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EDN

VOICE OF THE ENGINEER

AUG 16
Issue 17/2007
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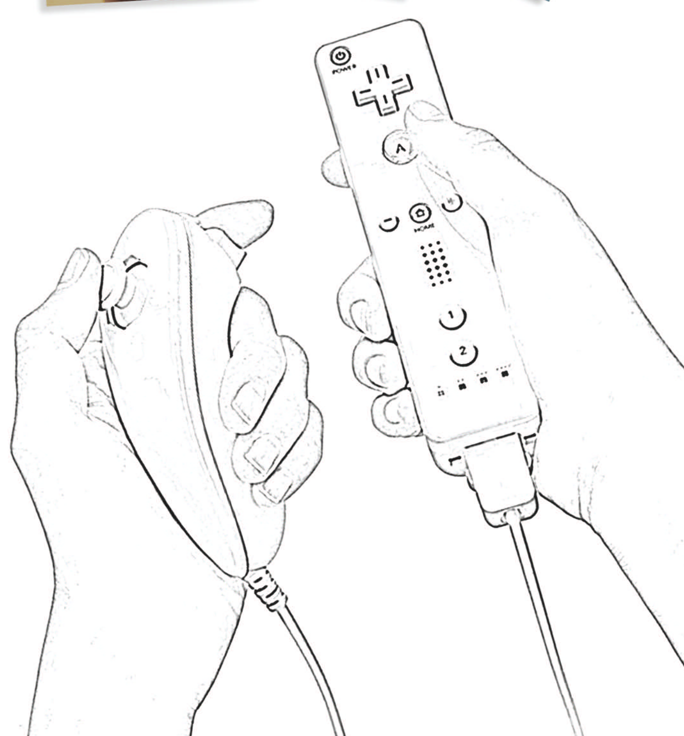

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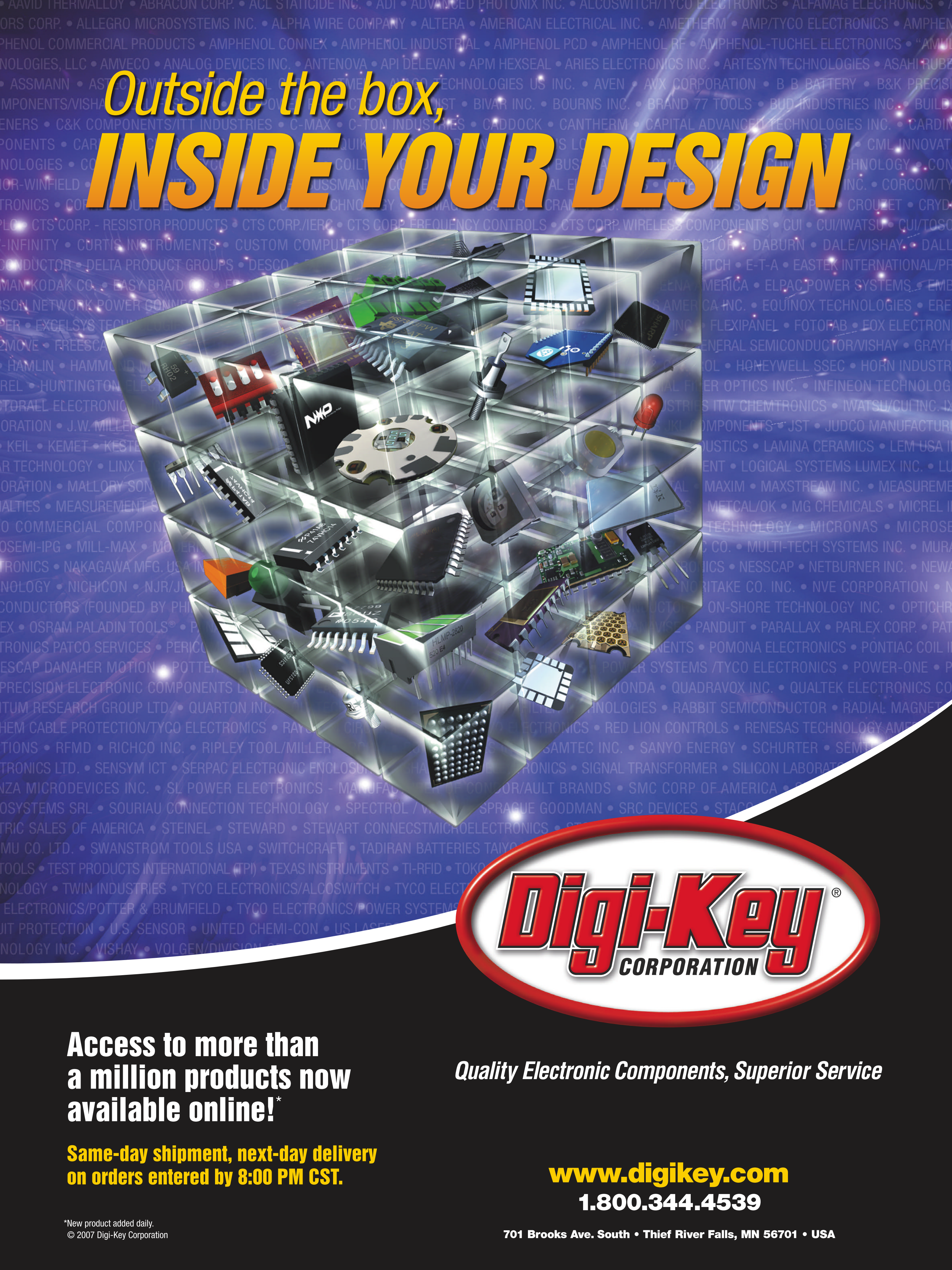

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- Mini SOIC-8 packaging (dual LMV652)
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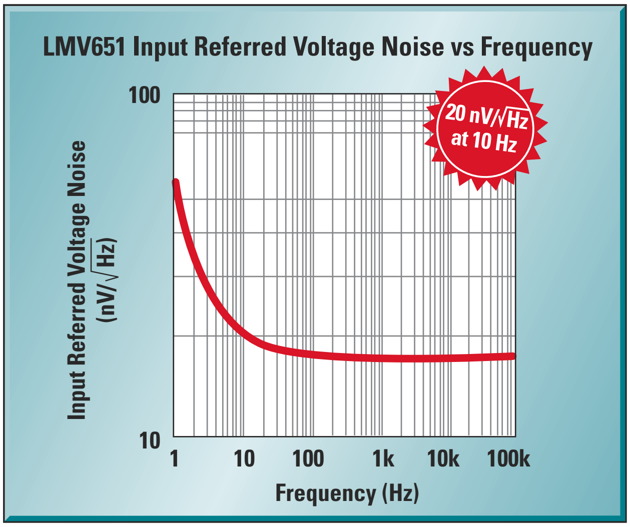

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- High unity gain bandwidth: 3 MHz
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- PSRR: 90 dB
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- Mini SOIC-8 packaging (dual LMV552)
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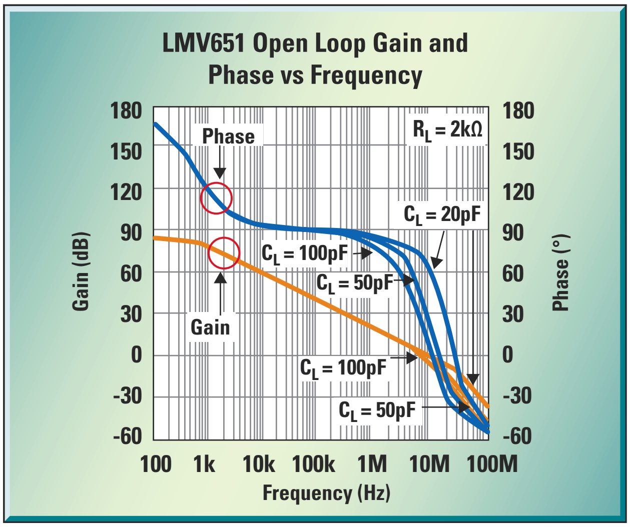

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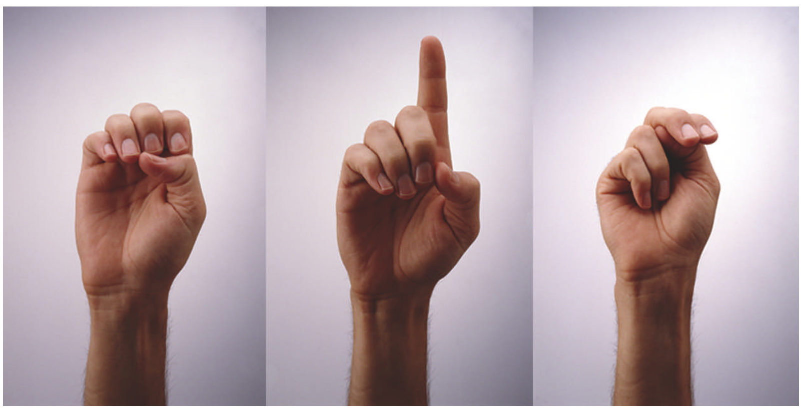
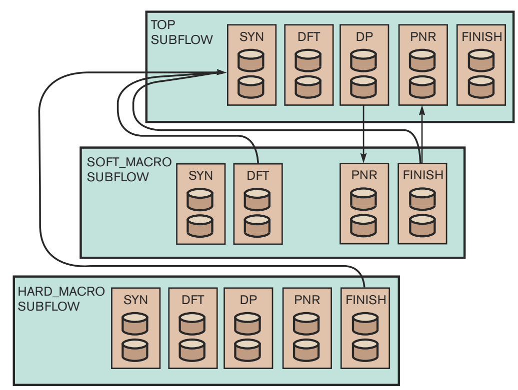
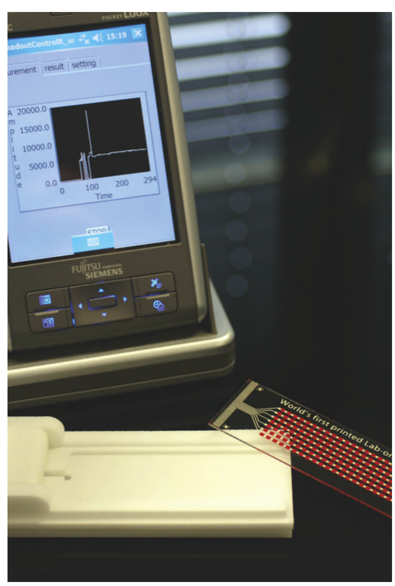
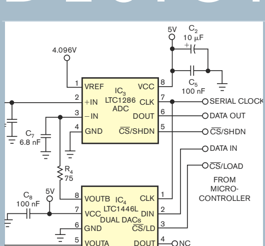






DESIGNIDEAS



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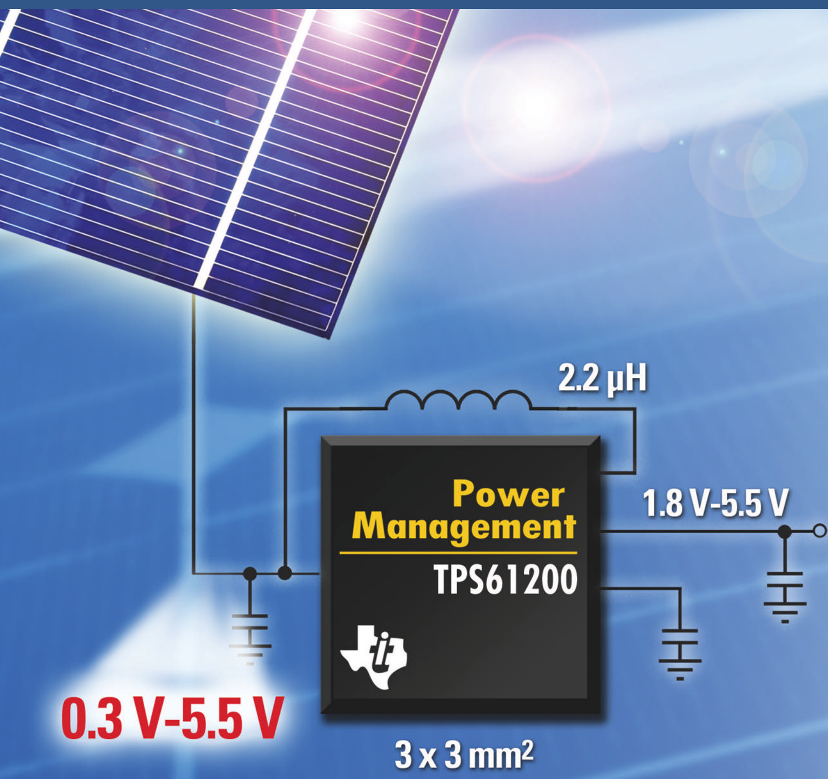
Manages Single Solar and Micro-Fuel Cells



Applications

- Single solar cell and micro-fuel cell powered products
- 1-/2-/3-cell alkaline, NiMH or 1-cell Li-Ion battery-powered products
- Portable solar charger
- Portable audio and media players
- Digital still camera
- Digital radio player

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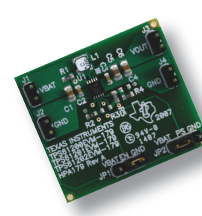

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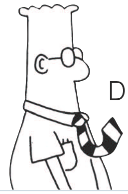

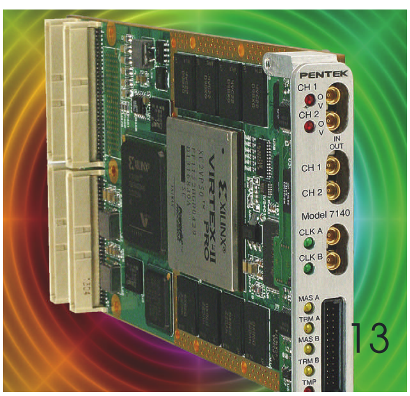

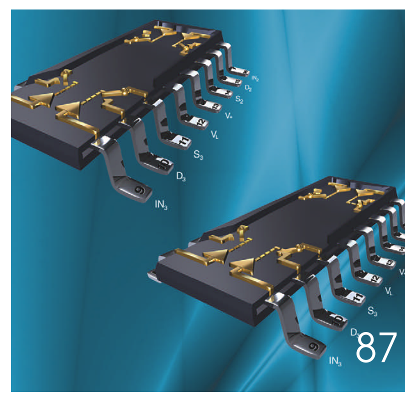

DEPARTMENTS & COLUMNS

PRODUCT ROUNDUP

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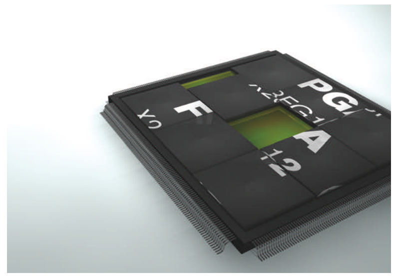

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We're proud to announce a significant upgrade to our video section, *EDN* Tech Clips. Tune in today to check it out, and while you're there, view our latest Video Design Idea, in which Bonnie Baker, senior applications engineer at Texas Instruments and a regular *EDN* columnist, demonstrates a simple way to add DAC functions to a microcontroller-based system using only an op amp and two passive components.
→ www.edn.com/techclips

FROM *EDN*'s BLOGS

Efficient power-grid reporting and response
From PowerSource, by Margery Conner

Last week, I had a long conversation with one of the system architects for a new intelligent power grid. "Intelligent" refers to virtually all pieces' of the grid having sensor and communication capability. Aside from the gee-whiz claims of a smart grid that will be able to fuel our plug-in hybrid electric vehicles at night from energy that we sell to the grid from our roof-based solar cells during the day, what's the practical short-term benefit to a power customer of an intelligent power grid?

Here's the answer: Generally speaking, utilities today rely on people calling in to report an outage to know when there's a problem. The equipment today was designed and often installed 50 years ago with little or no remote-monitoring capability. Knowing immediately what the problem is allows the grid to take action to ensure that other parts of the grid don't also go down.
→ www.edn.com/070816toc5

BY MAURY WRIGHT, EDITORIAL DIRECTOR

“Mind of the Engineer” yields range of responses

In my last column, I highlighted some of the results of our “Mind of the Engineer” research (**Reference 1**). Most of that column comprised answers to aided-response—multiple-choice—questions. But *EDN* received a huge number of open-ended, verbatim responses as well, especially to the question: When thinking about how your engineering role has changed in the past three years, what has been the greatest challenge? I thought you might be interested in a sampling of the responses.

Management certainly took its share of criticism, in terms of both technical competence and project definition and execution.

- “Management is going downhill, technically. [Managers] also have a very shortsighted mentality. I am continuously told about the time to market and that ‘we might miss the market.’ I wonder what Henry Ford thought about this … if he thought his product would disappear in six months.”
- “Many projects are started in a rush because we needed this product ‘yesterday.’ Ultimately, the project is abandoned in a few months when the next ‘got-to-have-it’ project comes along.”
- “The poor reasoning used by management for developing a new product, which is mostly based on near-term gains and success instead of long-range success. The rabid need for instant gratification, whether cash reward, bottom-line profits, or shareholder value, instead of a steady plan based on either customer needs or quality product.”

You may remember from the previous column and even from the 2006 study that engineers are taking on more and more tasks, both within multiple engineering disciplines and in sales, marketing, and manufacturing. Here, too, participants had some things to say about their challenges:

- “The greatest challenge has been meeting unplanned sales/support demands and still accomplishing my existing product-development goals.”
- “Integrating the digital and analog worlds has become a little easier because of the work done by the manufacturers. I am doing a lot more analog work than ever and at higher speeds than I ever envisioned.”
- “I find myself responsible for more phases of the design and more facets of it. I have taken over the tasks of other engineering disciplines, because we don't have those engineers in the organization. Now, I’m also responsible for the QC [quality control], the testing, even some of the mechanical-engineering aspects of the product design.”

The challenges of global and offshore issues were also prevalent responses:

- “‘Offshoring’ new designs and product development to Taiwan and mainland China, whether complicated or not. The US engineer, therefore, must constantly compensate [for] or redesign the changes the contract manufacturers perform without permission.”
- “New designs that US engineers out of college should be working on get outsourced, and, therefore, these new engineers are not getting the exposure [to] and enjoyment of designing and developing a product. They are put in a role as managing the designs, not performing them.”
- “Pressure to do more things more quickly at higher quality levels than ever before. Pressure from offshoring of engineering jobs makes it necessary to be ‘superproductive’ to match the large number of inexpensive offshore engineers that can be used to cover for lower capability and efficiency in low-labor-cost areas.”

My last column ended on a positive note, with the observation that most respondents to our survey would recommend the engineering profession to a student. Alas, not all see things as quite so rosy, as the following comment clearly states:

- “Engineers used to be respected professionals; now we’re just commodity items. Stress is rising, job satisfaction is falling, job security has become nonexistent, and all this is taking product quality down with it.”

But not all is lost, according to the following respondent:

- “Learning to adapt new technologies to new products, which may contain new technologies, as well. That is both the greatest challenge and the greatest source of pleasure in the job.”EDN

REFERENCE

1 Wright, Maury, “Research confirms suspicions and reveals surprises,” *EDN*, Aug 2, 2007, pg 10, www.edn.com/article/CA6462565.

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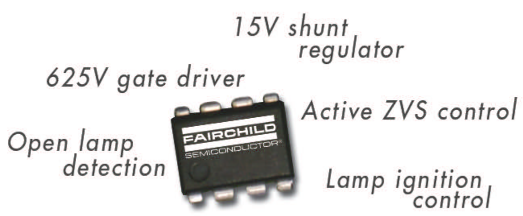

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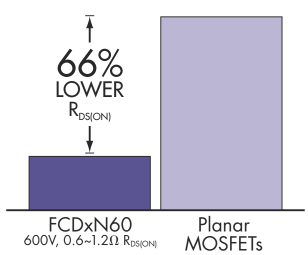

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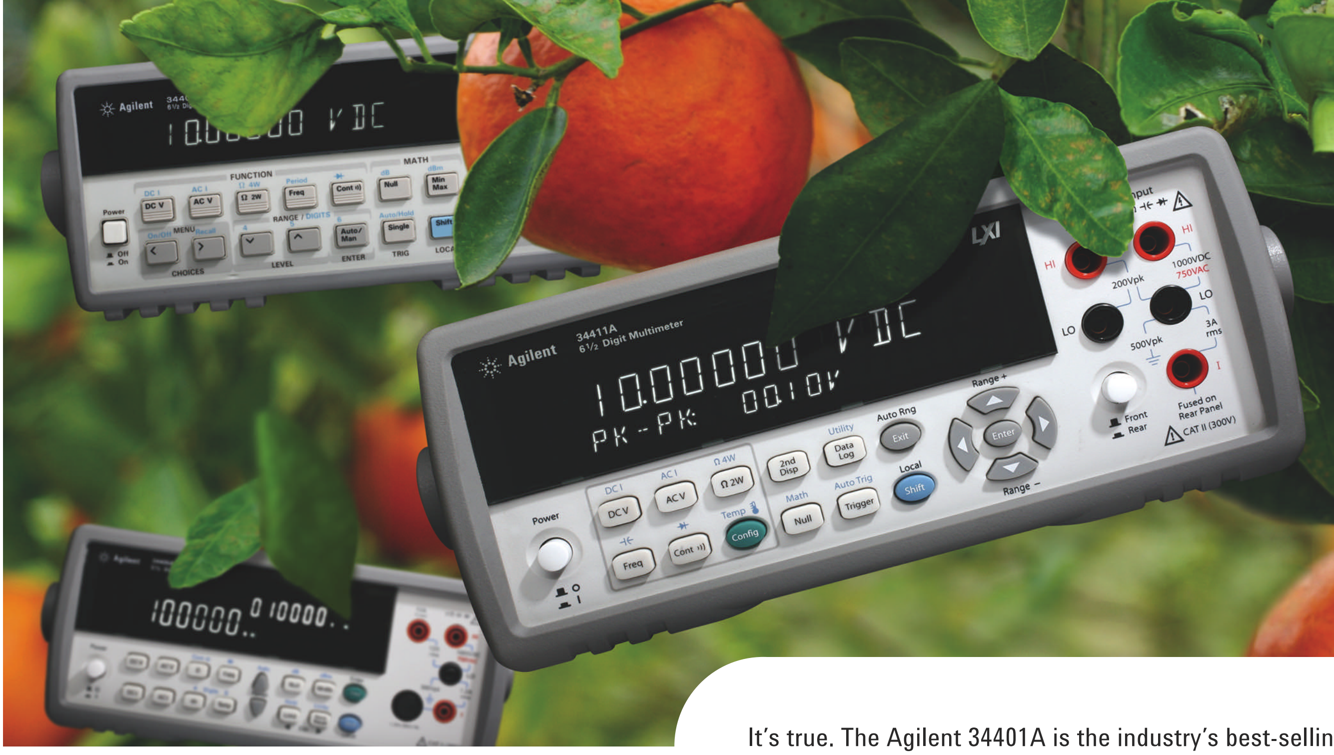

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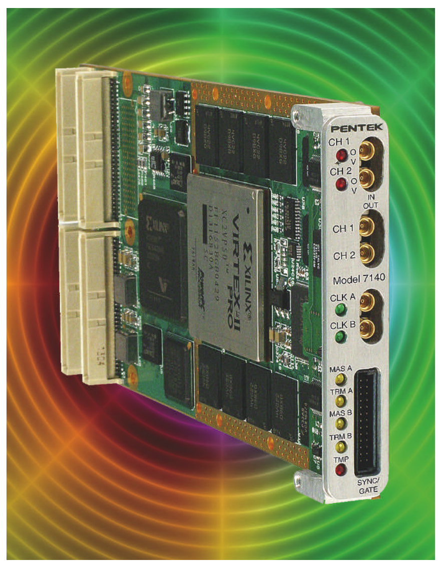
Agilent Technologies

Digital downconverter expands transceiver bandwidth

With signal-intelligence, radar, and communications-systems applications in mind, Pentek recently released the Model 7140-420 dual digital transceiver with an integral FPGA-based digital downconverter and interpolation filter. The module is a complete software-radio system in a PMC/XMC form factor and features two ADCs and two DACs for direct connection to high- and intermediate-frequency ports. The module handles a range of input- and output-signal bandwidths from 4.8 kHz to 40 MHz, allowing signal-intelligence users to easily move from an 8-kHz-bandwidth voiceband signal in one application to a 10-MHz cell-phone signal in the next. Pentek supports libraries, device drivers, and software-development tools for PCs running Windows 2000/XP or Linux operating systems and PowerPCs running VxWorks, Linux, or eCos operating systems. Prices start at $11,995, and delivery is eight to 10 weeks.

—by Warren Webb

▷**Pentek Inc**, www.pentek.com.



The Pentek Model 7140-420 dual digital transceiver features digital-downconverter and interpolation-filter intellectual-property cores to boost bandwidth range.

FEEDBACK LOOP

"Why should one constrain oneself to 100-Mbit Ethernet in the home by using Category 5 (cable), when Category 6 costs pennies per foot more and allows for gigabit Ethernet? In most home-Ethernet setups, far and away the largest percentage of the cost is for the labor to pull the wire, punch it down, and mount it in wall outlets. I have some fresh, new, 1000-foot reels of Cat 5 if you want one for slightly more than the price of a song."

—Reader Ben Myers, in *EDN*'s Feedback Loop, at www.edn.com/article/CA6455604. Add your comments.

MEMS-based resistor divider sets ohmic resistance and TCR

Temperature-sensitive circuits, such as those in analog instrumentation, optical networks, or power supplies, usually require temperature compensation. For those applications, Microbridge has added electronic temperature compensation to its line of MEMS (microelectromechanical-system)-based adjustable resistors, which the company calls "rejustors," to make a passive electronic-temperature-compensation-resistor divider (see "Rejustors change resistance by thermal annealing of polySi," www.edn.com/070816p1).

The highly accurate, 30-kΩ MBT-303-A divider comprises two resistors in series. You can set each resistor's value to 21 to 30 kΩ with an accuracy of 0.01%. You can adjust both ohmic resistance and the positive and negative TCR (temperature coefficient of resistance) for each resistor after you mount the chip in a PCB (printed-circuit board), allowing compensation for any stresses or changes during manufacturing. Setting the rejustor takes approximately a second. The MBT-303-A requires no power source during operation, has no wiper resistance, and needs no external temperature sensor because it has its own temperature sensor and adjustment controller. It can handle as much as 1 mW of power and frequencies into the gigahertz range. Available in a 16-lead QFN package or an eight-pin SOIC package, the new MBT-303-A passive rejustor is currently available for sampling and costs $1.67 (1000).

—by Margery Conner

▷**Microbridge Technologies**, www.mbridgetech.com.

Apache announces product for IC-to-package power and EMI analysis

Expanding on its RedHawk and Sidewinder IC-power-analysis tools and its Sahara-PTE on-chip thermal-analysis tools, Apache Design now is entering the system-analysis market with Sentinel, a new product that addresses system-level power integrity, I/O-SSO (input/output-simultaneous-switching-output), and EMI (electromagnetic-interference) challenges across ICs, packages, and, eventually, PCBs (printed-circuit boards). In May, the company announced the Sentinel-CPM (chip-power model) for chip-to-package power integrity and LC (inductance-capacitance)-resonance modeling; the Sentinel-SSO high-capacity I/O-subsystem-simulation tool for pad and package selection; and the Sentinel-EMI tool for simultaneously modeling EMI in IC cores and I/O. "Power- and signal-integrity challenges do not stop just at the boundary of SOC [system on chip]," says Apache's chief executive officer, Andrew Yang. "[The challenges] go through I/O and off-chip through the PCB, and they determine what package designers should use and what power pads they should allocate."

Traditionally, separate groups design ICs, packages, and PCBs; as a result, each group tends to overdesign, which delays projects from reaching the market and adds cost. Over the last few years, EDA vendors, such as Cadence (www.cadence.com), Sigrity (www.sigrity.com), and Rio Design Automation (www.rio-da.com), have been offering IC-package and PCB co-design tools. Apache is one of the first companies to take on power issues in this domain.

Various cores in an IC generate noise that propagates to the I/O through the power-ground network in the form of voltage drop and ground bounce. This noise couples into the I/O and affects its performance and the quality of the signal. This coupling noise can also propagate to the package and PCB through power pads. "In I/O-interface design, you cannot simply ignore core noise coupling into the I/O," says Yang. "But, because of the size and complexity of today's ICs, you cannot provide the switching activity of every gate and transistor in every core to the I/O." To avoid this problem, I/O designers typically run a SPICE simulation of 16 I/Os and then multiply the result by 10 to derive the behavior of a full bank of I/O.

> "Designers feed the results of RedHawk sign-off power-analysis tool into Sentinel-CPM, partition the design into blocks, and then use the tool to generate CPMs.

According to Yang, however, Apache has come up with a better way to accurately and simultaneously model the behavior of 256 or 512 I/Os and create a model that popular broadband-model generators—from vendors such as Ansoft (www.ansoft.com), Sigrity, Optimal (www.optimalcorp.com), and Fluent (www.fluent.com)—can read.

To achieve this performance, Apache created the Sentinel-CPM generator. Designers feed the results of Apache's RedHawk sign-off power-analysis tool into Sentinel-CPM, partition the design into blocks, and then use the tool to generate CPMs based on partitions in the chip design. A CPM is somewhat similar to an IBIS (I/O Buffer Information Specification) model in that it is package-independent and compact. However, IBIS models typically find use in performance modeling of a chip, whereas CPMs also provide power and ground information. "A CPM has complete information of the on-die parasitic elements, such as power-ground resistance, and all the capacitance associated with the chip, including capacitance from transistors and decoupling capacitors from power and ground," says Yang.

