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Embedded electronics guides casino gaming

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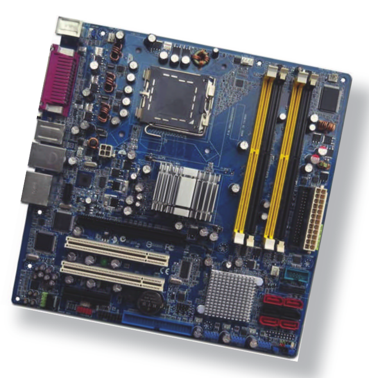

High-brightness LEDs usher in new applications and standards

43 As high-brightness LEDs increase in power, they will enable new applications ranging from architectural lighting to medical products. Energy Star lighting standards are evolving to keep the focus on total system efficiency.
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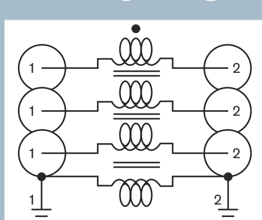
The Hot 100 Products of 2007

31 It's a tough job, and *EDN*'s editors receive thousands of product announcements. They narrow down the choices into the hundreds of newsworthy items that each year grace the pages of *EDN*. You'll find amplifiers, temperature monitors, communication processors, sensors, switches, timing-analysis tools, routers, supercapacitors, and much, much more.

DESIGNIDEAS



Hello zero power

Hello ultra-small packages

Hello MAX IIZ CPLDs

BYE BYE STANDBY

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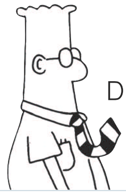
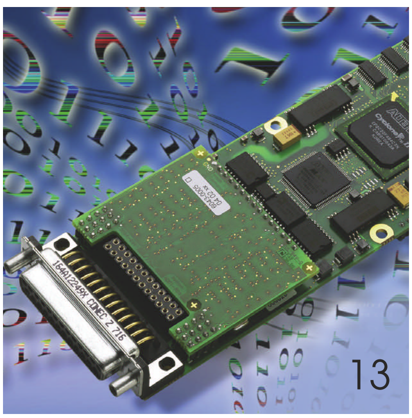
pulse





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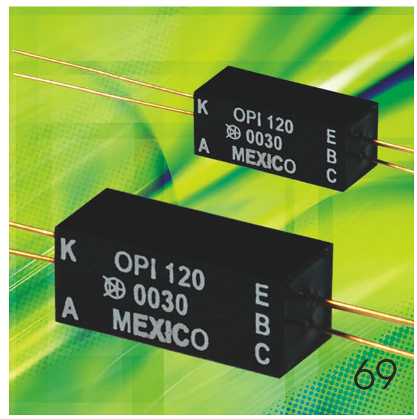

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DEPARTMENTS & COLUMNS

PRODUCT ROUNDUP

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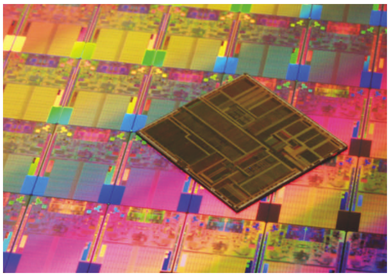

ONLINE ONLY

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Intel software upgrade for Apple Leopard hints at Penryn use in Macs
Intel's upgrade of its software-tools suite for Mac OS X Leopard suggests to some that Macintosh computers may soon use 45-nm Penryn processors.
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Google confirms mobile-phone open-platform effort
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Micron marks entry into solid-state-drive market with three form factors
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Why design engineers need to know about lithography
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Gartner warns of 2008 semi-industry downturn
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Intel formally debuts 45-nm Penryn processors
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TSMC head signals expanded role for foundries
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Samsung cut 1600 jobs, report says
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READERS' CHOICE

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Outdoors-only LCD malfunction puzzles portable-product designers
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Coin-shrinking and can-crushing with an EM pulse
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Voices: Dave Fullagar, analog-IC designer and entrepreneur
→www.edn.com/article/CA6500213

Battery monitor also enables constant-power-boost converter
→www.edn.com/article/CA6495298

Aunt Judy: Beware relatives' repairs
→www.edn.com/article/CA6495303

HOT 100 DETAILS

Our annual Hot 100 Products feature (pg 31) lists our editors' picks for the year's most significant products in a number of categories. At www.edn.com/hot100 you'll find our original coverage of all 100, plus Hot 100 lists stretching back to 1999.
→ www.edn.com/hot100

Show us your holiday lights
One sure sign of the holidays around here is the arrival of a brief Design Idea article from 1999 near the top of our weekly site-traffic reports. We're not sure how many people actually build the device described in "Simple tester checks Christmas-tree lights" after finding it via frantic searches, but the phenomenon puts us in the holiday spirit nonetheless.

Speaking of which, if an attack of merriment has caused you to go a little overboard with the holiday lights, we'd love to see it, especially if your power-gobbling display involves computer control. Shoot a short video, hit the second link below to upload it, and we'll feature some of the madness on EDN.com.

Simple tester checks Christmas-tree lights
→www.edn.com/article/CA46423

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BY MAURY WRIGHT, EDITORIAL DIRECTOR

Holiday wishes target technological harmony

As I write this column in early December, I've yet to even think about holiday shopping, but my son was quick to proffer a lengthy wish list. That list and a gentle prodding from Matt Miller, editor-in-chief of EDN.com, remind me of a column that I wrote seven years ago (see "Holiday wishes," *Commverge*, Dec 1, 2000, www.edn.com/article/CA54538). In 2000, I made my wishes for technological developments that I believed would be good for the high-tech segment. Reflecting on that column, here are my wishes for 2008.

Ironically, one of my wishes for 2000 was for harmony in the DVD-standards area. Sony (www.sony.com) was then championing a proprietary DVD+R/W format, whereas the DVD Forum (www.dvdforum.org) had adopted DVD-R/W as the industry standard. Well, it's déjà vu all over again. Once again, Sony is duking it out in the DVD area, promoting its proprietary Blu-ray format for high-definition DVD. If the past is any guide, neither HD (high-definition)-DVD nor Blu-ray may emerge victorious. Both the DVD+R/W and the DVD-R/W flavors of DVD-rewritable technology still exist, and most drives now support both. Dual Blu-ray and HD-DVD support looks likely in the high-definition-DVD segment, as well.

But will Sony ever learn? I wish that the company that I once so admired would get on with building great products and forget revenue streams from royalties it achieved by having mass-market-product vendors adopt its IP (intellectual property). I've made this wish before. Meanwhile, just as in the rewritable-DVD skirmish, high-definition-DVD is not taking off in the market, and Sony's delays have cost the company more than it can ever recoup in royalties.

I'm also wishing for harmony in the wireless arena. I hope that 2008 will see a unified 802.11n spec and products that at least approach the range and speed that the spec promises. Then again, 2008 will probably see the battle escalate over the next-generation standard even as vendors deliver the n products that underdeliver to consumers. Although I've for now abandoned 802.11n (see "Immaturity in 802.11n products guides a return to a wired LAN," *EDN*, Aug 21, 2007, www.edn.com/article/CA6470534), I wish for the capabilities that the vendors have promised.

I also wish that the UWB (ultra-wideband) and Wireless USB camps would deliver on their promises. I recently wrote a blog post about the complaints a wireless-industry executive made about the media's testing of products to the spec (see "Wireless USB exec questions press reviews based on actual specs," *EDN*, Oct 31, 2007, www.edn.com/071214edb1). Well, I wish the UWB, wireless-LAN, and cellular camps would all produce and deliver on realistic and attainable specs.

In 2000, I also wished for resolution on several HDTV-related issues. Thankfully, the industry reached an accord on modulation schemes, and we now enjoy reasonably good HDTV service. But the industry still hasn't got the interface issues right. The HDMI (high-definition-multimedia-interface) specification has inherent problems that resulted from the insistence of content owners to impose egregious DRM (digital-rights-management) schemes. Again, the content owners and other interested parties lose more money than they could hope to gain when they place roadblocks in the way of technology adoption.

I complained about the music industry in 2000, and I'm happy to say we've seen great progress in a transition to a downloading-friendly business model. We still have a long way to go. Now, the cellular carriers still want their cut of music sales. I wish for music that I can download once and play on any device I own. We're close to that goal, but we're not yet there.

One thing I'm adding to my list this year is a return to broad cross-licensing pacts in the industry. In the quarter-century leading to the new millennium, widespread cross licensing drove innovation. Nowadays, no one cooperates, and the industry wastes too much money on court battles. Meanwhile, the innovation that comes from collaboration has disappeared. We need it back.

Finally, and please read this sentence for the words and without regard to the origin of the words and your own beliefs: I wish for peace on earth and good will toward men. Globally, we'd all benefit from a peaceful 2008. Talk to you next year.EDN

Contact me at mgwright@edn.com.

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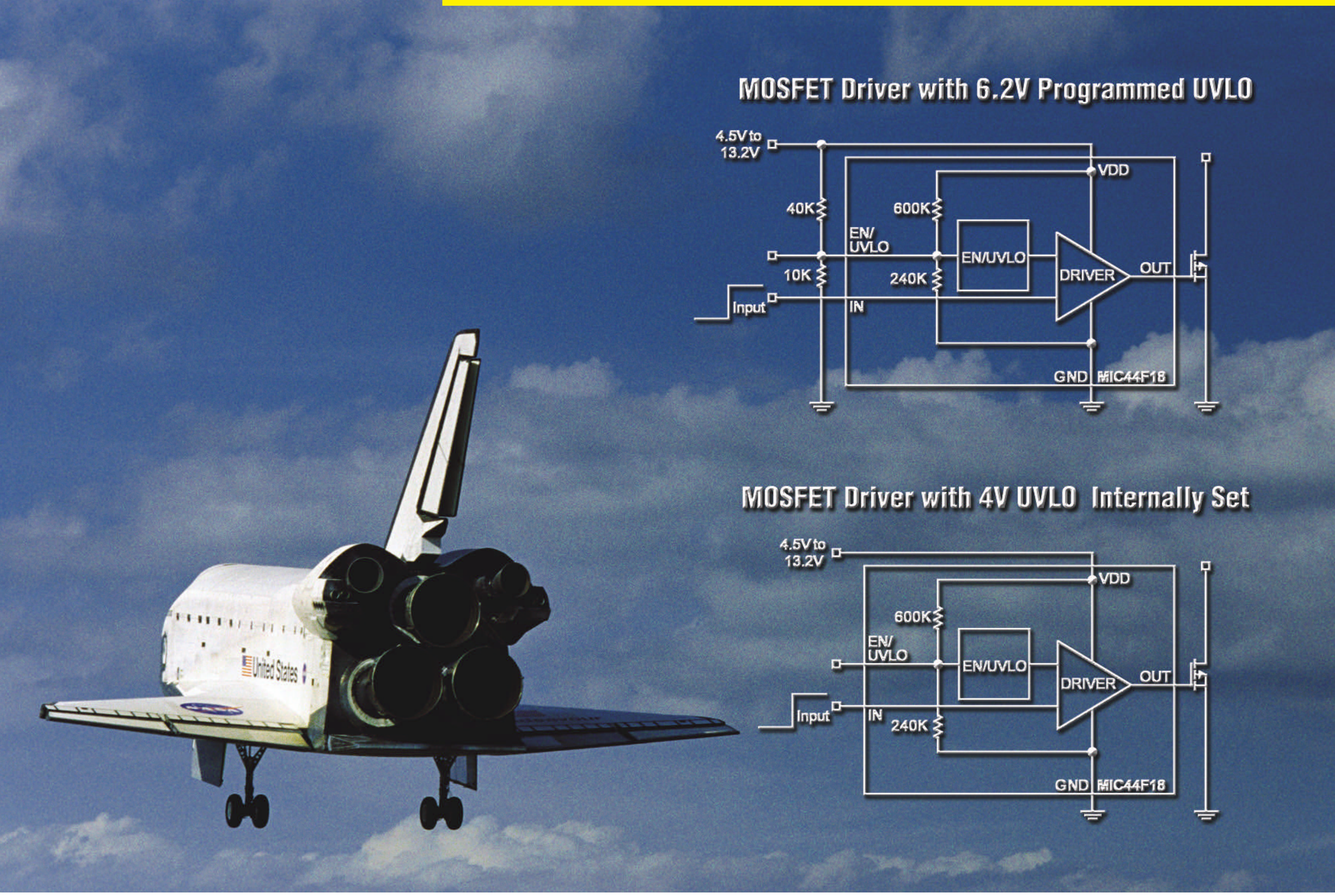
Driving To New Frontiers...
Micrel's Ultra High-Speed MOSFET Drivers

6A, 10ns Rise/Fall Times, Ultra High-Speed MOSFET Drivers



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Reed Electronics Group

EDITED BY FRAN GRANVILLE

pulse

INNOVATIONS & INNOVATORS

Lawsuit has implications for digital control of power subsystems

A federal-court jury found that Artesyn Technologies' digital POL (point-of-load) PMBus-compatible product had infringed on Power-One's Z-One digital-power-management-and-control patents. In the lawsuit, Power-One claimed that Artesyn infringed on its patent that applies "to a digital-power-control system for controlling and monitoring an array of point-of-load regulators using a serial bus for communication with and control of the point-of-load regulators." In a conference call with industry analysts and press after the announcement of the ruling, Power-One said that the ruling will affect any power-supply company using PMBus in the POL-system market and that power-supply companies cannot move ahead in implementing a digital-control scheme in such an application without a license from Power-One. (PMBus is an industry-supported command set for controlling various kinds of power supplies over a digital bus.)

Power-One has another patent that addresses embedded digital-power controllers, but that patent was not a part of this court case. However, depending on how power-subsystem designers use digital-power ICs, they may need to get a license from Power-One. For example, according to Power-One, a design using a digital-power IC within a POL dc/dc converter to control power-subsystem communications will need a Power-One license. If the design is for an ac/dc converter, however, Power-One has no claim. Artesyn may appeal this ruling.

The POL-power-supply market will grow to approximately $1 billion in the next few years. Power-One's market share is currently about 1 to 2%. Based on this ruling, Power-One expects its market share to grow to about 10% by 2010. To see what *EDN* readers are saying about this court ruling, go to www.edn.com/071214p1 and www.edn.com/071214p2.
—by Margery Conner

▷**Power-One**, www.power-one.com.
▷**Artesyn**, www.artesyn.com.
▷**PMBus**, www.pmbus.org.

Mezzanine card captures precise analog data

MEN Micro's recently unveiled M36N analog-input mezzanine board comes in an M-module form factor and features high-resolution data acquisition for the myriad analog signals designs encounter in industrial automation, measuring, and simulation applications. You can use the M36N, available in 16- or 18-bit versions, as an I/O extension for CompactPCI, PCI, PXI, or VME embedded systems as well as on stand-alone single-board computers. The module provides as many as 16 single-pole, grounded channels for voltage or current or eight channels for differential voltage or current. You can separately adjust each channel and input range for data-acquisition requirements. The board's 16-bit resolution provides an accuracy of at least 0.05% over the entire −40 to +85°C temperature range.

The new M36N analog-input board captures signals with 16-bit precision for applications in the motion, robotics, and instrumentation markets.

A fast ADC and autoincrementing multiplexer channel enable a total 16-bit acquisition time of 130 μsec. An Altera (www.altera.com) Cyclone II FPGA on the M36N controls signal conditioning and offers space for application-specific function extensions. You can implement the included Altera Nios II Softcore processor in the FPGA for intelligent pre-data-processing, noise-shaping, or additional functions. The price for the M36N starts at $850, and delivery time is six weeks.**—by Warren Webb**

▷**MEN Micro Inc**, www.menmicro.com.

Cadence makes logic verification OVM-savvy

Cadence Design Systems has added several enhancements, including support for the OVM (open-verification methodology), to its Incisive logic-verification-tool lineup. Traditionally, verification engineers have composed tool flows by mixing and matching best-of-class tools from multiple tool vendors. Often, the tools didn't work well together, which required engineers to create scripts and perform a lot of related manual work to make the tools work together in flows. So, in recent years, big EDA companies, such as Cadence, Synopsys (www.synopsys.com), and Mentor Graphics (www.mentor.com), have each begun to push all-in-one verification flows, trying to sell complete flows to customers and essentially shut out the competition from key accounts. Cadence's all-in-one flow is Incisive, whose major components include the IES (Incisive Enterprise Simulator) line of HDL (hardware-description-language) simulators, Specman testbench generator, and Palladium and Xtreme hardware-acceleration and -emulation systems.

In the latest revision of Incisive, Version 6.2, Cadence has improved the performance of some tools and added functions. Perhaps the most significant part of the revision is that IES now supports the OVM, which Cadence jointly announced with Mentor Graphics in August. OVM allows SystemVerilog tools from various vendors to share a common class library of functions, which helps engineers port code and testbenches between various OVM-compliant SystemVerilog verification tools and essentially use best-in-class tools. "The complementary aspect of OVM support is code portability and reuse," says Joe Hupcey, director of enterprise-verification marketing at Cadence. "If you create a block in that format, you can hand it off to other users, and they can instantly recognize how to wire it into their environment because it has a standard structure."

> "Cadence has given its Specman e-language testbench-generation system a new aspect-oriented generation engine.

As part of IES support for OVM, Cadence has added several class-based debugging utilities to help verification engineers manage object-oriented testbench code in their verification environments. Cadence has also created a multilanguage verification-builder utility for IES to help designers using a mix of verification components. Hupcey notes that many design groups may use a mix of SystemVerilog and e-language verification components and want to run those verification components in one flow. The new utility allows users to configure each verification component's parameters and quickly wire them together. "The tool looks for the formats and gives users a menu-driven approach to wire the components together and run them in a testbench," says Hupcey. Engineers can also use the utility to create a verification component from scratch.

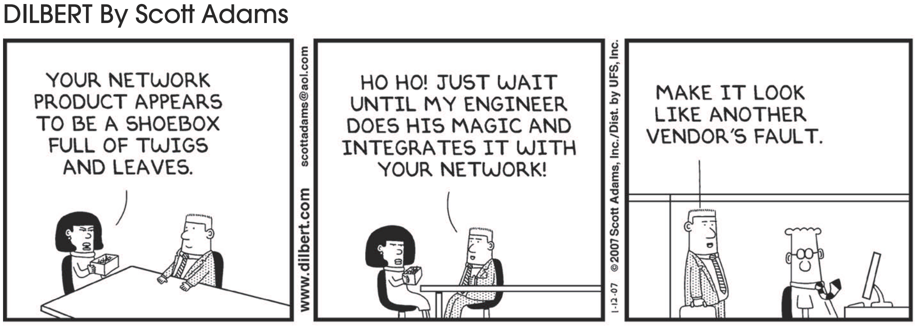
Another feature of the 6.2 release is that Cadence has given its Specman e-language testbench-generation system a new aspect-oriented generation engine. The engine provides a nearly fivefold increase in runtime performance for e-based verification environments. That improvement comes in handy as leading-edge designs start to reach 1 billion logic gates. The company ensures that the memory requirements don't become excessive; with the new engine, those requirements scale linearly, not exponentially. With the aspect-oriented engine, Specman also now includes a utility that identifies the variables that depend on one another and the variables that are independent. "In previous-generation tools, users would order the generation and sequence of events and stimulus," says Hupcey. "But, as designs get larger and designers use more outside IP [intellectual property], they can lose track of what the dependencies are and what activities should happen first in their designs." The new feature shows these dependencies up-front in the verification cycle so designers can better target their tests.

In addition to enhancing IES and Specman, Cadence has also announced that its Xtreme and Palladium hardware-assisted-verification platforms now comply with the Accellera (www.accellera.org) SCE-MI (Standard Co-Emulation Modeling Interface) 2.0, which facilitates communication between simulators and hardware-assisted-verification systems. Michael Young, director of hardware-verification marketing at Cadence, says that, with the compliance SCE-MI 2.0 draft, Cadence is announcing Version 2.0 of its TBA (transaction-based-acceleration) methodology and features to enhance co-emulation with its tools. Young notes that the biggest highlight of TBA 2.0 is a hybrid mode, which allows users to select which parts of a design run on a simulator, which run on simulation acceleration, and which parts run on an emulator. SCE-MI compliance means TBA designers can use multiple languages.

—by Michael Santarini

▷**Cadence Design Systems**, www.cadence.com.

DILBERT By Scott Adams



RF-test system supports 4×4 MIMO, 40-MHz IEEE 802.11n WLAN MIMO

Keithley Instruments has released a 4×4 (four-transmitter-, four-receiver-per-sector) MIMO (multiple-input/multiple-output) RF-test system for R&D and production testing of next-generation RF-communications equipment and devices. The system comprises the manufacturer's new Model 2920 VSG (vector-signal generator), Model 2820 VSA (vector-signal analyzer), Model 2895 MIMO-synchronization unit, and Model 280111 MIMO signal-analysis software. The system supports cellular, WiMax, and WLAN devices. The devices also boast ±1-nsec signal-sampler synchronization, less-than-1-nsec peak-to-peak signal-sampler jitter, and less than 1° of peak-to-peak RF-carrier-phase jitter. Because these specifications permit tight multiunit synchronization, the new system supports MIMO measurements on such signals as 40-MHz IEEE 802.11n WLAN MIMO.

In RF-communication devices, MIMO increases data throughput without using additional bandwidth. Keithley's new MIMO-test capability combines an advanced testing platform that will meet future product-development needs and provides the ability to test—through a simple software upgrade—the most complex signal structures, including IEEE 802.16e Wave 2 Mobile WiMax, 4G LTE (fourth-generation long-term evolution), and UMB (ultramobile broadband).

