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"I'D LIKE TO BUY A µ"

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USING HIGH-CURRENT INTEGRATED-SWITCH POWER-REGULATOR ICs

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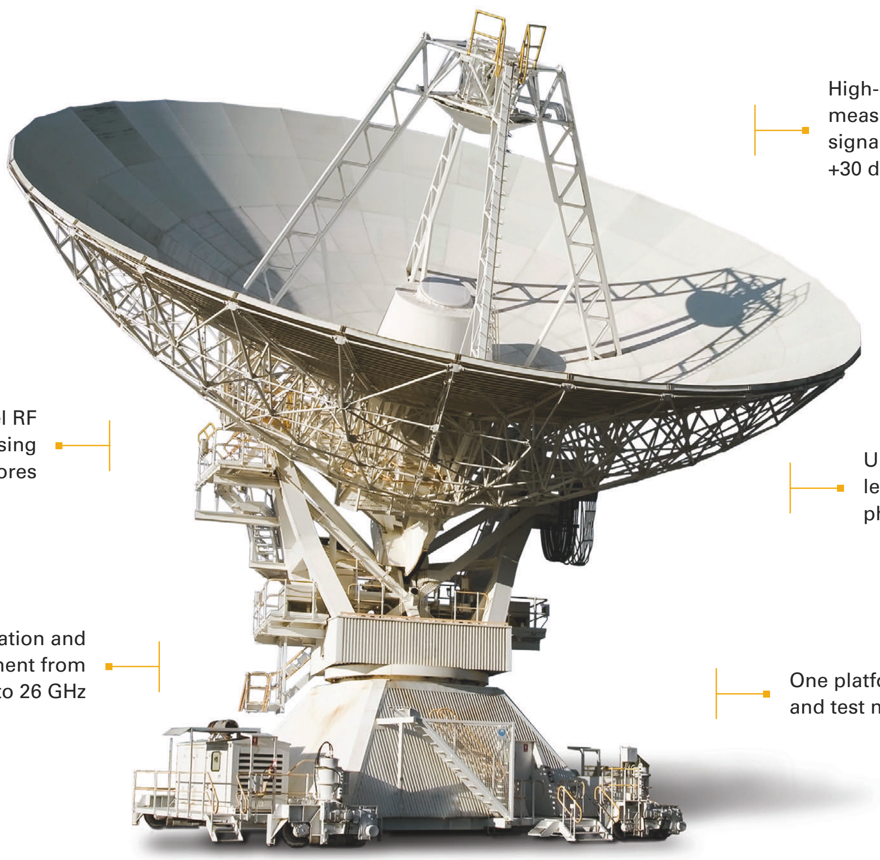

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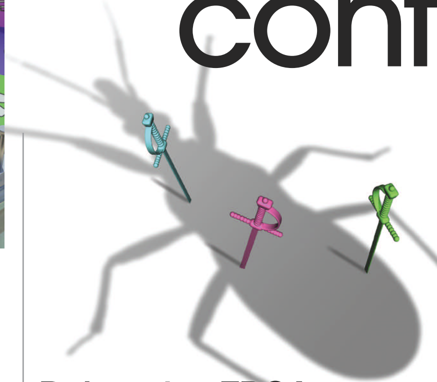

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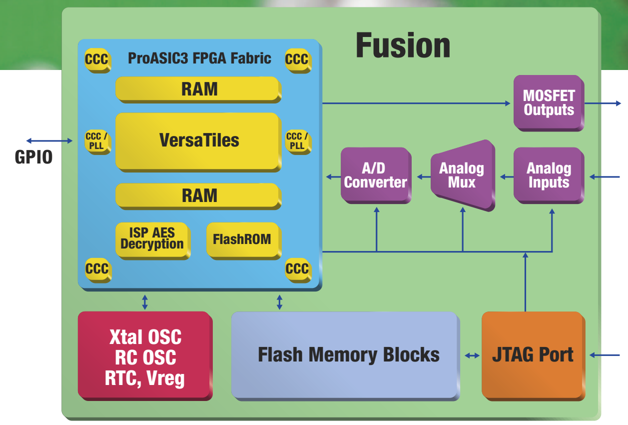

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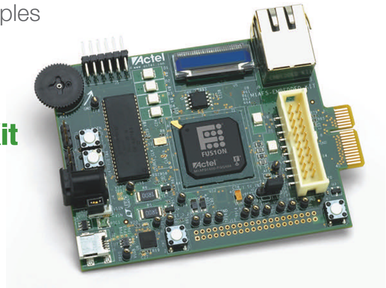

Hardware: **Fusion Embedded Development Kit**
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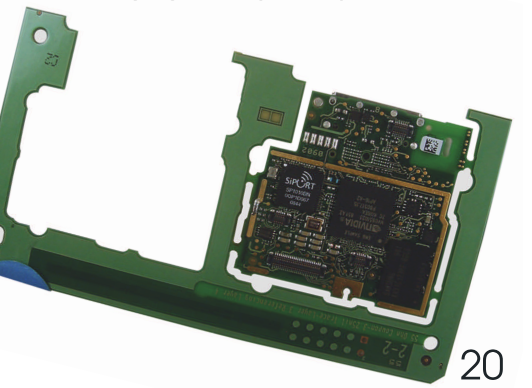

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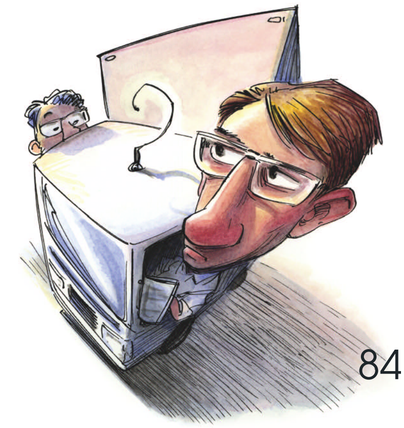

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DEPARTMENTS & COLUMNS

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EDN's Design Ideas, contributed by practicing electronics engineers, deliver practical, innovative circuit designs in a concise format complete with circuit schematic diagrams, application details, and even software code.
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Microprocessor Directory

The nine-page printed version of Technical Editor Robert Cravotta's annual Microprocessor Directory (pg 28) is a mere fraction of what this invaluable tool delivers. Go to www.edn.com/microdirectory for the full-strength online version, which includes technical details on every processor family from more than 65 companies; the ability to filter data based on *your* target application; exhaustive parametric tables arranged by company, instruction set, and instruction width; and expanded analysis of each company and its offerings.
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BY RICK NELSON, EDITOR-IN-CHIEF

Exhibits emphasize markets and development ease

At last month's Embedded Systems Conference in Boston, vendors highlighted an impressive range of technologies that address issues ranging from "green" applications to data and code security. Toward that end, companies presented asset-management systems, code-analysis tools, RTOSs, microcontrollers, data converters, and prototyping tools. Security products were on offer—both to prevent IP (intellectual-property) theft and to deter the insertion of malicious code. Craig Rawlings, director of product management at Certicom, highlighted his company's AMS asset-management system, which uses ATE (automated test equipment) or device programmers to inject a secure key into devices to prevent counterfeiting and support inventory control—unlocking only the features a customer has paid for. GrammaTech was on hand, featuring its CodeSonar static-code-analysis tool that identifies bugs and vulnerabilities at compilation. The company announced that it will support secure coding rules developed by US-CERT (United States Computer Emergency Readiness Team), the operational arm of the NCSD (National Cyber Security Division) at the Department of Homeland Security.

Among other highlights, Microsoft Corp announced the release of Windows Embedded CE 6.0 R3, which supports Windows 7 connectivity. Complementing Microsoft's move, Bsquare announced a Windows Embedded CE 6.0 R3 board-support package for the Texas Instruments OMAP (Open Multimedia Applications Platform) 3 evaluation module. And Enea announced its Enea OSE (Open Systems Environment) Multicore Edition, which focuses on the networking market.

Like Enea, many vendors presented exhibits focusing on specific markets and applications. NEC, for example, presented its lineup of microcontrollers in the context of what Bob Pinteric, NEC's general manager for multipurpose microcontrollers, calls the "smart house of the future." That scaled-down structure has transparent walls that highlight opportunities for deployment of NEC products in green applications. The structure accommodates smart solar panels, a smart meter, efficient appliances, and a ZigBee Pro network that enables wireless control of thermostats and lights. Samplify Systems announced a $1950 reference design for the ultrasound market. Employing the company's SAM1600 compressing ADCs, the reference design includes an entire ultrasound receive chain.

The MathWorks didn't introduce any products at the show, but it did announce that Cleveland FES (functional-electrical-stimulation) Center at Case Western Reserve University has developed FES devices with the help of MathWorks tools for model-based design. The FES devices send electrical impulses to electrodes implanted in the body, worn on the skin, or operating through the skin to restore movement to paralyzed limbs.

Although some exhibitors emphasized applications, others focused on tools to speed development. ARM in conjunction with NXP announced the mbed.org and mbed microcontroller rapid-prototyping tools. The tools include software support and a DIP (dual-inline-package) implementation of the NXP LPC1768 ARM Cortex-M3 microcontroller. Simon Ford, the mbed technical lead at ARM, says that users can get up and running in 60 seconds by plugging the 40-pin DIP into a solderless breadboard.

Renesas is offering a free Micrium kernel with its SH7216 microcontrollers. Other companies offered development boards and tools that help designers quickly prototype their ideas. Avnet Inc, for instance, previewed a $225 Xilinx Spartan-6 LX16 evaluation kit with an onboard battery to emphasize low-power applications. Avnet also previewed the $995 Spartan-6 LX150T FPGA development kit, which targets video, industrial-networking and -control, wireless-communications, PCIe (Peripheral Component Interconnect Express)-expansion, and general FPGA-prototyping applications. Both kits support the new FMC (FPGA-mezzanine-card)-expansion standard, which enables the addition of add-on modules and customization.

The NEC and combined ARM and NXP exhibits were notable for the clarity and forcefulness with which they emphasized application opportunities and the ability to rapidly begin prototyping, respectively, although NXP's talking fish was somewhat annoying, albeit effective in drawing a crowd—a key goal at any trade show. EDN

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Reed Electronics Group


MEET THE GUY that ELIMINATED HIS TEAM'S MANUFACTURING VARIABILITY ISSUES.

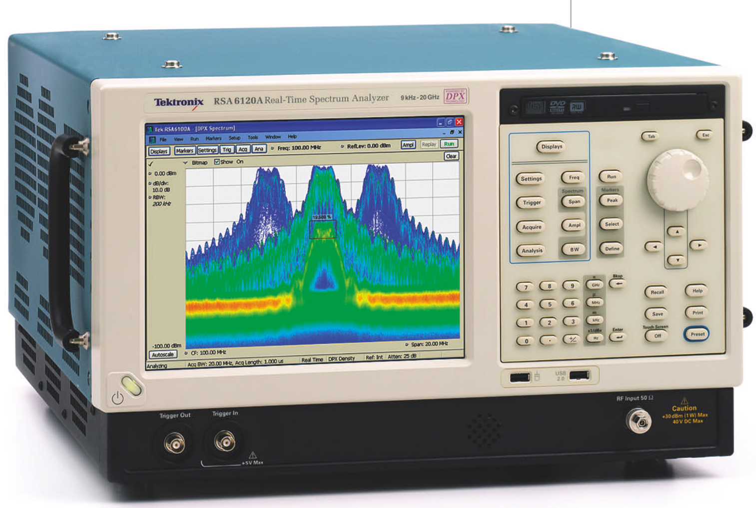
Tektronix spectrum analyzer reaches 20 GHz

Tektronix has expanded the RSA6000 series of spectrum analyzers to include the RSA6120A, which extends top bandwidth from 14 to 20 GHz, making the instrument suitable for applications operating at 12 to 18 GHz (see "Tektronix addresses RF/microwave challenges, hosts Mesuro at IMS booth," *Test & Measurement World*, June 14, 2009, www.tmworld.com/article/CA6665152). With a spurious-free dynamic range of 75 dB and a TOI (third-order intercept) of 19 dB above 6 GHz, the instrument offers the industry's best dynamic-range performance at these frequencies, according to Darren McCarthy, the company's technical-marketing manager for RF test. The instrument offers 3- to 8-dB better TOI performance than competing instruments that operate in the same band and in the 8- to 12-GHz band. With a 110-MHz real-time-capture bandwidth, the instrument outperforms traditional signal analyzers in real-time bandwidth and dynamic range.

The RSA6000 instruments target radar and electronic warfare, in which they analyze complex pulse trains; spectrum management, in which they scan wide spectrums yet focus on narrow bands of interest and act on specific signals; and radio/satellite communications, in which they handle new modulation formats that improve spectrum efficiency and analyze dynamic changes in cognitive and adaptive radios. "The RSA6120A provides our customers with a … combination of bandwidth and dynamic range to 20 GHz, allowing them to fully view RF signals in real time," says Bob Hiebert, director of marketing for Tektronix's RF-product line. The device allows you to dramatically reduce the time it takes to gain insight into high-frequency applications because users can trigger on low-level signals that traditional analyzers obscure or miss, he explains.

The RSA6120A incorporates a switched-filter preselector to optimize channel flatness operation for all measurements. Flatness across 100 MHz, for instance, is ±0.7 dB rms and ±1.5°. The RSA6120A also provides radar designers with signal-analysis tools, including impulse response and 26 other automated pulse-parameter measurements, statistical measurement, and waveform replay with acquisition history. The base price for the RSA6120A is $96,400.**—by Rick Nelson**

▷**Tektronix**, www.tektronix.com.



The RSA6120A spectrum analyzer extends top bandwidth from 14 to 20 GHz.

FEEDBACK LOOP

"I cannot count the number of engineers who believe they can attach the ground probe of an oscilloscope to these points. (Everybody has to do it once, right?). Seriously, this can kill people."

—Electrical engineer Alan Starkie, in *EDN*'s Feedback Loop, at www.edn.com/article/CA6685961. Add your comments.

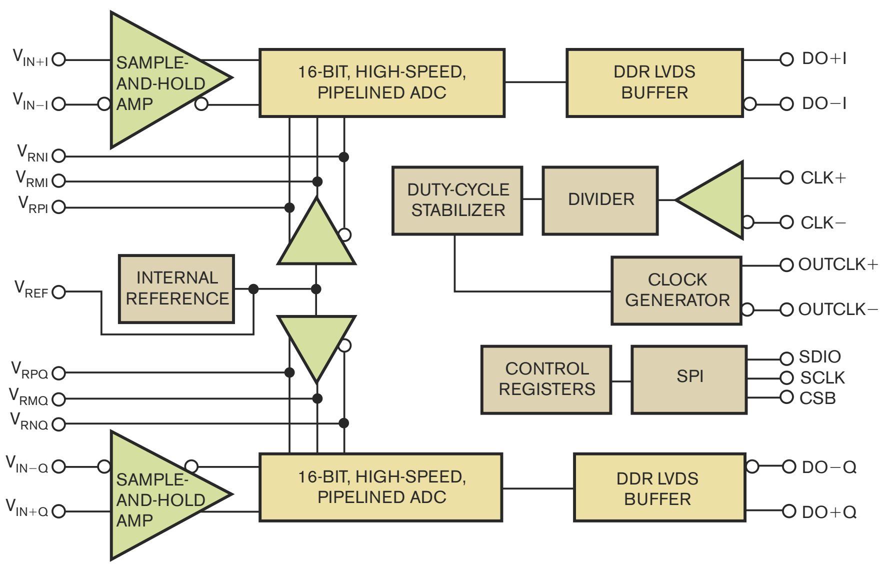
160M-sample/sec, 16-bit dual ADC works in base stations and instrumentation

National Semiconductor recently announced the low-power, 16-bit, 16M-sample/sec, dual-channel-pipeline ADC16DV160 ADC. The IC features differential inputs and dual-rate LVDS (low-voltage-differential-signaling) outputs. It operates from 1.8 and 3V supplies, and you can configure it for input ranges of 2.4, 2, 1.5, and 1V p-p. The unit achieves an SNR (signal-to-noise ratio) of 76.3 dBFS (decibels relative to full-scale) and an SFDR (spurious-free dynamic range) of 91.2 dBFS when you apply a 197-MHz input signal frequency at −1-dBFS amplitude. It has a full-power bandwidth of 1.4 GHz, and its internal reference voltage is 1.2V. Power consumption of both channels together is 1.3W at 160M sample/sec with an input amplitude of −1 dBFS and 100Ω-LVDS termination resistors. Communication takes place through an SPI (serial peripheral interface).

The ADC performs power-up calibration to ensure dynamic performance and to reduce part-to-part variations. You can recalibrate the ADC16DV160 at any time by cycling in and out of the power-down mode. It also contains an on-chip duty-cycle stabilizer with low additive jitter that allows a wide range of input-clock duty cycles without compromising dynamic performance.

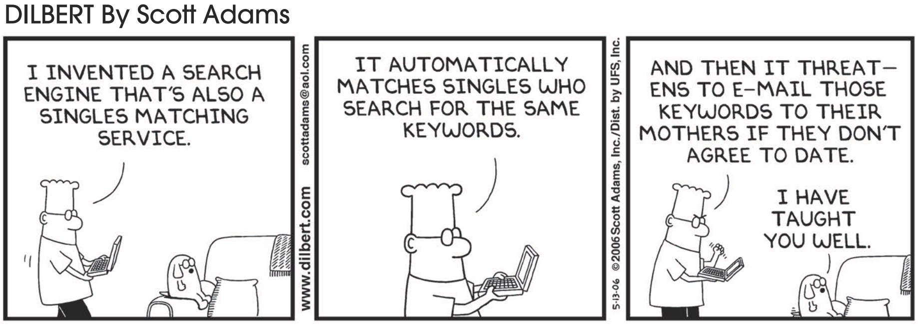
The ADC16DV160 comes in a 68-pin LLP package and sells for $140 (1000). Samples and evaluation boards are available; the boards interface directly to the company's WaveVision 5 software and data-capture board. Production quantities should become available in the late fourth quarter.**—by Paul Rako**

▷**National Semiconductor**, www.national.com.



The low-power, dual-channel ADC16DV160 suits use in cellular base stations and instrumentation.

DILBERT By Scott Adams



10.22.09

IMPLEMENTATION PLATFORM HAS TWO-TIMES-FASTER THROUGHPUT

At the Design Automation Conference (www.dac.com), which took place in San Francisco in July, Synopsys Inc highlighted the latest release of its Galaxy Implementation Platform, which, the company claims, delivers two-times-faster design implementation and sign-off throughput by leveraging multicore performance and MCMM (multicorner/multimode) technologies. Built-in support for multicore processing across the Galaxy Platform enables engineering teams to boost runtime performance using their servers. In addition, the Galaxy Platform includes new MCMM technology providing improved quality of results and faster design closure.

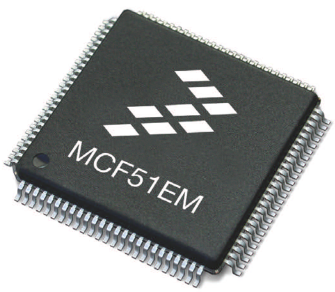
The 2009 release is the most recent result of an initiative Synopsys announced in March 2008 to deploy parallel, threaded, and other optimized computational technologies. The company now includes multicore technologies in its Design Compiler synthesis, TetraMax ATPG (automatic-test-pattern-generation), IC Compiler place-and-route, IC Validator physical-verification, Star-RCXT (resistance/capacitance-extraction), and PrimeTime static-timing-analysis tools. For more on Synopsys at DAC, go to www.edn.com/091022pa.

—by Rick Nelson

▶**Synopsys**, www.synopsys.com.

Microcontroller for power meters thwarts tampering

Government agencies and utilities are pushing to move the global power infrastructure to a smart grid—a transition that will rely on the installation of intelligent power meters in residences and businesses. Addressing that need, Freescale Semiconductor has introduced the MCF51EM microcontroller family for metering, including algorithms, tamper resistance, the ability to update without powering down, real-time-clock independence, and self-validation. Freescale based the family on the ColdFire microcontroller core. It includes code for calculating active, reactive, and apparent energy that meets IEC (International Electrotechnical Commission) 62053-22 International Energy Metering Specification Class 0.5 accuracy readings for active energy.



The MCF51EM integrates the firmware and peripherals interfaces to guard against tampering in energy meters.

The part's tamper-detection circuitry and firmware take data from sensors or mechanical switches that monitor physical intrusion or damage to a meter's case. The tamper-detection signal causes the chip's independent real-time clock to log the time and date of the tampering. The device also logs attempts to manipulate the meter's power rails, during which the meter can operate from a battery backup to log tampering incidents. The independent real-time clock also has 32 bytes of protected RAM that the clock's battery backup maintains.

The chip supports secure software updating in the field without powering down or rebooting with its segmented 128- to 256-kbyte flash memory. For example, a typical metering application might fit into 128 kbytes of RAM. The processor downloads the new software and builds a duplicate copy of the current software in the other 128 kbytes and then hot-swaps the new code after it has validated the code with a hardware-based CRC (cyclic-redundancy-check) test.

Rather than relying on software calculation of the phase lag between voltage and current, the part has four 16-bit SAR (successive-approximation-register) ADCs that feed into a hardware sequencer for fast, accurate phase measurements. The chip also includes an optoisolator interface for maintenance personnel's safety. A reference design employing the MCF51EM256 version implements a single- or three-phase smart electrical meter and sells for $3.60 (10,000).

—by Margery Conner

▷**Freescale Semiconductor**, www.freescale.com/metering.

SUPERSPEED USB TEST SUITE ELIMINATES THE NEED TO INTEGRATE MULTIPLE SUPPLIERS' SYSTEM COMPONENTS

LeCroy Corp has introduced a single-source lineup of test instruments that comprehensively support the USB (Universal Serial Bus) SuperSpeed 3.0 standard. The test suite integrates a selection of test instruments and software that addresses all transmitter, receiver, TDR (time-domain-reflectometer), and protocol tests that the specification currently defines for the cabled, bidirectional, 4.8-Gbps USB 3.0 bus, which can transmit data an order of magnitude faster than USB 2.0.

The product line includes the SDA (serial-data-analyzer) 813Zi oscilloscope for PHY (physical)-layer transmitter-compliance verification and debugging; the PERT (protocol-enabled-receiver/transmitter) tolerance tester for receiver testing; the WaveExpert ultrahigh-bandwidth sampling oscilloscope for critical characterization and TDR measurements; and the first USB 3.0 protocol analyzer-exerciser platform, the Voyager verification system, which addresses the protocol layer. Automated, easy-to-use QualiPHY compliance test software and USB 3.0 test fixtures enable rapid debugging and provide accurate and complete compliance testing.


Unlike the home-brewed test setups that USB 3.0 developers previously had to create, LeCroy's USB 3.0 test suite integrates high-performance instruments and software from one supplier.

According to the company, PERT is the only tool that manages issues such as the insertion and deletion of skip symbols without losing lock during automated testing programs, thereby enabling correct measurement of BER (bit-error rate). Because PERT combines into one instrument the capabilities of a signal generator, BER tester, protocol editor, and SDA system, it simultaneously monitors signal integrity and fully characterizes the receiver's tolerance envelope through the controlled introduction of various types and levels of signal stress, such as increased jitter. The USB 3.0 test suite's US list price is $276,000.

For more, go to www.edn.com/article/CA6699092.—by Dan Strassberg

▶**LeCroy Corp, www.lecroy.com.**

30V FET achieves 1-mΩ maximum on-resistance

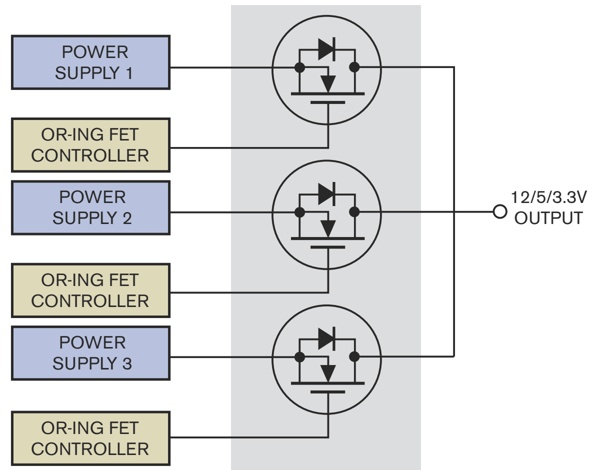
Fairchild Semiconductor used its PowerTrench process in building the new, 30V FDMS7650 MOSFET. The company guarantees the device for a 0.99-mΩ maximum on-resistance at 36A with a 10V gate drive; resistance rises to a maximum of 1.7 mΩ at 125°C. The FET has a pulse current of 450A and a junction-to-case thermal resistance of 1.2°C/W. With proper heat sinking, the device provides a power rating of 104W, and it features 15-nF maximum input capacitance and 209-nC maximum gate charge with a gate-to-source voltage of 10V.

Other features include 45- and 133-nsec maximum turn-on and turn-off delays, respectively; maximum rise and fall times are 38 and 34 nsec, respectively.

The device is useful as the ORing diode in server-farm power supplies. It provides an OR-diode function on the output of a single supply so that you can strap together multiple supplies for redundancy and reliability. The FETs are always on, so their efficiency affects the overall efficiency of these server farms. The low on-resistance also makes these parts useful as synchronous FETs in switching power supplies.

The FDMS7650 comes in an eight-pin-SOIC-derivative power-56 package with a large thermal bond pad. It operates in the −55 to +150°C temperature range and sells for 95 cents (1000).**—by Paul Rako**

▷Fairchild Semiconductor, www.fairchildsemi.com.



You can use the FDMS7650 FET as an OR-function diode in server-farm intermediate-bus power supplies or as the synchronous FET in switching power supplies.

PSOC AVAILABLE ON STANDARD 8- AND 32-BIT ARCHITECTURES

10.22.09

Cypress Semiconductor's PSoC (programmable system-on-chip) processors not only enable developers to dynamically reconfigure digital-logic blocks to form custom digital peripherals during runtime, but also support dynamically reconfigurable analog blocks to form custom analog peripherals–also during runtime. The runtime reconfigurability of PSoC peripheral blocks enables developers to reuse silicon resources for multiple tasks for different application modes. Until recently, Cypress integrated this flexibility only in its proprietary M8C processor architecture. The new PSoC 3 and PSoC 5 family of devices expands the list of integrated processor architectures with an 8-bit, 33-MIPS 8051 and a 32-bit, 100-Dhrystone-MIPS ARM Coretex-M3 core, respectively.

> The programmable digital blocks are reconfigurable as 8-, 16-, 24-, and 32-bit timers, counters, and PWMs.

As with the original PSoC devices, developers can dynamically reconfigure the high-precision, programmable analog blocks on the PSoC 3 and PSoC 5 devices during runtime into precharacterized, 12- to 20-bit-resolution delta-sigma ADCs with a sample rate as fast as 1M sample/sec for a 12-bit SAR (successive-approximation-register) ADC, 8- to 10-bit DACs, transimpendance amplifiers, mixers, one to 50× PGAs (programmable-gain amplifiers), op amps with 25-mA drive capability, and as many as four comparators with 30-nsec response time.

Likewise, the programmable digital blocks are reconfigurable as 8-, 16-, 24-, and 32-bit timers, counters, and PWMs (pulse-width modulators), as well as more advanced digital peripherals, such as CRC (cyclic-redundancy check), PRS (pseudo-random-sequence) generators, and quadrature decoders. These new families also support communications interfaces, including full-speed USB (Universal Serial Bus), I²C (inter-integrated circuit), SPI (serial peripheral interface), UART, CAN (controller-area network), LIN (local-interconnect network), and I²S (inter-IC sound), and some devices include an integrated PHY (physical)-layer interface for CAN and full-speed USB 2.0.

