-Go) stack; a CAN (controller-area-network) stack; a file system; a GUI (graphical user interface); a flash loader; a Modbus slave and master; and clock- and LCD-control modules. Designers have ported these components to numerous platforms from a variety of manufacturers, and they can run in any embedded system.

The company also offers µC/Probe, a versatile tool that enables engineers to visualize embedded systems in a live environment. When embedded-system developers use this product, it gives them a window into otherwise-inscrutable hardware platforms. Designers can implement µC/Probe for a variety of uses, from debugging to demonstrations.

Micrium's RTOS, µC/OS-II, is certified for avionics RTCA (Radio Technical Commission for Aeronautics) DO-178B and EUROCAE (European Organization for Civil Aviation Equipment) ED-12B; medical devices certified under FDA (Food and Drug Administration) 510(k) use µC/OS-II; and Micrium meets the requirements of the IEC (International Electrotechnical Commission) 61058 standard for transportation and nuclear systems. Its µC/TCP-IP is a compact, reliable, high-performance TCP/IP stack that enables rapid configuration of required network options.

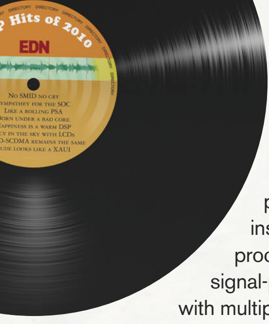
NATIONAL INSTRUMENTS • WWW.NI.COM

National Instruments empowers scientists and engineers with software such as NI LabView and modular, cost-effective, off-the-shelf hardware. With National Instruments LabView graphical-system-design platform, developers can design a signal-processing algorithm using a variety of methods, including graphical data-flow programming, state-based system design, text-based programming, dynamic system simulation, and configuration-based development. The design platform supports building functional prototypes and final implementations with off-the-shelf hardware that features real-time processors, FPGAs, and modular analog and digital I/O. LabView features graphical development tools for each of the three phases of DSP design.

For algorithm designers, LabView provides more than 600 math- and signal-processing functions ranging from filters to transforms to statistical analysis. In addition, tool kits and modules that extend LabView's capabilities to more specialized areas are available. One example is the LabView digital-filter-design tool kit, which provides interactive tools for design, analysis, and implementation of digital filters. This tool kit provides a variety of filter topologies and analysis tools for design, modeling, and implementation of both fixed- and floating-point digital filters. Other products include modulation, sound-and-vibration, and spectral-measurements tool kits.

For prototyping, National Instruments provides a variety of off-the-shelf hardware platforms, including the NI CompactRIO (rapid input/output) that comprises modular analog, digital, and communications I/O with an FPGA and a floating-point processor.

For deployment, the LabView microprocessor modules provide a path to programming both traditional DSPs, such as the Analog Devices Blackfin and the Texas Instruments c6000 series, and more general-purpose processors, such as those from ARM, PowerPC, and x86.



memory configurations.

The Moustique-IC2 is a C-programmable SIMD (single-instruction/multiple-data) processor targeting image-signal-processing applications with multiple options for SIMD-vector dimension, I/O, and memory configurations. All processors come with a software-development environment, application libraries, and proven SOC (system-on-chip) integration and verification packages.

SOUND DESIGN TECHNOLOGIES • WWW.SOUNDDESIGNTECHNOLOGIES.COM

Sound Design Technologies provides ultra-low-power DSP products for audio processing, and the company offers 3-D MCM (multichip-module), SIP (system-in-package), and HDI (high-density-interconnect)-substrate technologies. The programmable, multiprocessor Voyageur DSP platform maximizes instructions per microwatt using a reconfigurable architecture and an integrated high-resolution ADC and DAC in miniature packages. The reconfigurable-multicore system comprises hardware accelerators and DSP cores. The system includes five embedded DSP cores, four of which contain dual MAC (multiply/accumulate) units with customized instruction sets for audio processing, including single-cycle logarithmic and exponential functions. Hardware accelerators include FFT (fast-Fourier-transform)/IFFT (inverse-FFT) accelerators, hard-wired FENG (filter-engine) blocks of FIR (finite-impulse-response) and IIR (infinite-impulse-response) filters, and a perfect-reconstruction, programmable time-domain filter bank for subband audio processing.

GUIDE (Gennum Universal Integrated Development Environment), the Voyageur platform-development tool, supports developers' efforts for firmware development, debugging, and testing.

STREAM PROCESSORS • WWW.STREAMPROCESSORS.COM

Fabless semiconductor company SPI (Stream Processors Inc) offers parallel-processor options targeting consumer and industrial applications. Its Stream Processor architecture brings computing cost down to ASIC levels and makes the performance benefits of parallel processing easily accessible to programmers. Delivering more than 200 GMACs (billion multiply/accumulate operations), SPI's C-programmable stream processors enable designers to adopt a software-driven model and eliminate dependencies on inflexible ASICs or complex multi-DSP or FPGA implementations.

The company's Storm-1 family supports video- and image-processing in applications such as intelligent video surveillance, high-definition videoconferencing, broadcasting, and multifunction printers. The Storm-1 family comprises the software-compatible products—from the low-cost, low-power SP8LP-G30 suitable as a single-chip IP (Internet Protocol) camera, to the SP16HP-G220, which delivers 448 GOPS (billions of operations per second) of computation performance and targets high-end imaging and multichannel-video applications. The RapiDev tool suite, development kits, libraries, and a network of third-party developers help customers shorten time to market and slash total costs.

The Stream Processor architecture combines data parallelism with a sophisticated C development environment to simplify the programming task. To the programmer, the processor looks like a single core, in which the tools and underlying hardware manage synchronization, on-chip memory, and data movement. The compiler-managed memory hierarchy provides predictable performance, high ALU (arithmetic-logic-unit) use, and efficient bandwidth management.

STRETCH • WWW.STRETCHINC.COM

Fabless semiconductor company Stretch offers a family of software-configurable processors with embedded programmable logic. The processors target video and imaging, security, and industrial applications. System developers can easily program and configure Stretch processors using C/C++ development tools. The S6 architecture offers a second-generation ISEF (instruction-set-extension fabric), a processor array, and a programmable accelerator.

Stretch's reference designs are available for PCIe (Peripheral Component Interconnect Express) DVR (digital-video-recorder) add-in cards, stand-alone DVR systems, and IP (Internet Protocol) cameras. Supported resolutions range from CIF (Common Intermediate Format) to HD (high-definition) CCTV (closed-circuit television). Reference designs are available as development platforms or as fully featured OEM units. The Stretch IP (intellectual-property) library includes H.264 AVC (advanced-video-coding) and H.264 SVC (scalable-video-coding) codecs, as well as image-enhancement and video-analytics algorithms. A rich application programming interface is common across all Stretch reference designs.

TENSILICA • WWW.TENSILICA.COM

Tensilica offers 32-bit customizable data-plane processors, DSPs, and standard processor cores. The Diamond Standard 108Mini, 212GP, and 232L integrate a 32×32-bit multiplier and 32-bit integer divider. The Diamond Standard 570T includes dual 32×32-bit SIMD (single-instruction/multiple-data) multipliers and a 32-bit integer divider as well as 16-bit DSP instructions. Tensilica offers preconfigured DSPs for audio and video. The 330HiFi audio DSP includes dedicated audio instructions to decrease frequency requirements and supports more than 60 popular audio codecs. The 388VDO video DSP targets standard-definition D1.

In 2009, Tensilica introduced the ConnX DSP brand. The 16-bit, dual-MAC (multiply/accumulator)-unit ConnX D2 uses two-way SIMD instructions with a compiler that runs TI and ITU intrinsics. The ConnX Vectra DSP engine uses 64-bit instruction words with three issue slots for ALU (arithmetic-logic-unit), MAC, and load/store operations. The three-issue, VLIW (very-long-instruction-word) ConnX 545CK DSP has eight-way SIMD units, dual 128-bit load/stores, and a Viterbi convolutional coder accelerator. The ConnX BBE (baseband engine) 16 employs a core vector pipeline comprising 16 18×18-bit MAC units with instructions for FFT (fast-Fourier-transform) butterflies, parallel complex multiple operations and signal-filter structures.

All of the ConnX, audio, and video DSP offerings are options for the Xtensa LX3 configurable processor. Xtensa LX3 can deliver RTL (register-transfer-level)-equivalent I/O through direct interfaces that bypass the local/store operation. Designers can use the Xtensa LX3 processor to design their own custom DSPs.

Designers can mold Tensilica's Xtensa processors to fit the application by selecting and configuring predefined elements of the architecture and by inventing new instructions and hardware-execution units for maximum performance. The generated software-tool chain, including compilers and debuggers, reflects all of the designer's changes.

Tensilica offers a processor-development tool kit, which contains all of the tools necessary to create, analyze, and build high-performance DSPs and application-specific processors. The tool kit uses Tensilica's Eclipse-based Xtensa Xplorer integrated design environment, which serves as the cockpit for the design experience. From Xtensa Xplorer, designers can profile application code, identify hot spots that can benefit from acceleration, and make the changes necessary to speed up that code. Using a check-box menu within the GUI (graphical user interface), designers can configure processors to include needed features and remove features—options for processor interface, memories, operating-system support, EDA scripts, debugging and trace, and more.

TEXAS INSTRUMENTS • WWW.TI.COM

Texas Instruments offers a broad portfolio of programmable DSPs. The TMS320C5000 DSP platform offers reduced power consumption and advanced signal processing.

The TMS320VC5505 and TMS320VC5504 provide higher integration with low standby and active power for portable medical, biometrics, and audio/voice applications. The TMS320VC5505 eZdsp USB (Universal Serial Bus)-stick development tool offers a full-featured emulator and integrated development platform for only $49.

The TMS320C6000 DSP platform comprises high-performance fixed- and floating-point DSPs. The low-cost, networked TMS320C6743 DSP offers higher system performance, increased on-chip memory, and an integrated MAC (multiply/accumulate) unit for floating-point ease and precision with the efficiency of fixed-point processing. TI also offers the TMS320C6742, TMS320C6746, TM2320C6748, and OMAP (open multimedia-applications processor)-L138 with connectivity options and unique peripherals in a low-cost, low-power format for intelligent occupancy sensors and power-protection systems.

DaVinci video processors include processors, software, tools, and support for developing digital-video applications. The TMS320DM365 processor employs an ARM926EJ-S with an integrated image-signal processor for intelligent video processing and provides multiformat, multirate video with production-qualified H.264, MPEG (Motion Picture Experts Group)-4, MPEG-2, MJPEG (Motion Joint Photographic Experts Group), and VC1 (video codec 1) codecs. It targets use in video-security applications.

TI's ARM Cortex-A8 based OMAP35x processors, including the OMAP3503, OMAP3515, OMAP3525, and OMAP3530, provide laptoplike performance at handheld power levels. The OMAP35x processors target applications such as portable navigation devices, Internet appliances, and portable patient-monitoring devices.

TILERA • WWW.TILERA.COM

Tilera offers high-performance multicore processors targeting embedded-networking, security, multimedia-processing, and wireless-infrastructure applications. The Tile processor family targets applications requiring intensive packet processing for layers three through seven at 1- to 20-Gbps throughput. Services such as deep-packet inspection, flow monitoring, and intrusion prevention are ideal targets for Tilera's processors. In the multimedia and DSP arena, the Tile processors enable HD (high-definition)-video applications, such as videoconferencing, surveillance, and broadcast head-end equipment, as well as wireless-backhaul and baseband processing.

The Tile64 processor SOC (system on chip) has 64 full-featured processor cores plus system-integration blocks, including four DDR2-memory controllers with ECC (error-correcting code); two 10-Gbps, four-lane PCIe (Peripheral Component Interconnect Express) interfaces; two XAUI (10-Gbit-attachment-unit-interface) 10-GbE (gigabit-Ethernet) controllers; two 1-Gbit RGMII (reduced-gigabit media-independent-interface) Ethernet controllers; and 64 bits of flexible I/O that can support HD-video input or other high-speed interfaces. The device includes 5 Mbytes of cache, and each processor core can independently run a full operating system, such as Linux. It is available in speeds of 600 to 866 MHz.

Tilera based the Tile64 family on a tiled multicore architecture with a mesh-based on-chip interconnect that delivers as much as 32 Tbps of interconnect bandwidth between the cores and allows scaling the architecture beyond hundreds of cores. In addition to multicore processors, Tilera also offers turnkey PCIe appliance boards and a suite of multicore software-development tools.

Tilera's MDE (multicore development environment) is a complete standards-based multicore-programming option that enables developers to take full advantage of the parallel-processing potential of the Tile processor architecture. It includes a graphical IDE (integrated development environment) with ANSI

C and C++ compiler, a multicore-aware debugger and profiler, a hardware simulator, and Tilera's powerful iLib parallel-programming library. Tilera also delivers a standard runtime environment using full SMP (symmetric-multiprocessing) Linux 2.6 and a system hypervisor.

VERISILICON •
WWW.VERISILICON.COM

IC-design foundry VeriSilicon provides custom options and SOC (system-on-chip) turnkey services. The company acquired the ZSP division from LSI. VeriSilicon's licensable ZSP digital-signal-processing cores and star-IP (intellectual-property)-based SOC platforms target applications in the voice, wireless communications, and multimedia markets.

NEW **VIRAGE LOGIC •**
WWW.VIRAGELOGIC.COM

Virage Logic offers semiconductor IP (intellectual property) for the design of complex ICs. The company's product portfolio includes processors, interface IP, embedded SRAMs and nonvolatile memory, embedded test and yield-optimization products, logic libraries, and memory-development software.

Last year, Virage Logic acquired ARC's processors cores that ship in more than 425 million units annually in products such as digital and mobile TVs, portable media players, PCs, laptops, flash storage, digital cameras, and smartphones, as well as in medical and government systems. The ARC configurable 32-bit processors work with Sonic Focus audio-enrichment IP to offer SOC (system-on-chip) designers complete approaches with rapid, low-risk paths to market.

XILINX • WWW.XILINX.COM

Xilinx offers programmable-logic products. The Xilinx XtremeDSP development-tool package provides a comprehensive design suite that enables you to use The MathWorks' Matlab and Simulink modeling environments for FPGA design. Use this DSP-design environment early in the design flow to explore hardware options for high-level algorithms or to assemble complete DSP systems for production that are highly optimized and include RTL (register-transfer-level) logic, IP (intellectual property), and embedded processing.

The XtremeDSP tool package includes both System Generator for DSP and the AccelDSP Synthesis Tool. Together, they form a flexible, integrated, and powerful DSP-development environment for FPGAs. System Generator includes the Xilinx DSP block set, which helps produce optimized logic for Xilinx programmable devices. More than 90 DSP building blocks are available for the Simulink modeling environment.