Apache employed a partitioning approach to help users choose the granularity at which they want to model their designs. He advises users of the Sentinel-CPM tool not to use the tool to create a single port model. "In reality, chips have different switching in different locations, and, to truly model the behavior of the chip, you have to account for these spatial effects," says Yang. The tool's default is to create a model based on 64 ports, or partitions. Users can create 32-, 128-, or 256-port models. The higher granularity models are more complex and take longer to generate. In addition to RC (resistance-capacitance) information, each partition includes coupling or control sources that couple to every other partitioned block. Yang says that Sentinel-EMI accurately models all EMI sources, and the company is working with several commercial EMI-tool vendors to ensure that their tools can read the models. The price for the Sentinel product line starts at $100,000 for either Sentinel-CPM or Sentinel-SSO. Sentinel-EMI sells for $50,000 and requires Sentinel-CPM.

—by Michael Santarini

▷**Apache Design Automation**, www.apache-da.com.

DILBERT By Scott Adams

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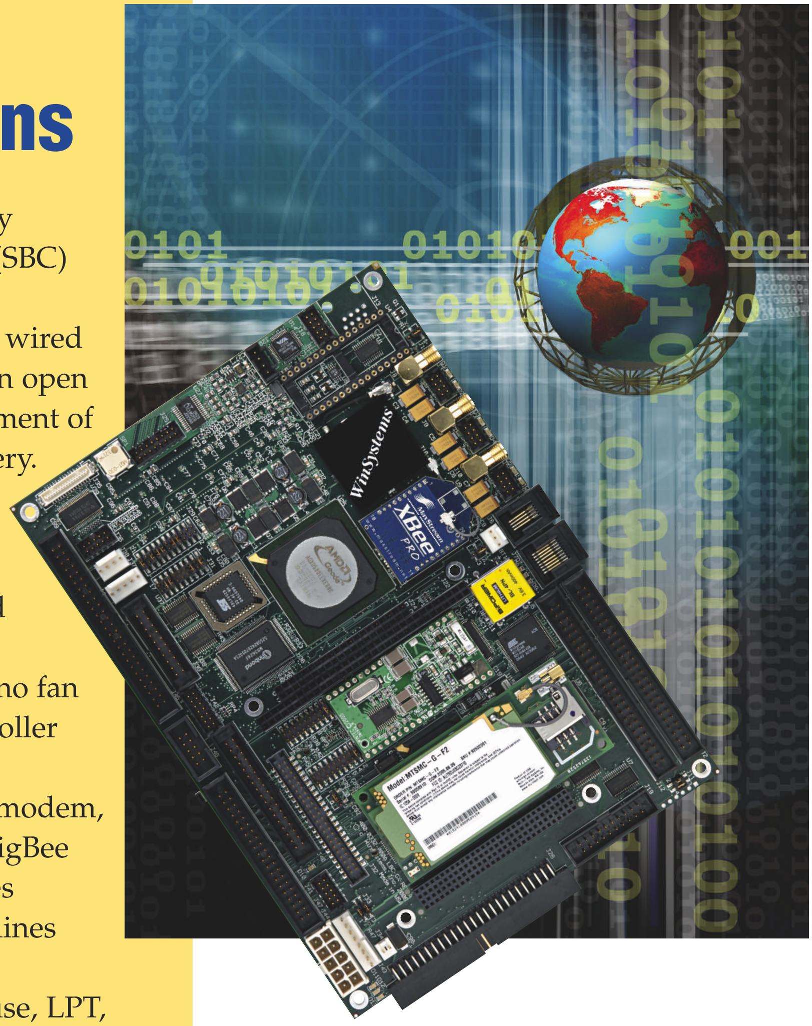

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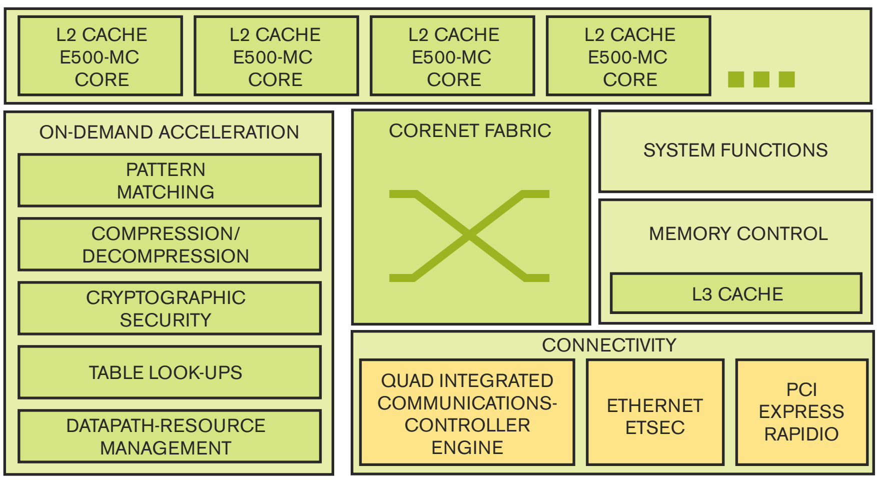
45-nm, multicore microarchitecture targets communications platforms

Freescale structured its next-generation multicore platform on a scalable on-chip fabric that supports concurrent, nonblocking connectivity for as many as 32 heterogeneous processor cores. The platform features application accelerators and a trilevel-cache hierarchy that supports 100%-hardware-based cache coherency. It will initially center on an enhanced 1.5-GHz Power Architecture e500-mc core, based on the e500 core, with backside L2 caches for each core, multiple L3 shared caches, and multiple memory controllers. The on-demand application accelerators include pattern matching, decompression, cryptographic security, table look-ups, and datapath-resource management to handle intrachip message passing and memory-buffer reservation.

The multicore platform will use a "hypervisor" environment to support multiple individual operating systems that can safely share system resources, including processor cores, memory, and other on-chip functions. Freescale plans to offer the first product it based on this platform for sampling in late 2008; however, a Virtutech simulation environment using Freescale's current-generation multicore MPC8572E and MPC8641D processors is available now. The simulation environment for Freescale's new multicore platform will be available in the fourth quarter of 2007.—**by Robert Cravotta**

▷**Freescale**, www.freescale.com.



The scalable microarchitecture can support as many as 32 e500 cores. These cores can interact with the on-demand application accelerators that include pattern matching, decompression, cryptographic security, table look-ups, and datapath-resource management to handle intrachip message passing and memory-buffer reservation.

PLUG-IN HYBRID VEHICLES CAN GREATLY IMPACT EMISSIONS AND PETROLEUM DEPENDENCY

Gasoline prices have soared, greenhouse-gas emissions are environmental concerns, and particulate emissions continue to have a health impact. It's clear that, even five years from now, the profile of our almost-exclusively gas-powered-automobile-based transportation system must change. Government regulations and public concern about foreign-oil dependency will demand it. One possible scenario has the US public switching to PHEVs (plug-in hybrid electric vehicles)–cars that rely on a battery with a range of 40 to 70 miles for their usual daily commute, with a small engine that can power the battery for an extended range. But do PHEVs just shift the pollution and fuel used to the nation's electrical grid?

To answer that question, the EPRI (Electric Power Research Institute) and the NRDC (Natural Resources Defense Council) last month released a study, "Environmental Assessment of Plug-In Hybrid Electric Vehicles" (www.epri-reports.org). The study concludes that PHEVs and the grid–both as it exists now and as it evolves by 2050–will work well together, with the adoption of PHEVs reducing US dependence on petroleum by 90% and reducing greenhouse emissions by 80%.

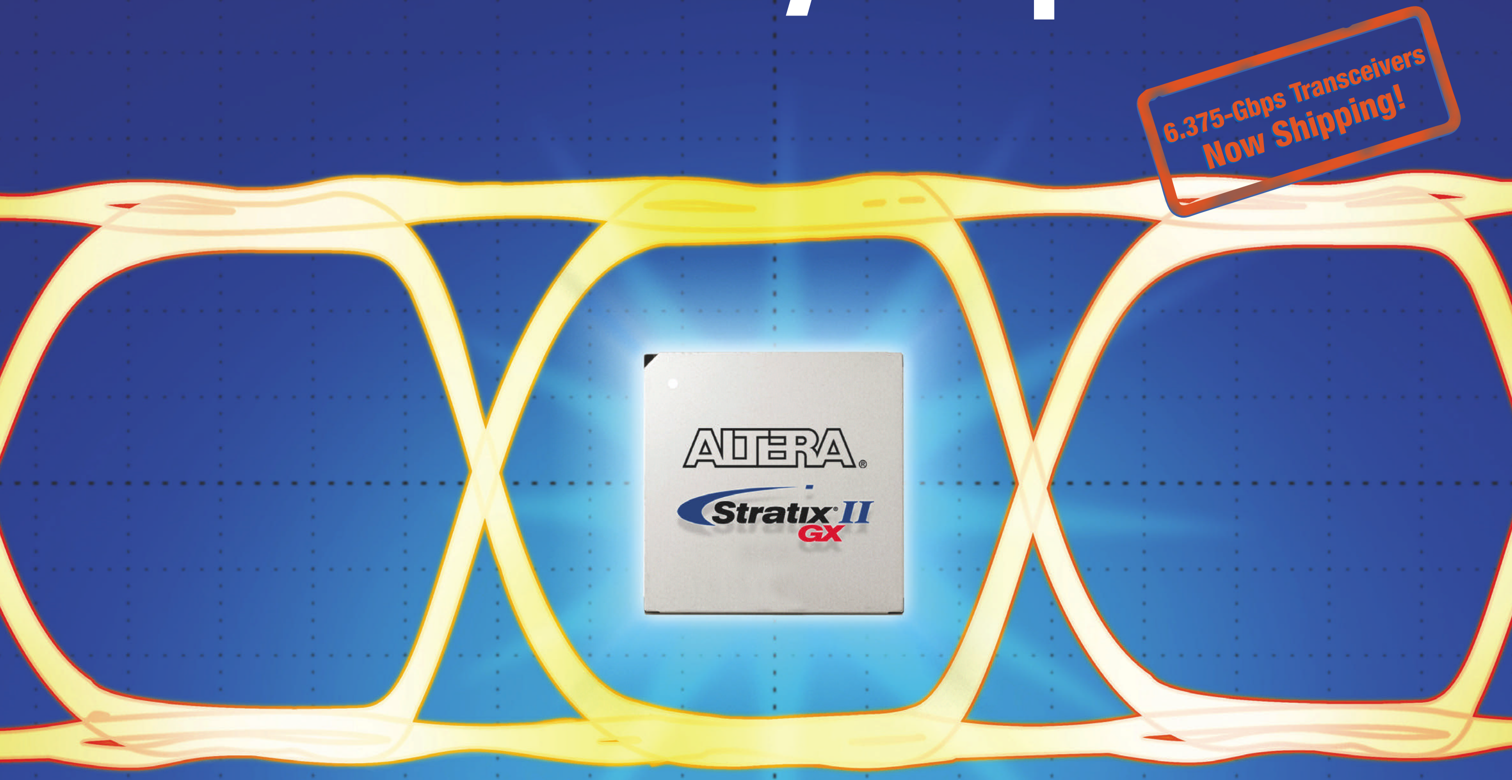
In the question-and-answer session that followed the organizations' introduction of the study, an audience member raised a question about the viability of PHEVs themselves; many question whether any battery today can meet the safety and durability requirements of combined deep cycling of the battery over lifetime distances of 100,000 miles. Representatives from General Motors (www.gm.com) and Edison International (www.edison.com) in attendance said that the history of battery development shows that new battery technologies consistently exceed the industry's initial expectations. For example, a partnership of Saft (www.saftbatteries.com) and Johnson Controls (www.johnsoncontrols.com) has demonstrated a battery that withstands the equivalent of seven years of deep cycling with a capacity loss of only 6 to 7%.

—by Margery Conner

▶**Electric Power Research Institute, www.epri.com.**

▶**Natural Resources Defense Council, www.nrdc.org.**

The FPGA Eye Opener!



Transmit eye diagram at 6.375 Gbps. For characterization details, see www.altera.com/stratix2gx/characterization.

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Ultrawideband sampling scope lets you see waveforms at points you can't probe

Compared with other scopes, LeCroy's WaveExpert 100H 100-GHz-maximum-bandwidth near-real-time-sampling oscilloscope provides significantly greater de-embedding power, which it demonstrates through an ability to perform previously impossible feats. "De-embedding" refers to an instrument's ability to make its effect on a measurement disappear by using digital-signal processing to show you what you wanted to measure but couldn't because connecting the instrument to the UUT (unit under test) changes what you are trying to observe.

Traditional de-embedding corrects for unavoidable changes that destroy a measurement's validity when you probe a point where a quantity of interest exists. With an SDA (serial-data-analysis) option, however, the new LeCroy scope's virtual-probing feature enables the display of waveforms that exist within the UUT but only at points you can't probe at all—for example, at circuit nodes buried within ICs.

The capability depends on the use of mathematical models to describe how the UUT affects signals you'd like to—but can't—observe and the scopes' ability to convolve the response of these models with signals you *can* probe. The scope can thus derive and display—almost in real time—waveforms that exist only at the inaccessible points.

The SDA option also includes the Eye Doctor analysis tool for line-receiver ICs in such ultrahigh-speed serial protocols as second-generation PCI Express, Serial ATA (Advanced Technology Attachment), XAUI (10-Gbps attachment-unit interface), and 10 GbE (gigabit Ethernet). These protocols operate at speeds of 5 Gbps and more. Eye Doctor merges the signal and channel responses to accurately measure receiver tolerance and display signals that would otherwise be inaccessible within the receiver. The combination of Eye Doctor and virtual probing also enables accurate measurement of stressed-eye patterns at the normally inaccessible receiver input, and equalized-receiver emulation provides a receiver's-eye view of equalized signals.

With its SDA option, the WaveExpert 100H 100-GHz-maximum-bandwidth near-real-time-sampling oscilloscope calculates and displays waveforms you cannot otherwise access, such as these from within ultrahigh-speed serial-line receivers.

Another characteristic of the ultrahigh-speed serial protocols is their use of very long data patterns. With one channel active, the scope can handle repetitive patterns as deep as 60 Mbits, represented by 510M samples—that is, an average of 8.5 8-bit samples per unit interval—according to LeCroy, the deepest memory of any sampling oscilloscope. Coupled with a new optional coherent-interleaved-sampling timebase, the deep memory yields a jitter noise floor of 230 fsec—that is, 0.23 psec—while it acquires long patterns at rates hundreds of times as great as those of other sampling scopes. Moreover, by enabling frequency-domain techniques to use long data sets for estimating jitter, the new scope avoids the overestimation that plagues estimates from scopes that have limited memory.

The WE-100H mainframe, which includes TDR (time-domain-reflectometer) and S-parameter software, costs $22,150 and accommodates four sampling heads. The coherent-interleaved-sampling timebase adds $16,950. Waveform memory of 510 Mbytes adds $6985. The SDA/Eye Doctor option adds $11,987. The list of eight sampling heads, whose prices top out at $52,500, includes five electrical and three optical units. Among the electrical units, a 20-GHz unit with TDR capabilities costs $7000, and a 100-GHz unit costs $32,000.

—by Dan Strassberg

▷**LeCroy Corp**, www.lecroy.com.

BRION'S TACHYON BOX OFFERS VIRTUAL TAPEOUT

Fresh from its acquisition by ASML, Brion Technologies is putting the D in DFM (design for manufacturing) with its new offering, Tachyon LAD (lithography-aware design). Until now, Brion offered only hardware-assisted systems for speeding OPC (optical-proximity correction) with the Tachyon OPC1 and LMC (lithography-model checking) with the Tachyon LMC products. Brion aims those tools at lithography/mask-data-preparation and manufacturing engineers. Now, the company is offering a version of its products for IC-design engineers to ensure that their IC layouts are lithographically correct.

The company's vice president of design businesses, Mike Gianfagna, former chief executive officer of Aprio Technologies (now part of Blaze DFM, www.blaze-dfm.com), says that Brion has a strong user base in the mask-making and manufacturing sectors with its Tachyon LMC and OPC1 offerings. Semiconductor manufacturers are using the tools not only to verify that masks are OPC-compliant, but also to create OPC rules and lithography models. "There is great validation and trust in the Brion engine for both modeling and OPC," says Gianfagna. "So, with Tachyon, Brion takes all the modeling validation and packages it to bring all the accuracy that happens during tapeout into the design flow itself. It is, essentially, a virtual tapeout."

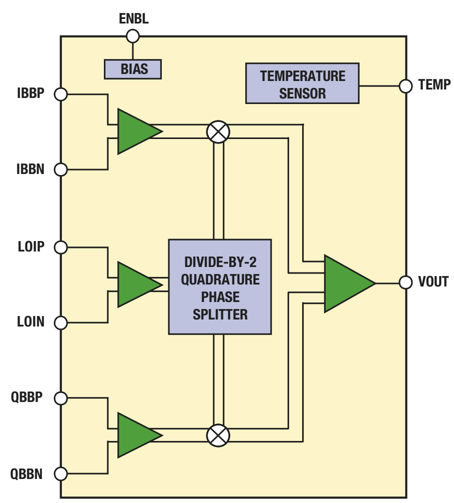
—by Michael Santarini

▶**Brion Technologies**, www.brion.com.

LEADING inside

A series of engineering insights by Analog Devices.

Broadband I/Q Modulator Eases Radio Design



ADL5385 I/Q Modulator Block Diagram

Modern digital radio transmitter design poses increasing challenges for equipment designers. The trend towards greater throughput of data is increasing the modulation density and carrier bandwidths of transmitted signals. To maintain good adjacent channel power ratio (ACPR) while transmitting the same rms power level, components with lower intermodulation distortion and lower noise must be used.

Baseband, IF, and RF bandwidth must be flat across the channel to maintain the spectral shape of the modulated carrier. When a radio transmitter design calls for operation over a very wide range of RF frequencies, the RF gain flatness of the overall signal chain becomes critical. Minimizing gain variations in the signal chain over frequency eases the burden of signal chain planning and budgeting.

The I/Q modulator is a critical component in the signal chain for modern digital transmitters. I/Q modulators perform the frequency translation that mixes the baseband signal to the desired location in the RF spectrum. An I/Q modulator consists of a local oscillator (LO) input that is split into in-phase (I) and quadrature (Q) components that are separated by 90°. These two signals drive separate mixers that are also driven by I and Q baseband signals. The outputs from both mixers are then summed to provide a modulated carrier either at RF or IF. The Analog Devices ADL5385 I/Q modulator contains these basic blocks (see illustration) and eases the designer's burden by providing broadband operation, high data rates, and excellent signal quality.

Many applications use a two-stage upconversion that requires more components, added cost, and complexity. The ADL5385 overcomes traditional polyphase limitations by utilizing an active divide-by-two LO splitter. The active splitter enables a wide tuning range that spans five octaves (50 MHz to 2.2 GHz). The LO and its complement are fed into two D flip flops. The output of the flip flops drives the mixer core. Because of the divide-by-two action of the LO signal, the LO must be twice the frequency of the desired RF output. LO symmetry is also extremely important as it directly contributes to the sideband suppression.

In single-channel modulation systems, data capacity can be increased by using higher order modulation techniques or by using more bandwidth. The challenge is to maintain flat gain across the bandwidth of the carrier to ensure that gain ripple is kept to a minimum, eliminating the need for precompensation. The ADL5385 0.1 dB baseband gain flatness extends out to 85 MHz, precluding the need for any precompensation for most applications.

Error vector magnitude (EVM) is a common measure of the quality of modulation of a signal, and it is directly affected by the quadrature and amplitude errors within the modulator. The amount of quadrature and amplitude errors can be gauged by observing the level of sideband suppression in a single-sideband spectrum. The native uncompensated sideband suppression of the ADL5385 is better than –38 dBc up to 900 MHz. Even higher performance can be achieved by adjusting the relative gain and phase of the baseband signals.

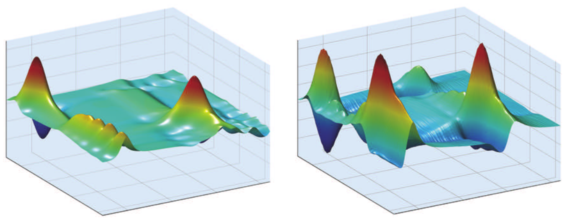
The low distortion of the ADL5385 enables it to achieve high output power levels with minimal adjacent channel leakage while allowing for less gain in the subsequent stages of the radio. This situation, along with the wide tuning range, permits the modulator to be used without factory calibration, significantly reducing the time and effort required for design and manufacturing.

To learn more about the ADL5385 and Analog Devices' extensive portfolio of RF and wireless components, visit *www.analog.com/LI-IQmod* or call 1-800-AnalogD. We offer data sheets, free samples, and additional information to help you with your radio design. ▶

*Author profile: **Yuping Toh** is an applications engineer in the RFW Products Group at Analog Devices.*

RESEARCH UPDATE

BY MATTHEW MILLER



The laser-induced energy emissions of semiconductor materials appear under existing theory (left) and in new experimental data (right). The large matching peaks in the right-hand image show pairs of particles called excitons oscillating in concert—a potentially useful effect for optoelectronic devices (courtesy JILA).

Researchers observe "crowd behavior" in semiconductors

Using atomic-scale measurements, scientists at JILA (which originally stood for the Joint Institute for Laboratory Astrophysics but now encompasses a wider breadth of science)—a joint venture of NIST (National Institute of Standards and Technology, www.nist.gov) and the University of Colorado at Boulder—have revealed a previously unknown type of collective behavior among semiconductor particles. The effect could prove helpful in the development of optoelectronic devices.

The researchers shot a sample of GaAs (gallium arsenide) with 100-fsec pulses of near-infrared laser light. Analyzing how the semiconductor altered the intensity and phase of the light, the researchers teased out a subtle coupling between pairs of particles called "excitons." By proving that excited particles oscillate in concert, the work supports advanced theoretical calculations about the electronic properties of semiconductors, thus refining scientists' ability to predict the magnitude and phase of emission signals.

Meanwhile, in another research project spying on group activity among electrons, researchers at the Massachusetts Institute of Technology have developed a novel spectroscopy technique that measures energy levels with resolution 1000 times greater than other methods.

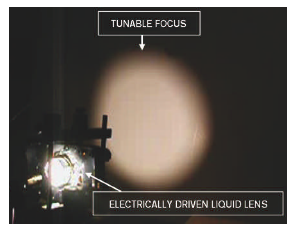
The work applies to electrons confined within 2-D planes—an arrangement that finds use in laboratory work and in high-frequency amplifiers, such as those in cell phones. The technique relies on quantum tunneling. By using short electrical pulses to induce electrons to tunnel from a 2-D system to a 3-D system and measuring the resulting voltage difference, the scientists deduced the energy state of the electrons in the 2-D system, according to MIT.

The experiments, which took place within a semiconducting crystal cooled to 0.1° above absolute zero, have revealed some surprising behavior, according to the researchers, who expect the technique to yield additional insights into physical phenomena involving electrons.

▷**JILA**, jilawww.colorado.edu.
▷**Massachusetts Institute of Technology**, www.mit.edu.

Licensing agreement advances tiny zoom lenses

Holochip has signed an agreement to license patented adaptive-lens technologies from the University of Central Florida (www.ucf.edu) for development in products for camera phones, digital cameras, and medical and military equipment. Shin-Tson Wu, a professor in the university's College of Optics and Photonics, earned the patents, which involve two approaches to adaptive lenses: liquid-crystal lenses, in which an external electric field induces liquid crystals to change their refractive index, and fluidic lenses, in which a flexible capsule containing a transparent optical fluid changes shape to adjust focal length.



A demonstration illustrates the ability of lenses based on liquid-crystal technology to alter their optical properties in response to applied voltages.

The fluidic approach suits space-constrained applications, and the liquid-crystal technology affords control over high-order aberrations that can lead to blurriness, making it suitable for applications in free-space optical communications and corrective eye wear, according to the university.

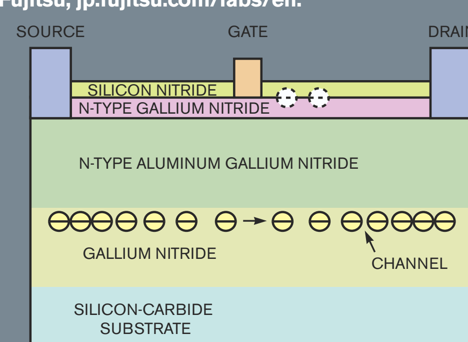
▷**Holochip**, www.holochip.com.

HIGH-RELIABILITY HEMTs GOOD FOR 100 YEARS AT 200°C

08.16.07

Fujitsu Laboratories reports that it has developed a technology to create high-power GaN (gallium-nitride) HEMTs (high-electron-mobility transistors) that can operate for more than 1 million hours at 200°C under a pinch-off condition with a drain voltage of 50V. A proprietary N-type GaN surface layer enables the high level of reliability by improving crystal quality and minimizing surface traps, according to the company. Devices based on the technology should find use in wireless-communication-infrastructure products, such as cellular and WiMax base stations.

▶Fujitsu, jp.fujitsu.com/labs/en.



Fujitsu claims this GaN HEMT structure delivers exceptional reliability.

BY PALLAB CHATTERJEE, CONTRIBUTING TECHNICAL EDITOR

Reading skills for IC design

There has been great progress in the worldwide education system to increase both the number of people who can read and their level of reading comprehension. Technology and semiconductors make possible a large part of this rise in reading education. This increased awareness of words and reading has changed the IC-tapeout flow. Current EDA tools allow long alphanumeric-string names, which, in turn, proivde a great deal of flexibility in the area of self-documentation to the design engineer. Most designs today have devices and nets with descriptive names. Instead of traditional labels, such as U10 or net162, companies label parts inputbuffer8, and signals have labels such as cache2address6.

This increasing number of descriptive terms greatly enhances an engineer's ability to keep track of components and connections at the device, gate, and runtime level. Using such terms simplifies the design-setup time for simulation, eases the interpretation of the output, and allows for automation of verification and regression testing.

A few guidelines exist for using these terms. In most reading books, lower-, mixed-, and upper-case text all mean the same thing: These cases just have different emphasis. Most EDA-design tools are based on parsing a text string as a variable, so specific alphanumeric sequences must match exactly to be the same. For a flow consisting of multiple EDA tools, the best practice requires designers to use only two options. First, differentiate items that should be different as separate signals with distinctly different name strings. For example, don't use "clock, Clock, and CLOCK"; instead, use "clock, Clock1, CLOCK2" in all instances. Second, all items with similiar labels become the same object—unconditionally and globally—at some point in the flow, such as clock, Clock, and CLOCK all becoming "clock."

With this text-parsing requirement, combining different forms of netlists to describe a complete circuit is a challenge unless uniformity exists in the naming conventions. To achieve this uniformity, a number of companies have instituted company-specific but tool-independent naming conventions. These naming conventions include such characters as *, _, [, and !; they also include library names and paths in calls to nonlocal modules, internal-versus-pin object-net names, and power-supply names.

With regard to naming conventions, how design engineers elect global signals and global supplies is the most controversial issue. Regular signals appearing in a netlist generally connect either by position in a list or by name at the module or subcircuit where they reside. For example, the netlist for a NAND gate has pins A, B, and OUT. The signal name A is local to just that subcircuit, and a design engineer may reuse the net name A on the description of another block without conflict.

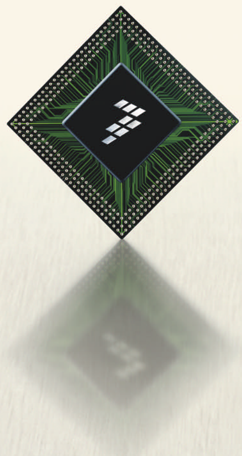
A global signal, however, does not appear in a pin list where it would get connected and possibly renamed at the next level of the assembly hierarchy. A global signal is a description of a wire connecting to all levels of a design, as the text string that names it determines. An example is GLOBAL=VDD. In this case, every device, module, or block that has a connection to a VDD net connects to the exact same VDD net. This scenario means only one VDD net exists in the design.

A lot of designers freely use the global declaration at the Verilog gate level, without realizing the implications on the device level and for physical-verification analysis. One of my customers had a design with 450 defined global names and only 26 pins. The LVS (layout-versus-schematic) check's interpretation of this situation was that the devices and ports with global names did not have to attach with wires to pass LVS. Most LVS run sets, unfortunately, use the command "connect by text." As a result, if a global signal exists in a netlist that resides in multiple modules or subcircuits, with the same labeling as that in the layout, then the LVS program will think that all of the text labels connect without actual wires to connect them.

As far as the LVS program knows, no errors exist. But electrons can't read, and you can't teach them how. Thus, they need real wires to go through to get from Point A to Point B. Deciding that it is OK to ignore an error message—that is, deciding that a waiver for an error is OK—is an instance of failing to implement the solution.

Remember three rules: Name different items differently, give the same name to items that are similiar, and use hard wires if you want to connect two things. **EDN**

Contact me at pallabc@siliconmap.net.



It helps BMW create cars that automatically adapt to the road.

How did one automaker enhance the driving experience? By working with Freescale to implement the industry's first use of FlexRay™ technology in the new BMW X5. Sensors collect data such as road speed, steering angle and acceleration and pass it along the in-vehicle network. The vehicle's suspension and handling then automatically adjust based on this information. Powerful Freescale microcontrollers are at the heart of this communications system, helping to create a smooth ride no matter how the road changes. Just one of the ways Freescale is making the world a smarter place—and putting automotive innovation into high gear. freescale.com/smarter

freescale™ semiconductor

BY MARTIN DELATEUR • CONSULTANT

Solid-state physics convinces customers

DANIEL VASCONCELLOS

I was working as a product engineer in the discrete division of a major semiconductor company in the early 1980s when the Big Three automotive companies—General Motors, Ford, and Chrysler—started to add many electronic accessories each model year. It was also when under-the-hood-temperature issues and reliability were major concerns, causing companies to change many 0 to 25°C specs to −40 to +125°C. Our customer rejected three shipments of 2N3906 transistors at incoming inspection, saying the parts had high leakage currents. I received some samples of the "defective" units but found nothing wrong. The problem reached my desk with only a week to resolve it before the automaker would have to shut down the production line. I flew out the next day with the returned units as well as some correlation units. Upon my arrival, the component engineer advised me that all the units were failing the 50-nA leakage test at 30V when he heated the units to 125°C. I had to close my gaping mouth when I realized he was applying the room-temperature specification across the full temperature range.