Both architectures support a 0.5 to 5.5V operating voltage. Sleep-mode power consumption is 1 μA for the PSoC 3 and 2 μA for the PSoC 5. Power consumption for hibernate mode is 200 nA for the PSoC 3 and 300 nA for the PSoC 5. Both families are pin- and application-programming-interface compatible with the 8- and 32-bit architectures, including programmable routing that allows you to route any signal, whether analog or digital, to any general-purpose I/O and to route the LCD-segment display and CapSense (capacitive-sensing) signals to any GPIO (general-purpose-input/output) pin.

For more on these products, go to www.edn.com/article/CA6699879.

—by Robert Cravotta

▶Cypress Semiconductor, www.cypress.com.

Rarely Asked Questions

Strange stories from the call logs of Analog Devices

What's the big deal about ABSOLUTE MAXIMUM RATINGS?

Q. "Is it alright to exceed just one of the parameters in the ABSOLUTE MAXIMUM RATINGS table, by just a little bit?"

A. While the answer may seem obvious to many, it does bear some discussion… oh, by the way, the answer is NO!

The majority of information contained within the pages of most datasheets is "typical" data. The performance shown in the graphs, tables and plots is predictable and easy to replicate in new designs, as long as the recommended operating conditions are adhered to. You'll also find minimums and maximums. These limits, specified by the manufacturer, are guaranteed by design or through exhaustive testing and yield analysis. The datasheet also has a section titled ABSOLUTE MAXIMUM RATINGS (ABS). This section deals with the ABSOLUTE MAXIMUM RATINGS a device can tolerate, but NOT operate at. Like fire, its best to keep your distance from the ABS limits; if you don't, you could get burned!

I'm not typing ABSOLUTE MAXIMUM RATINGS in capital letters here for dramatic effect (well, maybe a little bit), but this is actually how it appears in the datasheet. The ABSOLUTE MAXIMUM RATINGS table is spelled with all capital letters because it's extremely important. The following statement spells out the implications of ABSOLUTE MAXIMUM RATINGS. It can be found directly beneath the ABS table in our datasheets.

"Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability."

I think the statement is pretty clear, but I'll restate it just to make sure. The device is NOT designed to work at the values contained in the ABSOLUTE MAXIMUM RATINGS table. If you operate at or above the ABSOLUTE MAXIMUM RATINGS, there's a very, very good chance you will permanently damage the device!

Friends, take my advice and steer well clear of danger and peril by avoiding close contact with ABSOLUTE MAXIMUM RATINGS when designing any circuit or system. A good general engineering practice is to build margin into your designs. Resist the temptation to operate near the very edge of a device's ABS ratings; it's never a good idea and usually leads to problems down the road, especially when it comes to reliability.

To Learn More About Absolute Maximum Ratings
http://designnews.hotims.com/23122-101

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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VOICES

Leveling the playing field for small hardware start-ups

Andrew Huang is the designer of Chumby, an open-source-hardware device that serves as a customizable interface to the Internet and must compete with devices manufactured by high-volume production lines feeding goods to big-box retailers. He is among the first of a new breed of small-hardware-system entrepreneurs using China's electronics supply chain. Huang recently told *EDN* what he has learned in the process.

Why did you go overseas to manufacture Chumby?

A Chumby Industries is a start-up. We had no assembly line, and we weren't about to invest our small capital in a hardware-manufacturing infrastructure. By using a Chinese supply-chain partner, a small company can look and act like a huge company. The Chinese partner can provide supply-chain and procurement management, including costing, sourcing, and scheduling; quality engineering; testing approvals; certification; logistics planning; and order fulfillment. I can turn [around] a fairly complex PCB [printed-circuit board] in one night because electronic design is so modular. You start with a microcontroller, wire up the USB [Universal Serial Bus] interface, add a voltage regulator, lay it out, and [perform] design-rule checking. It can sometimes take longer to create the BOM [bill of materials] than the design itself.

However, when it's time to go into production, the board may not be manufacturable as is. In addition, how do I test 10,000 units, one every 30 seconds, and get the throughput I need? How do I get FCC [Federal Communications Commission] approval? I've got only X dollars in the bank: I can't leverage all that into my supply chain to put product on the shelf for my retailers.

Our Chinese manufacturing partners have a massive network of suppliers in China—really good relationships. I may need only 5000 of one part today, but our Chinese manufacturing partner buys 100,000 of those parts a year, and it can extend that quantity price break to me, which is value added in BOM costs. Then there are postponement services: The Chinese manufacturing partners have a working relationship with distributors, so they receive very good credit terms. If I were working on my own, they'd want cash upfront because no one knows who I am. The difference between 90-day terms and cash upfront is the difference between succeeding and failing, especially in today's credit market.

How do you design for a lean supply chain?

A Typically, the majority of any BOM by component count—not by value—is jellybean components such as

capacitors and resistors. Maybe 10% of the BOM line items comprises parts that are important to optimize for a long list of possible local-branded substitutes that are already in their supply chain. These local-brand parts are tricky to design with because they are often copies of a brand-name part and lack adequate documentation. To qualify these parts and modify my design, I'm expecting to do two to three spins on the board and that it will smoke the first time. But once I get through it and qualify the design, I will have saved about 90% of the cost of the expensive integrated part.

The important number is "time to revenue," which is how long it takes from purchasing parts and labor to receiving payment for selling the product. You want to avoid having to pay any bills to your suppliers before you capture revenue from your product's sales. Imagine designing a product that had no longer than two weeks' leadtime for any component and that ships directly from Shenzhen to the shelf of a store so the store is restocked every two weeks. You actually don't have to build too much to keep product on the shelf. Then, if I need to change inventory due to demand or a change in the economy, it's very quick to do so. The total capital outlay you need to keep a stock of products on retail shelves is significant, and a lean supply chain minimizes that stock.

Can the United States duplicate the lean supply chain?

A I kind of have this fantasy of setting up a Chinese-style efficient manufacturing line in the United States because it would be great if I could walk down the street to my fab line instead of having to get on a plane. But the obvious problem is that the labor-rate differential is so huge. And the Chinese do use a lot of manual labor … . I was shocked by how much in China is done manually, such as custom-order fulfillment and boxing orders.

Chumby comes with all these knickknacks in a little charms bag. The assembly line for kitting the bags is almost as long as [the one for] making the Chumby itself. I couldn't afford this [assembly] in the United States. Consumers have come to expect the beautiful out-of-box experience, such as power supplies with the cables bound up. If I were to include a note that said, "I apologize for sending you a bunch of unfinished parts and plastic stuff, but it's made in the United States, so you should love it," well, people would slam me.

But even if the labor rates were to change drastically, there's still no place in the United States that's like Shenzhen. For one thing, there are all those electronic parts in one very small area. And there's also just the comfort that people there have with electronics: I always feel like in Shenzhen I could walk down the street and ask, "Where can I buy a reel of resistors?" and anyone could point me in the right direction. In the United States, first, who knows what a resistor is, and, second, who knows what a reel of them is?

—interview conducted and edited by Margery Conner

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BY BONNIE BAKER

Take a risk; throw away those bits!

When designing an ADC, your initial approach may be to define the required resolution and select a device that matches your needs. To get the required system precision, you add the necessary analog gain modules and level shifts so that the signal of interest covers the entire full-scale input range of the ADC. As a first step in your design process, you often look at the source's output range. For example, a typical pressure sensor's output full-scale range is in the hundreds of millivolts. You then match the sensor's output range to the ADC's input by inserting an analog gain cell and level-shift circuitry to match the ranges of the sensor/ADC combination.

Suppose that you change your strategy and stop playing it safe. You can create a 12-bit system using a 24-bit converter and eliminate the need for analog gain and level-shifting circuits. For instance, a true 24-bit ADC is like having 4096 12-bit converters across the output range of the converter. This academic discussion is interesting, but, in reality, you will probably never find a noiseless 24-bit ADC. **Figure 1** shows the relationship between output codes and noisy bits of a realistic 24-bit delta-sigma ADC. The converter accepts a differential input signal and has an effective resolution of 19.5 bits rms.

You can use the 24 bits of the delta-sigma converter to substitute the analog functions of gain and level shift into this digital engine. Then, implement an increase in the delta-sigma converter's process gain by shifting the 12-bit window to the right or toward the converter's LSB (least-significant bit). Each 1-bit shift to the right is equivalent to doubling the process gain. As in the analog domain, an increase in process gain lessens the input range. In **Figure 1**, the output coding scheme of the delta-sigma converter is binary two's complement.

This approach also allows you to use the delta-sigma converter to sense the analog level shift of the circuit. When you ignore a few MSBs (most-significant bits), you actually allow a level shift of the input signal. A process gain of one has a bipolar full-scale analog input range of ±4.096V, or 8.192V p-p. A process gain of 32 changes the analog input range to 256 mV, or 8.192V/32. The value of MSB, MSB-1, MSB-2, MSB-3, and MSB-4 represents the system's average voltage level shift. To sweeten the pot, many 24-bit delta-sigma ADCs have on-chip PGAs (programmable-gain amplifiers). With delta-sigma ADC devices that have on-chip PGAs, you can increase the process gain by another product-specific factor of 64 to 128.

Although the total range of the 24-bit ADC is operational, your sensor might cover only a portion of the ADC's input range and output codes. Some designers dislike throwing away bits, emphatically claiming that they paid money for those bits and so they will use them.

On the other hand, you have the full resolution of 2^{24} codes at your disposal, and you can stand to lose some dynamic range because the goal is to acquire only 12 bits for your measurement. Think about the analog circuitry you have eliminated. By selecting that portion of the ADC range, you can focus on just the area of the signal response. Don't look back. Enjoy throwing away those bits and do so with great pleasure. **EDN**

Bonnie Baker is a senior applications engineer at Texas Instruments and author of A Baker's Dozen: Real Analog Solutions for Digital Designers. *You can reach her at bonnie@ti.com.*

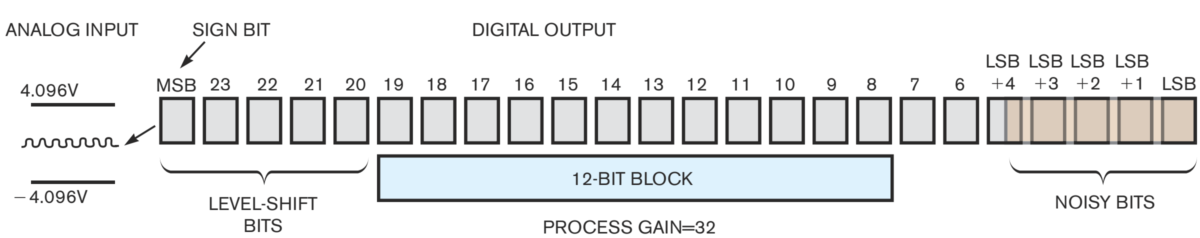
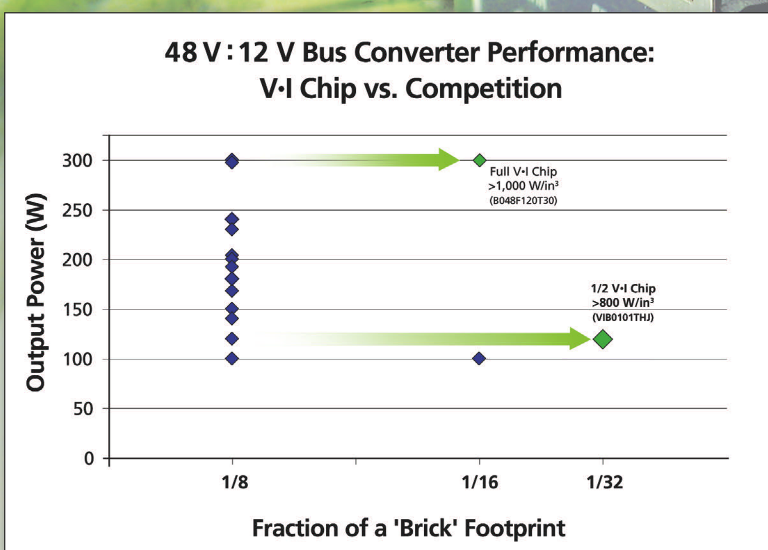


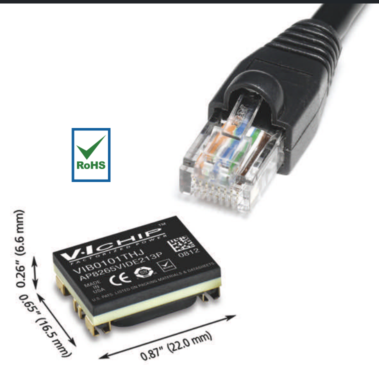
Figure 1 Use delta-sigma converters to implement process gain and level-shifting on an analog signal.

120 Watts

1/32 Brick Footprint

48 V : 12 V Bus Converter for Server, ATE, Telecom, and Industrial Control





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B048F096T24	Full	38 – 55 Vdc	9.6	240 W	96.2

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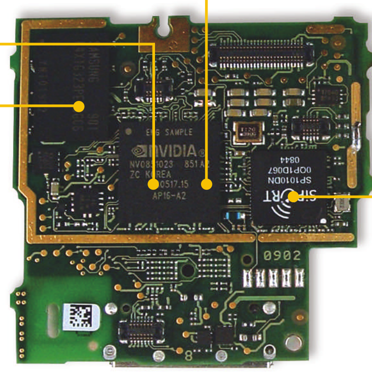
The Zune HD: more than an iPod touch wanna-be?

A few weeks ago, Microsoft began shipping the latest iteration of its portable-multimedia-player series. Notably more competitive with Apple's products than earlier Zune generations, the Zune HD even one-ups the iPod touch in several areas. How did Microsoft implement these accomplishments?

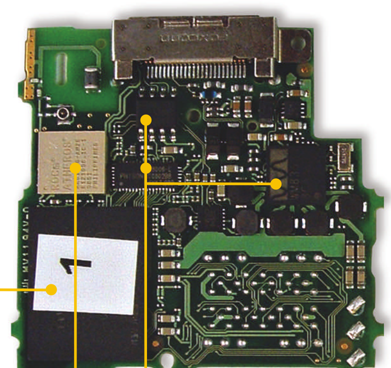
The Zune HD marks the first notable design win for Nvidia's Tegra CPU, an APX2600 running at a clock speed that Microsoft had not made public by press time.

Integrated hardware-acceleration blocks handle video decoding, graphics processing, and other tasks that would otherwise notably burden the ARM 11 core, consequently leading to both poor performance and degraded battery life. The Tegra CPU also contains dedicated still- and video-image processing logic, but Microsoft did not include a camera in the Zune HD design.

This unit contains a 1-Gbit, 32-bit Samsung K4X1G323PE-8GC6 mobile DDR SDRAM that runs at a 166-MHz memory clock rate. Do-it-yourself-repair company iFixit recently published a teardown that reveals a Hynix DDR SDRAM, however, thereby suggesting that Microsoft is buying memory at open-market rates instead of securing a single-supplier deal.



The Zune HD also includes a 3.7V, 2.45-Whr, 660-mAhr battery and a 3.5-in.-diagonal, 480×272-pixel, wide-screen Samsung AMS326FA05 OLED display. While the OLED's image quality is excellent in dim ambient-lighting conditions, bright sunlight washes it out. Its operating lifetime versus that of a traditional LED-backlit-LCD alternative may also be suboptimal.

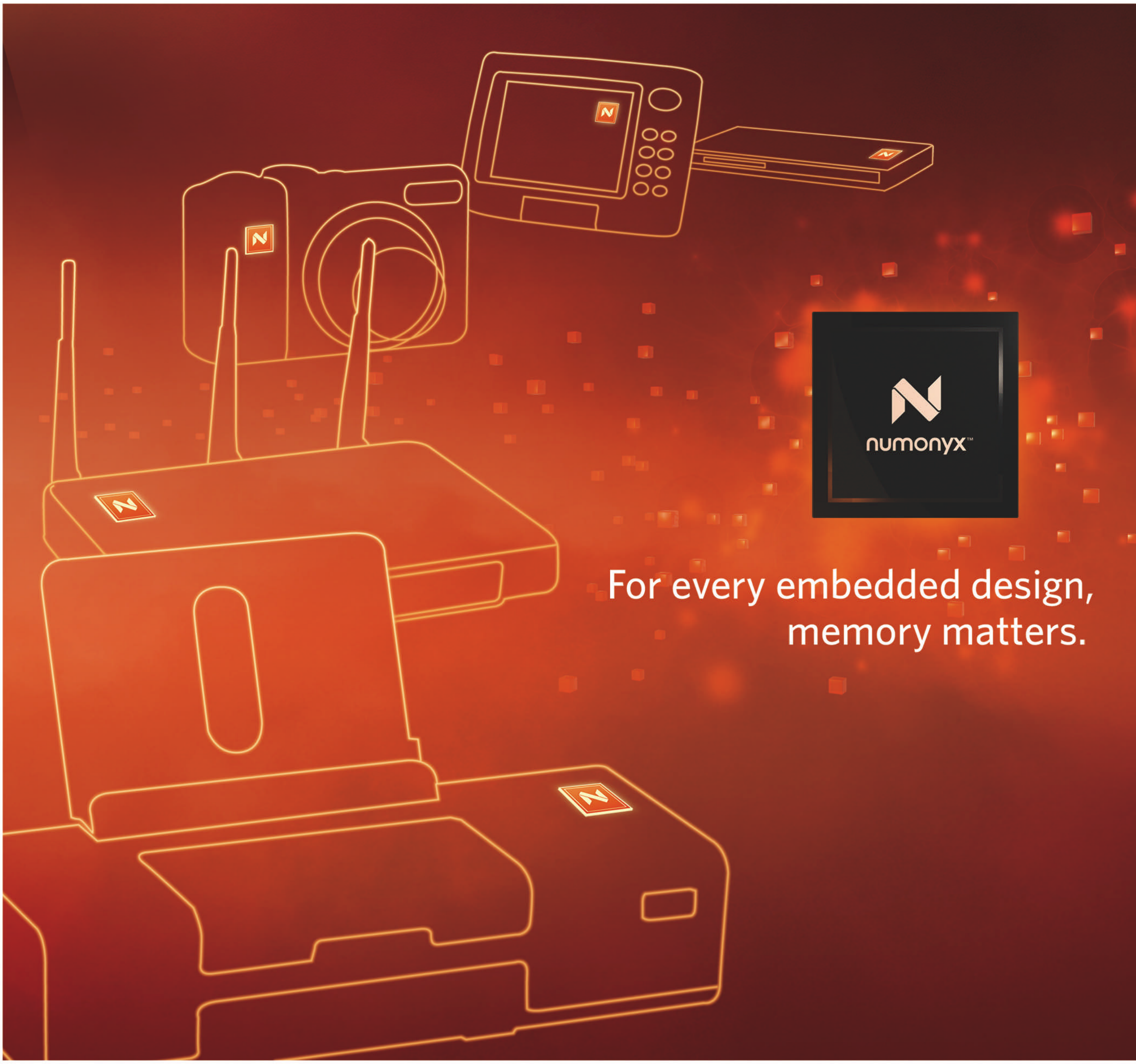


Nonvolatile storage in this particular 16-Gbyte Zune HD comprises a single Hynix NAND-flash memory; the unpopulated PCB site next to it is for a sibling IC in the 32-Gbyte product variant. Again, iFixit's analysis reveals Toshiba-fabricated NAND devices, suggesting that Microsoft decided that day-by-day best-price bargain shopping is preferable to a single-vendor lock-in. Also notable on this side of the PCB is Kionix's KXSD9 accelerometer.

An Atheros AR6002 IEEE 802.11g transceiver provides wireless connectivity. Unlike Apple's iPod touch, the Zune HD offers no Bluetooth capabilities.

Other notable ICs on this side of the PCB include a Wolfson WM8352 power-management device with an integrated two-channel audio codec, an Atmel AT88SC0808CA 8-kbit CryptoMemory EEPROM, and a Phison PS8006 NAND-flash-memory controller. The need for the PS8006 is unclear because the Nvidia Tegra CPU's specifications claim that it already offers "enhanced NAND-flash support."

The "HD" portion of the product moniker refers to the fact that the Zune HD can output 720p high-definition video to a tethered display through the device's dock connector and that it is the first multifunction mobile player to support hybrid digital radio, including the ability to gracefully degrade from digital to traditional analog radio reception in "fringe" environments with low SNR (signal-to-noise ratio). SiPort's SP1010 terrestrial digital-broadcast-receiver IC implements the hybrid digital function. Users can even tag tracks they're listening to on the radio for later acquisition from Zune's purchase and subscription-rental content options.



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BUGS CAN ORIGINATE AT EVERY STAGE IN THE FPGA DESIGN FLOW; DEBUGGING SUCCESS DEPENDS ON USING THE RIGHT TOOLS AND METHODS.

Debugging FPGA designs may be HARDER THAN YOU EXPECT

BY CHRIS SCHALICK • GATEROCKET

In the not-so-distant past, the question used to be, "Can you do that task in an FPGA?" With the advent of modern FPGA devices, however, the question has become, "Why wouldn't you use an FPGA?" Modern FPGAs' complexity rivals that of ASICs. The chips contain hundreds of thousands of flip-flops, multimegabits of RAM, thousands of DSP slices, multiple soft or hard processor cores, multiple SERDES (serializer/deserializer) channels, and more. Integration of FPGA designs no longer takes place with one hardware engineer working in relative isolation and designing from the ground up. Instead, modern projects require team-based design, substantial quantities of third-party IP (intellectual-property) cores, and complex hardware/software interactions. The ability to debug such an FPGA design determines time-to-market—and time-to-profit—success. However, debugging one of today's multimillion-gate FPGA designs is not a trivial task.

Consider a generic, high-level view of the conventional FPGA design flow (**Figure 1**). As an engineer, you could draw this **figure** in various ways—adding and rearranging the various blocks and arguing about minutiae. Newcomers who come to the design with faith in various aspects of the FPGA design flow soon discover how unfounded this faith can be. For example, it's common in FPGA IP to use two representations—one for high-level simulation and the other for the actual implementation. Many design-and-verification engineers assume that these two representations are guaranteed functionally identical. But sometimes they are not. It is also reasonable to assume that synthesis and place-and-route tools are robust and will not introduce errors in the design. But they sometimes do. When you move to FPGAs from ASICs, you may quickly discover that bugs can appear at any stage of the FPGA design flow.

AT A GLANCE

- Issues that arise during FPGA debugging include the quality of RTL (register-transfer-level) code, the quality of the IP (intellectual property), the quality of results from the synthesis engine, and the quality of results from the place-and-route engines.
- It's common in FPGA IP to use two representations—one for high-level simulation and the other for the actual implementation.
- IP models you use for simulation may differ in significant ways from the corresponding models the place-and-route software uses.

Most techies occasionally use design-related forums and sites. On these sites, real-world engineers post some cases spanning the FPGA design flow. The following examples illustrate the types of issues FPGA designers can encounter. The user, vendor, and tool names in this article are not the actual names of the participants. These examples involve a number of design issues: the quality of RTL (register-transfer-level) code, the quality of the IP, the quality of results from the synthesis engine, and the quality of results from the place-and-route engines.

CASE 1: RTL QUALITY

It isn't surprising to hear that you're going to get better or worse results depending on how you write your RTL code. Consider an example from open cores.org (**Figure 2**). This engineer's well-intentioned desire was to produce a better gate-level implementation netlist. Unfortunately, this code behaves differently in synthesis from the way it behaves in simulation, simply because the simulator ignores the synthesis pragmas.

Here, the pragma tells the synthesis tool that it can make arbitrary decisions about unspecified choices. This statement is contrary to what happens in the simulator. The end result of this difference is that inadvertently writing to an unspecified address actually overwrites a real register. One approach is to use linting tools, but most FPGA designers don't use them. Linting tools are common in ASIC environments, but design engineers who gained their experience in a traditional FPGA shop tend to have no ASIC tools lying around. Managers don't want to spend money buying such tools, designers don't want to spend time learning to use them, and so registers are overwritten.

CASE 2: IP QUALITY

In the case of ASIC designs, third-party IP vendors typically deliver their cores in the form of RTL, which may be encrypted, obfuscated, or unencrypted. Therefore, the same RTL representations of the IP blocks that you use during initial software simulation are the representations that you subsequently synthesize, place, and route along with the rest of the design. This commonality provides a high level of confidence that the RTL and gate-level representations are functionally equivalent.

The situation is different with FPGAs. IP vendors often supply two models—one at a high level of abstraction and one at the gate level. So the IP models you use for simulation may differ in significant ways from the corresponding models the place-and-route software uses. Often, the high-level simulation model contains behavioral constructs to make the software simulations run faster. Synthesis tools cannot handle these constructs, however. Moreover, subtle differences often exist between the behavioral- and gate-level representations that manifest themselves only when you deploy the FPGA design in its target system.

Consider an example from an FPGA vendor's user-forum site (**Figure 3**). Running the simulation on the gate-level netlist from the IP vendor shows different results from those of the behavioral model from the same vendor. In this case, the gate-level representation was correct and the behavioral model wasn't. In many cases, it's the other way around.

CASE 3: SYNTHESIS PROBLEMS

People believe that synthesis tools are more robust than they are. Even though some synthesis tools have been around for years, users are still logging bugs

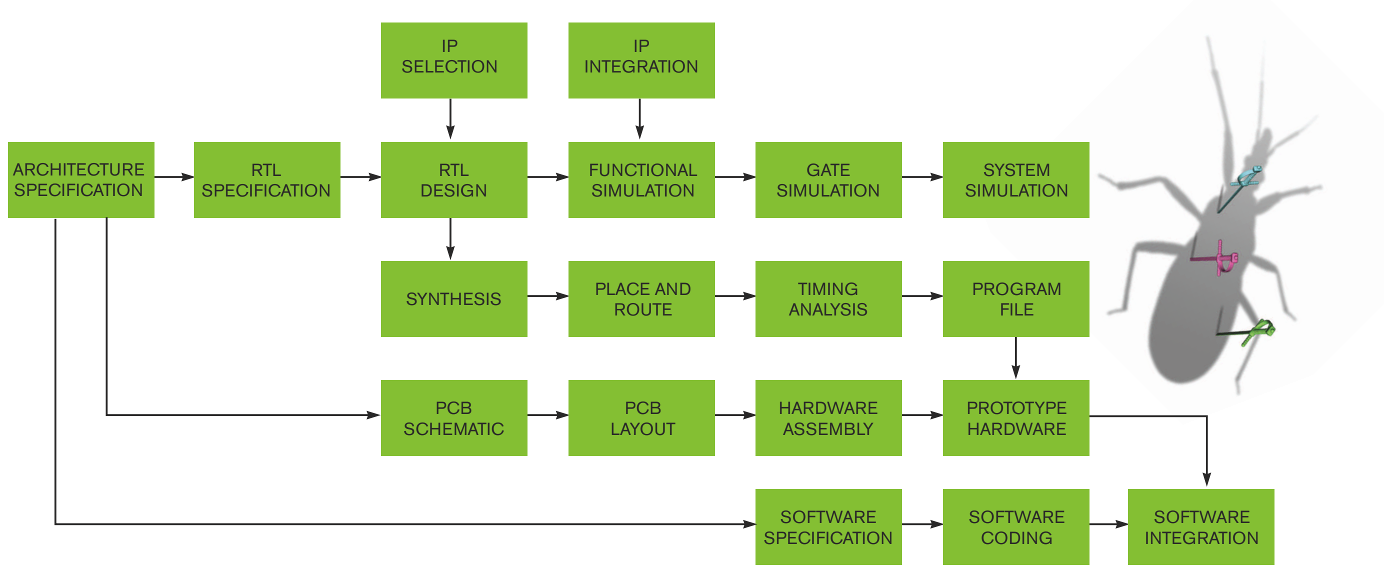


Figure 1 A modern FPGA design flow has many discrete steps.

against them. Consider a case from fpga-faq.com (**Figure 4**). This example involves a bizarre set of circumstances. First, the synthesis tool makes an odd choice. Then, critical warnings come up that are tremendously informative, but a deluge of messages buries them, causing the designer to overlook them.