The core of the MIMO-RF-test architecture comprises a new RF-signal generator and analyzer that operate in two-, three-, or four-channel configurations and that serve as stand-alone instruments or system components. The Model 2920 VSG, which generates frequencies as low as 10 MHz, offers maximum frequencies of 4 or 6 GHz. An optional 80-MHz-bandwidth AWG (arbitrary-waveform generator) with 100M samples of waveform memory allows testing of such commercial-communications signals as GSM (global system for mobile communications), EDGE (enhanced data for GSM evolution), WCDMA (wireless code-division/multiple access), cdma2000, SISO (single-input/single-output) WLAN, and 40-MHz IEEE 802.11n WLAN MIMO. In both 4- and 6-GHz configurations, the Model 2820 VSA provides 40-MHz bandwidth and can test the same range of signals as the Model 2920's optional AWG generates.

This 4×4-MIMO RF-test system's major components—a vector-signal generator and a vector-signal analyzer—are half-rack-width, 3U-high modules.

The Model 2895 provides the system instruments with such signals as a local oscillator, a common clock, and a precise trigger, and it synchronizes MIMO tests on configurations as complex as 4×4. This capability provides precise and stable alignment among as many as four signal analyzers and generators and allows accurate and repeatable measurements of OFDM (orthogonal-frequency-division-multiplexing) MIMO signals. The Model 280111 WLAN 802.11n MIMO-signal-analysis-software suite of PC-based tools supports single-channel and multichannel analysis of 802.11x signals. The software supports 4×4-MIMO-channel configurations. US prices for models 2820, 2920, 2895, and 280111 start at $22,500, $17,500, $9900, and $9500, respectively.

—by Dan Strassberg

▷**Keithley Instruments**, www.keithley.com/pr/077.

12.14.07

QUALCOMM MOVES 3G CHIPS TO 45-NM PROCESS

Qualcomm Inc this month announced that it has made the first phone call on a 3G chip it manufactured with 45-nm-process technology. Qualcomm made the call on the 45-nm chips received from TSMC (Taiwan Semiconductor Manufacturing Co, www.tsmc.com), the largest dedicated semiconductor foundry.

"Thanks to our close strategic-foundry-partner relationship with TSMC, Qualcomm is able to leverage leading-edge semiconductor-process technology to advance wireless communications," said Steve Mollenkopf, senior vice president of product management for Qualcomm CDMA (code-division/multiple-access) technologies, in a statement. Qualcomm did not state the technical details of the 45-nm chips in its release. However, industry sources report new 45-nm chips targeting mass-market smartphones with integrated chips on dual-core technology, multiband RF transceivers, ARM11 application processors, Bluetooth 2.1 EDR (enhanced-data-rate) systems, FM radio, GPS (global-positioning-system) units, and 5M-pixel-camera applications. Sources report that the chip sets support UMTS (universal mobile telecommunications system) or EVDO (evolution-data-optimized) Revision B, with full backward compatibility and GPS performance.

Qualcomm in August taped out on its low-power-optimized 45-nm process using advanced immersion lithography and extreme low-k intermetal-dielectric material. At the same time, the company announced that it had begun work on 40-nm-process technology. The fabless company had laid out its 45-nm strategy with TSMC, its traditional foundry partner, in November 2006. "The first-time silicon success of Qualcomm's 3G product using TSMC's 45-nm process is a testament to the integrated-foundry model that calls for end-to-end collaboration," said Mark Liu, senior vice president of operations at TSMC, in the statement.—by Suzanne Deffree

▶**Qualcomm, www.qualcomm.com.**

VOICES

Chano Gómez on powerline networking's "universal" hope

A profusion of incompatible "standards," the memory of poor initial products, and the technical challenge of the application have thus far retarded the adoption of powerline networking. Chano Gómez, vice president of technology and strategic partnerships with chip maker DS2 (www.ds2.es), offers insight into the UPA (Universal Powerline Association, www.upaplc.org) technology his company champions. Read an extended version of this interview at www.edn.com/071214voices.

What is the UPA's objective?

A The original goal of UPA was to create standards for coexistence between broadband-access and home-powerline networks. However, feedback from the market pointed to the need for real interoperability standards, so UPA decided to extend its scope to create UPA DHS [digital-home system] and also to certify product compliance with that standard.

That effort has been quite successful. The first 200-Mbps product introduced in the US consumer market was based on the UPA standard, and, according to [market-research company] The NPD Group, more than 50% of 200-Mbps products sold in the US retail market are based on the UPA specification and have the UPA logo.

How does the UPA technology modulate data and handle errors?

A UPA's PHY [physical layer] is based on OFDM [orthogonal-frequency-division-multiplexing] modulation. OFDM was chosen because of its inherent adaptability in the presence of frequency-selective channels, its resilience to jamming signals, its robustness to impulsive noise, and its capacity of achieving high spectral efficiency.

Detection and correction of errors is achieved by a concatenation of 4-D trellis codes and Reed-Solomon forward error correction, specially tuned to cope with the very special powerline-channel impairments. For those cases in which packets become so corrupted by noise that they cannot be recovered, a retransmission mechanism is used. Packet fragments are numbered individually, and each pair of transmitter and receiver keeps track of which one has been received correctly and which one needs to be retransmitted.

How does UPA compensate for varying noise levels caused by fluorescent lights and motor-driven products, such as vacuum cleaners and hair dryers?

A The interesting feature of noise in power-

line is that it's not like the famous "white-gaussian" noise in any digital-communications textbook. It's "colored" noise (stronger in some frequencies and weaker in others), nongaussian (with very strong peaks that do not follow a normal distribution), and nonstatic (with short periods of silence followed by shorts periods of strong noise). So, a powerline device has to find out which are the "clean" time/frequency slots and make sure to avoid the noisy ones. Once this is done, somebody will plug or unplug something in a room nearby, and you have to repeat the time/frequency analysis all over again, in only a few milliseconds, to ensure that the user does not experience any service interruption. Fortunately, advances in DSP and ASIC technology provide enough computing power to perform a pretty accurate time/frequency analysis of the communication medium.

How does UPA handle the reality that different circuit breakers may feed two power outlets, either in close proximity or not, which a consumer may want to interconnect via UPA? Even more challenging, what if these circuits derive from opposite phases of the 220V (US) source feed?

A First, let me clarify that the fact that two outlets are in different circuits does not necessarily mean that powerline technology won't work there. In general, there is sufficient signal coupling between the wires (due to capacitance) to ensure that a connection can be done with adequate performance. My impression is that a lot of people have bad memories from legacy home-control-powerline technologies that operated at much lower frequencies (kilohertz instead of megahertz) and that didn't work very well when sockets were in different circuits, phases, or both.

Having said that, it's also true that having signals "jumping" from circuit to circuit means that signal strength is slightly lower, so there is usually a certain amount of performance degradation in that situation. If you combine this [fact] with additional factors, such as a damaged wire and a strong noise source and a low impedance due to several devices being connected in parallel in the same socket, you may find sockets where a connection cannot be established.

There are cases (in extremely large homes, or industrial/commercial environments) where a combination of long distance and circuit/phase change could result in bad performance in some socket pairs. UPA provides a very elegant and efficient way of solving this problem using repeaters. The user needs to just connect an additional powerline adapter in a socket close to the electrical-switch panel, which is the electrical "center of gravity" of the building, and that adapter will automatically become a signal regenerator. As far as we know, this feature is unique to UPA technology. The solution is simple and elegant, because no configuration and no special hardware

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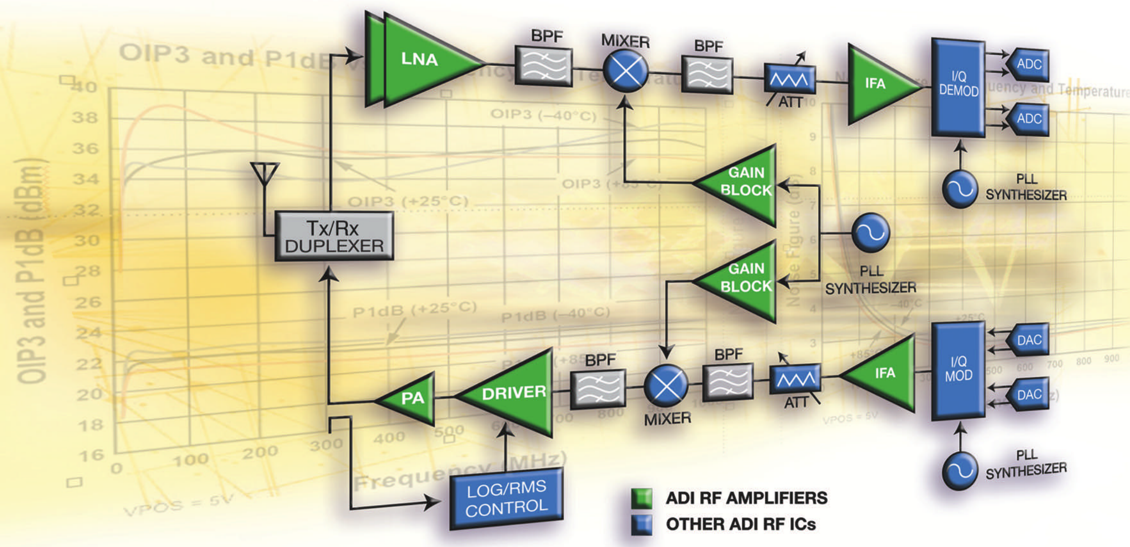

Low Noise Amplifiers (LNA)

Part Number	Freq Range (MHz)	Gain (dB)	OIP3 (dBm)	P1dB (dBm)	NF (dB)	Current (mA)	Specs @ (MHz)	Price
ADL5521	400 to 4000	15.3	35.3	22.5	0.8	65	1950	$2.15
ADL5523	400 to 4000	17.5	33.7	21.9	1.0	65	1950	$2.15

Intermediate Frequency Amplifiers (IFA)

Part Number	Freq Range (MHz)	Gain (dB)	OIP3 (dBm)	P1dB (dBm)	NF (dB)	Current (mA)	Specs @ (MHz)	Price
ADL5530*	DC to 1000	16.8	37.0	21.8	3.0	110	190	$1.56
ADL5531	20 to 500	20.3	40.9	20.7	2.7	101	190	$2.25
ADL5532	20 to 500	16.1	39.1	19.7	3.0	95	70	$2.25
ADL5533 (75 Ω)	30 to 1000	19.8	37.3	18.7	2.9	66	70	$2.55
ADL5534 (Dual)	20 to 500	19.8	41.8	20.0	2.5	90	70	$3.29

Gain Blocks

Part Number	Freq Range (MHz)	Gain (dB)	OIP3 (dBm)	P1dB (dBm)	NF (dB)	Current (mA)	Specs @ (MHz)	Price
AD8353*	1 to 2700	19.5	22.8	8.3	5.6	42	900	$0.48
AD8354*	1 to 2700	19.5	19.3	4.8	4.4	25	900	$0.48
ADL5541	50 to 6000	14.7	39.2	16.3	3.8	92	2000	$1.65
ADL5542	50 to 6000	18.7	39.0	18.0	3.2	92	2000	$1.65

Driver Amplifiers

Part Number	Freq Range (MHz)	Gain (dB)	OIP3 (dBm)	P1dB (dBm)	NF (dB)	Current (mA)	Specs @ (MHz)	Price
ADL5320	400 to 2700	13.7	42.0	25.6	4.2	104	2140	$2.55
ADL5322	700 to 1000	19.9	45.3	27.9	5.0	320	900	$3.48
ADL5323	1700 to 2400	19.5	43.5	28.0	5.0	320	2140	$3.48

*3 V bias is also supported.

All prices shown are $U.S. in 1k quantities unless otherwise noted.

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ANALOG DEVICES

or firmware is required. (Any powerline adapter can be a repeater.)

How do you educate consumers to ensure reliable powerline-network operation?

A We work on two fronts. On one hand, we work with our partners with more experience in the consumer market—companies such as Netgear, D-Link, and Buffalo Technology—to ensure that their product packaging and user manuals explain the best way to use the product—for example, recommending users to always connect the adapter directly into a wall socket and not into a surge-protected power strip.

Additionally, we try to provide useful feedback to users so that they can easily recognize which is the best way to use the product. In January 2007, we launched a reference design, code-named DH10PF, with multicolored LEDs, so that users can easily see if the network is operating at full performance: green for excellent performance, yellow for good performance, red for bad performance. Since then, other powerline vendors have started to borrow the idea, so it must be good.

Vendors market UPA as a "200-Mbps" technology, but it delivers only a percentage of that throughput. Why did UPA choose the peak PHY rate as the technology designator?

A Most 802.11g products have a label somewhere on the box that mentions "54 Mbps." If you measure TCP/IP [Transmission Control Protocol/Internet Protocol] throughput yourself, you'll see that the maximum you'll get will be around 25 Mbps. If you take two UPA powerline adapters and perform the same test, in the same conditions, you'll get a maximum speed of 95 Mbps. So, the ratio between maximum throughput and PHY data rate in UPA is not worse than in 802.11g.

If I had the opportunity to start all over again, without the historic context provided by other networking technologies, I wouldn't have used the 200-Mbps label. I'd rather use a label that describes the expected application of the technology. But, given that we had to introduce a new technology in a market where consumers already knew that 802.11b worked at 11 Mbps, 802.11g at 54 Mbps, and HomePlug 1.0 at 14 Mbps, we needed to provide a reference that consumers could use for performing an apples-to-apples comparison.

DS2 has recently touted "400-Mbps" technology. What kind of performance can users reasonably expect to see and when?

A From the performance point of view, you can expect roughly twice the performance of current 200-Mbps systems. We are not providing product details yet. You'll probably see more details at CES [Consumer Electronics Show] in January. The technology will be backward-compatible—in the sense of "fully interoperable"—with existing 200-Mbps UPA-compliant products, thus offering an easy migration path to our current customers. In the past, other vendors broke backward interoperability when they introduced new performance levels. That's the case with HomePlug AV products, which are not interoperable with HomePlug 1.0 or HomePlug Turbo products. We want to make sure we don't make that mistake in this case.

How much of a concern is data security across a shared power-distribution topology? And how do you educate consumers on the potential need to change the default encryption password and make other security adjustments?

A The latest Aitana chip set announced by DS2 at IDF [Intel Developer Forum] Fall 2007 provides 256-bit AES [Advanced Encryption Standard] encryption, which, as far as I know, is the strongest encryption available in any powerline product today. The encryption engine is hardware-based, and the system has been designed in a way that provides full performance regardless of whether encryption is used—unlike wireless systems, which usually have degraded performance when encryption is enabled. Aitana also supports 156-bit 3DES [Triple Data Encryption Standard] encryption for backward compatibility with previous products. Key-exchange protocols are software-based, which means that they can be upgraded easily if better protocols are created.

One aspect on which we have spent a lot of time and engineering resources is finding ways in which users can enable security as easily as possible, even without using a computer. This no-computer goal may seem extreme, but it's important to note that one of the most popular applications of UPA technology is for in-home distribution of IPTV [Internet Protocol-television] content. In many cases, subscribers to IPTV services may not even have a computer. They just signed up for the service because it was cheaper than regular cable or maybe had better content than satellite. They have no idea that their TV service is delivered via an ADSL2+ [asymmetric-digital-subscriber-line 2-plus] modem and don't even know what IPTV stands for.

For our DH10PF reference design, we came up with OBUS [one-button security], which basically allows the user to set up an encrypted network just by pressing a button on each powerline adapter within 30 seconds of each other. No computer required. No passwords to remember. If the LED is green, your secure network is up and running. Other vendors have tried similar ideas in the past, but with severe limitations: The units had to be connected physically close to each other for initial setup, and complex switches had to be configured for the system to work. We think our approach is the most user-friendly, and the fact that other vendors have started to borrow the idea seems to validate that [idea].

Is there hope for a true powerline standard?

A Our position here is clear: We need a single standard with a single PHY and a single MAC [media-access controller], so that all products are interoperable. We are willing to do whatever is needed to achieve this [goal], even if it means redesigning silicon and departing from our current PHY, MAC, or both. IEEE P1901 represents an excellent opportunity to achieve this [goal], but, so far, it looks like we as an industry may miss this opportunity again.

—**by Brian Dipert**

BY BONNIE BAKER

Delta-sigma ADCs in a nutshell

Delta-sigma converters are ideal for converting signals over a wide range of frequencies from dc to several megahertz with very-high-resolution results. **Figure 1** shows the basic topology, or core, of a delta-sigma ADC, which has an internal delta-sigma modulator in series with a digital filter. As you explore delta-sigma ADCs, you will find that, although they have a variety of other features, they all possess this basic structure. This column and the next three *Baker's Best* columns explore the basic topology and functions of these two modules.

The input signal to the delta-sigma ADC is an ac or dc voltage. This and the next three *Baker's Best* columns use a single cycle of a sine wave as the input signal. Using a 1-bit internal ADC, the internal converter modulator in **Figure 1** samples the input signal, producing a coarse, quantized output. The modulator converts the analog-input signal into a high-speed, pulse-wave representation. The ratio of ones to zeros in the modulator's output pulse train mirrors the input-analog voltage. Although the modulator produces a noisy output, future columns will show that the circuit "shapes" this noise into the higher frequencies of the output spectrum. This action paves the way for a low-noise, high-resolution conversion at the output of the digital filter.

At the modulator output, the digital filter addresses high-frequency noise and high-speed-sample-rate issues.

At the modulator output, the digital filter addresses high-frequency noise and high-speed-sample-rate issues. Because the signal now resides in the digital domain, you can apply a lowpass digital filter to attenuate the higher frequency noise and a decimator filter to slow down the output-data rate. The digital/decimator filter samples and filters the modulator's stream of 1-bit codes and creates a slower multibit code.

Although most converters have only one sample rate, delta-sigma converters have two: the input sampling rate and the output-data rate. The ratio of these two meaningful variables defines the system's decimation ratio. A strong relationship exists between the decimation ratio and the converter's effective resolution. A future column will examine how the modulator, digital/decimator filter, and adjustable decimation ratio work. **EDN**

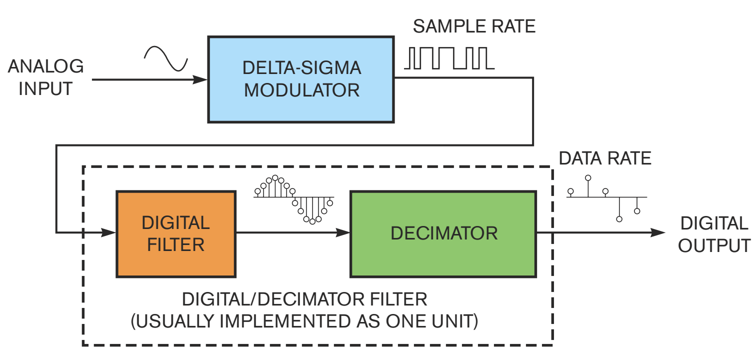

Figure 1 The core functions inside any delta-sigma ADC are a delta-sigma modulator and a digital/decimator filter.

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1. Baker, R Jacob, *CMOS Mixed-Signal Circuit Design: Volume II*, John Wiley & Sons, 2002, ISBN: 0471227544.

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

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TEXAS INSTRUMENTS
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BRIEF

Calibration in Touch-Screen Systems

***By Wendy Fang,** Precision Analog Applications, High-Performance Analog,*
***and Tony Chang,** Precision Analog Nyquist, High-Performance Analog*

Introduction

Today, more and more applications are using touch screens or touch panels for equipment with human/machine or human/computer interfaces. Figure 1 is a block diagram of a touch-screen system where the touch screen sensor lies on top of the system's display, in this case an LCD panel. Products equipped with a touch screen normally require calibration upon power up. This abbreviated article presents an overview of the calibration concepts for touch-screen systems. Please see Reference 1 for the complete article.

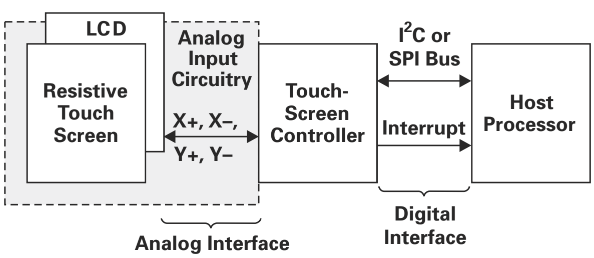

Figure 1. Typical four-wire resistive touch-screen system

Touch-Coordinate Errors

When pressure is applied to the touch screen, the touch-screen controller senses it and takes a measurement of the X and Y coordinates. Several sources of error can affect the accuracy and reliability of this measurement. The majority of these errors can be attributed to electrical noise, scaling factors, and mechanical misalignments. This article addresses only the latter two.

Scaling factors and mechanical misalignments originate in the parts and assembly of the touch screen and the display. Typically, the touch-screen controller and display in a system do not have the same resolution, so scaling factors are needed to match their coordinates to each other. "Real-world" scaling factors may vary from part to part and may need to be calibrated to reduce or eliminate any mismatch. An example is shown in Figure 2, where the X-axis scale is the same on the LCD and the touch screen, or $k_X = S_X/S'_X = 1$; but the LCD Y-axis scale is larger than that on the touch screen, with the scaling factor of $k_Y = S_Y/S'_Y = 3.6/4 = 0.9$. Thus, a point P (X′, Y′) = (2, 2.222) on the touch screen should be scaled to (X, Y) = (2, 2) for the LCD (the host).