The engineer did not acknowledge that semiconductor performance should change with temperature. I pulled out my 1967 copy of *Physics and Technology of Semiconductor Devices* by Intel founder Andy Grove to show him how the leakage current increases with temperature (**Reference 1**). You can simplify the equations and graphs to the basic rule that leakage doubles for every 10°C increase in temperature. This explanation was not enough to release the product, so we went to the incoming-inspection lab to test my correlation units and production samples using a Tektronix 576 Curve Tracer and a TO-92 heating probe. All the parts showed the same leakage characteristics with temperature that you would expect from silicon.

After another meeting, the component engineer agreed to approve the shipments only after the lots had passed a large sampling plan. We expanded the 2N3906 limit of 50 nA at 25°C to 50 μA at 125°C and began to sample the lots.

During the final tests, the thermal heat probe failed and could not be used on the remaining lots. Once again, the engineer refused to approve the units based on a smaller sample and my solid-state-physics lessons. Not wanting to be any part of a department that caused a lines-down situation for one of the Big Three, I had to come up with a solution.

Again pulling out the textbook, I demonstrated how base-emitter voltage relates directly to the die temperature, as well. Again, you can simplify the equation when applying it to silicon, which reduces the saturated base-emitter voltage by 2 mV for every degree Celsius and translates to a 200-mV reduction in voltage for the added 100°C in temperature. Using the Tek 576 Curve Tracer, we could watch the voltage drop while heating the unit with my lighter. Once the unit met or exceeded temperature, we could change to leakage mode and confirm that the parts were good. I completed the sampling using this method, and the component engineer approved the parts. The next day, the production manager told me that he had to send out five 2N3906s per car to dealers, because that week's production of cars had been shipped without them. Mechanics at the dealership had to install the critical components, which drive the LEDs that light up when your door or trunk is ajar. **EDN**

REFERENCE

1 Grove, Andrew S, *Physics and Technology of Semiconductor Devices*, John Wiley and Sons, 1967.

Martin DeLateur is a consultant who spent 30 years as a product engineer at Fairchild and National Semiconductor. Contact him at delateurm@all2ez.net.

POWER designer

Expert tips, tricks, and techniques for powerful designs

No. 119

Color-Management LED Drivers Have a Bright Future

— By Tomi Koskela, Applications Engineer

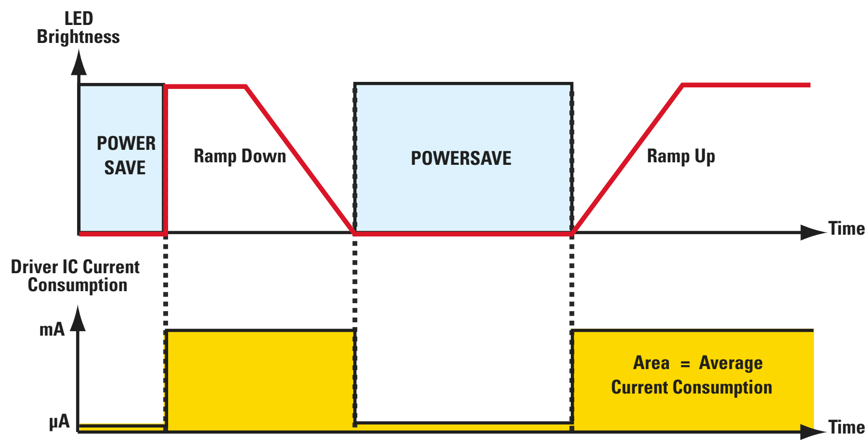


Figure 1. Automatic Power-Save-Mode Operation in the LP5521 LED Driver

Introduction

Color LEDs are becoming more and more popular in portable consumer devices such as mobile phones, portable media players, and gaming and navigation devices. They are commonly used for indication lights, which could be an RGB LED where the color changes according to the event such as Short Message Service (SMS) or incoming calls. These types of LEDs can be driven in various ways such as LED drivers, General Purpose Input/Output (GPIO) pins on the Power Management Unit (PMU), or advanced Lighting Management Unit (LMU).

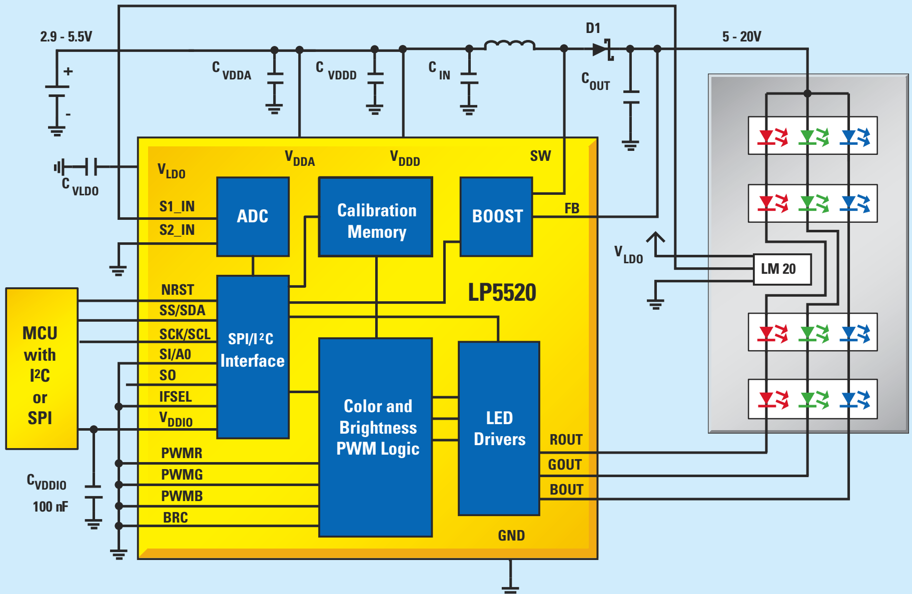
One area that RGB LEDs have been used heavily is for personalizing handsets with keypad lighting, fun lighting, and phone cosmetics. RGB LEDs also can be used for display backlighting. Increases in the RGB-LED count on mobile phones create challenges for the LED drivers as well. The most common challenges in driving color LEDs in portable devices are power consumption, control interface/programmability, EMI, overall solution size, and system cost. Two key areas driving color LEDs in portable devices warrant detailed discussion: indicator and cosmetic lighting, and display backlighting.

NEXT ISSUE:
Switching Regulators for Space-Constrained Apps

National Semiconductor
The Sight & Sound of Information

RGB LED Driver Generates Highly Efficient “True White” Backlighting

LP5520 Provides Innovative, Easy-to-Use, Instant Color Gamut Improvement for Small Format Displays



Features

- Temperature compensated LED intensity and color
- Individual calibration coefficients for each color
- Color accuracy ΔX and ΔY ≤ 0.003
- 100% NTSC color gamut, brighter color, better picture quality
- User programmability for effects, aging, dimming
- PWM control inputs for each color

Product	Description	Packaging
NEW! LP5520	RGB Backlighting LED driver with integrated white balance compensation	microSMD-25
NEW! LP5521	Programmable, low power, 3-channel LED driver	microSMD-20, LLP-24
NEW! LP5522	Autonomous single LED controller with one wire interface	microSMD-6
LP5526	Lighting Management Unit with high voltage boost converter with up to 150 mA serial flash LED driver	microSMD-25
LP5527	LED driver for camera flash and 4 LEDs with I²C programmability, LED connectivity, test, and audio synchronization	microSMD-30
NEW! LP55281	13 channel LED driver with audio sync, LED connectivity test and independent PWMS/PWMS blinking cycles	microSMD-36

Ideal for navigation systems, mobile phones, medical devices, and other portable devices

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Color-Management LED Drivers Have a Bright Future

Color Indicator LEDs and Cosmetics Lighting in Portable Devices

New features in mobile phones and most other consumer portable devices are power dependent. Display backlighting and LEDs overall consume considerable power in handheld devices; therefore, power savings with LED driving is critical. Most of today's new LED drivers are focused particularly on improving the overall power efficiency.

The conventional way of driving an indicator LED is with simple current sinks, or with some GPIO pins. These types of LED-driving methods require application-processor control each time the LED is activated. An example application is the indicator LED blinks when an SMS message arrives. When the application processor is required to wake up each time the light effect occurs, the power consumption due to this lighting effect adversely affects battery life.

For a power-conscious, simple indicator-LED driver, it is ideal to program the blinking sequence to the driver and leave the sequence running without application-processor control. This way the processor can be in sleep mode when the device is not in use while the LED driver handles the blinking sequences itself. When a simple on/off control is required with a single, low-forward-voltage color LED, a step-up DC-DC converter is not necessary and the overall power consumption is further reduced. This type of LED driver can be made extremely small and requires a minimal number of external components, or perhaps none at all.

Programmable Lighting Sequences Provide Further Power Savings

The ability to control lighting sequences can improve the power-saving capability on mobile devices. An example of a device with this capability is the LP5522 LED driver from National Semiconductor. Blinking sequences are trained to the LP5522 driver with a single-wire interface. After a training command, the driver can repeat the sequence without external control. The LED current can be adjusted with an external resistor while the default current without the resistor is 5 mA. The size of the LP5522 device is 1.2 mm x 0.8 mm x 0.6 mm and the LED is the only external component, making this small and reduced BOM solution ideal for space-constrained and system-cost-sensitive portable applications.

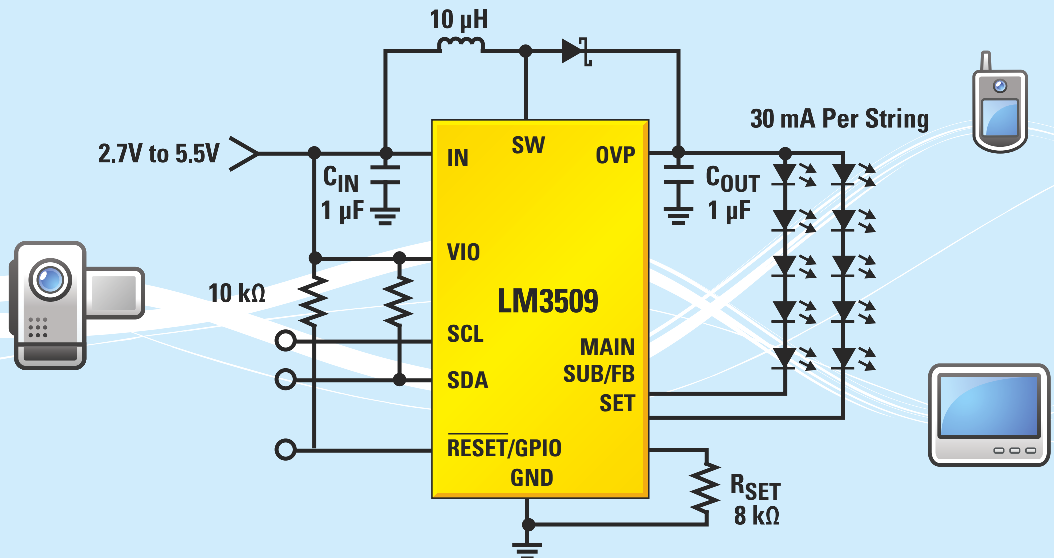
When LEDs with higher forward voltage are used, the single-cell Li-Ion battery voltage is not always sufficient to drive the LEDs. In this case, a step-up DC-DC converter is required. A step-up converter can be either capacitive (charge-pump or switched capacitor) or inductive (magnetic boost). Today, a charge-pump converter is used in driving low-voltage parallel-LED drivers, and a magnetic-boost converter is used in high-voltage serial-LED drivers.

For complex lighting sequences such as smooth transitions between different colors, a sophisticated control method is required besides a simple enable-control pin. An I^2C-control bus is widely used in many portable devices as it provides greater flexibility for controlling an LED driver via only two wires. Usually there are other components, for example a camera module, using the same bus. Therefore, LED driving should not use all of the I^2C bandwidth. Controlling the LED brightness in real time creates considerable I^2C traffic.

A new charge-pump-based color-LED driver, such as National's LP5521 device, allows minimum real-time control by incorporating internal memory for sequencing. Lighting sequences are written to an internal memory after power-up, and an external trigger pin or I^2C write is used to start the sequences. When the sequence is running, processor control is not required. When the phone is in standby mode, the application processor can be in sleep mode while complex lighting sequences can still be achieved. Sequences can include time delays, ramps, blinking, loops, and sending/receiving trigger signals.

Industry's First LED Driver Offering True Linear Dimming for the Human Eye

LM3509 Dual-Output Constant-Current LED Driver Operates at 90% Efficiency

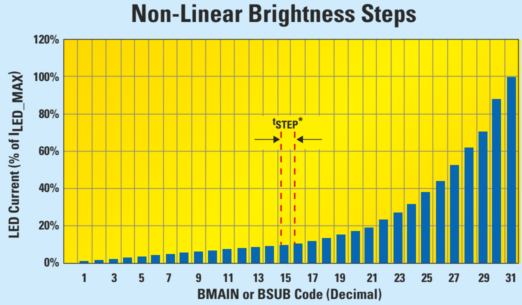


Dual White LED Bias Supply

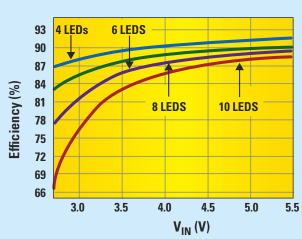
Features

- 32 Exponentially spaced dimming states with 800:1 LED current ratio
- Auto-dimming function enables transition from one dimming state to the other at different speeds
- Integrates OLED power supply
- 2 independently controlled constant current outputs for main and sub displays
- Drives 10 LEDs at 30 mA with 0.15% current matching
- Simultaneously drives 5 LEDs at 20 mA and delivers 21V at 40 mA for OLED power supply
- I²C-compatible programmable brightness control

Non-Linear Brightness Steps



*t_{STEP} is the time between LED current steps programmed via bits RMP0, RMP1



Ideal for driving LEDs in mobile phones, digital cameras, and navigation system displays

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Color-Management LED Drivers Have a Bright Future

Reducing Power Consumption in LED Drivers

To further decrease power consumption, the LP5521 driver has an automatic power-save-mode operation. The DC-DC converter in the LP5521 device starts up only when the Li-Ion battery voltage is not sufficient enough to supply the LEDs. The LP5521 driver also shuts down other unused blocks when the LEDs are not active and while the sequence is running internally. This significantly decreases the average power consumption. Automatic power-save-mode operation implemented in the LP5521 LED driver can be seen in ***Figure 1.***

A charge-pump-based RGB-LED driver such as the LP5521 device requires only four small capacitors. With a small footprint and minimum external components, the total solution size can be as small as 7 mm^2. The small solution height makes it suitable for slim design applications. Also with such a small solution size, it is possible to create a localized rather than centralized solution, meaning that the LED driver is located near the LEDs. This way the PCB routing is much easier, and the EMI is reduced. The LP5521 LED driver has external control pins which are used for synchronizing several drivers, making it possible to achieve very interesting lighting effects.

RGB LEDs as Small-Panel Display Backlighting in Portable Devices

Typically, small-panel LCD-display backlighting can be achieved with a couple of white LEDs. The problem with white LEDs is that their spectrum is not ideal for photographic reproduction. This is caused by the fact that white LEDs are basically blue LEDs with yellow phosphor on top. The spectrum has two peaks: one at blue, and a second at yellow. A typical white-LED versus RGB-LED spectrum can be seen in ***Figure 2.***

To filter the right color to each color cell (red, green, blue), color filters are used. Color filters waste some of the power and even after color filtering, the color spectrum passing through the LCD is not ideal. With white-LED backlighting, it is possible to get up to 75% of the National Television Standards Committee (NTSC) colors on an LCD display (the red end of the conventional LCD display is especially limited). When RGB LEDs are used for LCD-display backlighting, the color reproduction can be adjusted to cover over 100% of the NTSC color gamut which results in brighter color and better picture quality. With optimized color filters, less power is wasted than in white-LED backlighting. The structure of an LCD display can be seen in ***Figure 3.***

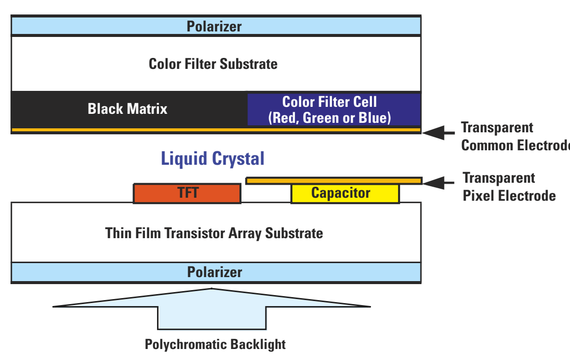

Figure 3. Structure of an LCD Display

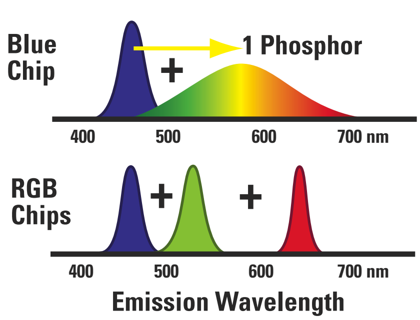

Figure 2. Typical White-LED vs. RGB-LED Spectrum

Generating "True White" Backlighting Through Open-Loop Compensation

With RGB backlighting, the LED driver must correct the brightness balance between the primary colors (red, green, and blue) when the LED temperature changes. The LED driver keeps the white point of the RGB backlight adjusted correctly at any operating temperature. Compensation can be either closed loop or open loop. With closed-loop compensation, an optical sensor is used for

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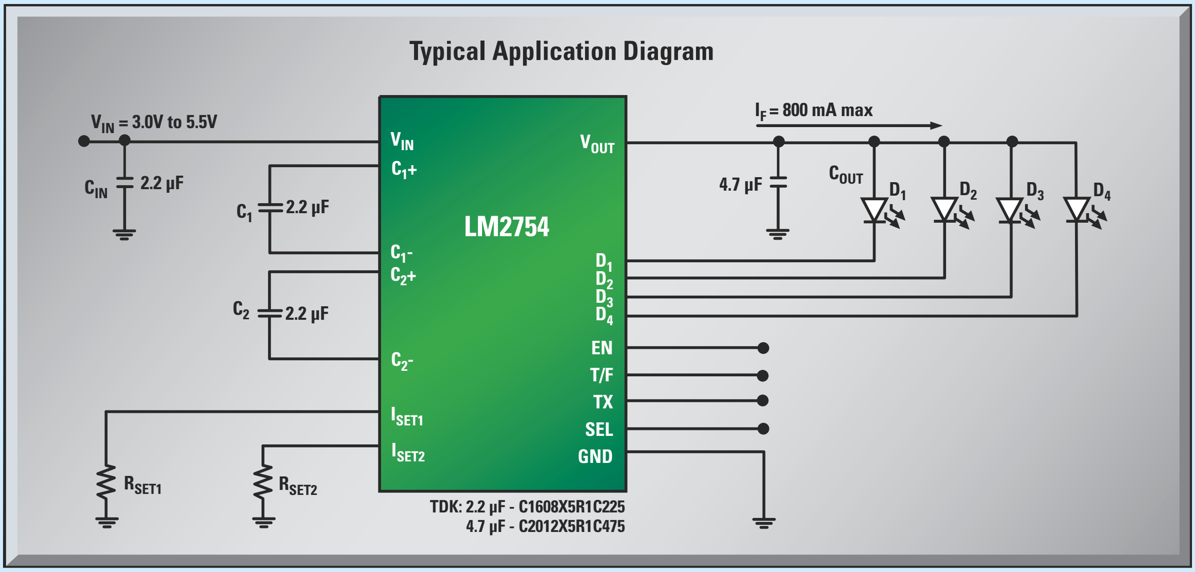

LM2754 Features

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- No inductor required
- True shutdown output disconnect
- <1 µA shutdown current
- TX input ensures synchronization with RF power amplifier pulse
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- Internal soft-start limits inrush current
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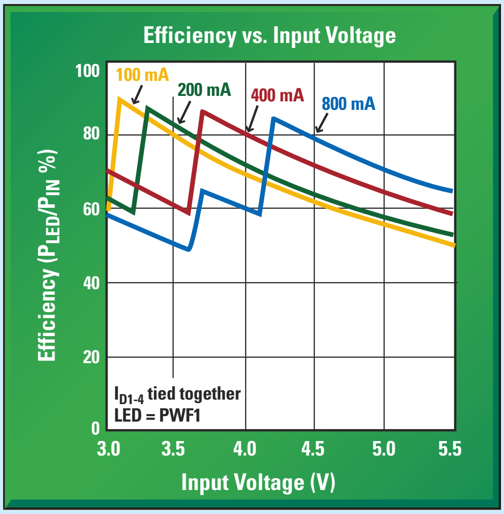

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Color-Management LED Drivers Have a Bright Future

measuring the white point. With open-loop compensation, the temperature is measured and predefined compensation curves are used to adjust the white point.

For RGB backlighting, National offers the LP5520 RGB-LED driver, which is an open-loop-compensated LED driver. The principle of the open-loop color compensation can be seen in ***Figure 4***. With open-loop compensation, an accurate white point is maintained through the operation temperature range. The temperature compensation curves are measured for the actual RGB-LED type used in the application, and these curves are programmed to the chip's internal EEPROM memory. The chip is integrated into the LCD display module, and the module manufacturer programs compensation curves in production. An RGB-LED backlight-optimized color filter is used as well.

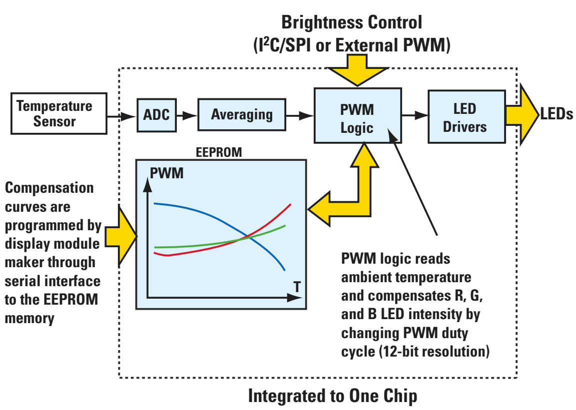

Figure 4. Principle of Open-Loop Color Compensation in the LP5520 LED Driver

Controlling display brightness with the LP5520 device is similar to that of white-LED backlighting. The brightness level is controlled through a SPI or I^2C bus, and the LP5520 device calculates the actual Pulse Width Modulation (PWM) values according to the compensation curves to maintain the white point. Automatic fade in and out can be used to get a smooth transition. The brightness can be controlled alternatively with an external PWM, and the LP5520 device also has an interface for an ambient-light sensor. Therefore, this color compensation is invisible to the manufacturers, and no special software is needed for controlling the RGB backlight. Fast implementation of an RGB-backlit display to end devices is possible because display vendors have ready-made solutions available.

Additional LED Driver Features

Because the number of LEDs in handsets and other portable consumer devices is continually increasing, a fast and reliable way to test the connection to each LED is needed. Testing LED connectivity in end-device production usually requires test points on the PCB for each LED, or optical testing must be used. Incorporating test points to the application PCB is not an easy task considering how tightly packed PCBs in portable devices are today. Furthermore, optical-testing methods are difficult and expensive to implement.

With built-in LED-connectivity tests in LED drivers, it is possible to test the connection to each LED through an I^2C or SPI bus and get accurate results in milliseconds. This makes the production testing very easy to implement and it is also fast and effective. For example, the LED-connectivity test has been integrated into the LP55281, a quad RGB-LED driver. The LED-connectivity test is just one example of a built-in feature which provides extra value to designers.

Conclusion

RGB LEDs create interesting possibilities to personalize handsets and other portable consumer devices. However, increasing and more versatile use of RGB LEDs in handsets create challenges for the LED drivers. The most significant challenge is how to drive all of these LEDs efficiently in a cost-effective manner and in the smallest solution size. National's new family of lighting-management products provides solutions that meet the challenges of these new lighting trends. For more information, please refer to **lighting.national.com.** ■

Power Design Tools

Lighting Solutions Guide

For information on National's LED lighting solutions and to download the guide, visit:

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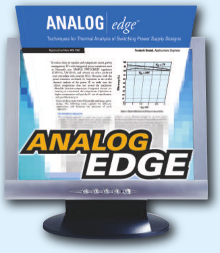

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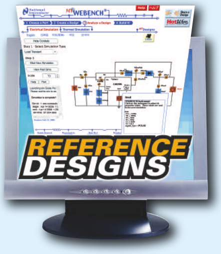

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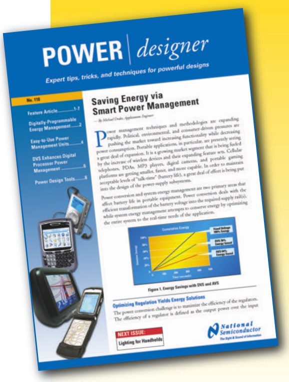

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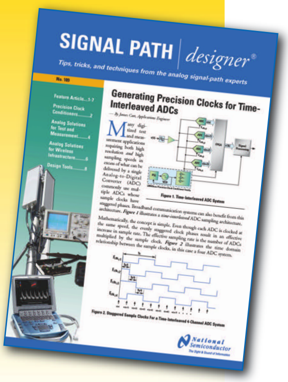

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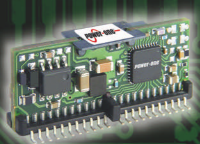
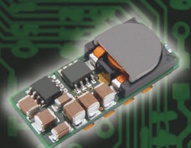


Z-Series Digital POLs



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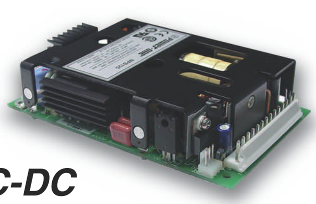

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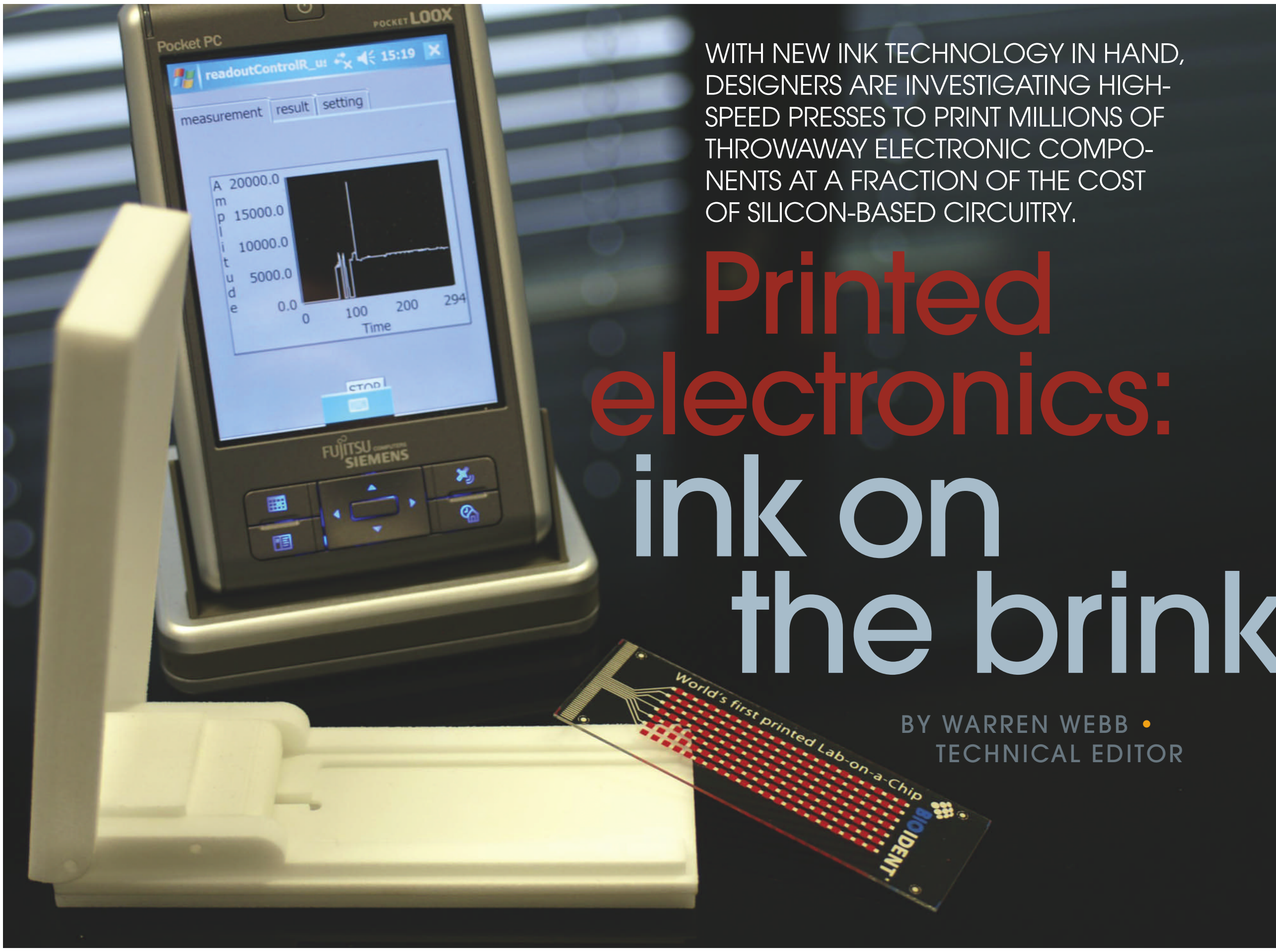
Printed electronics: ink on the brink

BY WARREN WEBB • TECHNICAL EDITOR



Bioident Technologies' PhotonicLab Platform analyzes multiple samples in real time with a printed semiconductor photodetector under each well.