XMOS • WWW.XMOS.COM

Fabless semiconductor company XMOS develops SDS (software-defined silicon). The company's programmable devices are available for $1 to $15. To ensure that development costs do not negate the unit-cost savings, the company offers an innovative way to access the programmable hardware through a software-based design flow that bypasses hardware descriptions and logic synthesis.

XMOS bases its technology on XCore, a compact, event-driven, multithreaded processor. This 32-bit RISC processor supports as many as eight threads and is integrated with support resources into the XCore tile building block. Multithreading permits concurrent processing of distinct functions, ranging from I/O interfaces to complete software applications. With as much as 400 MIPS per tile, the XCore engine has the performance to implement multiple complex real-time hardware and software functions.**EDN** www.RFM.com

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- NEW 300-510 MHz RFIC (TRC105)
- 300-1000 MHz SAW-Based RX
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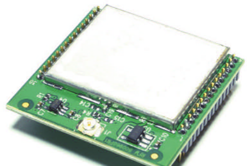

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HIGHLIGHTS: 2.4 GHz; IEEE 802.11b/g standard; multipoint and point-to-point networks; DSSS technology; up to 11 Mb/s data rate; 10 mW RF power; 50 meters typical indoor and 250 meters typical outdoor transmission ranges; Analog, Digital and Serial I/O; 1.05 sq. inch footprint.

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WSN802GDK

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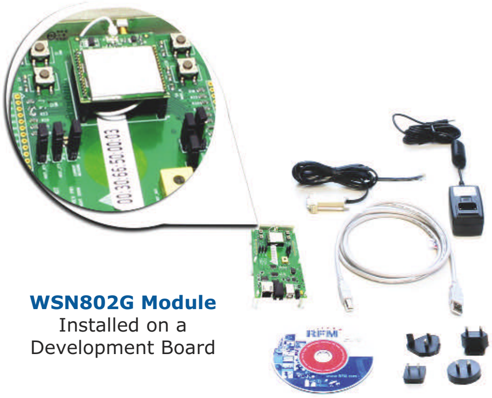

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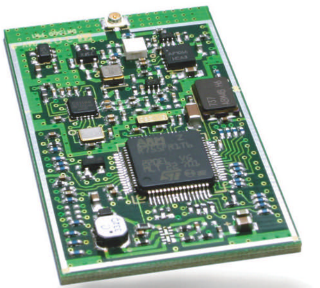
HIGHLIGHTS: 900 MHz (DNT900) and 2.4 GHz (DNT2400); proprietary FHSS technology; multipoint, point-to-point, and peer-to-peer networks with "tree routing"; configurable data rates from 38 kb/s to 500 kb/s; configurable RF power of 1 mW to 1 W (DNT900) and 1 mW to 100 mW (DNT2400); 40+ mile range (DNT900) and 5+ mile range (DNT2400) with omni-directional antennas (antenna height dependent); Analog, Digital and Serial I/O; 2.8 sq. inch footprint.



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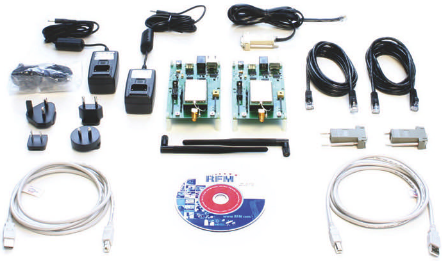
DNT900DK or DNT2400DK

$359
Dev Kit



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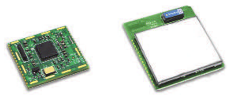
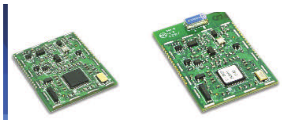
1 mW Low Power

LPR2430 OR ZMN2430

LPR2430A OR ZMN2430A with Chip Antenna





LPR2430ER OR ZMN2430HP

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100 mW Extended Range

ZMN2430 Series 2.4 GHz 802.15.4 ZigBee® Wireless Sensor Networking (Mesh). Comprised of the low-power 1 mW RF power ZMN2430 / ZMN2430A and the high power 100 mW ZMN2430HP / LPR2430HPA, the RFM ZMN2430 Series modules are based on the IEEE 802.15.4 wireless standard and the ZigBee protocol stack.

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2.4 GHz

460.8 kb/s
WIT2410 @ 10-100 mW
WIT2450 @ 40-250 mW

921.6 kb/s
WIT2492 @ 10-100 mW

1.23 Mb/s
WIT2411 @ 10-100 mW

RF Module Portfolio at a Glance	FREQUENCY			MAX RF DATA RATE								RANGE										RF POWER					STANDARD				NETWORK			TECHNOLOGY			INTERFACE	
	434 MHz	900 MHz	2.4 GHz	4.8 kbps	9.6 kbps	172.8 kbps	250 kbps	460.8 kbps	500 kbps	1.23 Mbps	11 Mbps	Indoor 30 m	Indoor 100 m	Indoor >100 m	Outdoor 30 m	Outdoor 100 m	Outdoor 250 m	Outdoor 500 m	Outdoor 1,000 m	Outdoor 10,000 m	Outdoor >10,000 m	1 mW	10 mW	100 mW	250 mW	1 W	ZigBee	802.15.4	Proprietary	802.11	Mesh/S&F	Multipoint	Peer-to-Peer	Narrowband	Frequency Hopping	Direct Sequence	UART Only	I/O and UART
DM1810	✓	✓		✓								✓	✓	✓	✓	✓	✓						✓						✓		✓			✓				✓
DNT900		✓							✓*			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓		✓			✓
DNT2400			✓						✓*			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓		✓	✓	✓		✓			✓
LPR2430			✓				✓					✓	✓		✓	✓						✓						✓				✓	✓			✓		✓
LPR2430A			✓				✓					✓	✓		✓	✓						✓						✓				✓	✓			✓		✓
LPR2430ER			✓				✓					✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓				✓				✓	✓			✓		✓
LPR2430ERA			✓				✓					✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓				✓				✓	✓			✓		✓
WIT910		✓				✓						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓			✓			✓			✓		✓	
WIT2410			✓					✓				✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓					✓			✓			✓		✓	
WIT2411			✓							✓		✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓					✓			✓			✓		✓	
WIT2450			✓					✓				✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓				✓			✓			✓		✓	
WSN802G			✓								✓*	✓			✓	✓							✓							✓		✓				✓		✓
XDM2140			✓				✓					✓	✓	✓	✓	✓	✓					✓	✓					✓	✓		✓				✓		✓	
ZMN2405			✓				✓					✓	✓		✓	✓						✓					✓				✓					✓		✓
ZMN2405HP			✓				✓					✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓			✓				✓					✓		✓
ZMN2430			✓				✓					✓	✓		✓	✓						✓					✓				✓					✓		✓
ZMN2430A			✓				✓					✓	✓		✓	✓						✓					✓				✓					✓		✓
ZMN2430HP			✓				✓					✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓			✓				✓					✓		✓
ZMN2430HPA			✓				✓					✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓			✓				✓					✓		✓

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RFIC Portfolio at a Glance	FREQUENCY										DATA RATE			RANGE			RF POWER			TX CURR		RX CURRENT				MODULATION & TECHNOLOGY					FEATURES			INTER FACE		PACK-AGE	
	303.825 MHz	315 MHz	403.5 MHz	418 MHz	433.92 MHz	868.35 MHz	914 MHz	916.5 MHz	902- 928 MHz	2.4 GHz	19.2 kbps	115.2 kbps	Up to 256 kbps	100 m Line-of-Sight	200 m Line-of-Sight	600 m Line-of-Sight	0 dBm	4 dBm	10 dBm	6 mA	15 mA	1.8 mA	3.0 mA	4.3 mA	11 mA	OOK / ASK	Single Channel	FSK	Multi-Channel	FHSS	Duty Cycle	Clock Recovery	Start Symbol	Digital	SPI	4 X 4 mm	5 X 5 mm
TRC103						✓	✓	✓	✓			✓		✓	✓	✓			✓		✓		✓			✓		✓	✓	✓	✓	✓	✓		✓		✓
TRC104										✓		1 M		✓	✓	✓	✓			13 mA				18 mA				✓	✓	✓	✓	✓	✓		✓	✓	
TRC105	✓	✓	✓	✓	✓							✓		✓	✓	✓			✓		✓		✓			✓		✓	✓	✓	✓	✓	✓		✓		✓

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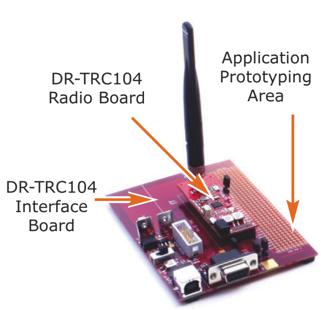

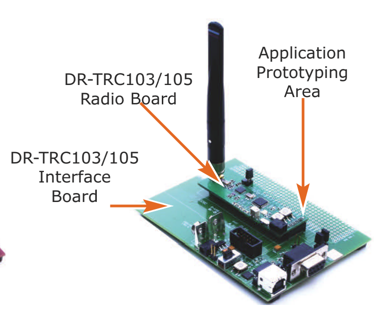

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BY RON CHOI • EVE

Save time and money with smart debugging method

TOOLS ALONE DON'T SOLVE THE PROBLEM; YOU MUST COUPLE GOOD TOOLS WITH AN EFFECTIVE DEBUGGING STRATEGY.

The design of modern SOCs (systems on chips) requires increasingly thorough verification to ensure that manufacturers don't spend millions on mask revisions when first silicon has problems. A widely bandied number suggests that designers spend 70% of their time in verification. Companies spend big money purchasing verification tools; savings in silicon-spin costs mitigate the cost of those tools. That is, the avoidance of other costs reduces the effective cost of ownership of the tool that generated the savings.

Even though verification takes the lion's share of the design time, it's generally an activity that designers can plan and, as long as things go well, is more or less predictable. But debugging is an activity you can't plan in detail because you can't plan for an unexpected bug when you don't know of its location and nature. The amount of time it takes to debug a problem adds directly to the cost of the project. Conversely, any expenditures on tools or other means of reducing debugging efforts reduce the cost of ownership of those tools. Tools alone don't solve the problem, however. You must couple good tools with an effective debugging strategy to reap the full potential of the tools.

Emulators provide an effective means of reducing debugging time by allowing faster execution of a target design—especially one that's running embedded software—than is possible through simulation. Today's designs are enormous and complex, however. Perversely, the better job a designer has done, the more likely it will be that any bugs reside deep in unsuspected corners of the design and are hard to find. As often as not, you'll discover some pathological case after long execution. It can take billions of clock cycles before you encounter the bug.

Other system considerations can further lengthen the debugging process. Even if the bug occurs relatively early in the normal operation of the system, simple system initialization can take a nontrivial number of clock cycles, making repeated runs expensive. Randomly poking around is ineffective if the bug isn't deterministic; even if you find the bug once, it won't happen in the same way the next time. Poor planning may even necessitate multiple recompilation cycles to provide the necessary observability of the design, further lengthening the debugging process.

Replicating a bug requires deterministically and repeatedly re-executing many clock cycles until you can identify the problem. Therefore, it's essential that a debugging strategy makes the most effective use of those cycles, allowing "debugging convergence" as quickly as possible. Even though debugging seems more chaotic than verification in that you cannot plan for debugging, a modicum of forethought and a disciplined debugging process combine with the right tools to dramatically reduce debugging time and minimize the frightening unknowns of elusive bugs.

A well-thought-out debugging process includes three critical phases (**Figure 1**). The first, the preparation phase, happens before you execute a design. It puts in place the groundwork that will be necessary if debugging becomes necessary, reducing the need for future compilation. The second phase, investigation, happens when debugging starts. It quickly and effectively narrows down the range in which you can find the bug. The third phase, detailed debugging, occurs when you burrow into the design within that range to identify and fix the bug.

PREPARATION BEFORE COMPILATION

Depending on the tools at your disposal, you can furnish a DUT (design under test) with triggers and probes that can give you access to and control over the inner workings of the design. But indiscriminately adding debugging constructs into the DUT in the hope that you'll close all means of escape for any bug will quickly chew up logic, memory, and pins. You must strike a balance between specificity and flexibility.

Triggers monitor activity for an event and then activate some signals when that event occurs. If the event is a function of any RTL (register-transfer-level) signals in the DUT, then a trigger comprises some arbitrary logic between those signals, creating a static trigger signal. This trigger involves logic that you can't change without recompiling the design. If the event involves comparison of some internal state to a constant value, then you can obtain greater flexibility by creating a register to hold the comparison value and allowing that reg-

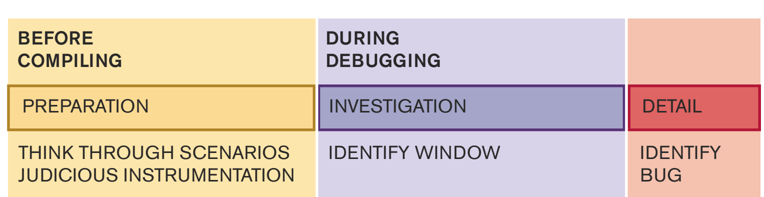

Figure 1 A well-thought-out debugging process involves preparation, investigation, and detail phases.

ister to load during debugging. This dynamic trigger allows you to modify the triggering condition without recompiling the design.

The development of assertion technology provides yet another means of generating an interesting event. Assertions allow you to monitor what's going on inside the design and to generate an alert when something goes wrong. A synthesizable SystemVerilog assertion builds a behavior monitor into the DUT. If the expected behavior fails, then the logic asserts a flag (**Figure 2**).

Triggers and assertions give you information about when but not why an event occurs. You must probe deeply into the DUT to understand what's going on when the DUT misbehaves, and you have choices and trade-offs. The basic characteristics of a probe are how it accesses the internal nodes and how it stores its data for waveform generation.

The obvious way to probe a DUT is simply to create a signal that taps some internal critical node. The benefit is the ability to observe the DUT at high speed; the cost is in interconnect, meaning that you can't randomly probe everything. You must compile in a fixed connection, meaning that you can't change it without recompiling.

To add more flexibility, given a limited means of extracting probe information, you can identify broad groups of related signals that you may want to probe and then, when debugging, select one of the groups at a given probe output to view without recompiling. If you employ an emulator, the technology underlying the emulator may provide yet another way to access signals. In the case of an FPGA-based emulator, you may have access to a back door that allows interrogation of all of the nodes in the DUT. For example, Xilinx (www.xilinx.com) Virtex FPGAs have a read-back feature that provides debugging access to all points of the design, including memory. Because this mechanism uses a built-in FPGA, it requires no FPGA resources to implement and, hence, no compilation. The trade-off is that such read-back has a dramatic impact on clock speed, so you can't use it indiscriminately as a way to capture a bug.