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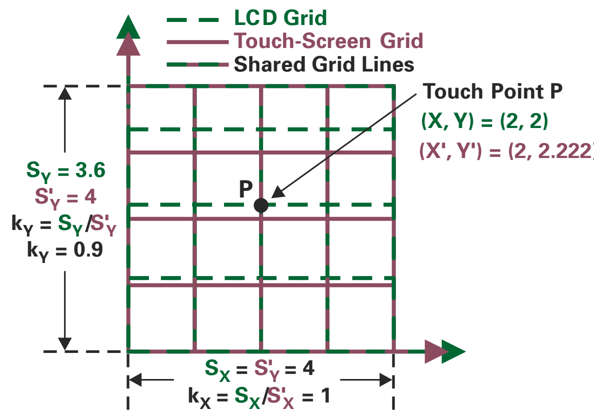

Figure 2. Scaling factors on the Y axes of LCD and touch screen

Mechanical misalignment between the display and the touch screen includes moving and rotation errors, as shown in Figure 3. Figure 3a shows the relative position shifts of ΔX in the X direction and ΔY in the Y direction; and Figure 3b shows the relative rotation, Δθ, between the LCD and the touch screen.

Consider a point P, read as (X′, Y′) on the touch screen. The display should read a moving error like that shown in Figure 3a as (X′ + ΔX, Y′ + ΔY). For a rotation error like that shown in Figure 3b, the point on the touch screen is $(R \times \cos\theta,\ R \times \sin\theta)$, or on the display is $[R \times \cos(\theta - \Delta\theta),\ R \times \sin(\theta - \Delta\theta)]$, where R is the distance from origin C, or (0, 0), to the point P.

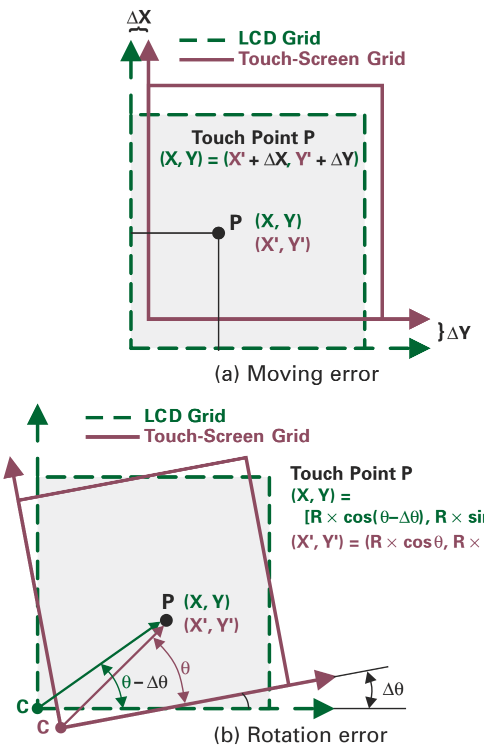

Figure 3. Mechanical misalignments

Mathematical Expressions for Calibration

Calibration of the touch screen translates the coordinates reported by the touch-screen controller into coordinates that accurately represent the point and image location on the display or LCD. The result of calibration is a set of scaling factors that allow correction of the moving and rotation errors that are due to mechanical misalignments.

Consider the point P, represented as (X, Y) on the display and (X′, Y′) on the touch panel. Counting in the scaling factor in Figure 2 and the moving and rotation errors in Figure 3, the touch-screen coordinate X can be expressed as

$$\begin{aligned} X &= k_X \times R \times \cos(\theta - \Delta\theta) + \Delta X \\ &= k_X \times R \times \cos\theta \times \cos(\Delta\theta) + k_X \times R \times \sin\theta \times \sin(\Delta\theta) + \Delta X \\ &= k_X \times X' \times \cos(\Delta\theta) + k_X \times Y' \times \sin(\Delta\theta) + \Delta X \qquad \textbf{(1)} \\ &= \alpha_X \times X' + \beta_X \times Y' + \Delta X, \end{aligned}$$

where $X' = R \times \cos\theta$, $Y' = R \times \sin\theta$, $\alpha_X = k_X \times \cos(\Delta\theta)$, and $\beta_X = k_X \times \sin(\Delta\theta)$. Similarly, the touch-screen coordinate Y can be expressed as

$$\begin{aligned} Y &= k_Y \times R \times \sin(\theta - \Delta\theta) + \Delta Y \\ &= k_Y \times R \times \sin\theta \times \cos(\Delta\theta) - k_Y \times R \times \cos\theta \times \sin(\Delta\theta) + \Delta Y \\ &= k_Y \times Y' \times \cos(\Delta\theta) - k_Y \times X' \times \sin(\Delta\theta) + \Delta Y \qquad \textbf{(2)} \\ &= \alpha_Y \times X' + \beta_Y \times Y' + \Delta Y, \end{aligned}$$

where $\alpha_Y = -k_Y \times \sin(\Delta\theta)$, and $\beta_Y = k_Y \times \cos(\Delta\theta)$.

From Equations 1 and 2 it is obvious that to get the coefficients α_X, α_Y, β_X, β_Y, ΔX, and ΔY, at least three independent points are needed. The points are independent if they are not on one linear line. Assuming that (X_1, Y_1), (X_2, Y_2), and (X_3, Y_3) are three independent points selected on the LCD, and (X'_1, Y'_1), (X'_2, Y'_2), and (X'_3, Y'_3) are the corresponding points on the touch screen, Equations 1 and 2 can be used to write Equation 3 in matrix form:

$$\begin{pmatrix} X_1 \\ X_2 \\ X_3 \end{pmatrix} = A \times \begin{pmatrix} \alpha_X \\ \beta_X \\ \Delta X \end{pmatrix} \text{ and } \begin{pmatrix} Y_1 \\ Y_2 \\ Y_3 \end{pmatrix} = A \times \begin{pmatrix} \alpha_Y \\ \beta_Y \\ \Delta Y \end{pmatrix}, \qquad \textbf{(3)}$$

where

$$A = \begin{pmatrix} X'_1 & Y'_1 & 1 \\ X'_2 & Y'_2 & 1 \\ X'_3 & Y'_3 & 1 \end{pmatrix}.$$

Calibration Methods

The three independent calibration points shown in Equation 3 should be sufficient to get the scaling factors required to correct the mechanical misalignment between the touch screen and the system display.

To resolve Equation 3, both sides can be multiplied by the inverse of matrix A to get

$$\begin{pmatrix} \alpha_X \\ \beta_X \\ \Delta X \end{pmatrix} = A^{-1} \times \begin{pmatrix} X_1 \\ X_2 \\ X_3 \end{pmatrix} \text{ and } \begin{pmatrix} \alpha_Y \\ \beta_Y \\ \Delta Y \end{pmatrix} = A^{-1} \times \begin{pmatrix} Y_1 \\ Y_2 \\ Y_3 \end{pmatrix}, \qquad \textbf{(4)}$$

where A^{-1} is the inverse of matrix A. The three points—(X_1, Y_1), (X_2, Y_2), and (X_3, Y_3)—are designed/selected on the display surface, and the elements in matrix A are measured from the touch screen during calibration.

Example: Three-Point Calibration

On a display with 256 × 768 resolution, three calibration points are chosen: (64, 384), (192, 192), and (192, 576). During calibration, the three points (678, 2169), (2807, 1327), and (2629, 3367) are measured from a touch panel with 12-bit or 4096 × 4096 resolution. Equation 3 can then be populated with these known values.

$$\begin{pmatrix} X_1 \\ X_2 \\ X_3 \end{pmatrix} = \begin{pmatrix} 64 \\ 192 \\ 192 \end{pmatrix} \qquad \begin{pmatrix} Y_1 \\ Y_2 \\ Y_3 \end{pmatrix} = \begin{pmatrix} 384 \\ 192 \\ 576 \end{pmatrix}$$

$$A = \begin{pmatrix} 678 & 2169 & 1 \\ 2807 & 1327 & 1 \\ 2629 & 3367 & 1 \end{pmatrix}$$

Applying Equation 4 results in $\alpha_X = 0.0623$, $\beta_X = 0.0054$, $\Delta X = 9.9951$, $\alpha_Y = -0.0163$, $\beta_Y = 0.1868$, and $\Delta Y = -10.1458$. Thus the equation for X, from Equation 1, is

$$X = 0.0623 \times X' + 0.0054 \times Y' + 9.9951;$$

and the equation for Y, from Equation 2, is

$$Y = -0.0163 \times X' + 0.1868 \times Y' - 10.1458.$$

The complete article in Reference 1 includes a five-point calibration example, algorithms for three-point and n-point calibration, and notes about algorithm implementation.

Reference

1. View the complete article at
http://www-s.ti.com/sc/techlit/slyt277

BY PALLAB CHATTERJEE, CONTRIBUTING TECHNICAL EDITOR

Pcell and IP realities for fabless design

The current methodology for SOC (system-on-chip) design employs a hierarchical approach that maximizes the use of IP (intellectual-property) blocks. This method replaces the previous one, which used flat files full of gate-level structures. Third-party IP providers and in-house groups supply these IP blocks. Most of the in-house-created IP blocks are hierarchical assemblages of primitive devices that automatic cell generators, such as Pcells, create.

For large IDMs (integrated-device manufacturers) and large companies, this model works well. But to use this methodology, a company needs a full-time engineering and CAD (computer-aided-design) staff keeping the Pcell generators synchronized. The company also requires in-house macro design and characterization, as well as partnership arrangements with IP providers so that the IP remains current with the process rules and characterization. These staffing resources are in addition to the CAD support staff's installing and maintaining the EDA tools in the design flow and providing all the stitch-and-launch code interfacing between tools.

Smaller companies generally do not have these luxuries. The limited manpower resources at most small companies and the need to time-share that manpower over multiple tasks in the course of a design project make these luxuries infeasible. These limitations drive the smaller fabless companies to rely on PDK (process-design-kit) packages from the foundries as the basis for all information. For most subwavelength processes of less than 180 nm, these PDKs have design rules and model changes on a quarterly, monthly, and sometimes even weekly basis.

As a result of the constant changes in PDKs, most companies have time only for validating and correcting their custom IP blocks. For this task, downloadable technology files and verification files provide the most definitive information on the yield and reliability parameters of the process. Most print documentation is not as current as electronic files. A statistical-design approach suits systematic-design validation, allowing changes to individual parameters without context.

But the lack of resources to keep everything current creates other serious problems for smaller design teams. From a physical-verification perspective, the major challenge occurs when the design team begins point-rule optimization for yield enhancement. The quantity of interrelated design rules complicates this task, resulting in a set of rules that does not track.

The use of I/O cells from third parties and foundries creates another challenge. These I/O cells tend to be more specialized than the core-library devices in the foundry's eyes, and the IP provider develops these cells early in the process life cycle. As a result, these devices do not incorporate ongoing process enhancements, as the IP supplier updates them only every few years.

The last revision issue is with the coding for the Pcells or auto-device generators. IP groups create Pcell-generator code for new processes mostly by modifying previous-generation legacy Pcell code. The method of modifying legacy code brings with it assumptions, work-arounds, patches, and parameters that were originally created to solve anomalous problems in previous process nodes, and these anomalies may not exist or be relevant for the current node. This method also limits the Pcell environment to using the process parameters and relationships that were available at the time of code migration and not incorporating the latest manufacturing enhancements. A large number of the Pcells, despite having geometrically accurate coding, create nonmanufacturable structures, such as donuts with no construction line, off-grid vertices, and self-intersecting structures. As a result, correctly using these Pcells requires converting most of them to hard cells and then modifying them to meet current PDK requirements.

Using the structured-hierarchy methodology for SOC construction is a good and valid approach. However, most companies must allocate significant resources to PDK support, Pcell and custom-design support, in-house macro-revision control, third-party IP-revision control and waiver tracking, and I/O-cell-revision control and waiver tracking. Subwavelength-design flows have a significantly higher cost—both in manufacturing dollars and resources—than large-geometry processes. Most companies see only the manufacturing costs, but the engineering-resource allocation is what keeps most projects from completing on schedule. EDN

Contact me at pallabc@siliconmap.net.

BY PHIL OUELLETTE • METTLER-TOLEDO INC

Surprise, surprise

DANIEL VASCONCELLOS

I once had to track down an intermittent power-on-reset problem. I designed an 8052-processor-based USB peripheral with external memory. The design used 74VHC573 octal latches to demultiplex the memory bus and for memory-mapped I/O. The power supply was more complicated than usual due to the requirements of this device: It needed USB power regulated to 3.3V dc, boosted up to 6V dc, and then regulated back down to create a 5V-dc reference. Because this peripheral received its power from the USB, we had to comply with USB-power specs: a 10-μF-capacitor-equivalent maximum inrush current and maximum 100-mA current draw from the USB supply. Due to the voltage-level translations in the power supply, the overall efficiency of the power supply was approximately 50%.

During systems testing, we started getting reports of intermittent problems during boot-up. Some units were slow to start up, and some would not start at all. We cycled power off and then back on, and they would all then work. Initially, I couldn't reproduce the problem in the lab. All of the power-supply components were operating well within their rated capacity, and the reset circuitry was triggering at the correct voltage level. I added an external reset switch to the board to let me better examine the reset process and discovered that, when I held the processor in reset, the 5V-dc supply voltage dropped below the reset chip's threshold voltage, which was the immediate cause of the boot-up failure. Further investigation showed that the USB-supply current increased to almost double its normal value while the processor was in reset. This doubling of supply current exceeded the current rating of the 3.3V low-dropout regulator, and its output dropped below 3V dc. This drop, which greatly increased current draw while the processor was in reset, was definitely not something I had expected to see.

I started debugging the problem by measuring the current draw of each chip on the PCB (printed-circuit board). Everything was nominal until I got to the latches. Instead of the microamp current draw I was expecting to measure, each one was drawing 20 mA. After the processor came out of reset, the extra current draw stopped, and everything began operating normally. We were using the latches correctly according to their data sheet, and the system functioned properly after reset. Disconnecting the external memory didn't change the reset current draw into the latches. After some fruitless investigations of the latches and external circuitry, I turned my attention to the processor. Port 0 of the 8052 processor is unique in that it has no internal pullup resistors like the other ports on the processor. This fact gave me an inkling of what might be the root cause of the problem. The 8052 data sheet defines the port pin's state on exiting reset but doesn't define the state while the processor is in reset. It turns out that Port 0 goes into high-impedance (open-collector) mode when the processor is in reset. This scenario leaves the inputs to the latches floating, which is undesirable. I added external pullup resistors to the Port 0 processor pins, eliminating the problem.

We had taken this memory-expansion design directly from the Intel 8052 data book, and we have used it in many designs over the past 25 years without ever seeing a problem. In retrospect, I realized that all of these designs must also draw additional current while in reset, but no one had noticed this requirement before because none of the designs have power supplies with such strict current limitations. Designers would have attributed any current spike at start-up to inrush current and would have ignored these spikes. **EDN**

Phil Ouellette is a senior engineer at Mettler-Toledo Inc. Like Phil, you can share your tale and receive $200. Contact Maury Wright at mgwright@edn.com.

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Microfuel cell enables ubiquitous computing

This fall's Intel Developer Forum in San Francisco included a section on technologies that will help extend the computing time of laptop computers. Medis Technologies (www.medistechnologies.com) demonstrated its fuel-cell-based, $19.95, 1W 24/7 Power Pack for handheld devices, such as cell phones and MP3 players. The 3.8×2.7×1.4-in. device provides approximately 20 Whrs of energy—enough to power an iPod for at least 60 hours or provide approximately 30 hours of cell-phone talk time. It comes with a standard connector and multiple adapter tips. It complies with ROHS (restriction-of-hazardous-substances) directives, and you can recycle; just mail it back in its original box to the manufacturer. The company's next-generation product will be a 20W device capable of powering a laptop.


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AS THE MERCURY DROPS below freezing, it's nice to be able to focus our attention on something hot. For some of you, this scenario might mean lounging on a sunny beach in Hawaii, piña colada in hand. For *EDN*, it's compiling our annual Hot 100 Products list. The following pages list those products and technologies we chose from our print and Web pages in 2007 that our editors believe generated heat in the electronics community—from analog ICs to test-and-measurement devices. Warm up (pun intended) by reading the list here, and then go to www.edn.com/hot100 for links to *EDN*'s original coverage of each of these hot and innovative products. (Be careful you don't burn yourselves!) And, as always, for continuous new-product coverage, visit www.edn.com/productfeed.

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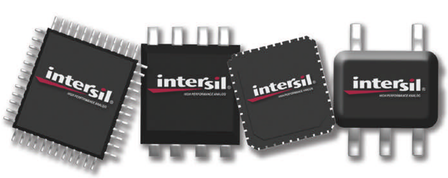

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WITH LEGAL-GAMBLING REVENUES SKYROCKETING AND ELECTRONICS TECHNOLOGY AT CENTER STAGE, EMBEDDED-SYSTEM MANUFACTURERS ARE LINING UP TO BET ON THE FUTURE.

BY WARREN WEBB • TECHNICAL EDITOR

EMBEDDED ELECTRONICS GUIDES CASINO GAMING

When you step into a casino in Las Vegas or thousands of other gambling venues around the world, you immediately face a bombardment of multimedia sounds and images from a vast collection of embedded devices, all carefully designed to provide entertainment and maximize stockholder revenue. These modern electronic gambling machines employ the latest high-performance computing and graphics technology along with built-in security to protect the system integrity and guard against hacking. In addition to the multitude of gaming devices, the industry has adopted electronics technology to provide real-time player tracking, surveillance, security, data analysis, and accounting. Casinos also depend on system manufacturers and embedded-system designers to provide a constant flow of increasingly complex gaming products to attract the next generation of casino patrons.

An enormous potential market exists in the gaming industry for embedded boards and devices. Experts predict that worldwide revenues from casino gambling will grow from almost $70 billion in 2004 to more than $100 billion in 2009. The United States alone generates approximately 60% of this revenue. As these revenues increase and new venues, such as American Indian casinos, proliferate, operators are investing in the latest electronic-gaming machinery to attract players from the competition. Other gambling operations, such as legal bookmaking, lotteries, pari-mutuel wagering, and even charitable bingo games, are also turning to embedded electronics to speed play and enhance information delivery.

Electronics in gaming has its roots in the slot machines that casino owners in Las Vegas placed in the early days to entertain the wives and girlfriends of serious gamblers. Slot machines have since transformed from these vintage mechanical contraptions that accept and pay off in coins to today's electronic marvels that accept only paper currency and pay out with a voucher. Although modern slot machines may offer denominations as low as one penny, designers structure these games to encourage players to increase their bets with multiple pay lines and hidden bonuses. Even traditional table games, such as blackjack, poker, and roulette, have electronic equivalents or add-ons to enhance the experience and to speed play. Electronic gaming today accounts for 70 to 80% of casino revenue.

WEB THREAT

If you ignore the nongaming entertainment that casinos provide, the Internet provides most of the elements necessary to be a potential threat to the legal-gambling industry. For example, a reasonably fast desktop computer connected to the Internet can duplicate the entire visual and acoustic stimulus necessary to duplicate most casino games. An online-gambling site should be able to entice players with higher payouts by eliminating the labor, real estate, and even the specialty electronics that brick-and-mortar casinos require. Although many of these Web sites do exist, Internet gambling runs into a complicated series of laws and regulations. The Federal Wire Act prohibits gambling businesses from using telecommunications wires to transmit bets, and credit-card regulations forbid these wires' use in online gambling. To avoid these regulations, gambling Web sites require prepayment by check and reside outside the United States.

AT A GLANCE

- Casino gaming is a huge and growing industry that depends solely on embedded electronics and software for new devices.
- Gaming devices must incorporate sophisticated physical and software obstacles to discourage hackers and safeguard internal circuitry.
- Embedded boards for the gaming industry must guarantee an extended life cycle and pass a detailed configuration certification.
- New casino industry trends, such as mobile and server-based gaming, will require a new generation of hardware, software, and security.

Despite the possible challenge from the Internet, the casino-gaming industry is stable and offers plenty of opportunities for embedded-system designers and manufacturers. Similar to the military and aerospace segments, the highly regulated casino-gaming devices require certified manufacturing and testing processes. Before an electronic slot machine appears on a casino floor, it must undergo a detailed certification audit by an outside testing organization, such as GLI (Gaming Laboratories International). These audits examine physical security, random-number generation, software integrity, documentation, and all electronic circuitry. GLI offers a series of gaming-machine standards, which regulating agencies can use as is or modify.

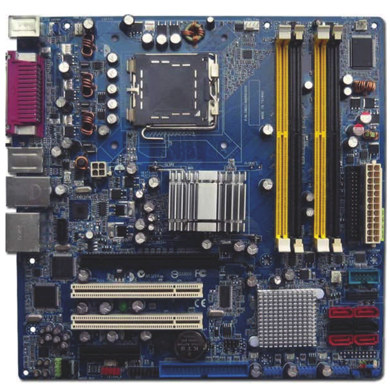


Figure 1 The iQ965-CI single-board computer combines Trusted Platform Module security technology and multimedia I/O for gaming-device applications.

Product certification is an expensive process and is valid for only a single hardware and software configuration. Because regulating agencies must recertify any changes or updates, system designers usually employ tried and true subsystems with long-term availability. The cost of certifying a new embedded board will easily exceed the cost of purchasing or remanufacturing a board even if it means using old technology with components nearing end-of-life status. Manufacturers in highly regulated industries have developed multiple techniques, such as bulk component purchases and extended production contracts with silicon vendors, to extend product life cycles.

Gaming devices must incorporate physical deterrents to dissuade hackers and safeguard internal circuitry. Manufacturers typically use a hardened enclosure requiring specialized equipment to open. Designers should build the internal parts of PCBs (printed-circuit boards) with security in mind. For instance, hiding the critical signals inside the internal layers in BGA (ball-grid-array) packages makes probing and reverse-engineering the devices more difficult. Although hackers can remove some formulations with acid, the use of epoxies and conformal coatings also protects all or part of a product's sensitive internal circuitry. In addition to physical protection, embedded-system designers also employ open security standards. For example, the TCG (Trusted Computing Group) Standard 1.2 limits access to protected data, authenticates the identity of computers, and manages user privacy. An embedded TPM (Trusted Platform Module) enables these functions by monitoring the boot process to create hash values or checksums for the important elements, such as the BIOS, device drivers, and operating-system loaders. The TPM stores these values and compares them with the reference values that define the trustworthy status of the platform. The TPM also provides public/private-key RSA (Rivest/Shamir/Adleman) encryp-

tion and decryption along with a tamper-proof on-chip memory for keys and passwords.