In this case, the tool acknowledges that it's making an odd choice and is telling the user that it's worried. In many cases, the tool thinks that it's doing the right thing and doesn't say a word. The problem stems from aggressive optimizations on the tool's part. Today's designs are large and their corresponding synthesis can take a long time, so synthesis-engine developers take short cuts. Whenever the synthesis-engine developer cuts a corner, however, he must account for an enormous set of possible conditions. Assumptions can turn into errors.

```
I2C Core RTL Simulation / FPGA mismatch...:

Subject:  I2C Core RTL Simulation / FPGA mismatch...
msg#00024, hardware.opencores.cores

I'm using an FPGA to verify an ASIC which is using the
I2C core. I'm getting a mismatch between the RTL simu-
lation & the actual FPGA gates when writing to the I2C
CR (command register). I setup the 2 prer bytes with
known values. Then when I write the Cr register, the
value written to the cr overwrites the prer(7:0). This
is the case only in the FPGA. In rtl simulation, it
works as expected.

Upon further examination of the rtl code, I think I
have found an issue.  Please correct me if I'm wrong.

Here's the code snippet with the case statement...

// generate registers
always @(posedge wb_clk_i or negedge rst_i)
  if (!rst_i)
    begin
      prer <= #1 16'hffff;
      ctr   <= #1 8'h0;
      txr   <= #1 8'h0;
    end
 else if (wb_rst_i)
  begin
      prer <= #1 16'hffff;
      ctr  <= #1 8'h0;
      txr  <= #1 8'h0;
    end
  else
    if (wb_wacc)
      case (wb_adr_i) // synopsys full_case paral-
lel_case
        3'b000 : prer [ 7:0]  <= #1 wb_dat_i;
        3'b001 : prer [15:8] <= #1 wb_dat_i;
        3'b010 : ctr             <= #1 wb_dat_i;
        3'b011 : txr             <= #1 wb_dat_i;
      endcase

Does the // synopsys full_case parallel_case not tell
the synthesis Tool that ALL the cases are listed? All
other cases are considered "don't care" by the synthe-
sis tool, right?

The "cr" register is mapped at address 3'b100. This
case is not
Listed in the case statement, so this bit is optimized
away and is not considered important.

That's the problem... now when address 3'b100 is writ-
ten, the case statement sees it as 3'bx00 and the
prer(7:0) is written as well as cr.

Does the case statement not need a default line which
keeps the
Previous values for the 4 registers? Am I misunder-
standing this concept?
```

Figure 2 In this posting from opencores.org, an engineer wanted to produce a better gate-level implementation netlist, but the code behaves differently in synthesis from the way it behaves in simulation.

CASE 4: PLACEMENT-AND-ROUTING PROBLEMS

As a final example, consider a power-up initialization problem from fpga-faq.com (**Figure 5**). In this case, the place-and-route tool doesn't know what to do; it decides that a register must have some state, so it makes an arbitrary—and unfortunate—choice that causes the silicon to do something odd and unexpected. The engineer is coming up with solutions but is unsure whether they will work because visibility into the root cause is so low.

These examples are teasers; you occasionally hear more complex stories. In one such story, a design team lost weeks go-

```
January 9th, 2008, 12:00 AM
username
Vendor Pupil
Posts: 9 Rep Power: 558

VHO bug for FFT v2.2.1 (streaming)
I have simulated a 2048 point FFT v2.2.1 (streaming)
in both ModelSim and vendor tool. In vendor tool cor-
rect streaming  behaviour is observed, with assertion
of master_source_sop  immediately following assertion
master_source_eop, and  master_source_ena remaining
high at all times.

When simulating the VHO file in the simulator incor-
rect behaviour is observed, with a gap between master_
source_eop and master_source_sop assertions, during
which time master_source_ena is taken low.

Attached are the plots of what I have described. Does
anyone know of a solution to this problem? (Besides
trying the latest ver FFT core which is not an option)

#2    January 9th, 2008, 12:08 AM
Location: Bochum Germany
Posts: 1,011

Hello username,
if the error is with the FFT compiler generated simu-
lation model, who about Modelsim gate level simulation
of the Vendor compiled FFT design? I guess, the simu-
lation model may be faulty,

Regards,contributor
……
#4    January 9th, 2008, 05:54 PM
Posts: 9
Rep Power: 558

Re: VHO bug for FFT v2.2.1 (streaming)
Thanks for the response contributor. I did try regen-
erating the VHO using the post synthesis netlist gen-
eration as you suggested.

This has fixed my problem but of course results in
considerably slower simulations.

username
```

Figure 3 In this posting, a user finds that running the simulation on the gate-level netlist from the IP vendor yields different results from those of the behavioral model from the same vendor.

EACH FUNCTIONAL BLOCK IN THE DESIGN SHOULD BE ABLE TO RESIDE IN THE SOFTWARE DOMAIN, THE HARDWARE REALM, OR BOTH.

ing back and forth with IP vendors trying to work out a problem. In one case, a place-and-route tool optimized some core functions out of the vendor's own IP. Nevertheless, you can do astounding things with a modern high-end FPGA and associated design tools. You can—in one day and on your desktop—synthesize a design that's equivalent in complexity to a Pentium CPU, run place-and-route tools, and generate the corresponding FPGA-configuration file. Just five years ago in the ASIC world, you needed a design center for one to three months to come up with a workable place-and-route strategy.

Despite these advantages, the downside is that errors can creep into the design at every stage in the process, and these errors often don't manifest themselves until the design is in a real board in the laboratory, by which time they can be difficult and time-consuming to detect, isolate, identify, and resolve. Software simulation provides a high level of visibility into the design, but it runs relatively slowly even at the RTL. By comparison, running the design in real FPGA hardware, such as a development or prototype board, provides hardware speeds, so any problems quickly manifest themselves by crashing and burning. Due to lack of visibility into the chip, it can be difficult to determine what's gone wrong. Is there an error with the RTL source code that causes it to behave differently with the simulator from the way it behaves with the synthesis engine? Are there functional differences between one or more of your behavioral third-party IP blocks and their gate-level equivalents? Is it perhaps a case in which your RTL and IP are functionally correct, but the synthesis engine, place-and-route engine, or both have introduced errors? Or do you have a mixture of all of these situations?

```
Hello Sir,
    We have investigated this and discovered that the
message "Critical Warning: Ignored Power-Up Level
option on the following nodes --..."  is a side effect
of a synthesis bug. This bug occurs if there is a
State Machine Synthesis with the following conditions:

1. The State Machine is specified in VHDL.
2. The State Machine inferred by Integrated Synthesis
(map) does NOT have a reset signal in it.
3. State Machine Processing is set to either Auto or
One-Hot
4. Software version x.y is being used.

    If your state machine has a reset in it you can
ignore this message. Your design will provide expected
results on the board.  If your state machine does not
have a reset you will need to add a reset to it, else
it will not work on the board.

This bug exists in software version x.y only. It has
been fixed in version x.y service pack 1 which will be
released ...
```

Figure 4 In this posting from fpga-faq.com, the problem stems from aggressive optimizations on the tool's part.

Answering all these questions requires a different approach. Software simulations offer visibility into the design but are slow. Verifying the design in hardware is fast but provides limited visibility into the internals of the system. So the answer is to create an environment in which software and hardware representations of the design can coexist. In other words, each functional block in the design should be able to reside in the software domain, the hardware realm, or both.

For example, consider a design comprising, say, 100 functional blocks. Some of these blocks could be your own internally developed, proven IP from previous projects; some could be IP from third-party vendors; and some would be your new "secret sauce" to differentiate your design from all others. Now, suppose that you could immediately move the gate-level representations of any known-good blocks, such as your internally developed IP and trusted third-party IP cores, for example, into the same type of FPGA you are targeting for your real-world design. Also assume that you could now verify these blocks in conjunction with the rest of the design running in your software simulator of choice. Right from the start, you have dramatically speeded your verification runs.

Now, as you verify each of the new blocks at the RTL or behavioral level in the context of the full-chip design, you could move the synthesized/gate-level equivalent of each verified block into the physical FPGA. As soon as any problems manifest themselves, you could repeat the verification run with the RTL version of the suspicious block, resident in the simulation world, running in parallel with the gate-level version in the physical FPGA. A software application could—on the fly—compare the signals from the peripheries of these blocks, along with any designated signals inside the blocks. This combination of conventional simulation with physical hardware and an appropriate debugging environment would make it possible to detect, isolate, identify, and resolve bugs, no matter where they originated in the design flow.

Leading FPGA vendors are continuing to innovate and produce larger, more complex chips that are quickly landing in applications that would have been ASIC-only just a few years ago. This fact means that lots of designers are on a steep FPGA-design learning curve, probably with limited resources and time. For FPGA vendors and tool suppliers, this situation presents a great opportunity to simplify and streamline development, thereby converting occasional users into lifelong customers. EDN

```
I want a FF in my XYZ project to be '0' at power-up;
be later set by an external input; and never subse-
quently reset.  I placed an SRFF with S to the exter-
nal input; clock to the clock; and R to ground. I
assumed it would power-up at '0' but I got analysis
and synthesis errors:

"Info: Power-up level of register inst is not speci-
fied -- using
Unspecified power-up level" and "output pins are stuck
at VCC or GND" - so I created an assignment:

set_instance_assignment -name POWER_UP_LEVEL LOW -to
inst

I was surprised it needed this, but it seems to work.
That sorted, I placed an inverter between the Q output
of the SRFF and an external output pin - I want the FF
to drive an external active-low signal.

This doesn't work in the simulator or the real sili-
con: the output is permanently asserted. But, if I
connect another output directly to q - so I have both
q and /q output pins - then it works!

I'm guessing that place / route software can't invert
the signal between the … FF and output pin, so it
needs to use another … cell just for the inverter, but
something goes wrong with the optimization.

Am I warm? Is this a known bug? Is there some option I
need to set, or must I dedicate an output pin for the
unwanted true q - just to make the /q output work??

I'm using software version x.y Web Edition.
```

Figure 5 A posting from fpga-faq.com discusses a place-and-route tool that makes an arbitrary choice that causes the silicon do something odd and unexpected.

AUTHOR'S BIOGRAPHY

Chris Schalick is the founder and chief technology officer of GateRocket, which specializes in FPGA-design and -debugging technology. He has 20 years of experience in modular-system design and behavioral-system modeling for consumer and industrial equipment. Schalick has held senior engineering positions for raster-imaging, data-networking, and semiconductor-test-equipment companies and was instrumental in delivering products to market at Teradyne, Tenor Networks, Packet Engines, and Cabletron Systems. He holds a bachelor's degree in electrical engineering from the Massachusetts Institute of Technology (Cambridge, MA).

BY ROBERT CRAVOTTA • TECHNICAL EDITOR

The 36th annual microprocessor directory

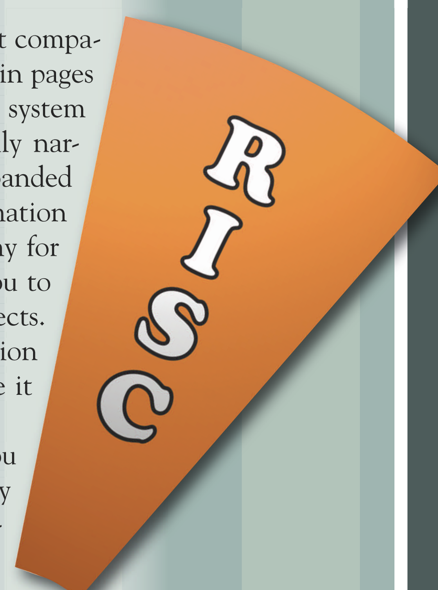
DON'T TAKE A CHANCE ON YOUR PROCESSOR SELECTIONS.

"I'D LIKE TO BUY A μ"

Welcome to the 36th annual *EDN* Microprocessor/ Microcontroller Directory. There are so many processor options available for embedded-system applications that it is easy to miss the perfect fit just because you do not know it even exists. The company roster and product listings in this directory continue to evolve and encompass new companies, and it is a testament to the variety of processors available and the tremendous variation among requirements, features, and types of applications for which designers are using microprocessors and microcontrollers. *EDN* is constantly uncovering companies that did not exist during publication of previous editions of the directory. If you notice that we overlooked a company, please let that company and us know that you missed it and would like to see it in the next update of the directory.

The print version of this directory is but a small fraction of the entire directory that stresses a company overview and new announcements since last year's directory. Visiting the online version at www.edn.com/microdirectory is the only way to examine all of the information available because it spans hundreds of pages—well beyond the capacity of the print update. The print version lists the companies selling software-programmable processors and cores and provides an overview for each as well as identifies the latest developments over the previous year at each company.

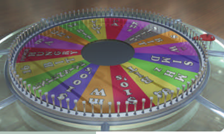
The online material lists third-party-software-development companies as a companion directory that is cross-linked on the main pages of each listing. This directory aims to provide designers and system architects enough visibility into processor options to quickly narrow the list of candidate processors for each project. The expanded online section presents each processor with detailed information and block diagrams. The directory uses a common taxonomy for describing and categorizing target applications that helps you to quickly find and compare competing processors for your projects. The Web material has more details on the common application taxonomy so that you can comment on it and we can refine it as appropriate.



The "Where are they now?" **sidebar** on the Web helps you find companies that we no longer list, whether because they closed their doors, they changed their focus, another company acquired them, or they spun off into a different company. As always, the Web site duplicates and greatly 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/microdirectory or by sending your comments and feedback to microdirectory@edn.com.

www.edn.com/microdirectory



ACTEL

Actel (www.actel.com) offers low-power and mixed-signal FPGAs that support ARM and 8051 cores, including a license- and royalty-free, 32-bit, FPGA-optimized ARM Cortex-M1 processor. The company's low-power ProASIC3L FPGAs feature 40 and 90% lower dynamic and static power, respectively, than its ProASIC3 FPGAs. The company's Igloo PLUS family of FPGAs focuses on power-, area-, logic-, and feature-per-I/O ratios in a programmable device. Actel's Libero IDE (integrated development environment) supports power-driven layout, advanced power analysis, and battery-life estimation.

ADVANCED MICRO DEVICES

AMD's (Advanced Micro Devices', www.amd.com) x86-based products span the consumer embedded-system market and serve enterprise-class servers and workstations, extending the x86 ISA (instruction-set architecture) across 32- and 64-bit PC, server, and workstation platforms with AMD64 technology. The company's x86 Geode processors target applications for the entertainment, business, education, and embedded-system markets. Opteron processors with Direct Connect Architecture and HyperTransport technology deliver 32-bit performance and enable the transition to 64-bit computing. Athlon 64 processors provide dual- and single-core computing for desktops that can run 32-bit applications at full speed while enabling new 64-bit software applications. The Mobile Sempron processor features range from lower power to full-sized mobile computing.

ALTERA

Altera's (www.altera.com) Nios II family of soft embedded processors features a general-purpose, 32-bit RISC CPU architecture in three configurations. The Nios II/f core emphasizes processing performance, the Nios II/e focuses on economy, and the standard Nios II/s core configuration balances performance and core size. The Nios II embedded-design suite includes 32-bit, single-precision, IEEE 754-compatible, floating-point support and the Nios II C2H compiler. Designers can add Nios II processors to their systems using the SOPC (system-on-programmable-chip) Builder tool. The Nios II C2H (C-to-hardware)-acceleration compiler enables developers to convert performance-critical C-language subroutines into hardware accelerators and integrate them into FPGA-based Nios II subsystems.

ALTIUM

Altium (www.altium.com) provides next-generation electronics-design software. Altium Designer's unified electronics-design environment encompasses all aspects of electronics-product design into one process within a single application. This helps designers manage their projects across broad design ecosystems and create connected, intelligent designs.

Altium Designer supports interactive FPGA-system design for vendor-independent electronic-product development using soft, hybrid, and discrete processors. It includes a number of royalty-free, 8- and 32-bit, FPGA-based soft processors, such as the 8051, Z80, PIC, and FPGA-independent TSK3000 32-bit RISC core. The software also features complete support for a number of processors, such as ARM7, Nios II, and Microblaze.

ANALOG DEVICES

Analog Devices' (www.analog.com) ADuC product family combines ARM7 or 8052 microcontroller cores with integrated precision converters; references; and sensor peripherals to target automation, industrial, and automotive applications. The ADuC706x family incorporates two 24-bit sigma-delta ADCs and analog peripherals with a 32-bit ARM7 core to target precision sensing applications. The company's Blackfin processor family combines signal-processing capabilities with control functions in a single 16/32-bit core.

AMCC

AMCC (Applied Micro Circuits Corp, www.amcc.com) offers embedded Power Architecture processors targeting control-plane, imaging, wireless-access, industrial-control, storage, and networking applications. The AMCC Power Architecture supports low-power operation, high-performance PCIe (Peripheral Component Interconnect Express) and PCI-X (PCI extended) 2.0 I/O interfaces, interfacing to DRAM, such as DDR2 SDRAM, accelerated GbE (gigabit Ethernet), and state-of-the-art security.

The PowerPC 460GT and PowerPC 460GTx target enterprise-class networking, storage, and wireless-infrastructure applications. AMCC also announced the PowerPC 460SX storage processor for high-throughput RAID (redundant-array-of-inexpensive-disks) acceleration.

AMCC's Titan core relies on Intrinsity's Fast14 logic to reach clock speeds as high as 2 GHz in 90-nm bulk CMOS and consumes 2.5W. Titan is part of a dual-core "processor complex" that supports coherent multiprocessing.

ARC INTERNATIONAL

ARC International (www.arc.com) licenses consumer IP (intellectual property) in the form of multimedia subsystems and related technologies. Sonic Focus, an ARC International company, licenses audio-enhancement software. The ARC Sound 210E subsystem targets high-quality audio for a low-power budget. ARC's new Energy Pro technology reduces SOC (system-on-chip) power consumption by as much as fourfold. ARC subsystems include a set of optimized and pre-integrated audio, imaging, and video codecs, as well as development tools. The ARChitect configuration tool enables developers to explore and create an ARC subsystem or processor tailored to an application's requirements.

ARM

ARM (www.arm.com) licenses semiconductor IP (intellectual property), including processors, peripherals, interconnect, and physical libraries targeting mobile, automotive, consumer-entertainment, imaging, networking, storage, security, and wireless applications. The company's range of processors includes the ARM7, ARM9, ARM10, and ARM11 families and the Cortex family featuring Thumb-2 technology. ARM also offers the SecurCore processor family targeting secure applications, such as smart cards and SIMs (subscriber-identity modules), and the Mali family of graphics processors. ARM's supporting software includes TrustZone technology for data security and DRM (digital-rights management), Jazelle execution-environment-acceleration software, IEM (Intelligent Energy Manager) technology, and RealView development tools.

The high-performance ARM Cortex-A9 MP-Core multicore processor features energy-efficient, scalable performance. The ARM Cortex-A8 processor targets consumer products running multichannel video, audio, and gaming applications with a power consumption of less than 300 mW in a 65-nm technology. The midrange Cortex-R4 processor targets next-generation embedded products. The ultracompact ARM Cortex-M3 processor targets cost-sensitive embedded-system applications, such as automotive-body systems, white goods, and networking devices. The ARM Cortex-M1 processor is developed for implementation in FPGAs.

ASIX ELECTRONICS

Asix Electronics (www.asix.com.tw) offers non-PCI (Peripheral Component Interconnect)-Ethernet controllers, USB (Universal Serial Bus) 2.0-to-Ethernet NIC (network-interface-card) controllers, and network SOCs (systems on chips) targeting embedded networking applications, such as home appliances, factory/building automation, industrial equipment, security systems, remote-control/monitoring/management, and streaming-media applications. Over the last year, Asix has focused on Wi-Fi speaker and Wi-Fi IP (intellectual-property)-camera reference designs that the company based on its new Wi-Fi SOC technology. The single-chip AX220xx microcontroller family has an SOC with TCP/IP (Transmission Control Protocol/Internet Protocol) and 802.11 WLAN (wireless-local-area network) MAC (media-access controller)/baseband.

ATMEL

Atmel (www.atmel.com) offers microcontrollers and microprocessors that it bases on its proprietary 8- and 16-bit RISC AVR; 32-bit AVR32; and ARM's Cortex-M3, ARM7, ARM9, and ARM11. This year, the company introduced the six-pin picoPower AVR Tiny10, which draws 200 µA while operating at 12 MIPS, 25 µA while idling, and less than 100 nA during sleep. The 32-bit AVR32 UC3L, with a built-in capacitive-touch interface and event system, consumes 0.5 mW/MHz in active mode, less than 2 µA with a 32-kHz RTC, and 100 nA in sleep. The 32-MIPS AVR Xmega with DMA, event system, and multilevel interrupts supports a worst-case 65.2-nsec response time.

The company's new Cortex M3-based SAM3, AVR32-based UC3A3, and ARM9-based SAM945G offer HS (high-speed) USB (Universal Serial Bus), plus interfaces for dual high-speed SD (secure-digital) card/MMC (multimedia card), SDRAM, and NAND flash with SLC (single-level cell) and MLC (multilevel-cell) ECC (error-correcting code). The AVR32 UC3A3 digital-signal controller has a built-in DSP that allows it to decode stereo MP3 at less than 25 MHz and AAC (Advanced Audio Coding) at 66 MHz. New reference designs include the Digital Audio Gateway kit and the plug-and-play CrytpoAuthentication kit.

AUSTRIAMICROSYSTEMS AG

Austriamicrosystems (www.austriamicrosystems.com) offers high-performance analog ICs with a focus on power management, sensors and sensor interfaces, and portable audio. The company's 200-MIPS, ARM9TDMI-based AS3525/27 integrated-audio-processor system combines strong calculating power, high-performance-audio features, and system-power-management options for battery-powered devices. The AS353x family integrates hardware accelerators for MP3, WMA (Windows Media Audio), and AAC (Advanced Audio Coding) for audio; WMV9 (Windows Media Video Version 9) Main Profile and Sorenson Spark for video; and high-performance postprocessing for enhanced GUIs (graphical user interfaces).

BEYOND SEMICONDUCTOR

Beyond Semiconductor (www.beyondsemi.com) licenses two families of 32-bit processor cores available as a Verilog RTL (register-transfer-logic) source or ChipX hard macros. All processors come with industry-standard software-development tools and operating-system support, including Linux and eCos. The modern, superscalar Beyond BA14 processor features dual-issue, out-of-order execution. With DSP instructions and an optional double-precision floating-point unit, it targets applications with demanding performance requirements. Implementing four-way cache and TLBs (translation-look-aside buffers) enables the Beyond BA22 to run modern Linux-multimedia applications.

BROADCOM

Broadcom (www.broadcom.com) provides a family of high-performance, low-power, integrated processors targeting data-networking and communications applications, as well as security, storage, 3G (third-generation)-wireless infrastructure, and high-density computing. The Broadcom broadband CMP (chip-multiprocessing) systems integrate as many as four 64-bit MIPS processor cores onto a single die. CMP scales system performance by sharing the workload across multiple cores.

CAMBRIDGE CONSULTANTS

Cambridge Consultants' (www.cambridgeconsultants.com) XAP processor soft-IP (intellectual-property) cores offer advanced computing functions at low cost and energy consumption. The latest XAP4 and XAP5 target applications such as wireless sensors, and their architecture minimizes the size of program and data memories to achieve small die area, especially when memory is embedded on-chip or integrated in an SIP (system in package).

Since announcing the latest 16/32-bit XAP5 in 2008, Cambridge Consultants has released new versions of its xIDE (integrated device environment) software-development and -debugging tools for XAP processors, including updates to GCC and other enhancements to improve programming productivity. Evaluation versions of xIDE for XAP4 and XAP5 are available.

CAST

Cast (www.cast-inc.com) offers IP (intellectual-property) cores for general-purpose 8-, 16-, and 32-bit processors. A configurable 8051 core executes instructions with one clock per cycle. Additional cores include 8-bit Z80 and 16-bit 68000- and 80186EB-compatible devices. Cast's 32-bit APS cores target embedded systems needing more performance than an 8051 can offer. They require as few as 7000 gates, perform at 0.6 Dhrystone MIPS/MHz, and use as little as 18 µW/MHz of power. A coprocessor architecture enables performance improvement for specific applications, and an ASP-DSP coprocessor is available.

CAVIUM NETWORKS

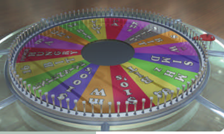
Cavium Networks (www.caviumnetworks.com) offers security and single-core and multicore MIPS64-based processors targeting networking, wireless, storage, and control-plane applications. The Octeon MIPS64 processors integrate one to 32 MIPS64 cores with high-performance networking, multicore acceleration, memory controllers, and advanced hardware-acceleration coprocessors. The Nitrox Security processors accelerate IPsec (Internet Protocol Security), SSL (Secure Sockets Layer), and WLAN (wireless-local-area-network) and encryption algorithms.

CIRRUS LOGIC

Cirrus Logic (www.cirrus.com) supplies high-precision analog- and mixed-signal and embedded processors for the audio and industrial markets. In the general-purpose-processor segment, Cirrus Logic offers highly integrated ARM9- and ARM7-based embedded processors targeting industrial and networked consumer applications. Cirrus Logic's NineSeries of ARM9-based products includes the EP9301, EP9302, EP9307, EP9312, and flagship EP9315. The entry-level EP9301 integrates Ethernet and two USB (Universal Serial Bus) 2.0 host ports, and the EP9302 adds MaverickCrunch and MaverickKey to go along with increased processing power and memory. The EP9307 adds a graphics accelerator, touchscreen and keypad support, and three USB ports. The EP9312 supports high-quality audio and an integrated development environment. The flagship EP9315 adds support for the PCMCIA (Personal Computer Memory Card International Association) interface in a single device.

COREWORKS

Coreworks (www.coreworks.pt) this year released the five-stage-pipeline, modified-32-bit-Harvard-architecture FireWorks, featuring a high-speed programming interface and DSP instructions. The architecture includes a 32-bit ALU (arithmetic-logic unit) and 32×32-bit registers. You can configure it to include a hardware multiplier, a barrel shifter, and a serial divider. It supports external interrupt requests, data caches, and instruction caches. A DMA core is also available. FireWorks uses an AMBA (Advanced Microcontroller Bus Architecture)/AHB (Advanced



High-Performance Bus) interface, into which you can plug peripherals.

CPU TECHNOLOGY

CPU Technology (www.cputech.com) offers multicore SOC (system-on-chip) devices and development tools that target computers and peripherals, communication/wired, general-purpose, imaging and video, industrial, medical, military/aerospace, mobile/wireless, and test-and-measurement applications. The Acalis family of field-programmable multicore chips provides security functions that protect IP (intellectual property) without impacting performance. The Acalis chips readily scale to more than 100,000 chips.

The CPU872 contains dual PowerPC 440 cores with floating-point units, dual streaming processors, dual MPI (message-passing-interface) processors, dual embedded DRAMs, and dual external DRAM interfaces. The CPU878 contains eight complete computational nodes on a chip for higher computational density with the same functions and protections as the CPU872.

CRADLE TECHNOLOGIES

Cradle's (www.cradle.com) CT3600 family of scalable MDSP (multicore-digital-signal-processing) processors integrates multiple general-purpose processors with multiple DSPs to improve processor efficiency for control code and computationally intensive media-processing algorithms. The CT3600 family comprises two products containing eight to 16 DSP processors on a single chip. The larger version, with 16 DSPs and eight general-purpose processors, operates at 350 MHz, supports 16 channels of CIF (common-intermediate-format)-resolution Simple Profile MPEG-4 encoding.