How the probed values are stored also affects execution time and flexibility. The highest-clock-speed option is for the values to be stored in memory modules on the emulator boards themselves. The challenge of using onboard memory modules is that space is limited: You can store only so many signals within a limited trace window. You get greater flexibility by

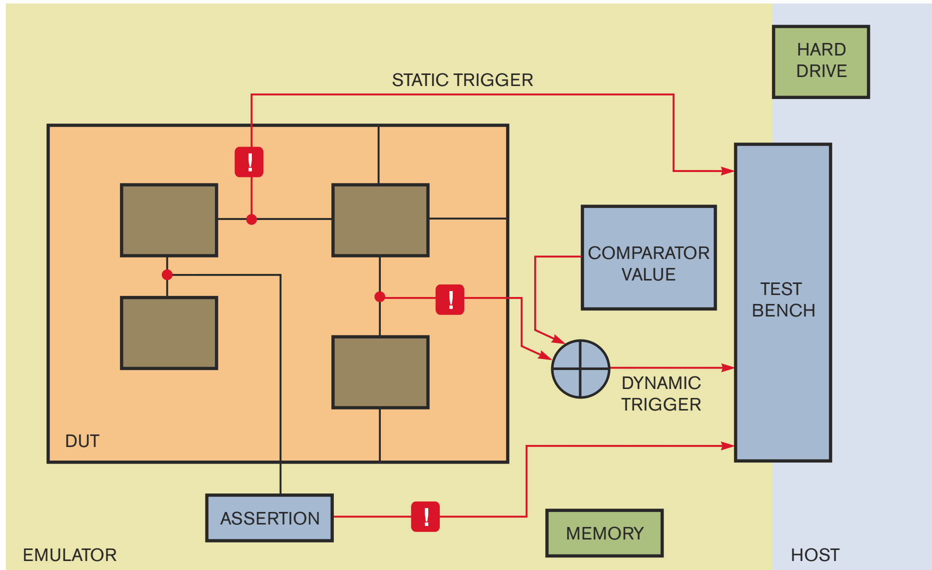

Figure 2 A static trigger involves logic that you can't change without recompiling your design. Dynamic triggering allows you to modify the trigger condition without recompiling.

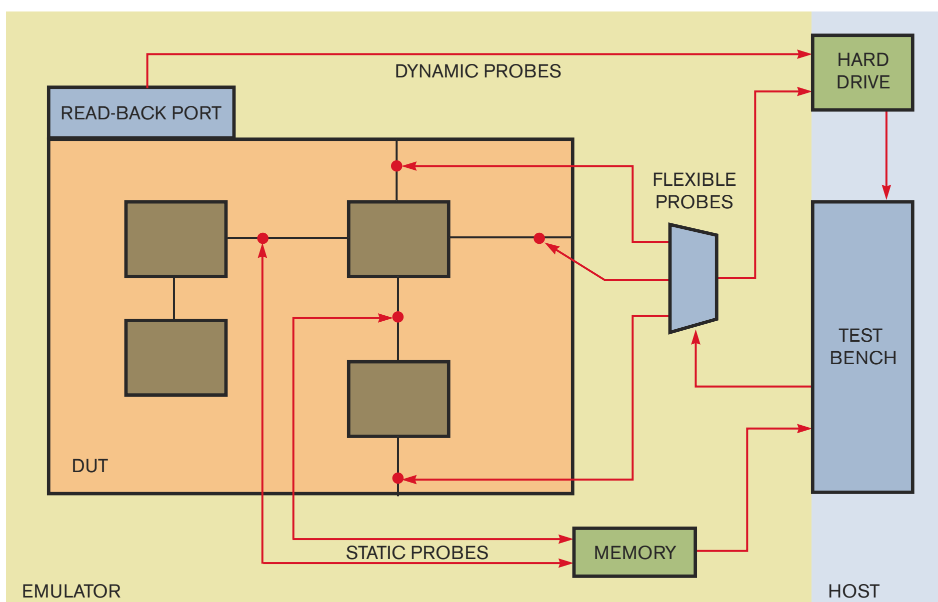

Figure 3 Static probes provide fastest execution but lowest flexibility, dynamic probes offer greatest specificity but slowest execution, and flexible probes provide moderate flexibility and execution speed.

streaming the data off the board and letting the host PC store it on disk. The trade-off is that the bandwidth of the hard disk limits clock speed.

Although you could theoretically mix and match these probe characteristics in different ways, you may want to limit the probes to three types (**Figure 3**): static probes, which are precompiled and trace into local memory; flexible probes, which allow selection of one of several groups of signals and store the data on disk; and dynamic probes, which use the read-back mechanism and also store data on disk. Static probes provide fastest execution but lowest flexibility, dynamic probes offer the greatest specificity but slowest execution, and flexible probes provide moderate flexibility and execution speed.

Given this selection of triggers, assertions, and probes, the preparation phase then consists of judiciously instrumenting the DUT before verification. The catch is that you want to have the tools available without having them encumber the DUT when you're not debugging. Therefore, you must minimize resource usage and make sure that you experience any impact from debugging execution only when debugging. The ability to enable or disable instrumented tools at runtime allows you to compile as much as possible up front without sacrificing verification time.

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THE INVESTIGATION PHASE

The goal of the investigation phase is to narrow down the scope of study to a manageable range. You want to eliminate the vast numbers of cycles that are unrelated to the bug or at least get them out of the way as fast as possible so that you can focus attention where it matters. If you do this investigation properly, this phase not only identifies when the problem happens, but also helps to locate the offending function or module.

Rapidly exercising broad swaths of execution requires abstracted technologies, such as TLM (transaction-level modeling). You don't want to exercise every gate in detail; you want to run quickly to see where things fail. Cycle-accurate transactors provide high performance and reproducibility and allow you to connect the DUT to your test bench and software debugger for analysis at the hardware or the software level.

Well-planned triggers and assertions pay off in this case. They give a high-level indication of when things are working and when they aren't. You can selectively turn them on and off to keep the DUT running at a high speed as you home in on the problem. Because you're not so concerned about detailed waveforms at this point and you are concerned about performance, static and flexible probes on main buses and interfaces are the workhorses for observing behavior. Solid upfront preparation provides a wide selection of probes available to you without recompiling.

The ability to save and restore the state of the DUT can also eliminate long initialization sequences. By saving the state of the system, you can return to that state directly to rerun the system, bypassing initialization. An emulator-runtime environment that provides such access to the detailed state of the system, including memory contents, can be of enormous value in reducing debugging time.

DETAILED DEBUGGING

Once you identify the range in which you need to dig deeper, you enter the detailed debugging phase, in which you examine detailed waveforms of portions of the DUT during a window of operation. TLM technology and state restoration are critical to quickly getting you to the window. Once in the window, static and flexible probes can rapidly generate traces, but dynamic probing can give you further access without recompiling when you need to check signals for which there is no precompiled probe—at the expense of clock speed. By limiting the use of dynamic probes to this phase, most debugging occurs at higher clock rates. Flexible and dynamic probes also let you generate waveforms over a practically unlimited window because they directly store their data on disk, allowing a gradual narrowing of investigation without fussing about a fixed window size.

To measure the impact of a well-planned debugging strategy and advanced debugging tools, compare traditional debugging and emulation techniques with a "smart"-debugging strategy using the ZeBu-XXL emulator on a 50 million-gate design. For a bug occurring after 12 billion cycles, the traditional approach takes slightly more than four hours plus data-transfer time. The smart approach on ZeBu takes slightly less than 30 minutes plus data-transfer time because you can delay the slowest aspects of debugging until the end, making the most efficient use of the emulator clock cycles.

The difference is more dramatic for another bug whose exact timing, sometime after 6 billion cycles, is unknown. Depending on assumptions about how many triggering attempts might be necessary to find the correct window in the traditional case, it takes four to 11 hours to complete traditional debugging and slightly more than 30 minutes for smart debugging on ZeBu.

These results confirm that the judicious use of a broad range of modern verification and debugging capabilities in a carefully planned process on an emulation platform that supports a wide range of tools can have a dramatic impact on debugging time. This method not only helps to reduce time lost to debugging, but also removes some of the chaos and unpredictability from the overall development cycle. The ability to more effectively manage these unknowns ultimately reduces the effective cost of ownership of the emulation tools, increases the revenue potential for the system, and makes for a less stressful experience for designers and managers alike. EDN

AUTHOR'S BIOGRAPHY

Ron Choi, product-marketing director at Eve (San Jose, CA), has a range of verification experience. He is knowledgeable about analog and digital simulation, hardware-verification languages, layered verification methodologies, emulation and system-level validation, and hardware/software co-verification. Choi has worked in EDA for the past eight years, first as a senior application consultant with Synopsys and then as a senior field-application engineer for Eve.

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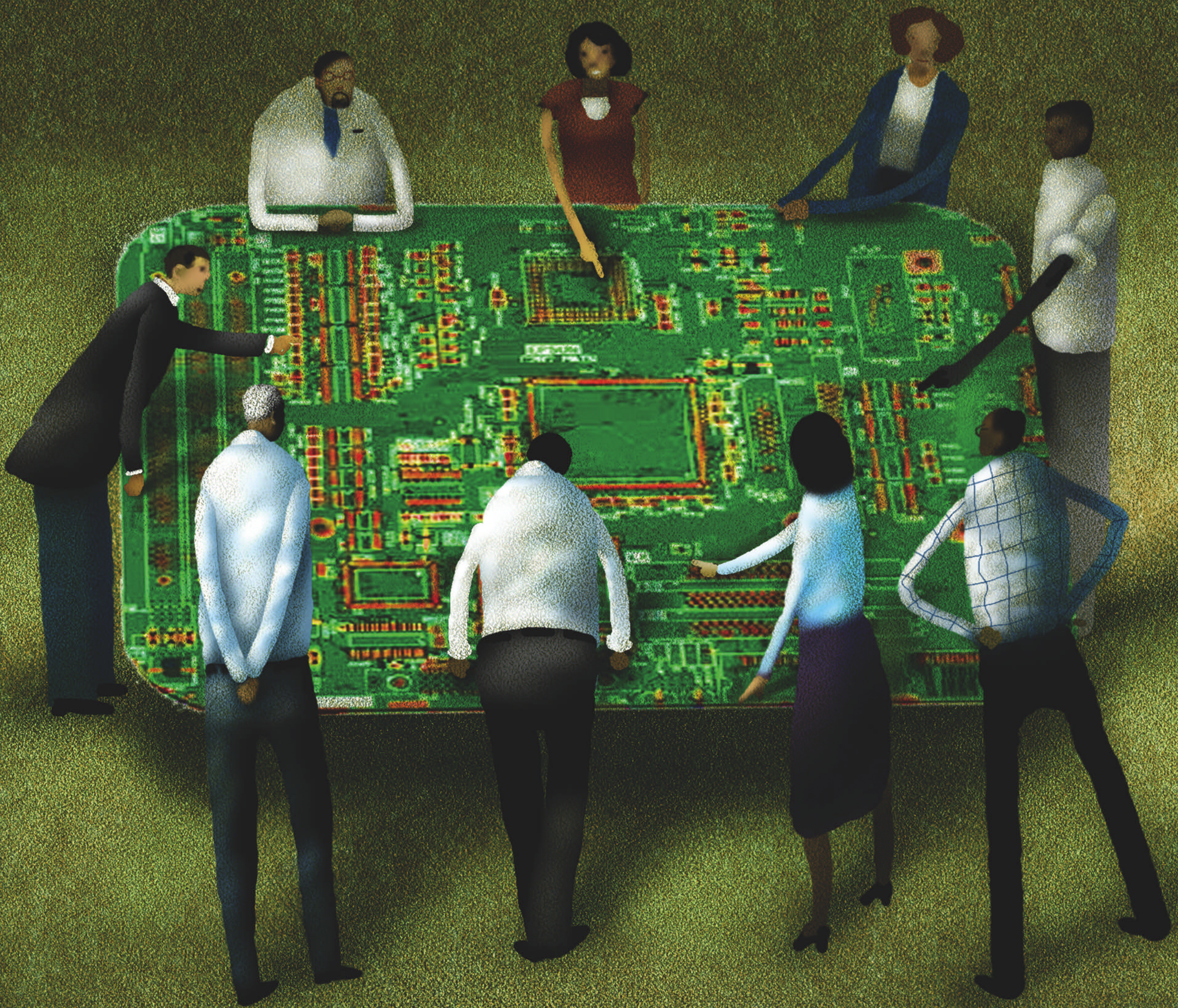
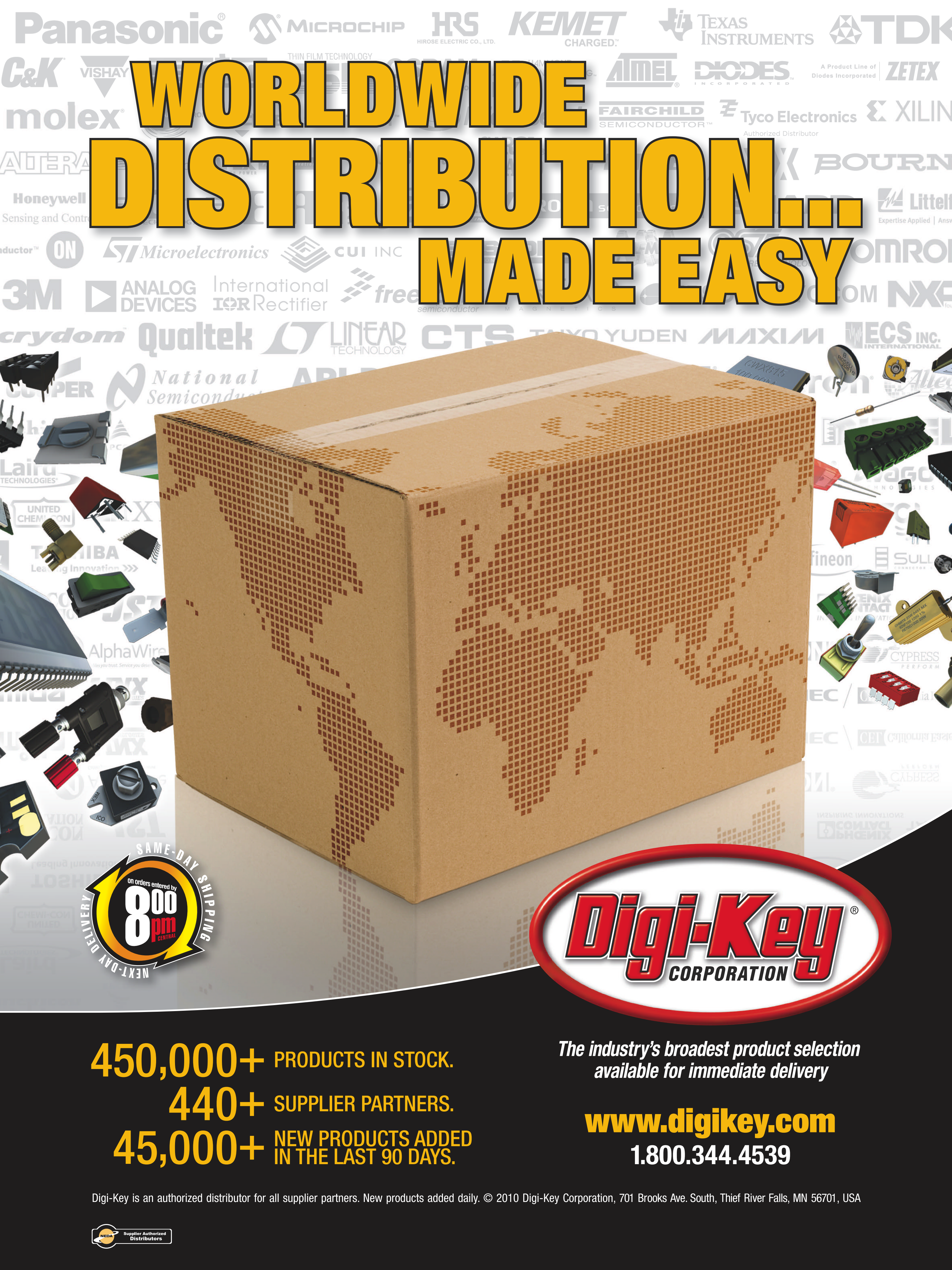


