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TOP 101 COMPONENTS

Survey Says Design Engineers Have Power On Their Minds

P. 20

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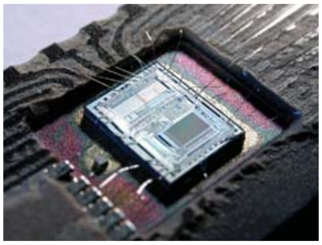

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EDITORIAL MISSION:
To provide the most current, accurate, and in-depth technical coverage of the key emerging technologies that engineers need to design tomorrow's products today.

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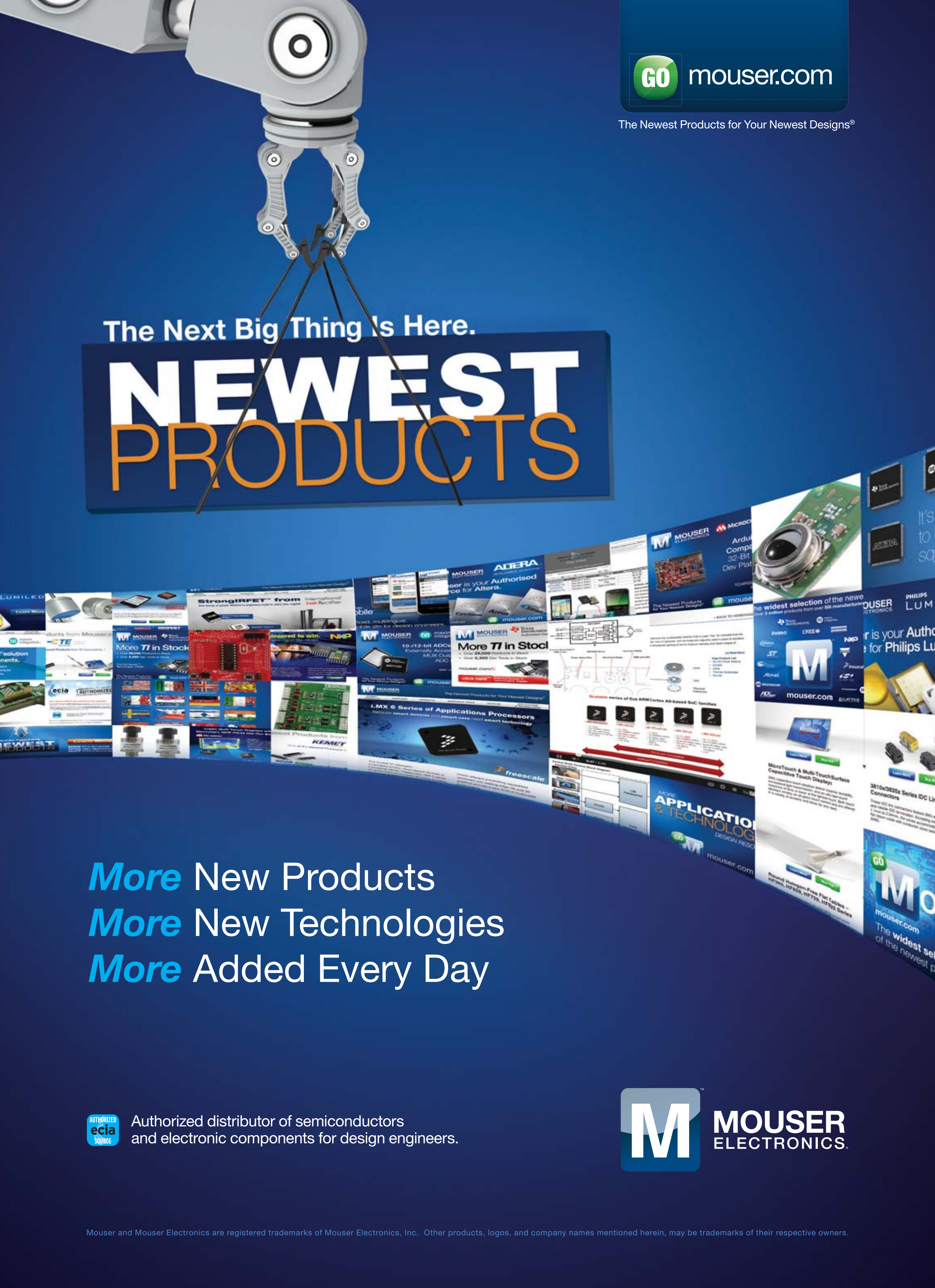
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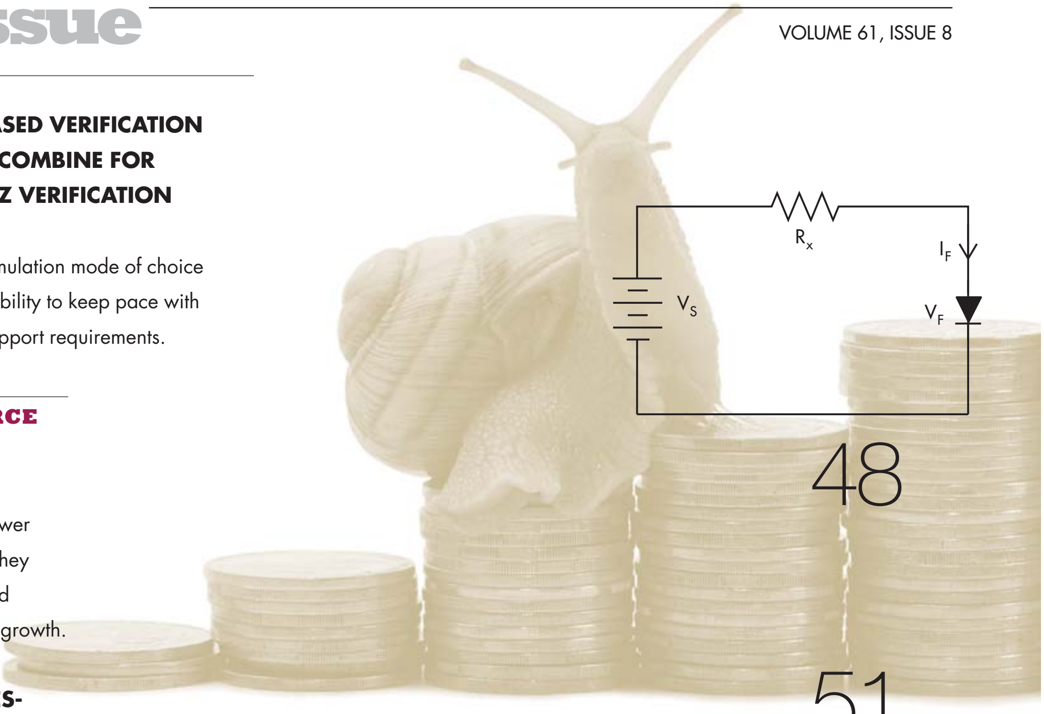

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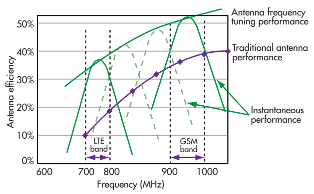

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Tesla Motors will expand its network of Superchargers, with 27 sations expected to open through the summer of 2013 and 98% of the U.S. and Canada covered by 2015.

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Passive Components Still See Ink And Innovation

Ohmite Manufacturing's RW5 and RW7 surface-mount wirewound resistors sport a finned body style that makes them a great fit for high-power-density applications.

When people first learn about electronics, they're usually taught how resistors, capacitors, and inductors interact in a circuit. Since these components have been around a long time, you might think there's nothing more to say about them and certainly not much innovation going on. Nothing could be further from the truth. Just look at our annual list of the Top 101 Components *(p. 20)* to see that fully 10% of them are passives.

We've written about these specific products and more over the past year. For instance, in our new online Ask The Expert series, Tamara Schmitz, an applications manager at Intersil, wrote about selecting components for prototypes. In particular, she wrote about selecting resistors. In the photo that accompanies her article, the resistors look like the common ones we're all used to seeing.

But Tamara also writes about a dizzying array of choices you might find at a distributor's Web site. She notes that "they are categorized by the way they are mounted: surface mount, through hole, chassis mount, array… or two others: precision or accessories. Many designers just start clicking away and hope for pictures that can be deciphered." You can find Tamara's full post by clicking on the Forums tab at *electronicdesign.com*.

Bill Laumeister of Maxim Integrated is also writing about passives, saying maybe they aren't so passive after all. "These apparently passive components can, and do, change the signal in unexpected ways since they contain parasitic portions," he said.

As an example of the continuing innovation in passive components, I'll point to two resistors that were just introduced by Ohmite Manufacturing. These are the RW5 (5 W) and RW7 (7 W) surface-mount wirewound resistors *(see the figure)*. As you might guess, their unique finned body style maximizes surface area and therefore cooling capacity and makes them a great fit for high-power-density applications. You can find a full description at *electronicdesign.com*. ed

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Compress Climate And Physics Datasets
For Petascale Computing

Multicore computing results are increasingly determined by the rate at which operands are fed to the cores and decreasingly by the speed or the number of cores. SDRAM and flash memory bottlenecks often slow down computations, but disk drive speeds can also determine the rate at which supercomputers deliver results.

Indeed, in high-performance computing (HPC) applications, "time to results" can be directly related to the rate at which numerical datasets, such as climate measurements, are read from disk, as well as the rate at which simulation results, such as 3D physics arrays, are stored to disk drives.

TITANIC COMPUTING

Today's supercomputers have immense computing power. Supercomputers are ranked according to a "flops" metric that's calculated using the rather dated Linpack benchmark.[1] Every six months, *www.top500.org* updates the list of the most powerful supercomputers. In November 2012, the fastest supercomputer in the world was the Titan supercomputer at Oak Ridge National Labs in Tennessee, clocking in at 17.6 Pflops (17.6×10^{18} floating-point operations per second).

Titan uses Intel x86 processors and Nvidia GPUs to achieve this prodigious calculation rate. Unfortunately, a supercomputer's Linpack rating rarely predicts the performance of everyday "codes," as the supercomputing programmers and users call their application-specific software.

Two application codes that require long calculation times and generate and consume multi-petabyte (10^{18} bytes) datasets are climate and physics simulations. It's not uncommon for climate and physics simulations to run for many months using hundreds of thousands of cores and to consume terabytes of RAM and petabytes of disk storage. The supercomputing community is actively evaluating various techniques, including compression, to reduce RAM, flash, and disk bottlenecks in supercomputing.

Climate simulations have been in the news since the late 1990s because they improve society's understanding of climate change. Climate scientists typically begin a simulation at a historical point where atmospheric, oceanic, and land temperatures were once measured. These simulations combine multiple abstracted, mathematical 3D models of the Earth's air, ocean, land, and ice conditions and advance the simulation one timestep at a time.

Depending on the purpose of the climate simulation, timestep sizes may range from minutes (weather forecasts having a daily or weekly duration) to months (climate simulations having 100-year durations). The output of every Nth timestep is saved for post-simulation analysis and visualization, where N may range from 1 to 100.

The beautiful, complex color weather maps we see on television and on the Internet are the outcome of such climate simulations, as are the decadal distribution and density maps of carbon dioxide, methane, water, clouds, and ice that are consistent with global warming.

Scientists are improving climate models in two aspects: improved grid density and more complex boundary interactions. Since atmospheric and oceanic grid densities have both spatial (x-y-z) and temporal (t) dimensions, improved grid density directly affects the size of intermediate timestep results.

A twofold increase per dimension in 3D spatial grid density creates intermediate datasets that are eight times larger, exacerbating the I/O challenges of climate simulations. Similarly, improving the accuracy of boundary interactions (such as between the air and ocean, or between ice and water) often

APAX NUMERICAL ENCODING RESULTS

Application	"Codes"	Datasets tested	APAX compression ratio at "same results"
Climate	Various	127 climate variables	4:1
Physics	LULESH	Sedov blast wave radius, density, thickness (three variables)	4.5:1
	MIRANDA	Mixing layer thickness, growth rate, energy density (six variables)	5.4:1
	pF3D	Laser intensity (incoming and back-scattered), plasma density (six variables)	6.2:1

requires higher grid densities at the boundaries. More complex models result in longer climate simulation times and more data to be captured and visualized.

IN THE LABS

One of Samplify's climate simulation collaborators participated in the latest Coupled Model Intercomparison Project Phase 5 (CMIP5) long-term climate simulation.[2] This group struggled to analyze the climate results it generated for CMIP5, which were 10 times larger than its CMIP4 datasets five years earlier. This group's problem occurred not in the generation of climate simulation data, but rather in the post-simulation data analysis and visualization phase, where slow disk reads threatened the group's timely delivery of well-studied CMIP5 results.

Lawrence Livermore National Labs (LLNL) operates a special research building called the National Ignition Facility[3] (NIF) that evaluates next-generation fusion energy. At NIF, the world's most powerful laser (actually a complex of 192 high-energy lasers) impinges on a tiny, gold-plated cylinder the size of a pencil eraser called a "hohlraum" (the German word for "hollow space") in which the fusion reaction occurs.

Because of the immense amounts of power and months of preparation required for each NIF experiment, it is significantly less expensive for LLNL to perform multiple hohlraum physics simulations in a supercomputer than it is to perform a single NIF experiment. LLNL's dedicated NIF physicists perform considerably more NIF simulations than experiments, but the complexity of laser-plasma interactions within the hohlraum requires the interaction of several physics simulations.

As with climate simulations, grid density and timestep size are key NIF simulation parameters, and LLNL physicists always want smaller grid and timestep spacing because better resolution provides additional physics insights. Simulating NIF's multi-physics interactions generates petabyte-scale datasets over months-long simulations using LLNL's Sequoia, the world's second-fastest supercomputer.

Samplify collaborated both with Deutsches Klimarechenzentrum (DKRZ; German Climate Computing Centre) and LLNL in experiments that demonstrate that lossy compression of climate and physics datasets maintains the simulation results while reducing the memory and disk I/O bottlenecks by factors of four and six. The table summarizes the results of compressing climate[4] and physics[5] datasets using the APAX universal numerical encoder. These two papers are the first to document that compression's effects maintain simulation results for large, complex HPC calculations while significantly reducing memory and disk bottlenecks. ed

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AL WEGENER, CTO and founder of Samplify, earned an MSCS from Stanford University and a BSEE from Bucknell University.

News & Analysis

Xbox One And PlayStation 4 **Look More Alike**

It has an eight-core, x86, 64-bit Jaguar CPU with a Radeon GPU system-on-chip (SoC) from AMD with access to 8 Gbytes of RAM. It sports half a terabyte of hard-disk storage, a Blu-ray drive, and a 3D image sensor. Of course, it has Gigabit Ethernet, 802.11 b/g/n, USB 3.0, and HDMI output too.

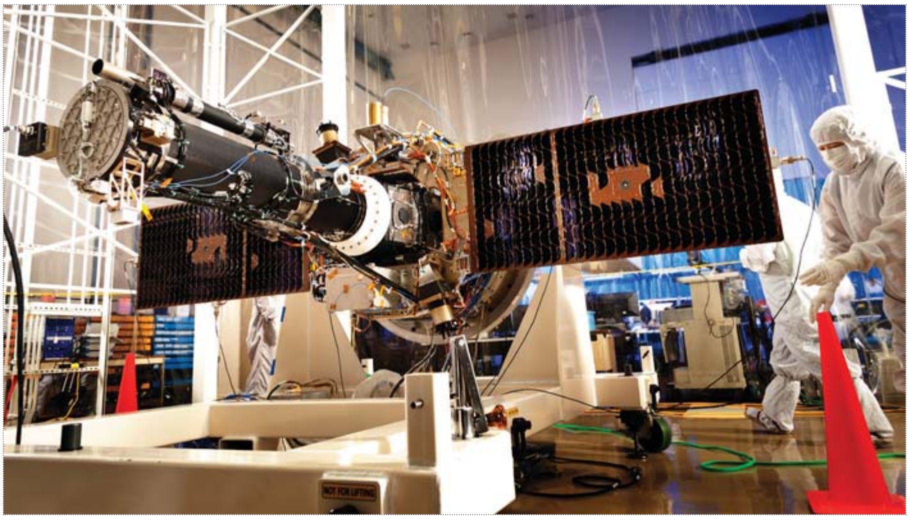
So what is it?

It could be the Microsoft Xbox One or the Sony PlayStation 4 *(see the figure)*. If you stand far enough back and don't look too closely at their specs, they look pretty much the same. Differentiating the two platforms is more difficult, but the developer's job is significantly easier.

Microsoft's Xbox One (a) and Sony's PlayStation 4 (b) are very similar architecturally, including the use of an eight-core SoC from AMD and a Blu-ray disc drive.

There are some differences. Sony uses GDDR5, while Microsoft went with DDR3. Sony's optional 3D image sensor is a pair of cameras, while Microsoft bundles the latest version of the Kinect.

These platforms will be among the first to use AMD's heterogeneous Uniform Memory Access (hUMA) support *(see "Unified CPU/GPU Memory Architecture Raises The Per-*



IMAGING TECHNOLOGIES TAKE FLIGHT

NASA SUBJECTED ITS Interface Imaging Spectrograph (IRIS) observatory to vibration and other testing before its June 26 launch. The satellite will use its ultraviolet telescope and multichannel imaging spectrograph to observe how solar material moves, gathers energy, and heats up as it travels through the lower atmosphere. *(courtesy of LM Photo)* ■

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Agilent 34970A/72A Data Acquisition Switch Units (DAQs) have achieved market leadership for more than a decade. Perhaps it's the 34970A/72A DAQ's unmatched capability. Or the 34972A DAQ's ability to control everything remotely via mobile interface. Or the BenchLink Data Logger software that lets you scan, monitor, control and analyze your data so you can quickly act on it. Maybe it's all of the above.

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formance Bar" at electronicdesign.com), which is part of AMD's heterogeneous system architecture (HSA). This puts the GPU and CPU cores into the same memory and cache space. Code that runs on the GPU will still be distinct from the CPU, but the tighter integration means less copying and quicker dispatching. The similar SoC architectures will make a developer's job much easier.

The software that the two vendors wrap around this hardware will be much different, though. Microsoft is using Windows as the basis for the Xbox One, but don't expect it to run Windows applications at this point. It's a gaming system, after all.

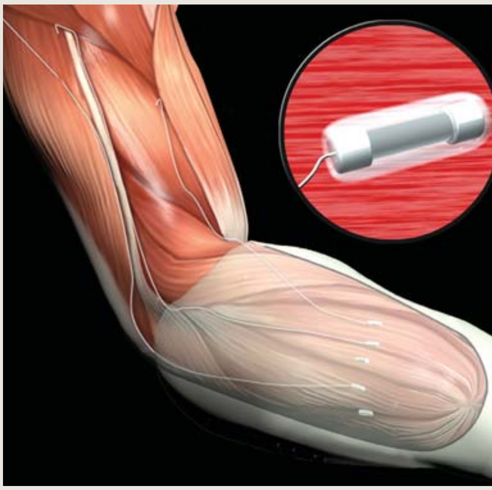
Power management is also critical to these designs. The latest multiplayer, 3D, first-person shooter games will tax the CPU and GPU cores. Yet these cores mostly will be idle when users are streaming videos or watching a movie on Blu-ray.

Virtualization is likely to play a central role as well. HSA makes virtualization work across the CPU and GPU cores. Games will be easier to modularize, but security will be improved. The vendors may open up their systems a bit more by providing a virtual machine for developers and maybe even users so they have a bit more flexibility in how they can use the platforms.

PC gaming platforms will still be able to deliver more computing horsepower, but the average PC or even a PC designed for gaming is likely to have less performance than these platforms. Whether portability between platforms will be improved remains to be seen, but at least the hardware is there.

HSA likely will impact non-gaming applications, but it now will have a rather public pair of components. ■

BILL WONG



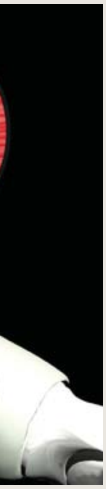
Merger Propels Wired Home Networking

The recent merger of the HomePNA Alliance with the HomeGrid Forum creates a new critical mass that should be an incentive for increasing the number of home area networks (HANs) using wired technology. Today, most networked homes use Wi-Fi for Internet access and video distribution.