Advansus, a joint-venture company of ASUS and Advantech, recently released a single-board computer addressing the multimedia, security, and longevity needs of the gaming industry. The iQ965-CI combines TPM-security technology and 7.1-channel amplified-audio performance with Intel's Q965 chip set and the Core 2 Duo processor (**Figure 1**). The MiniITX motherboard module features the Infineon SLB 9635 TPM chip set to ensure authenticity, software integrity, and confidentiality in network communications. The iQ965-CI receives its power from Intel 3000 graphics-media-accelerator technology, which supports DirectX 9.0c, Pixel Shader 2.0, 256 Mbytes of video memory, and a dual independent display through advanced digital-display or media-expansion cards. The motherboard accommodates one 16-lane PCI Express slot for a secondary display and includes one GbE (Gigabit Ethernet), two SATA (serial-advanced-technology-attachment), six USB, and two serial ports.

GAMING STANDARDS

As gaming-device manufacturers slowly adopt newer embedded-system technology, open standards for communications between boards, subsystems, servers, and management systems from multiple manufacturers become critical. The GSA (Gaming Standards Association) offers a series of communications specifications for free downloading at its Web site. The association's GDS (Gaming Device Standard) communications protocol controls the flow of information between a slot-machine controller and the local array of peripheral devices, including bill validators, card readers, and ticket printers. The GSA also supplies a G2S (Game-to-System) standard based on Ethernet, TCP/IP (Transmission Control Protocol/Internet Protocol), and XML (Extensible Markup Language), which will allow the industry to securely migrate to new technologies, such as server-based games over intranet or Internet environments.

Embedded technology in gaming also extends to the traditional table games. With the right data-capture tools, casino operators can monitor player behavior to detect card counting, adjust promotions, and minimize dealer errors. For example, International Game Technology, Shuffle Master, and Progressive Gaming International have joined forces to create the Table iD table-game-automation system. The system combines a software-based table manager, an RFID (radio-frequency-identification) chip-scanner module, and an optical card-shuffling shoe. The latest RFID gaming chips operate in the 13.56-MHz frequency range and store more than 10 kbits. During play, chip readers at each position identify and record the bets that each player makes. The multideck card shuffler and integral optical shoe record every card dealt to each player, exposing game-play patterns. The Table iD system calculates player betting patterns, summarizes dealer activity, and records player decisions per hour (**Figure 2**). The system automatically updates information such as average bet and win/loss record without user interaction.

Figure 2 The Table iD system collects information from RFID chips and card readers to provide a snapshot of each player's gambling activity.

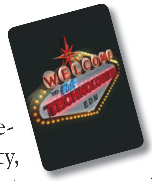
In a technology advancement that could revolutionize gaming devices, PureDepth Inc recently signed an agreement with International Game Technology to develop slot machines with 3-D displays. PureDepth's patented MLD (multilayer-display) technology uses two distinct screens to simulate depth (**Figure 3**). One of the two screens sits in front of the other, and a clear interstitial layer lies in between. When the system displays coordinated foreground and background images, they appear to be 3-D from any angle and without any loss of resolution. MLDs overcome issues of left- and right-eye convergence and restrictions in the viewing angle because they do not use a stereoscopic-3-D approach. The technology will allow slot-machine developers to replace the mechanical reels still present in many devices with a 3-D simulation. This all-digital approach also enables casinos to remotely change individual games to meet real-time demand.

Immersion also promises to upgrade the slot-machine- and video-poker-interaction experience with TouchSense technology, which provides a haptic response that synchronizes with sound and graphical-image changes. Active touchscreens can measure as much as 32 in. diagonally, and various responses depend on the ongoing action. For example, dragging a finger across displayed cards produces a click as each card is passed. Similarly, moving an on-screen slot lever produces a slight pulse as each rolling display comes to a stop. A small electromechanical actuator, like the vibrator in mobile phones, provides the physical movement; a tactile "effect" library controls this actuator. Immersion offers developers a TouchSense integration kit that includes the components, software, and guidelines for integrating the technology into production-ready designs.

Figure 3 With two distinct screens sitting one behind the other to simulate depth, PureDepth's MLD provides a realistic 3-D display.

ON-THE-RUN GAMBLING

The casino industry is revamping its networking infrastructure to prepare for the newest enterprise-level technologies: mobile and server-based gaming. The NGC (Nevada Gaming Commission) recently indicated that it will permit gambling on mobile devices within the casino and surrounding hotel grounds. Because the NGC is a leader in gaming trends, mobile gambling could easily become standardized worldwide. In a typical scenario, the casino would provide players with a mobile device that would connect wirelessly with the enterprise network. The player can then select various games and gamble while roaming in certain areas of the casino grounds. Obviously, this mobility creates a set of device- and network-security problems



for embedded-system designers. Devices must provide physical security, location awareness, and strong network authentication but still retain the size necessary for portability.

Server-based gaming consists of networks of individual gambling devices that are controlled from a central location. Each server can control networks at a single casino or multiple sites to provide software updates, schedule maintenance, or change the mix of games. Casino operators can target the game collection to the player demographics as well as experiment with new games for little cost. Server-based gaming also allows operators to coordinate bonus prizes among multiple groups of machines. The overall objective of server-based gaming is to reduce the cost of individual gaming devices by simplifying the internal computing requirements and eliminating device diversity. As with mobile gambling, server-based gaming creates security problems for system designers because data communications may travel outside the controlled casino environment.

Although casino gaming is a highly regulated and controlled industry, vendors are infusing new embedded technologies into the mix with each device generation. The size and growth rate of the industry continue to lure embedded-system designers and manufacturers for a share of the profits. The only potential risk to the industry's continued success is the possible legalization of Internet gambling, a scenario in which any hotel could transform itself into a casino using nothing more than a group of Internet-connected desktop computers. **EDN**

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+ For more on secure embedded systems, go to www.edn.com/article/CA434871.

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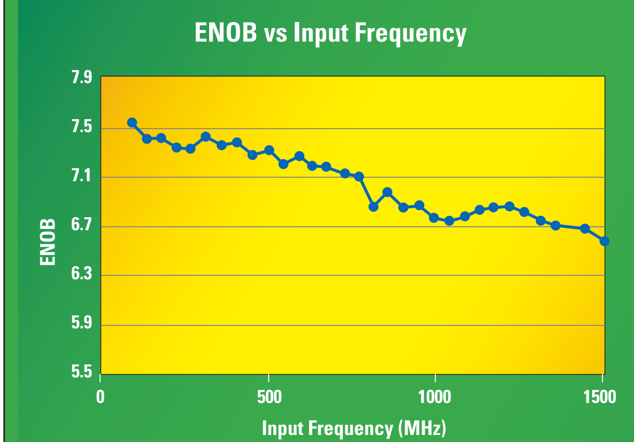

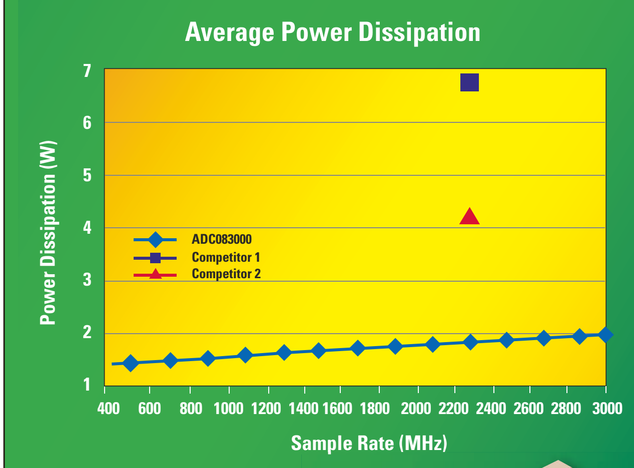

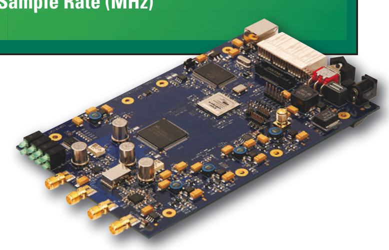

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HIGH-BRIGHTNESS LEDs usher in new applications and standards

AS HIGH-BRIGHTNESS LEDs INCREASE IN POWER, THEY WILL ENABLE NEW APPLICATIONS RANGING FROM ARCHITECTURAL LIGHTING TO MEDICAL PRODUCTS. ENERGY STAR LIGHTING STANDARDS ARE EVOLVING TO KEEP THE FOCUS ON TOTAL SYSTEM EFFICIENCY.

BY MARGERY CONNER • TECHNICAL EDITOR

The HB LED (high-brightness light-emitting diode) continues to increase in power: For example, Cree currently offers devices capable of producing 88 lm/W, and plans call for the emergence of 100-lm/W devices by year-end and 150-lm/W devices within five years. As individual components, HB LEDs are more efficient than incandescent or even fluorescent lights. However, at the system level, their advantages fade because you must factor in the power losses they entail, including ac/dc and dc/dc conversion and current regulation. In addition, the LED lighting fixture, or luminaire, introduces losses, and the LED assembly itself has thermal losses.

The US DOE (Department of Energy) recently finalized a new Energy Star specification for SSL (solid-state-lighting) luminaires so that system designers can use consistent comparison numbers for lighting sources and fixtures. Rather than looking at HB LEDs' luminous efficiency at the component level, the new specification looks at the overall luminaire efficacy.

Current-driven LEDs' light is directly proportional to forward current. The devices have the steep voltage-to-current curve you'd expect from a diode, in which even a small change in voltage results in a relatively large change in current and, therefore, brightness, making it important to control current rather than voltage (**Reference 1**). Many IC manufacturers, usually those in the power-controller business, have entered the LED-driver-current-regulator market. These vendors include Texas Instruments, National Semiconductor, Intersil, Cypress, Maxim, and Linear Technology.

In addition to the current regulator, the lighting system may have to include an ac/dc converter, or, for battery-powered systems, it may require a dc/dc boost converter. Overall, the system may lose 10 to 15% of the system power in conversion inefficiencies alone. In addition, the loss of as many as half the lumens in SSL can occur in the fixture itself due to reflection and lens losses.

The criteria for the Energy Star SSL specification will go into effect on Sept 30, 2008 (**Reference 2**). The specification has two parts. Category A covers parts that are available today. It states that a Category A-compliant recessed lighting fixture, or "downlight," must be 35 lm/W. Category B will cover the efficient SSL devices that will have emerged within three years. At that time, SSL will rival today's most efficient lighting systems using traditional light sources. For example, the best commonly available, high-performance T8 fluorescent-lamp and electronic-ballast systems currently produce approximately 100 lm/W. High-quality fixtures for these lamp-ballast systems are approximately 70% efficient, yielding 70-lm/W luminaire efficacy. Based on today's commercially available SSL technology, HB-LED luminaires cannot achieve the Category B level of minimum luminaire efficacy. However, LED technology is advancing rapidly and likely will meet Energy Star's Category B requirements. But LEDs have strengths in addition to efficiency and longevity, which make SSL worth pursuing even before further efficiencies are available. For example, dimming is difficult with fluorescent lighting, whereas it involves only a straightforward drop in current for LEDs. In addition, you can dynamically change the color of a room with LEDs by having arrays of cool- and warm-white LEDs. Expect that SSL will become a significant technology in home and industrial lighting in the next five years (**Reference 3**).

AT A GLANCE

- Overall lighting-system efficiency includes power conversion, current regulation, and the HB-LED (high-brightness-light-emitting-diode) fixture itself, not just the efficiency of the HB LED die.
- HB-LED-lighting systems are currently less efficient than the most efficient fluorescent lights. But the HB LEDs will catch up within three years.
- HB LEDs' additional advantages of pure light, ruggedness, and dimness control will help them move into new medical and lighting applications.

Most HB LEDs available today require dc voltage and current, so most of an SSL system comprises the conversion circuitry to convert from ac power to regulated dc power. However, Seoul Semiconductor recently introduced its Acriche HB LED, which runs directly off ac power (**Figure 1**). You use a single surface-mount resistor to set the input voltage, which can range from 100 to 110V ac and 220 to 230V ac. At the die level, the LED consists of layers of LED-semiconductor junctions. The diode junctions build up until the total forward voltage is relatively close to the ac voltage of 110 or 220V. The devices have two series of opposing LEDs. The first turns on and conducts over the positive-voltage half of the cycle, and the second conducts over the second half of the cycle, so that the LED emits light over the entire ac-voltage cycle. Running directly off the ac and simplifying the power-conversion circuitry increase system reliability and decrease design time. The Acriche HB LEDs come in two models: the AW3200 for 100/1110V and the AW3220 for 220/230V. Both versions provide 59 lm/W, which is lower than but comparable with the light that dc-powered HB LEDs produce.

Figure 1 The Acriche series of HB LEDs from Seoul Semiconductor runs directly off ac-line voltage with no power conversion or regulation. It provides 59 lm/W of light.

As energy costs continue to rise, lighting efficiency increases in importance. The US DOE estimates that lighting uses 20% of a building's electricity. However, in developing countries, which often lack reliable grid power, individuals can procure reliable nighttime lighting using solar-panel-based SSL to power batteries. The only other option is often kerosene lanterns, which are both dangerous and expensive (see **sidebar** "Solid-state lighting offers efficient relief for light-starved countries").

In addition to HB LEDs' obvious advantages of efficiency and lifetime, they have other strong points that make them attractive for nontraditional lighting applications. For example, their narrow light spectrum makes them well-suited for applications such as bilirubin lights. Bilirubin is a reddish-yellow organic compound derived from hemoglobin during the normal destruction of erythrocytes. An excess of bilirubin can cause hyperbilirubinemia, with symptoms including jaundice—yellowish discoloration of tissues, including the sclera, or "white of the eye," and bodily fluids. Although low levels of bilirubin are not usually a concern, large amounts can circulate to tissues in the brain and may cause seizures and brain damage in newborns. Fortunately, the condition usually responds to a phototherapeutic treatment because bilirubin absorbs blue light and breaks down into a water-soluble form that passes out of the body (**Figure 2**). The light is most effective in the narrow blue range of 458 to 462 nm. In the

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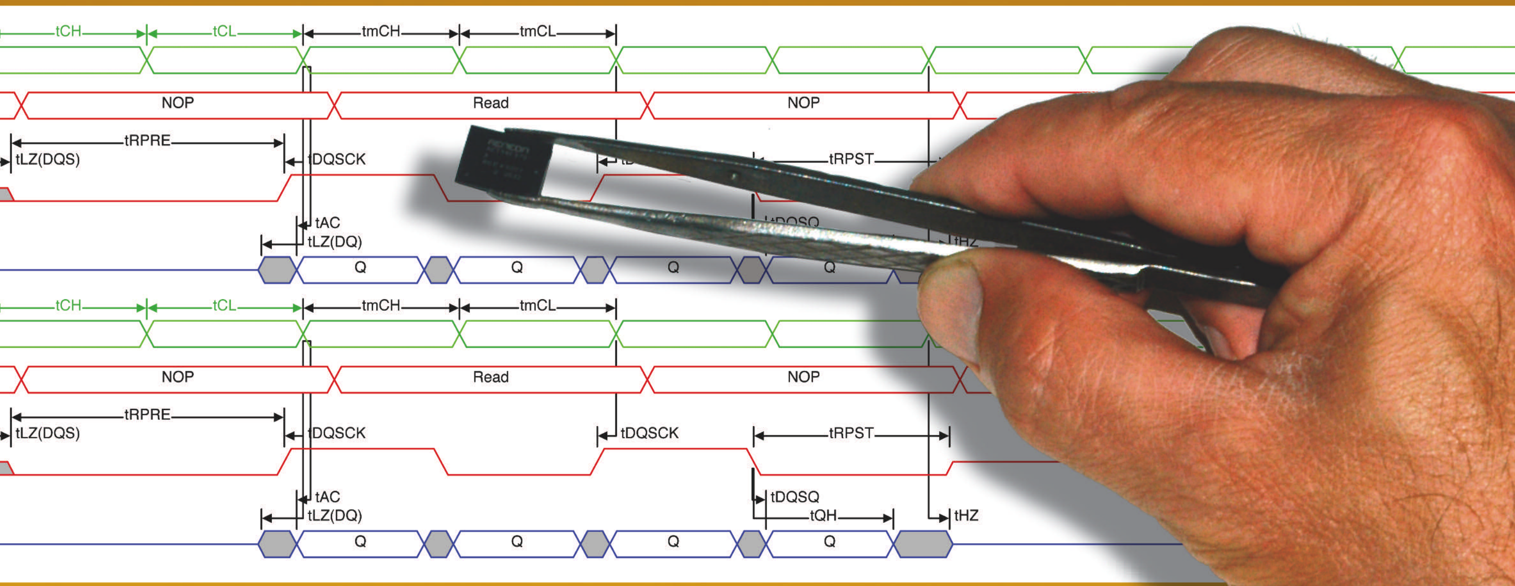

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past, therapeutic bilirubin lights have comprised custom-made blue fluorescent tubes and color filters. However, fluorescent lights have a relatively wide optical spectrum. Although the distribution centers on the desired wavelength, the spectral distribution has lobes on both sides, indicating light energy that is less effective at breaking down the bilirubin and resulting in a longer treatment period. Blue-LED bilirubin lights, in contrast, can target the correct frequency with almost no wasted light energy. In addition, LED-based bilirubin lights are mechanically stable, have greater longevity, and are cheaper than fluorescent devices. In the future, phototherapy will deliver light through

SOLID-STATE LIGHTING OFFERS EFFICIENT RELIEF FOR LIGHT-STARVED COUNTRIES

By Alan Li, Intersil

Some 1.6 billion people live in areas with abundant sunlight but little electricity. These people often must use expensive, heavily polluting, or hazardous methods for basic lighting. Now, the rapid evolution of LED (light-emitting-diode) technology promises to bring inexpensive, ubiquitous, off-grid solar lighting one step closer to reality.

One new-product concept comprises a laptop-sized, rooftop-mounted solar panel; heavy-gauge indoor wiring; and a lead-acid gel battery that powers eight 700-mA, highly efficient, 3.75V LEDs connected in series (Figure A). The Intersil ISL97801 HPLED (high-power-LED) driver powers this circuit. This driver has an integrated 3A switch, I/O short-circuit protection, and a configurable buck- or boost-driving architecture. In addition to PWM dimming, the ISL97801 can work with analog control that allows a rotary switch or an up/down-interface digital potentiometer to provide manual dimming, which further conserves energy.

Intersil has verified the circuit in the laboratory, where the circuit drives eight HPLEDs at 700 mA and 12V for 18W of lighting. Efficiency reaches 91 and 88% at 700- and 100-mA output current, respectively. In general, LED brightness can degrade by 20% from 25 to 100°C; therefore, thermal management is crucial. To alleviate thermal problems, you must mount the LEDs on a metal-clad PCB (printed-circuit board) and use adequate heat sinking. If cost allows, you can parallel multiple strings of LEDs with some logic design to cycle the individual PWM signals, thereby reducing the LEDs' power dissipation and keeping the LEDs' MTBF (mean time between failures) in check. Assuming that the application runs on a small-form-factor, 12V battery that you charge from the solar panels, this 18W LED light can operate for as long as a few hours, which is adequately bright with reasonable operating time for the people who need it most.

AUTHOR'S BIOGRAPHY

Alan Li is a staff applications engineer for consumer-power products at Intersil (Milpitas, CA).

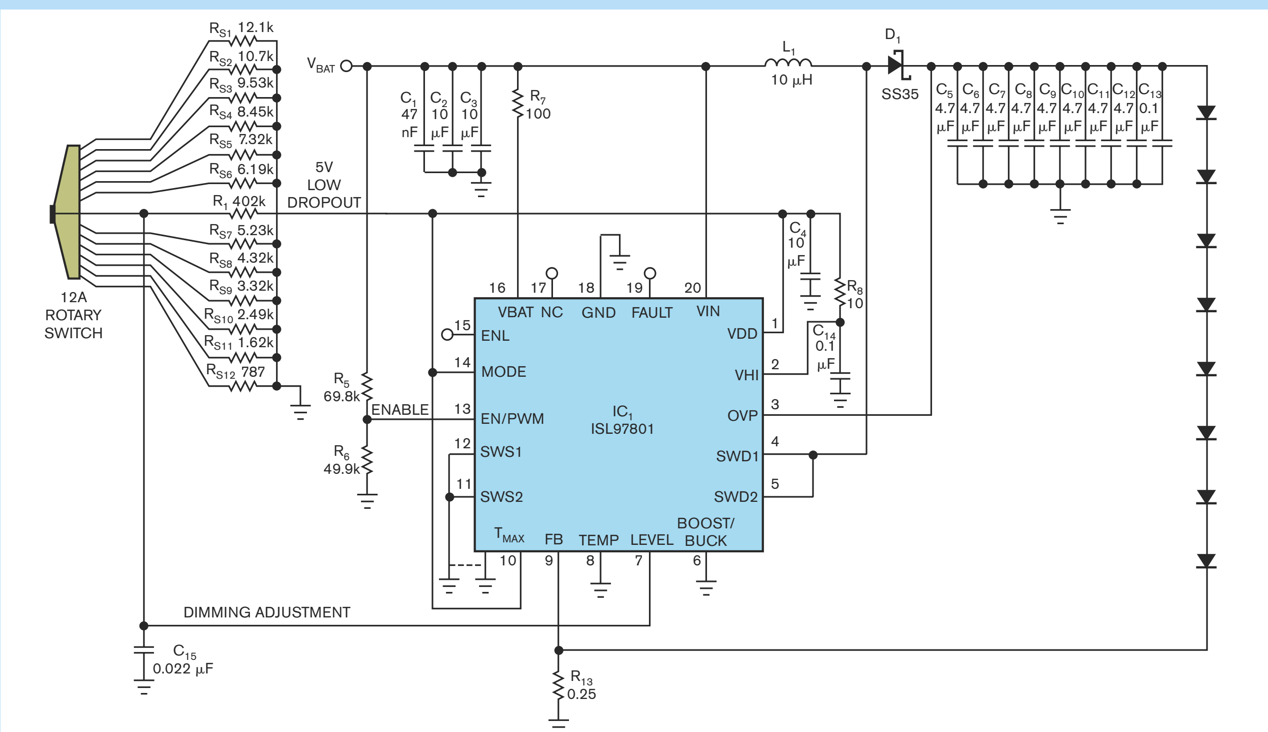

Figure A In areas lacking a reliable power grid, a solar panel charging a battery may be the only safe, cost-effective alternative to a kerosene lamp. This circuit allows for manual dimming to further conserve the battery power.