INSIDE

Including the TOP 25 North American Electronic Component Distributors ranking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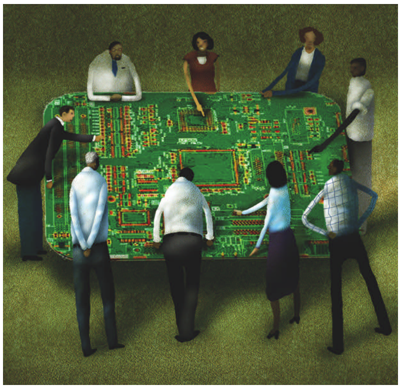

COVER: DAVE CUTLER

"BRINGING BETTER PARTNERSHIPS TO THE TABLE" continues with additional coverage online.

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A LETTER FROM THE EDITOR

Big changes to come

By **Barbara Jorgensen**

There weren't that many changes in the ranking of this year's Top 25 North American distributors versus 2009—but wait until next year.

Just as the 2010 list was going to press, the top two companies in the industry—Avnet and Arrow, respectively, both announced acquisitions of other Top 25 players. By next year, No. 4 Bell Microproducts will be part of the Avnet organization and No. 12 Converge will be part of Arrow.

It's been a long time since two such major acquisitions happened back to back. During the 1990s, Top 25 (then Top 50 or Top 100) distributors were getting acquired all the time—literally. Not since Avnet acquired No. 3 distributor VEBA in 2000 has there been such a shake-up in the rankings.

The other big story this year is Smith and Associates, which grew by 41% in the 2008-2009 period to move from No. 13 last year to No. 7 on the 2010 chart. Executives at Smith said this wasn't due to an acquisition or a major expansion—the growth was all organic. Sales at last year's top growth company, Mouser Electronics, declined by 4% between 2008 and 2009 but Mouser retained the same ranking as last year at No. 15.

This year there is also a new entrant to the list. World Pace Group, or WPG, is well-known overseas as the biggest broadline distributor headquartered in Asia. Through its acquisition of Jaco Electronics' components business in January of 2009, WPG enters the North American distribution market at No. 20.

By late 2009, the best thing distributors could say about the year was that it was over. The year was exceptionally difficult in the electronics supply chain. Unlike the prior worst downturn in 2001, the electronics industry had little or nothing to do with the economic conditions of the market. Instead, the global financial markets and the declining value of North American real estate had a far-reaching effect on spending, which meant most of the Top 25 saw sales decline last year. 2009 was a real test of relationships in the channel, as we discuss in this year's Top 25 supplement.

The remainder of 2010 promises to be better. Although first quarter earnings releases had not begun before press time, most channel execs expect results have to be better than 2009.

Freelance writer Barbara Jorgensen has been covering the electronics distribution industry for nearly 20 years, most recently as a Senior Editor at Electronic Business *magazine.*

TOP 25 North American Electronic

		CALENDAR YEAR 2009						% OF REVENUE 2009				
Rank	Company name	North American Revenue (millions of $)	Total Revenue 2009 (millions of $)	Revenue Change 2008-2009	5-year compound annual growth	Public/ Private	Independent/ Franchised	North America	Europe	China	India	Japan
1	Avnet[8]	7,497.0	16,660.0	-7%	9.1%	P	F	45.0%	32% (EMEA)	23% (Asia-Pacific)		
2	Arrow Electronics[9]	7,048.4	14,684.1	-12%	7.0%	P	F	48.0%	29% (EMEA)	23% (Asia-Pacific)		
3	Future Electronics[1]	2,971.8	4,572.0	-16%	N/A	PR	F	65.0%	N/A	N/A	N/A	N/A
4	Bell Microproducts[1]	1,268.9	3,021.2	-16%	N/A	P	F	42.0%	41.0%	0.0%	0.0%	0.0%
5	Digi-Key Corporation	695.2	926.9	-6%	10.0%	PR	F	75.0%	11.0%	4.0%	1.0%	3.0%
6	TTI, Inc.	598.9	1,015.0	-19%	5.5%	P	F	59.0%	34.0%	3.0%	0.05%	0.05%
7	Smith & Associates	437.0	437.0	41%	N/A	PR	I	100.0%	0.0%	0.0%	0.0%	0.0%
8	Newark[3]	422.2	429.9	-28%	N/A	P	F	98.2%	0.0%	0.0%	0.0%	0.0%
9	DAC	383.6	387.5	-21%	2.0%	PR	F	99.0%	0.0%	1.0%	0.0%	0.0%
10	Nu Horizons	371.8	641.0	-19%	N/A	P	F	58.0%	10.8%	15.5%	1.6%	0.0%
11	Sager Electronics[1]	306.9	310.0	-10%	N/A	PR	F	99.0%	1.0%	0.0%	0.0%	0.0%
12	Converge[6]	280.0	280.0	-10%	N/A	PR	I	100.0%	0.0%	0.0%	0.0%	0.0%
13	Allied Electronics[2,5]	278.2	281.0	-17%	N/A	P	F	99.0%	0.0%	0.0%	0.0%	0.0%
14	Carlton-Bates[2,4]	277.4	277.4	-28%	N/A	P	F	100.0%	0.0%	0.0%	0.0%	0.0%
15	Mouser Electronics	228.3	285.4	-4%	25.3%	P	F	80.0%	9.0%	3.0%	1.0%	1.0%
16	Fusion[6]	198.1	233.0	11%	9.65%	PR	I	85.0%	N/A	N/A	N/A	N/A
17	America II Electronics[1]	195.6	254.0	-8%	N/A	PR	I	77.0%	9.0%	5.0%	0.0%	7.0%
18	Richardson Electronics	173.7	496.4	-12%	6.0%	P	I	35.0%	25.0%	18.0%	0.0%	5.0%
19	Dependable Component Supply[1]	149.3	237.0	-12%	N/A	PR	I/F	63.0%	11.0%	23% (Asia-Pacific)		
20	WPG Americas[1,7]	140.0	140.0	600%	N/A	P	F	100.0%	0.0%	0.0%	0.0%	0.0%
21	PEI-Genesis	123.6	158.4	-8%	21.0%	PR	F	78.0%	20.0%	1.0%	0.0%	0.05%
22	Advanced MP Technology[1]	101.5	290.0	-10%	N/A	PR	I	35.0%	25.0%	25.0%	0.0%	5.0%
23	Electro Sonic[1]	95.3	100.3	-5%	N/A	PR	N/A	95.0%	N/A	N/A	N/A	N/A
24	Master Distributors	92.6	107.7	-7%	N/A	PR	F	86.0%	4.0%	6.0%	1.0%	2.0%
25	Bisco Industries	78.6	81.0	-13%	4.0%	PR	F	97.0%	<1%	<1%	<1%	<1%

Distributors are ranked by calendar year 2009 North American revenue.

N/A = Not available

Revenue figures are gathered from financial filings, company provided information, and Reed Business Information estimates.

Component Distributors

Rest of World	Total Employees 2009	Revenue per Employee ($ thousands)	% of Revenue from VA Services	% OF REVENUE 2009						Web Address
				% of Revenue Active Components	Passive, electromechanical, interconnect	Computer products/ systems	Contract Manufacturing	Services	Other	
0.0%	13,400	1,243.3	N/A	51.3%	9.3%	39.4%	0.0%	0.0%	0.0%	www.avnet.com
0.0%	11,300	1,299.5	N/A	66% active and passive		34.0%	0.0%	0.0%	0.0%	www.arrow.com
N/A	5,000	914.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	www.futureelectronics.com
17.0%	2,000	1,510.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	www.bellmicro.com
6.0%	2,023	458.2	10.0%	44.0%	50.0%	0.0%	0.0%	0.0%	6.0%	www.digikey.com
3.0%	1,965	516.5	15.0%	1.3%	98.7%	0.0%	0.0%	0.0%	0.0%	www.ttiinc.com
0.0%	265	1,649.1	N/A	74.0%	22.0%	4.0%	0.0%	0.0%	0.0%	www.smithweb.com
1.8%	1,317	326.4	20.3%	12.4%	48.0%	0.2%	0.0%	0.0%	39.4%	www.newark.com
0.0%	630	615.1	40.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	www.heilind.com
14.1%	778	823.9	70.0%	85.0%	7.0%	8.0%	0.0%	0.0%	0.0%	www.nuhorizons.com
0.0%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	www.sager.com
0.0%	350	800.0	35.0%	70.0%	8.0%	22.0%	0.0%	0.0%	0.0%	www.converge.com
1.0%	680	413.2	N/A	4.0%	57.6%	0.0%	0.0%	0.0%	38.4%	www.alliedelec.com
0.0%	N/A	N/A	N/A	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	www.carlton-bates.com
6.0%	648	439.8	8.0%	35.0%	57.0%	0.0%	0.0%	0.0%	8.0%	www.mouser.com
N/A	90	2,588.9	15.0%	60.0%	20.0%	20.0%	0.0%	0.0%	0.0%	www.fusiontrade.com
2.0%	N/A	N/A	6.0%	75.0%	23.0%	2.0%	0.0%	0.0%	0.0%	www.americaii.com
17.0%	760	653.2	10.0%	57.0%	15.0%	0.0%	0.0%	0.0%	28.0%	www.rell.com
3.0%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	www.dependonus.com
0.0%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	www.wpgamericas.com
0.05%	490	323.3	70.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	www.peigenesis.com
10.0%	N/A	N/A	10.0%	60.0%	30.0%	5.0%	0.0%	5.0%	0.0%	www.advancedmp.com
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	www.e-sonic.com
1.0%	153	703.9	N/A	10.0%	84.0%	2.0%	0.0%	2.0%	2.0%	www.masterdistributors.com
<1%	320	253.1	10.0%	2.0%	98.0%	0.0%	0.0%	0.0%	0.0%	www.biscoind.com

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[1]Revenue figures and percentages are Reed Business Information estimates.

[2]Revenue figures are Reed Business Information estimates.

[3]Newark is parent company Premier Farnell's (West Yorkshire, England) main North American presence in electronic component distribution. Revenue represents FY end 01/31/10.

[4]Carlton-Bates is a subsidiary of WESCO Distribution.

[5]Allied is a subsidiary of Electrocomponents plc.

[6]North America revenue percentages are Reed Business Information estimates.

[7]WPG Americas completed purchase of Jaco Electronics' electronic components distribution assets in January, 2009.

[8]Avnet Inc. announced in March it would acquire Bell Microproducts

[9]Arrow Electronics announced in April it would acquire Converge

Channel connections are key to success

Communication is vital for profitable partnerships

By **Barbara Jorgensen**

Successful personal relationships, experts say, require a lot of open communication. The same holds true for business relationships, particularly in the electronics supply chain.

Supply chain relationships are no longer about just sharing forecasts, industry participants say. "It's about reliability and trust and meeting frequently to review how well the relationship is working," says Colin Campbell, vice president, distribution, for catalog distributor Newark. "You have to be tightly linked with anyone you are going to do a supply chain program with."

More information is being shared than ever before. Environmental regulations such as RoHS require suppliers to disclose the materials makeup of their components. Pricing information must be passed between partners because component prices vary from region to region. Tracking an order from design through fulfillment ensures the appropriate partner gets compensated for their work. End-of-life (EOL) notifications allow customers to plan for a dwindling component supply. "We are in constant communication with our customers, particularly when things get volatile," says Chuck Delph, senior vice president of sales, Avnet Electronics Marketing Americas. "Nobody likes surprises."

After months of stability, the supply chain is beginning to see some volatility again. Component lead-times are stretching out and spot shortages are beginning to appear. As a result, the supply-demand balance is beginning to shift. "OEMs are beginning to forecast out as far as possible," says Alex Iorio, senior vice president of supplier management, Avnet Electronics Marketing Americas. "This is crucial to our customer's ability--and ours--to pipeline demand to component factories and make sure inventory is at an optimum level."

It's the kind of environment that tests supply chain relationships. As the market begins to improve, industry players are looking for opportunities to profit. But no one wants jeopardize a solid relationship for profits' sake. "Most supply chain relationships have terms built in to them to protect the parties involved," says Michael Knight, vice president of product marketing and supplier marketing for specialty distributor TTI Inc. "But the reality is, customers can vote with their feet at any time."

CRAFTING A WIN-WIN-WIN

Ideally, supply chain relationships benefit everyone involved. Programs such as vendor-managed inventory (VMI) are designed to give customers flexibility while providing distributors and suppliers with crucial forecasting information. As long as value is added at each link in the chain, partners can build profitable relationships. "Everybody is looking for value," says Tom Valliere, principal at consultancy Design Chain Associates. "Everybody is coming at this with a different set of problems."

In a common VMI model, an OEM will rely on its channel partners to have inventory on hand when the OEM needs it. Vendors carry enough product to cover a sudden uptick in demand or provide a means to dispense of excess product. Programs may consign inventory; schedule orders; flag inconsistencies; and automatically replenish low stock. "The reason VMI works is, it addresses the fundamental issues that customers have in planning for their materials requirements," says TTI's Knight." The more dysfunction there is in a customer's planning environment, the more they will get out of a VMI program."