HomePNA's standard uses the frequencies above the standard DSL spectrum to carry video and Internet traffic. AT&T's U-verse IPTV services use this technology. But with the availability of the ITU-T's G.hn wired technology, equipment OEMs and service providers are slowly migrating to this flexible standard, which supports phone-line wiring, coax, or ac power-line media.

The HomeGrid Forum (HGF) was created to support and champion G.hn, while the HomePNA Alliance sought to build and promote its own wired home networking technology. Under the HomeGrid Forum name, both will perform compatibility and interoperability testing and certification as they move to build the G.hn marketplace. The HGF also will continue to support and certify HomePNA products.

G.hn has been finalized for several years now but has been slow to show up in homes. The lack of certified silicon has been one problem, but so has the general lack of consumer knowledge about the various types of home network wiring potential. With most homes having an installed base of ac power line, telephone wiring, and cable TV coax, no new wiring is needed. The organizations will make a more consolidated effort toward G.hn's promotion and development. ■ **LOUIS E. FRENZEL**



INTERFACES AID AMPUTEES

THE DEFENSE ADVANCED Research Projects Agency (DARPA) is developing leaded implantable myoelectric sensors to be used as a novel peripheral-interface technology with targeted muscle re-innervation. These interfaces use signals from nerves or muscles to control prosthetics and provide direct sensory feedback. *(courtesy of DARPA)* ■

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Survey Says Design Engineers Have Power On Their Minds

A supercapacitor, two dc-dc converters, and a charging coil garner four of the top 10 spots on our annual list of the Top 101 Components.

Welcome to our yearly roundup of the Top 101 Components, compiling the most sought devices in the electronics OEM industry. We regularly receive mountains of product announcements about connectors, power sources, passives, LEDs, sensors, and more. Our editors then select the most noteworthy for our design engineering audience.

We post these products on our Web site and promote them via e-mail newsletters, tracking reader interest via Web site analytics. This year, we also asked vendors to tell us what they thought their best products were in the past 12 months. Readers then picked their favorite components of the ones we've published and those that were nominated by the vendors.

Many design engineers are thinking about power and seeking more information about innovative power sources. In fact, 23 of the products on the list are categorized as power sources, and four of the top 10 are power-related: the CLK series of supercapacitors from Cellergy, the LXDC series of dc-dc converters for Murata Americas, the E200E series of dc-dc converters from MicroPower Direct, and the IWAS-3827EC-50 charging coil from Vishay Intertechnology.

SENSOR CLAIMS TOP SPOT

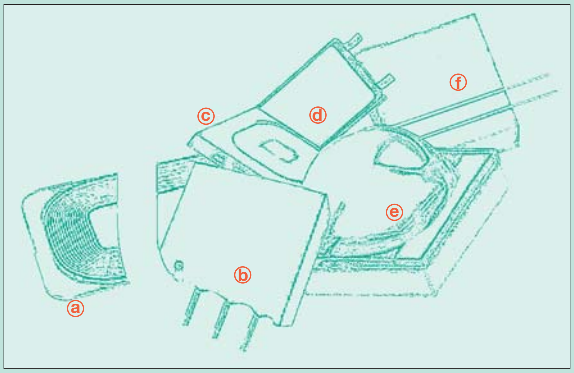
Though power sources made a strong showing, the component at the very top of the list is a sensor, the STMicroelectronics LIS3MDL. This is ST's first discrete magnetometer, and it sparked quite a bit of interest among our readers. Announced in February, the LIS3MDL is now going to mass production.

One of the interesting applications of this standalone three-axis magnetometer is indoor navigation, where it reliably calculates dead-reckoning when no satellite signal is available. The part also can be combined with other discrete sensors from ST such as a three-axis micro-electromechanical systems (MEMS) accelerometer or three-axis MEMS gyroscope to build sensors with as many as nine degrees of freedom.

ST has some indication of how this sensor might be used in novel applications due to its experience with a 6x iNemo part, an accelerometer plus magnetometer. Hapilabs, a company based in Hong Kong, has developed a product called HAPIfork, which helps individuals monitor and track their eating habits. With the help of indicator lights and gentle vibrations, the device alerts users to the fact that they are eating too fast. HAPIfork uses an ST accelerometer and a magnetometer module, as well as an STM32 microcontroller.

LEDs TAKE SECOND PLACE

One of the hottest areas in electronics today is solid-state lighting, so it makes complete sense that new LEDs would



Vishay Intertechnology's IWAS-3827EC-50 is designed for the wireless charging of 5-V portable electronics (a). Micro Power Direct's low-cost E200E dc-dc converters deliver 2 W of reliable output power (b). Osram Opto Semiconductors' latest automotive LEDs offer high light output at high currents (c). Cellergy's CLK supercapacitors feature twice the capacitance of the company's general-purpose CLG series (d). Cree's XLamp series LEDs provide discrete (XB-D) and multicolor (XM-L) LED options for applications ranging from architectural to vehicle and display lighting (e). The standalone LIS3MDL three-axis magnetometer developed by STMicroelectronics measures 2 by 2 by 1 mm (f).

2013 TOP 101 COMPONENTS			
Rank	**Product**	**Company**	**Category**
1	LIS3MDL magnetometer	STMicroelectronics	Sensors
2	XLamp series LEDs	Cree Inc.	LEDs
3	CLK series of supercapacitors	Cellergy	Power sources
4	LXDC2UR/LXDC3EP series of dc-dc converters	Murata Americas	Power sources
5	E200E series of dc-dc converters	MicroPower Direct	Power sources
6	DCM4826X stepper-motor drive module	Haydon Kirk Motion Systems	Motors & motion control products
7	Oslon Black Flat LED	Osram Opto Semiconductors	LEDs
8	IWAS-3827EC-50 charging coil	Vishay Intertechnology	Power sources
9	T24-WSS wind-speed sensor	Mantracourt	Sensors
10	SBS75x family of PCB connectors	Anderson Power Products	Interconnects
11	Pi Sandwich case	Bud Industries	Cabinets & enclosures
12	A1250 bipolar switch	Allegro Microsystems	Switches
13	White Lite SSL connectors	Global Connector Technology	Interconnects
14	Displix LEDs	Osram Opto Semiconductors	LEDs
15	Nanominiature connectors	TE Connectivity	Interconnects
16	HyperLink PoE injector/midspans	L-com Inc.	Power Sources
17	2M series micro-miniature connectors	Amphenol Aerospace	Interconnects
18	TSL4531 ambient light sensor family	ams AG	Sensors
19	ESD-Safe MLC capacitor series	AVX Corp.	Circuit protection devices
20	ESD-SafeT X7R capacitors	AVX Corp.	Passive components
21	WM7121/WM7132 MEMS microphones	Wolfson Microelectronics	Sensors
22	VCNL3020 proximity sensor	Vishay Intertechnology	Sensors
23	Transreflective TFT displays	Phoenix Display International	Displays
24	ULS series of dc-dc converters	Murata Power Solutions	Power sources
25	SPD500 pressure sensor	Sensirion AG	Sensors
26	AH1806/AH1808 Hall-effect switches	Diodes Inc.	Switches
27	RUW15 series of dc-dc converters	Murata Power Solutions	Power sources
28	MLO3 series capacitors	AVX Corp.	Passive components
29	F77 series of ultrasonic sensors	Pepperl+Fuchs	Sensors
30	TACmicrochip series capacitors	AVX Corp.	Passive components
31	MiniMax push-pull interconnect	Fischer Connectors	Interconnects
32	BFS 33M true color sensor	Balluff	Sensors
33	CSM series of current-sense resistors	Stackpole Electronics Inc.	Passive components
34	ZWS10-30B series power supplies	TDK-Lambda Americas	Power sources
35	2Pro PPTC/MOV hybrid device	TE Circuit Protection	Circuit protection devices
36	BL3100C18650XSXPPGQA intelligent battery pack	GlobTek Inc.	Power sources

pique our readers' interest. In this particular case, the product that made the greatest impression during the past year is the Cree XLamp series of LEDs: the discrete (XB-D) and multicolor (XM-L).

Built on Cree's SC³ Technology Platform, the XB-D White LED delivers 139 lumens and 136 lumens per watt in cool white (6000 K) or 107 lumens and 105 lumens per watt in warm white (3000 K), both at 350 mA and 85°C.

Multicolor XM-L LEDs combine very high efficacy at very high drive currents, delivering 1000 lumens with 100 lumens-per-watt efficacy at 3 A in a 5- by 5-mm footprint. They're designed for very-high-lumen applications such as high-bay, indoor commercial, or roadway lighting.

Cree wasn't the only company that placed an LED in our top 10. Osram Opto Semiconductors secured the seventh position with its Oslon Black Flat LED. Designed for automotive front lighting applications, the LED features high light output at high currents, uniform light distribution, thermal stability, and strong contrast. It employs Osram's UX:3 chip technology, which is based on the company's ThinGaN process. This technology uses a metallic mirror below its active layer and a well-defined scattering surface for optimized light extraction.

SUPERCAP LEADS POWER QUARTET

When Cellergy announced a supercapacitor with double the capacitance of its CLG series last year, our readers noticed, placing it third on our list. The CLK series comes in two form factors, 17 by 17 and 28 by 17, and has an extended temperature range from –40°C to 85°C. Capacitance ranges from 30 to 240 mF.

Supercapacitors are generally used for pulse applications and in conjunction with batteries to assist in delivering energy to the load. Cellergy plans on expanding the CLK series to include additional voltages and a version with lower leakage current.

Small dc-dc converters nailed the next two spots. Murata Americas touted its LXDC micro dc-dc converters as the world's smallest when they debuted in June

2013 TOP 101 COMPONENTS			
Rank	Product	Company	Category
37	USB 2.0 connector	Conec	Interconnects
38	PXS series of power supplies	UltraVolt Inc.	Power sources
39	High-power TVS diodes	AVX Corp.	Circuit protection devices
40	CeeLok FAS-T connector	TE Connectivity	Interconnects
41	SMA6F series TVSs	Vishay Intertechnology	Power sources
42	PS25203 EPIC sensor	Saelig Co.	Sensors
43	PH9185NL transformers	Pulse Electronics	Power sources
44	Smart Position Sensor	Honeywell Sensing and Control	Sensors
45	9286 series wire-to-wire connector system	AVX Corp.	Interconnects
46	Illuminated tactile switch series	C&K Components	Switches
47	A1128 Hall-effect switch	Allegro Microsystems	Switches
48	RBE-12/20-D48 dc-dc converter	Murata Power Solutions	Power sources
49	PDJack connector	Molex	Interconnects
50	SM3KWxxA/SM5KWxxA series TVS modules	ProTek Devices	Circuit protection devices
51	PwrBlade series connector	FCI	Interconnects
52	Okami OKX series of dc-dc converters	Murata Power Solutions	Power sources
53	OA109AP/OA172SAP series LED cooling fans	Orion Fans (Knight Electronics)	Cooling products
54	Tekal series of aluminum housings	Teko Enclosures	Cabinets & enclosures
55	JCK60 series dc-dc converter	XP Power	Power sources
56	DF50 connector	Hirose Electric Co. Ltd.	Interconnects
57	GCL-536 series switch	CW Industries	Switches
58	BD9521 battery disconnect switch	Gigavac	Switches
59	ERGO-CASE XS enclosure systems	OKW Enclosures Inc.	Cabinets & enclosures
60	NFC antenna	Pulse Electronics	Passive components
61	6U VPXtra 1000CD power supply	Behlman Electronics	Power sources
62	MK23 proximity switches	Meder Electronic Inc.	Switches
63	MPU-800S power supplies	MicroPower Direct	Power sources
64	15208A/25208A/35208A digital accelerometers	API Technologies	Sensors
65	DDR4 DIMM sockets	FCI	Interconnects
66	Intelligent fan trays	Verotec	Cooling products
67	DH50 series dc-dc power converters	Wall Industries	Power sources
68	AE458RFW series transformers	Coilcraft CPS	Power sources
69	GRN series power supplies	Power Sources Unlimited	Power sources
70	Shrouded male connectors	Mill-MaxX	Interconnects
71	Rig-Lok connector series	Amphenol Industrial Global Operations	Interconnects
72	Bulk Metal Z1-Foil (FRST) resistors	Vishay Precision Group	Passive components

of 2012. The LXDC2UR has a 600-mA current rating and measures 2.3 by 2.5 mm, while the LXDC3EP has a 1-A current rating and is 3.2 by 3.5 mm. Both combine Murata's proprietary materials and technical capabilities, specifically ferrite material expertise, multilayer processing, and power module design. Murata has since expanded the product lineup to accommodate higher voltage and current needs.

Fifth on the list, the MicroPower Direct E200E series dc-dc converters come in a four-pin system-in-package (SIP), a popular form factor with our readers. Six models operate from 5- and 12-V dc inputs and have single outputs of 5, 12, or 15 V dc. All deliver up to 2 W and are specifically designed to provide reliable voltage conversion and/or power-line isolations for space-critical board-level applications.

Rounding out the power sources quartet, Vishay Intertechnology's IWAS-3827EC-50 powdered-iron-based receiving coil targets the wireless charging of 5-V portable electronics. Compliant with the Wireless Power Consortium, it measures 38 by 27 mm. It also is 44% smaller and costs less than its predecessor, the IWAS-4832FF-50, yet has equivalent performance and greater than 70% efficiency.

TINY STEPPER-MOTOR DRIVE, A WIND-SPEED SENSOR, AND A PCB CONNECTOR

Securing sixth place is the tiny DCM4826X stepper-motor drive module from Haydon Kerk Motion Systems. The totally enclosed unit's mounting plate measures just 64 by 60 mm, with mounting-hole center-to-center distances of 52 by 38 mm. Total thickness is 34.4 mm.

Due to its small size, the DCM4826X is well-suited for multi-axis stepper-motor applications where space is at a premium. As a bipolar, two-phase chopper drive, it can be used with rotary stepper motors or stepper-motor-based linear actuators. The drive is integrated using the company's PDE User Interface via an RS-485 protocol or a computer USB port.

Ninth on the Top 101 is a sensor that measures wind speed and transmits the

CONNECTING YOUR WORLD

ExaMAX™ High Speed Backplan Connector System

The ExaMAX™ product platform is FCI's newest high speed interconnect solution delivering superior High Speed Backplane, Mezzanine and IO performance, scalable from 25Gb/s up to 40Gb/s signal speed, and providing the lowest total applied cost in the industry.

The ExaMAX™ product family will address a broad range of system architectures, including backplane, midplane, midplane orthogonal, direct orthogonal, cabled backplane, coplanar and mezzanine applications.

Mini-SAS HD Connectors

The Mini-SAS HD is the next generation SAS storage interface addressing channel bandwidth requirements of 6 Gb/s to 12 Gb/s meeting or exceeding the respective SAS 2.1 and proposed SAS 3.0 specifications. The Mini-SAS HD product provides greater port density (11mm port-to-port) versus the existing Mini-SAS 2.0 product (19.01mm port-to-port). The Mini-SAS HD product is compliant to the SFF-8643 and SFF-8644 industry specifications. Internal and external connector configurations of the Mini-SAS HD product include 1X1 (4x), 1X2 (8x), and 1X4(16x) and enables 4x and 8x cable assembly solutions which include EEPROM communication. The Mini-SAS HD profile design is PCI Express compatible and can be utilized in PCI Express architecture applications.

HPCE™ Cable Assembly

The HPCE cable product is a next-generation power cable assembly for demanding applications requiring high linear current density and low power loss. It offers both one-piece (cable to card edge) and two-piece (cable to header) solutions. Both have a low profile height (7.5mm) and are based on very cost-effective and highly reliable stamped-and-formed power contact technology similar to other power solutions from FCI.

The HPCE cable assembly incorporates an innovative power contact and housing design that permits a more compact and lower profile package for demanding AC and DC power distribution applications. HPCE cable assembly offers low profile height (for maximized airflow), significantly increased linear current density and low contact resistance characteristics make it ideal for next generation 1U/2U servers, storage enclosures, telecommunications equipment and datacom/networking equipment.

For more information,
please contact us at **communications@fci.com**
or visit us at **www.fci.com**.

FCI

data wirelessly. Mantracourt's T24-WSS-PR-A can make high-accuracy measurements over a 5- to 125-mph range. Its three-cup rotor is pressed on a stainless-steel shaft with a Delron body fitted with bronze Rulon bushings. The anemometer's output value can be calibrated and configured to the user's requirements. On the wireless side, the device powers down between transmissions to maximize battery life in the field.

Like last year, just one interconnect made it into the top 10. This time it's the SBS75x family of touch-safe, high-power connectors from Anderson Power Products. The female part is a right-angle connector that sits on the printed-circuit board (PCB). This dual-pole connector incorporates 105-A power contacts and four auxiliary power contacts for applications requiring single or low-power capability up to 20 A.

The male signal contacts on the wire side come in four lengths when sequenc-

2013 TOP 101 COMPONENTS

Rank	Product	Company	Category
73	BMA355 three-axis MEMS accelerometer	Bosch Sensortec	Sensors
74	Sfernice P16S potentiometer	Vishay Intertechnology	Passive components
75	193 PUR-SI solar capacitors	Vishay Intertechnology	Passive components
76	P105 MiniTactor	Gigavac	Switches
77	OOSD101T1402-45TS TFT display	OSD Displays	Displays
78	ASR series resistors	Stackpole Electronics Inc.	Passive components
79	Mini reed relays	Meder Electronic Inc.	Relays
80	EMH-54/3-Q48N-C dc-dc converter	Murata Power Solutions	Power sources
81	Non-contact proximity alarm	Standex Electronics	Transducers
82	Micro-SIM connector card	Molex	Interconnects
83	VLMU3100 UV LED	Vishay Intertechnology	LEDs
84	Miniature strain gauge	Vishay Precision Group	Sensors
85	FE series capacitors	AVX Corp.	Passive components
86	Family of ac-dc power supplies	Turck	Power sources
87	CCSO-914X SAW clock oscillator	Crystek Crystals	Timing devices

2013 TOP 101 COMPONENTS			
Rank	**Product**	**Company**	**Category**
88	GLV-24-150 LED power supply	Green Watt Power	Power sources
89	SBT-MicroSD-01 socket	Ironwood Electronics	Interconnects
90	OV8835 CameraChip	OmniVision Technologies	Sensors
91	HPS series pressure switches	Honeywell Sensing and Control	Switches
92	Microwave coaxial cables	Temp-Flex LLC, a subsidiary of Molex Inc.	Interconnects
93	Series 770 NCC connectors	Binder-USA	Interconnects
94	COOL-CC3 chassis	Curtiss-Wright Controls Defense Solutions	Cabinets & enclosures
95	FHD LCD module	NLT Technologies	Displays
96	Saf-D-Grid connector system	Anderson Power Products	Interconnects
97	9175/9176 series of connectors	AVX Corp.	Interconnects
98	BNO055 nine-axis sensor node	Bosch Sensortec	Sensors
99	MPA magnetic positioning sensor	Sick Inc.	Sensors
100	DF62 series of connectors	Hirose Electric Co. Ltd.	Interconnects
101	PPWA150B series of power supplies	Power Partners	Power sources

ing is required. They also provide a last mate/first break connection in relation to the power contacts. The touch-safe mating interface protects the user by eliminating finger contact with live circuits (per UL1977, section 10.2). The device saves space and increases design flexibility by eliminating the need to bring wires to the PCB. Press-fit containers on the housing secure and position the connector to the PCB prior to soldering.

FOR MORE INFORMATION

This wraps up our look at the top 10 components on this year's list. We'd also like to congratulate all of the companies whose innovative products made this year's Top 101. You can find the full roster of components in the table. The online version of the table contains links to the full product reports on *electronicdesign.com*, where you can find links to the manufacturers' Web sites and to many of the datasheets for these products. ed

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Wi-Fi And Bluetooth Rule The Airwaves

These two core wireless technologies continue to dominate short-range applications with new features and benefits.