CYAN TECHNOLOGY

Cyan Technology's (www.cyantechnology.com) low-power, 16-bit, embedded-communications, flash-based eCOG1k microcontroller implements a 25-MHz RISC Harvard architecture that includes internal flash memory, RAM, and cache. The external-memory interface supports addressability of 32 Mbytes. Additional features include a smart-card interface, a 12-bit ADC, a temperature sensor, and a proprietary port-configuration device.

CYBERNETIC MICRO SYSTEMS

Cybernetic Micro Systems (www.controlchips.com) produces ASICs to interface to peripherals that would be difficult to control from a general-purpose computer. The 100-pin, 8-bit P-51 microcontroller either sits between the host computer and the peripheral device or becomes the peripheral device. With a dual-port RAM interface on the host side in a PC104/ISA (industry-standard-architecture) format, the P-51 looks like memory to the host, but it has the intelligence and capability of an 8051.

CYPRESS SEMICONDUCTOR

Cypress' (www.cypress.com) PSoC (programmable system on chip) integrates configurable digital and analog peripherals, an 8- or 32-bit microcontroller, and three types of embedded memory. Target applications include automotive, communications, computers and peripherals, consumer, industrial, medical, motor control, and mobile/wireless devices. This year, Cypress introduced the PSoC 3 architecture, which it based on an 8-bit 8051 processor, and the PSoC 5 architecture, which includes a 32-bit ARM Cortex-M3 processor. The two new architectures feature high-precision integrated analog with 20-bit resolution and a PLD (programmable-logic-device)-based digital system with as many as 48 cascading datapaths.

The new TMA300 PSoC-based TrueTouch touchscreen-controller family marks Cypress' second generation of technology that can simultaneously interpret as many as 10 inputs from all areas of the screen.

The PowerPSoC family of single-chip, integrated embedded power controllers both controls and drives high-power LEDs. The PowerPSoC family integrates four constant-current regulators and four 32V MOSFETs with a PSoC.

DIGI INTERNATIONAL

Digi International (www.digi.com) offers net-centric Net+ARM processors that the company based on ARM7 and ARM9 cores. The NS9215 and NS921 networking processors with ARM926EJ-S cores operate at 75 and 150 MHz; both chips feature 10/100-Mbps Ethernet. The NS9360, NS9750, and NS9775 employ the ARM926EJ-S core. The NS9360 operates at 177 MHz and integrates 10/100-Mbps Ethernet, USB (Universal Serial Bus), an LCD, IEEE 1284, and serial I/O. The NS9750 operates at 200 MHz and includes all of the NS9360 features, plus PCI (Peripheral Component Interconnect) support. The NS9775 color-laser-printer processor operates at 200 MHz and integrates 10/100-Mbps Ethernet, USB, and PCI to improve the cost performance of color laser printers. Digi based the NS7520 on the ARM7TDMI core. It operates at 55 MHz and integrates 10/100-Mbps Ethernet, serial I/O, and general-purpose interfaces.

DIGITAL CORE DESIGN

DCD (Digital Core Design, www.dcd.pl) provides VHDL- and Verilog-synthesizable, ISO 9001:2000-certified IP (intellectual-property) cores of 8-, 16-, and 32-bit processors and bus interfaces, as well as fixed- and floating-point arithmetic coprocessors. DCD's DP8051XP/DP80390XP soft core is 100%-binary-compatible with the industry-standard, 8-bit 8051 microcontroller. DCD's microcontrollers implement fast 16- and 32-bit integer operations and single- and double-precision floating-point operations. The D68HC11 is fully compatible with the 68HC11A and the 68HC11E.

E2V

In partnership with Freescale Semiconductor, E2V (www.e2v.com) this year added products to its suite of high-reliability microprocessors and MRAMs (magnetic-random-access memories). In partnership with Tundra Semiconductor, E2V also introduced broadband-data converters, ASICs, and ISM (industrial/scientific/medical) transceivers targeting defense, space, avionics, telecom, industrial, medical, and automotive applications. E2V's microprocessor products range from the 68K family to the new-generation PowerPC devices and support peripherals. In addition to test and service facilities, the company offers long-term availability on the complete family of products.

EM MICROELECTRONIC

EM Microelectronic (www.emmicroelectronic.com) offers ultralow-power, low-voltage digital-, analog-, and mixed-signal ICs targeting battery-operated and field-powered devices in consumer, automotive, and industrial applications. EM Microelectronic's 4- and 8-bit microcontrollers target battery-operated devices, which often have low-standby-power requirements and perform periodic or on-demand actions.

FREESCALE SEMICONDUCTOR

Freescale Semiconductor (www.freescale.com) offers communications processors, microcontrollers, embedded processors, sensors, RF components, analog/power-management technology, and supporting software for automotive, consumer, industrial, networking, and wireless applications. Freescale bases its PowerQUICC (quad-integrated-communications-controller) processors on Power Architecture cores. PowerQUICC processors provide data- and control-plane processing for wireless and wire-line infrastructure, industrial control, enterprise networking, home and SOHO (small-office/home-office) networking, and pervasive computing. The QorIQ line is the next generation of Freescale's PowerQUICC-processors, targeting developers migrating to multicore designs. The company's Flexis-series devices target consumer and industrial markets. Flexis pin-for-pin-compatible 8- and 32-bit microcontrollers come with a set of on-chip peripherals and development tools.

Freescale's i.MX application processors target embedded, general-purpose-system and multimedia applications for homes, handheld devices, and vehicles. The processors employ Smart Speed technology to balance high performance with battery life.

FUJITSU MICROELECTRONICS

Fujitsu's (www.fujitsu.com) 8-, 16-, and 32-bit microcontrollers include general-purpose and application-specific versions targeting automotive, communications, computer-peripheral, industrial, and consumer applications. The F2MC (Fujitsu flexible-microcontroller) line includes the 8-bit F2MC-8L and F2MC-8FX series and the 16-bit F2MC-16L/16LX/16F series. The FR (Fujitsu RISC) series has a stepper motor and LCD controllers for auto, communications, computer-peripheral, industrial, consumer, and security applications.

GAINSPAN

GainSpan (www.gainspan.com), a Wi-Fi semiconductor and software provider, targets applications such as temperature monitoring for energy management, condition monitoring of industrial equipment, and monitoring streetlights for metropolitan areas. The GainSpan GS1010 Wi-Fi SOC (system on chip) integrates an 802.11b/g radio, an ARM7 microcontroller, and a power-management unit. The GMS (GainSpan management-system) software manages Wi-Fi devices that are asleep as much as possible to conserve energy. GMS resides in the network as an always-on intelligent interface.

HYPERSTONE

Hyperstone (www.hyperstone.com) offers the general-purpose E1 processors, the HyNet networking processors, and the NAND-flash controllers that the company based on a unified RISC/DSP architecture. This year, Hyperstone introduced the S7(B) SD (secure-digital) cards and MMCs (multimedia cards) and the F4 CF/PATA (CompactFlash/parallel-advanced-technology-attachment) NAND-flash-memory controllers. The CFA3.0/ATA6F4 controller targets uses in high-performance CF cards and SSD (solid-state-disk) drives. The S7(B) and F4 controllers support MLC (multilevel-cell) and SLC (single-level-cell) flash from all NAND-flash vendors.

IBM

IBM Global Engineering Solutions (www.ibm.com/technology) offers embedded microprocessor cores and microprocessors employing IBM Power Architecture technology. IBM's offerings include the 32-bit PowerPC 4xx family of embedded cores, along with 32- and 64-bit power- and performance-optimized microprocessors. IBM's PowerPC 405, 440, and 460 families of embedded cores offer scalable performance for custom-SOC (system-on-chip) integration. The cores are available in both fab-optimized and fully synthesizable versions.

IBM's PowerPC 750 family of 32-bit microprocessors targets cost- and power-sensitive embedded-system applications. The PowerPC 970 family of microprocessors offers performance-driven, 64-bit architecture with native 32-bit application compatibility. IBM's 970 family includes both single- and dual-core, VMX-enabled microprocessor offerings.

IDT

The IDT (Integrated Device Technology, www.idt.com) Interprise family of integrated communications processors delivers data processing at line-rate speed. IDT based the processor cores on the 32-bit MIPS ISA (instruction-set architecture). Interprise processors target SOHO (small-office/home-office) routers, Ethernet switches, WAPs (wireless-access points), and VPN (virtual-private-network) equipment.

IMEC

IMEC's (Interuniversity Microelectronic Centre's, www.imec.be) flexible ADRES (architecture for dynamically reconfigurable embedded system) consists of a tightly coupled VLIW (very-long-instruction-word) processor and a coarse-grained, reconfigurable array. The architecture template consists of computational, storage, and routing resources. The routing resources connect the computational and storage resources in a topology to form the ADRES array. Data accesses to the memory of the unified architecture take place through load/store operations. A script-based technique allows designers to generate instances.

IMSYS TECHNOLOGIES

Imsys (www.imsystech.com) develops reconfigurable-processor platforms. The company offers Internet-enabled reference modules that Imsys ships as ready-to-go subsystems. The integrated hardware and software platform targets wired and wireless communications, graphics-display technologies, and image processing in telecom, automotive, industrial automation, and consumer electronics.

INFINEON TECHNOLOGIES AG

Infineon Technologies AG (www.infineon.com) provides 8-, 16-, and 32-bit microcontrollers for motor control with dedicated hardware peripherals that reduce software overhead and external components. New 8-bit devices this year are the XC878 and XC864 families for sensorless field-oriented control of a PMSM (permanent-magnet synchronous motor). The new XE16xM additions to the XE166 family of real-time digital-signal controllers offer memory-protection and memory-checker functions. More demanding systems, such as ac servo drives, can take advantage of the new 32-bit TC1167 and TC1197 TriCore controllers, which offer dual MAC units. Infineon also extended its 16/32-bit automotive portfolio with two new series. The XC2300 family offers safety features for air-bag and power-steering applications. The XC2700 series targets use in electronic-engine control in motorcycles. The 32-bit Audo-Future microcontroller allows manufacturers to meet evolving standards for efficiency and emission reduction.

INNOVASIC

Innovasic Semiconductor (www.innovasic.com) supplies extended-life microcontrollers for industrial applications. The 32-bit fido1100 communications controller targets real-time Ethernet applications with RTOS-like features, including single-cycle task switching, scheduling, and programmable peripherals. Innovasic also supplies 16-bit 186 microcontrollers, such as the IA186EB and the IA186XLt 186, for new and legacy applications. They are fully compatible with their respective Intel devices. All Innovasic products come with an obsolescence-protection guarantee.

INTEL

In 2009, Intel (www.intel.com) released the L5518 and L5508 versions of Intel Xeon processors that target communications-market segments. These processors include options for applications in thermally constrained environments, such as blades and appliances for communication infrastructure. The Atom is the company's smallest and lowest-power processor; it targets small devices and low power and maintains the Intel Core 2 Duo instruction set. The newest generation of Atom offers four versions of processors and two new system-controller hub additions to Intel's embedded-system-business-division product lineup. The new products for the Atom processor Z5xx series include industrial-temperature options, as well as package choices better suited for in-car infotainment devices, media phones, ecological technologies, and other industrial-strength applications. Intel's N270 processor and 945GSE

Express chip set target the low-power needs of embedded-system markets.

INTELLASYS

IntellaSys (www.intellasys.net) based its multicore chips on the proprietary SEA (scalable-embedded-array) platform, which uses a dual-stack, synchronous, scalable architecture. The SEAforth-24 family packs a 634-processor array of 18-bit processors, each of which can operate at 1 BOPS (billion operations per second). Designers can dedicate any of the 24 cores individually or in groups to perform tasks. The SEAforth-24 directly drives an antenna, eliminating the need for external data converters.

NEW JENNIC

Fabless semiconductor company Jennic (www.jennic.com) targets wireless-connectivity applications, such as energy and environmental management, active RFID (radio-frequency identification), and consumer electronics. The company's integrated wireless microcontrollers focus on IEEE 802 15.4, ZigBee Pro, and 6LoWPAN (Internet Protocol Version 6-over-low-power-wireless-personal-area-network) standards. The company's products include low-power wireless microcontrollers, modules, development platforms, protocols, and application software.

This year, Jennic announced a networking stack to enable a single-chip implementation of 6LoWPAN. The company also announced a single-chip, 32-bit wireless microcontroller, which it based on the ZigBee Pro and IEEE 802.15.4 standards and combines low operating-current consumption and high memory density in a single-chip, wireless microcontroller. Jennic also announced the Time of Flight ranging engine that will enable the development of next-generation wireless mesh networks for battery-powered and data-rich applications.

K-MICRO

K-Micro's (Kawasaki Microelectronics', www.k-micro.us) ASIC technologies and design support target the consumer-electronics, computer, office-automation, networking, and storage markets. K-Micro's computing subsystem includes a MIPS32 24Kf processor, the Sonics SiliconBackplane and Sonics3220 Smart interconnects, and the SafeNet SafeXcel security engine. Single- and dual-core processors are available.

LATTICE SEMICONDUCTOR

Lattice's (www.latticesemi.com) open-source LatticeMico32 soft microprocessor core combines a full 32-bit-wide instruction set with 32 general-purpose registers. The microprocessor has a Harvard architecture with independent instruction paths and datapaths. These paths terminate in individual Wishbone buses.

The LatticeMico32 license agreement is downloadable from the Lattice Web site. The license preserves the open nature of the core by permitting use alongside proprietary designs and allows hardware implementation and distribution without the need for a subsequent license agreement. This feature provides users with visibility into the microarchitecture's flexible implementation and portability to ASICs or future FPGAs. The MSB (Mico System Builder) tool generates LatticeMico32-based systems in Verilog.

Lattice also provides the open-source 8-bit LatticeMico8, the 8051, 68xx series, PIC, and 6502 microcontrollers through its partners Cast, Digital Core Design, and Western Design Center.

MAXIM INTEGRATED PRODUCTS

Maxim Integrated Products (www.maxim-ic.com) offers 8-, 16-, and 32-bit microcontrollers for embedded-system applications. Maxim expanded its product offering in early 2009 by acquiring Innova Card and the Zatara and Crimzon product lines from Zilog. In addition to its recent acquisitions, Maxim introduced several new MAXQ products, targeting a mixture of low-power, high-security, and metering applications.

The MAXQ610 16-bit microcontroller combines nanopower stop-mode current, high performance, and peripherals targeting power-conscious consumer applications. Maxim's MAXQ1103 and MAXQ1850 secure microcontrollers provide fast encryption accelerators and tamper-detection circuitry to respond to attacks. The MAXQ3108 comprises a 16-bit DSP core for intensive data processing and a 16-bit user core for supervisory functions.

MICROCHIP TECHNOLOGY

This year, Microchip Technology (www.microchip.com) introduced 8- and 16-bit PIC microcontroller families with nanoWatt XLP (extreme-low-power) technology and sleep currents as low as 20 nA. Microchip's inductive-touch-sensing technology works with all of the company's microcontrollers, and it enables touch-sensing, including through gloves and on surfaces with liquids present and through plastic, stainless steel, or aluminum panels. The dsPIC33 DSCs (digital-signal controllers) enable digital power and lighting with as much as twice the performance at a lower price than first-generation devices. The enhanced, midrange, 8-bit PIC-microcontroller-core families provide more memory, greater efficiency, faster operation, more communications, touch-sensing, and low-power operation.

Microchip's PIC microcontrollers and dsPIC DSCs span more than 600 8-, 16-, and 32-bit devices. The portfolio spans low-cost, six-pin, 8-bit microcontrollers through the high-performance, cost-effective, 64- and 100-pin, 80-MHz, 32-bit PIC32 family.

MIPS TECHNOLOGIES

MIPS Technologies (www.mips.com) offers processor architectures that target home entertainment, communications, networking, and portable multimedia products. MIPS recently ported Android to the MIPS architecture. Initially targeting mobile phones, Android now targets DTVs (digital televisions), mobile Internet devices, digital picture frames, VOIP (voice-over-Internet Protocol) devices, and set-top boxes.

NEC ELECTRONICS AMERICA

NEC Electronics America (www.am.necel.com) offers highly integrated, reliable, low-power, all-flash microcontrollers for multipurpose designs and application-specific devices. The company's 32-bit V850 series microcontrollers feature low-voltage operation, DSP functions, and on-chip peripherals.

NEW NETRONOME

Netronome (www.netronome.com) develops programmable semiconductor products for intelligent flow processing in network and communications devices. The company's products include network-flow processors and acceleration cards that scale to more than 20 Gbps. The new NFP (network-flow-processor)-32 family of processors and acceleration cards finds use in carrier-grade and enterprise-class communications products. They combine high-performance network, content, and security processing with general-purpose processors, such as Intel's IA, through I/O virtualization. The NFP-32xx is backward-compatible with the Intel IXP28XX.

NXP

NXP (www.nxp.com) offers a portfolio of several hundred Cortex-M3, ARM7-, ARM9-, and 80C5-based microcontrollers. NXP's ARM-based LPC1000, LPC2000, and LPC3000 families include highly integrated peripherals. The Cortex-M3-based LPC1300 series is the latest addition to the LPC1000 family and targets low power consumption and low cost. The Cortex-M3-based LPC1700 series operates as fast as 100 MHz and provides users of the ARM7-based LPC2300 series with a pin-compatible upgrade path to Cortex-M3. The LPC3200 and LPC3100 series add 10 new devices to the ARM926-based LPC3000 family. This year, NXP presented its implementation of ARM's new Cortex-M0 architecture. The ARM-based LH7 and LH7A families feature high-performance integrated LCD controllers.

OKI SEMICONDUCTOR

Oki Semiconductor's (www.okisemi.com) Advantage Microcontroller family comprises ARM-core based products ranging from the ML671000 with a built-in USB (Universal Serial Bus) controller to the high-performance, 120-MHz, ARM946E-based 6200 series with instruction and data caches. Oki's 4060, 4050, 675K, and 674K series ARM7 Advantage microcontrollers offer variations in frequencies, memory sizes, caches, features, and packages.

PMC-SIERRA

PMC-Sierra's (www.pmc-sierra.com) MIPS-based processors target metropolitan-transportation, storage-area-networking, wireless-equipment, VOIP (voice-over-Internet Protocol), Internet-routing-equipment, enterprise-switch, and multifunction- and laser-printer applications. PMC-Sierra's family of 64-bit, integrated, 1-GHz CPUs delivers high performance, low latency, and low power consumption. The MSP (multi-service-processor) family targets use in CPE (customer-premises equipment), such as wired and wireless VOIP-terminal adapters, home gateways, voice-enabled routers, and NAS (network-attached storage).

RABBIT SEMICONDUCTOR

Rabbit Semiconductor (www.rabbit.com), a Digi International company, provides high-performance, 8-bit microprocessors and development tools for embedded control, communications, and Ethernet connectivity.

RAMTRON

Ramtron's (www.ramtron.com) FRAM (ferroelectric-random-access-memory)-enhanced Versa 8051 microcontrollers combine a high-performance SOC (system on chip) with nonvolatile FRAM. FRAM writes at bus speed with virtually unlimited endurance and low power for guaranteed data integrity in systems that require rapid and frequent writes and low power consumption. Versa 8051 microcontrollers let designers upgrade 8-bit applications without a costly investment in a new architecture and code.

RENESAS TECHNOLOGY

Renesas' (www.renesas.com) processor offerings for embedded systems extend from low-power, 8- and 16-bit microcontrollers to high-performance, 32-bit microprocessors. The R8C/Tiny series targets electronic ballasts, handheld power tools, and motor-control systems. Devices in the R8C/3x group target automotive-body-control applications and operate from 1.8 to 5.5V. The H8S/2153 targets advanced communication equipment, and the H8SX/2164 targets baseboard-management-controller applications. In the M16C series, the 64-MHz R32C/100 series incorporates advanced peripherals, such as FlexRay controllers.

The SuperH SH72544R series targets next-generation automotive power trains. SH7262 and SH7264 microcontrollers target digital-audio systems, media-player accessories, and graphical-display applications. The SH7730 series for industrial applications achieves 480-MIPS performance and includes FPUs (floating-point units) and MMUs (memory-management units).

SH-Mobile application processors include the 266-MHz SH-MobileL3V2 that handles many video formats and provides high-resolution video capture. The SH-MobileR2 targets use in personal navigation devices, portable media players, and video and VOIP (voice-over-Internet Protocol) terminals.

SAMSUNG ELECTRONICS

Samsung (www.samsungsemi.com) offers 16- to 32-bit processors targeting handheld-system applications, including smartphones, VOIP (voice-over-Internet Protocol) phones, portable GPS (global-positioning-system) devices, gaming systems, and PDAs (personal digital assistants). Samsung's family of mobile application processors features ARM920T-, ARM926EJ-, and ARM1176-based RISC cores.

SEMTECH

Semtech (www.semtech.com) offers 8- to 22-bit microcontrollers that interface sensors and radio transceivers and target autonomous, battery-operated, wireless devices. These devices operate at a constant one instruction per clock that is independent of the type of operation and addressing mode. The Radio Machine device for ISM (industrial/scientific/medical)-band-transceiver interfacing includes a low-power RISC core with the BitJockey, a serial interface for radio protocols, and a UART. The Sensing Machine device includes a low-power RISC core with the high-resolution ZoomingADC sigma-delta ADC and a programmable preamplifier.

SILICON LABORATORIES

Silicon Laboratories' (www.silabs.com) portfolio of mixed-signal, 8-bit microcontrollers integrates high-performance analog peripherals and a high-speed core in a tiny footprint. This year, the company expanded its F900 family of low-voltage, low-power devices, targeting portable- and space-constrained-system applications. Silicon Labs also introduced the F7xx family of high-pin-count, capacitive-touch-sense controllers. The company expanded its F5xx automotive-microcontroller family for space-constrained LIN (local-interconnect-network)- and CAN (controller-area-network)-gateway and body-electronics applications. Silicon Labs offers a complete embedded-wireless approach for applications requiring less-than-1-GHz speeds with the combination of the low-power, high-performance EZRadio receiver family and the low-power F9xx microcontrollers.

SST

SST (Silicon Storage Technology, www.sst.com) based its FlashFlex family of 8-bit microcontroller products on the company's SuperFlash CMOS-semiconductor-process technology. These microcontrollers implement the 8051 instruction set and are pin-for-pin compatible with standard 8051 microcontroller devices. FlashFlex devices are available in single- or dual-block configurations, and they are ISP (in-system-programmable) and IAP (in-application-programmable). These microcontrollers target consumer, communication/wired, imaging and video, audio, industrial, and motor-control applications.

STMICROELECTRONICS

STMicroelectronics (www.st.com) offers a comprehensive portfolio of 8-bit microcontrollers and high-performance, 32-bit ARM-based microcontrollers with a wide range of peripherals. The 32-bit STM32 family, which employs an ARM Cortex-M3 processor, now provides 46 fully compatible devices. The 72-MHz Performance Line stresses new levels of performance and energy efficiency. The 32-bit Access Line stresses 32-bit processing at a 16-bit cost. The STM8 core is a cost-sensitive, 8-bit-microcontroller family.

STRETCH

Fabless semiconductor company Stretch (www.stretchinc.com) provides software-configurable processors for computationally intensive applications. Stretch's S6000 series targets high-speed video and image processing. With these applications in mind, Stretch has developed two reference-design kits using S6000 family software-configurable processors, a PCIe (Peripheral Component Interconnect Express) DVR (digital-video recorder), and an IP (Internet Protocol) camera.

TENSILICA

Tensilica (www.tensilica.com) offers 32-bit customizable data-plane processors, DSPs, and standard processor cores. All of Tensilica's processor cores, even the Xtensa configurable processors, come with software-tool chains that automatically match any changes the designer makes. This year, the company introduced its next generation of customizable processors, the Xtensa 8 and Xtensa LX3. Xtensa 8 has all the basic configurable capabilities, and Xtensa LX3 offers designers opportunities to bypass the system bus with direct FIFO (first-in/first-out) and GPIO (general-purpose-input/output) capabilities. It introduced the ConnX baseband engine, creating a processor core for computationally intensive receiver and demodulation units, and the ConnX D2 DSP engine, creating an efficient, basic dual-MAC (multiply/accumulate)-unit DSP. It also introduced codecs for the HiFi 2 audio engine, including support for all international digital-radio standards, a Bluetooth SBC (subband-codec) decoder, a DTS-HD (Digital Theater Systems high-definition) Master Audio decoder, a Real Audio decoder, and a Dolby DAB+ decoder. The company ported the RealVideo codec to the 388VDO video engine.

TERIDIAN SEMICONDUCTOR

Teridian Semiconductor (www.teridian.com) designs, sells, and provides engineering support for its mixed-signal ICs, which find use in energy, automation, networking, and secure-access systems. These ICs connect customers' digital systems to the analog inputs in utility-metering, industrial-automation, set-top-box, digital-TV, VOIP (voice-over-Internet Protocol), electronic-identity, and point-of-sale applications. The 78Q8430 targets Ethernet applications requiring reliable connectivity and QOS (quality-of-service) levels, such as industrial-networking, set-top-box, digital-television, and other consumer-broadband or audio/video equipment. The 71M653x family includes residential-single-phase and commercial- and industrial-three-phase ICs, offering as much as 256 kbytes of storage with 10-MIPS processing power.

TEXAS INSTRUMENTS

Texas Instruments' (www.ti.com) microcontroller portfolio includes the ultralow-power, 16-bit MSP430, the 32-bit Stellaris ARM Cortex-M3, and the TMS320C2000 microcontrollers for real-time control. TI acquired Luminary Micro and added devices to the MSP430- and C2000-platform families. Expanding the MSP430 portfolio, TI introduced the MSP430F55xx family with embedded full-speed, 12-Mbps USB (Universal Serial Bus), with more than 35 device options offering enhanced peripheral and analog integration, increased memory and package selections, and several low-cost devices with prices starting at less than $1. The new LM3S9000 series of ARM Cortex-M3-based Stellaris microcontrollers features a fully integrated 10/100 Ethernet MAC (media-access controller)-plus PHY (physical)-layer, USB 2.0 full speed OTG (On-the-Go), and integrated Bosch CAN (controller-area-network) technology. The Stellaris devices also include larger on-chip memories, enhanced power management, and expanded I/O and control capabilities. The TMS320C2834x Delfino floating-point controllers double performance to 300 MHz and include 516 kbytes of single-cycle access RAM, high-resolution PWM (pulse-width-modulation) outputs, 32-bit quadrature-encoder modules, and other control-oriented features.

TILERA

Tilera (www.tilera.com) offers high-performance multicore processors targeting embedded networking, security, and multimedia-processing applications. The Tile64 processor SOC (system on chip) has 64 full-featured processor cores plus a rich suite of system-integration blocks. The device includes 5 Mbytes of cache, and each processor core can independently run a full operating system, such as Linux. Tilera based the Tile64 family on a tiled multicore architecture with a mesh-based on-chip interconnect.

TOSHIBA AMERICA

Toshiba America Electronic Components (www.toshiba.com/taec) offers highly integrated, 8-, 16-, and 32-bit CISC microcontrollers with embedded SuperFlash memory and 32- and 64-bit, MIPS-based TX RISC microprocessors. TX RISC microcontrollers suit calculation-intensive applications that require large memory capacity and DSP-like functions, such as consumer digital-camera lenses, digital camcorders, and automotive-air-bag systems. Both the CISC and TX families have peripherals for handheld information consoles, home-security systems, calculators, toys, HVAC (heating/ventilation/air conditioning), instrumentation, digital TV, IP (Internet Protocol) set-top boxes, home-entertainment gateways, white goods, and automotive-body controls. Toshiba continues to support its family of 8-bit, low-power microcontrollers with TLCS-870/C1 cores that process one instruction in a single clock cycle.