One of the major benefits for a customer in a VMI relationship is not holding inventory. Buying, warehousing and managing inventory adds costs for OEMs. One advantage of using a distributor in a VMI relationship is flexibility: distributors handle many different component lines and can assemble them into a kit for just-in-time delivery to a manufacturing site.

Using a distributor for VMI can make particular sense for small electronics OEMs, says Valliere. "Small companies lack the resources of the larger companies—they don't want to duplicate overhead such as purchasing and

Supply chain programs "are all about reliabilty and trust and meeting frequently to review how well the relationship is working."

Colin Campbell
Newark

materials management—so they can outsource as much of that as they want through a distributor."

A key factor in a successful VMI relationship is managing customer information. Customers forecast their component demand and provide as much other data as possible: order quantities, shipment dates, EMS factory location; environmental or trade restrictions, etc. Communication can be automated, personal, or a combination of the two. Partners will also outline their expectations: how much of an upside a distributor is expected to handle; pricing parameters; frequency of updates; and policies regarding non-cancelable/non returnable items (NCNR). "These discussions are customer specific and we make sure we have a process to support the customer and help mitigate risk," says Avnet's Delph. "The frequency of communication will vary based on the customer," says Newark's Campbell. "We have an annual meeting to set goals and then we deal with things day to day or week to week."

AVOIDING ANOTHER DISASTER

All of this communication is targeted at minimizing the risk of not having enough inventory when the customer needs it; having too much inventory; or having the wrong parts at the wrong place. It also acts as a reality check for suppliers and distributors. During the Internet bubble of 1999, orders were padded in anticipation of allocation; high forecasts weren't scrutinized and historic buying patterns were overlooked. When demand stopped, the supply chain was left holding billions of dollars' worth of excess inventory in 2001. Today, VMI and other supply chain programs are more carefully constructed. "All of these types of programs are most successful when you go in with very clear expectations," says Jennifer Bleakney, vice president for National Semiconductor Corp.'s (NSC) Worldwide Distribution and Customer Support. "There has to be shared risk; full visibility and clearly defined goals."

Nevertheless, risk is never entirely avoided. Components have a shelf life and unsold parts eventually have to be disposed of. Order cancellations leave unclaimed inventory somewhere in the supply chain. Components that are custom-made for a particular customer may be non-cancellable/non-returnable (NCNR), meaning the customer has to take and/or pay for the parts even if they don't use them. Partners in the supply chain frequently outline the terms under which a party can be liable for unused inventory (see "Why some partnerships aren't perfect," page 62). Just like VMI programs themselves, NCNR parts are determined on a customer-by-customer basis. "What is an exception to one customer might be standard operating procedure for another," says Newark's Campbell.

From the OEM standpoint, the ideal VMI relationship allows customers to place orders as needed without contractual obligations. Some distributors specialize in this model by always having inventory on hand. Future Electronics Inc. and Digi-Key Corp., as two examples, maintain their overall levels of inventory based on a number of factors, including general market data, customers' historic buying trends and their own risk assessment models.

"We have inventory on hand. We take in product without hesitation. We carry it without commitments," says Chris Beeson, vice president, sales and volume business division, for catalog distributor Digi-Key. Beeson says Digi-Key's wide customer base ensures there will always be demand for a product. Many of these customers are small OEMs and EMS companies specializing in quick-turn, low-volume orders. Digi-Key's business model asserts that always having stock on hand; not requiring forecasts; and not bonding or consigning inventory provides the greatest possible flexibility for customers. "Our industry has a lot of complexity and a lot of business practices exist," says Beeson. "That's compounded now by shorter product lifecycles, suppliers that are very focused on proprietary products; and distributors dealing with date-coded inventory. All of these things factor into our inventory management as well as the question 'should there be any barriers to providing service?'"

Future operates under a similar model on a larger scale. The broadline distributor has a constant handle on its inventory by operating on a single IT system, worldwide, throughout the company. The inventory is managed centrally, so Future can track it in real time. "I think we have a critical advantage in having the same IT system around the globe," says Lindsley Ruth, corporate vice president for Future Electronics. "We have one global process, one common approach and we use real-time programs. We are very focused on making sure inventory is on the shelf and available to sell. Our IT system allows us to bond inventory at the right level and have it available at anytime to handle unplanned demand."

CAN WE BE OF SERVICE?

Although distributors bear the brunt of carrying inventory in a VMI relationship, there are built-in advantages for the channel. "One of the benefits of VMI is you build a 'moat' around your customer," says TTI's Knight. "The more complex the relationship, the more difficult it is for a customer to switch [vendors]."

Most VMI relationships are custom, meaning communication and other protocols differ from customer to customer. Scrapping such a program with one vendor and starting up with another is time-consuming but far from unprecedented. "While it may be complex for a customer to switch its business, it doesn't mean we don't do the things expected of us, or if there is a hiccup or hitch we don't fix it immediately," says Knight. "You have to earn that business every single day."

Good VMI relationships enable distributors to be close to their customers and have visibility into their bill-of-material (BOM) and inventory needs. With this insight, distributors can be pro-active about selling complementary products to these customers; subbing in parts they carry on their linecard, or offering incentives to buy inventory that's building up for various reasons. Distributors involved in their customers' design process can align their linecard with customers' production needs. "We have talked about the supply chain, but a huge component of optimization is the design chain," says Avnet's Iorio. "If we get involved right at the design phase, we can construct a customer's supply chain to have the right product with the right lifecycle available right when they are ready to build."

The channel sees the most profitable opportunities, however, in the service sector. VMI offloads the work of ordering, storing and shipping inventory from the OEM to the distributor. The challenge for distributors lies in compensation for those services. Decades ago, to differentiate themselves in the market, distributors began offering value-added services—kitting, bar-coding, tape and reel, programming, etc.—to deepen their relationships with their customers. The cost of these services was bundled into the overall component order. In the years since, services have become more sophisticated and more costly to provide. The channel has tried to charge for services independent of a component purchase. This fee-for-service model did not work as customers perceived they were paying a higher price. Some distributors have spun off a services business—such as Avnet's Logistics unit—but typically, services are still tied to components.

Still, experts say, the benefits outweigh the burdens. "VMI can drive a premium associated with service," says DCA's Valliere. "Distributors can make more money selling services [than just components alone.]"

THE VALUE OF VISIBILITY

While suppliers may directly manage inventory for a small portion of their customer base, most outsource that task to distributors. "Component suppliers are really getting out of the fulfillment business," says Valliere. "They are trimming their list of direct customers and relying on distribution for both demand creation and fulfillment."

Similar to customers, suppliers are able to hold less inventory when their distributors have a far-reaching VMI program. "National has been shifting customers to distribution for quite some time; I'd say greater than 50 percent of our customer base goes through distribution," says National Semiconductor's Bleakney. "This has been a long-term focus for us—shifting the appropriate accounts through distribution—enabling us to support thousands of customers."

The flow of information from the distribution channel is a useful tool for suppliers. Distributors reach a wide and diverse customer base and can aggregate a suppliers' sales across that base. "From my perspective, the one asset that epitomizes the value of VMI is the visibility," says National Semiconductor's Bleakney. "It requires some level of forecasting as far out as we can see and if there is volatility in demand it helps us all plan better."

When things do go wrong, says Avnet's Delph, it's usually due to a lack of communication. "In a [customer] situation where I have to get involved, somewhere in the process we didn't have the right communication," he says. "That's when the customer gets surprised." ●

Why some partnerships aren't perfect

Aligning everybody's expectations can be a challenge

By **Barbara Jorgensen**

"Trust, but verify" was a favorite phrase of Ronald Reagan's. It's not a bad philosophy to apply to the supply chain.

As amicable as most supply chain relationships are, things still go wrong. In most cases, partners rely on best practices and contractual agreements to protect all parties when products become obsolete, orders are cancelled, or excess inventory begins to build. Channel players don't like to make a big deal of contracts, but they are a reality of today's supply chain.

"When you talk about a contract, it's something we put in place to protect the distributor as well as the customer," says Chuck Delph, senior vice president of sales, Avnet Electronics Marketing Americas. "But what it's really meant to do is make sure our teams are communicating regularly on the scope of services our customers are expecting and that there is a strong line of communication about what the risk of exposure is at any given time."

In the electronics supply chain, "risk" and "exposure" are all about inventory. During the industry downturn of 2001, excess inventory cost the supply chain billions of dollars in write-offs for products that were never built or consumed. The channel has since improved its processes and adopted practices that should avert a similar disaster. At the same time, the supply chain has become more complex and companies increasingly risk-averse. Protection and flexibility are a delicate balance. Channel players recommend suppliers, distributors and customers outline their respective expectations upfront; communicate as often as possible; and respond quickly when something goes wrong.

RETURN TO SENDER

For example, return privileges have been a longtime practice in the channel. Component suppliers allow customers and distributors to return products under certain circumstances. This practice intends—among other things—to ensure old or substandard parts aren't circulating in the supply chain.

But sometimes, the issue of returns gets sticky. When there's excess inventory—a customer orders more product than they can consume—returns make a good inventory management system. When there are non-cancellable/non-returnable (NCNR) orders—usually proprietary parts designed for a single or very narrow customer base—returns aren't encouraged. When there's slow-moving inventory that might get old and eventually lose its value, returns help refresh inventory. But pushing products back through the channel can cause excess inventory; requires complex credit accounting practices; and raises traceability issues if products aren't retuned in original packaging. Custom products can't be re-used. When inventory, in effect, becomes useless, it ends up on someone's books as a write-off.

If components are still viable when a customer cancels an order, those products can be sold to other customers in the supply chain. This is an area in which distributors excel: they have an extremely broad customer base so it's highly likely some customer can use the excess product. This works best with products targeted at broad and general use. It doesn't work as well with proprietary components. These NCNR products are essentially of no value to the majority of the supply chain. "[NCNR] products have always been an issue—and for good reason," says Michael Knight, vice president of product marketing and supplier marketing for specialty distributor TTI Inc. "They can be very difficult to forecast."

NCNRs might be negotiated between supplier and customer or distributor and customer. The exposure to NCNR differs greatly. Like VMI programs,

"What [contracts] are meant to do is make sure our teams are communicating regularly on the scope of services our customers are expecting."

Chuck Delph
Avnet Electronics Marketing

NCNR contracts tend to be customer-specific. "There are some situations in which we will enter into an agreement where a customer wants an unusual product," says Colin Campbell, vice president, distribution, for catalog distributor Newark."We'd like to emphasize the products that we normally stock. But we will work with the customer to meet their needs. We stipulate upfront what service levels and what elements are included in the agreement."

"With NCNR we have to manage the situation very carefully," says Lindsley Ruth, corporate vice president for Future Electronics Inc. "We have to make sure the customer doesn't end up with excess—or that we don't end up with these products. You also have to be careful with automation [inventory replenishment systems particularly] if you are dealing with a high-risk, high-priced articles. But most people understand the nature of these products and are in constant communication with one another."

Suppliers and distributors acknowledge that OEMs face a lot of complexities when it comes to component selection. On one hand, customers want to differentiate their products. On the other hand, they want to minimize the risk of buying too much inventory. "Our industry has a lot of practices that exist to manage risk," says Chris Beeson, vice president, sales and volume business division, for catalog distributor Digi-Key Corp. "The financial aspects [of the supply chain] are important to everyone in the channel—there's cash flow; ROWC; margin pressure and the list goes on. I think what's happening is we are realizing that one size doesn't fit all."

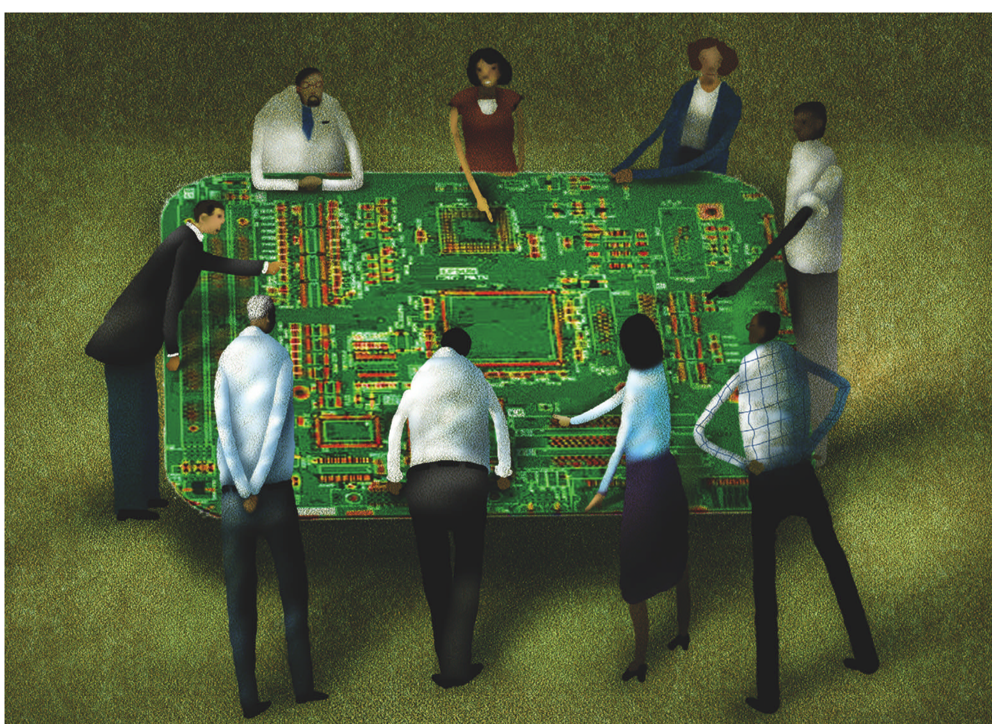
"All of these types of programs are most successful when [suppliers, distributors and customers] go in with very clear expectations."

Jennifer Bleakney
National Semiconductor

WHEN FORECASTS DON'T WORK

While the supply chain runs best on shared forecasts, predictions aren't viable for some customers. Small EMS companies, for example, specialize in low-volume prototypes and fast-turnaround products. "The nature of the [sourcing] relationship is hand to mouth," says Beeson. "Their ability to forecast is limited and from a traditional perspective, the ability to hold and bond inventory always carries some risk. So here you have a customer base that that, when faced with contractual relationships, could find themselves in a situation where they could not take advantage of a typical supply chain methodology." Most distributors try to meet the needs of such customers, and some specialize in the hand-to-mouth model. Each distributor has their own way of managing inventory and risk. "We bring together a base of knowledge and experience to make sure we are able to minimize risk in a volatile environment," says Alex Iorio, senior vice president, supplier management, Avnet Electronics Marketing Americas.