With dozens of short-range wireless standards to choose from, engineers still defer to Bluetooth and Wi-Fi. After more than 15 years, they continue to grow, improve, and provide new features and benefits. These amazingly useful technologies both use the 2.4-GHz industrial-scientific-medical (ISM) unlicensed spectrum. Wi-Fi also has access to the 5-GHz and 60-GHz ISM spectrum.

WHAT'S NEW WITH BLUETOOTH?

The most recent version of Bluetooth, 4.0, incorporates all of its previous features but adds Bluetooth Low Energy (BLE). Also known as Bluetooth Smart, BLE uses a different set of technical and radio techniques to ensure very low power consumption compared to the original Bluetooth standard *(see "Bluetooth's Background" at electronicdesign.com)*.

BLE's data protocol was changed to support low-duty-cycle transmissions or very short transmission bursts between long periods. The low duty cycle and extremely low-power sleep modes enable BLE products to operate for many years on a coin cell. BLE also provides a group of application programming interfaces (APIs) for fast and easy application development.

BLE still operates in the same ISM license-free 2.4- to 2.483-GHz frequency band as standard Bluetooth, but it uses a different frequency-hopping spread-spectrum (FHSS) scheme. Standard Bluetooth hops at a rate of 1600 hops per second over 79 channels that are 1 MHz wide. BLE FHSS uses 40 channels that are 2 MHz wide to ensure greater reliability over longer distances. Standard Bluetooth offers gross data rates of 1, 2, or 3 Mbits/s. BLE's maximum rate is 1 Mbit/s with a net throughput of 260 kbits/s.

Also, BLE uses Gaussian frequency shift keying (GFSK) modulation. It offers a power output of 0 dBm (1 mW) and a typical maximum range of 50 meters. Security is via the 128-bit Advanced Encryption Standard (AES). An adaptive frequency-hopping technique that avoids interference, a 24-bit cyclic redundancy code (CRC), and a 32-bit message integrity check all improve link reliability. The most common network configurations are point-to-point (P2P) and star. Latency is only 6 ms.

Most low-power wireless networks are involved in consumer, medical, health, or sports and fitness applications. These mobile applications require small size and coin cell power that can function for years without attention.

Consumer applications include electronic leashes to locate people, animals, or things; proximity detection for use in iden-


Wi Fi

tification, authentication, and wireless locks; RFID-like (radio-frequency identification) cases; automatic meter reading; toys; automotive applications such as On-Board Diagnostic II connector plug-ins; home-area networks; human interface device (HID) peripherals like mice and keyboards; and game controllers.

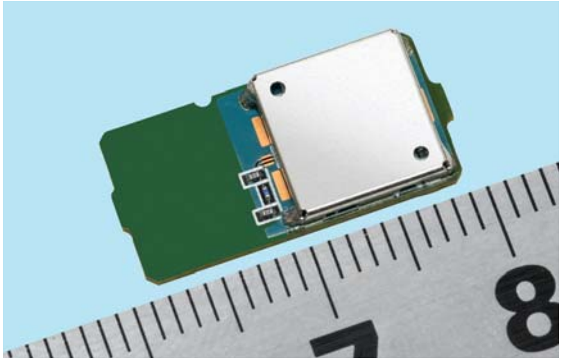
Medical and health care applications include heart-rate monitors, temperature monitors, instrumentation, and body-area networks. Similarly, sports and fitness applications include sports watches and monitors, heart-rate belts, bike computers, speed and distance monitoring, and fitness equipment.

BLE isn't compatible with standard Bluetooth, though. It is a separate radio on standard Bluetooth 4.0 chips. BLE devices do not interoperate with classical Bluetooth. But such interoperability could be implemented with a dual-mode IC that integrates a standard Bluetooth radio and a BLE radio, operating separately but not at the same time. They also can share an antenna. Dual-mode devices are available separately for low-power-only applications.

Bluetooth Smart Ready refers to the dual-mode chips of version 4.0. It handles previous versions of classic Bluetooth in addition to BLE. Bluetooth Smart is BLE only. It won't connect with any other version of Bluetooth except for Smart Ready 4.0 or other BLE devices. Classic Bluetooth is compatible with previous versions and Smart Ready devices. It won't connect with Smart devices.

Recent announcements from Apple, Google Android, and Microsoft (Windows 8) indicate software support for the new Bluetooth standards. This support will expedite connectivity with Smart devices to smart phones, tablets, and laptops.

Multiple vendors offer dual-mode and BLE chips, including Broadcom, CSR, Dialog Semiconductor, EM Microelectronics, Nordic Semiconductor, Texas Instruments, and the TTP Group. Nordic Semiconductor, for example, offers the nRF51822 BLE radio *(Fig. 1)*.



1. Nordic Semiconductor's nRF51822 Bluetooth Low Energy module can be embedded in almost any application. The radio features data rates of 250 kbits/s, 1 Mbit/s, and 2 Mbits/s with an output power of +4 dBm and a receive sensitivity of –92.5 dBm. The module incorporates an ARM Cortex M0 CPU with 256 kbytes of flash and 16 kbytes of RAM.

WI-FI REVIEW

Wi-Fi is the trade name of the IEEE's wireless local-area network (WLAN) standard, designated 802.11. A suffix at the end indicates the standard version. 802.11n is the current most widely implemented variant found in Wi-Fi access points, hotspots, and routers. Wi-Fi is also in most of today's laptops, all tablets and smart phones, and smart television sets.

The 802.11 standard defines both a physical layer (PHY) and a media access control (MAC) layer in the networking scheme. While the MAC tends to remain mostly the same, the PHY changes to include the most recent wireless technology for greater speed and link reliability.

The first generation 11b showed up in 1997 and uses direct sequence spread spectrum (DSSS) to achieve data rates to 11 Mbits/s in a 20-MHz channel in the 2.4-GHz ISM radio band. With the growth of the Internet, that low speed soon became a disadvantage.

The second-generation 802.11a appeared in 1999. It was the first to use the 5-GHz ISM band and orthogonal frequency division multiplexing (OFDM) with 64 subcarriers spaced 312.5 kHz apart. Channel bandwidth was 20 MHz, and binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), 16-phase quadrature amplitude modulation (16QAM), and 64-state quadrature amplitude modulation (64QAM) types were defined, permitting the data rate to increase to a maximum of 54 Mbits/s.

While the 802.11a version was more robust because of the OFDM characteristics that mitigated multipath reflections and the 5-GHz assignment meant less interference, the higher frequency still limited the range. This version was never too popular despite its advantages.

The big breakthrough came when the 802.11g standard was approved in 2003. It is essentially the same as 11a but operates in the 2.4-GHz band. Using the same OFDM and modulation options, it too can deliver up to 54 Mbits/s. It was immediately popular because the many IC companies competing for the business brought chip prices very low.

The current 11n standard is a further improvement over 11a/g. It adds 40-MHz channels and multiple-input multiple-output (MIMO) features to the OFDM, allowing data rates to increase to as much as 600 Mbits/s.

MIMO uses multiple receivers, transmitters, and antennas to achieve spatial division multiplexing (SDM). SDM transmits fast multiple data streams concurrently

within the same 20- or 40-MHz channel bandwidth. Pre-coding and post-decoding as well as unique path characteristics distinguish the data streams. The data rate then can be multiplied by a factor roughly equal to the number of data streams.

The 11n MIMO standard permits up to four transmit and four receive channels (4x4), although 1x2, 2x2, and 3x3 versions are more widely used. The 600-Mbit/s data rate is achieved using 4x4 MIMO with 64QAM in a 40-MHz channel.

What makes 11n so popular is its ability to carry video, enabling wireless connectivity in TV sets, DVD players, and other video equipment. Using compressed video (H.264, MPEG4, etc.), full HD signals can be transmitted reliably with the higher levels of MIMO.

The WLAN space is dominated by 11n Wi-Fi, which is available in all smart phones, tablets, and laptops. It also is the wireless technology of most hotspots and access points, including millions of home wireless routers. It's increasingly being embedded in other consumer electronics. And, it's backwards compatible with previous standards, allowing 802.11a/g equipment to be used.

2. The Texas Instruments SimpleLink Wi-Fi CC3000 BoosterPack development board and MSP430 LaunchPad evaluation kit speed the creation of Wi-Fi based IoT applications.

The latest version of the standard is 802.11ac. It isn't fully ratified yet, but it's essentially complete. Finalization is expected in 2014. It uses the 5-GHz ISM band only for minimum interference and maximum available bandwidth. Furthermore, it continues the use of MIMO and OFDM. Some key changes boost theoretical data rate in excess of 3 Gbits/s, depending on modulation, channel bandwidth, and MIMO configuration. The primary changes are its 80- and 160-MHz wide channels in addition to the usual 40-MHz channel.

As the bandwidth increases, so does the number of OFDM subcarriers to a maximum of 512 at 160-MHz bandwidth. OFDM also adds 256QAM, which further boosts data rate. And, 11ac defines a greater number of MIMO versions with a maximum of an 8x8 configuration. A multi-user version, MU-MIMO, is defined as well. The standard additionally supports coexistence and compatibility with previous 11a and 11n devices. Transmit beamforming is an option to extend range and ensure link reliability.

Products for 11ac are emerging. Routers and access points are showing up, but few user devices include it. But because of its many advantages in speed and freedom from interference, you will eventually see 11ac capability not only in laptops but also tablets and smart phones.

Another recent version of Wi-Fi, 802.11ad, uses the 60-GHz ISM band. It is backwards compatible with all previous versions, including 11a/b/g/n/ac, as the

AVAGO TECHNOLOGIES

Driving and Protecting IGBTs in Inverter

Introduction

The ACPL-339J is an advanced 1.0 A dual-output, easy-to-use, intelligent IGBT gate drive optocoupler interface. Uniquely designed to support MOSFET buffer of various current ratings, the ACPL-339J makes it easier for system engineers to support different system power ratings using one hardware platform by interchanging the MOSFET buffers and power IGBT/MOSFET switches. This concept maximizes gate drive design scalability for motor control and power conversion applications ranging from low to high power ratings.

The ACPL-339J is also integrated with short circuit protection, under voltage lockout (UVLO), "soft" IGBT turn-off, and isolated fault feedback to provide maximum design flexibility and circuit protection.

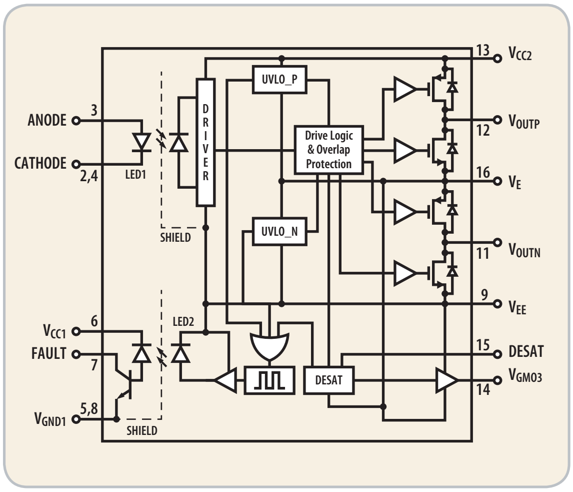


Figure 1: Functional diagram of the ACPL-339J gate drive optocoupler

Driving IGBTs

One of the key feature of gate drive optocoupler is its ability to provide high peak output current to charge or discharge the gate of the IGBT quickly to prevent switching loss. Avago's gate drive optocoupler has output current ranging from 0.4A up to 5A which can be used to drive small IGBT directly. For IGBT with higher ratings, discrete PNP/NPN bipolar buffer stage is usually used. By changing the buffer stage to MOSFET, it maximizes gate drive design scalability and power conversion efficiency.

Figure 2 shows different BIPOLAR buffers are used to drive different class of IGBTs from 50A to 600A. As the size of IGBT gets bigger, higher peak current is required at the gate of the IGBT to turn it on efficiently. The magnitude

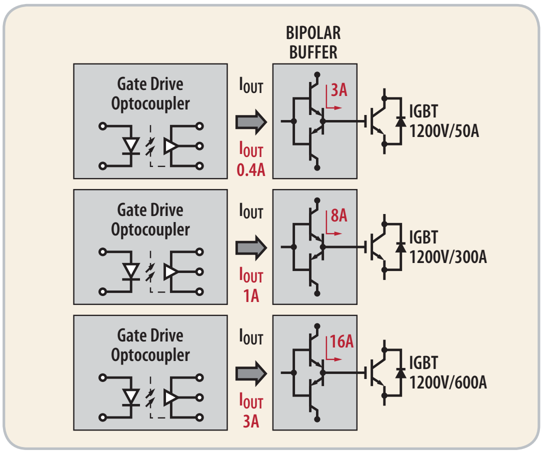


Figure 2: Gate drivers with different output currents to match BIPOLAR buffers

of the BIPOLAR's output current is a factor of its base current, I_B and the transistor current gain, β. In another words, gate drivers with different peak output currents and matching BIPOLAR buffers are needed to achieve the peak gate current required by different class of IGBTs.

MOSFET buffers on the other hand are voltage controlled devices and their current amplifications are independent on the previous gate driver stage. Figure 3 shows MOSFET buffers with different internal turn-on resistance, R_{DSON} to deliver the peak gate current required by the different class of IGBTs. Although the ACPL-339J output is specified at 1A, the switching of the MOSFET buffer will happen as long as the ACPL-339J output voltage crosses the input threshold of the MOSFET buffer.

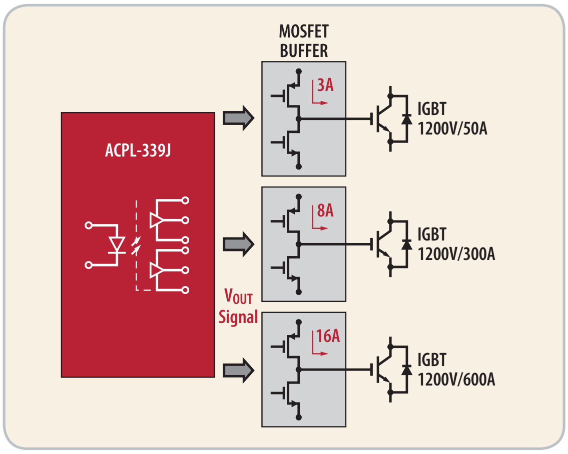


Figure 3: ACPL-339J to drive MOSFET buffer with different output current capability

The ACPL-339J makes it easier to support different system power ratings using one gate drive platform by interchanging the MOSFET buffers and power IGBT/MOSFET switches. And all these changes can be made without redesigning the critical circuit isolation and short circuit protection.

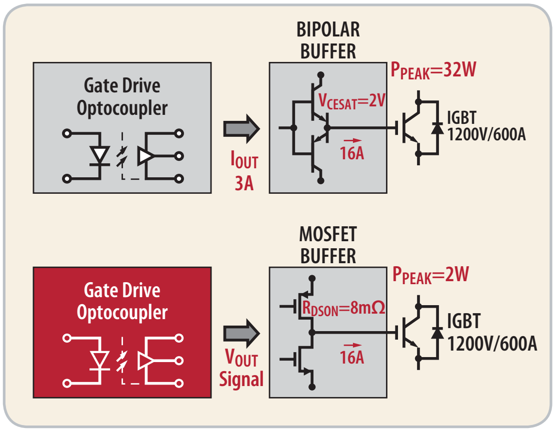


Figure 4: MOSFET buffer consumes less power and improves the overall efficiency

BIPOLAR buffer uses a compounded structure consisting of 2 or more transistor stages cascaded to achieve high current gain. The drawback is the increased in saturation voltage, V_{CESAT} and the output not able to pull to the rail. This results in high power losses when the BIPOLAR buffer delivers high peak output current to the gate of the IGBT. The power loss from the BIPOLAR buffer increase tremendously as higher peak current is needed by the gate of the IGBT.

MOSFET buffer has "rail-to-rail" output and lower internal turn-on resistance, R_{DSON} while delivering higher peak current compared to bipolar buffer. The MOSFET buffer in figure 4 shows significant power reduction when compared to the BIPOLAR buffer delivering the same peak current.

Protecting IGBTs

The IGBT's collector-emitter voltage (V_{CE}) can be monitored by ACPL-339J DESAT pin during IGBT normal operation. When short circuit occurs, high current flows through the IGBT and it comes out of saturation into DESAT mode. This causes the IGBT's V_{CE} to increase rapidly from a saturation voltage of 2V. Once its crosses the ACPL-339J's threshold of 8V, a short circuit fault is registered and soft shutdown is triggered. The ACPL-339J's V_{GMOS} pin will switch on an external transistor to slowly discharge the gate of the IGBT to achieve the soft shutdown effect. The rate of the soft shutdown can be adjusted by the size of the external transistor and resistor to minimize the overshoot at the IGBT. And lastly, the entire DESAT operation is completed by reporting the FAULT through a built-in insulated feedback path to the controller.

Summary

The concept of ACPL-339J driving MOSFET buffer helps to maximize gate drive design scalability from low to high power systems. This helps to reduce design cycle time and together with the integrated short circuit protection and feedback, the gate drive design is simplified with less PCB space and costs.

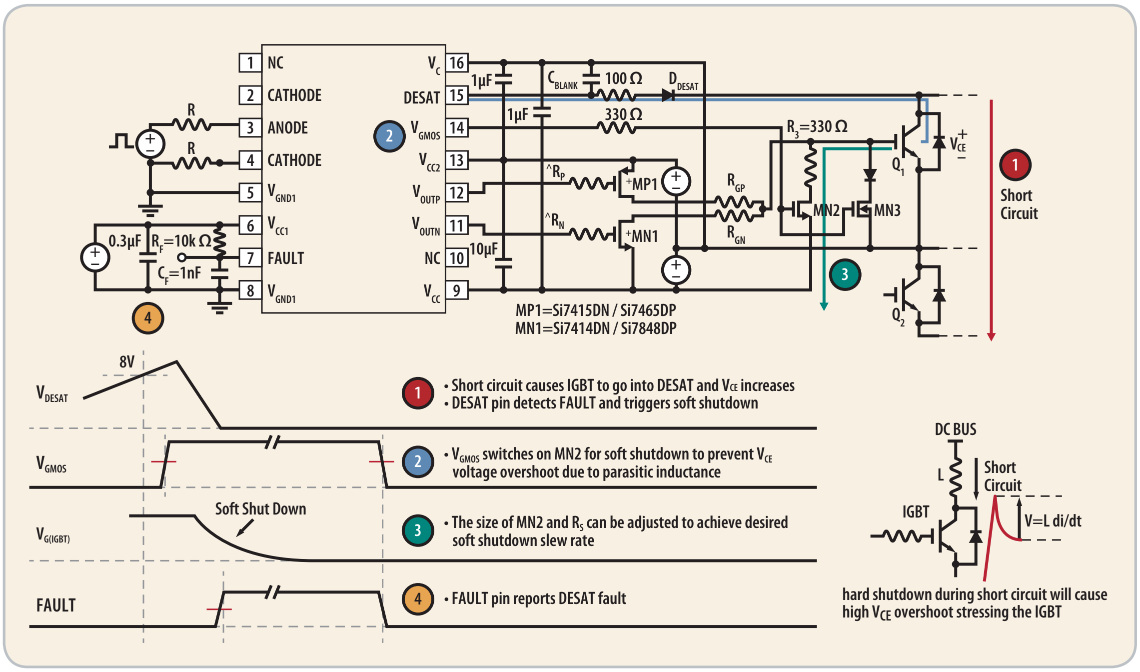


Figure 5: Short circuit protection, "soft" IGBT turn-off, and isolated fault feedback

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MAC layers of the protocol are similar. The 11ad version is also known by its trade name, WiGig. The Wireless Gigabit (WiGig) Alliance, the trade association supporting and promoting 11ad, recently merged with the Wi-Fi Alliance *(see "The Wi-Fi Alliance Ensures Compatibility" at electronicdesign.com)*.

