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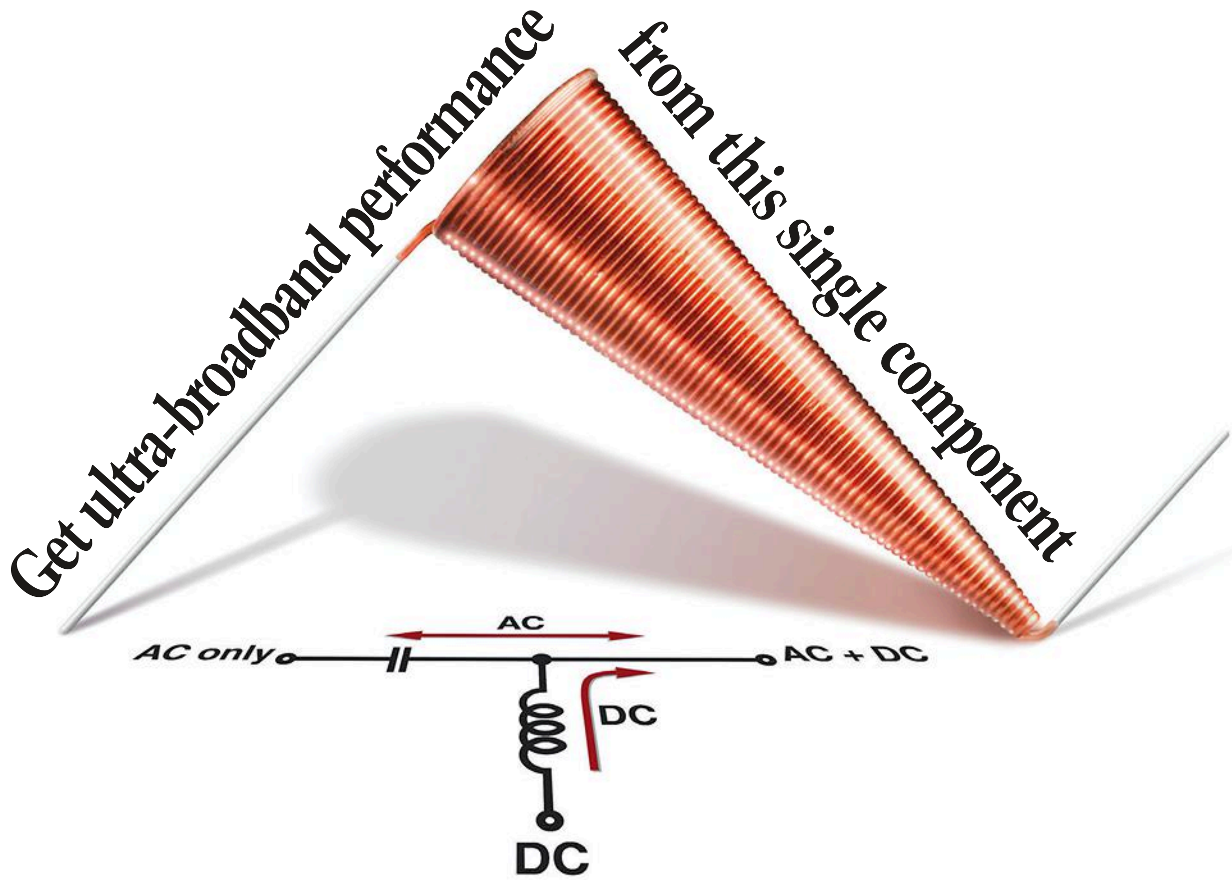

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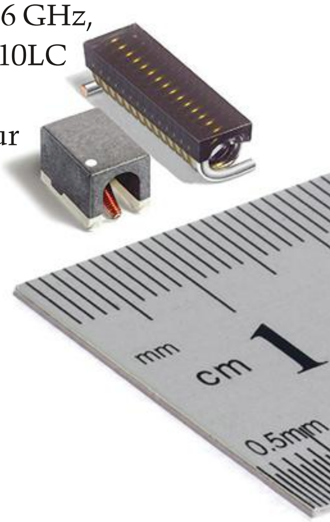

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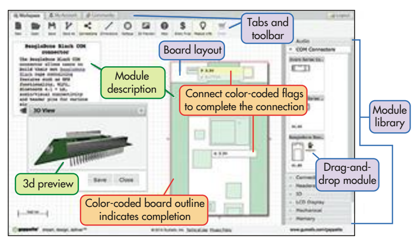

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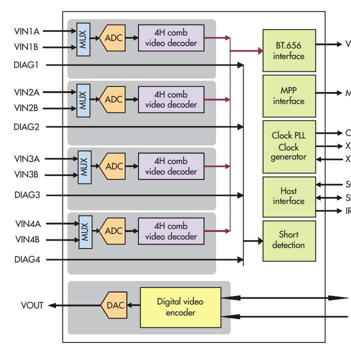

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To provide the most current, accurate, and in-depth technical coverage of the key emerging technologies that engineers need to design tomorrow's products today.