UBICOM

Ubicom (www.ubicom.com) develops communications and media processors and software platforms that target real-time interactive applications and multimedia-content delivery in homes. The company provides to OEMs optimized system-level products, including wireless routers, access points, bridges, VOIP (voice-over-Internet Protocol) gateways, connected digital-photo frames, streaming-media devices, and other network devices. The StreamEngine 7000 series of processors delivers nearly twice the performance with lower power in a smaller package than the StreamEngine 5000 family.

VIA TECHNOLOGIES

VIA Technologies (www.via.com.tw), a fabless supplier of power-efficient x86 processor platforms, targets the PC, client, ultramobile-system, and embedded-system markets. The company supports a spectrum of computing and communication platforms, including its ultracompact main boards.

WESTERN DESIGN CENTER

Western Design Center (www.westerndesigncenter.com) licenses its 65xx microprocessor IP (intellectual property). The company's product line includes the 8-bit W65C02SRTL and 8/16-bit W65C816SRTL licensable IP. The company also offers 8- and 8/16-bit processor devices.

XILINX

Xilinx (www.xilinx.com) provides programmable-logic products, including embedded processors, FPGA platforms, and development tools that find use in aerospace and defense, wired- and wireless-communications, automotive, audio- and video-broadcast, industrial-control, test-and-measurement, and consumer applications. The Virtex family of high-performance FPGAs includes the PowerPC 32-bit hard core. The configurable, general-purpose, 32-bit MicroBlaze soft core is available for use with the Spartan family of low-cost FGPAs and Virtex-platform FPGAs.

XMOS

XMOS (www.xmos.com) provides a new type of programmable chip, software-defined silicon, which the company based on an array of high-performance, event-driven processors. You create designs in high-level languages, delivering hardware performance from a software-based design flow. XMOS devices blend a high-performance processor architecture with a responsive I/O structure to provide designers custom silicon that solves a class of design problems.

ZILOG

Zilog (www.zilog.com) offers the 8-bit Z8, Z8 Encore!, and Z80 Acclaim microcontroller families targeting industrial and consumer markets. The company this year sold its Crimzon and Zatara product families to Maxim. Zilog also offers single-board computers, application-specific software stacks, and development tools targeting energy-management, monitoring, metering, and motion-detection applications.

BY FREDERIK DOSTAL • NATIONAL SEMICONDUCTOR

Using high-current integrated-switch power-regulator ICs

LEARN THE THERMAL CONSIDERATIONS SO YOU DON'T GET BURNED.

Switching regulators with integrated power transistors provide simplicity, require few components, and make compact step-down power supplies. Few of these devices can supply more than 5A load current, so, when designing with these high-current integrated-switch regulators, you must consider thermal management, bypassing of the supply voltage, and board layout. At load currents of 5A or more, these topics become critical, and you must understand them before selecting a power-management architecture.

Simplicity and size are the biggest advantages of combining the power switch with the control circuitry on one IC. In addition, you can use the MOSFET the semiconductor company selected to go with the control circuitry, and you can minimize the required PCB (printed-circuit-board) area because the power supply requires only one IC instead of a controller IC and one or more power-switch ICs. A disadvantage of an integrated design, however, is that high-power output currents are present on the sensitive control die. Also, the thermal dissipation of the power switch instantaneously heats up the control circuitry.

With these advantages and drawbacks in mind, you can decide whether to use an integrated power switch. **Figure 1** shows a step-down dc/dc converter with an integrated power switch, or regulator IC. Designs with an external power switch comprise a controller IC plus a discrete power switch, usually a MOSFET.

For thermal considerations, you must determine through direct measurement how much electrical power turns into heat inside the regulator IC. Alternatively, you can assume total power-supply efficiency and then break down the losses into conduction losses and switching losses. You then assign them to the components on the PCB (**Reference 1**). A switching regulator at 5A of output current typically dissipates 2W of power. To prevent the silicon from exceeding its maximum temperature limit, you must dissipate the power away from the silicon through the package to the PCB and, ultimately, to the surrounding air. You must optimize PCB layout to achieve the best flow of heat. Fans effectively cool circuits, but, for most applications, using a fan is unacceptable due to cost, noise, and maintenance issues. Getting by without a fan often requires the use of convection air cooling or large heat sinks.

A thermal plot of an IC with 15V input, 3.3V output, and a 5A load current shows hot spots (**Figure 2**). The hottest area is freewheeling diode D_1. To aid in the thermal dissipation of the diode, choose a Schottky diode with a low package thermal resistance. You might replace the SMC-packaged diode of **Figure 2** with a D-Pak or D2Pak that has lower thermal resistance than the SMC package.

Choosing a package requires a trade-off between pin count and the thermal resistance. Standard packages have either many pins and higher thermal resistance or fewer pins and lower thermal resistance. A good package for high power dissipation is the TO-263 thin package, which has a large exposed pad like the classic TO-263 package but is much thinner.

THERMAL CONSIDERATIONS

When you incorporate thermal considerations into the design of a PCB, your primary goal is to efficiently conduct energy away from the heat source. If you effectively achieve this goal, the whole board has an even temperature distribution. Your next concern is moving heat from the PCB into the surrounding air or adjacent materials, such as the product casing. The more copper a PCB has, the better the heat transfer away from any hot spots is. Copper also helps heat transfer

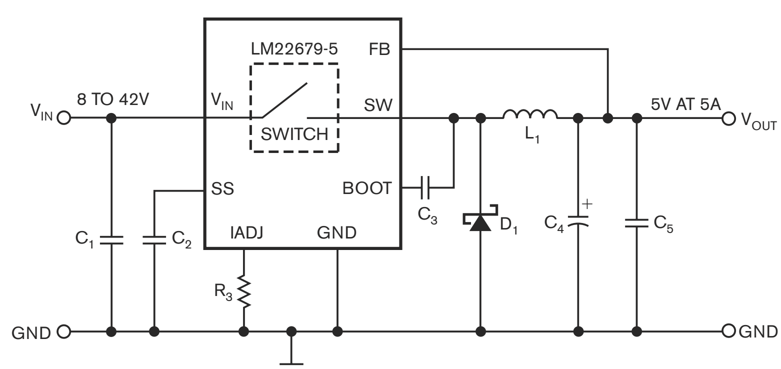


Figure 1 This step-down buck dc/dc-converter IC features an integrated power switch.

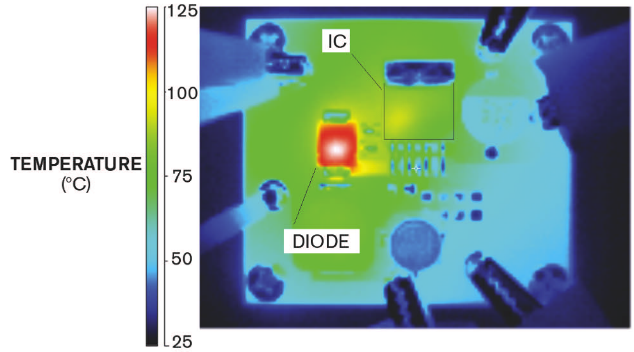


Figure 2 A thermal camera takes an image that shows hot spots on a PCB.

away from the board. More layers within the PCB enable better heat transfer than does one or two layers. A common PCB standard uses two ounces of copper per square foot of board area. You are better off with thicker copper, larger copper areas, and more PCB layers.

Use vias between the hot spots and the bottom of the board to effectively conduct the heat away. You should also fill the vias with solder, which does not have the best thermal conductivity but conducts heat much better than does air. However, not all board-manufacturing processes allow for solder-filled vias. Manufacturers often place small vias next to each other for good thermal transfer. The most thermally effective vias are those that are as close to the heat source as possible—often right below a thermal pad of the regulator IC. Unfortunately, not all manufacturing processes allow such a placement. You should spread the heat-generating components around the PCB to avoid hot spots, but the electrical considerations call for close placements. You must find a compromise.

ELECTRICAL CONSIDERATIONS

It is difficult to keep the voltage supply for the regulator's internal rails clean. Many circuit blocks in the IC, such as the internal bandgap reference and the comparators for the feedback loop, need low noise to perform correctly. In a buck regulator, the input trace is a noisy node because it quickly switches from full current to no current. Integrated power regulators often use separate pins for the supply voltage of the internal rails and as the input to the main power switch. With packages having low thermal resistance, the IC may have only one supply pin for the internal voltage and the power stage. In such cases, you must filter the input-voltage pin to keep the switching noise low. Use a high-quality ceramic bypass capacitor and connect it close to the input-voltage and ground pins. This rule is among the most important for step-down voltage regulators, and it is especially important for regulator ICs with integrated power switches.

The second important rule is to keep ac traces as short as possible. Circuits in which the current flow changes as the power switch changes state are ac traces. It is important to keep these traces especially short to minimize trace-inductance-generated voltage offsets. The shorter these traces are, the less voltage offset the IC generates across them, and the resulting system noise is lower. You can find the ac traces by printing the schematic of a circuit three times. Use a pen on one of the printouts to draw along the traces in which current flows when the power switch is on. Use the second printout and mark where current flows when the power switch is off. On the third printout, mark all the traces that you marked on the previous two printouts but not on both of them. This approach yields a plot with all the ac traces.

Several ac current flows occur in a buck regulator, including the most critical traces: those during the on-state of the switch, the off-state of the switch, and between the two switch states (**Figure 3**). Small circuit loops and thick traces minimize the parasitic trace inductance. In contrast to thermal design, the electrical requirement is to keep components, especially along the ac traces, as close together as possible.

To decide whether you can use an integrated power-MOSFET step-down regulator, you must do more than look at the maximum input-voltage range and load current. Thermal considerations are important because they can rule out the implementation of an integrated power switch. Integrated-switch power-management circuits can well serve systems with forced airflow with low ambient temperatures or short peaks at maximum load current. EDN

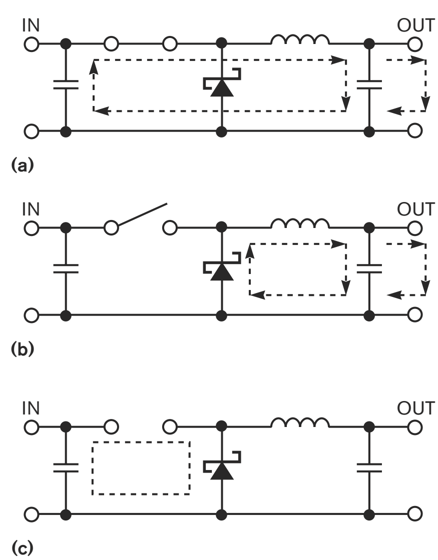


Figure 3 The ac current flows in a buck-regulator circuit during the on-state of the switch (a), the off-state of the switch (b), and between the two switch states (c).

REFERENCE

1 Dostal, Frederik, "Techniques for Thermal Analysis of Switching Power Supply Designs," Application Note 1566, National Semiconductor, February 2007, www.national.com/an/AN/AN-1566.pdf.

AUTHOR'S BIOGRAPHY

Frederik Dostal is an application engineer at National Semiconductor's design center (Phoenix). He joined the company in 2001, and his responsibilities have included support for Europe and Central Europe and coverage of many automotive accounts. Dostal's current position involves product development and support for switching regulators and controllers. He holds a degree in electrical engineering from the Friedrich-Alexander-Universität (Erlangen, Germany) and is a member of the IEEE.

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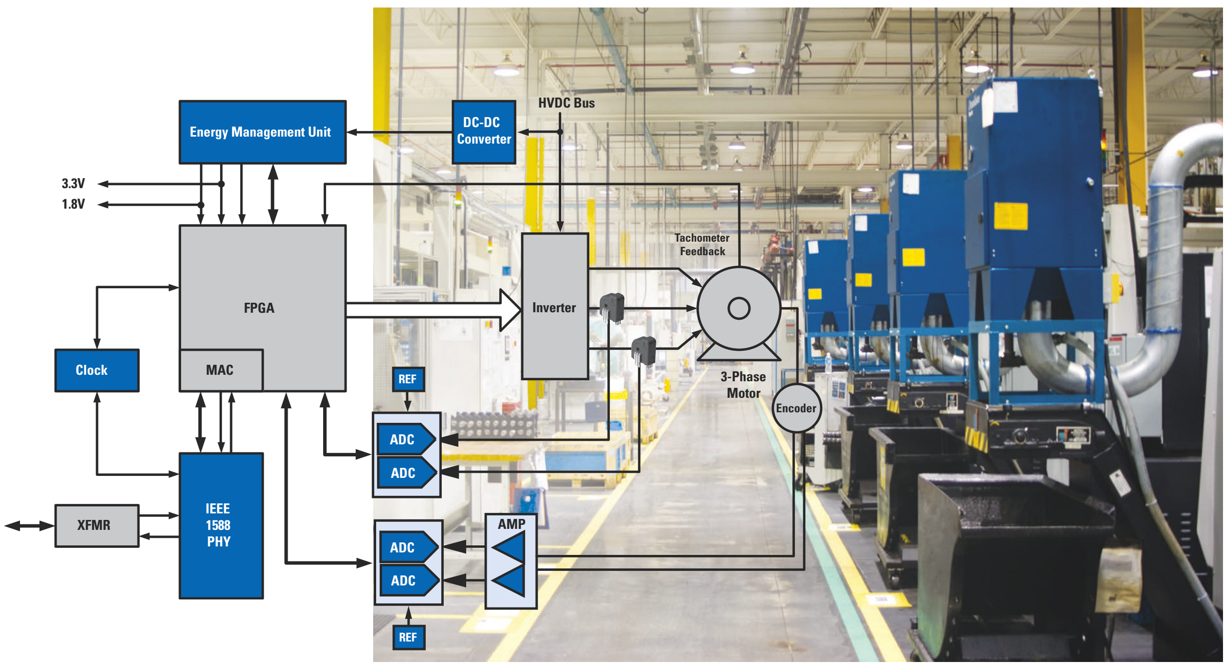

Shown: Factory Automation Application Diagram

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READERS SOLVE DESIGN PROBLEMS

Astable multivibrator gets hysteresis from positive-feedback stage

Robert Larson, Seattle, WA

Many designs exist for logic-based astable multivibrators, one of the simplest being an RC feedback loop around a single inverting Schmitt trigger inverter (**Figure 1**). The output charges the capacitor to the upper switching threshold, at which point the output switches to its opposite state, the threshold switches to a different value, and the capacitor's charging current reverses direction. When the capacitor's voltage crosses the lower threshold, the output and threshold both toggle back to their original values, and the process repeats. The timing depends on both the RC time constant and the hysteresis resulting from the spread between the two threshold values (**Figure 2**). Unfortunately, although inverter manufacturers specify the hysteresis voltages in their data sheets, the devices have a fairly large range. In addition, they likely have some temperature dependence. These uncertainties make it difficult to design the circuit to have a predictable oscillating frequency.

A simple inverter, without the hysteresis to let it overshoot the nominal threshold, charges the capacitor to the threshold voltage and stops in its narrow linear region. At this point, the negative feedback from the inverting output to the input regulates the output to the threshold voltage. Adding another inverting stage injects hysteresis of a different form by means of positive feedback, which external passive

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TABLE 1 74VHC04 RESULTS

Resistance (kΩ)	Timing capacitance (pF)	Hysteresis capacitance (pF)	Expected results: Hysteresis voltage (V)	Expected results: Total time period (nsec)	Measured results: Hysteresis voltage (V)	Measured results: Total time period (nsec)	Total time differential (%)
10	470	100	0.88	3462	0.75	2930	18
10	470	220	1.59	6850	1.8	7340	–7
10	12,000	12,000	2.5	333,526	2.6	364,800	–9
0.3	220	220	2.5	221	1.75	240	–8
1	12,000	12,000	2.5	34,086	2.5	36,000	–5

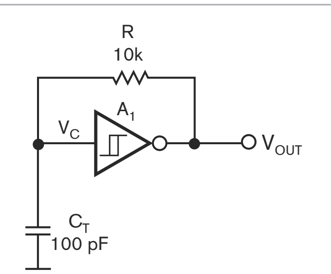

Figure 1 A basic astable multivibrator uses a Schmitt trigger and an RC network.

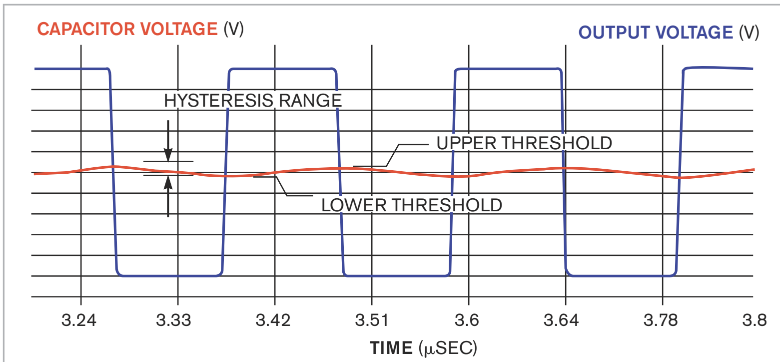

Figure 2 A part's hysteresis, in large part, determines switching thresholds.

parts determine (**Figure 3**).

Whenever Stage 1 crosses its threshold, the extra Stage 2 injects an additional charge through a feedback capacitor to make the timing capacitor's voltage jump past the threshold. The RC charging current reverses direction to get back to the threshold voltage. When it gets there, the hysteresis-injection circuit again jumps the voltage past the target so that the RC timing circuit must again reverse the charging current to seek the threshold voltage (**Figure 4**). This process continues endlessly at a fairly predictable rate. In the **equations**, C_T is the timing capacitor, C_H is the hysteresis capacitor, V_{THRESH} is the threshold voltage, V_{LOW} is the low output voltage, and V_{HIGH} is the high output voltage.

You can view the hysteresis-overshoot voltage, V_{HYST}, as the result of a capacitive voltage divider that timing capacitor C_T and hysteresis capacitor C_H form. When Stage 1 toggles Stage 2, its output jumps from a low value to a high value or from a high value to a low value by an amount of $V_{HIGH}-V_{LOW}$, and the voltage of the timing capacitor jumps by $V_{HYST}=(V_{HIGH}-V_{LOW})(C_H/(C_H+C_T))$. Second, the voltage of the timing capacitor relaxes back toward Stage 1's output voltage by drawing current through both the timing capacitor and the hysteresis capacitor.

Thus, the relaxation time constant is $R(C_T+C_H)$ and the relaxation voltage is either $V_{CT}=(V_{THRESH}+V_{HYST}-V_{LOW})\exp(-t/R(C_T+C_H))$ or $V_{CT}=(V_{HIGH}-(V_{THRESH}-V_{HYST}))\exp(-t/R(C_T+C_H))$, depending on which half-cycle is occurring. You calculate the time from $V_{THRESH}+V_{HYST}$ back to V_{THRESH} as $t_1=-R(C_T+C_H)\ln((V_{THRESH}-V_{LOW})/(V_{THRESH}+V_{HYST}-V_{LOW}))$. For the other half-cycle, $t_2=-R(C_T+C_H)\ln((V_{HIGH}-V_{THRESH})/(V_{HIGH}-V_{THRESH}+V_{HYST}))$.

You should add the total propagation time ($t_{PLH}+t_{PHL}$) through stages 1 and 2 to the total period. Unless you want the circuit to operate at its maximum frequency, these propagation times become insignificant. The period prediction then depends only on passive-component values and their tolerances, temperature, and aging coefficients. The series combination of C_T and C_H, however, presents a capacitive load to Stage 2. This load affects Stage 2's rise and fall times, the sum of which you must add to the total period, T.

In the case of CMOS parts, such as the 74VHC04 from Fairchild Semiconductor (www.fairchildsemi.com), rise and fall times depend on the output resistance of the part as well as on the external components. If you model the Stage 2 output as an RC circuit, you can estimate the 10 to 90% exponential rise and fall times as $t_{RISE2}=t_{FALL2}=2.2R_O(C_TC_H/(C_T+C_H))+t_O$, where t_{RISE2} is the rise time, t_{FALL2} is the fall time, R_O is the output resistance of the part—30Ω for the 74VHC04—and t_O is the no-load rise time—in this case, 4.5 nsec for the VHC04. Thus, the total period is $t_1+t_2+2(t_{PLH}+t_{PHL})+t_{RISE2}+t_{FALL2}$.

Also note that the timing depends on inverter output voltages and the location of the threshold voltage within that range. For example, a CMOS part whose outputs are close to the power rails is more predictable than a TTL (transistor-transistor-logic) part, and a 74HC part with a midpoint threshold voltage has a more symmetric output than an HCT part whose threshold voltage is offset for TTL interfacing.

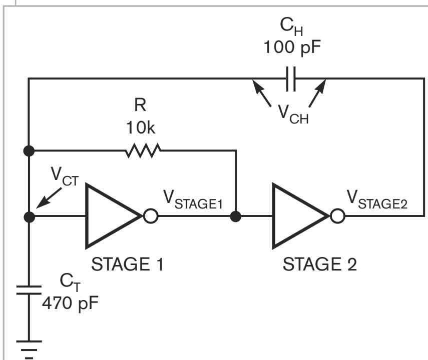

Figure 3 The addition of a positive-feedback stage provides hysteresis to a simple inverter stage.

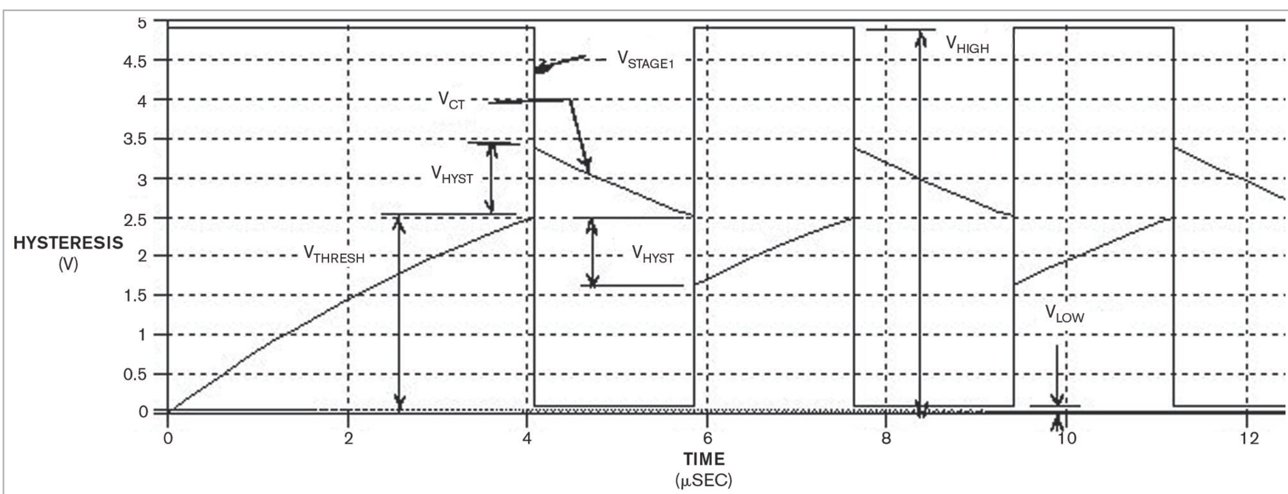

Figure 4 Hysteresis results from a charge burst from Stage 2 that jumps the timing-capacitor voltage past the switching threshold by a known, fixed amount.

For higher frequencies, you must use smaller resistor values, smaller timing-capacitor values, or both. For predictable results, the value of the timing capacitor should be no less than 10 times the inverter's input capacitance, which ranges from 3 to 10 pF for a typical CMOS, and R should not be so low that it significantly loads down the output. As a precaution, the value of the hysteresis capacitor should not exceed that of the timing capacitor so that it does not exceed the maximum input voltage on Stage 1. If the value of the hysteresis capacitor were much greater than that of the timing capacitor, then the threshold voltage and the hysteresis voltage would approach 7.5 and −2.5V, respectively. The 74VHC04 part proves the calculations using 5% resistors and 20% capacitors.

Table 1 summarizes the results, which are within the component tolerances. **Figure 5** shows a typical input and output plot.EDN

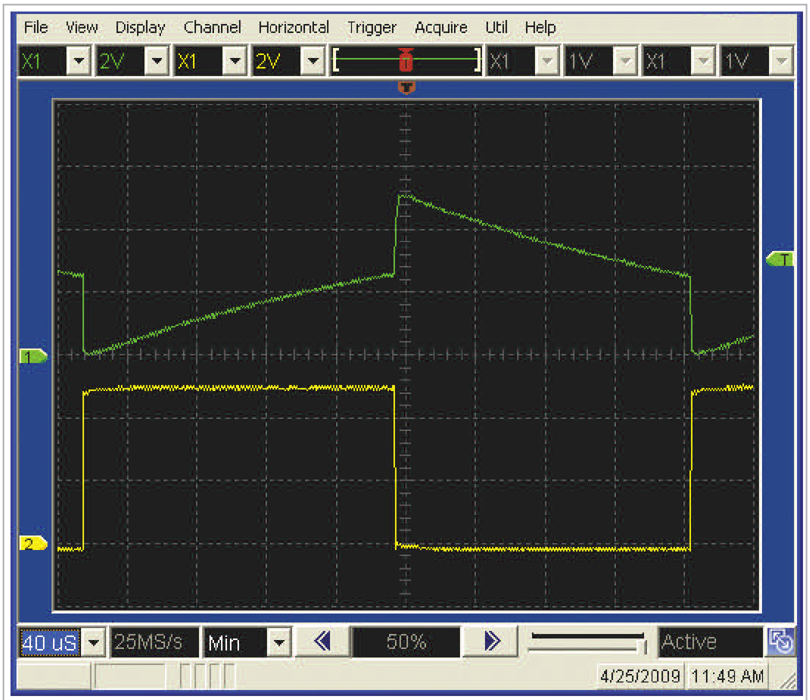

Figure 5 The circuit is well-behaved at low frequencies.

Class B amplifier has automatic bias

Pierre Corbeil, Paradox Innovation, Montreal, PQ, Canada

Class B amplifiers are prone to crossover distortion, which occurs in the output stage in which conduction transfers from one transistor to the other. To prevent crossover distortion, a bias current must flow in both transistors simultaneously. The bias current prevents both transistors from turning off in the transition region. Classic bias circuits keep a constant dc polarization voltage between the bases of the two transistors. Often manually adjusted, it keeps the two transistors on the edge of conduction when there is no signal present. Such a circuit is sensitive to temperature and needs some form of compensation to prevent thermal runaway, which can lead to failure. **Figure 1** shows an approach in which automatic bias eliminates the problem.