WiGig uses the unlicensed ISM 60-GHz band from 57 to 64 GHz, dividing it into four 2.16-GHz bands. Its OFDM primary modulation scheme can support up to 7 Gbits/s, making it one of the fastest wireless technologies available. A single-carrier mode uses less power and is a better fit for some portable handheld devices, delivering up to 4.6 Gbits/s. Uncompressed video can be transmitted at both speeds. The WiGig specification also provides AES security.

Because of the small antenna size at 60 GHz, gain antennas are normally used to boost signal power and range. The maximum typical range is 10 meters. WiGig products use antenna arrays that can provide beamforming. This adaptive beamforming permits beam tracking between the transmitter and receiver to ensure that obstacles can be avoided and speed maximized even under changing environmental conditions.

One clever feature of the standard is its use of a protocol adaption layer (PAL). This software structure talks to the MAC layer and allows simplified wireless implementation of other fast standard interfaces like USB, HDMI, DisplayPort, and PCI Express.

Wi-Fi continues to be one of the most widely used wireless technologies in history. More than 1 billion Wi-Fi enabled devices were shipped in 2011, and those shipments are expected to double by 2015. Many new devices in the works are related to consumer media products, health/fitness/medical, automotive, smart meters, and automation products.

WHAT'S NEW WITH WI-FI?

The IEEE 802.11 Working Groups keep a running agenda of development. They work on the next major standard versions as well as many additions and improvements to the basic standards. The most significant standards include:

- 802.11e: provides quality-of-service (QoS) features that allow Voice over Internet Protocol (VoIP) and other critical services to be carried over Wi-Fi
- 802.11i: provides full security for Wi-Fi in the form of Wired Equivalent Privacy (WEP), Wireless Protected Access (WPA), and Wi-Fi Protected Access 2 (WPA2)
- 802.11s: brings automatic ad hoc mesh networking to Wi-Fi
- 802.11u: a protocol between access points and clients that permits internetworking with support for authentication, authorization, and accounting with network selection, encryption policy enforcement, and resource management; facilitates automatic connections and network handoffs
- 802.11y: brings Wi-Fi to the 3650- to 3700-MHz band

One of the most interesting new versions is the 802.11p standard, which will be deployed in V2x or vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) systems. These systems are part of the proposed Intelligent Telecommunications System (ITS), which provides safety and traffic information to vehicles using telematics. Called the Dedicated Short Range Communications (DSRC) wireless system, this standard is similar to the 802.11a Wi-Fi standard.

The Dedicated Short-Range Communications (DSRC) system uses the IEEE 802.11p standard and a protocol known as Wireless Access in Vehicular Environments (WAVE). The DSRC is assigned a 75-MHz segment of spectrum from 5.85 to 5.925 GHz. There are seven 10-MHz channels designated by even numbers from 172 to 184. These channels are half the size of a standard 20-MHz 802.11 channel to minimize Doppler shift and multipath fading. A European version of the system is assigned 50 MHz of bandwidth for five channels.

The spectrum permits vehicle and roadside unit (RSU) infrastructure radios to form vehicular ad hoc networks (VANETs). These dynamic networks will provide short-lived intermittent connectivity to implement various safety applications for collision avoidance and road safety. Connections are automatic. The 802.11p standard radio is half duplex with a data rate in the 6- to 27-Mbit/s range and has an estimated maximum range of 300 meters (1 km).

3. The Ruckus Wireless 7782 outdoor carrier-grade access point uses 30° and 120° antenna patterns to improve link reliability, capacity, and speed.

The WAVE protocol uses the standard PHY and MAC layer of 802.11a but uses IEEE 1609 for the upper layers including a MAC extension, a logical link control (LLC) layer, network and transport layers that include IPv6 with User Datagram Protocol (UDP) and Transmission Control Protocol (TCP), and an upper message application layer. The 1609.2 standard also provides security. Several types of short message formats have been developed for different conditions.

Then there are projects still being developed by the Task Groups, such as 802.11ah. This modification to existing standards would allow operation in sub-1-GHz bands to extend the range and implement applications such as smart meters. Another new standard in development, 11af, targets the TV white space opportunity. It seeks to meet the legal requirements for channel access and coexistence in the TV white space bands.

White space refers to the unused TV channels that are present around the U.S. The idea is to use the vacant channels for short-range data transmission. The number and location of these unused channels vary widely, so cognitive radio techniques are used to identify vacant channels that are least likely to interfere with the TV channels. A national database of TV station locations and open channels lets the cognitive radio hop to an appropriate channel. You will hear of 802.11af referred to as Super Wi-Fi or White-Fi.

The 802.11af standard defines the PHY and MAC layer for white space operation. While the standard is still under development, the basic features are defined. It uses the TV channels in the 470- to 710-MHz range, or UHF TV channels 20 to 31. The channel bandwidth is 6 MHz. The basic modulation scheme is OFDM with BPSK, QPSK, 16QAM, or 64QAM. The transmit power level is 20 dBm, and the antenna gain is 0 dBi.

These low frequencies offer exceptional range, far greater than other Wi-Fi versions in the 2.4- and 5-GHz range. Ranges to several miles are possible. Data rates will vary depending on modulation type, range, and other factors. Equipment for white spaces initially will use proprietary wireless standards. The 802.11af standard will be used with these early systems as well as another IEEE standard, 802.22.

A WI-FI FUTURE

While Wi-Fi appears to be everywhere, soon it will be even more widespread. It is already available on many airlines so passengers can connect to the Internet in flight. It is used in printers and cameras. But that's not all. Wi-Fi also is targeting the machine-to-machine (M2M) field and the Internet of Things (IoT).

Wi-Fi appears to be emerging as the wireless technology of choice in home networks and even appliances. ZigBee and Z-Wave wireless devices are already in the home, and they require some kind of gateway to connect to the Internet. Since many homes have a Wi-Fi network, it is a natural choice for home networks. Whirlpool, LG, and other companies use Wi-Fi to collect usage data on their refrigerators, washers, and other appliances.

Texas Instruments designed its SimpleLink Wi-Fi CC3000 BoosterPack to help engineers develop Wi-Fi enabled IoT products. It offers simplified Wi-Fi connectivity for microcontroller-based systems and works with TI's MSP430 and TivaC series for MCUs. The TI CC3000 module is a self-contained wireless network processor that simplifies the implementation of Internet connectivity *(Fig. 2)*.

Wi-Fi also is increasingly being deployed in factory automation, petrochemical plants, and other challenging RF environments. Enterprise-class throughput is combined with a broad operating temperature and rugged packaging to provide a reliable wireless access point for industrial users.

Carrier-grade Wi-Fi refers to ruggedized access points (APs) with special performance characteristics. The Ruckus Wireless ZoneFlex 7782 outdoor AP features 802.11n operation in the 2.4- and 5-GHz bands *(Fig. 3)*. Its internal smart antennas provide 120° and 30° patterns for improved capacity and performance.

The latest and most ambitious use of Wi-Fi is in offloading data from cellular networks. Cellular carriers are trying hard to handle the big explosion of data, like video to smart phones and tablets. The ongoing upgrade to 4G LTE is going well but takes time and capital investment. In many instances, the networks are not keeping up with the demand for speed.

Wi-Fi networks are being implemented to handle the load. When a cellular connection cannot handle the speed, the user is passed off to a nearby Wi-Fi network if one is available. Many cellular carriers are adding or expanding their own Wi-Fi networks to ensure that the offload process can occur seamlessly. The offload is not fully automatic, but work is in progress to make that happen. Carriers are discovering that Wi-Fi offload provides cheaper and faster service than LTE. Look for more hardened, carrier-grade Wi-Fi as cellular providers implement the offload option. ed

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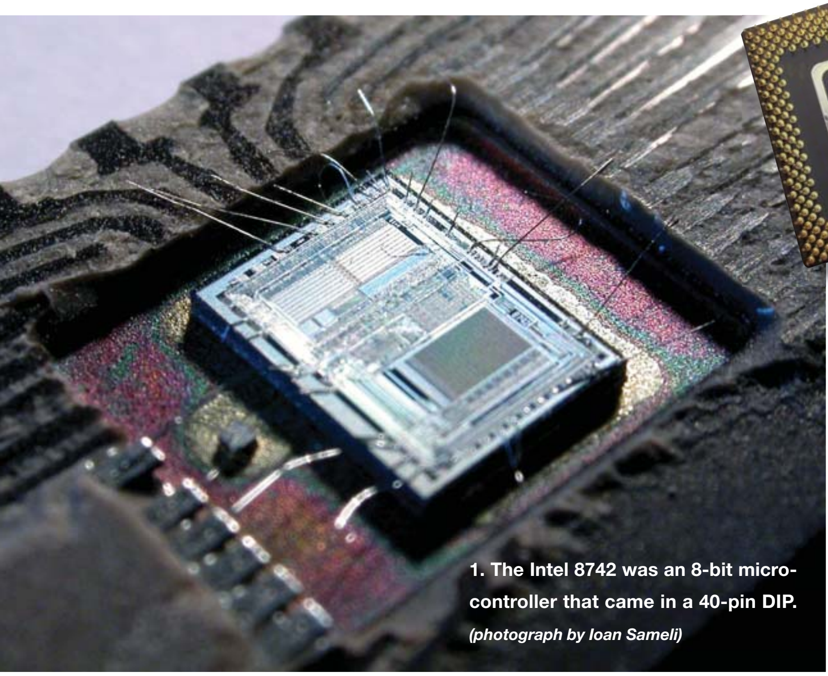
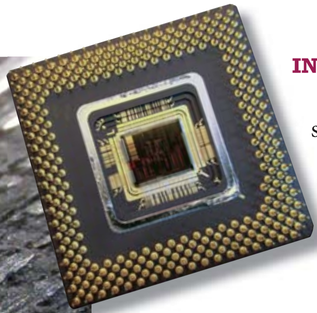
Advanced Packaging Delivers Capacity AND PERFORMANCE

High-density BGAs and 3D stacking increase compute and storage density.


1. The Intel 8742 was an 8-bit microcontroller that came in a 40-pin DIP. *(photograph by Ioan Sameli)*


2. Intel's many Pentium generations utilized a multilayer package to link the bonding wires to the I/O pins.

Chip die sizes continue to grow, as does the number of connections. The switch to high-speed serial interfaces reduced the required pin count, but that simply slowed the pin count down.

Dual inline packages (DIPs) used to be the mainstay for the electronics industry, and many applications still use them. They worked well with sockets and circuit boards. Through-hole connections allowed double-sided and then multilayer boards.

The problem is that DIPs hit limitations as they scaled down in size and the number of connections rose. These days, surface-mount technology (SMT) has become the primary way to utilize electronic components.

INSIDE THE CHIP

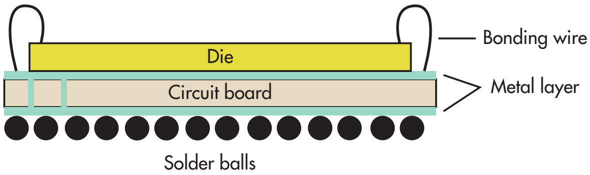
The die inside a chip are much smaller than the chip. A lead frame typically surrounds the die. Early microcontrollers were delivered in packages as large as 40 pins like the 8-bit Intel 8742 *(Fig. 1)*. The die has a large bonding pad. A bonding wire connects the pad to a lead in the lead frame that is the pin on the exterior of the chip.

DIPs limited the size of pins, but the approach still works for some surface-mount packages. For example, flat-pack packages are internally similar to the technology used on the 8742, but the exterior pins were designed for surface mounting. Dual and quad flat-pack (QFP) chips are now very common for surface-mount applications.

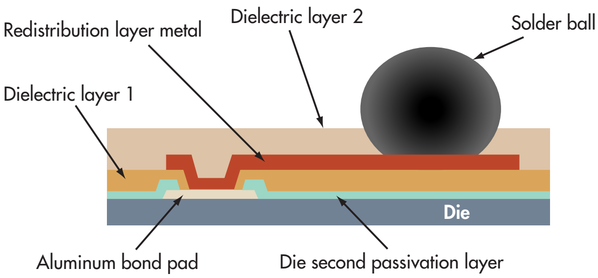
Leadless chip carriers (LCCs) essentially eliminate the leads but keep the same internal architecture. The connections are exposed on the bottom and sometimes the side of the chip. These chips allow denser circuit boards. Some LCC form factors can be mounted in matching sockets. These form factors typically were processors or more expensive components.

A single lead frame does not work well with chips that sprout hundreds of pins. A move to stacked frames like the ones used in Intel's Pentium allows more bonding wires to be connected in a smaller area *(Fig. 2)*.

Ball grid arrays (BGAs) place the chip on top of a double-sided circuit board *(Fig. 3)*. The bonding wires on top of the



3. A BGA has solder balls on the bottom of the circuit board. The die sits on top, and the bonding wires connect the die to the board. Through holes connect the top layer to the bottom.



4. Freescale's Kinetis KL02 wafer-scale package has the solder balls attached directly to the die.

die connect to a small, double-sided circuit board. Solder balls are attached to the bottom of the board, and through-holes link the balls to the pads connected to the gold bonding wires.

CHIP AND WAFER SCALE PACKAGING

BGAs are moving toward chip-scale packaging (CSP), where the die size is very close to the package size. In some cases there are cooling and power challenges.

Wafer-scale packaging eliminates the BGA circuit board and attaches the solder balls directly to the die *(Fig. 4)*. Freescale's Kinetis KL02 uses this approach. This 48-MHz, 32-bit Arm Cortex-M0+ microcontroller fits into a 1.5-mm by 2-mm package *(Fig. 5)*. The chip is so small, it can be used in medical devices that would be swallowed. Of course, using only 36 µA/MHz helps keep power requirements down as well.

COMPOUND CHIPS

A package usually includes a single die. This simplifies the overall design, and it's normally the configuration required for a chip. A larger die can address higher-density applications.

Unfortunately, moving to a larger die is not always an option. In other instances, multiple dies may be required because each die needs to be created separately. This is often the case when different technologies are required. For example, some analog or power circuits are better when they are not built on the same die as the digital components.

There are several ways to create a system-in-package (SiP), not to be confused with single inline packages (SIPs), which are simpler DIPs. Multichip SiPs come in a number of forms where multiple die can be blended in one package. We will take a look at 3D die later. 3D tends to be a much different approach than simply packaging die together.

Multichip carriers enable designers to put more than one die into the package. There are numerous multichip solutions, but in general they employ a circuit board to connect the chips together and to link them to the pins or solder balls.

Multichip carriers give designers a common pin-out but utilize different dies, possibly to provide faster processors or more memory. These chips often are used to combine processor and support chipsets so a system-on-chip (SoC) can fit into a single chip. Intel has taken this approach with a number of chips, and the company is not alone.

Another way to mix multiple chips together is to stack them on top of each other *(Fig. 6)*. The dies are not the same size, so the bonding wires can be attached to each die.

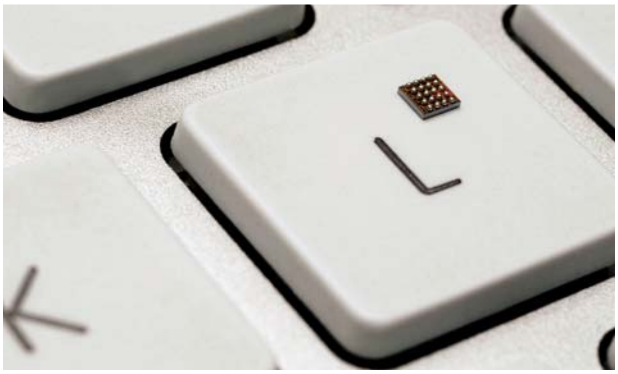
Not all die can be stacked, but the approach has proven very popular with mobile devices. Smart phones and tablets often require stacked solutions to address their small size. Apple's A4 and A5 SoC solutions for the iPhone and iPad add a memory die on top of the dual-core processor.

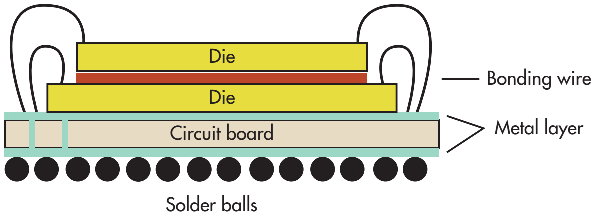
Multichip carriers and stacked die each have challenges. They are more complex to build and require exacting standards. Power distribution and heat distribution are also significant issues in most applications. The issues depend upon the chips employed and how they are utilized.

For example, multichip carriers like those used with high-end microcontrollers have die that dissipate considerable amounts of heat. Separating them in a multichip carrier enables better heat distribution to heatsinks. A stacked die would be a challenge because the heat dissipation also can affect how the die are mounted.

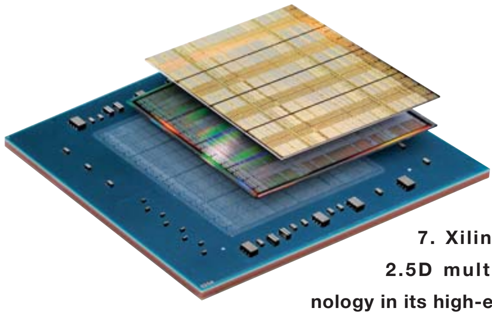
Stacked die will generate heat, which must be kept within a manageable range. That's why a smart phone can get rather warm, but it shouldn't get as hot as a processor chip within a PC. Two-level stacked die are common. Multilevel stacked die

5. Freescale's 32-bit Arm Cortex-M0+ Kinetis KL02 wafer scale package is only 1.5 mm by 2 mm.





6. Stacked die packages layer additional die on top of each other. These die are then wired together to provide a cohesive system. Designs need to address power and heat distribution due to multiple die.



7. Xilinx uses its 2.5D multidie technology in its high-end Virtex-7 FPGAs. It connects the multiple die using a metallic interposer layer.

are possible, but additional levels increase system complexity. Construction obviously requires more steps.

Multichip packages have other advantages. Each die in a package can be tested and verified prior to package construction. This makes it more likely that the package will result in a working system. Likewise, die can be binned (categorized) based on functionality and performance.

Multichip packages reduce wiring distances. Wiring density, although less than on-chip, normally is higher than off-chip wiring density. Likewise, the in-package wiring can be more efficient. It also is not as susceptible to the printed-circuit board (PCB) design. High-speed serial connections and parasitic capacitance issues tend to exacerbate these issues.

Multichip solutions are becoming more common because of the variety of technologies needed these days. Nanotechnology is often utilized for sensors like accelerometers. Developers are also looking for smart sensors and matching them up with a microcontroller. Mixing multiple sensors with the microcontroller allows sensor integration in a single package.

GOING PAST 2D

Multichip solutions result in more dense packages, but moving toward the die in terms of design can reduce size further while increasing connection density. This is important in a number of applications.

Xilinx's 2.5D technology takes this approach *(Fig. 7)*. It utilizes a 65-nm metallic interposer layer to connect up to four dies or "slices." The slices can be homogeneous or heterogeneous.

The Virtex-7 H580T employs two 28-nm FPGA slices and a high-speed SERDES slice with eight 28-Gbit/s transceivers implemented in 40-nm technology. The SERDES can be mixed with the FPGA slices, but the result is suboptimal in terms of performance and efficiency. The hybrid approach provides the best of both silicon technologies.

The interposer provides a significantly higher slice-to-slice interconnect density that would be possible using bonding wires that are in turn better than doing the same thing off-chip. There are tens of thousands of connections between slices.

Improving the design tools was paramount in producing FPGA designs that take advantage of the multislice architecture. Xilinx's Vivado design tool does this *(Fig. 9)*. It knows about the multislice nature of the Virtex-7 as well as how the interconnects link the slices together.