"light cloths," which can even more efficiently deliver the treatment than a light box can.

A significant difference between HB LEDs and traditional incandescent or fluorescent lighting is that HB LEDs come in a greater variety of packages. Given this fact, you might expect standards in packaging to be on the way, but that scenario won't happen for at least another five years, predicts Mark McClear, director of business development at Cree. "Every time we make [HB LEDs] brighter, cheaper, and more efficient, we enable more applications. We're on a steep curve, doing all three at once, and an important component is the package. We have one type of package; our competitor might have another … not to confound the customer but because [one type of package] gets more light out, and light is valuable," he says.

The rapid advancements in HB LEDs bring up a concern for eye safety, which these devices' designers often overlook, according to Cary Eskow, director of Avnet's LightSpeed SSL and LED business unit. "The rapid advancement of HB LEDs may have outpaced safe and careful design," he says. The most obvious hazard to the eye is from the intensity of the light: Some HB LEDs can deliver as much as 150 lm from a small die. In some circumstances, this amount of light can damage the eye through either photothermal or photochemical processes.

Figure 2 Blue LEDs, like those in this bassinet system from Natus Medical, target the most effective blue-light spectrum of 458 to 462 nm for the treatment of hyperbilirubinemia in infants.

Our human blink response offers little protection to these kinds of damage because the response doesn't occur at the ends of the visual spectrum where the damage occurs.

Photothermal injury occurs when the temperature of the retina increases by approximately 10°C. Because of the way heat flows in the retina, this damage directly relates to spot size; it increases as the size of the focused spot decreases, much as the pressure of a pinpoint on your skin is more painful than the same pressure applied with a finger tip. This type of damage tends to dominate as the wavelength lengthens from approximately 550 nm (green) through yellow, orange, and red to IR (infrared).

Intense violet and blue light, on the other hand, can cause photochemical injury to the eye. Blue light and short wavelengths can be 1000 times more dangerous than IR radiation. Again, the blink response is of no help in this situation. Eskow strongly suggests that designers keep safety as a primary design consideration for HB LEDs as the devices make their way into an ever-increasing variety of applications, from lighting to medical and even to toys. EDN

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You can reach Technical Editor Margery Conner at 1-805-461-8242 and mconner@reedbusiness.com.

Rarely Asked Questions

Strange but true stories from the call logs of Analog Devices

What's your amplifier's febricity due to electricity?

(or Accurate temperature measurement...it's all a matter of degree)

Q. What's the best way to measure the die temperature of a small package op amp or similar device?

A. There are a few ways to get at the junction or die temperature of a device, some better than others. The first uses the classic junction temperature equation shown below.

$$T_J = T_A + P_D\theta_{JA}$$

The junction temperature, T_J, is equal to the ambient temperature, T_A, plus the power dissipated by the device, P_D, multiplied by device's thermal resistance, θ_{JA}. In my experience, this calculation is fairly conservative, and yields junction temperatures approximately 30% to 50% higher than the actual junction temperature, depending on the manufacturer.

Another method is to use a thermocouple, which provides good results for larger packages, but has problems when trying to use it on smaller packages. For example, small packages such as the SC70 or SOT do not provide much area to attach a thermocouple. Even if you could attach one to the package, the thermal mass of a thermocouple actually acts as a heat sink, robbing the device of some of its heat and giving an erroneous result.

A third method uses an infrared (IR) camera. This method accurately measures the outside case temperature of a package and gives a good indication of the die temperature on smaller packages. In most cases, the difference between case and junction temperature is only a few degrees. A drawback to this method is IR cameras tend to be rather pricey, costing tens of thousands of dollars.

The last option is the least expensive and most accurate way to measure die temperature by using an on-chip diode as a

temperature sensor. From semiconductor physics, we recall that with a constant current applied to a PN junction, the junction voltage will change approximately -1 to -2 mV/°C over temperature. Characterizing the diode voltage over temperature enables the user to measure the diode voltage and readily determine the die temperature. The trick is finding a diode that can be used as the sensor on the op amp. Most op amps do not provide a dedicated diode for such purposes, but you can re-task existing diodes to perform this task. Most, if not all, of today's amplifiers have built in electrostatic discharge (ESD) protection diodes as well as input protection diodes. ESD diodes are connected from op amp inputs and output to the supply rails. Therefore it is possible to access these diodes and use them as outlined to measure the die temperature of the op amp. For a more detailed explanation of how to accomplish this measurement, please see "ESD Diode Doubles as Temperature Sensor" by clicking on or entering the link to the Analog Devices' RAQ page listed below.

To learn more about Die Temperature

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Contributing Writer John Ardizzoni is an Application Engineer at Analog Devices in the High Speed Amplifier Group. John has been with Analog Devices for 5 years, he received his BSEE from Merrimack College in 1988 and has over 27 years experience in the electronics industry.

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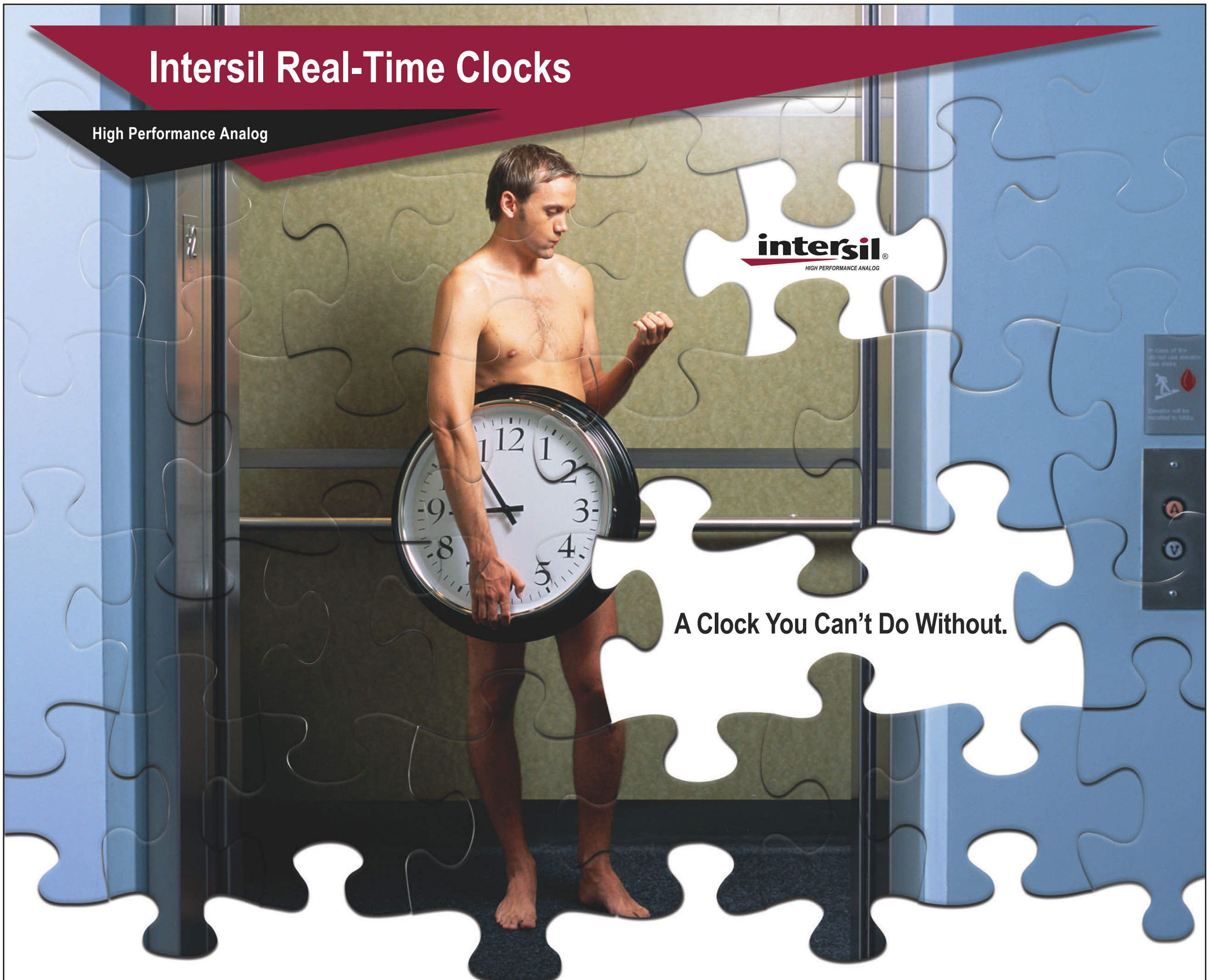

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Common mistakes in electronic design

DESIGNING FOR RELIABILITY PLAYS A CRITICAL ROLE IN THE ULTIMATE SUCCESS OR FAILURE OF YOUR PRODUCT AND HELPS YOU AVOID COMMON DESIGN MISTAKES.

Most executives responsible for managing product performance or warranty returns will tell you that the most common headaches in manufacturing come from suppliers or manufacturers. For example, a new, cheaper supplier used the wrong material, or a process went haywire for a day or two. These issues, which manufacturers often describe as "random" failures, are the primary drivers for the cost of quality. So, who cares about design? Well, you should. Designing for reliability plays a critical role in the ultimate success or failure of your product. Design plays an integral role in the manufacturability of your product. The easier the design is to manufacture, the greater its tolerance to the standard variation in all manufacturing processes. Design also plays an important role in component reliability, because designs that avoid the use of extended-value components and minimize the application of thermal and electrical stresses reduce the risk that marginal components will induce product failure.

You cannot overlook the degree of risk you incur by ignoring design-for-reliability issues. Component or manufacturing problems, as prevalent as they are, tend to affect a small percentage of products. For some manufacturers, however, a small percentage translates to costs of hundreds of millions of dollars. Design issues can kill every unit your customer uses. So, what are some of the most common mistakes in electronic design?

FLEX CRACKING

Flex cracking is one mistake. It most commonly occurs when the PCB (printed-circuit board) under a ceramic-chip capacitor bends excessively. The brittle ceramic-chip capacitor cannot respond to the strain and cracks. These flex events can occur during depaneling, testing, connector or card insertion, or attachment or from accidental dropping of the part or mechanical shock. Your approach to this problem depends on your cost constraints, design constraints, and the degree of acceptable risk. For example, you could use a shorter capacitor if you can find a similar capacitance and voltage in a smaller case. Alternatively, you could use a narrower bond pad, rotate the capacitor 90°, or move the capacitor 45 to 60 mil away from the flex point. Another approach is to use an open-mode capacitor or one with flexible terminations.

In one case study, an industrial-controls company had to maintain tight spacing between an attachment point, which the system was using as ground, and a large chip capacitor to ensure adequate electrical performance. Capacitors having flexible terminations and with similar electrical parameters were unavailable. The high density of the system prevented the designers from rotating the capacitor. The solution was to reduce the bond-pad width, measuring flexure during attachment and modifying torque limitations to ensure a low risk the capacitor's cracking.

YOU CANNOT OVERLOOK THE DEGREE OF RISK YOU INCUR BY IGNORING DESIGN-FOR-RELIABILITY ISSUES.

A similar issue arises with BGAs (ball-grid arrays). These leadless devices have limited compliance, and, if you place them near a flex point, such as a press-fit connector or an attachment, for example, they can experience cracking in the laminate, solder ball, or PCB. These devices offer fewer design approaches to designers than ceramic capacitors do. These approaches primarily consist of moving the BGA, using a thicker board, or adding ribs to the board for greater rigidity. BGA flex cracking has started to eclipse ceramic-chip-capacitor failures as more companies switch to the more rigid, brittle, and lead-free SAC305 tin-silver-copper alloy.

JOINT WEAR AND CUSTOM CONNECTIONS

Some of the most extensive design-for-reliability efforts focus on avoiding the wearing out of solder joints. The best approach to this problem is to assess robustness during the design phase by deriving predictions based on first- and second-order models or on FEA (finite-element analysis). You can also derive accelerated life tests from models that KC Norris and AH Landzberg developed at IBM in 1969 (**Reference 1**). However, the product-qualification segment of the design cycle often occurs too late to catch errors. With these straightforward tools available, why do solder joints sometimes wear out? Several drivers are responsible. Some, including failure to perform reliability modeling and failure to perform accelerated life testing, are obvious. Three reasons stand out, however, as the most common: the use of adjacent heat sources, excessive power dissipation, and the use of custom solder joints.

PCB designers think in only two dimensions. However, in certain applications, heat sources separate from the electronics can be hot enough, close enough, or both to cause a serious temperature rise on localized components. A designer may forget about these heat sources during modeling and may not install them during testing only to find that they cause solder joints to wear out after months or years in the field.

THE MOST COMMON COMPONENTS TO WEAR OUT ARE CUSTOM SOLDER INTERCONNECTIONS.

Excessive power dissipation becomes a problem in two ways. First, if a designer pays too little attention to components with high power dissipation during reliability modeling or fails to exercise them during testing, then the dissipated heat can accelerate solder-joint fatigue through elevated temperature or a change in temperature effects. These problems typically arise for components off the board, such as motors, generators, or high-current bus bars. Second, a designer might choose the wrong component or mislabel a component from the bill of materials. This error can be especially deleterious for chip resistors: Substituting a ⅛W resistor for a ¼W resistor can sufficiently elevate temperatures to induce solder joints to wear out.

JEDEC (Joint Electron Device Engineering Council, now the JEDEC Solid State Technology Association) is the primary driver of industry-standard test requirements for second-level packaging. Because of these standards, most component designs are sufficiently robust for all but the most severe environments, such as automotive-under-the-hood, satellite, and similar applications. Therefore, the most common components to wear out are custom solder interconnections. Designers often use these joints to mechanically or thermally connect components or the PCB to housing or other mechanical support structures. Just as with outside heat sources, designers sometimes fail to test these custom solder interconnections with the PCB assembly, meaning that they sometimes overlook this design issue during product qualification. A low-cost solution is to keep the solder joints at temperatures lower than 75 to 80°C, especially if the temperature of the components will vary over time. A better approach is to use physics-of-failure models to understand risks before finalizing your design.

ELECTROLYTIC CAPACITORS

Although designers love electrolytic capacitors because of their high capacitance, they hate them because they fail over time. This love/hate relationship has led to a range of methods for derating and predicting lifetime. What are the best

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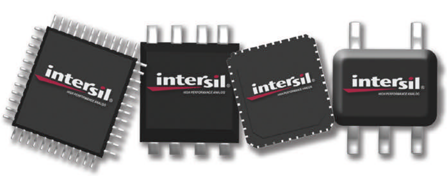

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approaches? It all depends on whether you are derating voltage, ripple current, or temperature. With voltage derating, remember that electrolytic capacitors work best when you apply voltage to them. With no voltage, they have no dielectric and no capacitance. Although electrolytic-capacitor manufacturers have over the last five years improved these capacitors' low-voltage performance, try to avoid voltages below 25% of the rated voltage. At the other end of the spectrum, designers create capacitors by applying voltages 150 to 200% greater than the rated voltage. In addition, applied voltage tends to have minimal influence on lifetime. Because of this fact, the derating guidelines specify a maximum applied voltage of 80 to 90% of rated voltage, although some manufacturers apply 90 to 100% of rated voltage.

Once you target a desired life cycle for your design, you can decide on the appropriate temperature derating. The industry-accepted equation is a doubling of life for every 10°C drop in temperature. Although some questions exist concerning the accuracy of this model, designers must be aware of three nuances. The first is that this life equation is relatively conservative—at least for reputable capacitor manufacturers. Vendors often define "lifetime" as 1 or 0.1% of failed parts, as opposed to the more standard MTTF (mean time to failure), which might yield a 63% failure rate. If your design lies between these extremes in desired lifetime, then it should be OK. Second, few applications experience constant temperatures. Users turn computers on and off, the sun rises and sets, and other similar temperature-affecting conditions occur. Make sure to incorporate variations in temperature into any lifetime calculation. Finally, all bets are off if there is elevated temperature due to an adjacent component, such as a resistor or a MOSFET. Some indications show that a highly localized temperature increase more quickly induces failure than the industry model predicts. Keep hot components away from electrolytics.

Ripple current on electrolytic capacitors is an odd electrical parameter. Designers tend to ignore or forget it in most bill-of-materials calculations. Remember that "equivalent" capacitors are not equivalent when it comes to ripple-current ratings. And manufacturers can "uprate" ripple current. Some companies allow applied ripple current to be 150 to 200% of rated ripple current. They achieve this flexibility because ripple current primarily increases capacitor temperature, and vendors often specify capacitor lifetime at rated temperature and rated ripple current. The lower the temperature at which the design can operate, the higher the uprating margin on the ripple current.

Designing for reliability plays a critical role in the ultimate success of a product and the company's bottom line. You must assess the evolving design, find potential weaknesses, and solve problems before they escalate. Recognizing and addressing potential problems will prevent manufacturing and supplier-quality issues later in the process—and will let you sleep better at night. **EDN**

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AUTHOR'S BIOGRAPHY

Craig Hillman, PhD, is chief executive officer and managing partner of DFR Solutions (www.dfrsolutions.com). He has a postdoctoral fellowship from Cambridge University, a doctorate from the University of California, and a bachelor's degree from Carnegie Mellon University (Pittsburgh).

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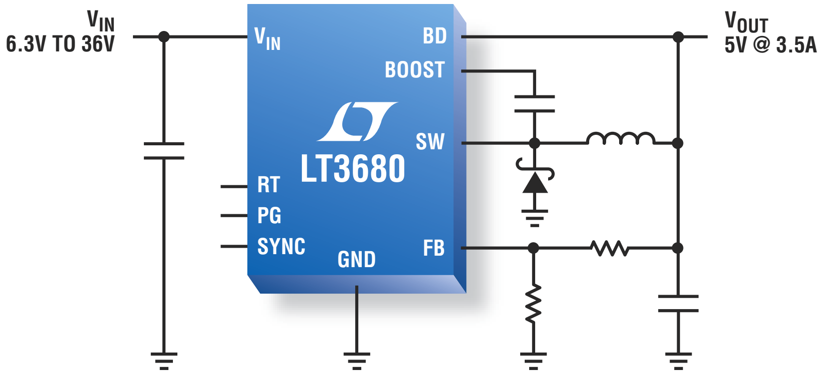

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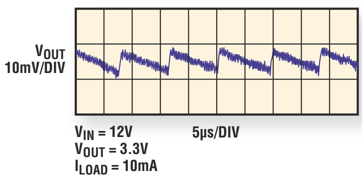
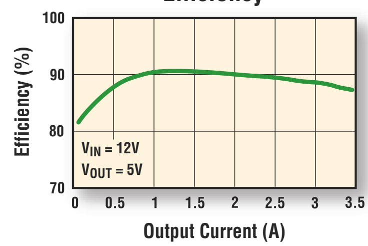


Efficiency



2.4MHz, 3.5A I_{OUT}, 75µA I_Q, 10mV_{P-P} Ripple, 3mm x 3mm DFN

Linear's growing family of 36V input-capable buck converters has the performance and features demanded by automotive, industrial and medical applications. These devices have programmable and synchronizable high frequency operation to keep externals small and high efficiency conversion to minimize thermal issues. Many devices feature micropower operation, suitable for always-on applications. With very low output ripple from no-load to full load, these converters reduce noise and provide best-in-class output currents in compact packages.