"In a supply chain program, the most important predictor for the future is the immediate past," says Future's Ruth. "We look at what is reasonable. We want to make it simple—if we bond inventory we release it as customers need it in a quantity that makes sense. In terms of liability and risk, we understand that things are going to happen. The key is the speed of execution in addressing those issues and making sure it doesn't happen again. We find people don't like to deliver bad news, so salespeople may sit on a return request or a cancelation. We encourage addressing it immediately and swiftly to correct the issue."



DAVE CUTLER

“We bring together a base of knowledge and experience to make sure we are able to minimize risk in a volatile environment.”

Alex Iorio
Avnet Electronics Marketing

Distributors and suppliers prefer to avoid hard and fast rules when a customer engagement is out of sync. Clear, consistent and upfront communication goes a long way toward avoiding problems. “All of these types of program are most successful when you go in with very clear expectations,” says Jennifer Bleakney, vice president for National Semiconductor Corp.’s (NSC) Worldwide Distribution and Customer Support. “There should be shared risk, full visibility and shared goals. Customers should outline their expectations relative to shared risk.”

“We tend to communicate with the customer so we can see an inventory slowdown in real time and ask them if they want to back their supply chain down,” says Avnet’s Delph. “We ask what they want to do with the inventory. We can burn it off, we can slow it down—the only time you see NCNR come up is when we can’t use the product anymore. Then the question becomes how do you remove that inventory? Are there other avenues for it? What does the supplier support? Even in the worst case scenarios we work to see that there are no surprises.”

Everyone acknowledges that the supply chain has come a far way from the glut of 2001 when the industry was flooded with inventory that was built to forecast but never consumed. All parties in the supply chain tightened up their practices, improved their diligence, and adjusted to a more realistic business environment. Nevertheless, players agree, there is always room for improvement.

“I think what the entire supply chain continues to need to improve is how we serve customers, whether it’s through the channel or whether it’s regional or global,” says NSC’s Bleakney. “We always need more forward visibility to end-customer demand.”

While supply chain agreements contain a large element of trust, each party should conduct their due diligence. “I think when you build an agreement on the needs of the customer, through the rights types of discovery, everybody benefits,” says Avnet’s Delph. ●

Technology optimizes channel bonds

Keeping products and information flowing

By **Barbara Jorgensen**

It wasn't that long ago when technology was going to replace distribution relationships in the supply chain. Specifically, the Internet was going to render many of the services provided by the channel obsolete. Instead, the Internet has become one of the many tools suppliers, distributors and customers use to optimize their complex relationships.

Even though the Internet has enabled self-service for designers and buyers, customers are not bypassing the channel in favor of managing their own supply chains. Distributors are able to pull together the offerings of hundreds of suppliers and aggregate them into one place. Engineers, procurement professionals and planners use distribution Internet sites for component research; price; performance parameters; part substitutions and environmental compliance status, etc., and then, if appropriate, enter into relationships that require a higher level of technology integration. While some supply chain relationships can run on technology alone, "there is also a lot of individualized attention customers need," says Chris Beeson, vice president, sales and volume business division, for catalog distributor Digi-Key Corp. "We are committed to building whatever capabilities our customers require."

In many respects, technology has strengthened supply chain relationships. Component suppliers, for example, do not have to be directly linked to their end customers to get input on their demand expectations and technology needs. Distributors can service customers on behalf of the supplier as if the service comes direct. How all of this is communicated is up to the customer, and there are standards or proprietary options for transmission. "Whether it's through a proprietary protocol, EDI or RosettaNet PIPS, we have engaged with distribution to optimize communication in the supply chain," says Jennifer Bleakney, vice president for National Semiconductor Corp.'s (NSC) Worldwide Distribution and Customer Support. "One of the things we look for is continuity of data—a set of standards and transaction sets so we can understand the data coming in. We continue to make our business engagements as seamless and as responsive as possible."

When entering into a supply chain relationship, industry players advise against relying on technology alone. "Of course we have [forecast] data, but then it's up to our organization to have conversations with our customers on a regular basis," says Chuck Delph, senior vice president of sales, Avnet Electronics Marketing Americas. "When that happens, we rarely have surprises."

Although customers usually drive the technology that manages a supply chain relationship, distributors and suppliers have to be in sync. "We work collaboratively so we understand [customers'] forward-looking demand—our arrangements cover all aspects [of the relationship] from how we communicate; what data is communicated; how we reconcile differences; and how we use that data within the planning and manufacturing environment," says NSC's Bleakney.

The channel has spent the better part of the past decade improving the way signals are sent and received. The optimism of 1999 led to the inventory excess of 2000-2001. Now, forecasts go through a number of procedures to make sure they are based as much as possible on actual demand. Industry executives point out that even though market demand slowed abruptly just before the current recession, demand and supply stayed well within balance. "Distribution has generally done a great job of managing forecasting

Technology "helps us to find what is of interest to our customers and what is relevant to their needs."

Alisha Mowbray
Newark

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since the bubble of 10 years ago," says Eric Sussman, director for Americas distribution for connector maker Molex Inc.

One of the challenges for the channel will be continuing to provide a range of supply chain services to suit all customer needs, and providing those options in a way that is profitable for all parties involved. "VMI is one example of a supply chain service implementation; in-plant stores or proximity warehouses are another," says Alex Iorio, senior vice president of supplier management, Avnet Electronics Marketing Americas. "They are all pointed in the same direction: optimizing the trading relationship. It's up to us to make sure [customers] have as much or as little support as they need. We believe we have a full suite of services and we can assist any customer regardless of how large or how small an engagement they need."

There are other issues on the horizon for the channel. Digi-Key's Beeson says the supply chain should look at the social networking phenomenon and try to determine how it may affect business relationships. Just like the last 10 years has been about optimizing technology, "the next 10 years may be about figuring how Facebook and Twitter and blogs fit into the business environment and if they also figure into productivity," Beeson says. ●

BUILDING A COMMUNITY

Technology has enabled a free-flow of information back and forth between suppliers, distributors and customers. At the same time, though, the proprietary nature of much of this information and partners' desire to protect privacy requires that this information be shielded from the rest of the world. Building a community among peers that also compete against one another is a daunting prospect.

Element14, a forum provided by Newark, is designed to bring the engineering community together for discussion and problem-solving. The site is not linked to Newark's catalog or purchasing sites and does not promote any particular technology, supplier, or Newark marketing promotion. Engineering and purchasing have distinct needs says Alisha Mowbray, senior vice president of marketing for Newark, "and element14 is targeted at engineering." The catalog distributor sees element14 as one more way distributors can build relationships with their customers.

"We have known for years that information is the key to the design engineer," she says. "As we got deeper into the analysis we saw the need for engineers to collaborate with other experts in the field. What is unique about design engineers is, once they have made their purchasing decision, they push the decision through the channel and then move on. Early in the design process they are in the research phase. Then when they are ready to buy, they move on."

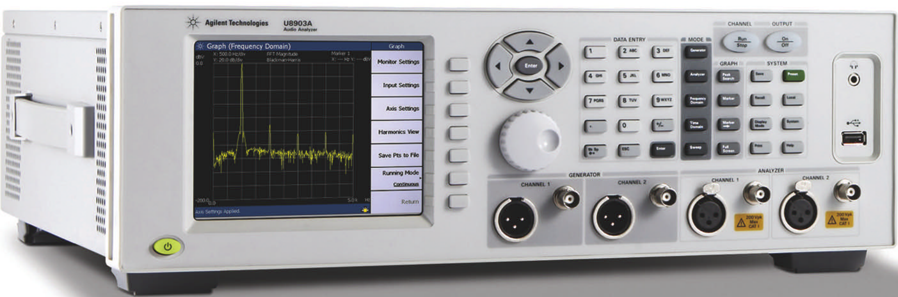
Discussion topics on element14 are driven by participants. There is an open forum and the option for private collaboration and groups. Newark also makes experts available to answer questions. Some are from Newark suppliers, others are in the academic or research fields, Mowbray says. "This is community driven, meaning, it's agnostic—it's not just our suppliers."

Users of element14 are not marketed to or sent follow-up e-mails. If business is pulled through the site, it is at the behest of the user. "These are people that don't want to be marketed to and not interested in receiving e-mails and calls," says Mowbray. "If someone is searching for information and there are types of products they are looking for, we will help them get that information. The community needs to customer driven. Pushing products is contrary to the point."

Of course, Newark hopes once a design decision is made a purchasing decision will follow. But element14 also helps the distributor stay on the cutting edge of the engineer's mind. "From our standpoint, it gets us an opportunity to stand right next to the customer," Mowbray says."We don't want to downplay the IT investment and expertise involved--this is leading our industry--but I think the ongoing work is around how you engage your supplier and customer base and how to reach out to experts."

It's more about coordination and engagement, she adds. "We are building a longer term relationship whether it is with the supplier, customer or even pre-customer. We don't think we are going to make big dollars, but users are talking about new technologies and new solutions and we can use our internal expertise to pick this up and leverage it. It helps us find what is of interest to our customers and what is relevant to their needs." ●

"I need a faster, more accurate audio analyzer."



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designideas

READERS SOLVE DESIGN PROBLEMS

Read multiple switches and a potentiometer setting with one microcontroller input pin

Kevin Fodor, Palatine, IL

The circuit in this Design Idea provides a way to convey mixed analog and digital inputs into a microcontroller using one input pin. The output of the circuit connects to a microcontroller's ADC-input pin. The circuit comprises a single variable resistor and a number of SPST (single-pole/single-throw) switches (**Figure 1**). The pushbuttons allow the user to select modes, states, or options, and the analog input provides a method of conveying an adjustable parameter. The implementation requires you to analyze a parallel resistor circuit and a voltage divider. If you carefully select the resistor values, the circuit provides a discernible analog input as well as a number of discrete pushbutton-input states.

Selecting the resistor values is a multistep process, and a spreadsheet, which you can download at www.edn.com/100422dia, aids in performing the calculations. Say, for example, that you want 5-kΩ potentiometer R_{ADJ} to produce a 0 to 100% value into the microcontroller. Typically, you would map the sampled value of 0 to 255 into a 0 to 100 value to represent a percentage. However, by selecting the values of bias resistor R_{BIAS}, you arrive at a direct analog input centered on the 0 to 255 range of the ADC—for example, 78 to 178.

To compute the appropriate high- and low-side bias-resistor values, the following **equations** solve this circuit as a simple voltage divider:

$$V_{LOW}=\frac{R_{BIAS}}{R_{ADJ}+2\times R_{BIAS}}\times V_{MAX};$$

$$V_{HIGH}=\frac{R_{BIAS}+R_{ADJ}}{R_{ADJ}+2\times R_{BIAS}}\times V_{MAX}.$$

Substituting and solving for R_{BIAS} and given that the maximum voltage reports a value of 255, the maximum low voltage reports a value of 78, the maximum high voltage value reported is 178, and R_{ADJ} has a value of 5 kΩ yield the following **equation**:

$$R_{BIAS}=\frac{V_{LOW}\times R_{ADJ}}{V_{MAX}-2\times V_{LOW}}=\frac{R_{ADJ}\times(V_{HIGH}-V_{MAX})}{V_{MAX}-2\times V_{HIGH}}=3875\Omega.$$

The computed value of R_{BIAS} is 3875Ω. Using a standard value of 3.3 kΩ, the potentiometer's input ranges from 73 to 182. This range yields a larger dynamic range than you need but allows for a guard range between the potentiometer's values and the pushbuttons' values. Because the position of R_{ADJ} affects the overall resistance the circuit sees when you press either switch, the microcontroller must interpret a range of values for each switch. To determine the switch resistance, R_{SW}, for either S_1 or S_2, you use a parallel-resistor network at both extremes of the potentiometer's position.

When you press S_1 and R_{ADJ} is at the maximum position, the effective resistance of the bottom leg of the divider is R_{SW} in parallel with the series combination of R_{ADJ} and R_{BIAS}. At the minimum position, the effective resistance is R_{SW} in parallel with R_{BIAS}:

$$R_{EFFMAX}=\frac{R_{SW}\times(R_{ADJ}+R_{BIAS})}{R_{SW}+R_{ADJ}+R_{BIAS}};$$

$$R_{EFFMIN}=\frac{R_{SW}\times R_{BIAS}}{R_{SW}+R_{BIAS}}.$$

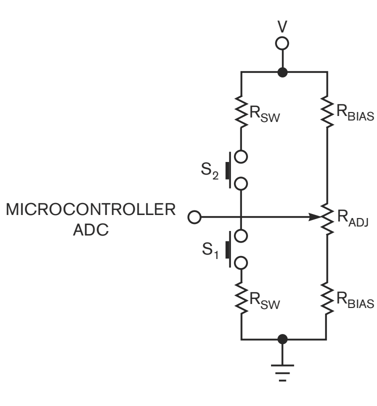

Figure 1 This circuit allows one microcontroller pin to read multiple switches and a potentiometer value.

DIs Inside

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You determine the value when you press S_1 by evaluating the voltage divider that R_{BIAS} and R_{RFFMAX} form:

$$V_{S1MAX} = \frac{R_{EFFMAX}}{R_{EFFMAX} + R_{BIAS}} \times V_{MAX}.$$

Observe that when R_{ADJ} is at its maximum value and you press S_1, it must produce a value less than the smallest value R_{ADJ} produces by itself to uniquely determine that you have pressed the switch. So the maximum effective resistance, R_{EFFMAX}, must produce a value less than the maximum low voltage, as the following **equation** shows:

$$R_{EFFMAX} < \frac{R_{BIAS}^2}{R_{BIAS} + R_{ADJ}}.$$

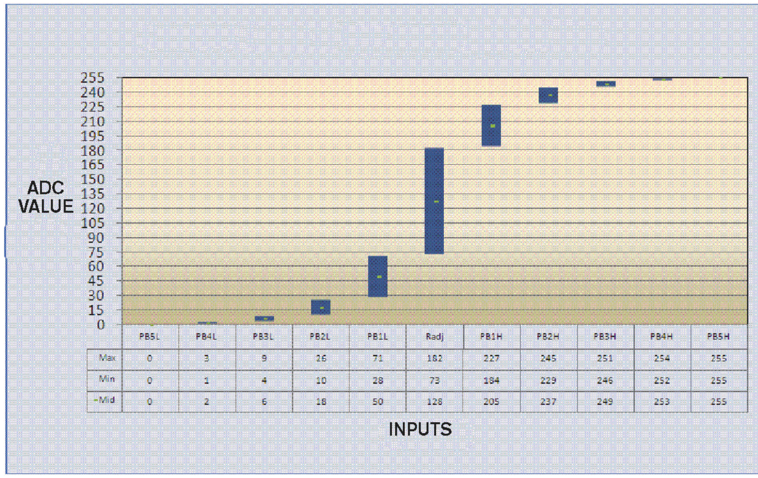
Substituting and solving this equation for the switch resistance yields:

$$R_{SW} < \frac{R_{BIAS}^3 + R_{BIAS}^2 \times R_{ADJ}}{R_{ADJ}^2 + 2 \times R_{ADJ} \times R_{BIAS}}.$$

Using the spreadsheet to compute the switch resistance yields 1558Ω, and you can choose a nominal 1.5-kΩ resistor. This selection causes S_1 to produce a range of 28 to 71 when you press it, depending on the potentiometer's position. Likewise, choosing the same value for S_2 produces a range of 184 to 227. These ranges are bands of values that you can use to determine which switch you pressed regardless of the potentiometer's position. Although selecting symmetrical resistor values is not necessary, it minimizes the number of calculations you need to perform and simplifies the design. Furthermore, selecting smaller series switch resistors opens the guard range between them and the potentiometer, which may be desirable if the resulting values are too close together. The microcontroller uses a small subroutine, **Listing 1**, which you can download at www.edn.com/100422dia, to determine both switch positions and the potentiometer's setting.