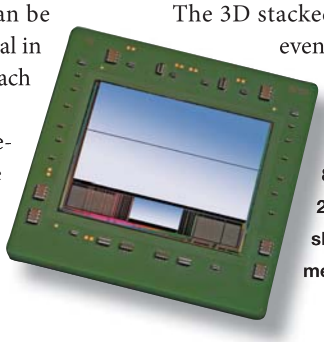
The 2.5D interposer approach is similar to the multichip carrier except on a much smaller, finer scale. The approach works very well with FPGAs that need a high-density slice-to-slice interconnect. This more regular interconnect approach could be applicable to mixing other array-style dies such as memory die including DRAM and flash or other non-volatile storage. Here the wide parallel connects would be more efficient, eliminating the transceivers and SERDES now found in many high-density memory interfaces.

The approach would be more challenging for mixed logic slices since the technology is relatively new. Still, the approach would be a good way to mix a hard-core processing slice with a set of FPGA slices and high-speed SERDES. Nothing like this has been announced yet, and it will be at least a couple of years before it might occur.

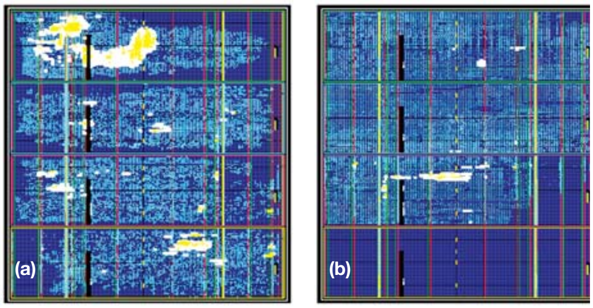
3D MEMORY STACKS

Stacked die are one form of die-on-die packaging technology that has a long track record. Stacked 3D solutions also are emerging. They employ through-silicon vias (TSVs) to create a true 3D chip. They have the advantage in terms of connection density and efficiency, but they do have heat and power distribution issues like the stacked-die approach. Power has to be distributed through the die to the next one above. The same is true for heat.

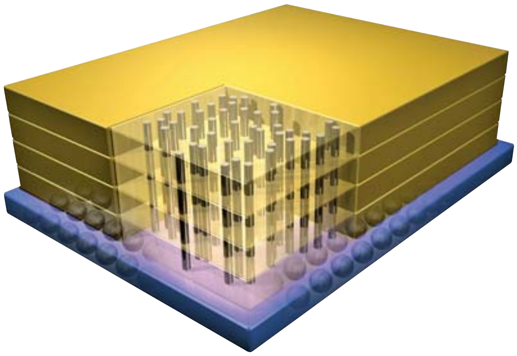
The 3D stacked chip holds a lot of promise and may eventually be as common as multilayer PCBs are now. For now, memory solutions are taking advantage of this approach.



8. The Xilinx Virtex-7 H580T employs two 28-nm FPGA slices and a high-speed SERDES slice with eight 28-Gbit/s transceivers implemented in 40-nm technology.



9. Xilinx's Vivado design tool accounts for the multislice nature of the Virtex-7 when turning an initial layout (a) into an optimized layout (b).



10. The Hybrid Memory Cube (HMC) stacks multiple memory die on top of a logic layer. The die are stacked on top of each other, and they are connected via though-silicon vias (TSVs).

The Hybrid Memory Cube (HMC) Consortium has delivered its first specification, which defines an architecture with a logic layer and multiple, identical memory die stacked on top of it in a 3D TSV configuration *(Fig. 10)*.

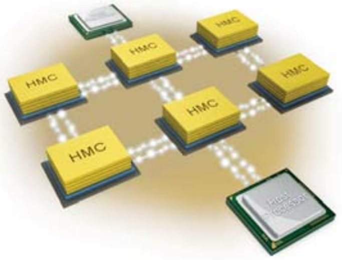
The logic layer provides the access mechanism to the memory die and the high-speed serial interface to the outside world. The approach eliminates the bonding wires found in stacked die solutions using TSVs for connections between memory chips and to the logic layer. An HMC has four or eight memory die. A board designer will only need to contend with the capacity and standard interface in a fashion similar to DRAM modules today.

There are architectural differences between a DRAM module and an HMC. DRAM modules are designed to work with a single host, although that host may be part of a multicore NUMA system. HMCs are designed to work with multiple hosts and can be employed in an array *(Fig. 11)*. An array of HMCs increases the capacity potential but also the system's bandwidth potential. A host attached to any point of the array has full access to the entire memory.

Multiport support of a single HMC has design implications for multihost environments such as network switching. It simplifies host memory management and provides scalable support that would otherwise require more complex host designs like those found in high-end, multicore processors.

The multiport HMC interface uses high-speed serial links like PCI Express but with its own HMC protocol. It is scalable by lane like PCI Express, and a single HMC chip can support hosts with different link requirements. The interface is host agnostic, although a host will obviously need an HMC interface. This should be a software design exercise for FPGAs.

HMC represents a major change in memory architectures. It should be able to provide a 15x bandwidth increase compared to DDR3 while cutting power per bit by 70%. The 3D architecture reduces the memory footprint by 90%. Of course, the memory system should have a lower latency and higher availability than existing memory solutions.



11. HMCs can be connected in an array to increase density and throughput with a number of hosts.

Companies like Micron hope to deliver HMC chips soon *(Fig. 12)*. Initially, HMC is targeting high-performance applications such as networking and servers. Thicker chips will stand out , but initially they will be much like packages already found on systems. Standard pin-outs will make designing with HMC chips easy with multiple sources for the hardware. HMC hardware will be available in the next year or so.

HMC targets DRAM. In the future, it could address nonvolatile storage. Designers are mixing flash and DRAM like Viking Technology's ArxCis-NV hybrid DDR3 DRAM module, which also incorporates flash backup storage. It might simply be a matter of adding flash memory die to the HMC stack. ed


12. The HMC package is designed to deliver a 15x performance improvement over existing DDR3 modules while using 70% less energy.

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Matterform Founders
Discuss Their 3D Scanner

Even the mainstream media has been covering 3D printers and how they are going to revolutionize manufacturing, especially for small businesses *(see "Tap New Technologies To Produce Practically Perfect Prototypes" at electronicdesign.com)*. So if 2D printers have 2D scanners, why shouldn't 3D printers have 3D scanners? The Matterform 3D Scanner costs less than $600 *(see the figure)*. Company cofounders Adam Brandejs and Drew Cox explain the technology.

WONG: Tell me about the scanner.

MATTERFORM: It's the world's first truly affordable 3D scanner for anyone! It allows you to take a physical object and turn it into a digital 3D model on your computer. From there, you can print your file on any 3D printer or online printing service or use the model you created in an animation or video game. It's lightweight, portable, and compact, making it easy to integrate into your workspace. Anyone can use it. End of story. Unfold it, plug it in, place an object on the scan bed, and press go! It's that simple. Really.

Not only is it the first affordable 3D scanner, but for the first time ever in the home 3D makerspace comes a product that you can actually be proud to have on your desk. Long gone are the days of laser-cut wood and threaded rod projects. Get creating and scanning right out of the box. When not in use, the scanner easily folds and tucks away on a shelf, and because of the built-in handle it also makes it easier for you to transport it should you ever want to.

Its high-resolution scan is created with a high-definition camera and dual lasers. All scanners are fully assembled and tested prior to shipping. There are no kits here. Its easy folding design makes storage or transport simple. Multiple quality settings can be chosen, but an average scan is 3 minutes. Scan objects up to 190 mm by 190 mm by 250 mm (7.5-in. diameter and 9.75-in. height). Dual stepper motors provide full software control over the scan bed and the z-axis. See the point cloud being captured in real time!

WONG: How does it work?

MATTERFORM: The unit works from a standard 5-V dc power supply and is connected to the PC via a single USB 2.0 connector. The software was designed from the ground up and works seamlessly with the hardware. Free to use and download, the software is available for PC, Mac, and Linux. Whether you've used 3D software before or if you're just getting into it now, you'll find the software was designed to be as easy as possible. After a one-time setup, scanning becomes as easy as one click. We know you want to spend your time creating things and being creative, not calibrating, tweaking hardware, or figuring out yet another tool.

Because the scanner is one solid desktop device, the objects you scan are accurate and precise. Unlike software-based solutions, it gives dimensional data, making 3D scans far more useful. We're aiming to make the 3D files compatible with all major CAD packages, 3D modeling software, and 3D printers. Currently, models produced from the

The low-cost Matterform 3D scanner is the ideal complement for 3D printers.

scanner can be saved as .STL, .OBJ, and point cloud .PLY formats, making it easy to integrate scans within existing systems, such as 3ds Max, Maya, SolidWorks, Cinema 4d, Google SketchUp, Rhino, and TrueSpace.

Currently the resolution of the scannner, on a 4-in. figurine, is 0.43 mm at 0.5° scans, with an accuracy of ±0.2 mm. We're quite excited about the current results and are working every day to continue improving the resolution.

WONG: How does the scanner compare to other alternatives?
MATTERFORM: Other alternatives start at $3000, so the Matterform 3D Scanner is by far the cheapest.

WONG: You used crowd funding to get started. How has that worked out?
MATTERFORM: Very well. We've achieved over five times our goal with over $400,000 contributed so far.

WONG: What future enhancements might be in the works?
MATTERFORM: Many! Including color. ed

ADAM BRANDEJS (left in the photo) is a programmer, sculptor, Eagle PCB junky, hacker, and maker. He has been making things all of his life, from robots and code to sculptural art that tours art galleries all over the world. He was dry walling at 7, picked up his first soldering iron at 10, was programming Commodore 64s at 12, picked up 3DS Max r2.5 in high school, fixed everyone's computer during university, and spent a few years in advertising making Web sites for Audi, Coca Cola, Budweiser, and countless other big name companies.

DREW COX (right in the photo) has been an entrepreneur since he was 18 and making things since he could move his hands. Professionally, he has been a programmer, artist, art director, and graphic designer. Unprofessionally, he is an inventor, hacker, and mad scientist. His career path has led him to help build brands like Labatt, Budweiser, Audi, Honda, and Coca Cola. His hobbies and passion have brought him to respect the names of Prusa, Sherline, Arduino, and every person who has ever contributed to open source projects.

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Transaction-Based Verification And Emulation Combine
For Multi-Megahertz Verification Performance

Transaction-based verification is becoming the emulation mode of choice because of its unique ability to keep pace with the growing verification support requirements of the latest high-performance, industry-standard interfaces.

Design complexity has grown with each successive generation of system-on-chip (SoC) evolution. SoCs now include many industry-standard interfaces, multiple processor cores, on-board memories, and embedded firmware and software. With this growth, we've seen verification complexity grow exponentially, driving engineers to seek advanced verification methodologies.

While in-circuit emulation (ICE) promises megahertz verification performance, its dependence on protocol-specific rate adapters combined with the sheer number of high-speed, protocol-specific physical interfaces has proven to be a recent challenge for today's advanced designs. Transaction-based verification (TBV) holds the key to bridging the performance of emulation with the flexibility and simplicity of simulation.

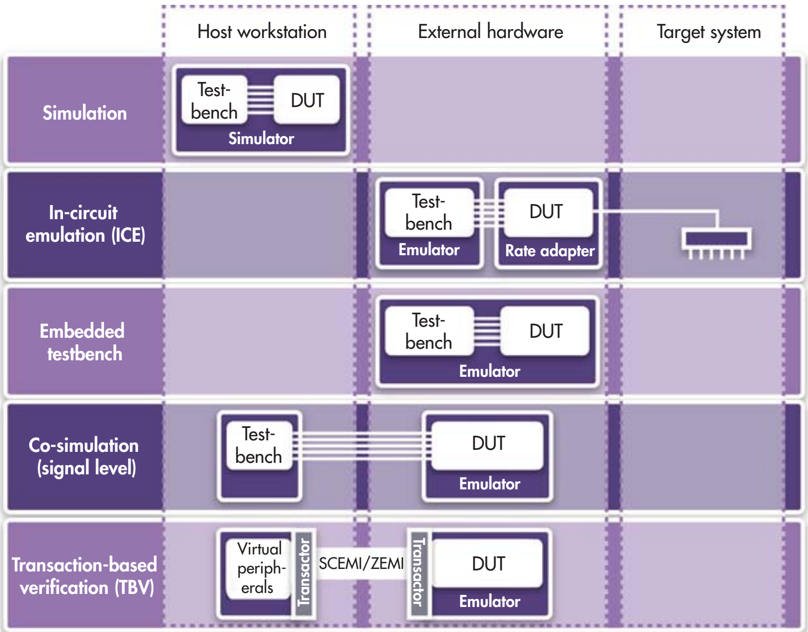
By adopting accelerated transaction-based emulation strategies, designers can move their verification strategy up a level of abstraction and achieve the leap forward in verification performance and productivity that is necessary to fully debug and develop the most complex electronic hardware and software-based systems. Different use modes are available in today's emulation systems, and TBV is becoming the preferred emulation mode for achieving multi-megahertz verification performance.

SIMULATION

Today, simulation continues to be the workhorse of complex verification. Most verification is done using simulation, finding more than 95% of bugs. Simulation usually runs on a single workstation, and its environment consists of two components: the design under test (DUT) and the stimuli generator—the testbench *(Fig. 1)*.

With simulation, the design runs at a wire level and is clock accurate, which means there is a wire-level interface between the testbench and the DUT. For a full chip, these wires may be the device pins. With the addition of various monitors and checkers, the interface between the DUT and testbench can grow to include thousands of wires.

Simulation is still what's used for most register transfer level (RTL) development and design. Nevertheless, for designs requiring hardware/software co-verification, as well as those



1. This graphical description of the most commonly used emulation modes highlights the location of the testbench, the design under test, any rate adapters and physical interfaces, and potential performance bottlenecks.

utilizing many industry-standard protocol interfaces, maximum verification performance is required. Simulation performance is often limited by the performance of the host PC or workstation on which it executes. A large SoC, designed to run at 1 GHz, may clock at 1 Hz or less in simulation on a standard PC.

To put that into perspective, if the operating-system (OS) boot-up sequence for a cell phone, whose processor is running at 1 GHz, were to take 10 seconds, the same boot-up sequence, simulated on a host PC at 1 Hz, would require 1 billion seconds (317 years). Very few design teams enjoy a project schedule that can accommodate that.

As a result, more and more design teams are adopting some form of hardware-assisted verification. Today's high-performance emulators run very fast and support many operating modes. Synopsys' Zebu, for example, reduces the boot-up time for the above example from more than 300 years to less than an hour with its transaction-based verification mode.

IN-CIRCUIT EMULATION

The first widely used emulation platforms were introduced in the early 1990s and were limited to ICE. With ICE, the idea is to eliminate the host PC or workstation, which was (and still is) the performance bottleneck. First, the DUT is moved from the host PC to dedicated emulation hardware. Next, a live "target system," or a physical device, replaces the PC-based testbench.

A physical cable connects the two. The cable is often plugged into the very socket that the SoC will eventually plug into. This combination eliminates the host workstation or PC, allowing the design to run several orders of magnitude faster, typically at the maximum performance of the emulator itself.

ICE is not without its challenges, however, as an emulator is rarely fast enough to run at the same speed at which a target system would normally operate. In the early days, the entire target system had to be slowed down to match the speed of the emulator. This tended to be very complicated, and many devices, such as disk drives, simply could not be slowed down. Thus, rate adapters were introduced.

A rate adapter acts as a buffer, collecting all the required information from the DUT and—once the data (wire-level signal changes) is sufficiently cached—sending it at real-time speed to the target system. It also captures data from the target system at full speed, caches it, and then plays it back at emulation speed to the DUT.

While this approach works well for fairly simple protocols, today's SoCs include many complex, high-speed interfaces, each of which would require a rate adapter to be connected to an emulator. Even when a rate adapter is available, the constant evolution of speed and complexity of individual protocols (such as SATA2 versus SATA3) has made timely rate adapter development difficult. Speed requirements alone typically delay, and in more recent cases eliminate, the availability of rate adapters for the latest protocols.

Another characteristic of ICE is the simple fact that the physical devices connected to the emulator often require an operator to be physically present—for example, to push a reset switch or power-cycle the target system. This makes it difficult to leverage an emulator that is centrally located.

EMBEDDED TESTBENCH

In an attempt to leverage the existing simulation environment, as well as to avoid some of the limitations of ICE, many design teams in the mid-1990s adopted an embedded testbench approach that moves the entire simulation testbench onto the emulator. This eliminates the physical interfaces required by ICE, and with them, the need for rate adapters.

Unfortunately, such a testbench must be synthesizable to be loaded onto an emulator. Because virtually no simulation testbenches are synthesizable in today's advanced verification environments, this method is limited in use.

A variation (special case) of this approach is commonly used today. Leveraging the emulator's large reserves of physical memory, designers load this memory with system software, such as firmware, drivers, or an entire OS. The DUT's embedded processor can then run that software directly as if it were running in the actual system, effectively making the software a testbench. This approach is relatively simple to implement, and since there are no physical connections, the emulator runs at its highest level of performance

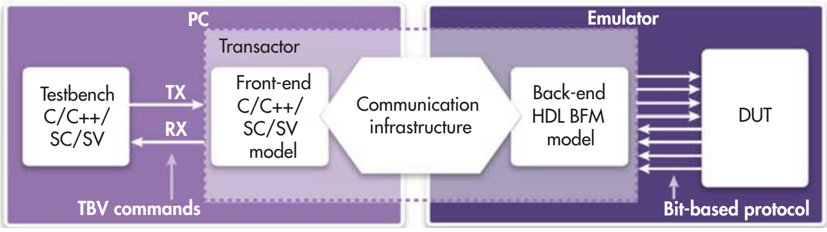
As the software is only being run through the processor, this approach still lacks the ability to test interfaces between different chip protocols. Additionally, because it requires a fairly complete processor implementation, it can only be used relatively late in the design cycle. As a result, it is generally best suited for late system-level hardware verification and early hardware/software bring-up.

CO-SIMULATION

With co-simulation, also called simulation acceleration, the DUT is moved to the high-performance emulator as with the other use models. The testbench, though, remains on the host PC or workstation. A wire-level interface connects the two.

This verification approach is very straightforward, as it leverages the existing simulation testbench and eliminates the need for external rate adapters. However, the actual verification performance is heavily limited by the performance of the host PC, the complexity of the existing testbench, and/or the wire-level interface between the testbench and the DUT.

In a typical verification environment, there are thousands of signals at the interface, with many changing multiple times within each clock period. With wire-level co-simulation, each signal must be transferred between the testbench and DUT on



2. In the transaction-based verification environment, the back-end portion of the transactor and the DUT, which remains unchanged, are located within the emulator. This requires that they both be written with synthesizable RTL.

every transition. Even though the emulator can run orders of magnitude faster, it must wait for these transfers to complete.

In addition, the emulator will often be stalled by the performance of the testbench itself. If tightly coupled to the testbench, which is common in pure simulation environments, the emulator will quickly stall, waiting for the slower testbench to react to incoming signals and produce the next set of stimuli. As a result, most designers do not use this mode for general verification. But they do use it as a stepping stone (to validate the DUT functionality on the emulator) for TBV.

TRANSACTION-BASED VERIFICATION

TBV raises the level of verification abstraction away from a wire-level interface to run thousands to a million times faster than simulation on a host PC. It simplifies the communication between the testbench and DUT so a design team can access the full performance benefit of the emulator.

With TBV, like co-simulation, the DUT is loaded onto the emulator, and the testbench resides on a host PC. But instead of a wire-level interface, TBV uses a high-performance interface using transaction-level protocols that are executed on the emulator. This transaction-level interface allows the testbench to be tightly or loosely coupled to the DUT.

The communication between the testbench, now working at a protocol level, and the DUT, which still requires a wire-level interface, is accomplished through a transactor. The transactor converts the high-level commands from the testbench into the wire-level, protocol-specific sequences required by the DUT, and vice versa. The key is that all the wire-level communications are wholly contained within the emulator itself and run orders of magnitude faster as a result *(Fig. 2)*.

Another key difference of transaction-based verification is that the transaction-level interface allows the testbench to stream data to the DUT, which the transactor buffers automatically. This speeds up the execution of the testbench. With this methodology, it is also possible to have multiple transactions active across multiple transactors. Together, these transactors enable the emulator to process data continuously, which dramatically increases overall performance to that of a pure ICE environment. As noted earlier, this is orders of magnitude faster than any wire- or pin-based verification approach.