In this Class B amplifier, R_1 sets the bias current at idle mode with no signal. Emitter current for Q_3 is $(V_{CC}-V_{BIAS}-V_{BEQ3}-V_{BEQ1})/R_1$, where V_{CC} is the power-supply voltage, V_{BIAS} is the dc voltage on the emitters of Q_1 and Q_2, V_{BEQ3} is the base-to-emitter voltage of Q_3, and V_{BEQ1} is the base-to-emitter voltage of Q_1. Q_1 and Q_2 mirror this current because Q_1 and Q_3 share the same base current, as do Q_2 and Q_4. Assuming that the four transistors are perfectly matched, all of them have the same base current and the same collec-

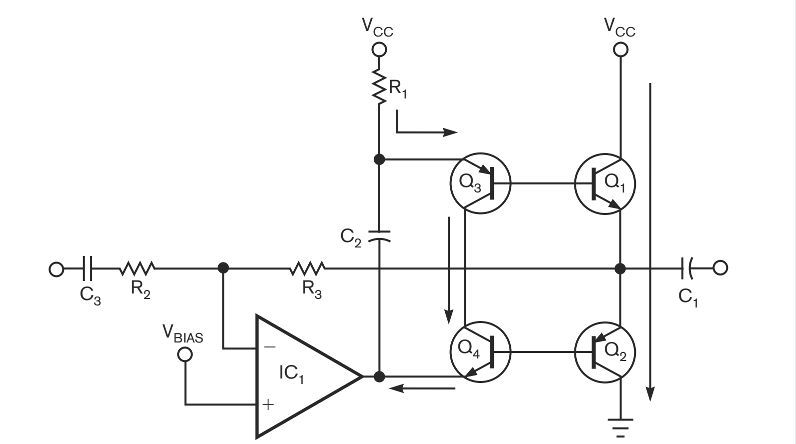

Figure 1 A bias current flows in the transistors that prevents Q_1 and Q_2 from being off simultaneously.

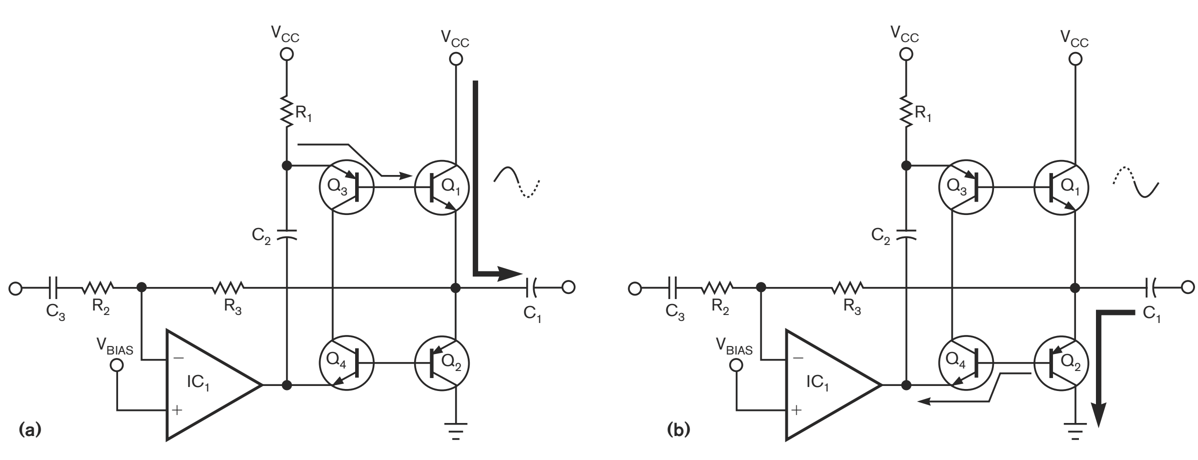

Figure 2 On a positive half-cycle, current flows from Q_1 through C_1 to a load (a). On a negative half-cycle, current flows through Q_2 (b).

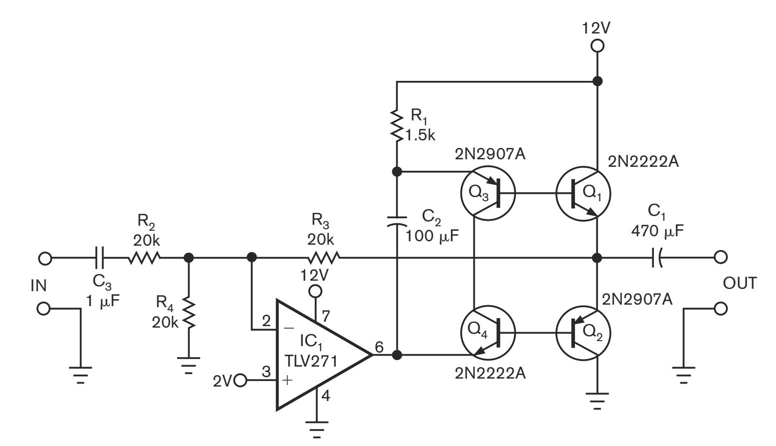

Figure 3 A typical application of this Class B circuit is a headphone amplifier.

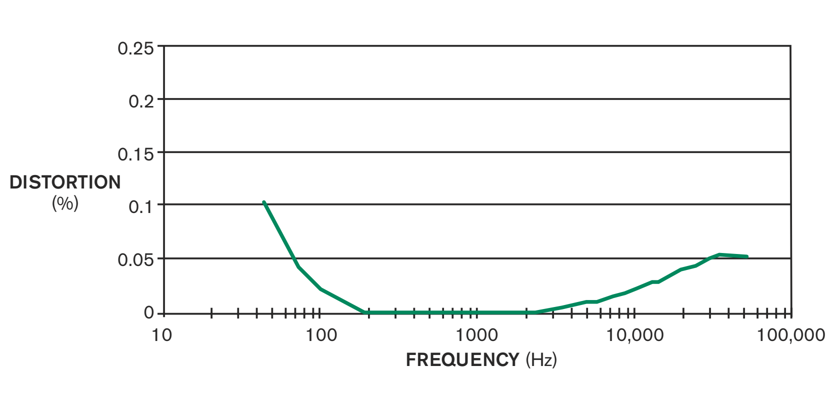

Figure 4 This graph shows distortion as measured on the circuit of Figure 3.

tor current, so the emitters of Q_1 and Q_2 precisely mirror the current in R_1. Transistor matching is unnecessary, however. With unmatched transistors, either Q_3 or Q_4 must operate in saturation, and, because the mirror effect depends on the transistors' current gain, h_{FE}, the difference between Q_1/Q_2 bias current and the current in R_1 can be significant. This circuit automatically adjusts the voltage on C_2 to compensate for temperature and the transistors' characteristics.

When a signal is present, the current gain is the h_{FE} of output transistor Q_1 or Q_2 (the same as for a classic Class B amplifier). On the positive part of the signal, Q_1 carries the load current. Because the base current increases, Q_3 enters saturation. On the negative part of the signal, Q_2 carries the load current and Q_4 saturates.

Figure 2 shows the ac-current path. The maximum average load current is the idle current in R_1 times the current gain of Q_1 times two. The op amp must be able to sink the base current of Q_2 (load current/h_{FE})+(($V_{CC}-V_{BE}\times4$)/R_1). A typical application of this Class B amplifier delivers 0.25W into 8Ω (**Figure 3**). **Figure 4** shows the total harmonic distortion over the 45-Hz to 50-kHz band—that is, 1V rms into 8Ω.EDN

Cable tester uses LEDs to find faults

Pavel Šádek, Apri, Rožnov pod Radhoštěm, Czech Republic

This Design Idea describes a simple cable-test machine that visually shows continuity issues on a 16-wire cable harness for ultrasonic-parking-aid systems. A subcontractor produces the harness in low volumes, making it impractical to use an automated tester. For simplicity, the test signal drives LEDs for a visual indication of continuity.

The circuit in **Figure 1** generates a binary number from zero to 15 (0000 to 1111). You can generate the numbers with a 555 timer and a binary counter, but this circuit uses a tiny, eight-pin microcontroller. A four-wire bus sends the digits to two four- to 16-line 74HC154 decoders, which generate active-low signals on their 16 lines. Inverting the outputs of the driver decoder with a 74HC04 inverter provides a drive signal for an LED and current-limiting resistor on each harness wire.

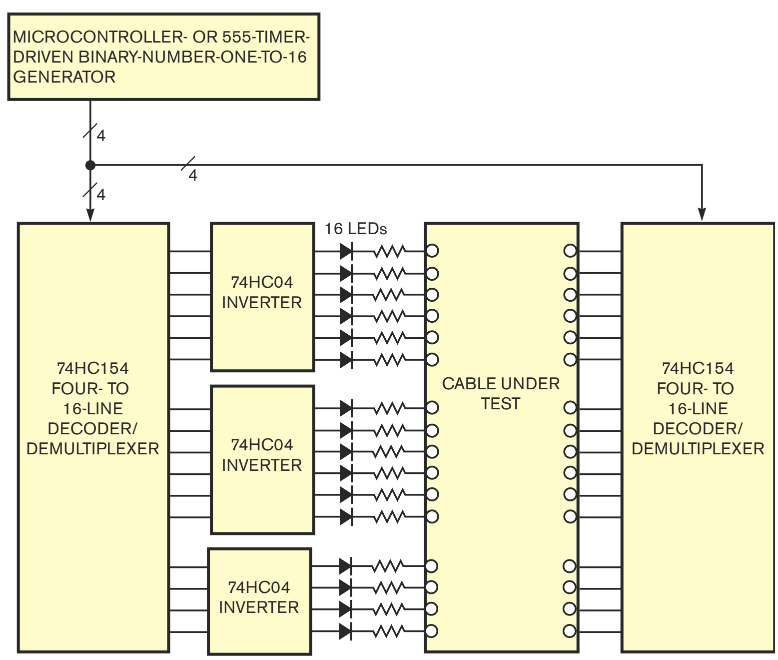

Figure 1 A pair of four- to 16-line demultiplexers selects cable-harness wires for testing.

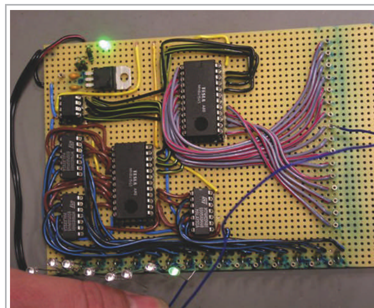
Figure 2 The cable-harness tester uses LEDs to indicate good connections.

The tester should produce one and only one illuminated LED for a good wire as the circuit scans the harness. If the scan is fast enough, all LEDs will all appear to be on, although each is on for just one-sixteenth of the time. **Figure 2** shows the completed circuit with eight LEDs, but it has room for 16 LEDs.

Broken wires in a harness, wrong wire positions, or other continuity failures lead directly to the turn-off of the corresponding LED. Swapped wires can also lead to the turn-off of two LEDs. Meanwhile, only one cathode is driven high, whereas the others are driven low, and only the cathode's anode is driven low, whereas the others are driven high. So only correctly connected wires could pass this test.

If you need to test harnesses with more that 16 wires, you can cascade additional decoders. You can also use a high-pin-count microcontroller in the same way. **EDN**

Dual-coil relay driver uses only two MOSFETs

Mehmet Efe Ozbek, PhD, Atlim University, Ankara, Turkey

Latching relays change their states when you apply a short voltage pulse to their coils. Because these relays require no continuous coil currents to keep their states, you can save considerable power in the driver circuit. In one type of latching relays, you can alternately energize dual coils to change the relay state. Simply apply voltage to one coil for the set state and to the other coil for the reset state. Applying a 25- to 50-msec-wide voltage pulse to the coils is sufficient for operating the relay. Many relays can operate with a continuous coil current, and some dual-coil relays have internal contacts that interrupt the coil current after it completes a state change. Continuous coil voltages can drive such relays if energy efficiency is not a big concern.

The need to differentially drive the coils results in crowded drive circuits for dual-coil relays. Drivers usually in-

clude logic elements to make sure to energize only one coil at a time. The design in **Figure 1** uses only two MOSFETs to drive a dual-coil RF relay. The Agilent Technologies (www.agilent.com) N1810UL RF switch has dual 24V coils and internal current-interrupting contacts.

When logic input is high, Q_1 conducts and changes the relay state by activating L_1. The states of the current-interrupting contacts also change. Meanwhile, Q_2 is off because Q_1 pulls down its gate, which avoids fighting between the coils. If you then apply a low signal to the logic input, Q_1 turns off and keeps the L_1 coil inactive. Because R_1 pulls up Q_2's gate, Q_2 turns on and energizes L_2. The 1N4007 diodes prevent inductive kickback. The idea is applicable to dual-coil relays with continuously rated coils or with current-interrupting contacts. In the absence of current-interruption contacts, L_1 can serve as a pullup, and R_1 therefore becomes redundant.EDN

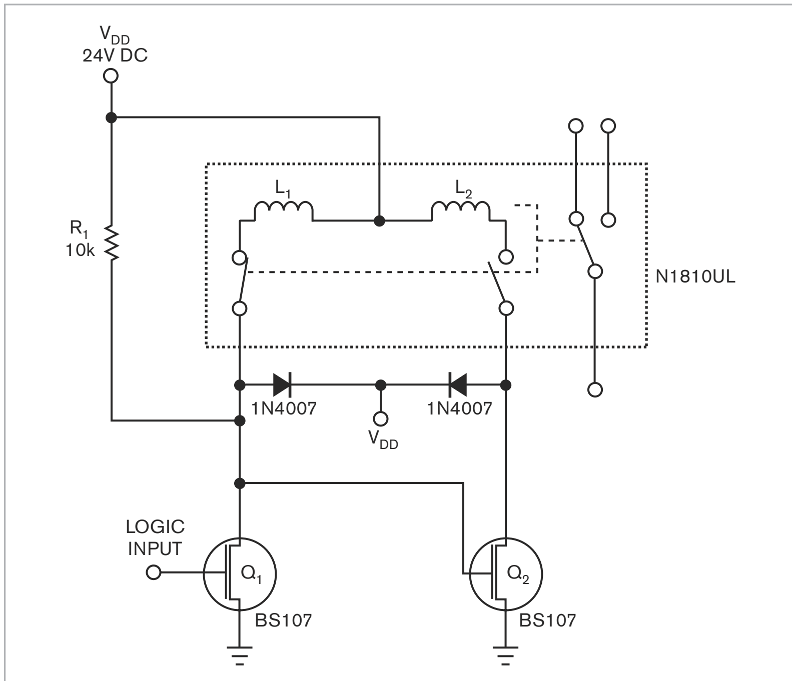

Figure 1 Using two MOSFETs to differentially drive a dual-coil latching relay eliminates the need for any logic components.

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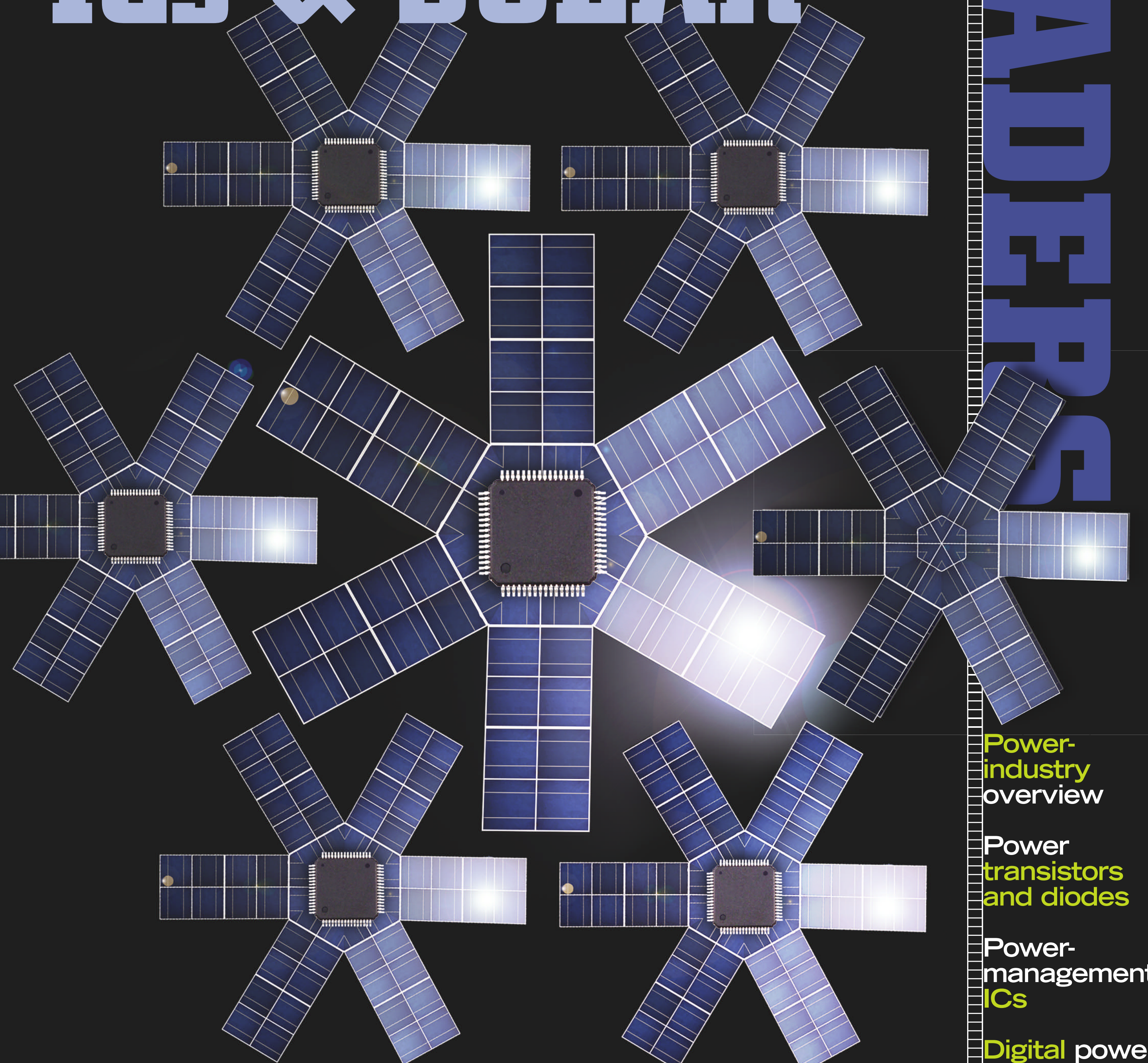

Power-industry overview

Power transistors and diodes

Power-management ICs

Digital power

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PV-industry power shifts downstream

MARGERY CONNER, TECHNICAL EDITOR

Power-industry overview

Last year was the first since 2000 that the semiconductor industry's revenues dropped. The power-management-IC segment, however, bucked the trend by eking out a 1% gain. Likewise, the decidedly unglamorous power-transistor and -diode segment, already at almost $15 billion, promises to continue to grow. How does the power-semiconductor industry manage to grow in the face of this worldwide recession?

Increasing the power efficiency of products pays the owner back in savings. For example, a data-farm server's energy costs exceed its price after only four years. Utility-bill savings—for both the server and the air conditioning to cool the server farm—more than pay back the small premium for a more efficient server. In addition, government and industry groups, such as Energy Star and Climate Savers, are establishing minimum power efficiencies and power factors for power-supply equipment. The power devices that enable these savings will continue to represent a successful market as long as energy and environmental costs are concerns.

Power vendors are seizing the opportunity to entrench or increase their position in the industry by investing in new production capabilities. For example, Infineon opened a 100,000-foot MOSFET facility in Malaysia, and First Solar, a manufacturer of photovoltaic cells, established itself as the cost leader in the solar industry with its monolithic-thin-film-module manufacturing process, investing in plants in the United States, Germany, and Malaysia. It takes guts to invest in a down market, but their confidence should pay off over the next several years.

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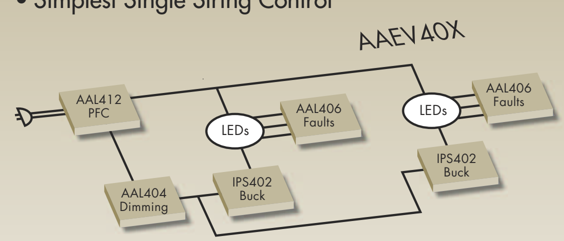

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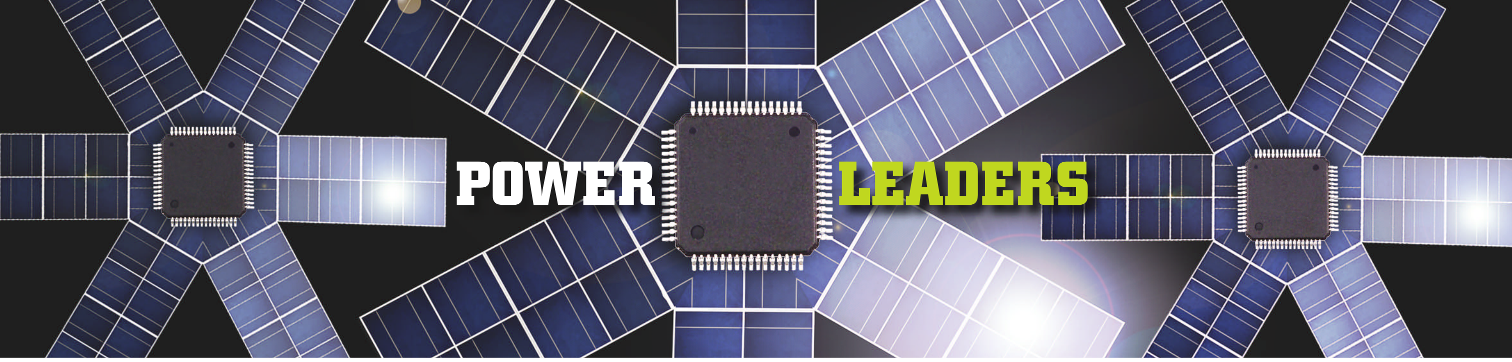


Power transistors and diodes

POWER TRANSISTORS AND DIODES ARE THE WORKHORSES of the semiconductor industry: Without them, you cannot move or transform any significant amount of electrical energy. The servers populating enormous data farms, white goods with their newly efficient motors, hybrid-electric cars, and home theaters rely on power transistors and diodes that switch and manage their power requirements.

Steve Ohr, research director for analog and power semiconductors at Gartner, points out the "marriage" between power-management ICs and power transistors in high-current applications, such as the point-of-load supplies for server farms. "You don't get 85 or 90% energy-transfer efficiency without carefully matching the switching characteristics of your switching regulators to the turn-on and turn-off capabilities of your transistors," he says. "Fractions of a second can 'save the world,' environmentally speaking."

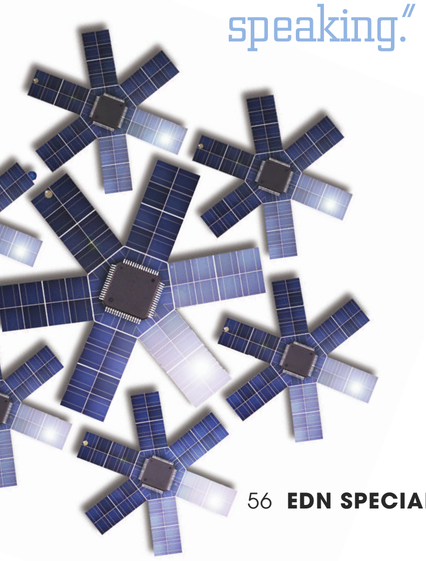
There wasn't much change in the top power-diode vendors in 2008 (**Table 1**), but the top

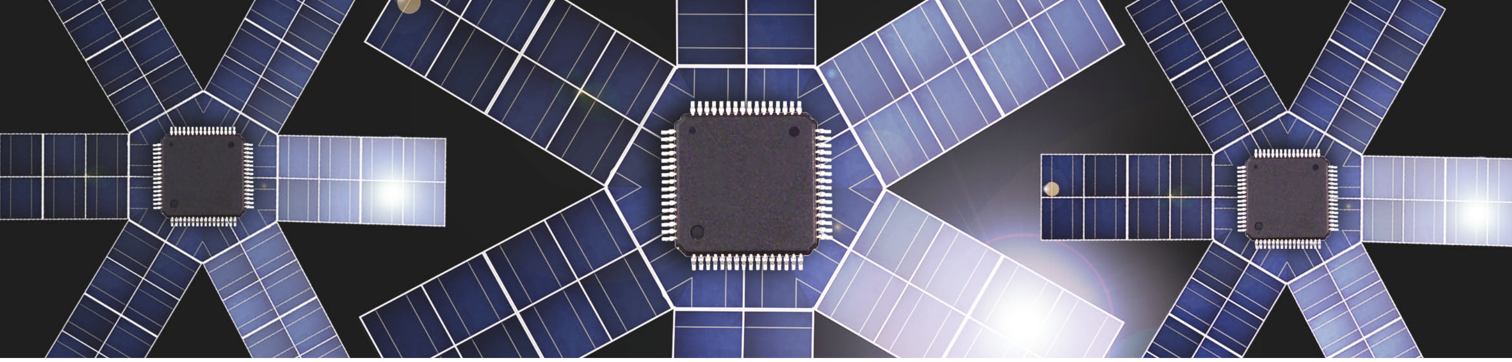
"Fractions of a second can 'save the world,' environmentally speaking."

TABLE 1 TOP 10 POWER-DIODE VENDORS

2008 rank	2007 rank	Company	2007 revenue ($ million)	2008 revenue ($ million)	2007 to 2008 change (%)	2008 market share (%)
1	1	STMicroelectronics	499	508	2	16
2	2	Vishay	349	337	−3	11
3	3	Microsemi	237	236	0	7
4	4	Shindengen Electric	225	231	3	7
5	5	Toshiba	199	187	−6	6
6	6	Nihon Inter Electronics	178	179	1	6
7	7	On Semiconductor	156	166	6	5
8	8	Lite-On Semiconductor	139	132	−5	4
9	9	Pan Jit	132	131	−1	4
10	12	NXP	107	111	4	4
		Others	983	943	−4	30
		Total market	**3204**	**3161**	**−1**	**100**

Source: Gartner, August 2009





STMicroelectronics was caught in the recession's downward draft affecting PCs and consumer electronics.

power-transistor vendors saw some shuffling (**Table 2**). According to Ohr, it is easy to account for the fact that Infineon and Fairchild traded places: Infineon opened its new 100,000-foot MOSFET facility in Malaysia and has been competitive in the market for 20 to 30V MOSFETs that find use in dc/dc converters. Both Toshiba and International Rectifier also address that market, but Mitsubishi is coming on strong in high-voltage IGBTs (insulated-gate bipolar transistors), which will support hybrid-electric vehicles and electrical power-transmission products.

Continuing down the list, there's even more activity. Vishay, On Semiconductor, and STMicroelectronics are all competing for the Intel PC VRM (voltage-regulator-module) market, a big user of power transistors that took hard hits in the third and fourth quarters of 2008. In addition, STMicroelectronics was caught in the recession's downward draft affecting PCs and consumer electronics in the second half of 2008.