Printed electronics may be the next big thing in our technological future and promises extremely low-cost, flexible, and disposable circuitry that you can manufacture with custom ink-jet printers or high-speed presses. Leading-edge companies are using specialized ink technology to transform basic circuit elements, such as thin-film transistors, resistors, inductors, and capacitors into printed batteries, displays, sensors, RFID tags, interactive packaging, solar panels, and even speakers. Although the printed-electronics concept has been around for years, recent advances in conductive-ink chemistry and flexible substrates promise to deliver a flood of new markets and application areas.

Unlike traditional silicon-based circuitry, you manufacture printed electronics using an additive process that deposits multiple layers of conductive, semiconductive, and dielectric materials onto a flexible medium, such as plastic film, foil, or paper. Most current printing processes—such as ink jet, roll-to-roll offset, flexography, rotogravure, or screen printing—can place individual layers. With a relatively small investment in capital equipment for manufacturing and the ease of producing millions of copies on demand, printed electronics will target high-volume, simple-function consumer applications previously impractical for silicon-based circuitry. Research organizations predict huge growth in printed-electronics products. For example, IDTechEx (www.idtechex.com) forecasts that the market for printed and thin-film electronics will exceed $1 billion in 2007 and grow to $5 billion by 2011 and $48 billion in 2017.

Disposable-battery testers integrated into the product or packaging were one of the first widely used printed-electronics applications. These low-cost, interactive testers rely on conductive inks to form a resistive-heating element and temperature-responsive inks to provide the display. In an example, Duracell prints a wedge-shaped resistor directly below the thermochromic-display area (**Figure 1**). When the user presses the conductive traces onto the terminals, current flows through the resistor and heats the display strip depending on the current the battery

AT A GLANCE

- Innovative designers are using conductive-ink technology to create low-density printed circuitry for user-interface applications.
- With thin-film transistors, resistors, capacitors, displays, batteries, and speakers available, the number of applications for printed electronics is enormous.
- You can simultaneously and directly apply many printed electronics applications with conventional graphics onto product packaging.
- New ink technologies and high-speed roll-to-roll presses enable sophisticated printed circuitry at much lower cost than silicon-based components.

provides. A fully charged battery offers enough current to heat the entire wedge and provide the "good" indication. Duracell prints the tester electronics as part of the battery packaging at little additional cost.

Although printed electronics will not approach the sophistication or performance of silicon-based circuitry, plenty of applications exist in which adding a few electrical components to the manufacturing process can create new markets. Many potential applications for printed electronics are in intelligent and mass-produced items at the human-interface level. For example, flexible paper or polymer substrates allow designers to create interactive signage, clothing, labels, wallpaper, books, newspapers, and

Figure 2 Electronic-paper displays employ an active-matrix backplane of printed transistors and conductors to produce portable electronic-reader products.

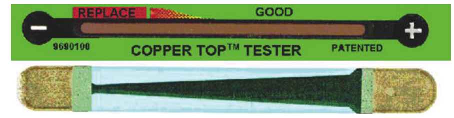


Figure 1 Interactive battery testers use conductive inks to form a resistive-heating element and temperature-responsive inks to indicate the charge (courtesy Duracell).

product packaging. You can directly embed these applications into the environment, and they fit into the vision of pervasive computing. In many cases, printed electronics requires no additional setup or assembly, unlike conventional electronics—in which the installation costs may exceed the price of the device.

PRINTED TOYS

With a portfolio of patented conductive-ink technology, T-Ink is a pioneer in printed-electronics applications. The company's approach is to target consumer goods, packaging, and promotions applications that do not require extensive design and testing cycles. T-Ink technology replaces switches, wires, buttons, speakers, lights, and batteries with printed-ink, touch-activated applications. Successful products include an interactive tablecloth for Hallmark (www.hallmark.com), place mats for McDonald's (www.mcdonalds.com), pillow radios, and interactive games. The company also offers a series of educational toys to teach children spelling and math through the act of coloring onto printed conductive inks that trigger an appropriate audio response.

Manufacturers also employ printed electronics in the creation of OLED (organic-light-emitting-diode) displays. These displays rely on organic compounds that a multilayer-printing process deposits in rows and columns onto a flat carrier. Unlike the traditional liquid-crystal type, OLED displays require no backlight, have a faster response, and consume less power. You can print organic materials onto many substrates, including flexible or even fabric materials, creating roll-up or wearable displays. A possible drawback of OLED displays is the reduced lifetime of certain colors of organic materials. At this year's Consumer Electronics Show (www.cesweb.

The Ultimate in Ethernet PHY Solutions

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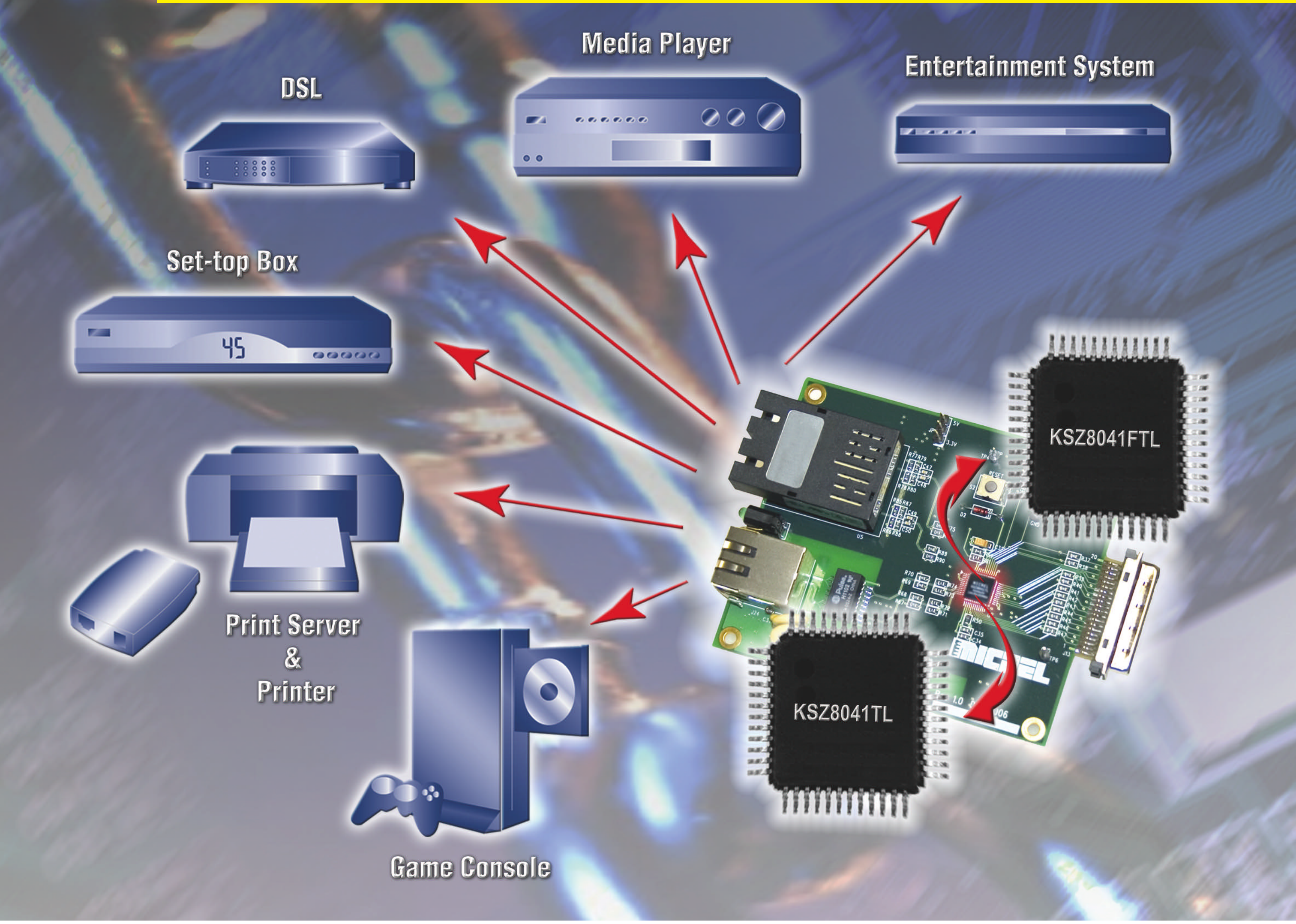

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- LinkMD® TDR-based cable diagnostics for identification of faulty copper cabling
- MII, RMII and SMII interface support
- MII/RMII Back-to-Back Mode
- MIIM (MDC/MDIO) management bus for PHY register configuration
- Fully compliant to IEEE 802.3u standard
- Single Power Supply (3.3V)
- Available in 48-pin TQFP package

Figure 3 The Cypak intelligent-pharmaceutical-packaging system records medication use and is programmable to deliver patient reminders.

org), Sony demonstrated a prototype high-definition television with a 27-in. OLED display and a contrast ratio of greater than 1 million-to-one.

Electronic paper is another display variation that benefits from printed electronics. The migration of colored microparticles, which an active-matrix backplane of printed transistors and conductors charges, forms images on electronic paper. Also known as an electrophoretic display, electronic paper reflects light like ordinary paper and is bistable, thus indefinitely storing text and images without power. Plastic Logic recently opened a factory in Dresden, Germany, to make flexible displays based on the electrophoretic films from E Ink Corp. The facility will produce flexible active-matrix-display modules for "take-anywhere, read-anywhere" electronic-reader products (**Figure 2**).

It is not surprising that printed-electronics applications abound in the medical market in which almost half of all patients incorrectly take their medications. Manufacturers are producing smart packaging with printed sensors and, sometimes, printed batteries to improve drug delivery. Cypak produces a medical-delivery system for carded-blister packs known as IPP (intelligent pharmaceutical packaging). The system records the number of pills removed and each time you remove a pill from the blister pack for later read-back by placing the IPP on a Cypak reader (**Figure 3**). You can program the package to remind the patient that it is time to take more medication, and the application can ask the patient to answer simple questions regarding his physical or mental state by pressing an answer key printed on the paperboard.

LAB ON A CHIP

Bioident Technologies, a leader in optoelectronic-test equipment for life sciences, recently announced a multiwell

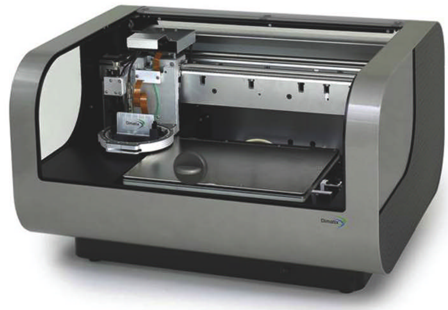

Figure 4 Essential in printed-electronics-prototype development, the Dimatix DMP-2800 printer deposits layers of fluidic materials using a disposable piezoelectric cartridge.

Figure 5 With layers of zinc and manganese dioxide to create the anode and cathode, Power Paper creates flexible and disposable printed batteries.

lab-on-a-chip prototype that it bases on printed semiconductors. The PhotonicLab Platform prototype includes a 1×3-in. nanotiter plate—a type of lab-on-chip device with multiple wells that can hold testing agents to perform laboratory functions. The nanotiter plate includes a photodetector array that Bioident bases on printed-semiconductor technology, with one pixel under each well. This array converts light into electrical signals, enabling simultaneous, real-time analysis on multiple agents. The system eliminates the need for high-precision translational stages, which are common among microplate and biochip readers. Placing the detector directly beneath the sample makes precision motion of the sample and detector unnecessary. Bioident's PhotonicLab Platform uses technology the company bases on organic semiconductors to print light-emitting and -detecting capabilities directly onto any surface, including glass, enabling on-chip analysis and diagnostics.

Audio speakers are one of the more unlikely applications for printed electronics, because they require mechanical movement. Yet, researchers involved in Mid Sweden University's (Sundsvall, Sweden, www.miun.se) Paper Four project have created an interactive paper billboard that emits recorded sound in response to a user's touch. They make printed speakers by printing electromagnets from conductive ink and stretching the paper over cavities in the poster board. Recent progress in rare-earth, metal-based magnetic materials allows the high-speed printing of low-cost permanent magnets. The printed electromagnets vibrate with induced current to create sound. When you produce the interactive billboards in sufficient quantities, they can be inexpensive and disposable. The researchers have produced a video showing the features of the printed paper billboard (**Reference 1**).

You can produce, or at least prototype, many printed-electronics products on relatively inexpensive desktop printers using specialized ink cartridges. The Dimatix DMP-2800 series printer from Fujifilm deposits layers of fluidic materials on any 8×11-in. substrate, using a disposable piezoelectric cartridge (**Figure 4**). The machine has a printing area of approximately 200×300 mm with an adjustable height and can print with resolutions as high as 5080 dpi. Unlike thermal ink jets, piezoelectric print heads are compatible with a variety of materials, including solvents, aqueous solutions, and ultraviolet curing fluids. Additionally, a system waveform editor allows the user to manipulate the electronic pulses to the print head to optimize the shape of the fluid drops that the nozzle ejects. The 16-nozzle drop-on-demand ink-jet cartridge is adjustable for a 1- to 10-pL nominal drop volume and is refillable. Prices for the DMP-2800 series printers start at less than $30,000. Each system includes the

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printer, a supply of print cartridges, and driver and application software.

PRINTING WIRES

Although all printed-electronics applications use a variety of conductive liquid to create component-to-component wiring, most inks have relatively high resistivity. These circuit paths work for many applications, but some designs call for extremely low resistance. In the past, designers have used liquids with suspended silver-metallic flakes to increase conductivity. But this approach requires pressure or heat to fuse the particles. To overcome this problem, NovaCentrix has developed a new line of inks and formulations for high-speed printing of electronic devices. The company's Metalon process uses nanoparticles of silver and copper to allow direct printing of electronic circuits on low-temperature substrates. Potential applications include RFID antennas, transistors, solar-cell contacts, display backplanes, and electrostatic discharge/electromagnetic-interference films. NovaCentrix has a novel technique for curing or sintering metal-nanoparticle-based films by exposing them to a brief, intense pulse of light from a xenon flash lamp. This photonic-curing technology rapidly and selectively heats and fuses nanoscale metallic-ink particles, forming highly conductive paths.

Nonvolatile memory is an essential element in the growth of the printable-electronics industry. Product applications employing flexible memory could include intelligent packaging, game cards, and medical devices to store information for later display to the customer. Another application is printed antifraud and anticounterfeit security tags that store product identification and security information in rewritable memory. Thin Film Electronics is working to develop low-cost volume-production processes for its nonvolatile-printed-polymer-memory technology. Thin-film memories include a printed bottom and top electrode with a ferroelectric, nonvolatile, rewritable polymer sandwiched between. The Thin Film system eliminates the need for transistors in memory cells, a substantial simplification over alternative memory designs.

The key to many printed-electronics applications is a reliable source of power integral to the product. The obvious example is a printed battery that sits idle until you activate the application. Power Paper has developed such a power source. It requires no metal case, and you can print it onto most flexible materials (**Figure 5**). The batteries, which have a shelf life of about three years, comprise proprietary printed layers of zinc and manganese dioxide to create the anode and the cathode. In addition to outside licensing, Power Paper uses its batteries to power microelectrical pharmaceutical and cosmetic patches to enhance the delivery of active ingredients to the skin. The patches target conditions such as skin damage, aging, wrinkles, hyperpigmentation, and photo damage.

Printed electronics has the potential to greatly expand the role of the circuit-design engineer. Designers may find themselves working in a traditionally nonelectronic industry to add new functions to product packaging or signage. With the lowest cost silicon still orders of magnitude more expensive than printing and a constant flow of new ink technologies, you can expect explosive growth in disposable electronic products. In addition, electronic applications are ideal for the multitude of printing presses that will sit idle when society completely switches to virtual books, newspapers, and magazines.EDN

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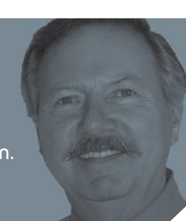


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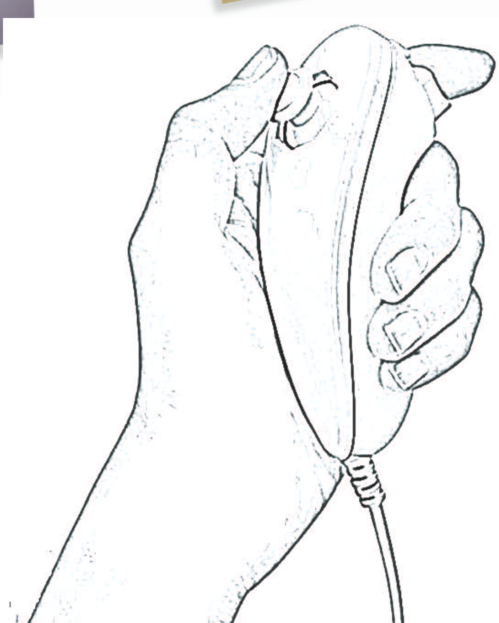
BY ROBERT CRAVOTTA • TECHNICAL EDITOR

RECOGNIZING GESTURES

BLURRING THE LINE BETWEEN HUMANS AND MACHINES

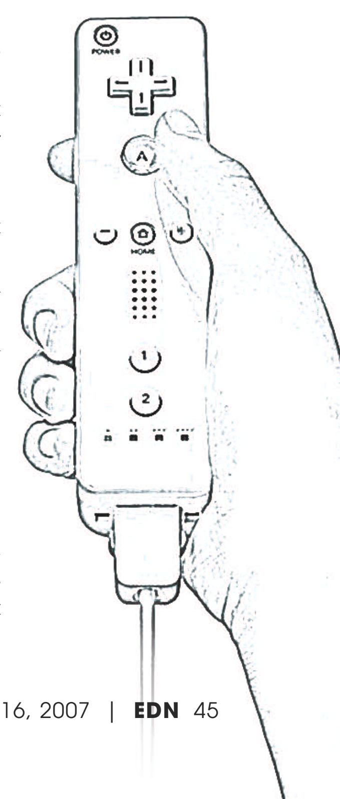


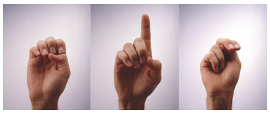
he most basic and simplest gesture is pointing, and it is an effective method for most people to communicate with each other, even in the presence of language barriers. However, pointing quickly fails as a way to communicate when the object or concept that a person is trying to convey is not in sight to point at. Taking gesture recognition beyond simple pointing greatly increases the type of information that two people can communicate with each other. Gesture communication is so natural and powerful that parents are increasingly using it to enable their babies to engage in direct, two-way communication with their care givers, through baby sign language, long before the babies can clearly speak (**Reference 1**).

The level of communication between users and their electronic devices has been largely limited to a pointing interface. To date, a few common extensions to the pointing interface exist. They include single- versus double-click or tap devices and devices that allow users to hold down a button while moving the pointing focus, such as mice, trackballs, and touchscreens. A user's ability to naturally communicate with a computing device through a gesture interface and a speech-recognition interface, such as a multitouch display or an optical-input system, is still largely an emerging capability. Consider the new and revolutionary mobile phone that relies on a touchscreen-driven user interface instead of physical buttons and uses a predictive engine that helps users with typing on the flat panel. This description could apply to Apple's iPhone, which the company launched in June, but it can also apply to the IBM Simon, which the company launched with Bell South in 1993, 14 years earlier than the iPhone. Differences exist between the two touch interfaces. For example, the newer units support multitouch gestures, such as "pinching" an image to size it and flicking the display to scroll the content. This article touches on the nature of how gesture interfaces are evolving and what they mean for future interfaces.

Much of the technology driving many of today's latest and innovative gesture-like interfaces is not exactly new: Most of these interfaces can trace their heritage in products or projects from the past few decades. According to **Reference 2**, multitouch panel interfaces have existed for at least 25 years, and that length of time is on par with the 30 years that elapsed between the invention of the mouse in 1965 and the mouse's reaching its tipping point as a ubiquitous pointing device, which happened with the release of Microsoft Windows 95. Improvements in the hardware for these types of interfaces enable designers to shrink and lower the cost of end systems. More important, however, these improved interfaces enable designers to leverage additional low-cost software-processing capacity to use it to better identify more contexts so they can better interpret what a user is trying to tell the system to do. In other words, most of the advances in emerging gesture interfaces will come not so much from new hardware as from more complex software algorithms that best use the strengths and compensate for the weaknesses of each type of input interface. **Reference 3** provides a work-in-progress directory of sources for input technologies.

In addition to the commercial launch of the iPhone, this year has borne witness to the Korean and European launch of the LG Electronics-manufactured, Prada-designed LG Prada phone, the successful commercial launch of Nintendo's Wii gesture-interface console, and the pending launch of the multitouch Microsoft Surface Platform (see **sidebar** "Multitouch surfaces"). Are the lessons designers learned from previous iterations of gesture interfaces sufficient





AT A GLANCE

- Many of the gesture interfaces we see in innovative products can trace their roots back several decades.
- Gesture interfaces find more use than just in games and infotainment devices; they also control systems in industrial and medical environments.
- Much of what makes a gesture interface reliable and useful, such as inferring or predicting intent, is not obvious to the user.
- The success of an interface is in how well it handles uncertainty with the user.
- Devices with modern interfaces must consider how to manage wireless and network connectivity between systems so that they appear as one system to the user.

to give today's latest innovative products the legs they need to survive more than a year or two and finally usher in the promising age of more natural communication between humans and machines? These platforms have access to large amounts of memory and worldwide connectivity through the Internet for software updates. So, perhaps the more relevant question is: Can the flexible, programmable nature of these platforms enable the gesture interfaces to adjust to the set of as-yet-unlearned lessons without going back to the drawing board?

Gesture-recognition interfaces are not limited to just gaming and infotainment products. Users of Segway's PTs (personal transporters) intuitively command their transporters by leaning in the appropriate direction to move forward, stop, and turn left or right (**Figure 1**). Some interfaces focus on capturing a rich range of subtle gestures to emulate using a real-world tool rather than issuing abstract commands to a computer. For example, Wacom's Intuos and Cintiq tablets coupled with tablet-enhanced paint- and graphics-software programs can faithfully capture an artist's hand and tool motions in the six dimensions of up and down, left and right, downward pressure on the tablet surface, stylus-tilt angle, stylus-tilt direction, and stylus rotation. This feature enables the software to recreate not only the gross motions, but also the fine motions, such as twisting a user's hand to more realistically emulate the behavior of complex objects, such as paint and drawing tools.

Another example of capturing subtle motions to enable the emulation of the direct manipulation of real-world tools is Intuitive Surgical's da Vinci Surgical System. This system employs a proprietary 3-D-vision system and two sets of robots—the masters and the EndoWrist instruments—to faithfully translate the intent of a surgeon's hand and finger motions on the masters to control the EndoWrist instruments during robotic laparoscopic surgery (**Figure 2**). Decoupling the surgeon's hand motions from the on-site surgical instruments through the masters not only allows the surgery to require only a few small cuts to insert the surgical tools into the patient, but also affords the surgeon a better posture to delay the onset of fatigue when performing long procedures. It also enables greater surgical precision, an increased range of motion, and improved dexterity through digital filtering than if the surgeon directly manipulates the surgical tools, such as in traditional laparoscopic surgery.

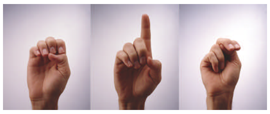
The 3-D-vision system is a critical feedback interface that enables surgeons to effectively use the da Vinci Surgical System and avoid mistakes. Additionally, the system complements the visual-feedback interface with some simple haptics or force feedback such as that to detect when internal and external collisions occur during a motion. Research organizations, such as at Johns Hopkins University, are using the da Vinci Surgical System to study technologies that support a "sense of touch." "The da Vinci is a perfect 'laboratory,' as it provides high-quality motion and video data of a focused and stylized set of goal-directed tasks," says Gregory D Hager, professor of computer science at Johns Hopkins. "We envision using the statistical models we develop as a way of making the device more 'intelligent' by allowing it to recognize what is happening in the surgical field."

Figure 1 The Segway PT interface translates the leaning direction of the user into commands to move the PT in a direction (courtesy Segway).

UNSEEN POTENTIAL

"Great experiences don't happen by accident," says Bill Buxton, principal researcher at Microsoft. "They are the result of deep thought and deliberation." His decidedly low-tech example involves two manual juicers that look similar and have the same user interface (**Reference 4**). If you can use one, you can use the other. The juice tastes the same from each, and each takes the same amount of time to make the juice. However, they differ in the method and the timing of a user's applying the maximum force. The juicer with the "constant-gear-ratio" effect requires the user to apply the maximum force at the end of the lever pull, whereas the other juicer delivers a "variable-gear-ratio" effect that reduces the pressure the user needs to apply at the end of the lever pull. In essence, the qualitative difference between the juicers is the result of nonobvious mechanisms hidden in the interface.

These examples of gesture-recognition interfaces are direct-control interfaces, in which users explicitly tell or direct the system to do what they want. However, the emerging trend for embedded or "invisible" human-machine



interfaces is an area of even greater potential. Embedded processing, which is usually invisible to the end user, continues to enable designers to make their products perform more functions at lower cost and with better energy efficiency. As the cost of sensors and processing capacity continue to drop and the processors are able to optimize the essential functions of the systems they control, an opportunity arises for the extra available processing to provide an implicit or embedded human-machine interface between the user and the system. In other words, users may imply their intent with the system without consciously being aware they are doing just that. This emerging capability is essential to

MULTITOUCH SURFACES

Multitouch interfaces have existed in some form for the last 25 years, and the time of their ubiquitous adoption is either fast approaching or upon us with this year's commercial offerings, such as the Apple iPhone and the Microsoft Surface (reference A and B). These multitouch displays enable users to operate directly on the displayed objects with their hands and fingers rather than mentally correlate the position of an on-screen cursor with the motion of a pointer, such as from a mouse. The multitouch interfaces offer a richer array of interactions than single-touch or single-focus interfaces that are common today. Apple based the iPhone's multitouch interface on a capacitive-touch technology that limits interactions to only those from the user's fingers; it supports gestures such as flicking the screen to scroll content and "pinching" the screen to zoom in and out on content.

Perceptive Pixel has released a demonstration video showcasing the company's work with a large multitouch display. It shows a variety of gestures and contexts that could benefit from a multitouch interface (Reference C). At press time, no additional information other than the video was available; however, a few items are worth noting. The display-and-touch-panel system is on a wall and is much larger than a typical display available to consumers today. In many of the scenes, more than one person is operating the touch display at once; sometimes, they are working together, and, at other times, they are working independently on different objects. The operator is using both of his hands at the same time during most of the video, and he effects a tremendous number of actions in a short period. The examples of manipulating 3-D virtual objects are probably harbingers of things to come. Finally, the room is dark, which suggests that the sensor implementation is not appropriate for all environments; however, other sensor implementations could deliver similar sensitivity in different environments.

Microsoft announced the table-top-like Surface multitouch-display interface in May, and the company expects production equipment to be available in November. The platform works by shining a near-infrared, 850-nm-wavelength light source on the bottom of the table's surface and using multiple infrared cameras to detect reflections of that light when objects and fingers touch the surface of the display (Figure A). The use of the near-infrared light allows users to employ the table in ambient light. A textured diffuser over the display causes the near-infrared light to reflect back to the cameras under the table in a way that allows the software to meaningfully identify fingers, hands, motions, and other real-world objects. The platform supports many of the same types of direct-interaction gestures as the other multitouch examples, such as flicking and pinching, but the interface adds a new twist: It can interact with dozens of real-world objects in addition to the hands and fingers of many users at once. The table-top form factor is natural for supporting face-to-face collaboration among multiple people, electronic content, and real-world objects.

The ability of the platform to bridge real-world objects with virtual objects is profound for gesture-interface actions. Users can place wireless devices on the display, and the platform recognizes, invisibly establishes communications links with, and identifies them with a circle around them on the surface display. The user can drag content, such as photographs, from one device to the surface interface of another device on the table. The data transfer can eliminate the need for cables between the devices, and the transfer of virtual objects between the real-world devices can consist of natural dragging and dropping gestures.

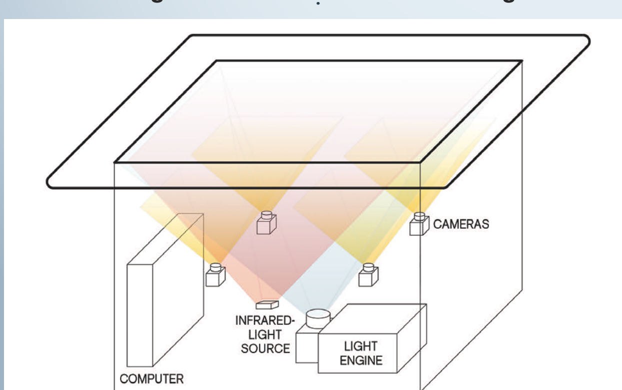


Figure A A conceptual (not accurate for intellectual-property reasons) artist's rendition shows the Microsoft Surface components (courtesy Microsoft).

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A Microsoft Surface, www.microsoft.com/surface.