Selected 36V+ Buck Converters

Part No.	V_{IN} Range	I_{OUT} (A)	Frequency	I_Q	Package (mm)
LT®3470	4V to 40V	0.2	Hysteretic Mode	26µA	2 x 3 DFN-8, ThinSOT™
LT3502/A	3V to 40V	0.5	1.1MHz/2.2MHz	1.5mA	2 x 2 DFN-8
LT3505	3.6V to 36V, 40V Max.	1.4	300kHz to 3MHz	2mA	2 x 3 DFN-8, MSOP-8E
LT3681	3.6V to 34V, 36V Max.	2.0	300kHz to 2.8MHz	50µA	3 x 4 DFN-14
LT3684	3.6V to 34V, 36V Max.	2.0	300kHz to 2.8MHz	0.85mA	3 x 3 DFN-10, MSOP-10E
LT3481	3.6V to 34V, 36V Max.	2.0	300kHz to 2.8MHz	50µA	3 x 3 DFN-10, MSOP-10E
LT3685	3.6V to 38V, 60V Max.	2.0	200kHz to 2.4MHz	0.85mA	3 x 3 DFN-10, MSOP-10E
LT3480	3.6V to 38V, 60V Max.	2.0	200kHz to 2.4MHz	70µA	3 x 3 DFN-10, MSOP-10E
LT3680	3.6V to 36V	3.5	200kHz to 2.4MHz	75µA	3 x 3 DFN-10, MSOP-10E
LT3508	3.7V to 36V, 40V Max.	1.4 x 2	250kHz to 2.5MHz	4.6mA	4 x 4 QFN-24, TSSOP-16E

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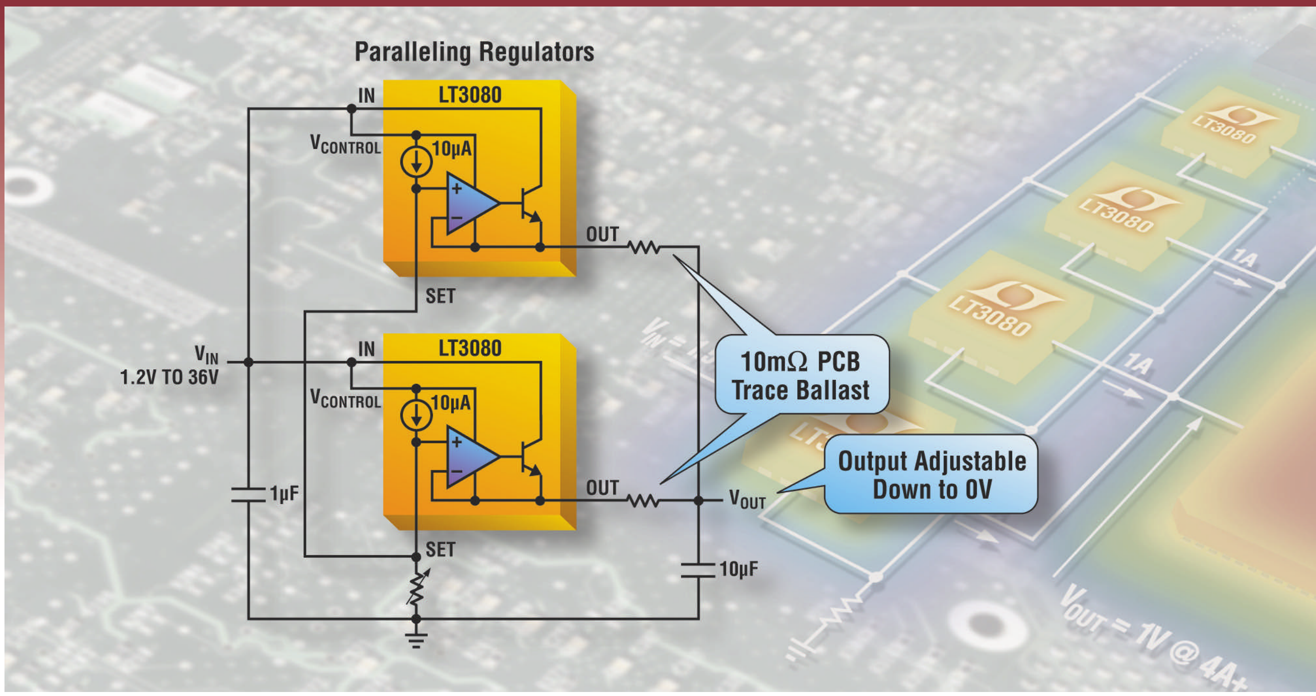


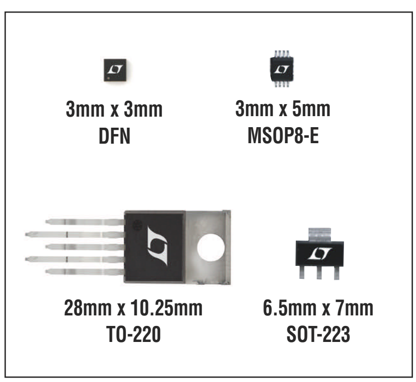
Easily Paralleled: Get High Output Current Without Hot Spots!

The LT®3080 is a new generation of linear regulator compatible with modern surface mount circuit design. Its input voltage is specified up to 36V, providing good margin for transients in many applications. Also, the output of the LT3080 is adjustable with a single resistor down to 0V and devices are easily paralleled for higher output current or to spread PCB heat. The input to output dropout is 1.3V when used as a three terminal regulator. The collector of the power device can be connected separately from the control circuitry to enable dropout voltages of only 300mV, ensuring high efficiency conversion.

Features

- Outputs Can Be Paralleled
- Output Current: 1.1A
- Low Dropout Voltage: 300mV @ 1.1A
- Low Noise: 40μV_{RMS} Wideband (100kHz)
- Stable 10μA Current Source Reference
- Single Resistor Programs V_{OUT}
- V_{OUT} Down to 0V
- V_{IN} Up to 36V (40V Abs Max.)

LT3080 Packaging Options



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LINEAR TECHNOLOGY DESIGN NOTES

Highly Integrated Quad 16-Bit, SoftSpan™, Voltage Output DAC for Industrial and Control Applications

Design Note 431

Mark Thoren

Introduction

Digital-to-analog converters (DACs) are prevalent in industrial control and automated test applications. General-purpose automated test equipment often requires many channels of precisely controlled voltages that span several voltage ranges. The LTC2704 is a highly integrated 16-bit, 4-channel DAC for high-end applications. It has a wide range of features designed to increase performance and simplify design.

Unprecedented Integration

The LTC2704 provides true 16-bit performance over six software selectable ranges: 0V to 5V, 0V to 10V, –2.5V to 2.5V, –5V to 5V, –10V to 10V and –2.5V to 7.5V. Four single-range voltage outputs would normally require four current-output DACs, two reference amplifiers and four output amplifiers—seven packages if dual amplifiers are used. Implementing multiple ranges discretely is prohibitive. Design Note 337 explains the difficulty in implementing multiple ranges, including the cost of precision-matched resistors and the performance limitations of analog switches. Control is also complicated, requiring extra digital lines for each DAC and for range control. The LTC2704 integrates all of these functions into a single package with no compromises, and all functions are controlled via an easy-to-use 4-wire SPI bus.

Ease of Use

The LTC2704 provides many features to aid system design. The voltage output and feedback are separated, allowing external current booster stages to be added with no loss in accuracy. The C1A, C1B, C1C and C1D pins allow external frequency compensation capacitors to be used, either to allow capacitive loads to be directly driven by the LTC2704's outputs, or to compensate slow booster stages. The V_{OS} pins provide a convenient way to add an offset to the output voltage. The gain from the V_{OS} pin to the output is –0.01, –0.02 or –0.04, depending on the selected range. While this seems like a simple function to perform externally, implementing it inside the LTC2704 eliminates concerns about matching the temperature coefficient of the external offsetting resistor to the internal resistors.

Example Circuits

Figure 1 shows several ways to use the LTC2704's features. The offset pin of DAC A is driven by an LTC2601 DAC through an LTC1991 amplifier. This provides ±50mV of "system offset" adjustment in the ±2.5V and 0V to 5V ranges, ±100mV of adjustment in the –2.5V to 7.5V, ±5V, and 0V to 10V ranges and ±200mV of adjustment in the ±10V range. The C1 pin is left open for fast settling. An LTC2604 quad DAC can be used to drive all four offset pins, and can share the same SPI bus as the LTC2704.

DAC B drives a 1µF capacitor through a 1Ω resistor, with 2200pF of additional compensation. This is useful for applications where the load has high frequency transients, such as driving the reference pin of an ADC.

DAC C drives an LT3080 low dropout regulator, providing up to 1A of output current. This can be used to power test circuitry directly. Global feedback removes the offset of the regulator, maintaining accuracy at the output.

DAC D is boosted by an LT1970 power op amp, providing 500mA of drive current, either sourcing or sinking. Once again, global feedback preserves DC accuracy.

Conclusion

The LTC2704 provides a highly integrated solution for generating multiple precision voltages. It saves design time, board space and cost compared to imple-mentations using separate DACs and amplifiers.

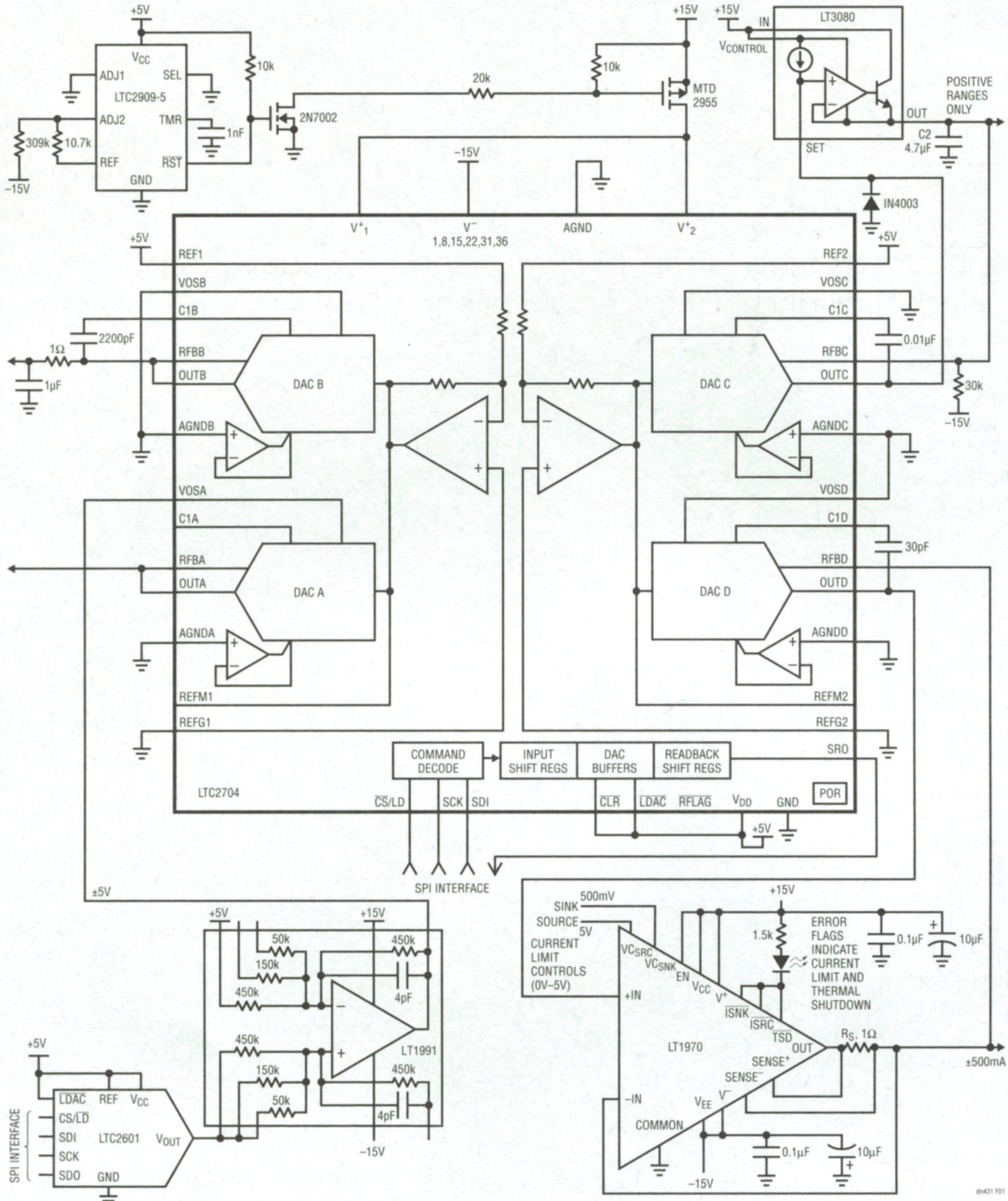

Figure 1. LTC2704 Application Examples

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Actively driven ferrite core inductively cancels common-mode voltage

W Stephen Woodward, Chapel Hill, NC

An earlier Design Idea illustrated one approach to that traditional headache for the analog designer: the dreaded ground loop (**Reference 1**). That Design Idea described a simple and efficient multichannel circuit. But it's an asymmetrical CMV (common-mode-voltage) approach in that it works only at the receiving end of a cable. It therefore applies only to signal inputs and does nothing for outputs. However, in cases in which CMV consists of purely ac noise, a different CMV-remediation method—active inductive cancellation—works bidirectionally and therefore cancels CMV-error components in both input and output signals.

Engineers have for many years used passive-CMV inductive cancellation (**Figure 1**). Sometimes called a "humbucker transformer" because the power mains' 60-Hz "hum" is often a dominant CMV component, the CMV inductor comprises a primary winding in series with the ground connection between the signal source (1) and the destination (2) and a secondary winding with a 1-to-1 turns ratio.

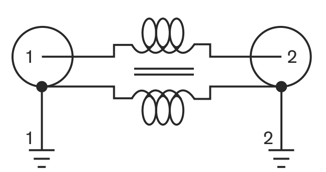

Figure 1 In the classic humbucker configuration, the CMV inductor comprises a primary winding in series with the ground connection between a signal source (1) and a destination (2) and a secondary winding with a 1-to-1 turns ratio.

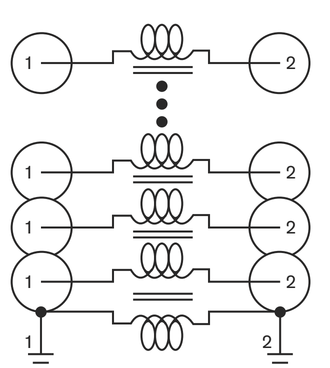

Figure 2 You can extend the passive approach in Figure 1 to multiple channels at the expense of a large magnetic component.

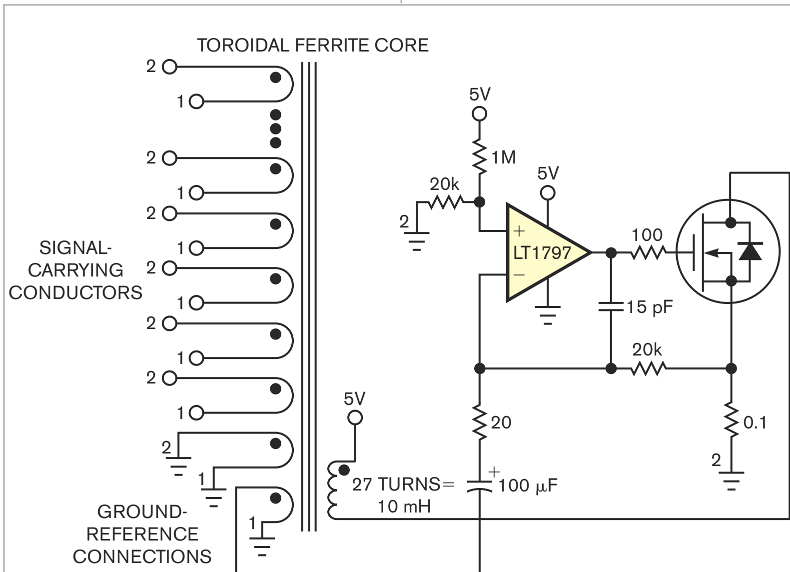

Figure 3 Using the active drive of the CMV core, you can achieve CMV reduction of 40-dB or more cancellation, extending from tens to millions of hertz.

DIs Inside

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The principle of the CMV transformer relies on magnetic coupling between the primary and the secondary, such that any voltage that appears across the primary induces an equal and opposite voltage in the secondary, thus canceling it. You can easily extend the principle to multiple signal channels simply by adding more secondary windings—one secondary for each channel (**Figure 2**).

However, the Achilles' heel of the CMV transformer is the fact that the decibels of cancellation fall off at the low-frequency end of the noise spectrum. This situation occurs because noise cancellation depends on the fact that the inductive reactance of the windings must be much larger than the impedance of the cable. Hundreds of millihenries of inductance are necessary to satisfy this criterion for frequencies as low as 60 Hz. For multichannel applications requiring cancellation for frequencies as low as 60 Hz, this fact translates to lots of copper, core, bulk, and weight. However, if you don't mind if your designs consume a little power, then a work-around exists: actively driving the CMV core.

In **Figure 3**, the power amplifier comprising the LT1797 high-frequency op amp and MOSFET forces the driven core to precisely cancel CMV as sensed in the ground-reference connection. The result is such a large multiplication of the apparent winding inductance that you can reduce the "windings" to a simple single pass-through of the toroid core. In other words, you need to thread a multiconductor-signal cable only once through the "hole in the doughnut" to achieve CMV of 40-dB or more cancellation, extending from tens to millions of hertz. EDN

REFERENCE

1 Woodward, W Stephen, "Amplifier cancels common-mode voltage," *EDN*, May 10, 2007, pg 82, www.edn.com/article/CA6437955.

Improved optocoupler circuits reduce current draw, resist LED aging

Peter Demchenko, Vilnius, Lithuania

It seems deceptively simple to establish galvanic isolation with the help of optocouplers between circuits that operate at different ground potentials. Optocouplers draw power from the isolated circuit, and switching can be relatively slow and uncertain because of LED aging. Substitutes without optocouplers, such as the ADUM12xx from Analog Devices (www.analog.com) or ISO72x from Texas Instruments (www.ti.com), are available. This Design Idea describes a method of improving the simple optocoupler.

Figure 1 shows two popular designs of 0V synchronization with ac. An attempt to reduce power draw from the isolated circuit by decreasing the optocoupler's LED current with a corresponding increase of the optocoupler's load resistor yields slower and more uncertain switching. To achieve faster and sharper switching, you would have to sacrifice power efficiency; however, the benefit of this sacrifice is limited because of the inverse relationship between power efficiency and the ac-voltage magnitude.

An optocoupler's LED emits almost continuously during nearly all ac cycles exceeding the nominal, leading to low power efficiency and relatively fast aging of the optocoupler. One more drawback is excessively large and nearly uncontrollable zero-crossing error; the circuit's sensitivity threshold depends on the parameters of the optocoupler. The designs in **Figure 1** do not provide an ideal approach. With respect to efficiency, they can draw 5 to 100 mA, depending on the optocoupler's current-transfer ratio and the ac amplitude.

The design in **Figure 2** overcomes the problems of excessive power consumption, uncertain switching, and LED aging. It lends itself well to wide-ac-range applications. Compared with the circuit in **Figure 1**, **Figure 2**'s LED emits only in close vicinity of the zero-crossing point and receives its power from the previously charged capacitor, so you can reduce the average current draw by a factor of 10 to 100. The design also provides faster, more

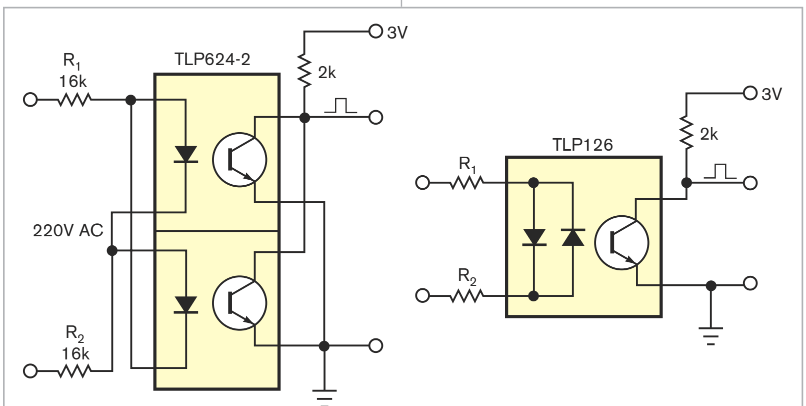
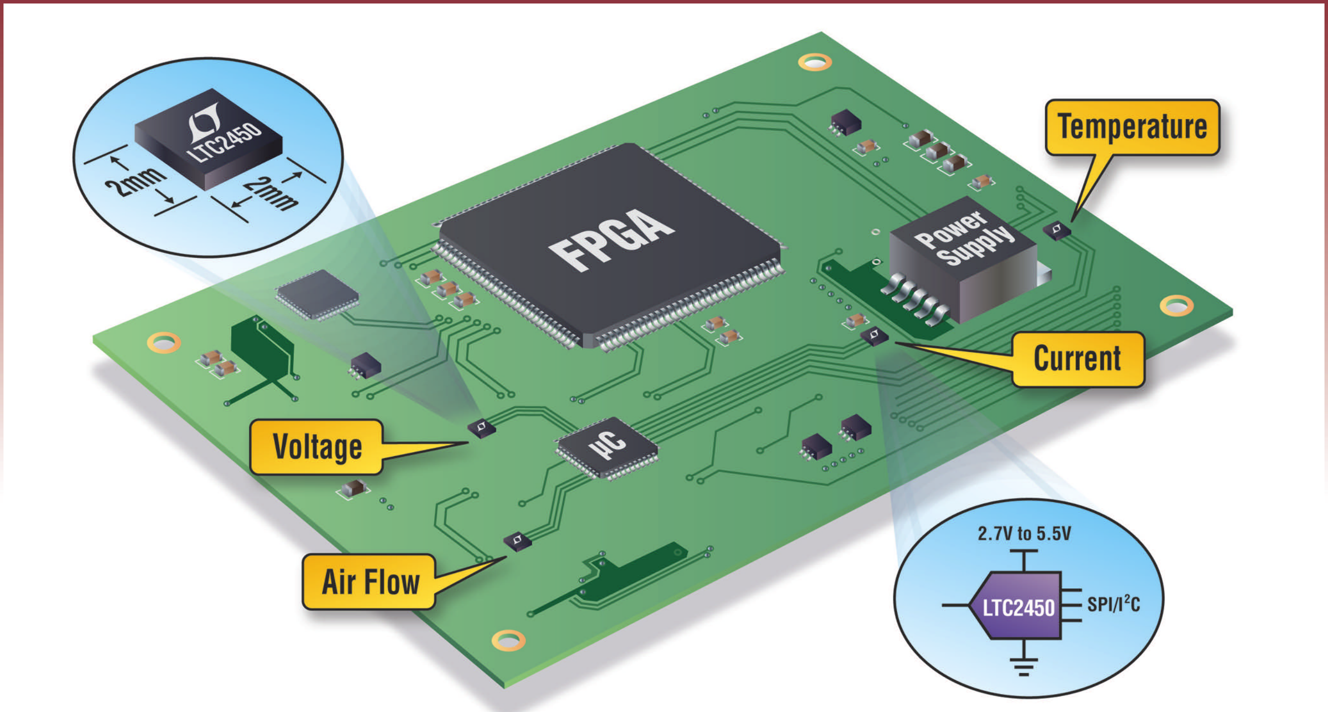


Figure 1 Establishing galvanic isolation with the help of optocouplers between circuits that operate at different ground potentials looks deceptively simple. Optocouplers draw power from the isolated circuit, and switching can be relatively slow and uncertain because of LED aging.