The limitation of this technique is that you cannot press more than one pushbutton at any time. In addition, the microcontroller can read the potentiometer's position only when you are not pressing any other pushbuttons. This example shows how to use two pushbuttons, but the number of pushbuttons can vary. Input ranges are available for as many as 10 pushbuttons and one potentiometer, all of which share the same input pin (**Figure 2**). Although the computed ranges do not overlap and are unique, it is doubtful that your ADC hardware can reliably distinguish these bands under all circumstances. Choosing smaller resistor values keeps these bands farther apart, creating a larger guard range.

Using this technique with four pushbuttons and one potentiometer is well within reason. Experimenting with the spreadsheet helps make quick work of determining just the right series-resistor values for each switch and its output range.EDN



	PB5L	PB4L	PB3L	PB2L	PB1L	Radj	PB1H	PB2H	PB3H	PB4H	PB5H
Max	0	3	9	26	71	182	227	245	251	254	255
Min	0	1	4	10	28	73	184	229	246	252	255
Mid	0	2	6	18	50	128	205	237	249	253	255

Figure 2 The circuit can have 10 pushbuttons and one potentiometer.

Three-transistor modulator-amplifier circuit works with swept-control frequencies

Horia-Nicolai L Teodorescu and Victor Cojocaru,
Gheorghe Asachi Technical University, Iasi, Romania

Many applications require a circuit to perform pulse modulation and voltage amplification to drive a load with a train of impulses. A typical application is driving a piezoelectric generator in a robot. Other applications include driving small motors or LEDs. Echolocation and ultrasound visualization use a sweeping-frequency, or chirp, signal. Nonlinear distortion is not important in these applications. When you drive a piezoelectric load, its natural resonance removes any frequency components other than the fundamental. This circuit combines a modulator and an amplifier into a single stage. The compactness of the circuit makes it appropriate for portable-system applications.

The load is in series with two switches (**Figure 1**). The input signal controls S_2, S_3 controls S_1, and the modulating signal controls S_3. This circuit's mod-

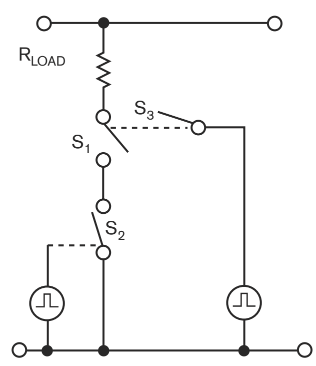


Figure 1 This simple modulator uses three switches.

ulation operation is similar to that of an AND gate. The switches must have internal resistance to dissipate the harmonics that the resonant load reflects. This circuit uses transistors Q_1 and Q_2 as switches, although they operate in the active region (**Figure 2**). Their operation resembles that of controlled resistors, and they perform voltage and current amplification. You drive Q_2 with a 42-kHz signal that matches the load's resonance. You modulate the Q_3 transistor with a periodic low-frequency impulse signal. These impulses open Q_3, which drives Q_1 and Q_2 toward saturation. When Q_3 opens, it drops the voltage across the base of Q_1, blocking

IF THE LOAD IMPEDANCE VARIES, THE CIRCUIT DOES NOT DEGRADE THE IMPULSE SHAPE.

the state of Q_2. Q_1 and Q_2 operate conjointly; Q_1 conducts only when Q_2 is conducting. You can view this scheme as a differential amplifier in which the signal in one branch controls the load of another branch.

Q_2 and Q_3 operate over large signals yet remain in the active region most of the time. The resistor values in the base and collector of Q_1 are critical. When the frequency of the signal is higher than the load's resonant frequency, D_1 protects Q_1 from the effects of L_1 and of harmonics on the LC circuit. The collector voltage has a spectrum rich in harmonics due to the nonlinear behavior of transistors. This characteristic is not a serious disadvantage because the resonant load removes the harmonics.

The value of R_1 is critical to the current and voltage amplification of the Q_1/Q_2 stage. The swing of voltage in the collector of Q_1 is sensitive to the value of R_1 (**Figure 3**). Q_1 operates in the active mode because its collector voltage increases slowly toward the maximal value. The significant glitch at small collector voltages shows that the blocking process partly occurs in the active regions of Q_2 and Q_3. If the load impedance varies, the circuit does not degrade the impulse shape. This situation is true even at twice the load's resonant frequency. The circuit functions with input voltages of 4.5 and 11V. This voltage range allows you to drive the circuit with a 5V microcontroller (**Reference 1**).EDN

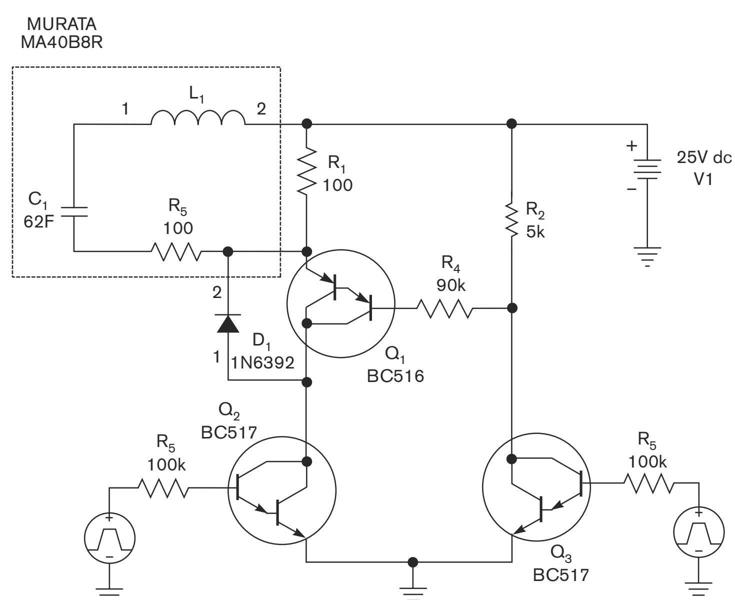


Figure 2 A three-transistor modulator with a resonant load works over a large input range.

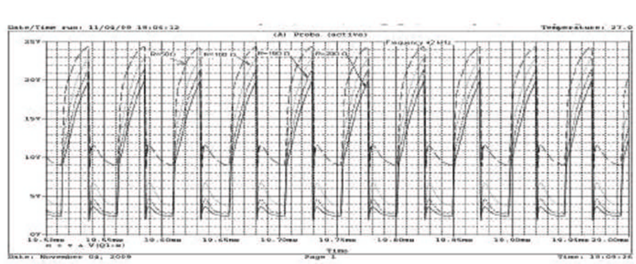


Figure 3 Changing the value of R_1 yields different response waveforms.

REFERENCE

1 Teodorescu, Horia-Nicolai L, "Algorithm for Adaptive Distance Estimators for Echolocation in Air," International Solid-State Circuits Conference, 2009, www.adbiosonar.ugal.ro/ad/content/funding.

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Tables ease microcontroller programming

Abel Raynus, Armatron International, Malden, MA

When creating microcontroller firmware, you often need to work with data arrays. Tables make easy work of data arrays, such as those for digital-code transformation, correction for sensor linearity, sophisticated calculations, and multiple output organization. **Table 1** shows how you can organize data in a table. Outputs A, B, and C have values based on the input value, V.

When using a lookup table, choose the proper microcontroller input and outputs. Assign values for input and outputs data in **Table 2**. These data can consist of constants in binary, hexadecimal, or decimal format or names. For names, you should assign a constant value to each one. For example:

```
data1  equ  $0a
data2  equ  $0b
data3  equ  $0c
data3  equ  $0d
```

Next, put the data from **Table 2** in either the beginning or the end of ROM, which makes the data easy to find. For definition of 1-byte data storage, use pseudo operators FCB or DB. For storage of data comprising 2 bytes, use FDB or DW, as in the following example:

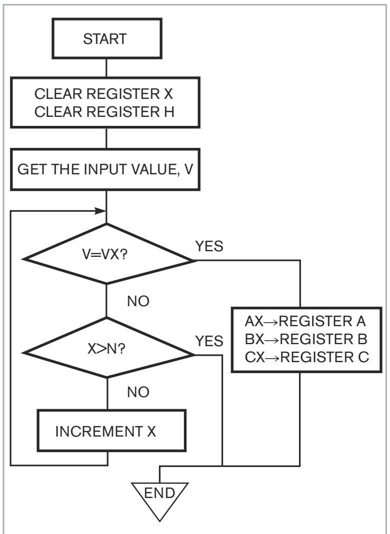


Figure 1 You can use a look-up table in microcontroller code.

```
ORG ROM
Vx  FCB  0T,2T,4T,6T
Ax  FCB  data1,data2,data3,data4
Bx  FCB  $aa,$bb,$cc,$dd
Cx  FDB  $1122,$3344,$5566,$7788
```

Note that commas separate the data. Don't place a comma after the last data, or it will be considered as $00.

When working with tables, you should always use indexed addressing mode. It provides access to data using variable addresses. Most microcontrollers have two index registers, X and H. Register X contains the low byte of the conditional address of the operand; H contains the high byte. The algorithm of working with tables is straightforward. After you detect the input value, you should then compare it with the table's input data. The X index determines this value, starting with X=0 and ending with X=N. In this example, N=4. When you find table data equal to the input value, you use the corresponding X as an index to load the output registers with their values. In the case of 2-byte numbers, you should load the output registers separately, first with a high byte and then with a low one. **Figure 1** illustrates this process.

The **listing** of assembler code is available from the online version of this Design Idea at www.edn.com/article/100422dib. In the **listing**, you can double-check the table content in memory at addresses $F800 through $F813. The listing uses Freescale (www.freescale.com) assembler because most of the appropriate applications employ inexpensive, 8-bit microcontrollers from Freescale's HC08 Nitron family. You can, however, use this approach with any type of microcontroller and assembly language. EDN

TABLE 1 OUTPUT VALUES VERSUS INPUT VALUES

Input V	Output A	Output B	Output C
V1	A1	B1	C1
V2	A2	B2	C2
....	....	....	....
VN	AN	BN	CN

TABLE 2 INPUT AND OUTPUT VALUES

Input V	Output A	Output B	Output C
V1=0T	data1	$aa	$1122
V2=2T	data2	$bb	$3344
V3=4T	data3	$cc	$5566
V4=6T	data4	$dd	$7788

Monitor alarm and indicator display multiple deviation boundaries

William Grill, Riverhead Systems, Lenexa, KS

A low-cost monitor can visually indicate a process problem, such as a failed cabinet fan or other high- or low-temperature characteristic. The microcontroller-based circuit in **Figure 1** provided a simple visual indication of both the direction and the magnitude of the temperature's deviation from a user-set mean in a solder pot. Using a Microchip (www.microchip.com) 12F675 controller, the coded sequences allow the user to both set the mean and scale the range of the monitored variation. The application uses the controller's internal clock and

two of the controller's four ADCs.

Asserting switch S_1 on Pin 4 copies the input voltage under test from Pin 7, which becomes the mean value. The code then evaluates the input-voltage deviation from the mean and applies scaled boundaries to a corresponding display format. The processor monitors both the input under test and a second analog level, on Pin 6, to scale the internal deviation/boundary tables. It then schedules as many as four sequences of one or both LEDs. The monitor also asserts an output on Pin 5 when the measured variation exceeds the third tabled boundary.

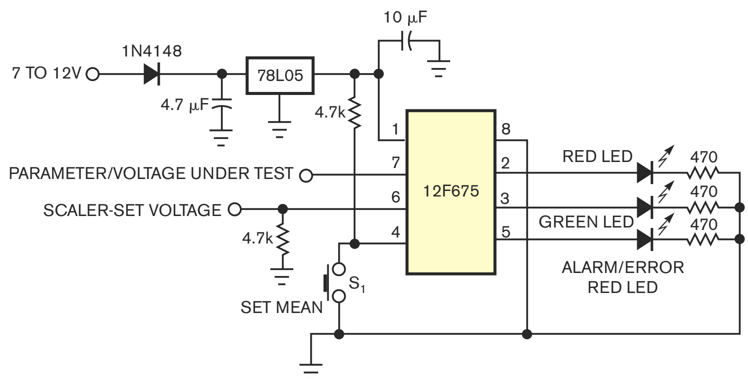


Figure 1 This microcontroller-based circuit provides a simple visual indication of both the direction and the magnitude of the temperature's deviation from a user-set mean in a solder pot.

The circuit provides independent positive- and negative-deviation tables and multiplies the ranges by interpreting the voltage on Pin 6, resulting in the application of a multiple from one to eight on the boundary limits. You configure the converter reference to use the controller's V_{DD} voltage. Using only 8 bits of the controller's 10-bit ADC, the deviation can be as small as one step or $1/256\times V_{DD}$, the drain-to-drain voltage. For a 5V reference, this voltage is approximately 9 mV.

Figure 2 shows the boundaries and their possible spans, which Pin 6 and corresponding display-format numbers set (**Table 1**). Using the provided minimum value of the deviation/boundary table, neglecting the error that results from the use of the 78L05 as a reference, and assuming the scal-

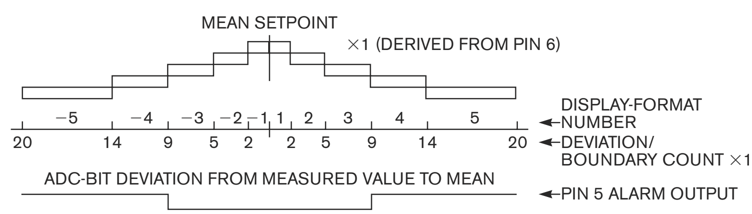


Figure 2 Pin 6 and the corresponding display-format numbers set the boundaries and their possible spans.

ing derived from Pin 6 result in ×1, the first display-format step, in this application, which occurs when the measured input deviates more than the deviation/boundary-table value times the scale derived from Pin 6 times 1/256 times the drain-to-drain voltage equals 2×5/256×1, or 39 mV.