B "Microsoft Surface: Behind-the-Scenes First Look (with Video)," *Popular Mechanics*, July 2007, www.popularmechanics.com/technology/industry/4217348.html.

C Perceptive Pixel, "Multi-Touch Demonstration Video," www.perceptivepixel.com.

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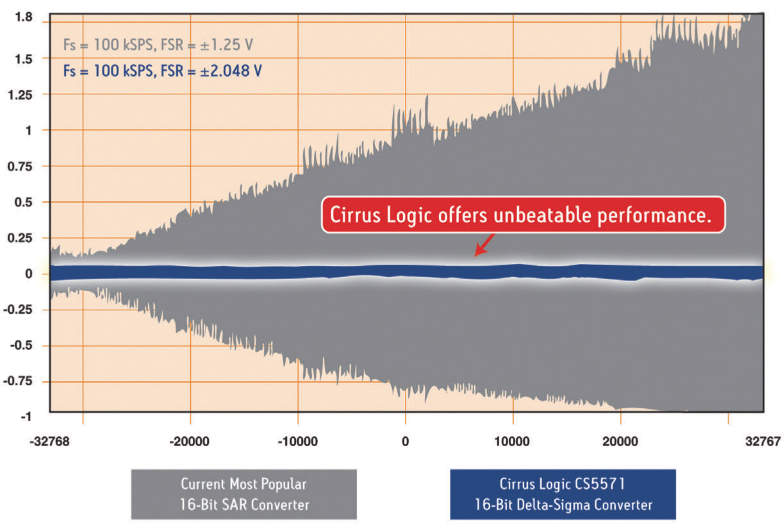

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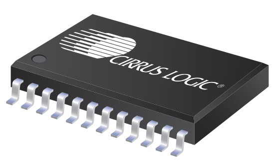

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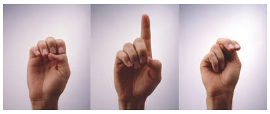

enabling systems to use predictive compensation to better accommodate a user's inexperience or errors and allowing the system to still perform what the user intended.

The Simon's PredictaKey keyboard explicitly listed to the user its top six predicted-letter candidates and allowed the user to explicitly select from that list. To take advantage of the prediction engine, the user had to explicitly engage with the engine's suggestions and choose from them. In contrast, the iPhone's typing interface manifests itself in several obvious and hidden ways to improve typing speed and accuracy. First, it presents specialized key layouts for each application so that only keys that are relevant are available for input. As the user types, the system may predict the word and present it to the user while they are typing; if the word is correct, the user can select it by pressing the space "key" on the display or just continue typing. Likewise, the system tries to identify potentially misspelled words and presents the word with the correct spelling in a similar fashion to allow the user to accept or ignore the proposed correction.

However, the new and invisible magic in the iPhone typing interface is that it compensates for the possibility of the user's pressing the wrong letter on the display panel by dynamically resizing the target area or tap zone assigned to each letter without changing the display size of any of the letters, based on its typing engine's predictions of what letter the user will select next (**Reference 5**). The letters that the prediction engine believes the user may press next receive a larger tap zone that can overlap with the display area of nearby, lower probability letters, which receive a smaller tap zone as a result. This feature increases the chances of selecting the predicted letter and decreases the chances of selecting an unpredicted letter that is adjacent to the predicted letter.

Although not considered a strict user interface, such as that between a user and a computer, some automobile-safety features implement an early form of implicit communication interfaces for predictive-safety features. As an example, to determine whether to warn the driver of an imminent lane departure, the system can examine the turn signal to determine whether the impending lane departure is intentional or accidental. People unintentionally and implicitly communicate their presence to passenger-detection systems that may control whether safety systems should deploy in the event of an accident. For example, the automobile may adjust how the air bag deploys to avoid certain types of injuries for passengers of different sizes. Electronic stability-control systems can compare the driver's implied intention, by examining the steering and braking inputs, with the vehicle's actual motion; they can then appropriately apply the brakes on each wheel and reduce engine power to help correct understeer (plowing), oversteer (fishtailing), and drive-wheel slippage to help the driver maintain some control of the vehicle.

Figure 2 The da Vinci Surgical System combines two robotic systems, the masters and the EndoWrist Instruments, with a 3-D-vision system to enable surgeons to better perform complex laparoscopic surgical procedures (courtesy Intuitive Surgical).

The control systems for the highest maneuverable fighter aircraft offer some insight into the possible future of consumer-level control of complex systems. Because these aircraft employ high levels of instability to realize their maneuverability, the pilot can no longer explicitly and directly control the aircraft subsystems; rather, the embedded-processing system handles those details and enables the pilot to focus on higher level tasks. As automobile-control systems can better predict a driver's intentions and correlate those intentions with the state of the vehicle and the surrounding environment, they may be able to deliver even higher levels of energy efficiency by reducing energy loads in situations in which they are currently unnecessary—without sacrificing safety. In each case, the ability of the system to better understand the user's intention and act appropriately correlates to the system's ability to invisibly and accurately predict what the user can and might do next.

No matter how rich and intuitive an interface is, its ultimate success and adoption depend on how well the user and the system can signal each other and compensate for the possible range of misunderstandings. Uncertainty or unpredictability between how to command a system and its resultant behavior can kill the immediate usefulness and delay the adoption of the gesture interface. Merely repetitively informing the

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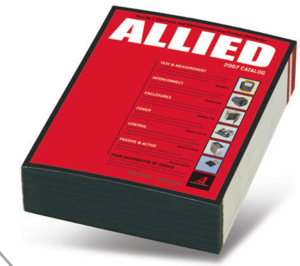

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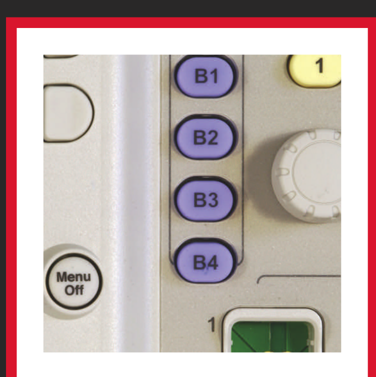

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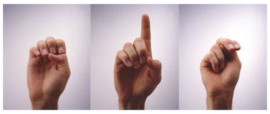

I'LL COMPENSATE FOR YOU

Modern interfaces are often more complex than they appear because they embody years of lessons designers have learned to compensate for how users view and interact with a system. The iPhone's predictive-typing engine couples with the dynamically resized tap zones to provide an example of the system's compensating for the user to reduce the frequency of unintentional inputs. This technology builds on and extends the techniques of past systems employed to improve key- or tap-based communication between user and system. One such older technology is keyboard-debounce filtering, which eliminates scenarios that occur when the system improperly interprets a single key press as multiple key presses because of transient properties of the input device.

The history of keyboard debounce illustrates a possible life cycle for an error-compensation mechanism. Errors were issues for early systems with electronic keyboards or touch displays that did not filter for debouncing. In these systems, the user is responsible for determining when the system misinterpreted a single key press as multiple presses. This situation places a low-value cognitive load on the user that can add to a user's frustration when using the interface. By filtering away debounce conditions, the user is free to focus on higher level tasks. Solving the debounce problem was once a differentiating feature, but it is now an assumed and normal capability.

The history of the delete-confirmation mechanism that many systems use today exemplifies how an interface capability can evolve to accommodate a better understanding of how users view the system. The delete-confirmation mechanism evolved from users' accidental deletion of data, such as files. With a command-line interface, a user could accidentally delete a file by using wild cards to specify an unintended file name for deletion. A pointing interface, such as a keyboard or a mouse cursor, allows accidental file deletion because the file name is based on where the cursor is pointing at the moment of the delete command.

An early change to user interfaces to compensate for this type of error was to ask the user to confirm the deletion; the user could verify the file name and spot an error before it occurred. A problem with this mechanism is that the confirmation applied to every deletion, and it easily became a mindless and automated key press or pointer click that lost its effectiveness as a safety step over a short time. The next compensation was to provide an undelete command to "fix" the failings of the deletion confirmation, and many systems now allow the user to skip or avoid the deletion-confirmation notice because it is often considered a low-value and high-noise way to protect data. A "trash-can" or "recycle bin" icon has replaced the undelete command; these features allow users to recover many deleted files. An analogous evolution occurred for in-application deletion of data with the introduction of the undo command and the eventual improvement of a multistep undo capability common in modern applications.

With each new compensation mechanism, the system took on more responsibility for understanding what users needed, even when that meant allowing users to reverse a previously irreversible action. At each stage of this evolution, the interface supported mechanisms that users could misunderstand or misuse. Each new compensation incorporated the lessons designers had learned about how the user might interact with the system to avoid future unwanted outcomes.


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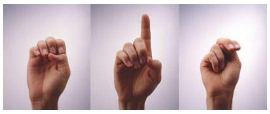

user that there is an error is insufficient in modern electronic equipment. These devices often guide the user about the nature of the error or misunderstanding and how they might correct the condition. Modern interfaces employ a combination of sensors, improved processing algorithms, and user feedback. This combination provides a variety of mechanisms to reduce ambiguity and uncertainty between the user and the system so that each can more quickly and meaningfully compensate for unexpected behavior of the other (see **sidebar** "I'll compensate for you").

One way to compensate for potential misunderstandings is for the system to control and to reduce the set of possible inputs to only those with a valid context, such as with the iPhone's specialized key layouts. Applications that can segment and isolate narrow contexts and apply strong goal-defined tasks in each one are good candidates for this type of compensation. Handwriting systems based on the Graffiti recognition system, such as Palm PDAs, improved the usability of a handwriting interface by narrowing the possibility for erroneous inputs, but doing so involved a significant learning curve for users before they could reliably use the system. Speech-recognition systems that require no training from a speaker increase their success rate by significantly limiting the number of words the systems can recognize, such as the 10 digits, or by presenting the user with a short menu of responses.

Another method of compensating for misunderstandings is to eliminate or move translations from the user to the system. HP Labs India is working with a pen-based device, the GKB (gesture keyboard), which allows users to enter phonetic scripts, such as Devanagari and Tamil scripts, as text input without the benefit of a language-specific keyboard. Another example is the Segway PT that once required a user to translate a forward and backward twist to correspond to a signal to turn left or right. Now, it instead allows the user to indicate left or right by leaning in the desired direction. In this case, the newer interface control removes the ambiguity of which twist direction aligns with which turn direction, and it aligns the control with the natural center-of-gravity use scenario for the system, which greatly increases its chances as a useful and sustainable interface.

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Another important way to compensate for potential errors or misunderstandings is to give users enough relevant feedback so that they can appropriately change their expectations or behavior. Visual feedback is a commonly used mechanism. The mouse cursor on most systems performs more functions than just acting as a pointing focus; it also acts as a primary feedback to the user about when the system is busy and why. The success of the gesture interface with the Wii remote hinges in part on how well the system software improves over time to provide better sensitivity to player gestures. It also depends on how well it provides feedback, such as a visual cue on the display, that points out how users can make small adjustments to their motions so that the system properly interprets their intended gestures.

Haptic or tactile feedback engages the user's sense of touch; it is a growing area for feedback, especially as a component of multimodal feedback involving more than a single sense. Game consoles have employed rumble features for years in their handheld controllers. The Segway PT signals error conditions to the user through force feedback in the control stick. The da Vinci Surgical System uses force feedback to signal boundary collisions, such as when the EndoWrist instrument makes contact with the surface of the cutting target. Haptic feedback can compensate for the weaknesses of other feedback methods, such as audio sounds in noisy environments.

Haptic feedback can also help offload

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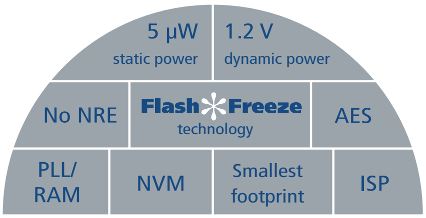

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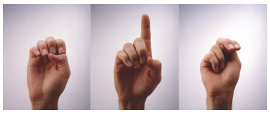

the visual sensory overload by freeing the user's eyes from seeking visual confirmation that the system has received an input to focus his eyes on other details. For example, the iPhone keypad does not implement haptic feedback to signal the user which key was pressed and when, so the user must visually confirm each key press the system processes. One company, Immersion, offers a way to simulate a tactile sensation for mobile devices by issuing precise pulse control over a device's vibration actuator within a 5-msec window of the input event.

When all other compensation methods fail to eliminate a misunderstanding, designers can employ a context-relevant response to address the uncertainty of a given input. A common response type is to issue a warning and to ask the user to repeat the input, but this situation risks frustrating the user if the system repeatedly requests the input with no additional guidance about what it needs. The system can make a best guess as to what the input was and ask the user to confirm that the guess is correct; this scenario also can cause frustration to the user if no method is available to refine the guess on a second try or if the system must too often confirm an input. A possible strategy for minimizing the use of these types of responses is for the system to profile the user's behavior and develop statistical models to better correlate guesses with what the user requests most frequently.

Gene Frantz, principal fellow at Texas Instruments, observes that the size of a system is scalable when you consider that networks can tie systems together. This consideration is increasingly important for modern devices. Consider that the iPhone, Wii, and Microsoft Surface include wireless-communication links with other systems. How these devices interact with other external systems correlates with how well they meet the needs of their users. Even as the world of gesture interfaces begins to stand on its electronic feet, we are increasing our expectations for our devices to apply the lessons we have learned for interacting with a single device to multiple devices seamlessly interacting with the user and each other. Those systems that can best predict the user's intent to minimize and avoid uncertainty and seamlessly pull together other systems in a connected world will likely drive the future of gesture interfaces. **EDN**

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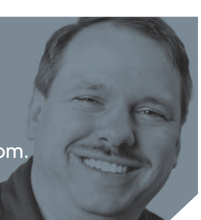

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SETTING UP A VERSATILE FLOW AND ENVIRONMENT IMPROVES DESIGN PRODUCTIVITY.

To handle numerous technical challenges associated with advanced process nodes, chip designers must have a design flow that adapts to evolving requirements and design goals. At the same time, design teams must also deal with project-related challenges, such as achieving consistent design development across geographically distributed design teams, ramping up new sites, and correcting issues with third-party-library and IP (intellectual-property) quality. Today's design flows must handle all of these challenges and still provide more flexibility, greater modularity, and new methodologies for achieving predictable design tapeouts.

To meet these goals, a design flow must be more than a means to solve design problems. It must also improve designer productivity and make design organizations more competitive. By implementing a versatile design flow and environment, design companies can:

- support multisite design efforts across geographically distributed teams with consistent sharing of design methodologies and project data;
- simultaneously handle multiple projects by quickly alerting team members to the latest best practices;
- move teams to projects with uniform flow execution;
- quickly adapt new libraries for a geometry or migrate to new geometries; and
- maximize designer productivity and minimize project delays with encapsulated methodologies and flow automation.

The Synopsys Professional Services group's customers use many foundries and libraries, implement a range of design applications, encounter many methodology challenges, support multiple points of design handoffs, and function with distributed teams. Accordingly, its design consultants encounter a full spectrum of design- and project-related challenges. The group has created a versatile flow to handle all of these challenges.

DESIGN FLOW AND ENVIRONMENT

The term "flow" has many meanings, so it is useful to clarify it and a few related terms. One of the most common flows is a reference, or reference-design, flow, which is a collection of scripts and best practices that describes the interoperability of data files across two or more EDA tools. You often tune these scripts for a targeted foundry's technology or a target design type, such as a core.

Closely related to the reference-design flow is a design methodology—a set of techniques and best practices to implement and verify a chip. For example, a methodology to implement a 20 million-gate chip containing a crossbar switch might include hierarchical partitioning, floorplanning with a fixed-target percentage of congestion constraint, shielding requirements on all clock and critical-signal nets, double-spacing-rule requirements for chip-level-clock and critical-signal routing, and multicorner-extraction-based signal-integrity analyses before sign-off.

In the most general sense, a design flow is a complete process that implements a design methodology or several design methodologies, such as the one previously described. You implement such a flow with a collection of ready-to-use scripts and utilities to run the tools, addressing both design- and project-related challenges. The flow might include standard practices from foundry reference flows. CAD and design teams typically configure the flow for project-specific use.

A design environment incorporates a design flow and adds the rest of the resources required to complete a chip. In addition to the flow, for example, the environment includes infrastructure, such as computing hardware and software; prescribed directory structure; data-management principles; consistent naming conventions; scripts to set up, use, and manage project data across design teams or projects; and the automation mechanics for executing the design flow and for rebuilding a chip.

NOT A PUSHBUTTON OPTION

Although flow automation is important for improving designer productivity, there is no such thing as a pushbutton design flow. Every design project has different requirements and input data that impose unique flow requirements. This fact argues against too much automation early in a project, when you need transparency in the processes. For example, you address many design-related challenges in floorplanning that are initially interactive, but you can automate them later in the project for rebuilding the chip after incremental changes.

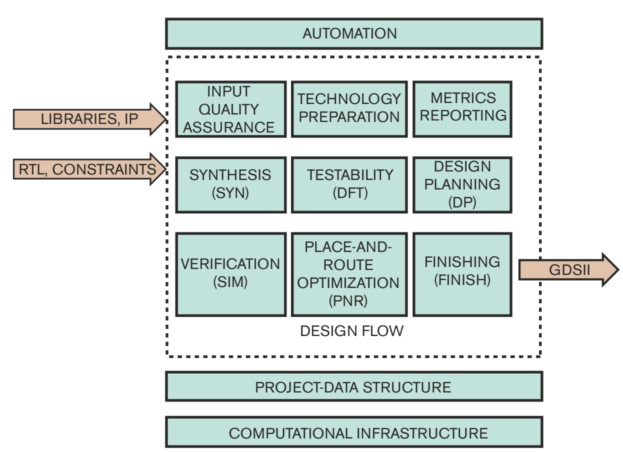


Figure 1 You can implement a good design by starting with a set of coupled layers.

Further, design flows are never static, because the underlying processes, libraries, IP, and EDA tools are dynamic. Keeping flows current requires ongoing investment and effort. A versatile, robust flow thus demands a good balance of modularity, configurability, and automation.

ROBUST DESIGN ENVIRONMENT

You can implement a good design environment in many ways. The Synopsys group recommends starting with a set of coupled layers (**Figure 1**). Here, "coupled" means having layers separated by function and connected through defined interfaces.

The automation layer gives you the flexibility to configure the design flow for project-specific goals and then capture and replay selected tasks. For example, the flow-automation requirements may include flow-step selection and replay, EDA-tool-version control with support for tool substitution, and built-in error checking and reporting throughout the design cycle. "Make" files offer an efficient model for such flow-step automation, and the automatic creation of correct-by-construction make files enhances flow automation.

The project data should be well-structured with a predefined data and scripting-interface model for single-site and multisite development. Good data management enables consistent job launching and management for efficient use of hardware and software resources. For example, organizing the technology and design-related files in separate directories allows you to reuse the same technology node across multiple users and even multiple projects.

The project-data-structure requirements may include a standardized directory structure to support flow execution across multiple users and sites, variable naming and scripting conventions for reuse, and preferred data management using a freeware or commercial revision-control system for individual and group development.

Using a scalable computing infrastructure lets you accommodate the changing needs of a single project or multiple projects in parallel. Runtime and design-quality metrics are valuable for guiding the deployment and updating of computer resources, and you can extract these metrics from the design flow.

When planning a new project, program managers can develop and use project-specific metrics that take into account the design team's size, the design's size, memory requirements, flow-step and task durations, and even the type of available computing servers. For example, Synopsys design centers use a computer farm of Unix- and Linux-based machines, job distribution using LSF (load-sharing facility), revision control using Perforce, and software-application access using a modules file (**references 1** to **3**).

At the heart of the design environment, the design-flow layer incorporates the EDA-tool flow and should embed the best practices and methodologies required to address all project-design issues. The design-flow layer addresses all of the chip-implementation tasks. Design teams integrate libraries and IP from multiple sources with varying degrees of quality and completeness. Qualifying this input data early in the design cycle avoids downstream surprises.

A typical project includes libraries from multiple vendors (such as standard cells, memories, I/Os, analog- and mixed-signal functions, and hard IP) and technology files from the selected foundry. Common problems include inconsistent timing and physical views in libraries; incomplete timing, physical, and logical models for new process nodes; and missing design rules within technology files or DRC/LVS (design-rule-check/layout-versus-schematic) decks. You achieve mea-

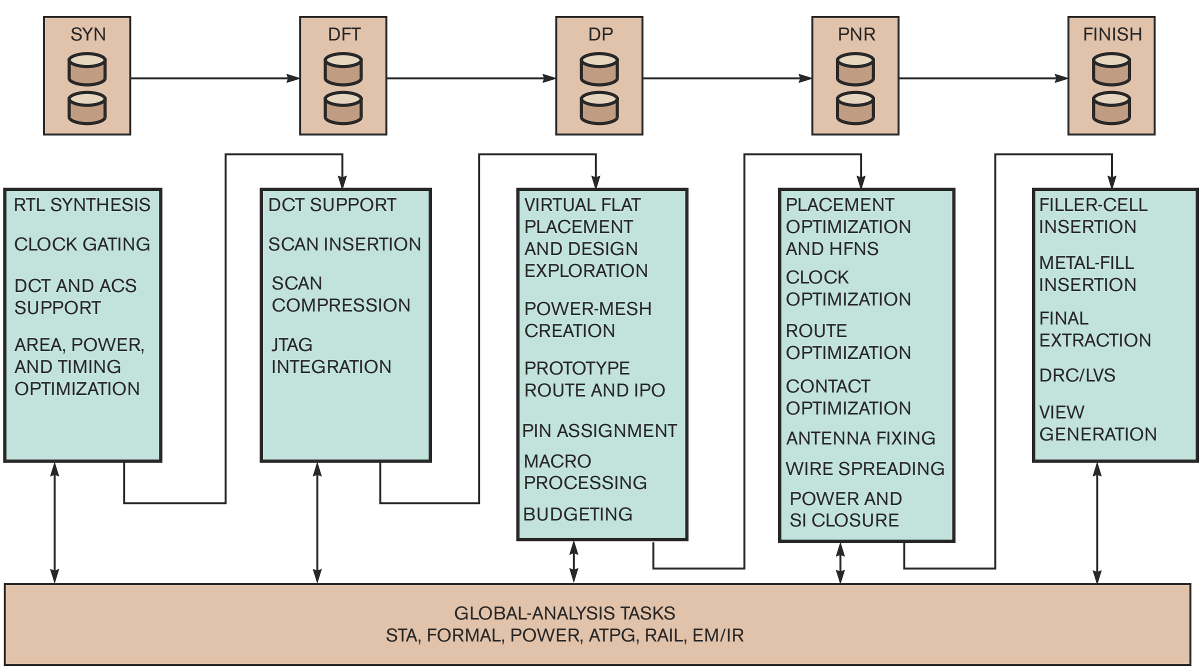
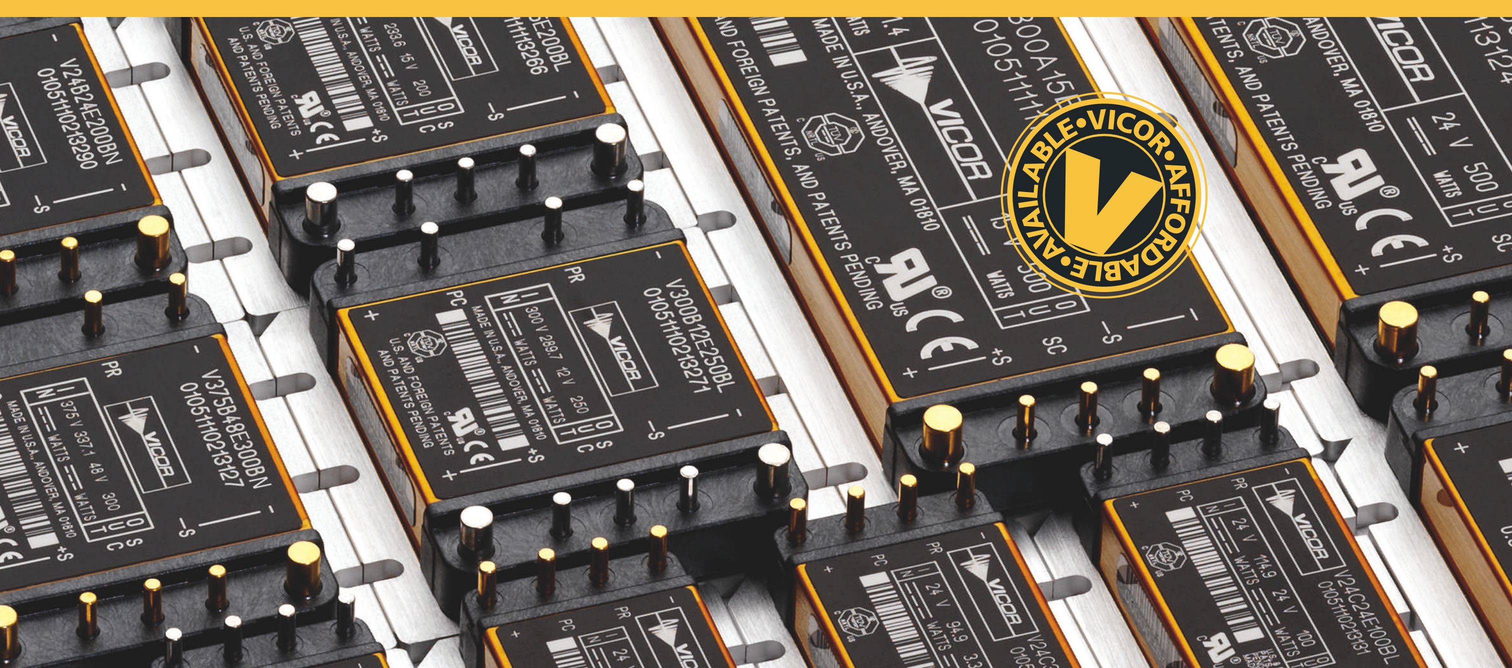


Figure 2 The RTL-to-GDSII implementation flow within Pilot Design Environment comprises five modular steps.



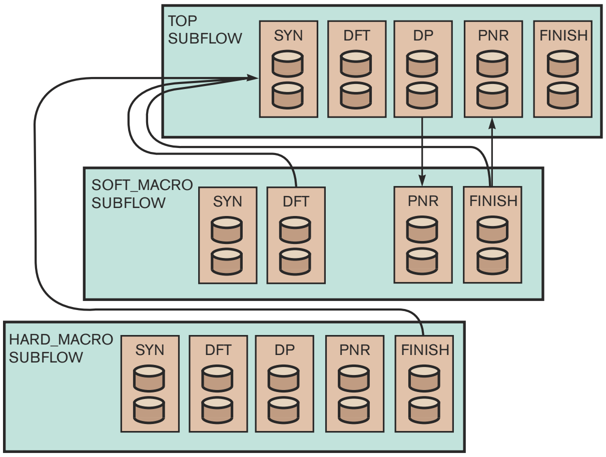


Figure 3 You can assemble modular-flow steps into a design-specific hierarchical RTL-to-GDSII flow using three subflows.

surable productivity improvement using a process to identify and correct these problems.

Two important processes enable designers to quickly prepare and qualify required input data at a project's start. First, incoming quality-assurance processes should focus on evaluating libraries, constraints, and RTL (register-transfer-level) files. Second, a method to generate correct-by-construction technology files from a single, up-to-date source—often the foundry—is necessary. Note that you should separate quality-assurance methodologies from the RTL-to-GDSII (Graphics Design System II) implementation-flow steps to ensure that project teams can retarget the same implementation flow for different process technologies and multiple libraries.

You should build the functional verification upon the structured project data to allow project teams to seamlessly share design data and output between implementation and verification of the same design. With the correct setup, you can export simulation-generated data files to the implementation side without manual intervention, thereby ensuring that teams use the right file versions to analyze and implement the design.

RTL-TO-GDSII IMPLEMENTATION FLOW

An RTL-to-GDSII implementation flow should provide modular steps for use across multiple sites and projects. The flow should also allow designers to modify individual steps for design- and project-specific needs. The RTL-to-GDSII implementation flow within the Pilot Design Environment comprises five modular steps (**Figure 2**).