Ultra-Tiny 16-Bit ADC



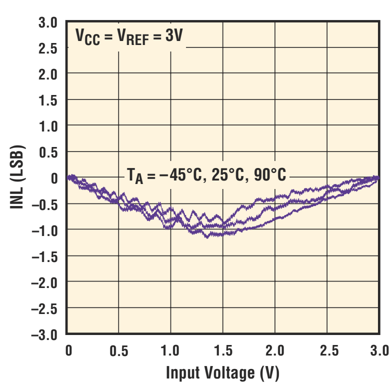
Easy-to-Use ADC Features 16-Bit Performance at a 12-Bit Price

The LTC®2450 packs a mighty punch with 16-bits of analog sampling performance and an internal oscillator in just $4mm^2$. The LTC2450 sets a new standard for monitoring system environments in compact, power-conscious applications. Thanks to the flexibility of either I^2C or SPI interface, you can measure voltage, current, temperature, airflow or other general purpose analog signals without compromising performance.

Features

- ±2LSB INL, 16-Bits No Missing Codes
- Ultra-Tiny 6-Lead, 2mm x 2mm DFN Package
- Low Power: 350μA I_Q at 60 Conversions Per Second, 0.5μA Sleep Current
- 60Hz (LTC2450-1) & 30Hz (LTC2450) Output Rate Versions
- SPI or I^2C Versions, Single-Ended or Differential Versions
- Internal Oscillator – No External Components Required

16-Bit Integral Nonlinearity Error



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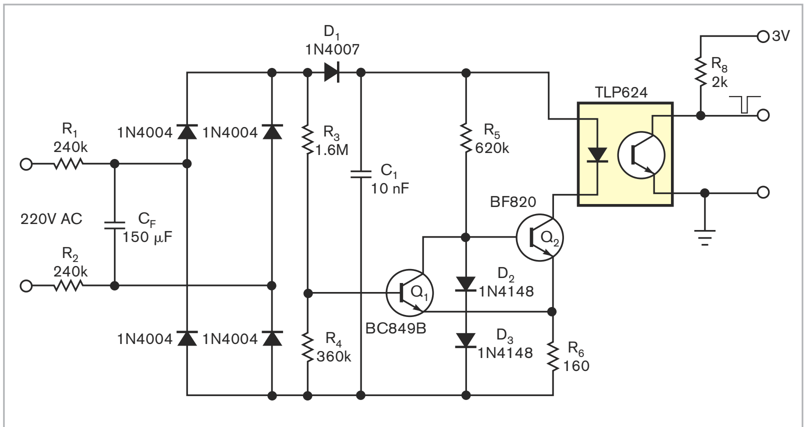

Figure 2 This circuit overcomes problems of excessive power consumption, uncertain switching, and LED aging.

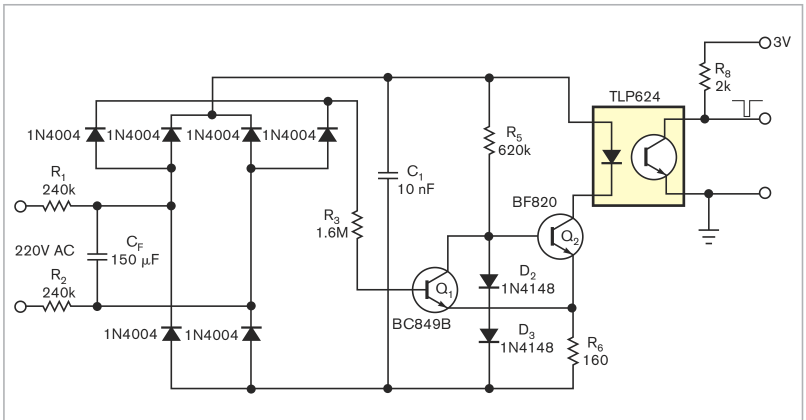

Figure 3 Another variant of this design shows how to manage without a requirement for minimal reverse current in D_1.

deterministic, and sharper switching. What's more, you can expect slower LED aging. Resistors R_1 and R_2 in **Figure 1** dissipate no less than 1.5W of power as waste heat, so changing them to 0.1W devices allows placement of additional components on the same board area (**Figure 2**).

The circuit's main components comprise amplitude detector D_1, capacitor C_1, and Schmitt trigger Q_1/Q_2 to control a current through the optocoupler's LED. D_2 and D_3 stabilize the base voltage of Q_2 and, hence, its collector current, which activates the optocoupler. Capacitor C_1 charges up through R_1, R_2, and D_1.

During nearly all of the ac-cycle time, except in the vicinity of the zero-crossing point, Q_1 is on, and Q_2 is off. Then, approaching the zero-crossing point, the state of Schmitt trigger Q_1 and Q_2 changes, and Q_2 discharges capacitor C_1 with the constant current, because the circuit comprising Q_2, D_2, D_3, R_5, and R_6 stabilizes current as $I=(2\times V_D-V_{BE2})/R_6$, where V_D is the voltage drop on D_2 or D_3 and V_{BE2} is the base-emitter voltage of Q_2.

Some applications require none of the hysteresis that is inherent to a Schmitt trigger; **Figure 3** shows such a design. It also shows how to manage without a requirement for minimal reverse current in D_1. This circuit, however, better suits pure synchronization and not thyristor control. Because of the stability of LED current, these designs provide an expanded input-ac-voltage range, which may be useful for a multistandard ac-powered gadget; an opportunity to set the LED current without the risk of overloading the LED; and a reduced influence of the optocoupler's instability. One more advantage of these designs is their inherently safer nature. In the case of a short circuit in their terminals, optocouplers deliver 10 to 100 times less current between the isolated and the nonisolated sides than the circuit in **Figure 1**. The optocoupler also offers advantages. Thanks to the low duty cycle, you can freely reduce the value of the optocoupler's load resistor, R_8, without sacrificing power efficiency. This reduction results in low zero-crossing error.EDN

Cascade two decade counters to obtain 19-step sequential counter

Jeff Tregre, Dallas, TX

This Design Idea offers a practical approach to cascading two or more Johnson counters together with a bare minimum of parts. The CD4017 Johnson decade counter finds use in simple circuits ranging from sound effects to LED displays. The counter's outputs are normally low and go high only at their respective decoded time slot. Each decoded output remains high for one full clock cycle. The dc-supply voltage can range from approximately 3 to 18V dc. The dc-current drain per each output pin (Q0 to Q9) is 10 mA. The circuit has passed tests at 12V dc at 0 to 150°F without anomalies.

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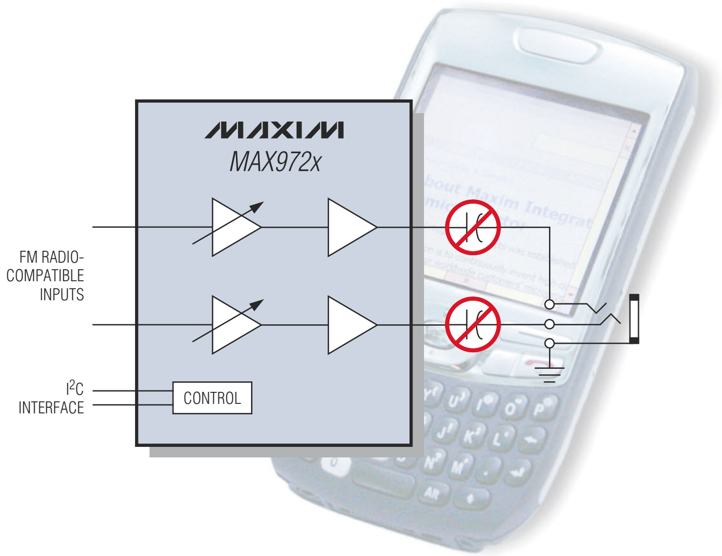

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MAX9726	Headphone amp with bass boost, 64-step volume control	2.7 to 5.5	20-UCSP (2 x 2.5), 20-TQFN (4 x 4)
MAX9729	Headphone amp with bass boost, 32-step volume control, input mux	1.8 to 3.6	28-TQFN (5 x 5)

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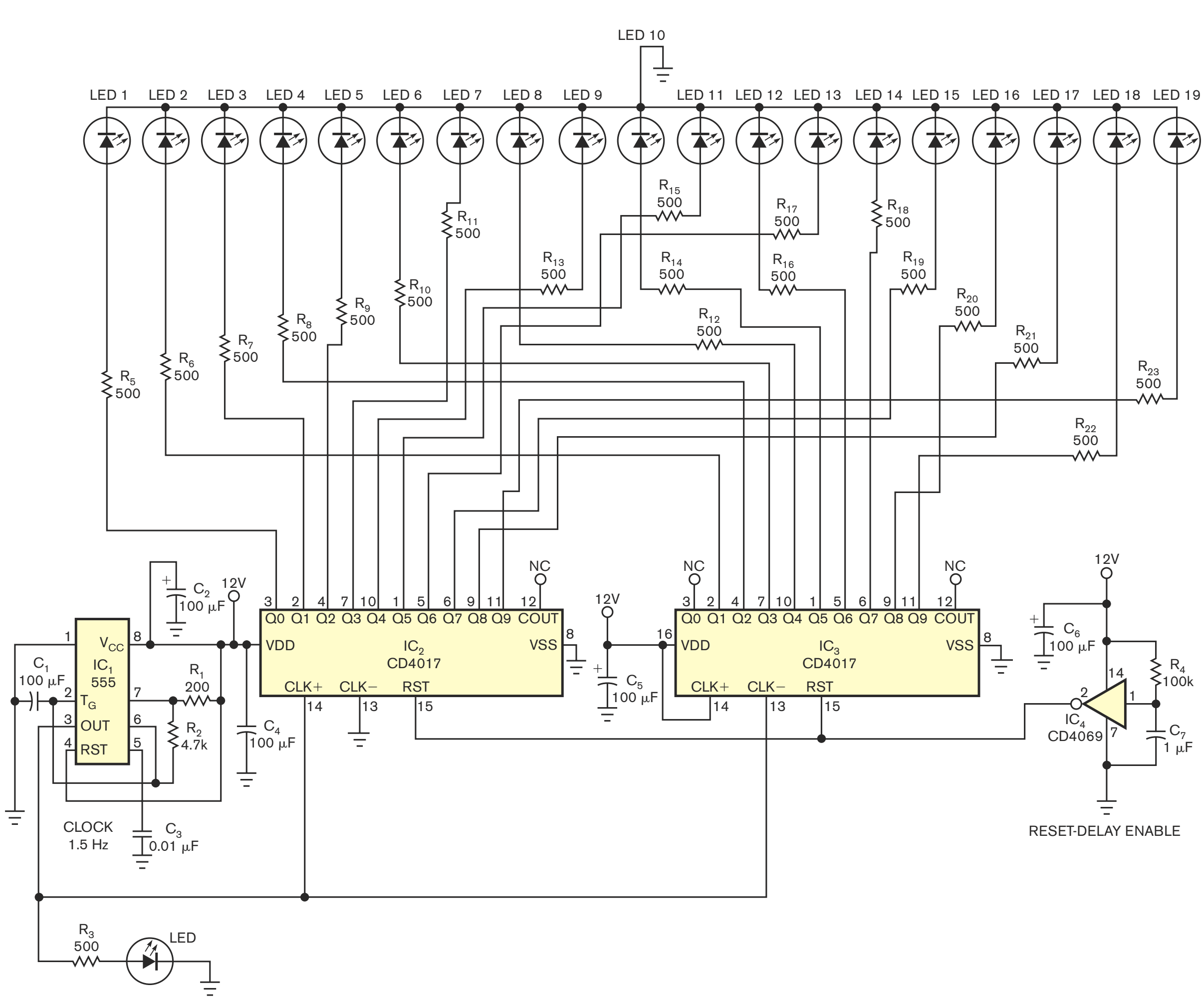

Figure 1 By interleaving the outputs of two cascaded CD4017 Johnson counters, you can obtain a 19-step sequential output.

The circuit in **Figure 1** uses only four ICs and yields a 19-step sequential count. You cannot get 20 outputs without adding more hardware because of the fact that, upon powering up, each CD4017 counter displays output Q0 as being on. Therefore, the circuit does not use output Q0 of IC_3 and can use only 19 of the 20 outputs.

At first blush, you might think that you could simply cascade two counters together using the carry-out pin, Pin 12, from one counter to feed the clock-input pin, Pin 14, of a second counter. But the problem with this configuration is that it does not provide sequential count from 1 to 20 because the first counter begins to count over again once it has reached 10. Such a configuration is a zero-to-99 counter because every 10 counts on the first IC counter causes one count on the second IC counter.

By hooking together two counters, you can obtain a sequential count from 1 to 19. The circuit uses IC_4, a CD4069 inverter, as a reset-delay enable to cause a few milliseconds of delay before each counter can begin to count. A high signal on the Pin 15 Reset clears the counter to its zero count.

Without the delay time, each counter powers up with a random output count such that several LEDs may be on. The circuit uses IC_1, a 555 timer, as the clock to generate a 1.5-Hz square wave. You can change the frequency by changing the RC time constant comprising R_1, R_2, and C_1. Keep in mind that, to obtain a 50% output duty cycle, make R_2 much larger than R_1. Pin 14 of IC_2 has a positive-edge clock trigger. Pin 13 of IC_3 has a negative-edge clock trigger. Therefore, when the clock goes high, IC_2 produces an output count. When the clock goes low, IC_3 produces an output count. By interleaving the outputs, you obtain a sequential count from 1 to 19. Because each clock cycle has both a high and a low state, after the first clock pulse, two LEDs will always be on—that is, LED 1, LED 1 and 2, LED 2 and 3, LED 3 and 4, and so on. Go to www.edn.com/071214di1 to see a short video clip of the finished circuit in action. **EDN**

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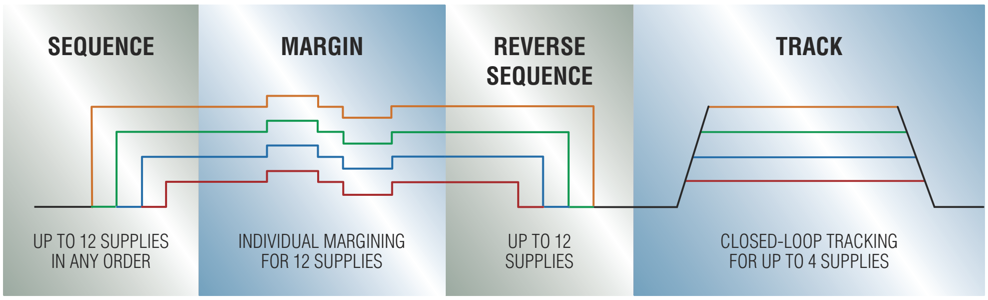

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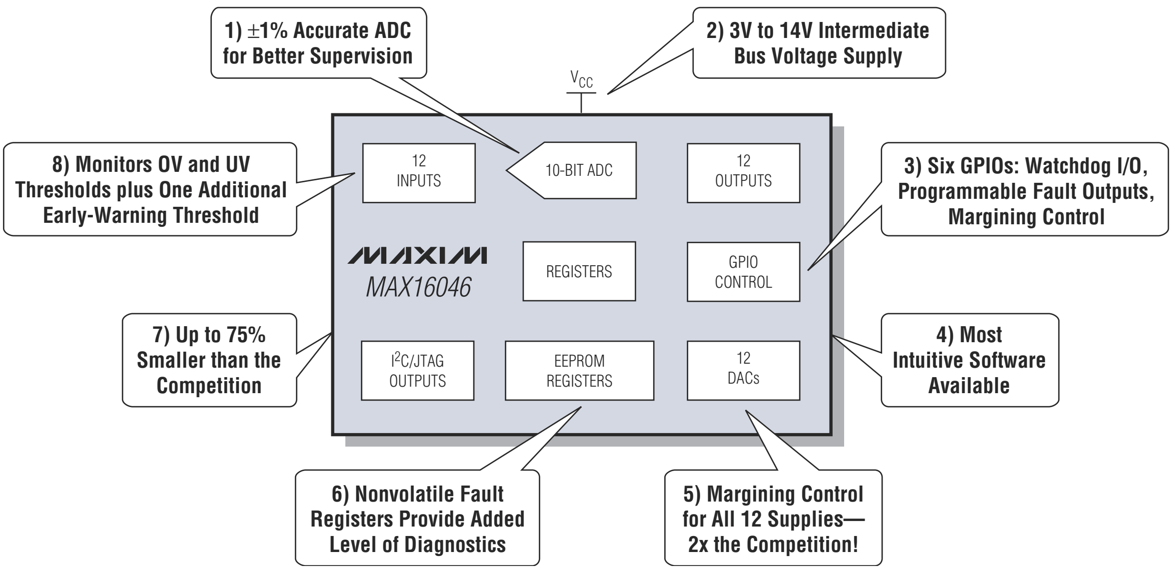

Part	No. of Voltages Monitored	No. of Outputs/FET Drivers	Reverse Sequencing	Supply Adjustment/ Margining	ADC for Voltage Readback	No. of Voltages Tracked	Overvoltage Monitoring	Operates Off of Intermediate Bus Voltage	No. of GPIOs	Package (mm x mm)
MAX16046	12	12/6	✓	12 DACs	✓	4	✓	✓	6	56-TQFN (8 x 8)
MAX16047	12	12/6		—						
MAX16048*	8	8/6		8 DACs						
MAX16049*	8	8/6		—						

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Dual-input sample-and-hold amplifier uses no external resistors

Marián Štofka, Slovak University of Technology, Bratislava, Slovakia

At least two classic ways exist to address applications requiring sampling of a sum of analog voltages. The most common way is to cascade a classic analog adder and a sample-and-hold amplifier. A classic analog adder is an op amp plus at least three precision resistors. The values of these resistors should be as low as possible so as not to deteriorate the bandwidth of the adder. On the other hand, such low-value resistors dissipate power. Further, the configuration of an adder-sample-and-hold amplifier suffers also from another drawback, which manifests itself when the two input voltages are close in magnitude but of opposite polarity. In this case, even if the magnitude of the input voltages is high, the resulting sum is low or no voltage if the magnitudes of input voltages are equal. Sampling a low voltage usually involves a high relative error of the output voltage because each amplifier has some dynamic errors, such as residual parasitic transfer of charge into the storing capacitor.

Another possibility is to use one amplifier per channel and add their outputs in a classic analog adder. Although this configuration avoids the problem with the high relative error of output voltage when input voltages are similar in magnitude and opposite in polarity, precision resistors in the adder still dissipate power.