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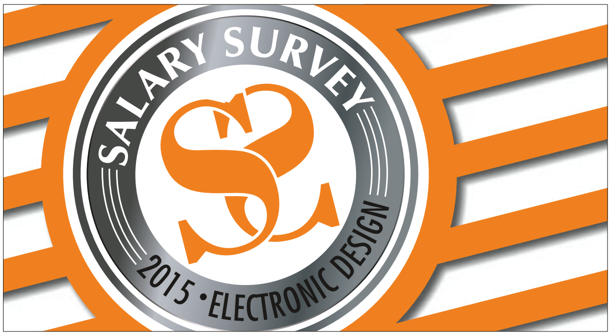

2015 COMPENSATION SURVEY: IT'S NOT ALL ABOUT THE MONEY

http://electronicdesign.com/salarysurvey

According to the nearly 3,000 electrical engineers that participated in *Electronic Design*'s 2015 Compensation Survey, the engineering profession is in a period of transition. On the one hand, companies are still in the process of recovering from the economic recession and risk-averse corporate culture. On the other hand, the Internet of Things (IoT) is slowly maturing into a reality for technology companies, igniting demand—and competition—for engineering expertise.

LONG-RANGE NARROWBAND MEETS AGRICULTURE

http://electronicdesign.com/communications/how-can-long-range-narrowband-improve-agricultural-efficiency

The growing world population and changes in food habits put pressure on the agriculture sector to grow food more efficiently. From controlling water usage and reducing spoilage to infestation control, long-range narrowband solutions can be a big piece of the puzzle.

blogs

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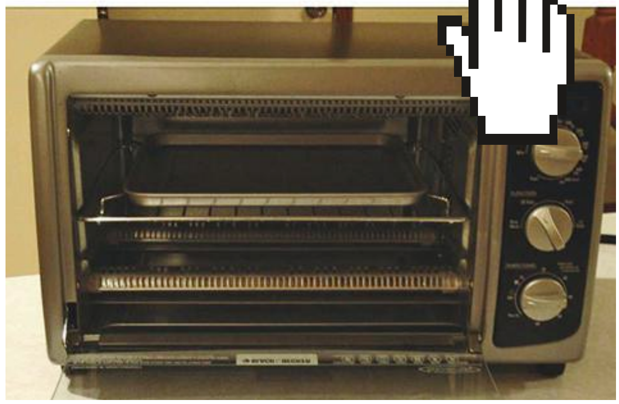
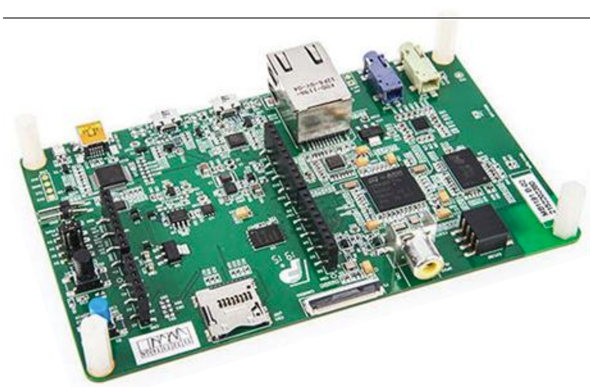


BUILDING A REFLOW OVEN AT HOME

http://electronicdesign.com/blog/building-home-or-very-small-office-electronic-circuit-prototypes-part-2

This blog—part two in a series on building home or very small office electronic-circuit prototypes—gives readers step-by-step instructions for turning a Black & Decker TO1675B convection countertop oven into a temperature-controlled reflow oven.



DEVELOPMENT TOOLS FEATURED AT ARM TECHCON 2015

http://electronicdesign.com/microcontrollers/gallery-development-tools-featured-arm-techcon-2015

This *Electronic Design* image gallery, part of our coverage of the 2015 ARM TechCon, looks at some of the latest development platforms and software tools targeting ARM Cortex-based processors.