You can assemble these modular-flow steps into a design-specific hierarchical RTL-to-GDSII flow using three subflows (**Figure 3**). The hard_macro subflow hardens blocks, such as ARM cores and other IP for chip-level integration. The soft_macro subflow is for implementing and delivering hierarchical-design modules for chip-level integration. You use the top subflow either to hierarchically integrate the chip design with design in-

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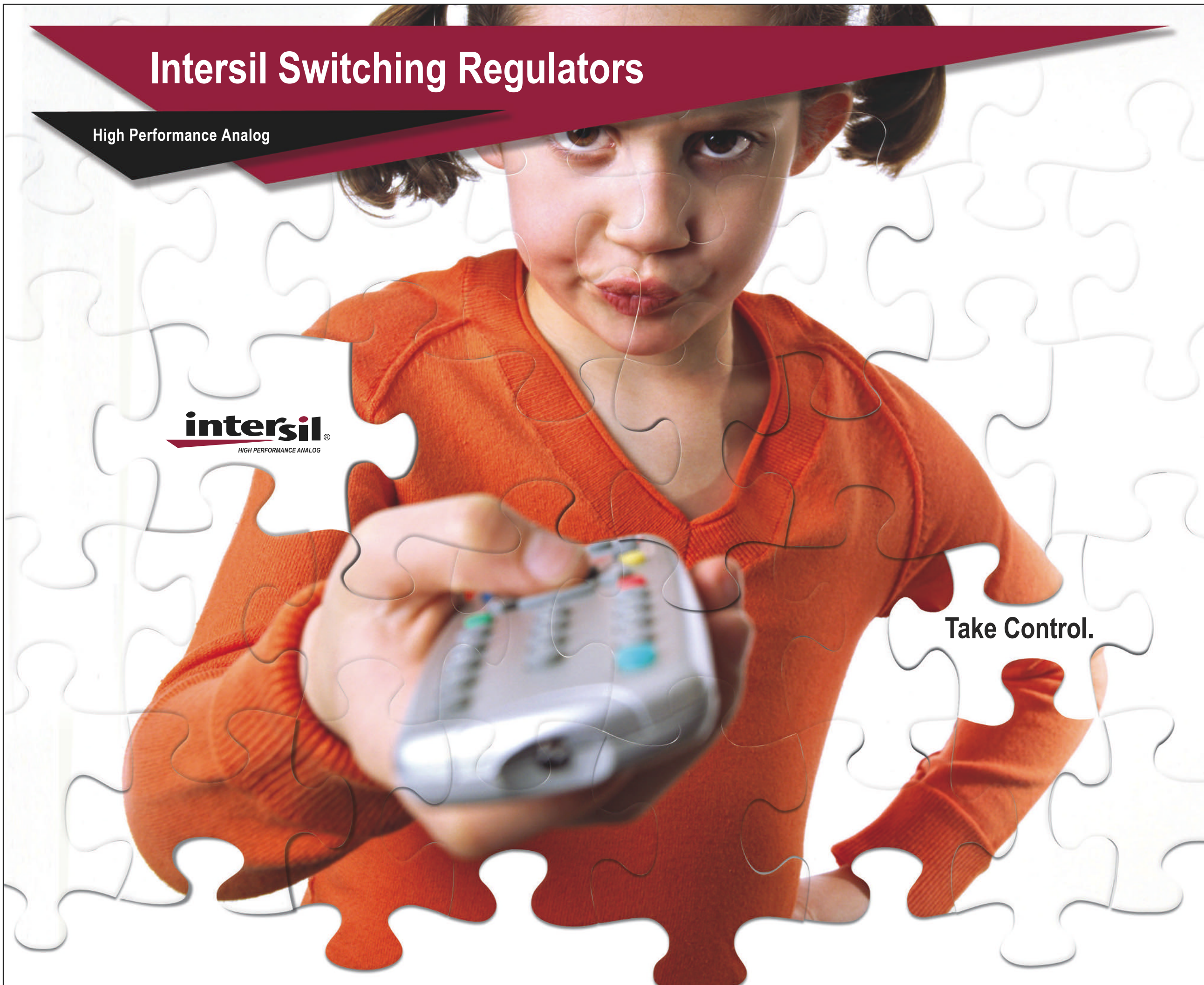

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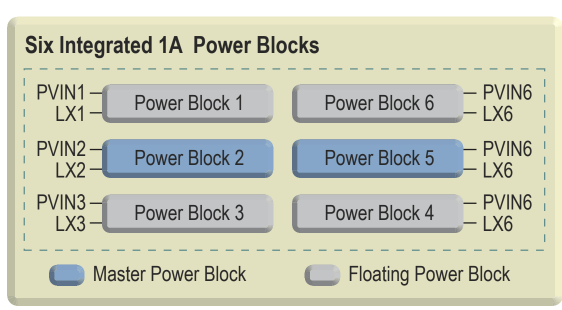

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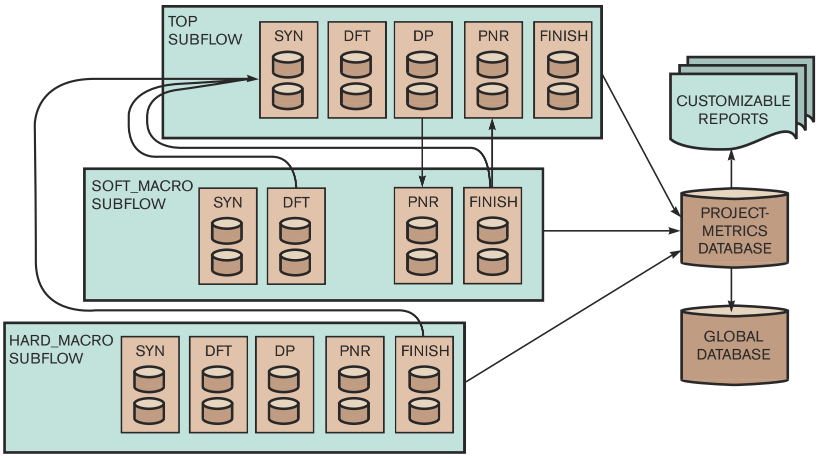

Figure 4 You can accomplish automation by embedding the metrics-tracking system within the flow architecture.

put from the other two subflows or to provide the flexibility to simply supply a flat implementation of the chip design.

This subflow architecture allows each project team to structure, configure, and automate the flow for its block-specific needs. Further, it gives project teams the flexibility and control to apply the same implementation flow to a range of design applications and design styles and to ensure consistent integration across multiple sites and handoffs.

Another key benefit of this approach is the ease with which users can introduce advanced EDA-product methodologies, reference flows, and best practices without rebuilding the baseline flow from scratch.

This flow implementation supports a variety of design methodologies and tool features to address design issues common in complex SOCs (systems on chips), such as high frequency, power management, signal integrity, reliability, yield, and testability. For recommendations on specific design methodologies for design planning, hierarchical planning, power management, and signal integrity, see **Reference 4**.

A MEASURED APPROACH

An important consideration when building a design flow is the means for collecting metrics associated with project execution. The monitoring and reporting of metrics throughout the design cycle can be of great value in helping designers assess design-completion status.

Some view with skepticism the need for determining relevant metrics and establishing techniques and discipline for measurement regarding these metrics' accuracy and value. Im-

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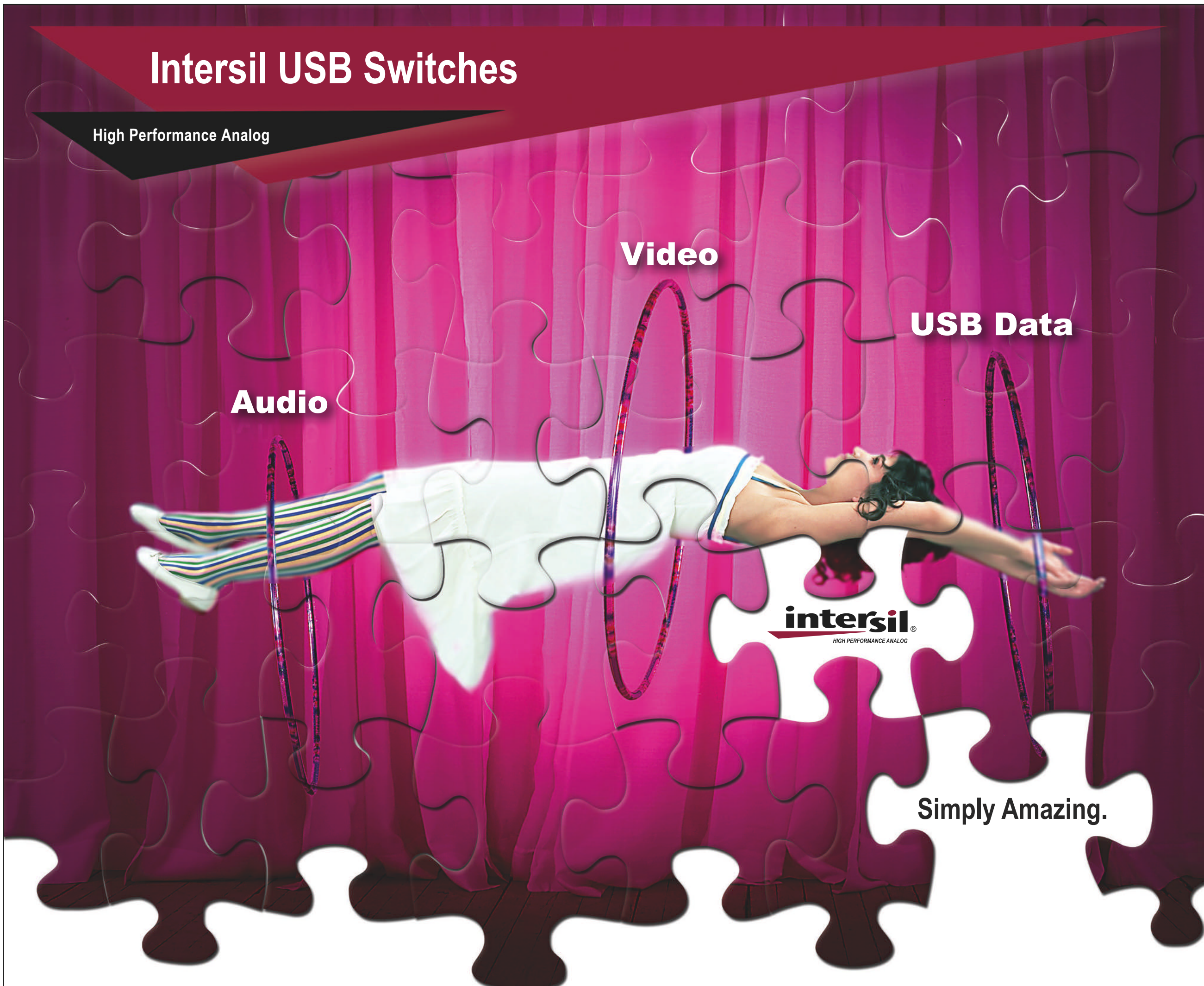

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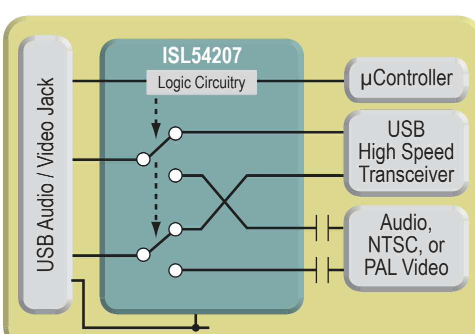
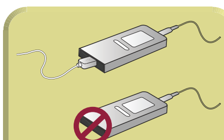
ISL54208	0.06	480	0.28 / 0.04
ISL54415	0.007	12	0.04 / 0.03
ISL54416	0.007	12	0.04 / 0.03
ISL54417	0.007	12	0.04 / 0.03





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Device	Audio THD 32Ω (%)	USB Speed
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ISL54400	0.007	12
ISL54401	0.007	12
ISL54402	0.007	12

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perfect as metrics may be, measuring the performance of the design flow in real time is an essential element to improving productivity. Flow metrics help designers and program managers determine where extra resources and time are necessary to ensure that teams complete design tasks on time.

Also, monitoring key metrics improves predictability by providing visibility into the health of the design and tapeout readiness. In the longer term, flow metrics help identify aspects of the flow that require improvement and provide a basis for quantifying the improvement from one flow version or project to the next. Additionally, metric reports improve communication of design-project status among stake holders, and teams can maintain reports on a project-tracking Web site or a project scoreboard for postproject analysis.

To avoid distraction from primary design tasks, capturing and reporting design metrics require automation for minimal overhead. Automated metrics simplify evaluation of tool-change needs, assessment of new-methodology choices, and identification of flow bottlenecks. You can accomplish automation by embedding the metrics-tracking system within the flow architecture (**Figure 4**).

Sample metrics include the design's physical size, cell use, number of nets, number of pins, number of instances, and the physical DRC status. Detailed QOR (quality-of-results) metrics relating to timing closure include the TNS (total negative slack), WNS (worst negative slack), number of timing violations, slack histograms, number of clocks, clock skew, and clock latency.

Equally important are the metrics associated with infrastructure resources. The metrics-monitoring facilities in the design flow can capture detailed statistics on CPU runtime, memory usage, and disk-space usage, as well as on EDA tools and versions. **Reference 4** contains a more detailed discussion of how to use metrics.

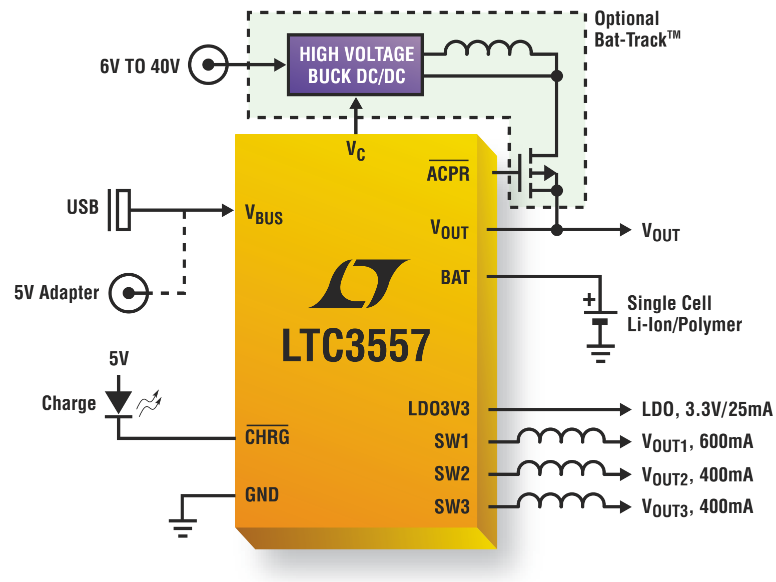
LESSONS LEARNED

Design-flow development is not an optional activity, though the efficiency and impact on design programs can vary greatly. Complex chips require a robust but flexible system to meet schedules and ensure tapeout success. Shorter market windows have put tremendous pressures on designers to meet aggressive schedules and performance targets. Without a well-defined flow and environment, designers have little chance of meeting these aggressive goals. Actively maintaining up-to-date design flows can help remove flow issues from the critical path. A well-defined environment also gives designers on-the-fly configurability to address new issues as they arise.

Second, attempting to create a one-size-fits-all flow is an unreasonable approach. Such an approach is expensive and is unlikely to support all the methods that CAD engineers and designers need. A practical approach is to create one modular, layer-based design environment in which you configure the design flow for project- and design-specific needs. The result is an easy-to-set-up, easy-to-use, and easy-to-support flow.

For example, a design can easily accommodate library and IP changes if you separate the technical-library preparation

Less Is More



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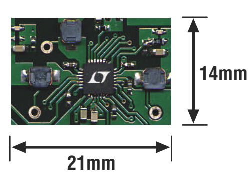
LTC3557 Demo Board



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and library-qualification methodologies from the RTL-to-GDSII flow steps, allowing designers to target the same implementation flow for multiple processes, technologies, and libraries. Similarly, a team can adopt new EDA tools and features if the flow steps are modular and separate from the automation layer.

Third, to maximize designers' flexibility, you should automate the design tasks and not the process. The focus should be on capturing design-specific tasks and ensuring repeatability of the tasks through automation. You can accomplish this task by separating the baseline flow from the automation and the project-data-structure layers.

Additionally, to ensure predictable implementation across multiple sites and multiple projects, apply a logical and consistent project-data structure, but do not hard-code the data structure in the design flow. Use variables within the design flow and common directory-naming conventions for the design tasks.

No matter how robust the design flow, nothing can replace the expertise that comes with experience and proper training on new tools and methodologies. This requisite knowledge helps project teams avoid what are often wasted iterations through the design process.

Finally, the development of the flow and environment is not a one-time activity, because processes, libraries, IP, EDA tools, and—more important—the underlying designs change constantly. Without periodic methodology enhancements, tool updates, and ongoing support, it is easy for the flow to become outdated, resulting in lost designer productivity and project delays.

The benefits of setting up a versatile design environment are numerous for both the CAD and the project teams but boil down to a simple concept: To achieve predictable time to results, you need a predictable design process. Furthermore, by making the design processes consistent and measurable, you can make systematic improvements, quantify results, and more easily share results among design teams. A robust and versatile design environment demonstrably and dramatically improves designer productivity and tapeout predictability, and you can deploy it with minimal overhead. **EDN**

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4. Synopsys, www.synopsys.com/sps/techpapers.html.

AUTHOR'S BIOGRAPHY

Director of the Design Flow Center of Excellence at Synopsys, Andy Potemski has more than 25 years of experience in the semiconductor and EDA industries. He has worked in design-engineering, consulting, and management roles at Synopsys and at IBM. Potemski graduated from Fairfield University (Fairfield, CT) with a bachelor's degree in electrical engineering and holds four US patents in IC design.

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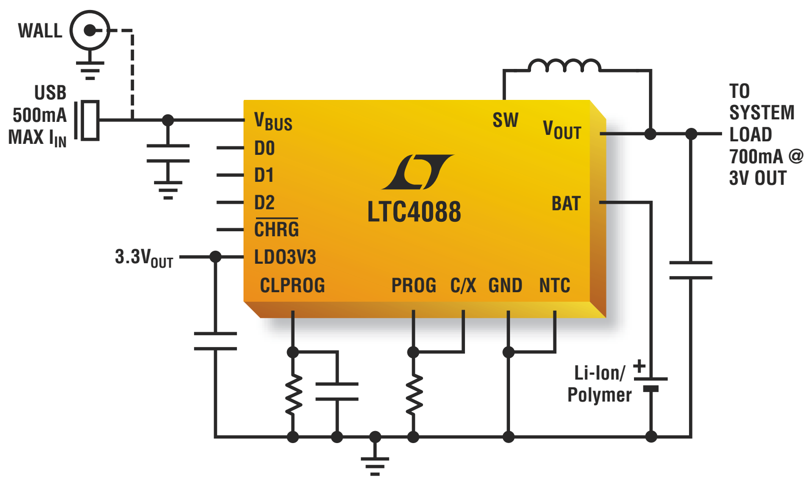

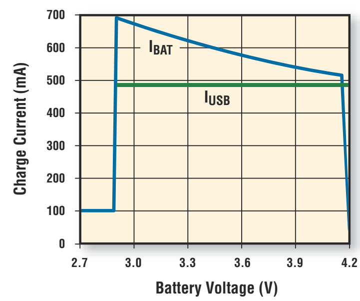

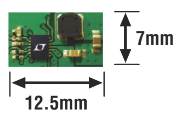

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LTC4066	Linear	4.35 to 5.5V (7V max)	Timer with C/x Indication	4mm x 4mm QFN-24	Integrated 50mΩ Low Loss Ideal Diode
LTC4085	Linear	4.35 to 5.5V (7V max)	Timer with C/10 Indication	3mm x 4mm DFN-14	Integrated 200mΩ Low Loss Ideal Diode (<50mΩ Capable Option)
LTC4089	Linear	4.35 to 36V (40V max)	Timer with C/10 Indication	3mm x 6mm DFN-22	Bat-Track, "Instant-ON" Operation, High Voltage Input Switching, with Current Limiting from USB
LTC4067	Linear	4.25 to 5.5V (13V OVP)	Timer with C/10 Indication	3mm x 4mm DFN-12	Up to 1.25A Charge Current, Integrated 200mΩ Low Loss Ideal Diode
LTC4090	Linear	4.35 to 36V (60V max)	Timer with C/10 Indication	3mm x 6mm DFN-22	Bat-Track, "Instant-ON" Operation, High Voltage Input Switching, with Current Limiting from USB

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READERS SOLVE DESIGN PROBLEMS

Circuit compensates system offset of a load-cell-based balance

Luca Bruno, ITIS Hensemberger, Monza, Italy

It's a challenge to interface a resistive bridge sensor with an ADC receiving its power from a 5V single-supply power source. Some applications require output-voltage swings from 0V to a full-scale voltage, such as 4.096V, with excellent accuracy. With most single-supply instrumentation amplifiers, problems arise when the output signal approaches 0V, near the lower output-swing limit of a single-supply instrumentation amp. A good single-supply instrumentation amp may swing close to single-supply ground but does not reach ground even if it has a true rail-to-rail output.

In this application, the sensor is a precision load cell with a nominal load of 5 kg, or about 11 lbs, to weigh objects on an aluminum pan weighing approximately 150g, or approximately 5 oz. Because of the pan's weight, the instrumentation amplifier's output signal can never go down to 0V, even if there are no objects to weigh. Now, the problem arises of how to compensate the instrumentation amp's output-offset voltage and the voltage that the pan itself produces.

A software approach is the simplest way to compensate the system offset. During power-up, there are no objects to weigh on the pan, and the system can thus acquire the offset voltage and hold the data in the microcontroller's memory, subsequently subtracting it from the data it acquired when there was an object to weigh. This approach, however, does not reach the 5-kg full-scale of the balance, reaching only 5−0.15 kg, or 4.85 kg.

This Design Idea shows how to achieve hardware compensation us-

DIs Inside

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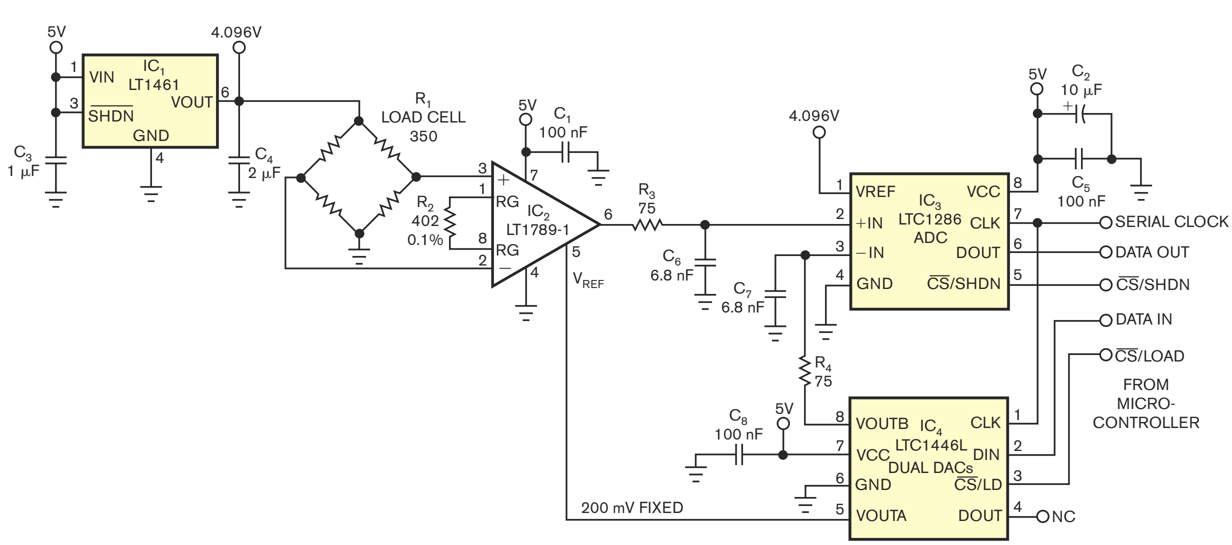

Figure 1 The serial dual DAC in this circuit gets an offset voltage from the microprocessor (not shown) during a power-on-calibration routine.

ing a microcontroller that, on power-up, starts a software routine to reset the system offset. The solution is a simple circuit based on four ICs from Linear Technology (www.linear.com) in **Figure 1**. A precision voltage reference, IC_1, has a high minimum output current of 50 mA. It provides an output voltage of 4.096V to power the load cell and to set the full-scale of the 12-bit ADC, IC_3. The highly accurate LT1789-1 instrumentation amplifier, IC_2, features maximum input-offset voltage of 150 µV over the temperature range of 0 to 70°C and maximum input-drift-offset voltage of 0.5 µV/°C over the temperature range of 0 to 70°C with rail-to-rail output that swings within 110 mV of ground. You set the gain through precision resistor R_2 to a nominal value of 500Ω to give an output span of 4.096V when the load is 5 kg and its maximum input signal is $V_{CC}\times S=4.096V\times 2$ mV/V=8.192 mV, where S is the sensor's sensitivity.

The output of DAC_A of dual-DAC IC_4 provides a reference voltage of 200 mV at the reference pin of the instrumentation amp to avoid saturation near ground of the amplifier itself, where its transfer characteristic is not quite linear. The amplifier's total worst-case output offset is: $V_{REF}+V_{PAN}\pm V_{OFFSET}$=200 mV+125 mV±500×150 µV=325 mV±75 mV=250 mV/400 mV, where V_{PAN}=125 mV and is the voltage that the pan's weight produces.

The system-output offset is thus 250 to 400 mV. On power-up, the microcontroller starts a routine that sets the output of the DAC_A equal to 200 mV, while it increases the output of the DAC_B of dual-DAC IC_4 until it is equal to the system offset on Pin 2 of ADC IC_3, and the result of the conversion is 000h. This result is possible because IC_4 contains two 12-bit DACs with the same full-scale voltage of 2.5V, making 1 LSB equal to 0.61 mV, which is smaller than IC_3's resolution of 1 mV. This figure corresponds to the resolution of the balance: 5000g/4096=1.22g. The maximum output voltage of the instrumentation amp with a maximum load of 5 kg is $4.096V+V_{OUT\_TOTAL\_OFFSET\_INA}$= 4.346V/4.496V, which is less than the minimum worst case over temperature of 4.62V high saturation.

IC_3 has a single unipolar differential input, so you can subtract from the +IN input voltage a constant voltage of value equal to the system offset that that DAC_B of IC_4 provides. During the first one and a half clock cycles, the ADC samples and holds the positive input. At the end of this phase, or acquisition time, the input capacitor switches to the negative input, and the conversion starts. The RC-input filters on the inputs of IC_3 have a time constant of 0.5 µsec to permit the negative and positive input voltages to settle to a 12-bit accuracy during the first clock cycle of the conversion time, using the maximum clock frequency, which is 200 kHz. If you want to increase the time constant, then you must use a lower clock frequency.

Furthermore, the DAC and ADC have a three-wire serial interface that easily permits transferring data to a wide range of microcontrollers with a maximum sampling rate of 12.5k samples/sec. When the ADC performs no conversions, it automatically powers down to 1 nA of supply current, and, if the microcontroller shuts down IC_1 through its Pin 3, the circuit draws a worst-case supply current of just 1 mA, because all the ICs are micropower. EDN

Voltage doubler uses inherent features of push-pull dc/dc converter

Ajoy Raman, Aeronautical Development Establishment, Bangalore, India

This Design Idea presents a minimal-parts-count, wide-range voltage doubler using the inherent voltage-doubling characteristics of a one-transformer push-pull dc/dc converter. The implementation uses a high-voltage Darlington-array driver, ULN2023A. The circuit exhibits a wide input-voltage range of 5 to 30V and provides a typical power output of 1 to 4W at moderate efficiency.

Figure 1 shows a simple, one-transformer dc/dc converter in which cross-coupled RC networks from the collectors of Q_1 and Q_2 to the corresponding bases provide regenerative feedback. In operation, the transformer alternates between positive and negative saturation, with collapse in transformer flux leading induced voltages to drive the transistors alternately off and on. The input-voltage and saturation charac-

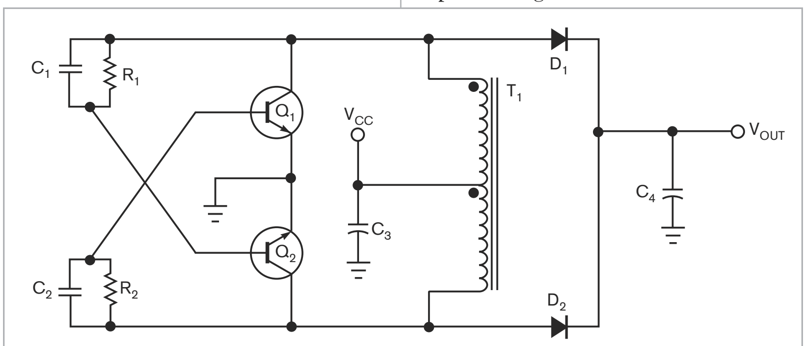

Figure 1 A simple one-transformer dc/dc voltage doubler has cross-coupled RC networks from the collectors of Q_1 and Q_2 to the corresponding bases. These networks provide regenerative feedback.