You can avoid these problems by using the circuit configuration in **Figure 1**, which uses no external resistors. In the steady state, the internal-tracking interval, the $\overline{Q}_D$ internal-logic signal is at an active-high level, enabling the A_1, B_1, and A_2 followers. Thus, the ground-referenced capacitor, C_2, charges to the V_{INA} voltage. The lower node of capacitor C_1 at Pin 2 of IC_2 gets temporarily grounded through the out-

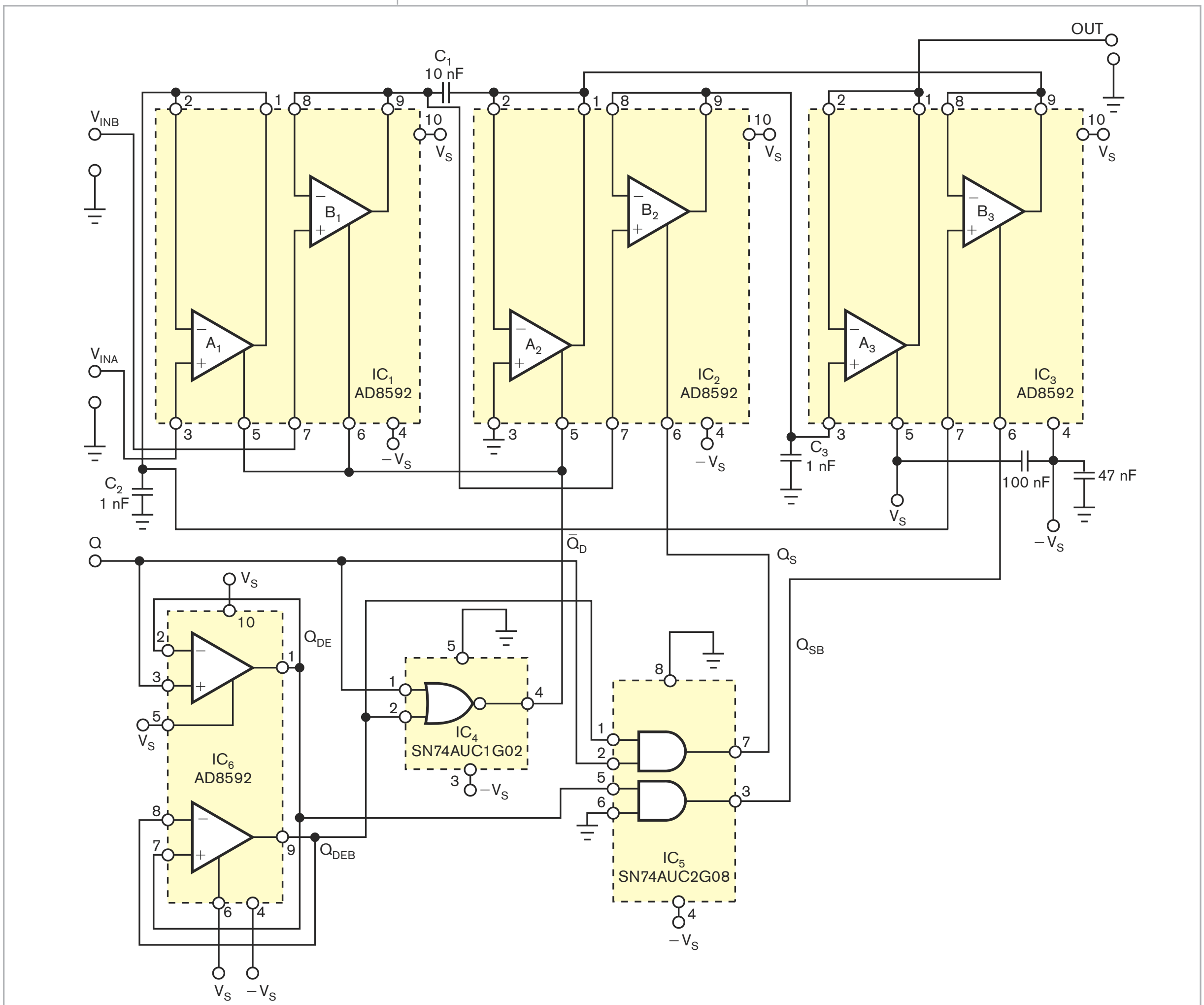

Figure 1 The basis of the operation of this circuit is the simultaneous tracking of the V_{INA} and V_{INB} input voltages on the C_2 and C_1 capacitors, stacking these capacitors within the sample interval, and storing the value of stack's voltage on the C_3 capacitor.

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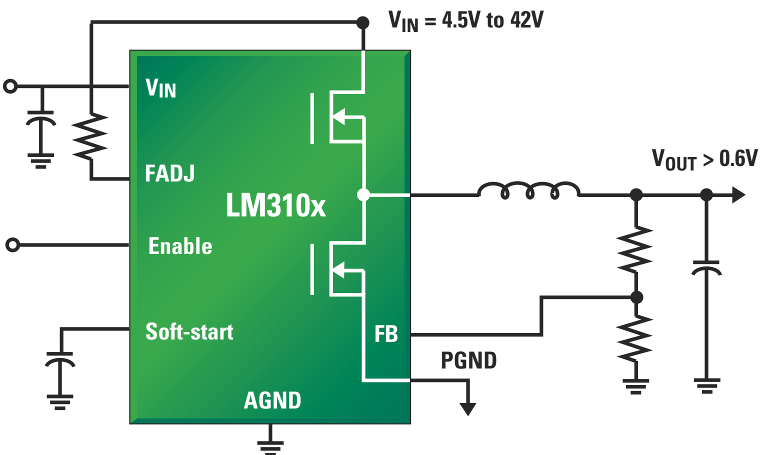
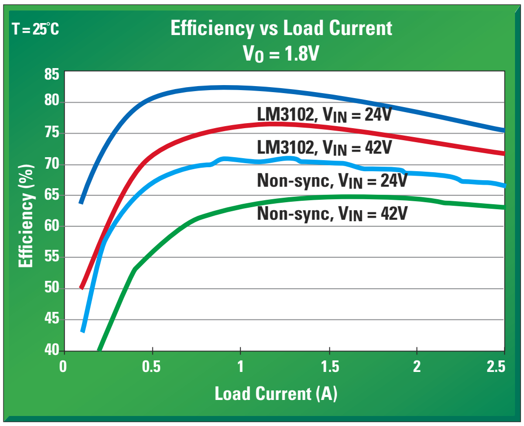
Constant-on-Time (COT) LM310x Regulators from the PowerWise® Family Need No Loop Compensation and Are Stable with Ceramic Capacitors





Product ID	V_{IN} Range (V)	Current (A)	V_{FB} (V)	Frequency (MHz)	Packaging
LM3100	4.5 to 36	1.5	0.8	Up to 1	eTSSOP-20
LM3102	4.5 to 42	2.5	0.8	Up to 1	eTSSOP-20
LM3103	4.5 to 42	0.75	0.6	Up to 1	eTSSOP-16

LM310x Features

- COT control provides lightning-fast transient response
- Stable with ceramic capacitors
- Near-constant frequency operation from unregulated supplies
- No loop compensation reduces external component count
- Pre-bias startup
- Discontinuous Conduction Mode (DCM) operation for a light load
- Enabled in National's WEBENCH® online design environment

Ideal for use in embedded systems, industrial controls, automotive telematics and body electronics, point-of-load regulators, storage systems, and broadband infrastructure

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The Sight & Sound of Information

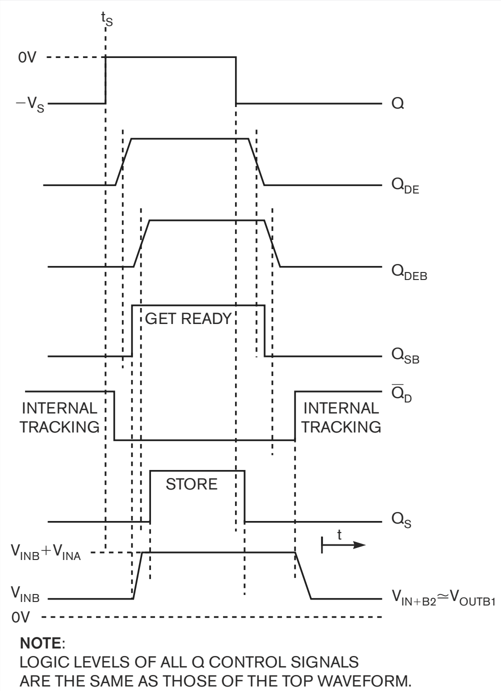


Figure 2 The bottom waveform shows that, at the upper node of the C_1 capacitor, the V_{INB} voltage appears within the tracking interval, and it rises to the value of the sum of both input voltages within the get-ready interval.

put of the A_2 follower while it charges to the V_{INB} voltage at its upper node at Pin 9 of IC_1. V_{INA} and V_{INB} are the input voltages at the A and B inputs, respectively.

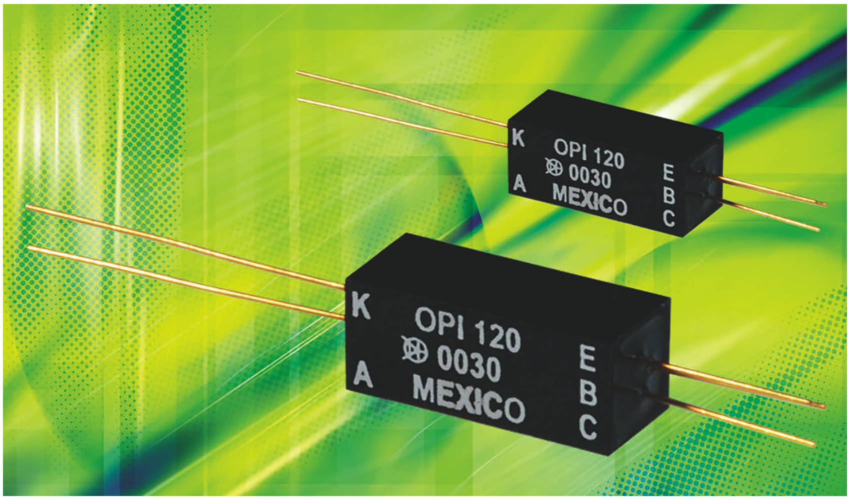
After a settling period, when all internal logic-control signals are low and all controlled followers are disabled, the Q_{SB} control-logic signal goes high. The potential at the lower node of C_1 goes from 0V to $V_{C2}(t_S)=V_{INA}(t_S)$ because of the enabled B_3 follower. $V_{C2}(t_S)$ is the value of voltage stored on the C_2 capacitor before the transition of the $\overline{Q}_D$ signal to an inactive-low level. The potential at the upper node of C_1 consequently rises to the value of $V_{C2}(t_S)+V_{C1}(t_S)=V_{INA}(t_S)+V_{INB}(t_S)$, as the bottom waveform in **Figure 2** shows. This trace is the only analog waveform in this **figure**. The active-low-to-high transition of the sampling-command logic signal, Q_S, gets slightly delayed with respect to that of the Q_{SB} logic signal, suppressing glitches in the output voltage. When Q_S is high, the sampled voltage of $V_{INA}(t_S)+V_{INB}(t_S)$, which is present at Pin 7 of IC_2, passes through the enabled B_2 follower to the C_3 capacitor and gets stored there until the next sampling command. The A_3 follower serves as an impedance converter. Dual op amp IC_6 serves as a tapped delay line, which, in conjunction with one single-NOR gate and one dual-AND gate, derives properly timed internal logic-control signals from the single external logic-control signal, Q.EDN

REFERENCE

1 "AD8592 Dual, CMOS Single Supply Rail-to-Rail Input/Output Operational Amplifier with ±250 mA Output Current and a Power-Saving Shutdown Mode," Analog Devices Inc, 1999, www.analog.com/zh/prod/0,,759_786_AD8592,00.html.

productroundup

CIRCUIT PROTECTION



Optically coupled isolators have hermetically sealed infrared-LED packages

Rated at 15 kV, the OPI120 and OPI123 series of optically coupled isolators feature a hermetically sealed, infrared-LED package with a phototransistor or photo-Darlington output. The isolators target high-voltage isolation between input and output and electrical isolation in harsh environments, including industrial, medical, and office equipment. Sealed in a precast, opaque housing, the devices have an optically transmissive path between the LED and the photosensor. Features include an LED with 890- or 935-nm peak wavelength, 150-mW forward-dc current, and 200-mW power dissipation. The OPI120 and OPI123 isolators have 25 and 20V minimum collector-emitter voltages, respectively, for the output photosensor, with a 5V emitter-collector voltage and 250-mW power dissipation. The OPI120 and OPI123 operate in −55 to +100°C temperature ranges, and prices range from $7.43 to $8.08 (1000).

Optek Technology, www.optekinc.com

Single-line ESD-protection diodes target space-limited applications

Aiming at portable electronics and other space-sensitive applications, the VESD03A1C-02Z, VESD05A1C-02Z, and VESD12A1C-02Z silicon, single-line, ESD (electrostatic-discharge)-protection zener diodes have 3.3, 5, and 12V reverse-working ranges. Within these working ranges, the diodes offer a high isolation-to-ground feature characterized by less-than-1-μA leakage current and less-than-85-pF capacitances. Providing a 0.6×1-mm footprint with a 0.4-mm profile, the diodes allow placement close to the interface connector or in front of the ESD-sensitive IC ports. The diodes clamp or short to ground any transient-voltage signal exceeding the reverse-breakthrough-voltage level. Negative-transient-voltage signals drive the diodes in the forward direction, clamping the transient close below the ground level. Available in an SOD923 package, the VESD03A1C-02Z, VESD05A1C-02Z, and VESD12A1C-02Z diodes cost $7 (1000) each.

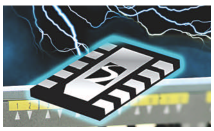
Vishay Technology, www.vishay.com

productroundup

CIRCUIT PROTECTION

Silicon device protects against lightning and ESD

Targeting telecom and network interfaces, the four-line RClamp-2504N 2.5V silicon device provides lightning-surge and ESD protection on Ethernet and high-speed digital interfaces. The device meets IEC 61000-4-x protection standards for EFTs (electrical fast transients). The product has a 2-pF typical line-to-line capacitance, allowing 2-GHz operation. The RClamp2504N costs 49 cents (1000).



Semtech Corp, www.semtech.com

E-Class series provides bidirectional protection at 6 GHz

Providing bidirectional protection and claiming characterization by passing dc without any performance degradation, the SurgeGuard E-Class series targets 6-GHz RF performance. Based on a gas-discharge tube packaged in the PRCONFSAF09E and PTCONxONF-09E small-geometry-form-factor packages, the devices provides a 10-times multiple-strike capability at 5- and 20-kA surge capability. Measuring 42×24 mm, the miniature PRCONFSAF09E arrester has N-type-to-SMA-type connectors and delivers a maximum of 300W RF power at 48 dBm at a maximum through current of 5A. Measuring 50×24 mm, the PTCONxONF09E arrester has N-type connectors and delivers a maximum of 30W RF power at 48 dBm at a maximum of 10A through current. The devices in the SurgeGuard E-Class cost $33 each.

NexTek, www.nexteklightning.com

ESD-protection device clamps input-ESD waveforms in nanoseconds

Joining the vendor's ESD (electrostatic-discharge)-protection family, the ESD9L single-line device provides 0.5-pF capacitance. Suiting use in cell phones, MP3 players, PDAs, and digital cameras, the device clamps a 15-kV input-ESD waveform, according to the IEC610000-4-2 standard, to less than 7V in nanoseconds. Available in a 1×0.6×0.4-mm SOD-923 package, the ESD9L5.0ST5G costs 15 cents (10,000).

On Semiconductor, www.onsemi.com

TEST AND MEASUREMENT

Digitizer/oscilloscope PCIe card includes two 12-bit ADCs

The UF2e-3027 digitizer/oscilloscope PCIe (PCI Express) card provides two 100M-sample/sec, 12-bit ADCs for simultaneous sampling, as well as 2G samples of onboard memory, allowing the device to record 10-second-long signals when both channels are operating at maximum rates. Additional features include options for dual-timebase sampling, synchronous digital inputs, asynchronous digital I/O, and the ability to synchronize as many as 542 channels. The UF2e-3027 digitizer/oscilloscope PCIe card costs $7390.

Strategic Test Corp, www.strategic-test.com

Module controls 32 I/O channels

You can program the four 8-bit ports on the SeaDAC Lite 8126 as inputs or outputs; the ports control 32 channels of digital I/O using a USB

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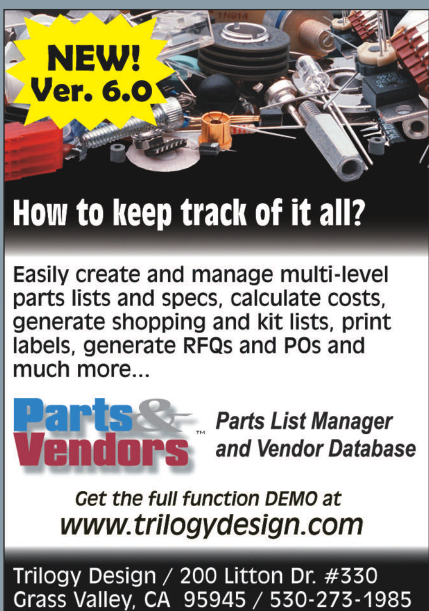

TEST AND MEASUREMENT

connection. A 50-pin header connects the module to solid-state-relay racks, allowing PC-based control of sensors, switches, security-control systems, and industrial-automation systems. Powered by the USB, the module has a 0 to 70°C standard operating temperature, with a −40 to +85°C optional operating temperature. The SeaDAC Lite 8126 module costs $99.

Sealevel Systems, www.sealevel.com

AMC load board targets testing and debugging of MicroTCA systems

The AMC (advanced-mezzanine card) load board suits testing the cooling and power of MicroTCA systems. The load board configures to 0, 20, 30, 40, 50, 60, and 70W wattages. Six LEDs on the front panel indicate which power level is activated. The AMC load board costs $300.

Elma Electronic, www.elma.com

USB analog-output module comes with AWG function

The USB-DA12-8A USB-based data-acquisition and I/O modules include eight independent 12-bit DACs and broadly configured AWG (arbitrary-waveform-generation) capabilities. Features include a 32-bit counter for precision-timed outputs, as many as 125,000 conversions/DAC/sec, and an onboard 128k-sample buffer. The module provides 0 to 2.5, 0 to 5, 0 to 10, ±2.5, ±5, and ±10V output ranges. The device also includes a DIN-rail-mounting provision and a board-only OEM option with PC/104 module size and mounting capabilities. With the AWG function, enclosure, screw-terminal adapter, and external power adapter, the USB-DA12-8A costs $525; available in the same configuration but without the AWG, the USB-DA12-8E costs $349.

Acces I/O Products, www.accesio.com

productroundup

EMBEDDED SYSTEMS

PCI serial interface has MD1 low-profile and Universal Bus compatibility

Providing MD1 low-profile and Universal Bus 3.3 and 5V compatibility, the OMG-COMM4-LPCI-DB25 low-profile PCI serial interface provides four RS-232 serial ports with 460.8-kbps data rates. The RS-232 port uses modem-control signals for increased compatibility with a variety of peripherals. A 16C864 UART provides 128-byte transmitter/receiver FIFOs for improved reliability in data-intensive applications. The OMG-COMM4-LPCI costs $229.

Omega Engineering, www.omega.com

CompactPCI card includes selectable-module library

Accommodating five independent function modules, the 78CS2 multifunction, single-slot CompactPCI card is configurable with the vendor's synchronous-to-digital converter, allowing 10 channels at 2.2 VA or five channels at 5 VA. An integrated GbE (Gigabit Ethernet) interface allows the transfer of data to and from the board without using the backplane bus. The port allows the use of the board as a stand-alone remote-sensor interface, requiring no separate computer board. Other modules are selectable from a library, such as a two-channel digital-to-LVDT (low-voltage-differential-transceiver) converter, a four-channel LVDT-to-digital converter, a 10-channel ADC, a 10-channel DAC, an ac synchronous-reference generator, a four-channel function generator, a 16-channel discrete I/O, a 16-channel TTL I/O, an 11-channel transceiver I/O, and a six-channel RTD (resistance-temperature detector). The 78CS2 CompactPCI card costs $3500 (100).

North Atlantic Industries, www.naii.com

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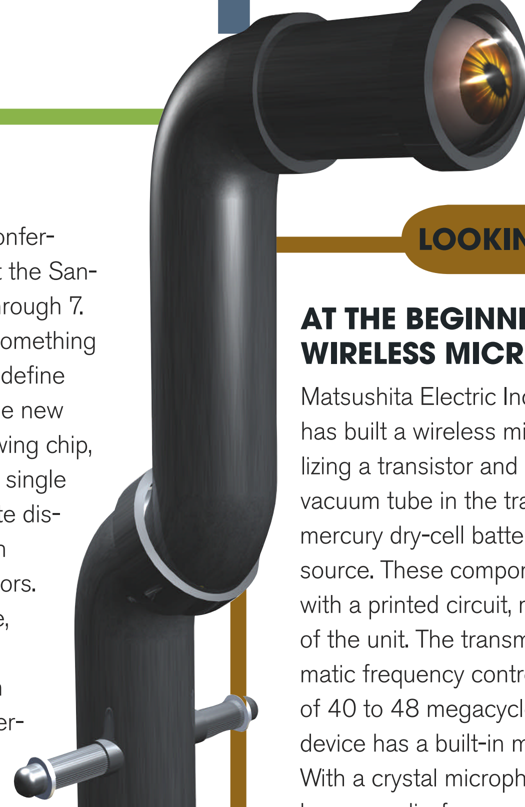

LOOKING AHEAD

TO DESIGNCON 2008

This long-standing electronics-design conference will open in its 2008 incarnation at the Santa Clara, CA, convention center, Feb 4 through 7. Evolving with the industry has become something of a specialty for this otherwise-hard-to-define event. This year, for example, there will be new tracks on RF-signal integrity and on viewing chip, package, board, and system design as a single co-design problem instead of as separate disciplines. There will also be a new pavilion for silicon-IP (intellectual-property) vendors. Technical papers will cover a huge range, from the conference's heritage in high-speed measurements and test to design techniques and even IC-verification-coverage metrics. In content, this has become a broad-based conference.

LOOKING BACK

AT THE BEGINNINGS OF WIRELESS MICROPHONES

Matsushita Electric Industrial Co Ltd has built a wireless microphone utilizing a transistor and a subminiature vacuum tube in the transmitter and a mercury dry-cell battery as the power source. These components, along with a printed circuit, reduce the size of the unit. The transmitter has automatic frequency control over a range of 40 to 48 megacycles, and the device has a built-in monitor speaker. With a crystal microphone, the unit has an audio-frequency response of 100 to 7000 cycles/sec within ±2 dB. Battery life for the transmitter is approximately 40 hours. When used with the companion receiver, the system limits output distortion to less than 2% on the program output and not more than 10% on the monitor output.

—*Electrical Design News*, December 1957

LOOKING AROUND

FOR THE NEXT INDUSTRY DRIVER

What if consumer electronics is not the market that will drive the electronics industry for the next five or 10 years? We've all heard so often that the consumer is in the driver's seat that it sounds like a principle of physics. But what if the global credit crisis depresses consumer spending worldwide and no next "big thing" emerges to take the baton from smartphones and HDTVs (high-definition televisions)? Is there another market ready to pick up a dropped baton? The intersection of bioelectronics and MEMS (microelectromechanical systems) seems promising, but it may be too far into the future. Energy conservation is a nearer term possibility but not yet a proven market. Applying electronics to save energy requires consumers to spend money to replace things they already have. It's an important question with no obvious answer.