Beyond performance, TBV offers designers several other advantages. Primarily, it eliminates the need for rate adapters and physical interfaces. With TBV, each physical interface is replaced with a transaction-level interface. Likewise, the rate adapter, required for ICE, is replaced with a protocol-specific transactor.

Unlike rate adapters, transactor models for the latest protocols are readily available off-the-shelf and are easily upgraded to accommodate protocol revisions. Synopsys today, for example, provides vast libraries of transactors for standard interface protocols as well as tools to enable the development of custom, proprietary transactors.

It is also possible to create an emulation-like environment by using transactors to connect the DUT to "virtual devices." A virtual device is simply a soft model of a device that runs on the host PC. A design using an HDMI transactor to test an HDMI interface, for example, would be able to leverage the same transactor to connect to an HDMI virtual display. This would allow the engineer to see the video output from the

DUT just as if it were connected to a physical monitor, without the need to physically connect to an actual monitor.

Some of today's virtual devices are bridges that provide connectivity to the actual physical device, but via the host PC (and a transactor). A USB bridge, for instance, connects a physical USB device, such as a memory stick, to the USB port of the host PC. As designed, the DUT only sees the USB drive and behaves accordingly once it detects the presence of the flash drive (for example, it installs a driver, if the OS is also being emulated).

An additional distinction of TBV is remote accessibility. As there are no physical interfaces connected to the emulator, a user can fully use and manage the emulator from anywhere in the world. When combined with virtual devices such as video displays, protocol analyzers, and audio processors, this distinction is very obvious.

A user from anywhere in the world can remotely view a virtual display. An ICE user, on the other hand, would need to be in the same room with the TV, which is cabled directly into the emulator. Remote accessibility is also available when connecting the emulator to an architectural model environment, such as Synopsys' Platform Architect and/or Virtualizer, which would also be done through a transaction-level interface.

A transactor consists of three parts: the front-end interface, a back-end RTL bus-functional model (BFM), and a physical communications channel.

The front-end interface is typically a behavioral model that runs on the host PC and interfaces to the testbench, usually through Direct Programming Interface (DPI) calls. It is written in C/C++, SystemC, or System Verilog. This piece converts high-level transaction-level commands and sends them across the physical interface protocol using either the Standard Co-Emulation Modeling Interface (SCEMI) standard or the Zebu Emulation Modeling Interface (ZEMI) language.

The interface channel between the front-end interface on the host PC and the BFM on the emulator may be implemented at the physical level using any high-performance interface standard such as PCI Express. A standard TBV protocol, such as SCEMI or ZEMI, runs on top of this physical interface. This protocol is transparent to the user.

The back-end hardware description level (HDL) BFM runs on the emulator and interfaces with the communications channel to send and receive transactions. Here, the transactions are converted to a wire-level interface that interacts with the DUT. Because the BFM resides on the emulator, it must be fully synthesizable. The BFM also must adhere to the target interface protocol and therefore must be fully functional.

So, as an example, the BFM would receive the high-level transaction command "read file" from the channel and convert it to the precise, cycle-accurate, wire-level handshake sequences that a physical direct memory access (DMA) controller, located within the emulated DUT, would need.

TBV IN THE DESIGN FLOW

TBV can be used throughout the flow, from the block level and beyond. Common applications include:

- Debug and verification of large blocks, subsystems, or complete SoCs
- Driver development or system-level verification when combined with virtualization
- Early hardware/software bring-up, including firmware, drivers, and OSs
- Full-chip power analysis and estimation
- System-level hardware/software co-verification or early software development when connected to prototyping hardware

CONCLUSION

TBV with emulation offers design teams a unique opportunity to accelerate SoC verification. By raising the level of abstraction of their verification environment, teams can achieve multiple orders of magnitude improvement in their verification performance. With TBV, designers have access to a platform that delivers megahertz performance for block- and system-level verification, as well as early hardware/software bring-up.

The use of transactors delivers all the benefits of in-circuit emulation without the challenges of rate-adapter availability and physical accessibility. When combined with virtual interfaces and system-level virtual models, TBV with emulation can be used throughout the verification cycle, with worldwide 24x7 access.

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Graphical, Numerical Techniques Size LED Array's Drive

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LED-BASED LIGHTING IS REPLACING incandescent and gas-discharge lamps in many situations. As practical lighting sources, and considering their directional nature, LED fixtures usually use multiple LEDs arranged in an array, with "m" LEDs in a serial string and "n" such strings in parallel *(Fig. 1)*. For the array configuration and the exponential I-V characteristics model of a single LED,[1] it's additionally possible to have a similar model representing the loading of such an array.

Since the single LED is a diode with a nonlinear forward-voltage/current, driving it with a fixed voltage source is generally not recommended. Rather, a serial (current-limiting) resistor is needed to equalize the power source and the load *(Fig. 2)*. However, sizing this resistor requires a significant analytical manipulation. Using the single-LED exponential model, a Kirchoff's voltage law (KVL) equation around the circuit loop gives:

$$R_x\left(ae^{bV_F}+c\right)+V_F=V_s \quad (1)$$

which can be rearranged to:

$$R_x=\frac{V_s-V_F}{ae^{bV_F}+c} \quad (2)$$

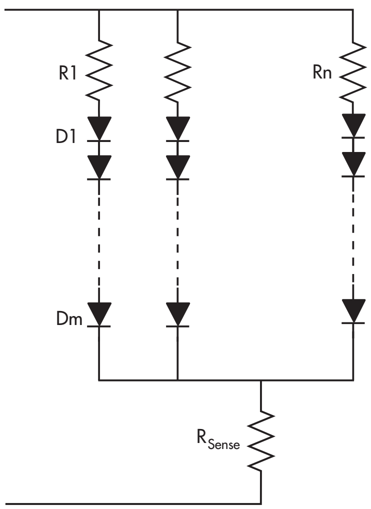
where a, b, and c are model parameters for a selected LED, as defined in the reference.

This is a challenge to solve symbolically, but it can be solved numerically with mathematical software tools. Alternatively, it can be solved graphically by separating the two key I-V relationship equations, $v + R_xI_F = V_s$ and $I_F = ae^{bv} + c$.

For example, using a Lumileds Luxeon Rebel ES LED with a 3.2-V dc source and a desired drive current of 0.5 A, the horizontal current line intercepts the LED curve at 2.92 V *(Fig. 3)*. Therefore, the series resistor will be $R_x = (3.2 - 2.92)/0.5 = 0.56\ \Omega$.

However, the graphical approach would not handle an LED array effectively, and the numerical method works better. To represent the array current i_A, the exponential model for the (m × n) array is modified, since voltage drops across current-limiting resistor R_n and sense-resistor R_{Sense} are usually small compared with driving-source V_s:

$$i_A=n\left(ae^{b\frac{V_s}{m}}+c\right) \quad (3)$$



1. Establishing the correct resistor size for each string of an array of n strings, where each strings has m LEDs, is challenging due to the nonlinear nature of the diodes.

With the array model, the switch-mode buck-regulating current driver in a closed-loop configuration *(Fig. 4)* can be described by a set of equations starting at the feedback point, circling around the control loop, and ending at the driver output:

- Current sensing:

$$V_f = i_A \bullet R_{Sense} \quad (4)$$

- Error amplifier:

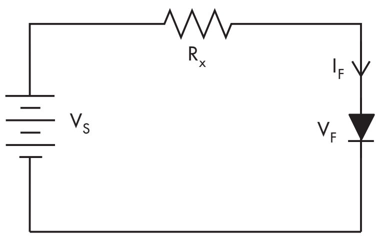
$$V_{er} = A(V_{Ref} - V_f) \quad (5)$$

- Effective error:

$$V_{ef}=\frac{V_{er}-V_F}{R_d}\bullet CTR\bullet R_e \quad (6)$$

- PWM ramp:

$$V_{Ramp}(t)=V_{Min}+\frac{V_{Max}-V_{Min}}{0.95\bullet T_s}t \quad (7)$$



2. Even for a single LED driven by a voltage source, the exponential current-voltage relationship complicates selection of the series-resistor value.

DESIGN NOTES

1µA I_Q Synchronous Boost Converter Extends Battery Life in Portable Devices

Design Note 516

Goran Perica

Introduction

Boost converters are regularly used in portable devices to produce higher output voltages from lower battery input voltages. Common battery configurations include two to three alkaline or NiMH cells or, increasingly, Li-Ion batteries, yielding a typical input voltage between 1.8V and 4.8V.

The 12V output converter shown in Figure 1 is designed to run from any typical small battery power source. This design centers around the LTC®3122 boost converter, which can efficiently generate a regulated output up to 15V from a 1.8V to 5.5V input. The LTC3122 includes a 2.5A internal switch current limit and a full complement of features to handle demanding boost applications, including switching frequency programming, undervoltage lockout, Burst Mode® operation or continuous switching mode, and true output disconnect. The integrated synchronous rectifier is turned off when the inductor current approaches zero, preventing reverse inductor current and minimizing power loss at light loads.

This unique output disconnect feature is especially important in applications that have long periods of idle time. While idling, the part can be shut down, leaving the output capacitor fully charged and standing by for quick turn-on. In shutdown, the part draws less than 1µA from the input source.

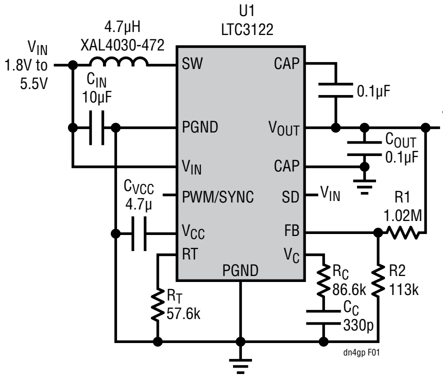


Figure 1. The 1MHz Operating Frequency and Small Inductor Make This Converter Suitable for Demanding Portable Battery-Powered Applications.

Because the batteries used in portable devices are usually as small as possible, they present high internal impedance under heavy loads, especially close to the end of their discharge cycle. Unlike other boost converters that struggle with high source impedance at startup, the LTC3122 prevents high surge currents at startup.

1.8V to 5.5V Input to 12V Output Boost Regulator

The circuit in Figure 1 is designed for high efficiency and small size. The LTC3122 operates at 1MHz to minimize the size of the filter capacitors and boost inductor, and uses Burst Mode operation to maintain high efficiency at light loads, as shown in Figure 2. At heavier loads, the converter can operate in constant frequency mode, resulting in lower input and output ripple. Constant frequency operation can result in lower EMI and is easier to filter.

Efficiency can be increased by running the LTC3122 at a relatively low switching frequency. Figure 3 shows the results of reducing the switching frequency from 1MHz to 500kHz.

Efficiency can be improved further by increasing the inductor size. Figure 4 shows the increase in efficiency

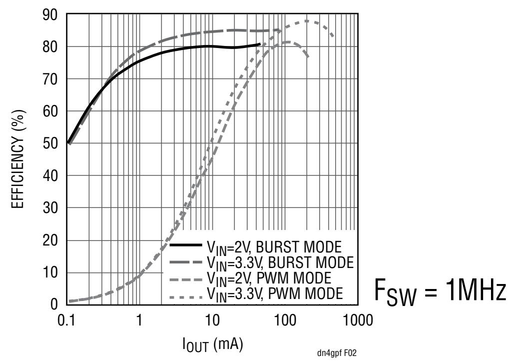


Figure 2. The High Efficiency of the LTC3122 Boost Converter Extends Battery Life in Portable Applications.

achieved by replacing the 4mm × 4mm boost inductor (XAL4030-472) with a 7mm × 7mm inductor (744-777-910 from Würth). The 90% efficiency at 10mA is 5% higher than the efficiency shown in Figure 3.

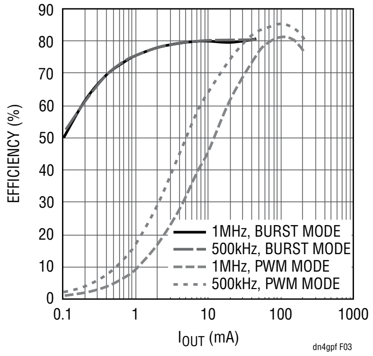


Figure 3. The Efficiency is Greatly Affected by the Operating Frequency. At 100mA Load an Additional 4% Can Be Gained by Reducing the Switching Frequency from 1MHz to 500kHz.

Battery size should be taken into account when considering inductor size. Using a relatively small inductor running at a high frequency may necessitate a correspondingly higher capacity battery to achieve the same run time at relatively lower efficiency. In other words, space gains achieved with a smaller inductor may be replaced by the need for a bigger battery.

Output Disconnect

Typical boost converters cannot disconnect the output from the input because of the boost diode. Current always flows from the input through the inductor and boost diode to the output. Therefore the output can not be shorted or disconnected from the input, a significant problem in many applications, especially in shutdown. In contrast, the LTC3122 includes an internal switch that disconnects the boost MOSFET body diode from the output. This also allows for inrush current limiting at turn-on, minimizing the surge currents seen by the input power source.

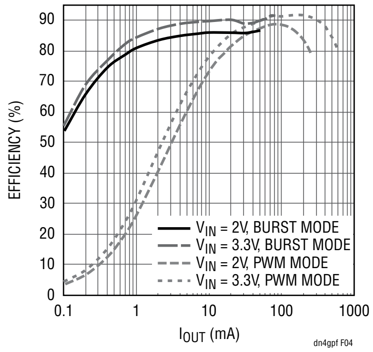
Figure 5 shows the output of the LTC3122 disconnected in shutdown. The output voltage is pulled to zero by the load following shutdown, and the LTC3122 consumes less than 1µA of current.

Start-Up Inrush Current Limiting

To simulate a real battery-operated application, the circuit in Figure 1 was tested with 1Ω of equivalent series resistance (ESR) placed between the power source and the LTC3122 circuit. Once the LTC3122 is enabled, it controls the startup so that the input power source can lift the output rail to regulation. The input current slowly ramps up. The input current overshoot required to charge the output capacitor is limited to only 200mA and the input power source voltage droop is limited to 0.5V, as shown in Figure 5.

Conclusion

The LTC3122 boost converter serves the needs of battery-operated applications that require low standby quiescent current and high efficiency. Unlike many other boost converters, it includes features, enabling operation from batteries near full discharge when battery ESR becomes high. Its very low quiescent and shutdown currents, combined with output disconnect, extend battery run time in applications with long idle periods. The LTC3122 includes a complete set of features for high performance battery operated applications and comes in a small, thermally enhanced 3mm × 4mm package.



F_{SW} = 300kHz

Figure 4. With a Lower Switching Frequency and a Larger Inductor, a Smaller Battery Can Be Used. Efficiency Gain Up to 30% in the 1mA to 10mA Load Range (in PWM Mode) Can Significantly Improve Applications That Operate with Light Loads.

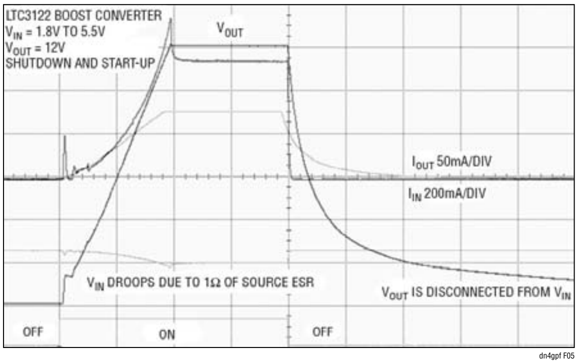


Figure 5. Inrush Current Limiting at Turn-On Minimizes Surge Currents Seen by the Input Source. The Output Is Disconnected from Input During Shutdown.

Data Sheet Download

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• Duty cycle, D:

$$V_{Ramp}(D \bullet T_s) = V_{ef} \quad (8)$$

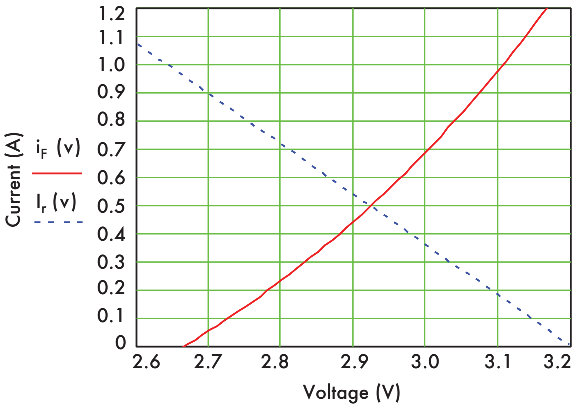
• Power stage:

$$\frac{V_{In}}{N_p} \bullet N_s \bullet D = V_s \quad (9)$$

With effort, all the equations can be consolidated into a single, closed-loop equation. Equation 10 is a transcendental equation with an exponential term that prevents us from solving it analytically, but it can be solved using computational techniques and software tools.

Reference

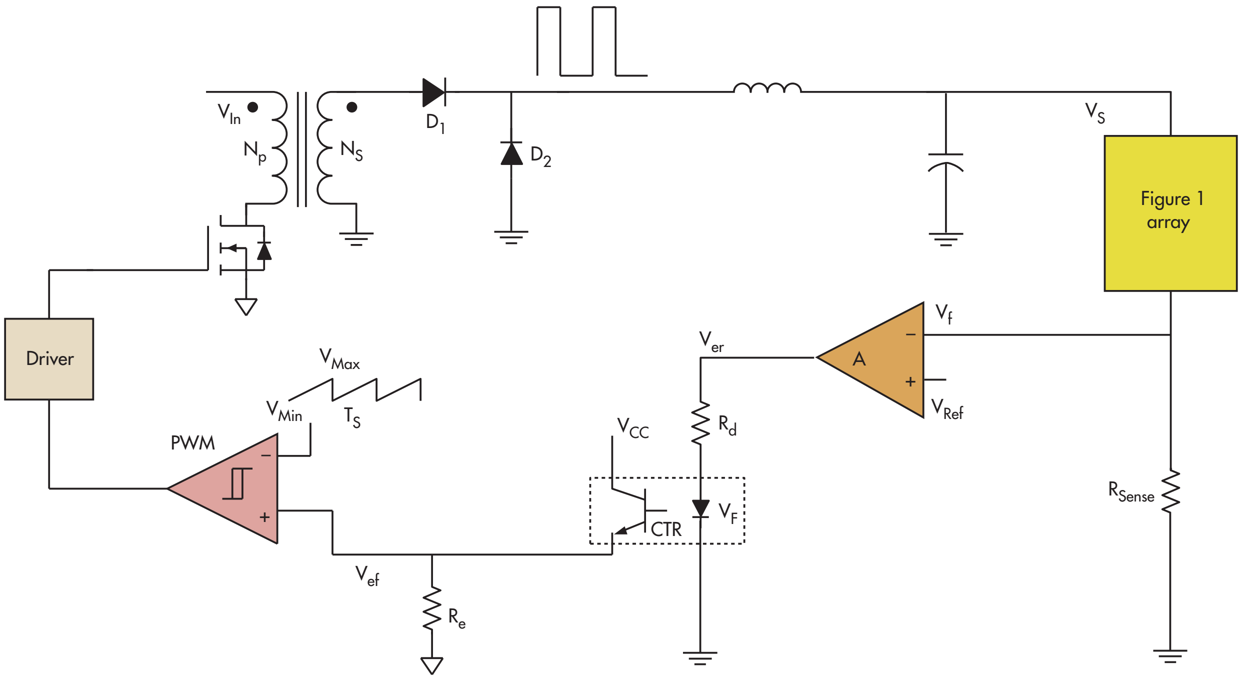
1. "Generate Realistic Models for LED Current Versus Voltage," Keng C. Wu; Electronic Design, Vol. 61, No. 1, p. 52, Jan. 10, 2013, http://electronicdesign.com/power/generate-realistic-models-led-current-versus-voltage



3. The intersection of the desired current line and the forward current/voltage curve (red) leads to the unique solution to the nonlinear equations of the LED model. (The blue line is the reverse-bias current/voltage relationship.)

$$\frac{V_{In}}{N_p} \bullet N_s \bullet \frac{0.95\left(\frac{A\left(V_{Ref} - n\left(ae^{b\frac{V_s}{m}} + C\right) \bullet R_{Sense}\right) - V_F}{R_d} \bullet CTR \bullet R_e - V_{Min}\right)}{V_{Max} - V_{Min}} = V_s \quad (10)$$

KENG C. WU has a BS from Chiaotung University, Taiwan, and an MS from Northwestern University, Evanston, Ill. He has published four books and holds seven U.S. patents.