You can change the display-sequence formats for the five positive boundaries, beginning in a green-LED flash, and five negative boundaries, beginning in a red-LED flash, to suit simpler go or no/go applications or other needs. The circuit may also find a use in airflow or other physical-parameter monitors.

Using the controller's ADC, you can monitor any parameter that you can represent with a voltage. You can modify the code-based tables to accommodate a variety of other display sequences, parameter nonlinearities, or error distributions.

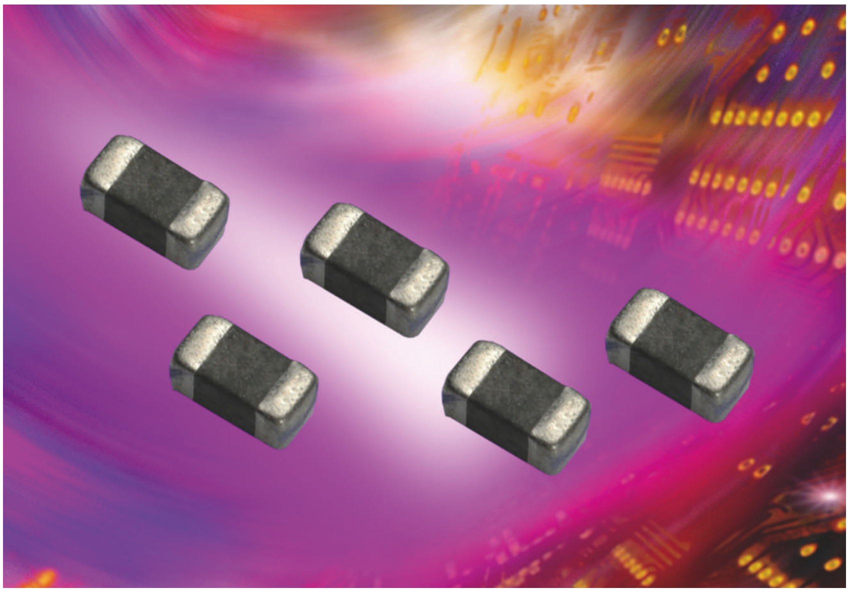
You can download **Listing 1**, code for the error monitor, from www.edn.com/100422dic. EDN

TABLE 1 DISPLAY-FORMAT NUMBERS AND TABLE-BASED SEQUENCE

Display-format number	Sequence
>5	Green, red/green, red/green, red/green
5	Green, green, green/red, green/red
4	Green, red, green/red
3	Green, green, green, red
2	Green, green, red
1	Green
−1	Red
−2	Red, red, green
−3	Red, red, red, green
−4	Red, green, red/green
−5	Red, red, red/green, red/green
≤5	Red, red/green, red/greeen, red/green

productroundup

CIRCUIT PROTECTION



High-voltage varistor comes in 1210 case size

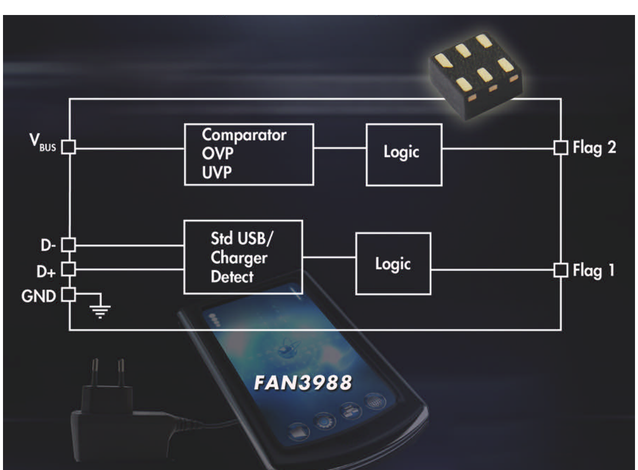
The VC121085S151 series joins the vendor's TransGuard series of multilayer varistors and includes a model with an 85V-dc rating in a 1210 case size. The single-chip devices provide bidirectional voltage protection in the on state and EMI/RFI attenuation in the off state. With a turn-on time of less than 1 nsec, the varistor can withstand multiple strikes and protects sensitive circuits from overvoltage conditions due to ESD, lightning, and inductive switching. The devices have a peak current rating of 250A, compared with 200A for competitive devices. Typical prices range from 8 cents to 14 cents (volume quantities).

AVX, www.avx.com

Overvoltage-protection IC provides USB/charger detection in portable systems

Targeting use in cell phones and handheld mobile products, the FAN3988 IC provides both overvoltage protection and USB/charger detection. The device senses the presence of a USB charger by continuously monitoring the D+ and D− lines for a shorted condition. It also monitors the voltage bus for undervoltage and overvoltage conditions. The FAN3988 allows end users to select an external P-channel MOSFET with the on-resistance and current the application requires. The device sells for 24 cents (1000).

Fairchild Semiconductor, www.fairchildsemi.com

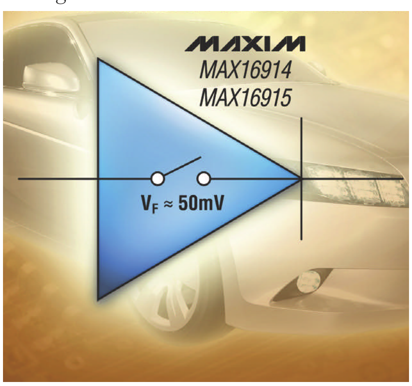


productroundup

CIRCUIT PROTECTION

Automotive-protection devices offer ideal-diode characteristics

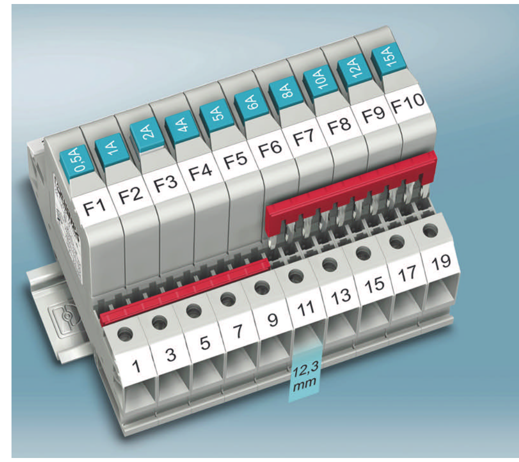
The MAX16914 and MAX16915 overvoltage-protection controllers target use in automotive and industrial systems that must withstand high-voltage and transient characteristics. The devices sense the input and output voltages of two back-to-back P-channel MOSFETs to provide overvoltage protection with ideal-diode characteristics. When forward-biased, the two PFETs have a voltage drop that is lower than that of a traditional blocking diode. During reverse-battery fault conditions, the two PFETs turn off to prevent reverse current flow. The units operate from 30 mA of quiescent current. The overvoltage threshold is resistor-adjustable and uses an indicator flag to alert the system to an overvoltage event. Prices for the MAX16914 and MAX16915 start at $1.60 (1000).



Maxim Integrated Products, www.maxim-ic.com

Circuit breakers measure just 12.3 mm wide

The UT-6 TMC M line of circuit breakers combines the advantages of both fuse-terminal blocks and thermal-magnetic circuit breakers. The series includes a resettable single-pole circuit breaker with a screw connection. The TMC clearly indicates a tripped circuit breaker, which users can reset with the press of a button. The series is available in 11 graded steps for nominal currents of 0.5 to 16A. Two bridge shafts simplify distribution. Measuring 12.3 mm wide, the UT 6-TMC M circuit breakers occupy 30% less space than conventional 17.5-mm units. Prices range from $13.55 to $14.70.



Phoenix Contact, www.phoenixcontact.com

2.5V protection device comes in SO-8 package

The 2.5V RClamp 2502L device comes in an SO-8 package for safeguarding fast-Ethernet and GbE interfaces from ESD, cable discharge, and lightning-surge transients. The two-line device features a low clamping voltage and a line-to-line capacitance of less than 5 pF. The device has a surge rating of 40A for secondary-lightning protection, making it applicable in Ethernet-rich communication-infrastructure applications. The flow-through layout contributes to enhanced signal quality and easy PCB routing. The RClamp 2502L costs 92 cents (10,000).

Semtech Corp, www.semtech.com

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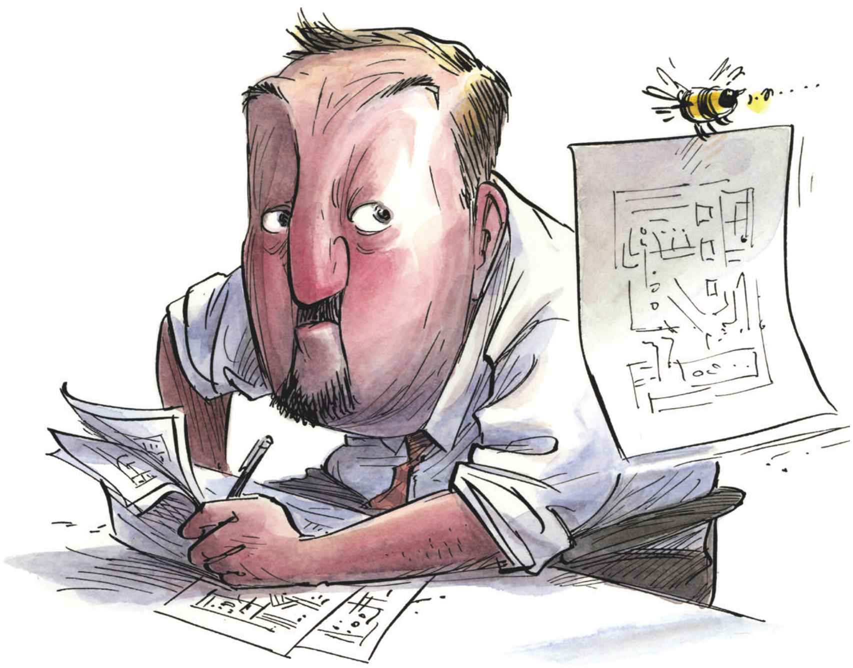
Sting like a bee



DANIEL VASCONCELLOS

As a design engineer some years ago, I "inherited" a design that was moving from the realm of university research into commercial production. The design worked on paper, but I had an inkling that it wouldn't work in the real world. The objective was to measure the surface charge of an electret. The method of accomplishing this goal was to place the electret a small distance from a capacitive plate that connected to a standard integrator. As the plate charged up, the integral of the required current would be proportional to the surface voltage. This idea is simple, but any stray leakage would scuttle the circuit.

Before handing off the design to me, its designer had demonstrated it as workable. I was naive enough to not ask any questions, and we went into production. Although there were some minor problems, the production units seemed to perform well enough that the design remained in place for almost 20 years. So, like the bumble bee that doesn't know it can't fly but continues to do it, this circuit didn't know it shouldn't work but kept on going.

With the passing of time, it became necessary to change manufacturers. I was no longer with that company but now on my own, and the company asked me to assist in updating the design. With some trepidation about the change, I forged ahead and breathed a sigh of relief when the new units performed slightly better than the original. I didn't understand why but was willing to accept it.

For various reasons, it was necessary to change the PCB (printed-circuit-board) fabricator. I didn't anticipate any changes, but my heart sank when all of the first five boards failed the basic tests. The only indication I had was that the leakage was too high.

After much thought and some trial and error, I determined that the preimpregnated PCB material itself might be the culprit. Some basic research showed that all the manufacturer had specified was that it should be FR (fiberglass-reinforced)-4. Some phone calls and e-mails led to the specifications for the material the manufacturer used in this batch. At 7×10^7-MΩ/cm volume resistivity, this batch was within specification. At this point, I questioned whether I was looking at the right figure and asked whether I could measure this parameter in a working system.

Because the design is a simple integrator, observing the discharge rate of the capacitor allowed me to deduce the total leakage for the circuit, a portion of which would be due to the volume resistivity of the board. Measuring a good board, I saw that the total leakage was on the order of 10^6 MΩ. Using one of the failing boards, I measured slightly less than 10^5 MΩ. This finding supported the idea that I was on the right track.

After some research, I found that a minimum required volume resistivity was 10^8 MΩ. Knowing this fact, I asked the PCB fabricator to make a new batch of boards. I was greatly relieved when the boards performed as I expected. PCB requirements now have a line that stipulates the minimum volume resistivity for the material!

Two key lessons for me emerged during this exercise: First, challenge the assumptions. The manufacturer assumed that a specification of FR-4 was sufficient. It turned out that the manufacturers had for all these years unknowingly exceeded the specifications and thus met the unstated requirement. Second, even though it may be essentially a dc circuit, a PCB is more than a holder of the components. It is a component in itself. EDN

Dave Pfaltzgraff is an engineer with Pitchfork Solutions LLC (Keymar, MD).

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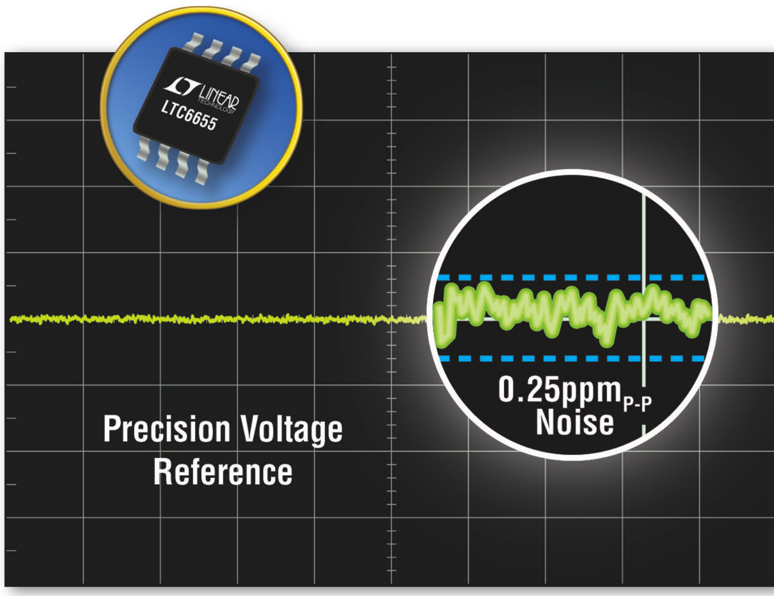

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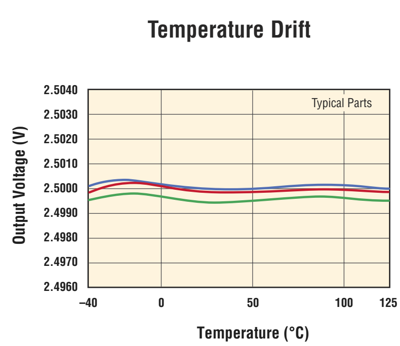

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