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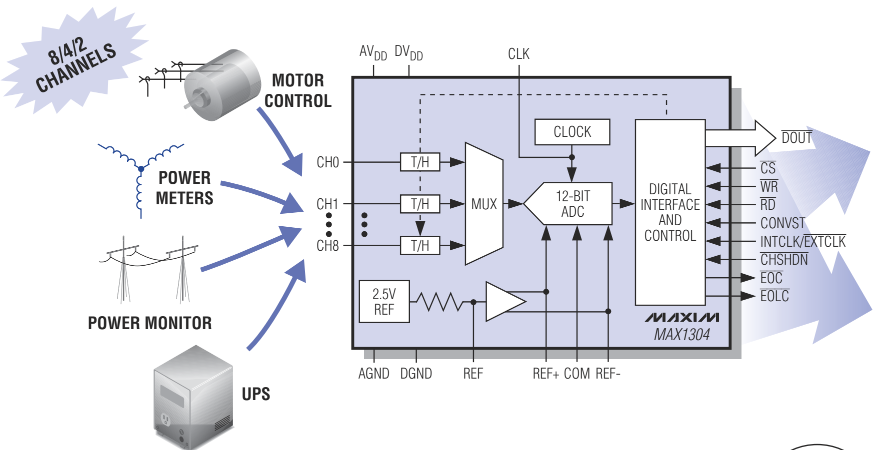

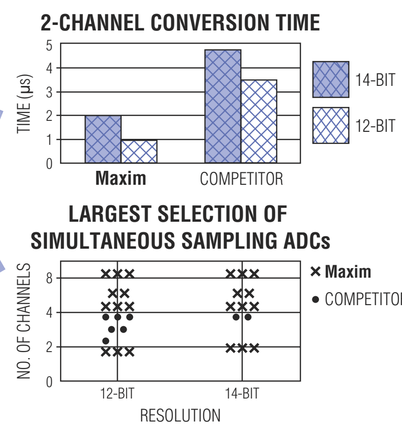

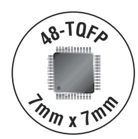

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TABLE 1 EXPERIMENTAL RESULTS

Input voltage (V)	Input current (mA)	Oscillating frequency (kHz)	Output voltage (V)	Load current (mA)	Power input (W)	Power output (W)	Efficiency (%)
5	245	1.79	7.59	105.95	1.22	0.8	65.77
10	250	4	17.68	104.13	2.5	1.84	73.72
15	274	6.06	27.7	111.7	4.12	3.09	75.08
20	280	8.2	37.9	110.12	5.6	4.17	74.53
25	242	10.53	48.1	88.23	6.05	4.24	70.15
30	205	13.33	58.7	66.25	6.15	3.89	63.23

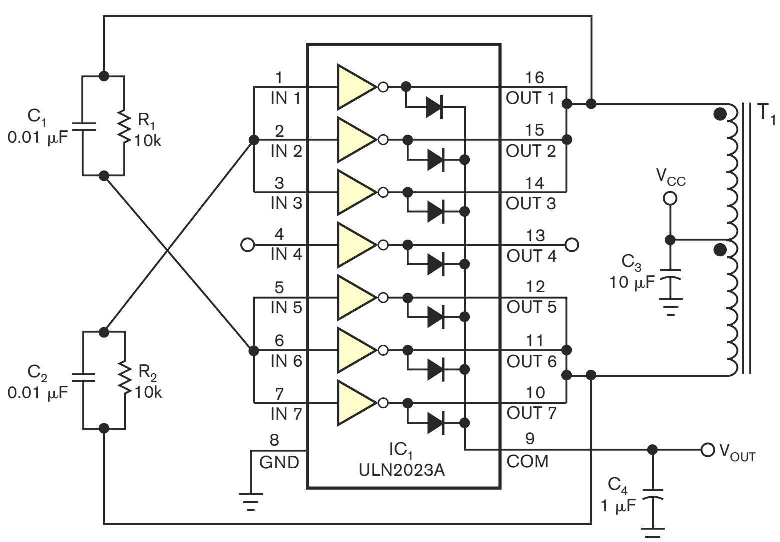

Figure 3 Taking advantage of the multiple drivers in one package, three drivers are parallel in each leg of the circuit.

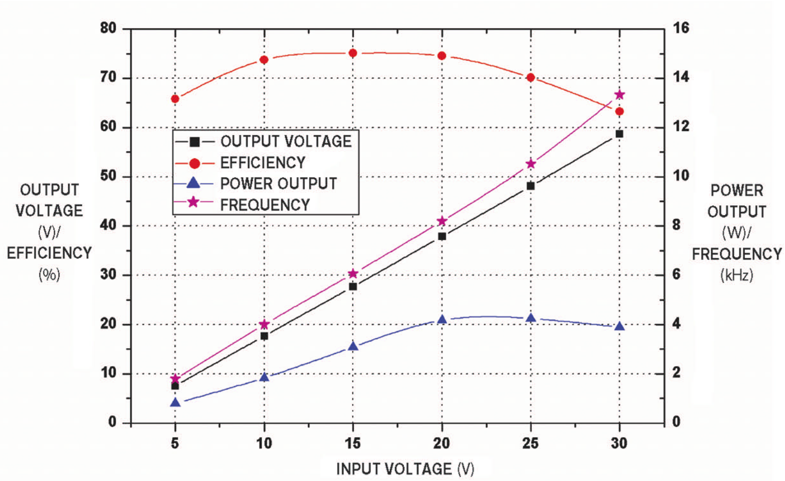

Figure 4 Experimental results show the circuit in Figure 3 operating as a low-power, moderately efficient, wide-range voltage doubler.

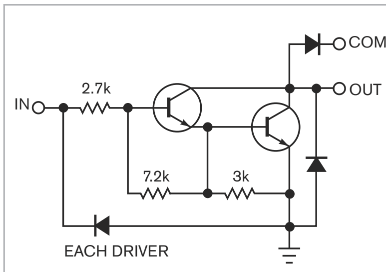

Figure 2 The internal configuration of the high-voltage Darlington-array ULN2023A driver exactly matches the requirements of the circuit in Figure 1 by providing rectifier diodes at the collector outputs.

teristics of the transformer core determine the operating frequency based on the relationship

$$f = \frac{V_{CC} \times 10^8}{4\beta_S AN} \text{Hz},$$

where V_{CC} is the input voltage, β_S is the saturated flux density in gauss, A is the cross-section area of the core in square centimeters, and N is the number of turns in half of the primary. The circuit uses the property that the collector-to-emitter voltage of each device is approximately twice the supply voltage, V_{CC}, plus induced voltages, which occur because of leakage inductance. Rectification and filtration of the collector voltages of Q_1 and Q_2 through D_1 and D_2 directly provide an output voltage that is approximately double the input voltage, V_{CC}.

The internal schematic of the high-voltage Darlington-array ULN2023A driver in **Figure 2** exactly matches the requirements for the circuit in **Figure 1** by providing rectifier diodes at the collector outputs. The voltage-breakdown specification of 95V meets the maximum requirement of twice V_{CC} plus transients when operating at an input of 30V. The device exhibits a low collector-to-emitter saturation voltage at the desired current level of approximately 100 mA and low switching times when switching at rates as high as tens of kilohertz.

Figure 3 shows the final circuit configuration. Three drivers operate in parallel, sharing the drive current, minimizing the collector-to-emitter

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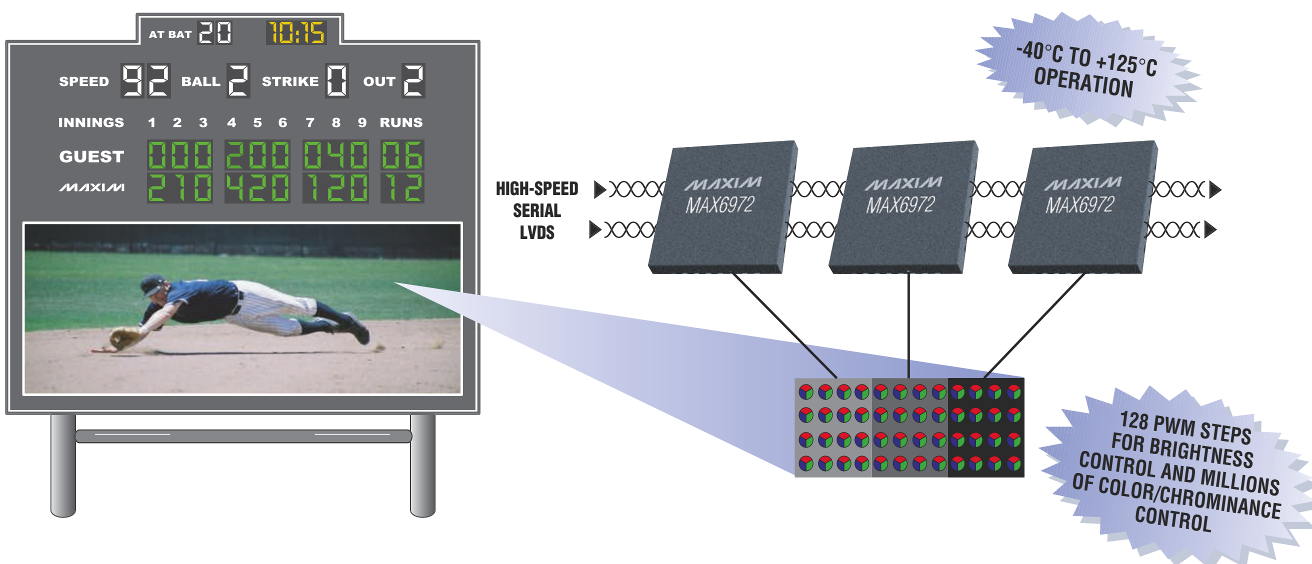

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voltage, and maximizing the permitted power dissipation. **Table 1** shows the experimental results with the voltage-doubler circuit operating over the input voltage of 5 to 30V. In that range, the input current is less than 300 mA to remain within the current values of the transformer at lower input voltages and within the power-dissipation limit of the ULN2023A at higher input voltages. **Figure 4** shows the plot of the experimental results, clearly indicating the operation of a low-power, moderately efficient, wide-range voltage doubler. EDN

Voltage timer monitors line-connected ac loads

Michael Petersen, Maxim Integrated Products, Sunnyvale, CA

A simple circuit monitors the elapsed time over which a line-connected ac load energizes (**Figure 1**). You can then access the elapsed-time count over a standard one-wire protocol. When you energize the ac load, the optoisolator provides pulses at the ac-line frequency to the input of the one-wire counter, a DS2423 IC. Thus, the counter continuously increments whenever you energize the load. Resistors R_1 and R_2 limit the current, and diode D_1 protects the optoisolator from reverse-polarity voltages during the negative half of the line cycle.

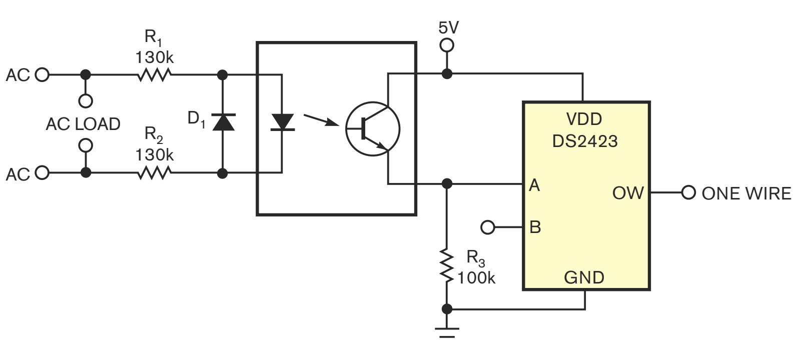

Figure 1 This circuit monitors line-connected ac loads by counting one pulse per cycle when the load is energized.

As an example, the circuit can monitor the duration of operating intervals for a 240V-ac well pump, thereby giving an indirect measure of the amount of water the well pumps and the approximate amount of power it consumes. The one-wire master counter—a Linux-based PC, for example—reads the elapsed count once per minute. Any change in the count from one reading to the next indicates that the pump is energized and running, and you calculate the length of time in seconds by simply taking the difference in counter values divided by the line frequency—60 Hz, in this case. The time in seconds equals the new count minus the old count divided by 60 Hz.

The circuit can monitor a water heater, a furnace, an air-conditioning unit, or any other ac-connected load. You may need to adjust the R_1 and R_2 values to accommodate line voltages other than 240V ac or the characteristics of other optoisolators. You can also monitor two independent loads by attaching a second optoisolator circuit to the Counter B input of a single DS2423. EDN

Cascaded converter boosts LED-drive capability

Grant Smith, National Semiconductor, Phoenix, AZ

Powering 20 to 30 white LEDs from three alkaline cells presents an interesting problem for the conventional boost converter. The required boost ratio and duty factor are simply impractical. If you are determined to design with off-the-shelf components, cascading two stages of boost can yield reasonable results. This topology has been around for decades, but engineers often perceive it as too complicated. There are, however, certain inherent advantages in this approach's component requirements. The first-stage switch need not tolerate the total output voltage of the second switch, and the second switch does not have the current requirements of the first. If the duty factor were not a concern, the current/voltage requirements of a single-stage boost would require a larger, more expensive switch that might easily approach the cost of both switches in the cascaded boost. You can also realize similar advantages of the inductors, rectifiers, and filter capacitors.

This Design Idea powers 24 white or ultraviolet LEDs in series at approximately 20 mA. At a nominal 4.5V-dc input, the measured efficiency is 84.2%. This figure is reasonable for a 2 to 2.5W converter. At a 3V-dc input, the overall boost ratio for a noncascaded converter is potentially more than 30-to-1, requiring an on-time duty factor of approximately 97%. In a cascaded boost converter, this duty factor is a function of the square root of the total boost ratio. This ratio equates to

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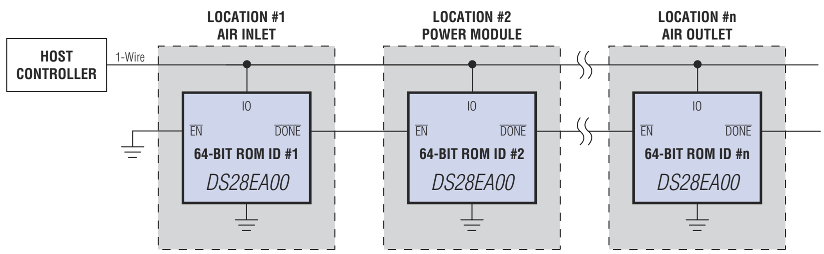

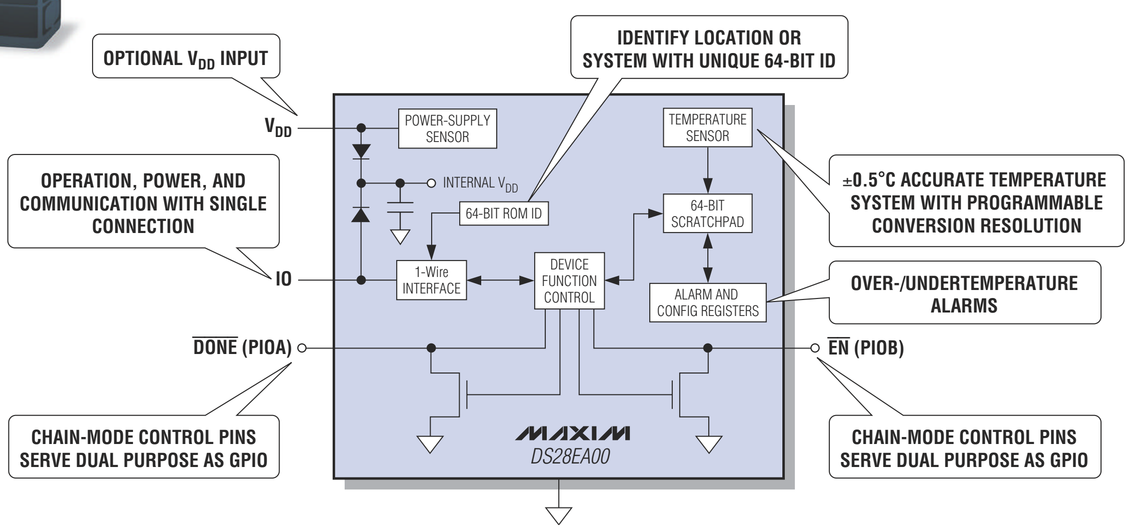

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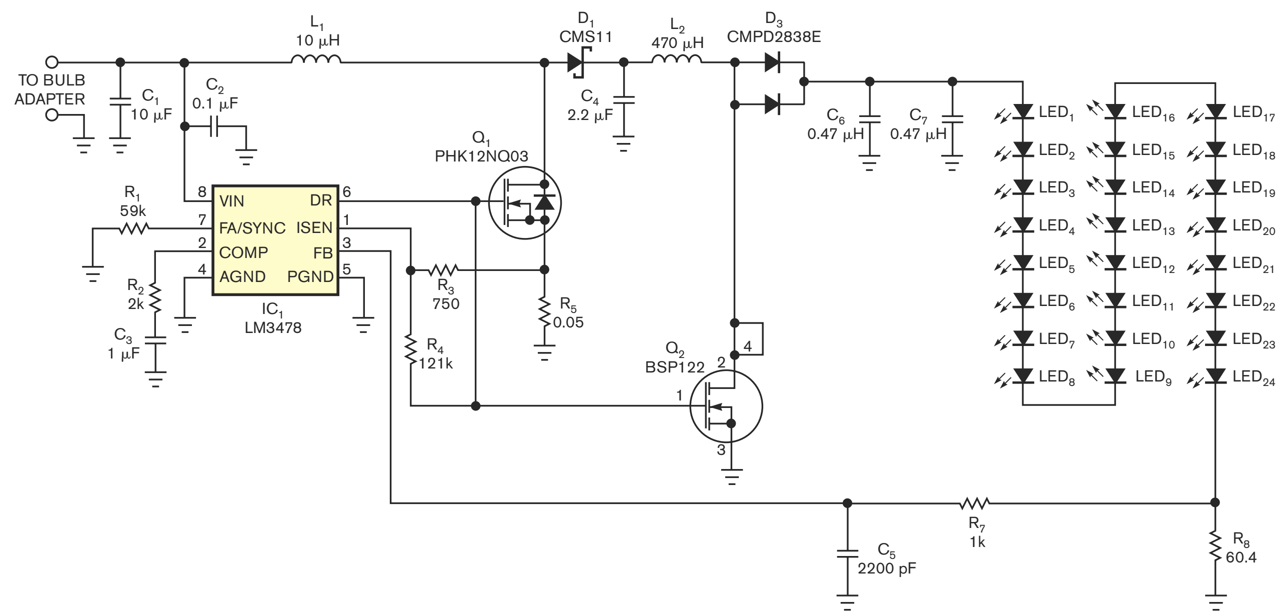

Figure 1 Comprising off-the-shelf components, this circuit cascades two stages of boost to drive a string of 20 to 30 LEDs.

a maximum of about 82% just before the occurrence of undervoltage shutdown. At a normal 4.5V-dc input, the duty factor should be slightly more than 77%.

The circuit in **Figure 1** implements a cascaded boost converter, which takes the place of the lens assembly in a popular heavy-duty flashlight. It includes 24 white or ultraviolet LEDs on one side of the circular PCB (printed-circuit board) and the active circuitry on the other. You can substitute red LEDs for three or four of the ultraviolet LEDs to offer an appropriate visible backlight. Although you may prefer to use a single high-powered white LED, high-powered ultraviolet LEDs appear to be unobtainable. This project uses 20 inexpensive LEDs offering 400 mW of optical power for 1.52W input at a more useful 30° viewing angle. Its directional nature also helps prevent accidental eye damage. Ultraviolet-light sources find use in many applications, including gem inspection, currency inspection, and scorpion detection.

The PWM controller, IC_1, an LM3478, operates at voltages as low as 3V dc, eliminating the need for a charge pump. The transistors are rated for less than 3V gate drive. IC_1 simultaneously drives Q_1 and Q_2. The circuit requires only one controller and uses off-the-shelf inductors. The first-stage inductor and filter capacitor can produce substantial ripple without adversely affecting the final output ripple. The first rectifier is an inexpensive, 40V Schottky unit, and the second is a simple signal diode rated for 120V.

IC_1 operates at a switching frequency of approximately 300 kHz, which R_1 sets. The design uses a current-mode-control scheme with slope compensation. A signal from current-sense resistor R_5 modulates slope compensation through R_3. In this case, the value of R_5 is small for enhanced efficiency. R_4 sums the signal with the gate-drive output to increase its apparent amplitude by the current-sense input at Pin 1. R_2 and C_3 are the usual compensation components. In this case, the response time of the converter is unimportant, so it is easy to choose the components.

It is easy to overlook the cascaded boost converter without sufficiently analyzing it. Mass-produced components that suit their function afford a more cost-effective and simple approach than you might realize at first. An integrated flyback regulator can easily require many components to provide this kind of solution without any real advantage. It is also likely to require custom magnetics.EDN

Dual transistor improves current-sense circuit

Robert Zawislak, PE, Consultant, Palatine, IL

In multiple-output power supplies in which a single supply powers circuitry of vastly different current draws, two perplexing steps are sensing the current that each output draws and deactivating the power supply in the event of an overload on that output. These issues are especially important in protecting the fragile PCB (printed-circuit-board) traces in low-level circuits. A typical circuit would use the base-emitter threshold volt-

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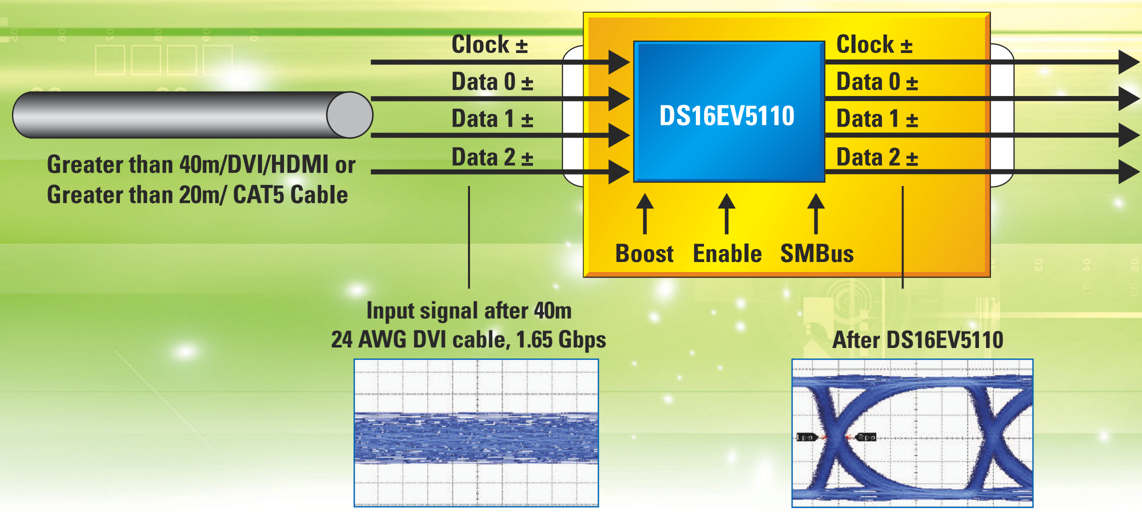

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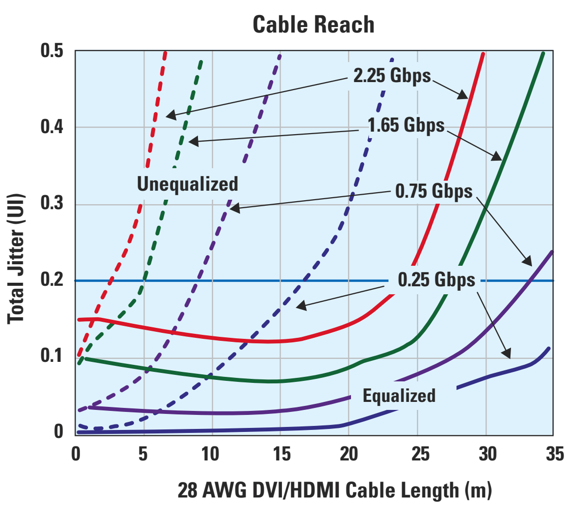
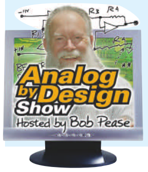


Analog by Design Show



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age of approximately 0.6V of a bipolar transistor to trigger the power-supply-protection circuits. Although economical, the transistor's threshold varies excessively over temperature; hence, the protection level is unstable.

The circuit in **Figure 1** essentially eliminates the base-emitter-voltage temperature-variation problem as the derivation of the output voltage and as a function of the load current. By using dual bipolar devices in one case, the manufacturer nearly perfectly matches the two devices. Although this Design Idea describes a positive power supply, you can realize a similar negative-output-supply current-sense circuit using a dual NPN transistor in place of the dual PNP that the **figure** shows.

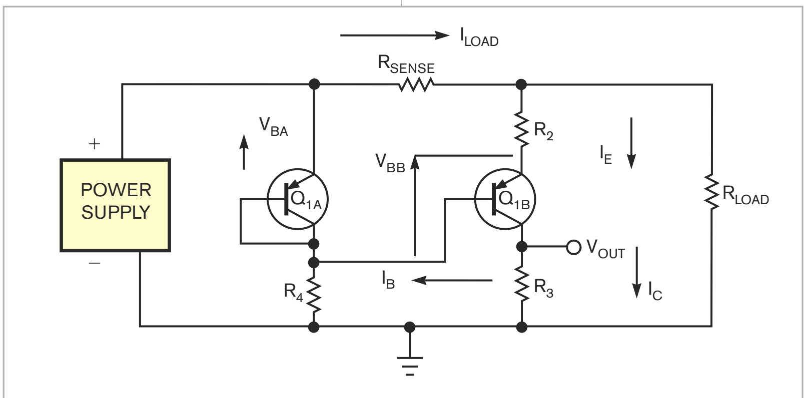

Figure 1 This simple two-transistor circuit provides a voltage output proportional to the current through sense resistor R_{SENSE}.

The following **equations** show the derivation of the output voltage as a function of the load current (referring to **Figure 1**):

$$V_{BA}+(I_{LOAD}\times R_{SENSE})+(I_E\times R_2)-V_{BB}=0.$$

$$[(V_{BA}-V_{BB})+(I_{LOAD}\times R_{SENSE})]-I_E R_2=0.$$

$$I_C+I_B=I_E.$$

$$(V_{BA}-V_{BB})+(I_{LOAD}\times R_{SENSE})-(I_C+I_B)R_2=0.$$

$$I_B=I_C/\beta.$$

$$V_{BA}-V_{BB}+I_{LOAD}\times R_{SENSE}-(I_C+I_C/\beta)R_2=0.$$

$$V_{BA}-V_{BB}+I_{LOAD}\times R_{SENSE}-[I_C\times(\beta+1)/\beta]R_2=0.$$

$$V_{OUT}=I_C R_3.$$

$$I_C=V_{OUT}/R_3.$$

$$V_{BA}-V_{BB}+I_{LOAD}\times R_{SENSE}-(V_{OUT}/R_3)(\beta+1/\beta)R_2=0.$$

If $V_{BA}=V_{BB}$, then $V_{BA}-V_{BB}=0$, and

$$I_{LOAD}\times R_{SENSE}-(V_{OUT}/R_3)(\beta+1/\beta)R_2=0.$$

$$V_{OUT}=I_{LOAD}\times R_{SENSE}[R_3/(\beta+1)](\beta/R_2).$$

If β is high, then $\beta/(\beta+1)\beta)\approx 1$, and

$$V_{OUT}=(I_{LOAD}\times R_{SENSE}\times R_3)/R_2.$$ **EDN**

LINEAR TECHNOLOGY

DESIGN NOTES

Tiny Universal LED Driver Can Gradate, Blink or Turn On Nine Individual LEDs with Minimal External Control – Design Note 422

Marty Merchant

Introduction

LEDs are the lighting workhorse of cell phones, MP3 players and diagnostic lights in telecom systems. Their uses are many, from utilitarian backlighting to eye-catching aesthetic effects such as slowly pulsing multicolor indicators. As device designers strive to differentiate their products on the shelf, the number and complexity of lighting effects grows. It would seem that each new effect requires significant additional hardware, and/or complex software, right? Actually, no, there is a way to apply these effects to a number of LEDs with only a single driver IC.

The LTC®3219 9-output universal LED (ULED) driver can be programmed to individually gradate, blink or turn on nine individual LEDs using *internal* logic and circuitry to drive nine 6-bit DAC-controlled LED current sources. Because the gradation and blinking features are controlled internally, effects can be realized without adding ICs, extensively tying up the I^2C bus or filling valuable memory space with complex programming subroutines. Any feature on any 0mA to 28mA output can be configured to activate via the external enable (ENU) pin or I^2C interface.

The LTC3219 operates from a 2.9V to 5.5V input. The charge pump provides up to 250mA output current, and to optimize efficiency, it automatically changes charge pump mode to 1x, 1.5x or 2x depending on the output current requirement. Any of these modes can also be forced.

Blinking and Gradation Modes

Each output can be set to blink each output with a 156ms or a 625ms on time and a 1.25s or a 2.5s period. Blink mode can be initiated and ended via the I^2C interface or using the ENU pin. Once blinking has been initiated, the LED(s) continue to blink without any interaction from the I^2C interface or the ENU pin. This allows the controlling interface device to shutdown and save battery power until needed.

The LTC3219 can gradually turn on, or gradually turn off any number of the LED channels. The gradation ramps up from 0mA to the programmed LED intensity with ramp times of 240ms, 480ms or 960ms (likewise for turn off). Like blinking mode, gradation mode can be implemented via minimal I^2C interaction or by the ENU pin as shown in Figure 1.

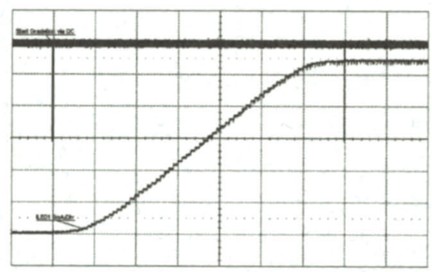

Figure 1. The LTC3219 Gradating an LED from 0mA to 28mA in 960ms. Prior to the Gradation Ramp, the Gradation Timer, Up Bit and ULED Registers Are Set. A Stop Bit on the Last I^2C Write Starts the Gradation Ramp. After the Gradation Ramp Has Finished, Gradation Is Disabled with the LED Set at Full Intensity

Single IC Drives Cell Phone Backlight, New Message/Missed Call/Battery Charger Indicator, and RGB Function Select Button

The circuit in Figure 2 illustrates a flip cell phone lighting circuit with four white LEDs for backlighting the keypad, a multicolor indicator, and a function select button illuminated by an RGB LED. The multicolor indicator consists of a red and a green LED. The RGB LED provides full color gamut, including white by varying its individual LED intensities.