4. Analysis of the switch-mode buck-regulating current driver in a closed-loop configuration for driving an array yields a set of equations that are better solved using numerical computation rather than an analytical, closed-form approach.

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JULY 11, 2013

Slow Recovery Still The Norm

Electronics industry executives adjust to slower industry conditions as they look to new regions and expanding markets for electronic content as key growth drivers.

SPEAKING TO OTHER ELECTRONICS supply chain executives in May, TTI's Michael Knight characterized 2012 as a year in which the electronics industry "went sideways," explaining the flat to very low growth most distributors in the sector experienced compared to 2011. This is new for an industry accustomed to sizeable year-over-year sales gains driven by new technologies and an ever-growing need for electronic content in just about all aspects of daily life.

"I think there's a possibility that 2013 will be another 'sideways,'" said Knight, TTI's vice president, Americas, in a separate interview in early May. "I think we'll see some slight 'up,' but that's not how the industry historically works. Plus or minus 2% or 3%, that's just not how our industry looks. But it's happening."

The slow economic recovery globally, combined with political uncertainty and other pressures here at home, is the main culprit, and most distribu-

Continued on Page 52

Globalization, Product Obsolescence Top Supply Chain Challenges

Distributors respond with tools to help engineers and procurement professionals meet the increasingly complex electronics supply chain, says Components Direct's Steve Martin.

Steve Martin

DISTRIBUTION RESOURCE RECENTLY CAUGHT up with Steve Martin, executive vice president of sales at Components Direct, a franchised distributor that specializes in excess, obsolete, and end-of-life electronic components. We asked Martin to discuss the state of the electronics supply chain and provide an industry outlook for the remainder of the year. He pointed to globalization, product obsolescence, and the increasingly important role of electronic commerce as key issues shaping the electronics supply chain. What follows are excerpts from our conversation.

DISTRIBUTION RESOURCE: What are some of the most important challenges facing the electronics industry today?

STEVE MARTIN: I think the number one challenge is globalization and the supply chain complexity that results from it. I see more globalization and a resulting leakage in collaboration between everyone in the supply chain. Companies are engaging in manufacturing product and distributing product in different

Continued on Page 58

Continued from Page 51

tors say they are thankful for the continued drive for more electronics, which is helping to temper the situation. The drive for smarter cars, medical equipment, appliances, and other consumer devices is helping boost sales for many companies, and so is factory automation as the trend toward producing products closer to home gains steam. It all adds up to an electronics marketplace poised for continued slow growth in the second half of the year, say Knight and others.

"It's looking to be a very slow recovery," says Julie Yuan, managing director of California-based regional electronics distributor Amidon. "It's certainly become more of a challenging marketplace."

THE NEW NORMAL?

Although conditions are improving, most economists predict continued challenges in the manufacturing sector and the overall economy for the remainder of 2013. In a late May economic update, the Manufacturers Alliance for Productivity and Innovation (MAPI) predicted 3% growth in the manufacturing sector this year—a moderate pace, but about a percentage point faster than the general economy. Looking further out, MAPI predicts 3.6% growth in the sector in 2014, also about a percentage point better than the general economy.

"The major constraint on consumers in 2013 is that wages are not growing much faster than the inflation rate and spendable income is further reduced by higher taxes," MAPI chief economist Daniel J. Meckstroth said, adding that despite volatility and the struggle for growth there are reasons for optimism between now and the end of the year. Rising home prices, pent-up demand for consumer durables, and more balanced job growth between manufacturing, mining/construction and service industries are a few key reasons.

Despite that optimism, electronics industry executives look to the remainder of 2013 with a cautious eye, and

Mouser Electronics is looking to expand its Americas business with new growth in Central and South America, says Steve Newland, vice president of sales for the Americas.

many are seeking growth by expanding their reach globally. Amidon is one such company. Yuan says the distributor will open an office in Hong Kong later this year to capitalize on its growing customer base in Asia. Similarly, large catalog distributor Mouser Electronics is looking to expand in the Americas. It is in the process of opening a new office in Mexico and is conducting a feasibility study to open one in Brazil. Expansion in the Americas follows Mouser's focused growth in Europe and Asia over the last few years.

"I see automation really shaping [the industry]," says Steven Engineering's Paul Burk. "Customers are asking to automate processes that they never have before."

"We're starting to get more focused on [Central and South America], [because] we've seen some nice growth in Mexico and Brazil," explains vice president of sales for the Americas Steve Newland, pointing to Mouser's mature business in North America.

For many, mature North American markets are complicated by the slow recovery here at home. Looking at U.S. manufacturing in particular, economic activity had slowed as of early June compared to the beginning of the year.

The Institute for Supply Management's Purchasing Manager's Index (PMI), which measures U.S. manufacturing activity, declined steadily from February to May, when it hit its lowest point in four years. May's PMI registered 49, a nearly 2% slide compared to April and signaling a decline in manufacturing activity.

A PMI above 50 indicates growth in the sector. A PMI below 50 indicates contraction. May's reading was the first contraction since November 2012 and only the second since July 2009. Purchasing managers interviewed for the survey indicated a flattening of demand due to the sluggish local and global economies.

REGIONALIZATION, AUTOMATION KEY FACTORS

Rising costs are another key concern throughout the supply chain. When it comes to transportation, logistics, and labor, such increases are signaling a new manufacturing trend that bodes well for many distributors. Some North American executives point to a trend toward regional manufacturing, also referred to as on-shoring or re-shoring, as original equipment manufacturers (OEMs) seek to build their products closer to where they will be consumed, especially large, heavy products that are costly to ship around the world.

The situation is heightened as labor costs increase in traditionally low-cost regions such as Asia. Avnet Electronic

Marketing's Ed Smith says the trend is helping to increase manufacturing activity in Mexico, as one example.

"I think what's happening is, companies are saying, 'I have certain products that are worth building in Asia and certain products I need to build in America [because] it's not worth the logistics cost to build them in Asia and ship them back,'" says Smith, Avnet EM's president for the Americas, adding, "I don't know if I'd call it on-shoring or re-shoring, but there is clearly an increase in manufacturing [in places such as] Mexico. Some may view it as on-shoring or re-shoring. I think there's just less going out and more being built in the regions where it's being consumed."

Angelo Hrenczuk, director of sales, thermal materials, for electronics manufacturer Laird Technologies, agrees and says he sees more automotive and appliance manufacturing returning to Mexico as well.

"The chasing of low-cost centers is going to have to end," Hrenczuk says. "Anything that's big and expensive to ship is coming back."

Hrenczuk adds that an increase in manufacturing in North and Central America will also signal an increased need for factory automation as manufacturers seek to become more competitive—another boon to many electronics distributors' business.

Northern California-based Steven Engineering is already reaping the rewards of that trend, says vice president of marketing Paul Burk. The specialty distributor of electronic components and industrial automation equipment is predicting double-digit growth this year, with factory automation work driving much of it. Burk points to medical/biotech, alternative energy (mainly wind), and food and beverage processing equipment as key growth areas for Steven Engineering.

"I see automation really shaping [the industry]," says Burk. "Customers are asking to automate processes that they never have before." ■

Capacitor Suppliers Meet
Growing Market Demands

The global capacitor market will grow 2.5% over the next five years, driven by demand for more complex electronics and innovative component solutions.

THE CAPACITOR MARKET is expected to reach $20.2 billion in revenue by 2018, according to a new report from industry research firm Research and Markets. The report predicts a 2.5% compound annual growth rate for capacitors worldwide, driven by trends that continue to affect the overall electronics industry, including demand for compact, portable, and more complex electronic devices and the accompanying need for better, smaller, and more efficient component solutions.

The anticipated increase follows a decline in the global capacitor market in 2012 due to slowing shipments of PCs and televisions, weaker production capacities for wireless handsets, and lower consumer and business spending on electronics, the report says. The industry also suffered from the lingering effects of natural disasters in 2011, particularly the Japanese tsunami early in the year and severe flooding in Thailand in the second half.

But the growing amount of electronic content that's employed in automotive applications and the increased demand for consumer electronics such as notebooks, ultrabooks, and smart phones are key trends driving capacitor growth over the long term. Component manufacturers are responding with enhanced products and solutions that offer greater efficiency and compact size to meet the new demands. Distributors were promoting many of these new offerings online this spring.

Kemet's T488 Small Case Substrate Terminal MnO2, T527 Facedown Polymer, and T529 Small Case Substrate Terminal Polymer tantalum chip capacitors offer the highest capacitance values available in both a standard 2012 and 3216 EIA case size with maximum package heights of as low as 1 mm.

ON THE MARKET

Kemet Corp. released a series of new tantalum chip capacitors in May: the T488 Small Case Substrate Terminal MnO_2, the T527 Facedown Polymer, and the T529 Small Case Substrate Terminal Polymer. These miniaturized solutions offer the highest capacitance values (22 to 220 µF) available in both a standard 2012 (2 by 1.2 mm) and 3216 (3.2 by 1.6mm) Electronic Industries Association (EIA) case size with maximum package heights of as low as 1 mm.

The capacitors also feature advances in counter-electrode technology and package design, resulting in the lowest equivalent series resistance (ESR) values available in the industry for these package sizes *(see the figure)*. Typical markets include computer/consumer and telecommunications. Mouser Electronics *(www.mouser.com)* is among the top distributors that are promoting the new offerings.

Regional distributor Tonar Industries *(www.tonar.com)* is promoting

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Few Companies Ready
For Conflict Minerals Regs

An IHS poll reveals that more than a third of electronics industry firms have made no plans to meet new requirements.

FEW U.S. COMPANIES say they are prepared to meet new government regulations for reporting their use of so-called conflict minerals, according to industry analyst IHS. The regulations, which took effect in August 2012 with initial reporting to begin in May 2014, are part of the Securities and Exchange Commission's Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010.

IHS polled 134 electronics industry managers this spring and found that just 7.5% said they were well prepared to meet compliance rules. More than 35% of respondents said they haven't started developing compliance plans, and the remainder of respondents were somewhere in the middle.

The new conflict minerals requirements apply to publicly traded companies but will have far-reaching implications for the electronics supply chain. Because manufacturers procure products and materials from all over the world, it's likely that one or more supply-chain partners will require information regarding the sourcing of conflict minerals, IHS explains.

Conflict minerals are raw materials mainly sourced in the Democratic Republic of Congo, where their trade fuels criminal networks and perpetuates violence in the region. The materials—tantalum, tungsten, gold, and tin—are used in the electronics market in everything from cell phones to pacemakers. IHS estimates that 15 cents worth of tantalum was in every smart phone shipped when Dodd-Frank was originally signed in 2010, for example. In 2012, this would amount to $93 million worth of tantalum in smart phones, IHS says.

Newark element14's Ken Manchen, director of safety, health, and environmental affairs for the electronic components distributor, has said the rule will affect distributors and suppliers as they must report back to customers on the presence and origin of conflict minerals in the components they supply.

"This requirement will apply to both private and foreign suppliers, even if not regulated by the SEC," Manchen said last fall. "A manufacturer will not be able to prepare a report without gathering reports from their suppliers."

Compliance is costly and time-consuming, but IHS notes industry efforts to help support the process. IHS's content solution strategist Scott Wilson points to the smelting industry in particular.

"Smelters are a good control point, and this simplifies how far back in the supply chain companies have to go," Wilson told an IHS webinar audience earlier in April.

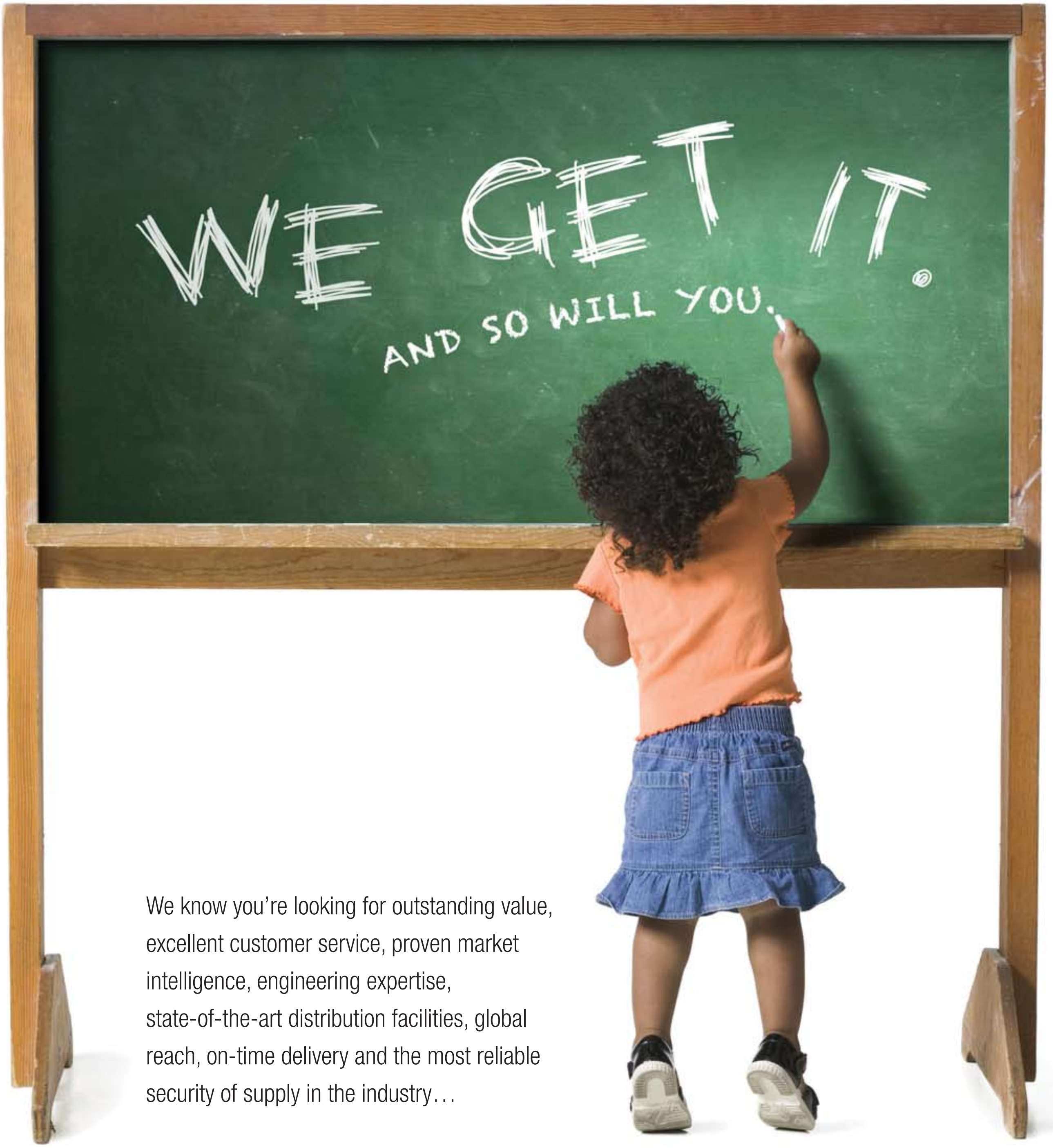
Wilson also pointed to resources such as the Organization for Economic Cooperation and Development, which has issued guidelines that outline the key aspects of compliance. He also said companies should focus internally on four key areas as they develop compliance strategies:

- Management systems: Most material requirements planning (MRP) and enterprise resources planning (ERP) systems can track materials, but may not be programmed to do so. Companies need to determine if their systems need additional capabilities.
- Identify and assess risk: Companies should prioritize the suppliers that are most likely to use or source conflict minerals.
- Respond to the risk: If suppliers don't share information, companies should consider alternative sources.
- Audit smelters: An Electronics Industry Citizenship Coalition (EICC) standard provides the necessary guidance and content. ■

Continued from Page 54

new products from Cornell Dubilier. The manufacturer expanded its line of SPCX and SPSX surface-mount aluminum polymer capacitors, which are now available with lower ESR and higher capacitance values, making them top-performing filter capacitors for board-level power conversion applications. Both types are supplied in a surface-mount molded package with the same footprint as a D size tantalum capacitor in a thin profile of 1.9 mm with voltage values ranging from 2 to 6.3 V dc.

ATC's ultra-broadband capacitors are among Digi-Key's *(www.digikey.com)* newest passive component offerings. They offer reliable and repeatable ultra-broadband performance from 16 kHz through more than 40 GHz. With ultra-low insertion loss, flat frequency response, and excellent return loss, the 550L series is ideal for dc blocking, coupling, bypassing, and feedback applications requiring ultra-broadband performance, the companies say. ■


WE GET IT.
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Continued from Page 51

parts of the world. This creates many challenges in ensuring that all standards of production and distribution are correctly adhered to and that, ultimately, the traceability of that product back to the original manufacturer has not been obscured in any way. Keeping a tight control on this process has been something our industry is continuing to deal with.

Another challenge is the reduction in the product lifecycle of more and more components, which ultimately leads to an increasing rate of obsolescence in the supply chain. As manufacturers reduce the lifespan of many parts, and innovations in technology are occurring at faster and faster rates, this results in an increase in parts becoming obsolete and no longer produced by the manufacturer. The demand for this product, however, may still be present, resulting in a severe mismatch between supply and demand.

DR: Counterfeit components are another challenge. What are the key issues buyers should consider when trying to keep counterfeit components out of their supply chains?
MARTIN: This is a really wide topic of discussion. There is a tremendous amount of things they need to do, but a few come to mind first. They need to work with a trusted supplier and have a continuous plan for vendor reduction. Also, they need to buy parts direct from the manufacturer or through the franchised or authorized distributor. If they go outside the authorized channel, there are a few telltale signs to look for: how many years a company has been in business; the size of the company in terms of revenue; and whether they are members of any industry trade groups. We're part of [the Electronic Components Industry Association], for example. In terms of warehousing, buyers need to know what the quality is, the handling, and the inspection process, both ingoing and outgoing. Does the supplier have a counterfeit screening or testing process in place? Are they ISO (International Organization for Standardization) certified? A lot of people say they're not certified but they are compliant. That should be a telltale sign. A supplier really needs to be ISO certified to be sure they're on the up and up.

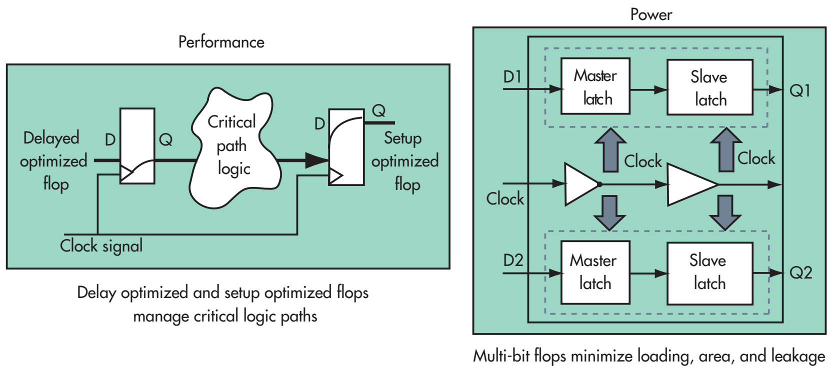
DR: Given the prevailing economic uncertainty worldwide, what is your outlook for electronics distribution this year?
MARTIN: Even though there's an ongoing recession in Europe and slow growth in China, we are optimistic. Last year was a building-block year. We expect right around 5% growth in 2013.