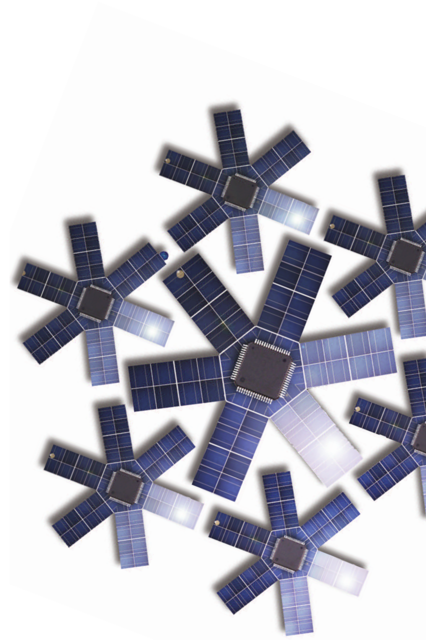
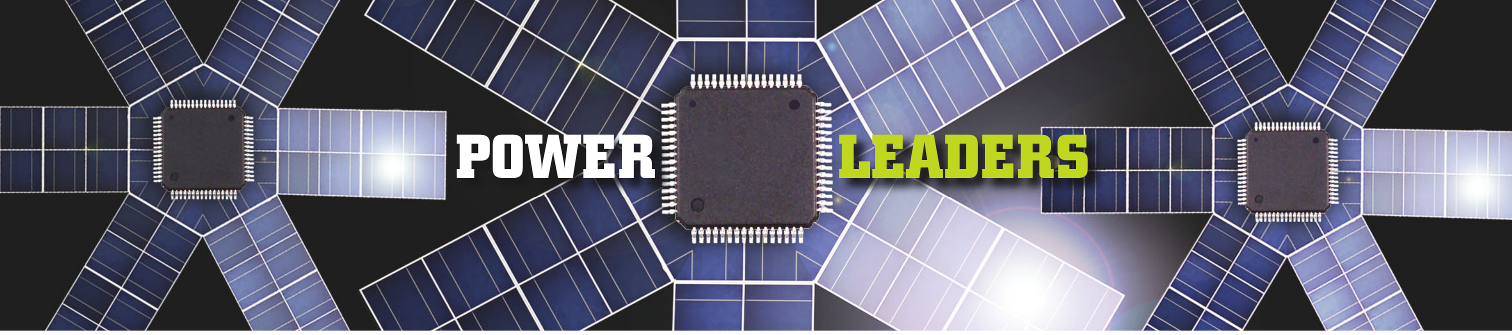


TABLE 2 TOP 10 POWER-TRANSISTOR VENDORS

2008 rank	2007 rank	Company	2007 revenue ($ million)	2008 revenue ($ million)	2007 to 2008 change (%)	2008 market share (%)
1	2	Infineon Technologies, including Qimonda	924	932	1	12
2	1	Fairchild Semiconductor	934	892	−4	11
3	3	Toshiba	718	789	10	10
4	6	Mitsubishi	596	636	7	8
5	5	International Rectifier	628	602	−4	7
6	7	Vishay	562	550	−2	7
7	4	STMicroelectronics	666	548	−18	7
8	8	Fuji Electric	475	490	3	6
9	10	On Semiconductor	309	322	4	4
10	9	NEC Electronics	321	285	−11	4
		Others	2057	2014	−2	25
		Total market	**8190**	**8060**	**−2**	**100**

Source: Gartner, August 2009



Power-management ICs

REFLECTING THE WORLDWIDE ECONOMIC RECESSION, the semiconductor industry last year showed its first revenue drop since 2000. However, although total semiconductor-industry revenue for 2008 declined by 5.4% to $255 billion, the market for power-management ICs grew 1% from $8411 million to $8473 million. Compare this result with the analog-semiconductor segment, including converters and amplifiers, which was flat. Revenue for ASICs (application-specific integrated circuits) and ASSPs (application-specific standard products) declined 2%, as did revenue for microcontrollers. The voltage-regulator segment has historically outpaced all other analog-IC segments, and, in 2008, it was again a relative bright spot in the semiconductor industry.

The top 10 companies haven't changed since last year (**Table 1**), but interesting things occurred in the power-management-IC market. For example, first-ranked Texas Instruments, fourth-ranked Linear Technology, fifth-ranked On Semiconductor, and seventh-ranked Intersil grew faster than the market.

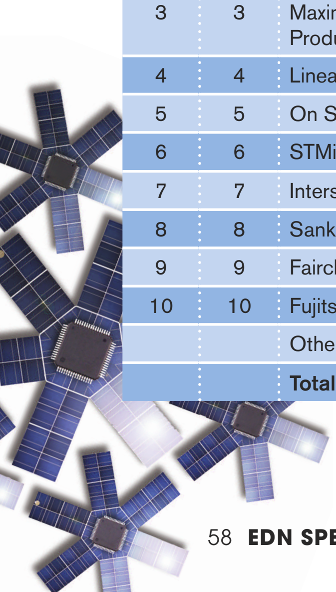
TABLE 1 TOP 10 POWER-MANAGEMENT-IC VENDORS

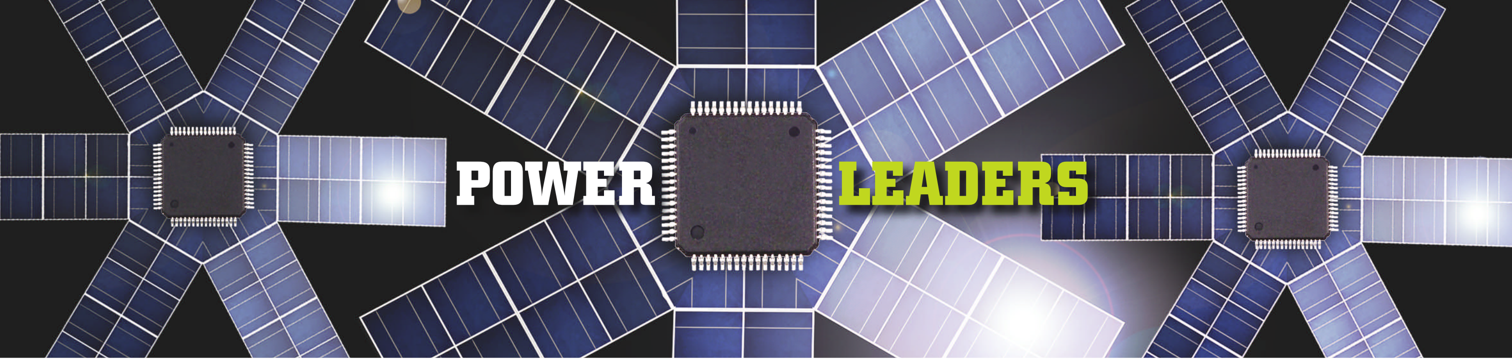
2008 rank	2007 rank	Company	2007 revenue ($ million)	2008 revenue ($ million)	2007 to 2008 change (%)	2008 market share (%)
1	1	Texas Instruments	1096	1161	6	14
2	2	National Semiconductor	899	831	–8	10
3	3	Maxim Integrated Products	683	682	0	8
4	4	Linear Technology	535	584	9	7
5	5	On Semiconductor	393	413	5	5
6	6	STMicroelectronics	368	376	2	4
7	7	Intersil	343	365	6	4
8	8	Sanken	304	280	–8	3
9	9	Fairchild Semiconductor	250	246	–2	3
10	10	Fujitsu Microelectronics	200	200	0	2
		Others	3340	3335	0	39
		Total market	**8411**	**8473**	**1**	**100**

Source: Gartner, August 2009

The growth area in power-management ICs for the year was infrastructure, such as large computers, communications servers, and industrial applications. Infrastructure applications are feeling both economic pressure from the threat of rising energy prices and regulatory pressure for environmental issues to more efficiently use power. Consumer markets, on the other hand, which always are under the thumb of competitive downward-pricing moves, faced the double whammy of the worldwide economic recession.

Steve Ohr, research director for analog and power semiconductors at Gartner, forecasts that those power-management ICs that target high-current and high-efficiency markets should continue to do well, whereas low-efficiency linear regulators will find less of a market and lower margins. Ohr sees unit growth at a compound annual growth rate of 8 to 15%, depending on the type of device.





Digital power

One of the most promising applications is in consumer appliances, which includes washing machines and dishwashers.

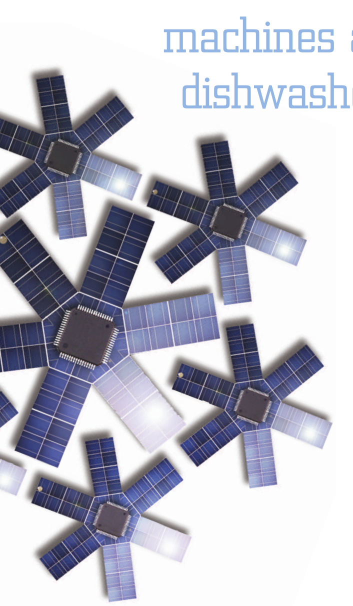
LAST YEAR, *EDN*'s power supplement discussed the still-young digital-power market in terms of overall market potential for digital controllers. Digital power has now matured to the point at which Gartner breaks out products by application type (**Table 1**). One of the most promising applications is in consumer appliances, which includes washing machines and dishwashers. For these applications, growth will follow implementations of the Smart Grid and residential smart utility meters. The smart meters will communicate over wireless connections, such as ZigBee, or wired BPL (broadband power line) and manage home power use by, for example, ramping down the agitation speed on a clothes washer to conserve energy and reduce home electric bills during times of peak power usage.

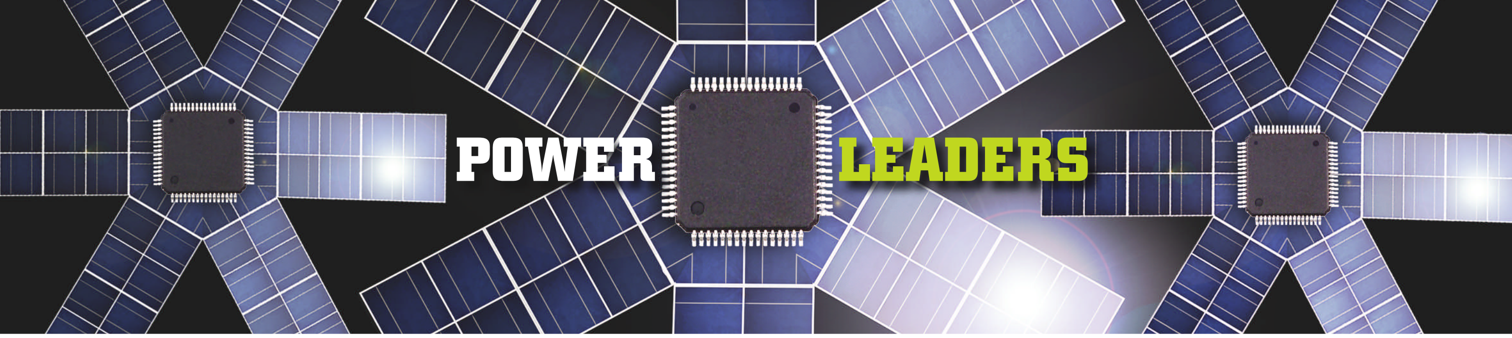
Note that this forecast assumes that revenue for digital-power management will grow by cannibalizing revenue for some types of straight analog voltage regulators—mostly controllers but also some ac/dc and dc/dc converters.

TABLE 1 REVENUE FOR VOLTAGE REGULATORS WITH DIGITAL POWER CONTROL ($ MILLIONS)

Applications	2008	2009	2010	2011	2012	2013	Five-year CAGR (%)
Data processing	28.7	48.3	98.8	173	244.3	326.1	46.5
Communications	25.6	43.5	60.2	90.1	118.1	153.2	28.6
Manufacturing systems	14.6	11.7	17.5	31.4	45.8	47.3	32.1
Energy management	9.7	16.7	25.7	34.3	44.8	55.5	27.2
Consumer appliances	2	3.5	7.5	11.7	20.1	33.5	57.4
Total	**80.6**	**123.7**	**209.7**	**340.4**	**473.2**	**615.6**	**37.8**

Source: Gartner, August 2009





Solar energy: photovoltaics

BY ALFONSO VELOSA III, GARTNER

AFTER YEARS OF DOUBLE-DIGIT GROWTH, the modern incarnation of the solar industry has run into its first major market cycle. Limited credit, jittery customers, and currency fluctuations have severely hit PV (photovoltaic) vendors. Gartner estimates that the worldwide PV market reached 5.4 GW and $16.3 billion in solar-cell revenue in 2008 and forecasts that PV-solar-cell revenues will decrease by more than 50% in 2009.

Three major trends will drive the vendors in the PV industry: the continued importance of government subsidies for PV systems and other renewable energy sources, power shifting downstream toward financiers of PV systems, and the adoption of downstream vertical strategies for PV companies.

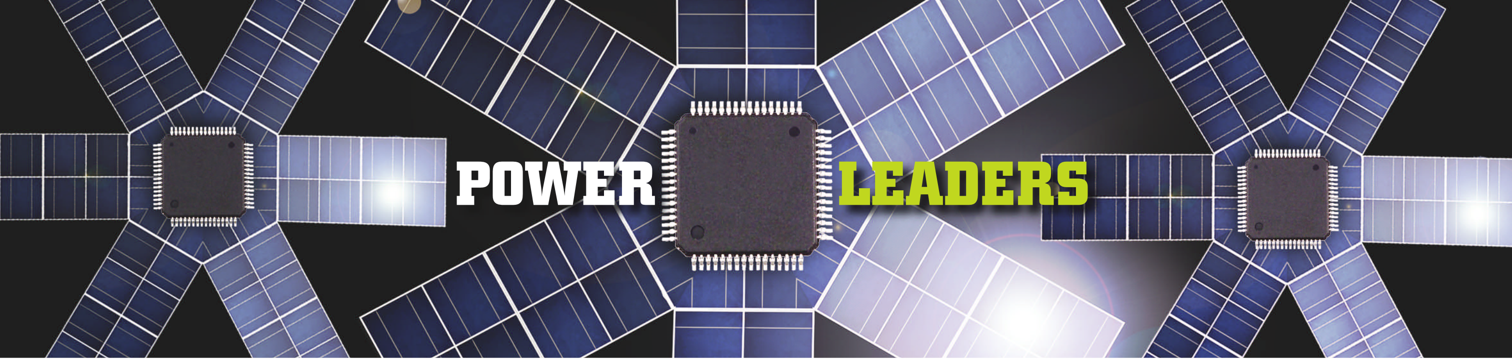
The market is still evolving and continues to show some volatility in the rankings (**Table 1**). Although all the companies had significant growth, Trina Solar grew the fastest in the market as it established a strong sales force in Europe, especially Spain, and operations expansion and solid contracts for raw materials. First Solar was the second-fastest-growing company as it established itself as the cost leader in the industry with its monolithic-thin-film-module manufacturing process with plants in the United States, Germany, and Malaysia.

The market dynamics for 2009 have shaped up differently from those of 2008. Almost all of the PV-solar-cell companies have shown a significant reduction in both shipments and sales. The only bright spot for the PV-solar-cell vendors is that their material costs have been decreasing in parallel with their sales, though several of them have had to go through legal action to renegotiate their materials contracts. Only First Solar, which arguably has a compelling price position and industry-leading costs, had greater revenues in the first half of 2009 than those in the first half of 2008. First Solar is shaping up to be the market-share leader for the industry, but, even so, it has had to finance some of its projects and recently introduced a rebate program in Germany for free field and commercial rooftop projects.

TABLE 1 TOP 10 PHOTOVOLTAIC-SOLAR-CELL VENDORS

2008 rank	Company	2007 revenue ($ billion)	2008 revenue ($ billion)	2007 to 2008 change (%)	2008 market share (%)
1	Q-Cells	1.2	1.7	44	10
2	SunTech Power	1.1	1.5	43	9
3	Sharp	1	1.5	47	9
4	First Solar	0.5	1.2	142	8
5	Yingli Green Energy	0.5	0.9	86	5
6	JA Solar	0.4	0.8	103	5
7	SunPower	0.3	0.7	NM	4
8	Motech	0.4	0.7	78	4
9	Kyocera	0.4	0.7	37	4
10	Trina Solar	0.2	0.6	176	4
	Others	3.9	6	52	37
	Total market	**9.6**	**16.3**	**68**	**100**

Source: Gartner, August 2009



PV-industry power shifts downstream

BY ALFONSO VELOSA III, GARTNER

Spot prices doubled in less than a year, exceeding $400/kg by mid-2008.

AS THE ECONOMIC CRISIS SPREAD on a global basis, the industry dynamics in 2008 shifted significantly. Early in the year, PV (photovoltaic) solar-cell supply could not meet demand. Looking up the supply chain for PV cells, supply of polysilicon was the critical gating factor for manufacturing PV solar cells.

Spot prices doubled in less than a year, exceeding $400/kg by mid-2008. As the economy slowed, PV demand quickly shrank. The shortage of polysilicon disappeared, and spot prices have collapsed to less than a quarter of their peak. The critical reason for this change was that manufacturers restricted, canceled, or repriced—at significantly higher interest rates—financing for projects. This change happened in conjunction with other core market changes, including the restrictions in funding in Spain, sharply reducing demand. German, Japanese, and US markets underwent a corresponding slowdown, with a concomitant delay in funding for new PV projects. Thus, those companies with money are in the driver's seat for the solar industry.

An additional factor for the US market is that most companies prefer to limit their capital expenditures, especially for noncore elements, such as electricity generation. The solar-power purchase agreement supports these companies by providing them with electricity from a renewable PV source (**Table 1**). The solar-power-purchase-agreement service model enables the host customer to implement a PV solar electric system without the usual capital investment. These companies install and own their PV systems and sell the electricity to end users under typically long-term contracts of 20 years. Beyond the electricity and the ability to make some marketing statements about using renewable energy sources, solar-power-purchase-agreement companies provide design, building, and operating services, which they may outsource, and finance services.

TABLE 1 TOP 10 SOLAR-POWER-PURCHASE-AGREEMENT FIRMS

Rank	Company	2008 projects (MW)
1	SunEdison	25
2	Solar Power Partners	13
3	Renewable Ventures	11
4	SolarCity	9
5	BP Solar	5
6	Perpetual Energy Systems	4
7	GE Energy Financial Services	3
8	Pepco Energy Services	2
9	SunRun	2
10	Honeywell	2
	Others	16
	Total	**93**

Source: Gartner, August 2009

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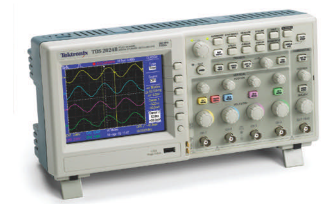
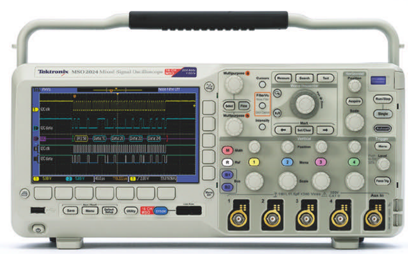


TDS1000B/TDS2000B Series
40 to 200 MHz



MSO2000/DPO2000 Series
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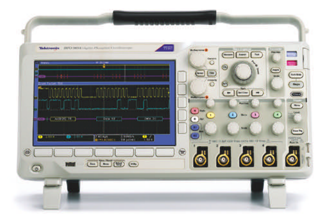

DPO3000 Series
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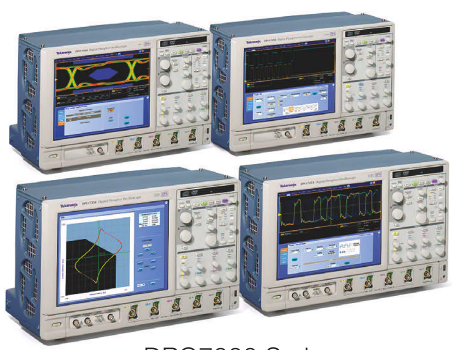

DPO7000 Series
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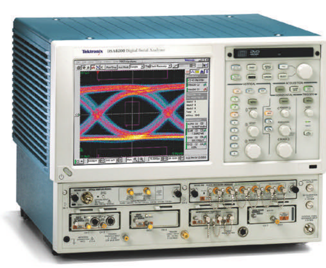

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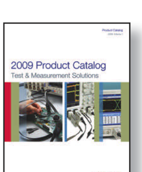

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Catching the NEXT WAVE

INSIDE

SUPPLY CHAIN holds its own

Times are tough, but there's less fallout than expected

By **Barbara Jorgensen**

The ongoing economic downturn continues to confound all predictions and wreak havoc in electronics industry forecasts. The one thing that seems certain is there will be a recovery. When that happens, the supply chain will look different, but not as radically as first expected.

At the beginning of this down cycle, many observers expected significant fallout in the supply chain as financially unsound companies failed. This hasn't happened on a wide scale—to the relief of many in the electronics industry. "This has been the remarkable part of it—there has been very little bankruptcy," says Eric Sussman, director, Americas distribution, for connector maker Molex Inc., Lisle, Ill. "Yes, companies have taken out additional insurance to cover a shortfall and payment terms have been stretched out, but there's been no widespread bankruptcy."

The question now turns to how well the supply chain is positioned to deal with a recovery. "Today, we all are managing our business differently," says Michael Long, CEO of Arrow Electronics Inc., Melville, NY. "Trying to keep our customers in product without a forecast has put some pressure on the supply chain. The good news is the supply chain is in better shape than ever and we have been able to react [to the recession] as an industry."

The industry's reaction, of course, has been to downsize. But industry-watchers wonder whether this downsizing could hamper the supply chain's response to an uptick in demand. Stripped-down manufacturers may have to borrow to ramp up capacity and credit remains tight. "The question is, when demand picks up, will manufacturers have funds to buy the materials they need?" says Brian McNally, president of Arrow Electronics' component business for Europe, Middle East and Africa. If credit lines are tapped out, "We're at the point in the cycle where financially strapped companies will begin to fail," says Roy Vallee, CEO of Avnet Inc., Phoenix.

Additionally, both suppliers and distributors say they have very little visibility into where demand is headed. "When we talk to our asset management people, they say 'we feel there will be greater demand.' Then the question [for suppliers] becomes 'so what do you build?'" says McNally. Channel executives say the ability to secure financing, visibility into end-market demand and managing inventory will be key to the electronics industry's transition out of the economic doldrums.

"The supply chain is in better shape than ever and we have been able to react [to this recession] as an industry."

Michael Long
CEO
Arrow Electronics Inc.

On borrowed time?

Component manufacturers, distributors and equipment manufacturers report business levels have declined anywhere between 15 percent and 30 percent since the beginning of the downturn. Companies throughout the supply chain have adjusted to this lower level of business by laying off employees, shuttering factories and buying inventory hand-to-mouth. "We've all closed plants, we've all reduced headcount," says Molex's Sussman. Generating cash at this reduced level of business has been tough, executives say. Access to credit remains a key concern in the channel.

"If companies have weathered this recession by borrowing to support a lower level of business and suddenly they have orders coming in, they'll need to buy materials and equipment," says Sussman. "Unless [these companies] have solid lines of credit, the ability to borrow could be a limiting factor to future growth." Companies that haven't responded to the market realities or used up their cash flow "will have a tough time climbing out of the barrel," says Long.

Channel executives expect this will be a problem only if there's a sudden surge in demand. So far, many distribution customers have been managing by securing credit from their channel partners. Although payment terms are stretching out, distribu-

tors continue to work with customers to secure product. Digi-Key Corp., in fact, has added personnel to its credit workout group, says Mark Larson, president of the Thief River Falls, Minn.-based catalog distributor. "We've actually hired in that area and in IT and the Web," Larson says.

But the channel is remaining extremely cautious about its own spending. "Working capital is a big focus," says Alisha Mowbray, senior vice president, marketing, for Chicago-based catalog distributor Newark. Newark has improved the capabilities of its internal systems to increase efficiency and improve customer service. "But we are still managing through the downturn by keeping our investments as low as possible," Mowbray says. "That's becoming more challenging because the market is coming back and you have to have product in-house." Distributors see opportunity to invest in inventory, they say, but lack of visibility into end-market demand is making it difficult to determine what mix of product is optimal.

Inventory: So far, so good

Throughout the recession, executives say, overall inventory levels in the channel have been in balance with demand. "I think the supply chain has been managed very well and a lot of attention has been paid to getting inventory levels in balance," says Arrow's McNally. "When the recession first hit, sales went down pretty quickly and the supply chain was left with 5 to 7 weeks of too much inventory, but companies have done a good job of whittling it down."

Customers have worked hard to deplete inventory and are running with as little product as possible, says Digi-Key's Larson. "I don't think distribution has changed its approach to inventory in general," he adds. Although there have been spot shortages throughout the downturn, opportunistic buying is at a minimum. "You can see how public companies that have ROI [return on investment] issues are under great pressure to take on—just as an example—tan-

"Working capital is a big focus for us. We are managing through the downturn by keeping our investments as low as possible."

Alisha Mowbray
Senior Vice President, Marketing, Newark

TOUGH TIMES FOR EMS

The electronics manufacturing services (EMS) industry has been hit hard by the recession. Reduced demand from struggling OEMs, overcapacity and solvency issues have pressured the industry's already-tight bottom line. During the last recession, when business dropped off, millions of dollars' worth of excess inventory was sitting at EMS factories. Pressure to push that inventory back through the channel strained relationships throughout the supply chain during the 2001 downturn.

The situation isn't as bad this time around. "As business has slowed, EMS companies have been working hard to get inventory under control," says Charlie Barnhart, principal of EMS consultancy Charlie Barnhart & Associates LLC. "That said, there are not a lot of options [for excess]—you either build it or send it back to where you bought it from. Nobody's issuing return materials authorizations (RMAs) right now."

Distributors concur that they haven't been getting a lot of pushback from the EMS channel. Distributors primarily serve the second-, third- and fourth-tier EMS companies that specialize in low-volume products, manufacture in the Americas and work closely with their end-customers to manage demand. "These EMS companies have a more personal relationship with their customers so they can make adjustments that don't cripple them," says Barnhart.

Although EMS companies work on razor-thin profit margins, nobody in the channel envisions widespread failures in the industry. "These companies are the manufacturing capacity of the electronics industry," says Craig Conrad, senior vice president for specialty distributor TTI. "OEMs have reduced their capacity so much—where are they going to go? I don't think the industry can afford [EMS] companies to fail."

talum capacitors if product leadtimes begin to stretch. But I don't think anyone believes the upturn will be anything but slow and steady."

Still, having the right mix of inventory is a concern. "Like most distributors, our inventory runs the gamut from the 'A' items—those that are widely used and multi-sourced—to the 'D' items that are highly proprietary," says Arrow's McNally. "We've seen a shift away from the A to the D items—demand is moving from commodity to proprietary. As a result, we've adjusted our commodity inventory." However, he points out, many proprietary products are in the semiconductor arena and semiconductor cycle times are still about 16 weeks. "Customers have become accustomed to leadtimes of about 4 weeks—the reality is it takes 16 to 20 weeks to build a semiconductor." When the channel finally gets a glimpse of actual demand, the right products may not be in the pipeline.

Cloudy, with a chance of collaboration

Catching that glimpse into demand may be harder this time than it has been in the past. This downturn, executives say, has been driven by banking, housing and consumer spending and not by the tech industry. As of the beginning of September, executives reported that book-to-bill ratios in most product segments had stabilized, if not increased. "Certain markets have a positive book to bill—but there hasn't been a consistent flow—we still have good days and bad days," says Arrow's Long. "We are not prepared to call a bottom yet."

"Everybody is confident the cycle will come back," says Jennifer Bleakney, vice president for Santa Clara, Calif.-based National Semiconductor Corp. Worldwide Distribution and Customer Support. "Declines have slowed or stopped and that is interpreted as very positive news."

For example, the automotive industry, marketwatchers say, has done a good job of burning off its excess inventory and could be poised for growth next year. "Clearly the transportation and automotive businesses were the first to be hit and hit very severely," says Craig Conrad, senior vice president for specialty distributor TTI Inc., Fort Worth, Texas. "Over the past 3 or 4 months that business is perking up really well and the revised forecasts are pretty rosy," adds Michael Knight, vice president of product management and supplier marketing for TTI. The market for medical equipment continues to be stable for distribution and alternative energy is spurring a lot of interest (see *Powering Up the Supply Chain*, page S10).

Another positive sign is the degree of design activity distributors have seen in recent months. "We've seen design activity at an all-time high," says Arrow's Long. "This gives us confidence that our customers are using this downtime wisely." The channel is seeing design momentum across industries, including automotive. "We are seeing activity around safety, climate control and fuel-mix management, all using electronics," says Long. Several distributors noted that design activity in the Americas has stalled in recent months and may be shifting overseas.

Still, no one can tell which market will gel—and when. Because of so much uncertainty, suppliers and distributors say collaboration is going to be crucial as the industry moves forward. "All of the issues we have dealt with in this cycle and in 2001 have taught us that collaboration and transparency are going to help us put things back together when the recession ends," says National Semiconductor's Bleakney.