When the cell phone is powered on or flipped open, the keypad and the function select button gradually illuminate to an intensity set by the baseband controller and CPU using the gradation feature of the LTC3219. The Function Select button may also gradually change colors using the gradation feature. After an idle period or during power off, the LEDs gradually turn off using the gradation fea-

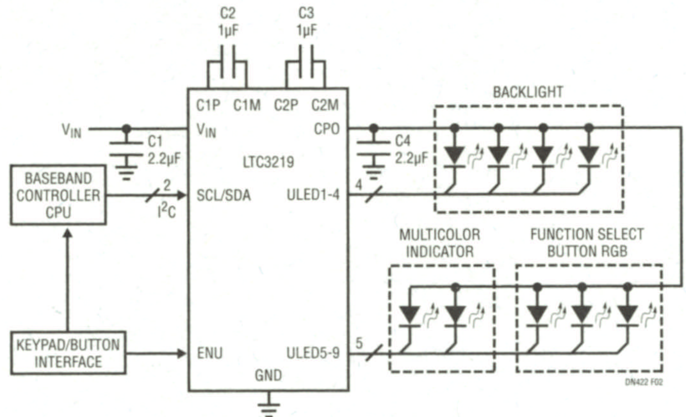

Figure 2. A Single IC, Multilighting Cell Phone Application. The LTC3219 Comes in a 3mm × 3mm 20-Lead QFN Package and Only Requires Five External Components

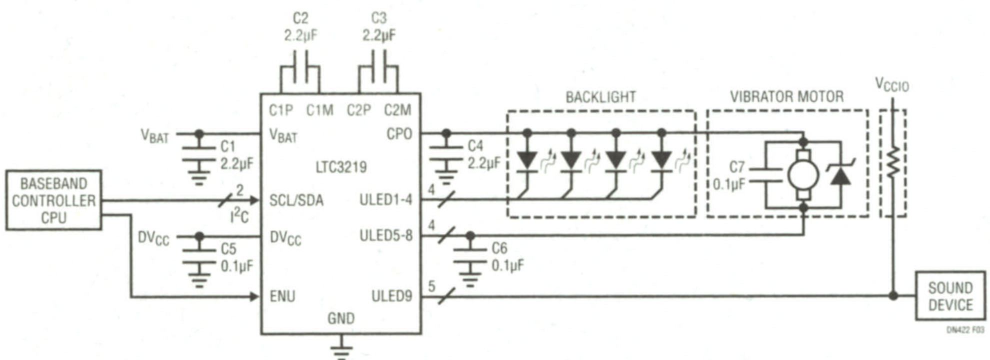

Figure 3. Cell Phone with Backlighting, Vibrator Motor and Sound Controller

ture. When a call is missed, the baseband controller and CPU set the multicolor indicator to blink red to indicate a missed call or blink green if the caller left a message. Once the multicolor indicator is blinking, the baseband controller hands off control to the external enable pin and shuts down to save battery power. The keypad and button interface holds the ENU pin high until the cell phone user takes action to turn off the blinking indicator.

Control for Cell Phone Backlight, Vibrator Motor and Sound

Cell phones use various combinations of vibration, sound and light to alert the users of an incoming call or message. Figure 3 illustrates a cell phone with four backlighting LEDs, a vibrator motor and a logic controlled sound device. A single logic pin, ENU, turns on all simultaneously.

If the vibrator motor requires more than 100mA, simply gang-up the ULED outputs to provide enough current. A small ceramic capacitor may be needed across the motor terminals and between the ULED output pins and ground to reduce inductive spikes and to prevent false dropout.

The speed and current in the motor is proportional to the voltage across the motor, so the voltage across the motor must be controlled in order to control the motor speed and current. One voltage-control method is to connect a shunt zener diode across the motor. Use a zener diode that provides the desired voltage across the motor with minimal zener current for maximum efficiency.

Conclusion

The LTC3219 is a LED driver and charge pump which can independently control nine outputs. Special features such as gradation, blinking, and GPO modes require minimal I^2C communication. The LTC3219 is an ideal device for many applications that use multiple lighting, logic or other current controlled devices.

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LINKING DESIGN AND RESOURCES

China's design houses are dying

China's independent-design-house business, which has been critical to the growth of indigenous distributors and semiconductor manufacturers, is dying.

Although the perceived threat to design engineers worldwide from these independent-design houses has been tangible in the past couple of years, the design-house business model has run into serious competition from ODMs (original-design manufacturers), which combine design with manufacturing; OEMs (original-equipment manufacturers), which are increasing their in-house-design capacity; and the overall consolidation of the Chinese OEM market, which is reducing demand for design services.

Design houses still play a highly visible—if shrinking—role between Chinese OEMs and their suppliers and distributors. They provide design options to OEMs, and they purchase semiconductors and components from suppliers and distributors. In that role, they have been especially important to suppliers and distributors, because they make decisions about which components designers should include.

But their clout is diminishing. OEMs have recently been beefing up their in-house-design staffs, particularly in the smartphone market, in which unique designs are critical. Meanwhile, ODMs, such as Taiwan's MTK (www.mtk.com.tw), are creating turnkey designs, chip sets, and software for the booming Chinese handset market. MTK won 40% of China's domestic handset market, according to industry sources. Except for Xiamen-based Amoi (www.amoi.com), most Chinese handset manufacturers use MTK's products to speed their time to market.

All these developments have cast a shadow over design houses, which enjoyed 300% profit margins in 2005. Two years later, they are lucky to get 15% profit margins, and, as of 2007, many have shuttered their businesses.

—by Amy Wang, Contributing Editor

GREEN UPDATE

EUP URGES LIFE-CYCLE MANAGEMENT

The European Commission (http://ec.europa.eu/index_en.htm) estimates that designers determine more than 80% of all product-related environmental impact during the planning phase and, for this reason, in 2005 published the EuP (energy-using-products)-framework directive. The directive, which aims to integrate environmental considerations as early as possible into the product-development process through the use of ecodesign requirements, came into force in August 2005, and EU (European Union) member states had until Aug 11, 2007, to implement EuP into national law.

EuP looks at the entire life cycle of a product—from design and manufacturing to use and disposal—with an eye on saving energy. It will require products to meet power-consumption guidelines that the EU sets. It will further force most manufacturers to do life-cycle assessments for their products to determine the environmental impact, including that from IC design and wafer fabrication. At each phase of an electronics product—from raw material to end of life—manufacturers must assess consumption of materials and energy, emissions to air and water, pollution, expected waste, and recycling.

The directive's impact goes beyond the electronics-supply chains of EU member states. Expect China's MII (Ministry of Information Industry) to release six more regulations in the second half of 2007 to tighten pollution controls in its electronic-product-supply chain in response to EuP.**—SD**

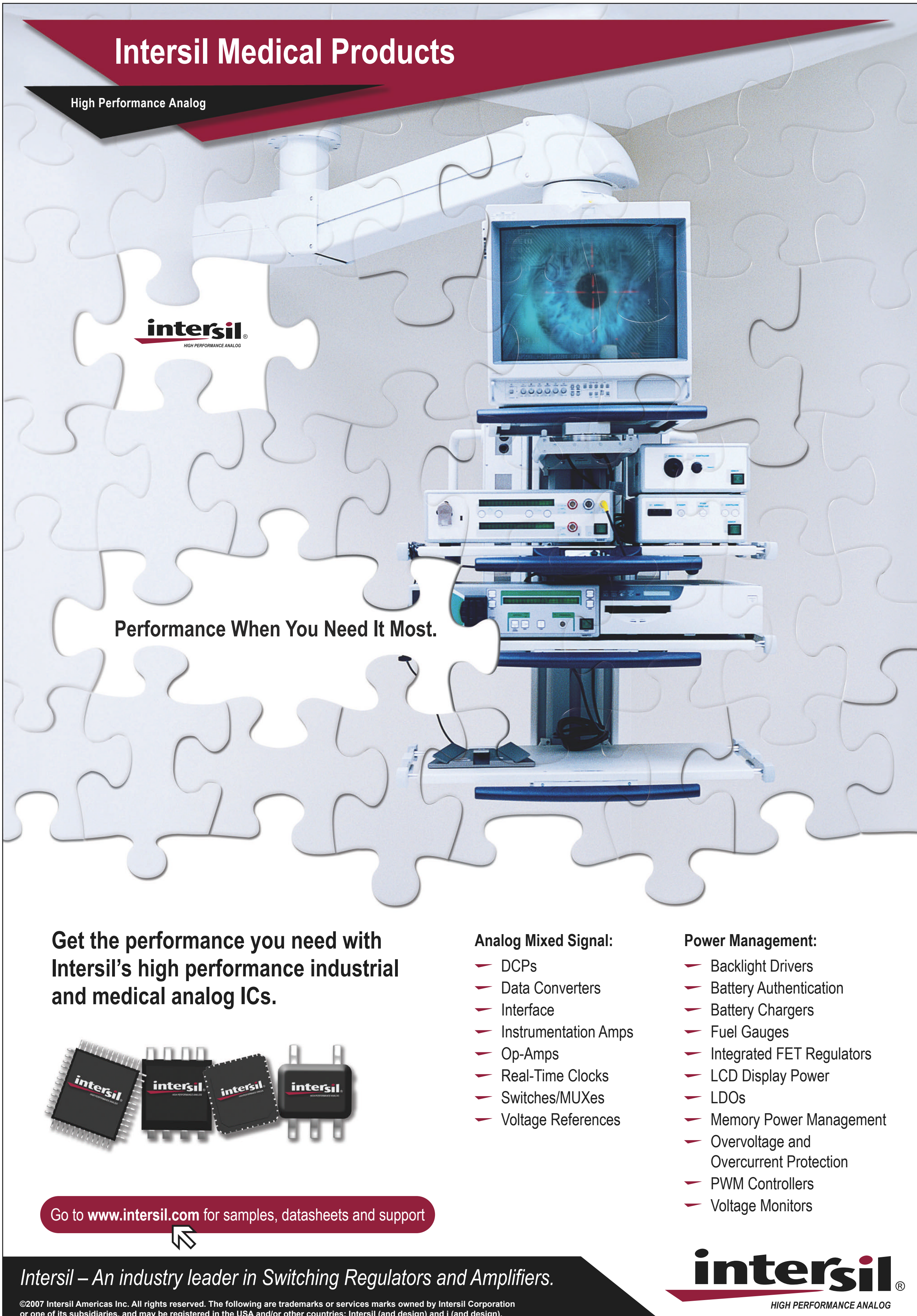
OUTLOOK

PRODUCTION ON THE RISE IN SOUTHEAST ASIA

Although China remains king of contract manufacturing with companies operating there generating an estimated 52.4% of all contract-manufacturing revenues, Vietnam is among the next locations emerging as hot spots for contract manufacturing as production rises in Southeast Asia.

Both iSuppli (www.isuppli.com) and In-Stat (www.instat.com) have reported that Asia will maintain its dominance in the EMS/ODM (electronics-manufacturing-services/original-design-manufacturing) markets for at least the next several years, with China leading the pack. In-Stat believes that China will account for some 76% of the Asian EMS/ODM market in 2011, a total-contract-electronics-manufacturing market whose revenue the research company projects will grow in 2011 to $281.8 billion.

However, both research companies have high expectations for the Southeast Asia region, whose revenue iSuppli reports will climb to $24.9 billion by 2011, a nearly $9 billion increase from $16.2 billion in 2006. By 2011, Southeast Asia will account for 7% of global electronics-contract-manufacturing revenue, up from 6.3% in 2006, the company predicts.**—SD**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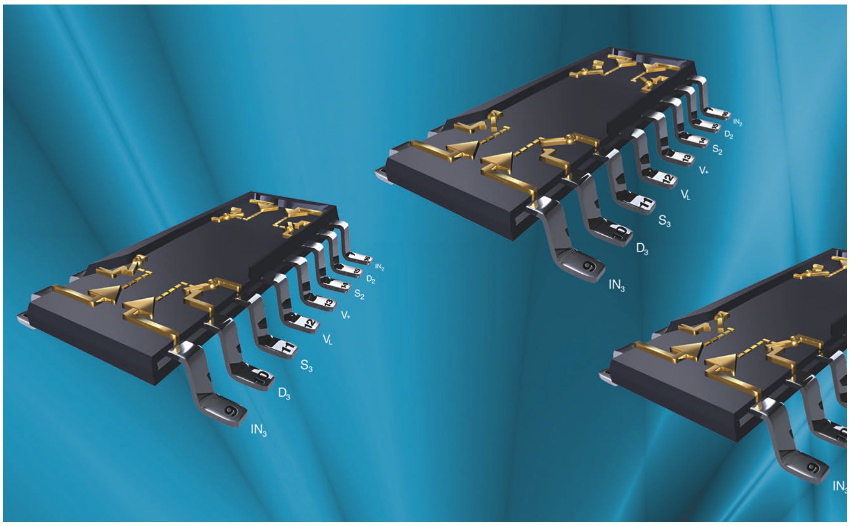
SWITCHES AND RELAYS



CMOS analog-switch series has four selectable SPST switches

The Siliconix DG451 and DG454 quad SPST (single-pole/single-throw) CMOS analog switches feature four selectable 44V SPST switches, each with a 4Ω on-resistance and a 0.2Ω typical flatness. Requiring no logic-voltage pin, the DG454 series eliminates the requirement for a 5V power supply for operation, does not require a PCB (printed-circuit-board) trace for connecting the logic-voltage pin, and requires no power-supply sequencing. The DG451 series provides a 15-μW power dissipation. The switches feature ±5 and ±15V dual supplies, a 12V single supply, 80-nsec turn-on switching speeds, 60-nsec turn-off switching speeds, and a ±15V analog-signal range. Available in TSSOP-16 or SOIC-16 packages, the Siliconix DG451 and DG454 cost $1.95 (1000).

Vishay Intertechnology, www.vishay.com

Controlled-load switch combines slew-rate and level-shift functions

Supporting 12V operation, the AAT4285 slew-rate-controlled load switch integrates level-shift and slew-rate functions in one device. Operating over a 3 to 12.3V input range, the P-channel MOSFET switch suits high-side-load-switching applications. The device maximizes load-switch power-handling capabilities with a 240-mΩ on-resistance at 12V, a 320-mΩ on-resistance at 5V, and a 25-μA quiescent current. The switch has a 100-μsec load-switch turn-on time. The AAT4285 costs 68 cents (1000).

Analogic Tech, www.analogictech.com

Illuminated tactile switch has a right-angle design

Available in multiple LED colors, the illuminated TL1260 tactile switch comes in a right-angle, through-hole design. Features include a 50-mA contact rating at 12V dc, 100-mV contact resistance, 500V-ac dielectric strength, and a 160-gf actuation force ±50 gf. Targeting telecommunications, consumer-electronics, audio/visual, and medical applications, the switch has a 50,000-cycle life expectancy. Available in a −20 to +70°C temperature range, the TL1260 costs 75 cents.

E-Switch, www.e-switch.com

Capacitive touch sensor features a single-chip control interface

Providing an intelligent single-chip-controller interface that responds to a user's touch, the QST108 capacitive touch sensor allows users to create capacitive touchpanels with as many as eight keys for product-user interfaces using conventional or flexible PCBs (printed-circuit boards). Sense electrodes provide the option of PCB-layout integration or printing using conductive ink with flexibility in electrode sizes and shapes. An electrode behind a nonconductive front panel made of glass or plastic allows detection of a finger touch. Required external components include one sampling capacitor and one resistor per channel. Driving as many as eight LEDs, the sensor features PWM (pulse-width-modulation) capabilities for driving a beeper output or controlling LED brightness. Debounced touch-detection results are accessible using individual outputs or through the I^2C interface. Available in an LQFP-32 package, the QST108 costs $1.08 (10,000).

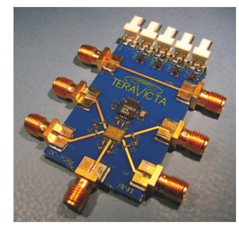
STMicroelectronics, www.st.com

Photomicrosensors accurately detect motion and position

Available in a U-shaped housing, the nonamplified EE-SX1 slotted phototransistors feature an emitter and a detector for improved alignment and aiming. The microminiature, transmissive photomicrosensors detect the presence of an object without direct contact, providing accurate detection of motion and position. The devices achieve high resolution using a 0.15- to 0.5-mm-wide aperture; an infrared LED and phototransistor design provide long life. An SMD version features a −30 to +85°C operating range, a through-hole version has a −25 to +85°C operating range, and a panel-mount version has a −20 to +70°C operating range. Available as small as 3×3×3.4 mm with slots ranging from 1 to 5 mm, the EE-SX1 sells for 50 cents to $1.10 (10,000). **Omron Electronic Components LLC, www.components.omron.com**

MEMS-switch configurations operate in the dc to 7-GHz range

Joining the vendor's switch family, the DPDT (double-pole/double-throw) and the SP4T (single-pole/four-throw) configuration in the dc to 7-GHz switch-product line feature MEMS-switch technology. Configured as two independent SPDTs (single-pole/double throws), the DPDT can handle differential signals or density improvements in multiswitch environments. Integrating four independently controlled HFDA switch elements, the SP4T suits signal multiplexing and use in applications with high integration and low insertion loss as critical parameters. The TT2214AD and TT1414AD cost $59.50 each (sample quantities) and $32.25 (1000). **TeraVicta Technologies, www.teravicta.com**



TEST AND MEASUREMENT

Digitizer improves measurement throughput

Designed in a standard short-PCI-card format, the Acqiris DP1400 high-speed digitizer combines data-converter-ASIC technology with a high level of component integration and 15W power consumption. The compact design and integrated technology target low power consumption, and a simultaneous multibuffer-acquisition and -readout mode improves measurement throughput. Suiting use in long or short PCI-bus slots, the device aims at semiconductor-component-test, hard-disk-drive-production-test, and industrial-

nondestructive-test applications. The Acqiris DP1400 digitizer costs $9490.
Agilent Technologies, www.agilent.com

Upgrade for vector-signal generator includes increased ARB memory

Adding a series of enhancements to the vendor's Model 2910 RF vector-signal generator, the Model 2910 Version 2.0 includes additional wireless-signal-generation waveforms, a power-calibration feature, and increased ARB (arbitrary-waveform-generator) memory for additional and larger waveforms. The Model 2910 Version 2.0 costs $13,400, an ARB option costs $3150, the flexible digital-modulation option costs $3500, and the GPS (global-positioning-system) option costs $2500. A firmware upgrade is free for Model 2910 unit owners.
Keithley Instruments, www.keithley.com

Digital-data recorder targets weapons- and jet-engine-testing applications

Suiting recording applications in weapons testing and jet-engine testing, the compact, high-performance DaqScribe DDR-200 portable digital-data recorder allows lower channel counts to record at 10-MHz per channel. The data recorder configures with either 32 channels of 24-bit ADC as fast as 100 kHz per channel or 32 channels of 16-bit ADC as fast as 1 MHz per channel. The 24-bit DDR-200-610-32 at 100 kHz per channel costs $29,995, and the 16-bit DDR-200-645-32 at 800 kHz per channel costs $32,995.
GE Fanuc Embedded Systems, www.gefanucembedded.com

PCI Express-based AWG boards come in 14-bit resolutions

The PCI Express based UF2-6030 series AWG (arbitrary-waveform-generator) board come with one, two, or four channels. Each channel has a 14-bit DAC, providing a synchronous output and three fifth- and fourth-order Butterworth lowpass-reconstruction filters with 25-MHz, 5-MHz, and 500-kHz bandwidths. The single-channel UF2e-6030 runs at a maximum of 125M samples/sec, the two-channel UF2e-6031 runs at 125M samples/sec per channel, and the four-channel UF2e-6034 runs 125M samples/sec over two channels or 60M samples/sec maximum over four channels. The UF2e-6030 costs $4190.
Strategic Test, www.strategic-test.com

productroundup

INTEGRATED CIRCUITS

Mobile-phone camera includes an antishake feature

Reducing image blurring, the 3M-pixel MT9T111 camera-phone image sensor has an on-chip antishake feature. Developed on the vendor's 1.75-micron pixel process, the device features JPEG compression and image processing on one chip. The MT9T111's cost ranges from $12 to $14 (10,000).

Micron Technology, www.micron.com

H.264 codec integrates Ethernet MAC and external flash-memory interface

The QL202B Main Profile H.264 codec operates as a stand-alone device, unlike its predecessor. Integrating a 10/100-Mbps Ethernet MAC (media-access controller) and an external flash-memory interface, the device allows switching from Main Profile to Baseline H.264 compression for low-latency operation. An integrated ARM processor and an audio DSP cut component count to an external DDR memory, a boot flash, an Ethernet PHY (physical layer), and power regulators. The QL202B consumes just a few hundred megawatts of power, meaning that designers can use it to build a basic camera subsystem that consumes less than 1.5W. The QL202B costs $14.50 (10,000).

Qpixel Technology, www.qpixeltech.com

Motor-control IC operates in three modes

Targeting motor-control applications, the single-axis MC73110 40-kHz PWM (pulse-width-modulation) waveform generator provides fully digital velocity and torque control of brushless-dc motors. The device requires a MOSFET or an IGBT (insulated-gate-bipolar-transistor) triple half-bridge for creating a complete intelligent motor controller. The generator operates in internal-velocity profile mode, velocity mode with an external command signal, and torque mode with an external command signal. Features include a software-programmable, 10-kHz velocity loop with coder or tachometer feedback, 20-kHz commutation and current loops, a six-step and sinusoidal commutation, an analog- or digital-command input, profile generation, and a digital-current loop. The generator can operate as a stand-alone intelligent-motion IC or using serial commands as a programmable axis controller. Additional functions include current-loop compensation, trajectory generation, commutation, velocity loop, encoder input, and Hall-sensor input. Available in a PQFP-64 package with a 3.3V operating voltage, the MC73110 costs $18.

Performance Motion Devices, www.pmdcorp.com

Wireless audio device targets digital-home-theater surround sound

Allowing wireless streaming of high-quality sound to two full-range speakers and a subwoofer, the MelodyWing SP wireless audio device offers uncompressed, wire-equivalent sound quality for home-theater surround-sound systems. The Smart Channel feature automatically selects the uncongested ISM (industrial/scientific/medical) radio bands at 2.4 and 5 GHz to avoid interference with other wireless equipment. Supporting SPDIF (Sony/Philips Digital Interface) and I²S standards, the device also provides support for 24 bits per channel for stereo, as well as 16-bit stereo, and a 90-dB dynamic range. The device supports 20m distances for single-room applications with an option to extend the range for custom

needs. Additional features include support for MP3, AAC (advanced-audio-coding), AC3, and DTS (digital-theater-sound) modes. The MelodyWing SP comprises the SST11SC03 transmitter board and the SST11SC04 receiver board, selling for $21.62 (10,000) each.
SST Communications, www.sst.com

10-GbE SERDES eliminates the need for external filter capacitors

The single-channel TLK1221 GbE (Gigabit Ethernet) SERDES (serializer/deserializer) device supports a 10-bit interface and complies with IEEE 802.3 GbE. Consuming 200 mW, the device suits EPONs (Ethernent passive-optical networks), 10-GbE switches/routers, and wireless base stations. The device requires no external filter capacitors. Features include full-duplex, point-to-point transmissions ranging from 600 Mbps to 1.3 Gbps; a 2.5V supply voltage; 3.3V tolerance on LVTTL (low-voltage-transistor-to-transistor-logic) inputs; and hot-plug protection. Measuring 6×6 mm and available in a QFN-40 package, the TLK1221 costs $3.25 (1000).
Texas Instruments, www.ti.com

High-performance processor targets QVGA portable devices

The VSP100 multicore chip targets devices incorporating high-quality video in QVGA portable devices with screens smaller than 2.5 in. Based on the vendor's ViViD media-processing engine, the high-performance processor features two customized VLIW (very-long-instruction-word) processing cores for video processing and a RISC processor. Available in an SMIC 0.13-micron process, the VSP100 sells for $5 to $6 (10,000).
Vivace Semiconductor, www.vivacesemi.com

Eight-channel video decoder aims at security and surveillance applications

Suiting video-security and high-capacity-DVR-surveillance applications, the CX25850/1/3 multiport video-decoder family provides eight channels for video decoding. The CX25850 and CX25851 contain four high-quality, 10-bit video decoders to convert analog-composite video to digital-4:2:2 video in the form of CCIR 656. Supporting 16 direct camera connections, the CX25853 contains eight of the same high-quality, 10-bit video decoders. The CX25850, CX25851, and CX25853 come in eTQFP-176, eLQFP-208, and eLQFP-256 packages, respectively. The CX25850, CX25851, and CX25853 cost $7, $8, and $12, respectively.
Conexant Systems, www.conexant.com

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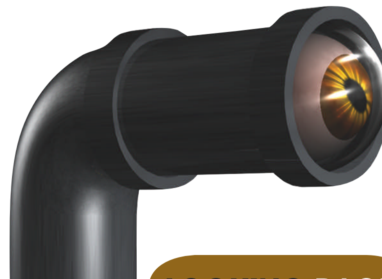

LOOKING AHEAD

TO THE POWER ARCHITECTURE DEVELOPER CONFERENCE

Much of the activity in technical conferences has shifted from industrywide events to users' group gatherings focusing on particular architectures. Power.org is no exception to this trend, having quietly turned from a gathering of suppliers and users of IBM's Power microprocessor architecture to a substantial industry organization. The group's Developer Conference, Sept 24 and 25 in Austin, TX, will offer four keynotes—including what's bound to be a showstopper by Cornell University Associate Professor of Astronomy Jim Bell showing images from the Mars Rover imaging systems. The conference will also include technical sessions on topics from embedded computing to SOC (system-on-chip) design with Power cores to multicore architectures and virtualization in embedded applications. This year, papers will discuss not only the Power architecture, but also the IBM Cell architecture, of Sony Playstation3 fame.

LOOKING BACK

AT THE ANCESTORS OF FLAT-PANEL DISPLAYS

Combining the principles of electroluminescence and photoconductance, a new system produces images on flat panels. The devices consist of flat glass panels with thin control layers of photoconductive and electroconductive materials. Sylvania Electric Products engineers have produced laboratory units in 2- and 4-in. squares. One type is a flat glass plate coated with horizontal conductive strips, an electroluminescent layer, and vertical conductive strips. A 2-in. square has 32 contacts horizontally and 32 vertically. By applying ac power to any horizontal and to any vertical contact, the material at the intersection of the two strips becomes electroluminescent. Thus, any one of 1024 squares can be lit individually.

—*Electrical Design News*, August 1957

LOOKING AROUND

AT WHAT IT MEANS TO BE MULTICORE

We have on our hands a word that is subtly shifting its definition. For Intel's marketing department, "multicore" appears to mean two or several independent CPUs on one die, working on independent tasks. In the embedded-system world, things become more complicated. "Multicore" is starting to mean a moderately large number of processor cores—not necessarily all the same—working in close concert to accomplish a mix of real-time and background tasks. As computing loads and deadlines become more demanding, we will have to further decompose the tasks into threads that can split among the processors. What started out as a way around process limitations in the PC world has the potential to infect embedded computing with an enormously complex new set of problems.

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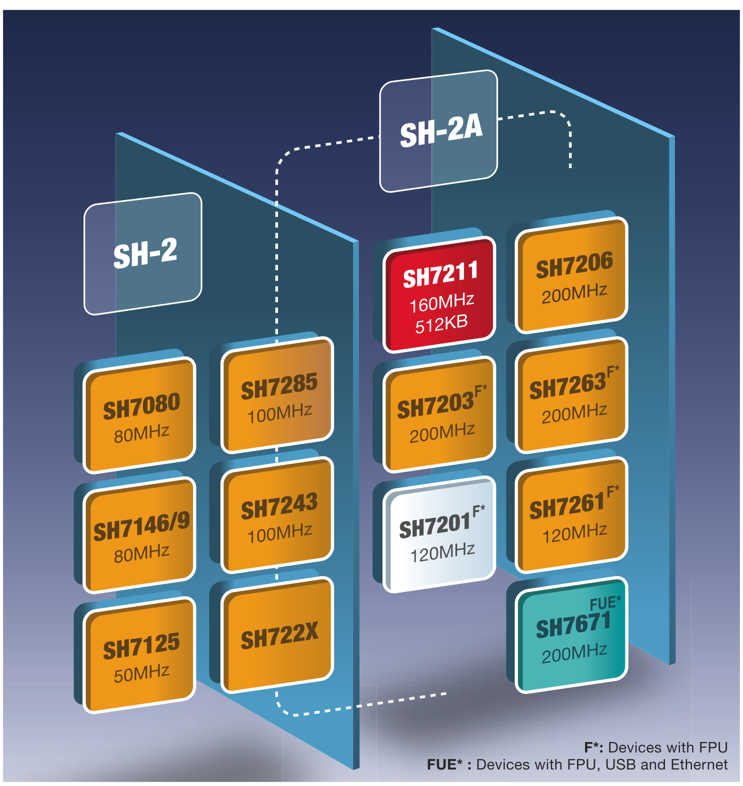
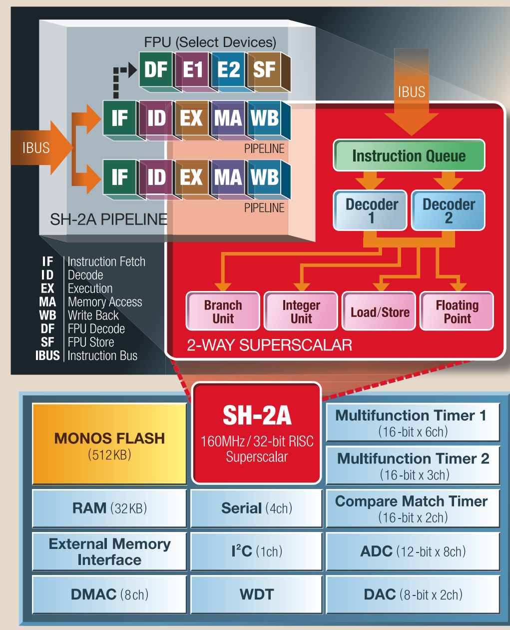
SuperH MCU Roadmap



HOT Products | **SH7211F** (R5F72115D160FPV)



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  - World's fastest embedded FLASH with 12.5ns read access time.
- **Fast Real-Time Control**
  - Register-Banks enable 37.5nsec (6 cycles) interrupt latency time.
- **High Integration**
  - Large on-chip flash and on-chip RAM
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*Source: Gartner Dataquest (April 2006) "2005 Worldwide Microcontroller Vendor Revenue" GJ06333

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