Another growth area within the electronics distribution industry that I predict we will continue to observe is an increase in the growth of online purchases made by many design and procurement engineers. People are beginning to recognize the important role that e-commerce plays within electronic component distribution, not just in facilitating online sales for parts, but also researching data on parts as well as price point variables.

DR: What end markets or geographies look most promising to you?
MARTIN: In terms of excess, obsolete, and EOL (end of life) components, we're seeing that North America is very promising. In addition, our e-commerce platform has seen substantial growth in the last four months [in places such as] Asia and South America. We see Brazil as a growing market, and we expect growth in Mexico as well.

DR: Similarly, which end markets or geographies look the most challenging?
MARTIN: Certainly Europe because of the economic difficulties there. But we're also seeing some challenges in Asia. There's great opportunity in Asia, but I also think with the counterfeit issue we're seeing that as a challenging market as well, particularly with the proliferation of counterfeit parts in China. If you look at China in particular, there are a lot of newer companies. Whether they are OEMs, OCMs, distributors, or [businesses] in the secondary market, a lot of companies are popping up in China on a daily basis, and there are no checks and balances on that. ■

High-Performance Computing Design Kit Optimizes Any SoC



The Synopsys HPC Design Kit comes with a range of flip-flop designs. Using flops designed for an initial delay and then setup can lengthen the critical path time (left). Lower loading, smaller size, and reduced leakage can be achieved using shared logic designs (right).

HOW DO you get the optimum system-on-chip (SoC) design? Tap the work of other experts in the field. The Synopsys Designware HPC Design Kit delivers more than 125 design cells and memories optimized for speed, space, and power. It can be applied to SoC designs that incorporate single-core or multicore CPUs, GPUs, and DSPs. It supports the latest TSMC 28-nm process today and is expected to extend this support to other nodes soon.

The new package can be applied to any design. It is different from ARM's Processor Optimization Package (POP), which targets specific architectures like the ARM CPU. POP-style solutions are fine when dealing with the main CPU, but this latest kit works with any CPU, GPU, or DSP core. It is probably unnecessary and possibly impossible to mix these approaches, but the new HPC kit will be ideal for custom designs.

The HPC kit includes a range of flip-flop designs *(see the figure)*. Each optimizes a different set of criteria. It would be great to have one design that is the smallest, fastest, and most power efficient, but normally there are tradeoffs so the fastest is not the most power efficient.

Critical-path designs can benefit by using a flip-flop that optimizes the delay from input to output, which adds more time to the critical path. Likewise, a flip-flop that can extend the setup time also adds time to the critical path, resulting in the ability to incorporate more logic between the two different flip-flop implementations. Logically they are the same at both ends, but the timing details are different.

In some instances, speed or critical-path timing is less of an issue. In this case, space and power efficiency can be optimized. Register designs that allow clock logic to be shared help. Synopsys calls these register designs multi-bit flip-flops.

Also, the range of cells is an advantage when mixing CPUs, GPUs, and DSPs in an SoC. CPUs may have a very high clock rate compared to the GPUs and DSPs in the mix. Using area-optimized two-port memory ensures reduced area and power implementation for GPUs.

The selection of design cells still requires tradeoffs, but targeted designs permit optimization for particular sets of attributes.

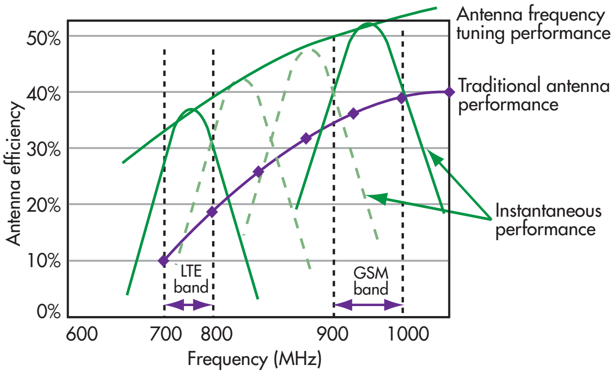
SYNOPSYS
www.synopsys.com **BILL WONG**

Digital RF MEMS Capacitor Maximizes Smart-Phone Antenna Efficiency

CAVENDISH KINETICS now offers a tunable RF MEMS capacitor that lets smart-phone antennas cover a wider range of frequencies to ensure good efficiency.

Antennas can't achieve maximum radiation efficiency unless they're precisely tuned to the frequency of operation. However, most smart phones using LTE and other broadband modulation schemes operate in multiple bands that can extend from as low as 700 MHz to over 2300 MHz. Multiple antennas partially solve the problem, but they take up too much space in an already restricted package—and add cost as well.

The solution is to tune the antenna to the band in use. The simplest way to tune an antenna is to add a variable capacitor that can change the resonant frequency. Electronically variable capacitors have been available for years but have some disadvantages. For example, some digitally variable capacitors use MOSFET switches to add or subtract capacitors to or from a parallel connected network of capacitors. The on resistance lowers the Q of the overall capacitance and, therefore, the efficiency.



Using the Cavendish high-Q digitally variable MEMS capacitor, tuning an antenna in increments significantly improves its efficiency compared to un-tuned antennas. The improved efficiency ensures reliable connections and higher data rates.

Cavendish solves this problem by using hundreds of tiny MEMS capacitors that are selected digitally in groups to vary the capacitance. The device behaves like a bank of 32 high-precision high-Q capacitors using a 1P32T switch with zero insertion loss. The capacitor has a 5-to-1 capacitance range from maximum to minimum, making wide-tuning frequency ranges possible. A serial peripheral interface (SPI) takes the digital code to vary the capacitance.

The figure illustrates the difference in performance between a standard un-tuned antenna and a Cavendish MEMS tuned antenna. Operating from 700 to 1000 MHz, the standard antenna efficiency is less than 40%. But tuning the antenna resonance at different parts of the range greatly improves the efficiency.

This improved efficiency means more transmitted or received signal to ensure not only a reliable connection to the cell site but also higher data rates. In some cases, a smaller antenna can be used or an extra antenna can be eliminated.

In addition to antenna tuning, the Cavendish digitally variable capacitor can be used to design variable impedance matching circuits, power amplifier networks, variable filters, and phase shifters and other networks that must be optimized for the operating frequency. It is available in a 2- by 2- by 0.4-mm chip scale package (CSP). Its operating voltage is 1.8 V. Production samples are available now.

CAVENDISH KINETICS
www.cavendish-kinetics.com **LOUIS E. FRENZEL**

Fast Precision SAR ADCs Battle For Sockets

LINEAR TECHNOLOGY and Maxim Integrated have announced high-precision successive approximation register (SAR) architecture analog-to-digital converters (ADCs) for the industrial and instrumentation markets. Linear's is faster with higher precision while Maxim's has a smaller footprint and integrates its own voltage reference, saving more board space.

Linear's 1-Msample LTC2378-20-1 boasts an internal clock and accepts external references that can range from 2.5 to 5.1 V. It offers ±2-ppm integral non-linearity (INL) and –0.5 differential non-linearity (DNL) (max), no missing codes at 20 bits, and a 104-dB signal-to-noise ratio (SNR).

Also, the LTC2378-20-1's data-sheet guaranteed minimum signal-to-noise plus distortion (SINAD) with a 5-V reference and a 2-kHz frequency is 101 dB, which calculates out to a 16.48 effective number of bits (ENOB). The ADC comes in a 16-lead mini small-outline package (MSOP) and a 4- by 3-mm dual flat no-lead (DFN) package. In lots of 1000 units, it costs $29.50 each. Linear offers less expensive speed grades as well.

Maxim Integrated's MAX11156 is an 18-bit, 500-ksample/s, differential input SAR ADC with a precision internal reference that allows for measuring a bipolar input voltage range of ±5 V. With an external reference, it can handle input ranges between ±3.05 V and ±5.19 V.

A patented charge-pump architecture permits direct sampling of high-impedance sources. The ADC also guarantees 18-bit no-missing codes. The inputs are sampled with a pseudo-differential on-chip track-and-hold that exhibits no pipeline delay or latency.

The MAX11156's SINAD is 91.5 dB minimum for a 14.9 ENOB. Its SNR is 93 dB, based on the internal reference. Standard packaging is a 12-pin, 3- by 3-mm thin DFN (TDFN). Unit pricing for the MAX11156 with built-in voltage reference is $16.90.

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The packaged devices cover a broad current range from 10 – 50A. Other key performance benefits include Tjmax of 150°C, positive VCE(on) temperature coefficient for easy paralleling and low VCE(on) to reduce power dissipation and achieve higher power density. Die products are also available.

More information is available on the **International Rectifier** website at **http://www.irf.com/whats-new/nr130606.html**
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Catalog Literature Review

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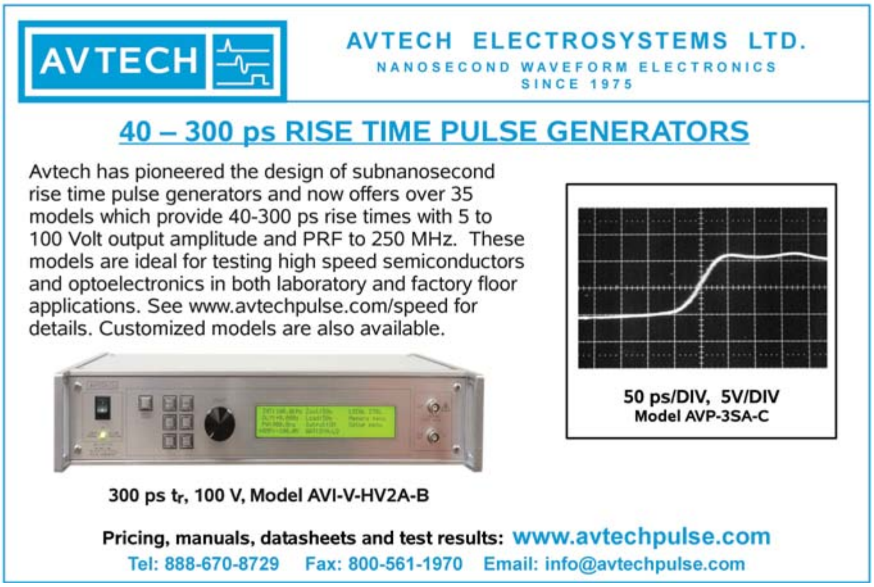

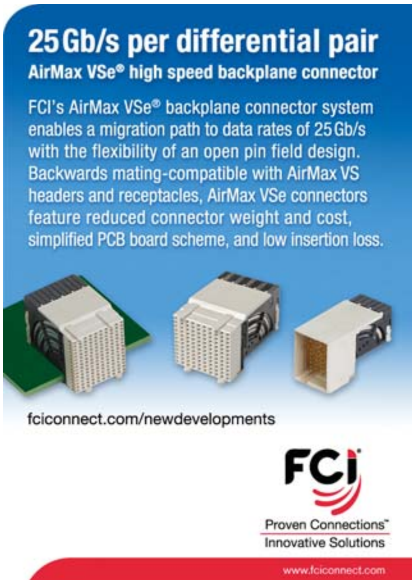

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BILL WONG | Embedded/Systems/Software Editor
bill.wong@penton.com

Are You Writing
Safe And Secure Software?

Secure Boot, iPhones, mulch, safety, and Ada—I promise to tie them all together, since they're all related. Sort of.

As a programmer, I try to write code that's not only functional but also safe, secure, and reliable. I work at learning the best techniques, using the best compiler tools, and taking advantage of the latest technology. Great. Everyone knows that C dominates the embedded space. But what if some of those things I learn or use aren't quite right?

Georgia Tech students attacked a poor, helpless iPhone using a string overflow bug in the phone's USB charger DRM support designed to restrict chargers to those licensed by Apple.

... BUT EVERYONE USES MULCH

So now the mulch. You've seen it everywhere on landscaped lawns. There are giant mounds around every tree. It looks great, if you like that kind of thing. It makes mowing, especially with large riding lawnmowers, so easy.

Unfortunately, piling bark mulch around most anything, especially trees, isn't a great idea. Compost is good around bushes, but trees don't like anything stacked up on their bark. There are other good uses for bark mulch, though.

C and C++ aren't quite as bad as mulch around trees, but using them just because everyone else does can be an issue because they're prone to bugs. Dangling pointers and buffer overflows are common C bugs.

... AND NOW THE IPHONE

Researchers at my alma mater, Georgia Tech, attacked an iPhone using a smart USB charger *(see the figure)*. Apple decided to use digital rights management (DRM) to restrict licensing of high-current USB chargers. Essentially, the charger handshakes with the phone using the USB data channel before it raises the amount of power delivered.

The charger sends a key in its handshake packet. The researchers caused a buffer overflow. This form of injection attack is common in jailbreaking smart phones and other devices. They take advantage of a software bug.

The number of buffer overflow attacks on everything from smart phones to servers is rather extensive, though. One might think that avoiding these kinds of problems would improve the safety and security of quite a few systems.

The new USB standard also provides a high-current feature, but it does not use the data link. Instead, it uses some creative analog signalling.

READ ABOUT ADA 2012, TO BE SAFE

This brings me to Ada, which is designed from the ground up for safety and security. Its features also turn out to make bug-free programming much easier. But from a programming perspective, I'm still a neophyte. I have been using it more and learning quite a bit about it, but I defer to the experts in trying to convince programmers about its advantages.

Safe and Secure Software - An Invitation to Ada 2012, a free e-book from AdaCore available at *www.adacore.com/safe-secure-booklet*, highlights programming issues that arise with any programming language. Of course, it explains why Ada 2012 is a better solution often because it does things that other languages, including C++ and Java, do not address.

For example, Ada's type system puts most others to shame. Its pointer support provides finer-grain control, allowing the compiler to catch more errors. Ada's storage management is something that most languages relegate to libraries, but there are reasons for incorporating it into the compiler.

Ada 2012 also brings contracts out of the SPARK comment realm and into the language itself. This is reason enough to take another look at Ada, but there is plenty more. The book shows the problems, how they are addressed with other languages, and why Ada was designed to address these issues.

The book offers a flavor of Ada, but it is designed for any programmer. It addresses Ada basics like built-in range checking that probably would have caught the iPhone charger problem. Hopefully, the book will get you thinking.

Still, C and C++ won't be abandoned en masse. Tools like MISRA C can help. I recommend looking into static and dynamic analysis tools because they do make a difference. ed

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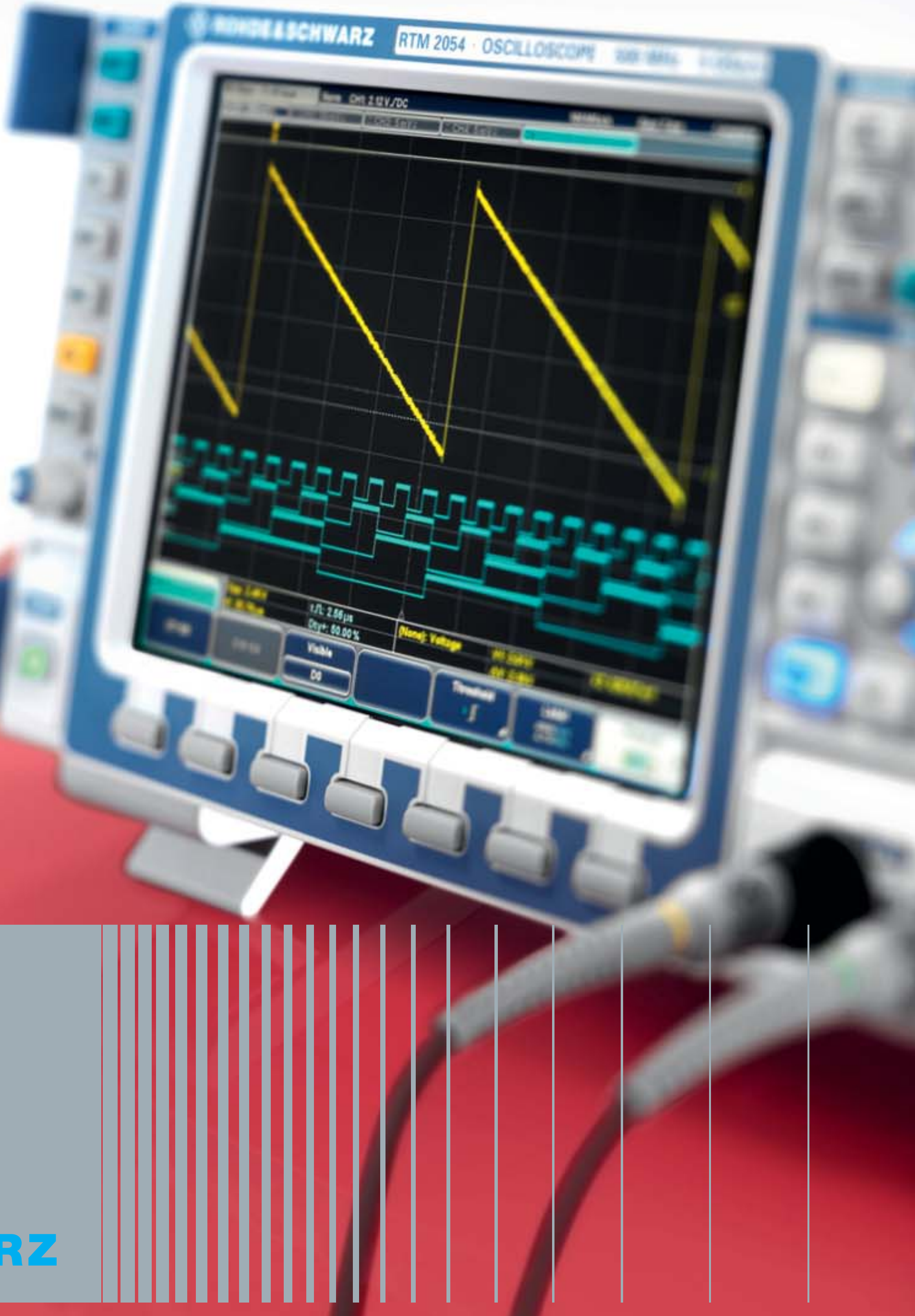

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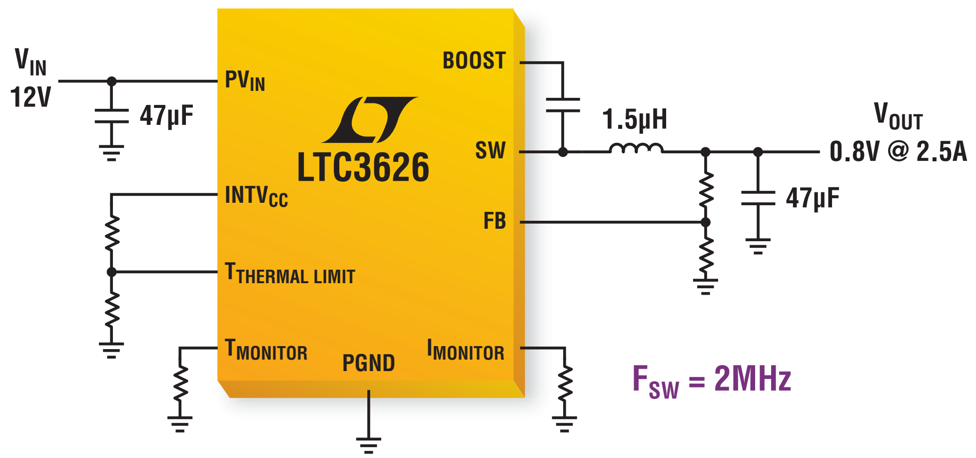
Time Domain Analysis
Mixed Signal Analysis
Frequency Analysis

20V, 2.5A SWITCHER+



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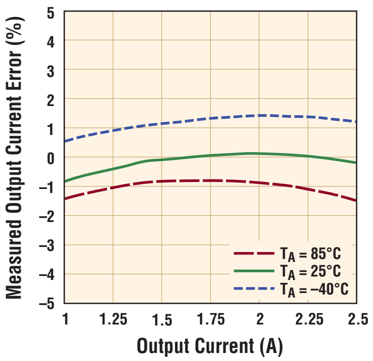
Output Current Monitor Error



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