Collaboration has improved since the last downturn, which is why the channel's inventory balance is in such good shape. "The supply chain has managed this downturn better than we did in the Internet bubble because we have better linkage between supplier, distributor and OEM and the willingness to share data has improved," says Arrow's McNally. "I also think the OEM and everyone in the supply chain understands the realities and is cautious about the changes this [recession] will bring."

The next wave

Even if the recession were to end with fewer players in the electronics industry, the supply chain would still become more complex, executives say. Globalization will continue to effect change in the channel. "The need to serve customers and suppliers globally—as opposed to locally or regionally—is rising," says Avnet's Vallee. "Even smaller OEMs are deciding to manufacture offshore and see the world as their market."

"Ten years ago, we were required to ship a part to a plant in Texas for a customer," says Long. "Now we are asked to ship the same part to Texas, China and Ireland for the same customer. Customer needs are changing the way we respond to that, and it's becoming more complex."

Doing more with less has forced a lot of change in the channel. "It's all being driven by cost," says Long. Companies have had to make choices where to spend

"The automotive business is perking up really well and the revised forecasts are pretty rosy."

Michael Knight
Vice President of Product Management and Supplier Marketing TTI Inc.

their money and have turned their focus inward. For component makers, that means capitalizing on their core technologies. "On the supplier side, the intent is to focus on specific technologies and end-markets and the stakes are very high," says Avnet's Vallee. "Coming in second is too expensive." At the same time, this narrower product focus also means suppliers can service fewer direct customers cost-effectively. "These are the large customers that represent the biggest part of their revenue stream," says Vallee. "Suppliers are relying more on technical distribution to cover the rest of the accounts."

Customers can now cherry-pick among the best technologies, but to do this, they also have to deal with multiple vendors. "When you had broadline component suppliers like Motorola, TI and National used to be, you had a suite of components from a single vendor that were designed to work together," says Vallee. "That's no longer the case. Designers can work with each vendor now—or they can work with a partner that manages multiple vendors." Distributors can help designers sift through those various offerings. "The fundamental change I have seen [in distribution] is they are assisting the designer in seeing the strength of each supplier," says National Semiconductor's Bleakney.

The channel's role continues to evolve beyond physical distribution into the information realm. This ranges from providing information on component availability to end-of-life roadmaps to the identity and amount of materials contained in the part. More and more, environmental regulations are dictating that a component's materials make-up be readily available. Compliance enforcement cases, particularly from the European Union, are on the rise. "Compliance is an area in which distribution plays a significant role," says Ken Stanvick, principal with consultancy Design Chain Associates. "Compliance is not a one-time event," he says. "There is a lot of data acquisition that has to be ongoing."

Distribution executives realize they have to provide these services and remain cost-competitive. "I think a good opportunity is one where you figure out how to do it cheaper," says TTI's Conrad. "To do that, you have to become more efficient. You can't be married to an existing business model." Companies throughout the supply chain must continue to adapt their models to the way customers want to do business. That, says Conrad, won't be about delivering parts—it's going to be about delivering parts and information.

POWERING UP the supply chain

Channel partners investing in the renewable energy market

By **Barbara Jorgensen**

The supply chain's confidence in the renewable energy market is comparable to its faith in the economic recovery—it's going to happen, but the question is when?

Component suppliers and distributors have been investing in resources targeted at the renewable energy and the energy efficiency markets. National Semiconductor Corp., Santa Clara, Calif., for example, has established a business unit focused on expanding its analog product portfolio deeper into energy-savings/efficiency applications. Likewise, connector maker Molex Inc., Lisle, Ill., is releasing products in the solid-state lighting arena to increase efficiency and extend product lifespan. Leading distributors Avnet Inc., Arrow Electronics Inc. and Future Electronics Inc. each have established business units supporting solid-state lighting components and designs. The supply chain, in general, is bullish on energy-savings and the potential for an expanding customer base. "Renewable energy is a big story for us," says Craig Conrad, senior vice president for specialty distributor TTI Inc., Fort Worth, Texas. "It's a source of new industry players on both the OEM side as well as the supplier side."

Industry executives agree that like the economic recovery, the movement toward renewable energy is inevitable. There are a number of factors that are driving the momentum, says Rick Zarr, PowerWise technologist for National Semiconductor. "The first are mandates or conservation efforts targeted at reducing energy consumption or breaking dependence on foreign power resources," he says. "A second is performance—the market for portable devices that, if they run longer, can command a premium. The third is infrastructure. Companies are looking to reduce the cost of ownership of structures such as data centers." Once a center is built, he points out, energy becomes the main cost.

One of National Semiconductor's efforts focuses on maximizing the energy capture of solar panels—a strategic fit to its power-management product portfolio. "National has been looking at ways to capture more of the value our analog technology creates in new, high-growth markets," says Ralf Muenster, director of the Renewable Energy Group at National Semiconductor. Renewable energy is one of the megatrends in the global push toward environmental friendliness and energy conservation. "This is going to be a decades-long trend and photovoltaic (PV) energy is at the forefront," Muenster says. "We

"[Energy conservation] is going to be a decades-long trend and photovoltaic energy is at the forefront."

Ralf Muenster
Director, Renewable Energy Group, National Semiconductor Corp.

GLOBAL SOLAR PANEL PRODUCTION FORECAST IN GIGAWATTS (revised forecast, crystalline and thin film panels)

	2008	2009	2010	2011	2012	2013
NEW FORECAST	6.5	7.5	13.5	15.5	17.2	19.7
OLD FORECAST	7.7	11.1	14.2	17.9	20.2	

SOURCE: iSUPPLI CORP., AUGUST 2009

Oversupply in the solar panel production market has prompted market analyst iSuppli Corp. to revise it forecasts downward.

investigated how we could leverage our expertise to make a difference in this movement." A few years later, he says, U.S. President Barack Obama outlined a U.S. directive toward the development of renewable energy. There are similar initiatives overseas, he adds—a full 50 percent of the world's solar capacity has been installed in Germany.

One of the problems with solar power is the loss of energy as electric current passes through a panel system. "From an electronics standpoint panels are passive," Muenster says. "They don't intelligently manage power." Current can be lost or degraded when shade hits a panel; one part of the PV array doesn't work; or there's a 'kink' in the flow of the current. National Semiconductor has developed a power optimizer that attaches to the panels of a PV array to maximize the harvest of solar energy. "Small mismatches don't have a deteriorating effect on the flow of current," Muenster explains, "like if a string of Christmas lights goes out or there's a kink in a hose. National's SolarMagic technology intelligently manages through those kinks."

Other kinds of intelligent power management include smart metering technologies. Smart meters are two-way communication devices that give real-time data on energy usage. Opportunities exist both at the energy grid level and at companies specializing in intelligent resource management, says Ed Smith, president of Avnet Electronics Marketing, Americas, headquartered in Phoenix. "There's a lot of demand for technology that helps use power more efficiently," he says.

So far, solar energy and solid-state lighting have garnered the most interest in renewable energy and power efficiency. Production of solar panels has increased so much that market research firm iSuppli Corp., El Segundo, Calif., predicts a supply glut (see chart). Distributors are well-positioned in energy-related markets once they take off. Because most energy-savings solutions are systems—made up of numerous components—the channel's broad base of products can be mixed and matched for optimum performance. The channel is already helping in solid-state lighting as lighting moves from an electrical market to an electronics market. "Lighting is interesting," says Zarr. "LEDs [light-emitting diodes] require a higher set of electronics—you have to put a circuit in a light system now—and it all gets more complicated. You need to think about heat dissipation because LEDs do not radiate their heat, so heat must be conducted away. Distributors are in a good position because they are familiar with all the products required to solve a problem." Vendors aren't always in the same position, he says. "For example, we do LED drivers, but we don't do cooling technology."

In addition to LEDs themselves, a full solution requires components that manage thermal loads, modulate power, focus and manipulate light and, in many cases, fit an existing footprint. Distributors have pooled experts in optical, thermal, mechanical and electrical design into cross-functional teams that help customers design LED systems for a variety of applications.

Distribution also serves a constituency—small and midsize OEMs—that need more technical assistance developing solutions. "It's not the large OEMs that will be the people interested in board solutions—they know their market and they just need the components," says Zarr. "With smaller companies, if you can provide a solution or a schematic and a bill of material, they are more likely to succeed."

Much of the activity on Newark's Element 14—an information portal and community for design engineers—centers around issues such as how to do LED retrofits. Design activity is picking up in the energy arena, says Alisha Mowbray, senior vice president, marketing, for catalog distributor Newark, Chicago. "A lot of people know there will be stimulus money coming for new energy solutions, but it's still a nascent market." Catalog distributor Digi-Key Corp., Thief River Falls, Minn., which also serves the design community, is developing sub sites on the Web to help flag product offerings for particular energy applications. "We are trying to create a more simple way for people to see these products without wading through a lot of other information," says Mark Larson, president of Digi-Key.

Still, the industry is waiting for something to push the market forward. Overall, the global economic situation has made businesses reluctant to spend money on anything, even eco-friendly infrastructure upgrades.

Executives believe an incentive from the U.S. government may help, at least in North America. "I think we are just now seeing the tip of the iceberg," says National Semiconductor's Zarr. "Just like anything else, you need pressure to change. Many companies feel the incentive for renewable energy will be coming from the government or from legislation, but haven't starting revamping yet."

"If you can provide a solution or schematic [for your customers], they are more likely to succeed."

Rick Zarr
PowerWise Technologist
National Semiconductor Corp.

GAINING perspective

Lessons learned from past recessions

By **Barbara Jorgensen**

On a global scale, economists have been comparing the current downturn to the Great Depression. The electronics industry's last worst downturn was in 2000–2001. Industry experts say the current recession will certainly distinguish itself from the rest—and drive further change in the supply chain.

"If we compare this with 2001," says Michael Long, CEO of Arrow Electronics Inc., Melville, NY, "that downturn didn't affect banking to the level it has this time. There was still access to capital—it was easier to borrow so you could continue to run your business. This time banking led the downturn and money has dried up. This effect has moved into the supply chain—people are buying only what they need to manufacture. Back in the tech wreck, [demand] dropped off a cliff."

Executives point out that the supply chain itself contributed to the 2001 downturn by vastly overestimating demand. This time, however, the industry is part of the collateral damage caused by a meltdown in global finance as well as overinflated real estate values. All this has trickled down to consumers as well as businesses. "In this downturn, this industry has been somewhat of a spectator—watching the impact to our business due to economics beyond our control," says Jennifer Bleakney, vice president for Santa Clara, Calif.-based National Semiconductor Corp. Worldwide Distribution and Customer Support. "We aren't passive spectators in the sense we are sitting back and watching a game being played that we have no control over—the industry is managing through the downturn. Collateral damage is what's left behind and what we have to put back together, and that will require a significant amount of collaboration."

Every downturn has prompted changes in the supply chain—some of them painful, says Bleakney. The channel has gone through massive consolidation and nobody expects that trend will cease. "Consolidation in the supply chain has driven cost models to where everyone in the supply chain has to identify their core competencies and not be all things to all people," she says. National Semiconductor, for example, used to supply a broad base of semiconductor products but is now focusing on analog technology. Distribution has gone through a similar evolution. "Not that long ago, distribution had inventory near every customer locale—now there's aggregated inventory and global hubs. [The channel] has evolved with the service model the industry needs."

To manage through the downturn, companies in the supply chain have shuttered factories, cut staff and implemented other cost-saving measures such as hiring freezes and furloughs. But past recessions have also taught electronics companies to selectively invest in their core competencies—even in a downturn. For distribution, core competency includes the ability to move a massive amount of products to widely dispersed locations throughout the world. "We have continued to make investment in ERP systems to make us more efficient and in vertical and emerging markets such as solid-state lighting," says Long. "We have always invested in down markets—we are the companies that take products to market in a cost-effective manner. If you stop investing, that ability goes down also."

Another core competency in the channel is support of suppliers' sales efforts. Cost pressures are moving suppliers away from a broad-based product offering and into specific technologies and markets. "Suppliers are channeling more resources toward the technology they are trying to sell and becoming a lot more specialized," says Long. This is changing the way suppliers go to market. "With a narrower product portfolio there are a smaller number of customers that suppliers can cost-effectively call on themselves," says Roy Vallee, CEO of Avnet Inc., Phoenix. "Vendors are relying more on distributors to cover the

"There are a smaller number of customers that suppliers can cost-effectively call on themselves. [Distribution can service] their other accounts."

Roy Vallee
CEO
Avnet Inc.

majority of their other accounts."

Increasingly, channel executives say, this means providing technical—as well as sales—support. Broadline suppliers used to offer a suite of products designed to work together. Designers could therefore go to one vendor for all their technical support. "Now if you have a question you have to call the FPGA vendor or the analog vendor—it's a lot more complex," says Vallee. "Customers can choose to deal with a bucket of vendors—or they can come to us." Distributors have invested in engineering personnel, programming centers and training to increase their technical acumen. "We are doing reference designs, applications-based support, designing ASICs—overall, we've become more technically competent," says Vallee.

Customers have also been feeling cost pressure to do more with less. As suppliers tighten their belts, fewer resources are available to customers that need technical assistance. "Customers are trying to design better, longer lifecycle products because the consumer is expecting more for their dollar," says Long. Designers are turning to the channel for design solutions as well as component selection and logistics. "Customers are coming to us and saying 'this is the problem—what will help me get across the goal line?'" says Vallee. "With a broad-based product offering, we can provide design support across the board."

"More and more we are being called upon to be a solutions provider," says Alisha Mowbray, senior vice president, marketing, for Chicago-based catalog distributor Newark. "Customers are looking for our ability to provide technical support and other information—not only are we getting 'you have to have the product in stock,' we are getting 'what can you do for me to help me do my job better?'" Increasingly, this includes guaranteeing the performance of the product. "Customers are becoming more aware of counterfeits and the fact that one counterfeit in a design can create all kinds of problems for a builder," says Arrow's Long.

Distributors increasingly see their role as making the complex seem simple. "Customers are managing more information than they ever have before," says Long. "There are design issues, environmental mandates, end-of-life issues, the risk associated with counterfeits—the list goes on and on." The channel has a long history of dealing with multiple vendors and hundreds or thousands of customers, he points out. "We're equipped to do this," says Long.

Information flow hasn't always been easy in the channel. Every company in the supply chain has proprietary information it wants to protect. Past recessions have taught distributors and suppliers they have to work together. In the 2001 downturn, a lack of communication between suppliers, distributors and customers led to excess inventory that glutted the supply chain. Customers wanted to push it back through the channel but nobody wanted excess inventory on their books. Working in tandem, some suppliers and distributors were able to successfully disperse inventory back through the customer base. Cooperation is now enabling suppliers and distributors to avoid another inventory glut. Customers are updating their forecasts more frequently. Suppliers and distributors are reality checking customer orders with one another and against actual consumption. "All of the issues we have dealt with in this cycle and in the 2001 cycle have taught us lessons that we will use from this day forward," says Bleakney. "Collaboration and transparency are the two things that will drive change in the supply chain."

Executives are confident the industry will come out of this recession and electronics will continue to drive better products and services. "I can't imagine anything that does not bode well for the future of electronics," says Craig Conrad, senior vice president for TTI Inc., Fort Worth, Texas. "Electronics content in everything is so pervasive. I don't see anything that will dim that."

Despite the current economic environment, he says, the value of distribution is on the increase for both suppliers and customers. "I feel the distribution value proposition has never been brighter," he says.

Industry trends will continue to play themselves out regardless of the economy, executives say. OEMs will continue to move offshore; suppliers will pare their distributor rosters; and forecasting will continue to be imperfect. New technologies will evolve and designers will push the price/performance envelope. But many of the trends that have influenced the evolution of the channel will remain.

"Consolidation will continue to be a factor," says Vallee. "When you go through periods of extreme stress like the one we are coming out of—that will accelerate consolidation." Globalization, and the channel's need to serve suppliers and customers globally as well as regionally, will also increase. "Distribution involvement in engineering is another rising trend," Vallee adds. "Consolidation, a global supply chain and technical competence are the things that are going to shape the future of electronics distribution."

"All of the issues we have dealt with in this cycle and in the 2001 cycle have taught us lessons that we will use from this day forward."

Jennifer Bleakney
Vice President
National Semiconductor
Worldwide Distribution
and Customer Support

AMPLIFIERS, OSCILLATORS, AND MIXERS

Class AB audio amplifier enables fast start-up

Suiting portable- and wireless-system applications, the NCP2991 Class AB audio amplifier has a −103-dB power-supply-rejection ratio. Resistant to time-division-multiple-access noise occurring during GSM transmissions, the device provides zero pop-and-click noise at start-up and shutdown. It provides a 0.015% THD level and delivers 1.35W output power to an 8Ω speaker or 1.1W to a 4Ω speaker. A selectable start-up time of 15 to 20 msec allows the amplifier to stay in shutdown mode, consuming 20 nA. Available in a 1.45×1.45×0.6-mm μBump package, the NCP2991 costs 22 cents (3000).

On Semiconductor, www.onsemi.com

Dual low-noise amplifier has selectable gain

The dual low-noise AD8432 amplifier features selectable gain and active matching of signal-source and amplifier-input impedances, reducing signal reflection. Using pin-strapping options, designers can select a gain of four, eight, 12, or 16; at a gain of four, the amplifier has a 200-MHz bandwidth. Aiming at communications-infrastructure and medical-ultrasound applications, the amplifier provides a $0.85\text{-nV}/\sqrt{\text{Hz}}$ input-referred voltage-noise figure. Additional features include a −40 to +85°C temperature range, operation over a 5V supply, and a differential output. Available in a 4×4-mm, 24-lead LFCSP package, the amplifier costs $1.99.

Analog Devices, www.analog.com

Bipolar-input audio op amp has low interchannel crosstalk

The dual-channel OPA1612 bipolar-input audio op amp, a new addition to the vendor's Burr-Brown audio line, features ±2.25 to ±18V operation from a 3.6-mA supply current per channel. Aiming at broadcast-studio equipment, analog-to-digital mixing consoles, and audio-test-and-measurement equipment, the op amp provides a $1.1\text{-nV}/\sqrt{\text{Hz}}$ noise density with a 0.000015% distortion at 1 kHz. Independent circuitry provides low crosstalk between channels. Available in an SO-8 package, the dual-channel OPA1612 audio op amp costs $2.75 (1000).

Texas Instruments, www.ti.com

JOHN BATE • VOLVO GROUP NORTH AMERICA

Keep on truckin'

DANIEL VASCONCELLOS

At our truck-manufacturing facility, the technicians in production called up engineering and said they couldn't fix a problem fault code, something that we had to fix before we could ship the trucks to the customer. Our transmitter was shutting down due to high VSWR (voltage-standing-wave ratio). Production replaced the failed transmitters as well as the antennas, but the fault returned. We had seen some of these intermittent failures in the field so were hoping to find a number of production trucks with the same problem. We armed ourselves with as much test equipment as we could think of—a few spare antennas, a couple of PCs to monitor the transmitter software, and a 75-lb network analyzer—and drove for two hours to our production facilities.

The first thing we did was set up the PCs to tell us the VSWR in the transmitter and reproduce the problem. Bingo! The first time it transmitted, we hit the high VSWR; the software fortunately shut down the system to prevent any more damage. When we unbolted the antenna from the roof of the truck—read: "removed the ground"—the VSWR improved dramatically.

Our specialties are electrical and software engineering, not antenna design. We leave this black art to the antenna manufacturers. We specify only the antenna characteristics, keeping the VSWR as close as possible to 1-to-1 at about 145 MHz. We were stumped but knew that, without a ground plane, we would kill the system's performance. Out came the network analyzer.

We set up the analyzer to read VSWR over the transmitter's receiving and transmitting frequencies of 138 to 150 MHz. We saw a well-shaped VSWR, although high on the transmitting side. We measured this VSWR with and without the antenna on the ground plane. The results showed why we were seeing faults. I opened up the display span to 100 to 200 MHz to see a bit more of the antenna bandwidth. We saw some significant differences and then realized that the antenna was not tuned to our 145-MHz requirement.

We took lots of pictures but still wondered why this problem had begun to show up. The antenna design wasn't supposed to change without our approval. Upon returning to the engineering center, we reviewed this work with another system engineer. He quickly disassembled the antenna because it "didn't look right." We found that the antenna manufacturer had changed the circuitry at the base of the antenna. We put a few of these antennas through the network-analyzer test and found that they were indeed different, even though the part numbers were the same.

Our system engineer quickly called the antenna rep, who told us that the designs did change from time to time—in this case "only twice" since the original design, the rep said, stating that one of our sister companies had requested a new design for a shorter antenna. The antenna engineers thought that they could redesign the base a little bit and have a common base between both our companies, saving a bit of money.

A seemingly small change greatly affected our "fault-free" system. Now we had to chase down and repair possibly hundreds of trucks. After a few trials, I found that cutting an inch off the antenna whip got the VSWR back in line; a few days later, we shipped the customer some fault-free trucks. EDN

John Bate is principal electronics engineer at Volvo Group North America (Greensboro, NC).

Go to www.edn.com/091022tales and click on Feedback Loop to post a comment on this Tale.

BY PANCH CHANDRASEKARAN

Get Up to Speed with Multi-Gigabit Serial Transceivers

Are you being asked to make your next-generation product design connect to a high-bandwidth network with an unfamiliar or a yet-to-be-defined protocol? Are you making the transition from parallel to serial I/O chip-to-chip communications? Or do you just need the highest-serial bandwidth, most reliable multi-gigabit transceivers the industry has to offer?

You are not alone. Serial connectivity is no longer just the design domain of communications engineers. Today, a growing number of designers in the consumer, automotive, industrial control, broadcast equipment, aerospace and defense markets are being tasked with developing products that employ multi-gigabit serial transceiver technology to communicate with next-generation, high-demanding, high-speed networks.

Today's quest for more bandwidth and better efficiency means that many designers like you must quickly get up to speed with the analog nuances of multi-gigabit serial transceivers. Luckily, Xilinx® has engineered its Targeted Design Platforms to help you.

Over the last two decades, the world's top telecommunications companies have relied upon Xilinx FPGAs' mix of logic functionality, high-speed memory, parallel connectivity, and serial I/O capabilities to create every generation of modern communications equipment.

With many years of experience serving the communication markets, Xilinx is able to help designers in a broad set of markets to quickly master gigabit serial transceiver technology and leverage it to create innovative products.

	MAINSTREAM	HIGH-END	ULTRA HIGH-END
LINE RATES	• Up to 3.2Gpbs	• Up to 6.5Gpbs	• Beyond 11Gpbs
FOCUS	• Simplicity, ease of design, and results	• Increased capabilities and performance	• Achieving breakthrough bandwdith
MARKET SEGMENTS: Wired	• Low-cost, efficient protocol bridging	• Advanced protocol mapping, performance optimized backplanes	• Cutting edge protocol support, advance processing capabilities
MARKET SEGMENTS: Wireless	• Low-cost, Femto/ Picocell deployment	• Cost/Power efficient, mainstream deployment	
MARKET SEGMENTS: Video Broadcast	• Efficient processing and routing capabilities	• Accelerated encoding and processing	• High-data aggregation/ routing, advanced processing capabilities
MARKET SEGMENTS: Consumer	• Cost-effective integration, simplified serial interfaces		
MARKET SEGMENTS: Automotive	• Low-power, cost-optimized, and flexible serial IO connectivity		
	SPARTAN LXT FPGAs	VIRTEX LXT FPGAs	VIRTEX HXT FPGAs

In 2009, Xilinx introduced both of its next-generation FPGA families — the high performance Virtex®-6 family and low-cost Spartan®-6 family providing Xilinx customers access to a full line of serial transceiver-rich FPGAs that can easily maintain line rates from up to 3.2Gbps in the Spartan-6 family, to up to 6.5Gbps in its Virtex-6 LXT devices, all the way beyond 11Gbps in the Virtex-6 HXT devices.

What's more, Xilinx announced this full range of serial connectivity-enabled FPGAs as the foundation of its new Targeted Design Platform strategy—combining the full line of transceiver-rich FPGAs with world-class tools, validated IP, reference designs, training, and support all delivered in domain and market specific kits. The Targeted Design Platforms allow customers to get their products to market faster than ever before.

With the ISE® Design Suite, customers can now get started on their designs targeting Virtex-6 HXT devices, as well as enhanced support for Spartan-6 LXT and Virtex-6 LXT and Virtex-6 SXT devices. Over the next several months, Xilinx will deliver a number of connectivity enabled design kits targeting wired, wireless broadcast video, packet processing, and traffic management application using either Virtex-6 devices for high performance, or Spartan-6 devices for low cost.

To learn more, visit the Connectivity Page at www.xilinx.com/connectivity where you'll find documentation, videos, links to software and IP downloads, and much more for helping you get up to speed no matter which fast lane you're on.

About the Author: Panch Chandrasekaran is the Sr. Product Marketing Manager at Xilinx Inc. (San Jose, Calif.). Contact him at more_info@xilinx.com

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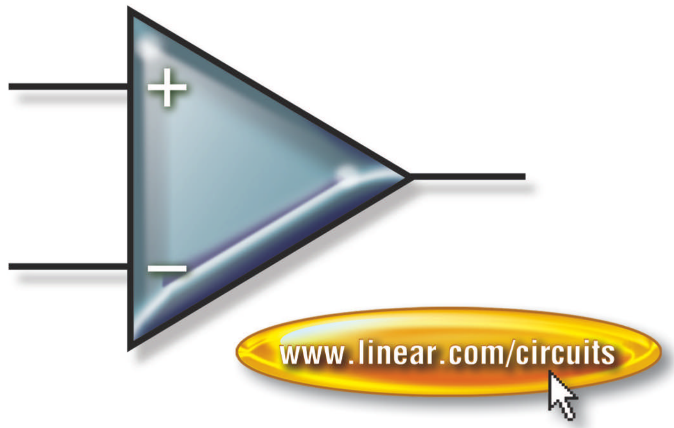

Tiny Package | Rail-to-Rail Outputs/Inputs | Minimal Drift | Low Noise | Low Bias Current | Wide Supply Range

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Precision Op Amps

Industry Standard Amplifiers	Description	Updated Amplifiers	New Features
LT®1078/9 LT2078/9	Precision, Micropower, Single Supply	LTC®6078/9*	Rail-to-Rail, Lower Noise, Faster, 125°C Specified
LT1008 LT1012 LT1097	Precision, Low Noise, C-Load Stable	LT1880 LT6010	Rail-to-Rail, SOT-23
LT1112 LT1114	Low Power, Matching Specs, C-Load Stable	LT1881/2 LT6011/2/4	Rail-to-Rail, 3mm x 3mm DFN
LT1494/5/6	Ultralow Power, Rail-to-Rail, Precision	LT6003/4/5*	Lower Supply Range, Smaller Packages
LT1055/6/7/8 LT1169	Picoamp Input Bias Current	LTC6240/1/2/4* LTC6084/5* LTC6087/8*	Rail-to-Rail, Lower Power, Smaller Packages, Faster, 125°C Specified
LT1013/4	Low Offset, Low Offset Drift, Low Power	LT1490A LT1491A	Rail-to-Rail, Rugged, 125°C Specified, 3mm x 3mm DFN
LT1028/LT1128	Low Noise, Low Drift	LT6200/1* LT6230/1/2	Lower Power, Faster, Rail-to-Rail, SOT-23
LT1007 LT1037	Extremely Low Noise	LT1677/8/9	Rail-to-Rail
LT1124/5/6/7	Low Noise, Low 1/f Corner, Precision	LT6202/3/4* LT6233/4/5	Lower Power, Faster, Rail-to-Rail, SOT-23
LTC1050/1/2/3	Zero Drift	LTC2050/1/2/4/5*	Smaller Packages, 125°C Specified

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