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Real Big Simulations

If you get a chance, visit the Bay-Delta Model *(see figure)* at 2100 Bridgeway in Sausalito, Calif., just across the Golden Gate Bridge. Built by the U.S. Army Corps of Engineers, it's a working hydraulic model of the San Francisco Bay and Sacramento-San Joaquin River Delta System. That comprises essentially all waterways around San Francisco and Silicon Valley.

The model was started in 1957 in response to the Reber Plan to fill in parts of San Francisco bay. Luckily the plan was scrapped, and the model has since been used for a wide range of projects. It's still operational and open to the public, although no longer used for active research. Computers now do that job, as is the case for most simulations these days.

The Bay-Delta model measures over 320 by 400 ft. and consists of a jigsaw puzzle of 286 five-ton concrete slabs. It's built to a 1:1000 horizontal scale and 1:100 vertical scale mirroring ship channels, rivers, creeks, and canals. It includes major wharfs and bridges like the famous bay bridges. The time scale is 1:100, so it's possible to watch the tides go in and out. Copper strips spread throughout simulate the proper hydraulic flow, because liquid movement is more efficient as the environment scales down.

The Bay-Delta Model, built by the U.S. Army Corps of Engineers, is a working hydraulic model of the San Francisco Bay and Sacramento-San Joaquin River Delta System.

The model did incorporate quite a bit of recording electronics. Plenty of applications still require this type of sensor information, especially when one considers "big data" analysis of distributed sensor networks providing real-time data. The main difference between now and then is many orders of compute magnitude. Sensor technology has also advanced significantly.

As an engineer myself, I can only say that I was blown away by the model's scope. I'm glad I was able to see it up close.

News

NEW MARKETS, LOWER COSTS

Driving Growth of M2M Technology

As a core component of the Internet of Things (IoT), machine-to-machine (M2M) technology is expected to branch out in a wide range of new markets, growing significantly over the next 10 years, according to a recent report from the research firm Signal and Systems Telecom.

The report, which surveyed almost 250 companies from over 70 countries, predicts that spending on M2M and IoT technologies—and the wireless networks that support them—will grow to nearly $250 billion by the end of 2020. In the next five years, the number of installed M2M devices will rise sharply to 10 billion, the report adds.

The proliferation of M2M devices can largely be attributed to the widespread availability of wireless technology. This has sparked the imagination of companies that are trying to simplify operations by monitoring and managing equipment remotely. Ordinary objects are being reinvented with digital sensing, computing, and communications components to transmit information on their status and the surrounding environment.

Hal Varian, chief economist at Google, says in an article with *Forbes* magazine that M2M technology is growing more widespread as components and wireless networks become more sophisticated and less costly. "The price of sensors, processors, and networking has come way down," he says. "Since Wi-Fi is now widely deployed, it is relatively easy to add new networked devices to the home and office."

The report notes that, aside from fitness bands and other consumer electronics, the technology is migrating into markets, such as connected cars, telematics, building automation, smart homes, manufacturing, and infrastructure. M2M devices are also being used in sensor networks to alert engineers of structural building damage, or monitor cargo in the shipping industry.

Temperature sensors and switches are being used more frequently in building and home automation. *(Image courtesy of Jens Braune del Angel and edited from the original by* Electronic Design*)*

Steve Prentice, vice president of Gartner Inc., a research firm specializing in information technology, notes that the "number of connected intelligent devices will continue to grow exponentially, giving 'smart things' the ability to sense, interpret, communicate, and negotiate, and effectively have a digital voice."

The report also underlines the potential for M2M technologies to transform the ways in which companies carry out industrial and commercial operations. For instance, utilities companies are managing the distribution of electricity with smart meters, and government agencies have begun to lay the groundwork for smarter cities and infrastructure. The cities of San Diego and Jacksonville, for instance, have started testing sensor-enabled street lamps to monitor traffic and get severe weather warnings.

For years, however, M2M technology has suffered from the perception of being fragmented and restricted to proprietary systems, according to Mobeen Khan, assistant vice president of Industrial IoT Solutions at AT&T, in an interview conducted by *Tech Radar*.

"This is because M2M solutions are specific to each industry," he says. "Therefore it is extremely difficult to develop a uniform solution to fit all the individuals' needs of each vertical industry." Historically, he adds, M2M technologies have been designed for specific industries, keeping entry costs high and discouraging organizations to invest in custom M2M systems.

The report came as many other independent research firms predict that the total number of installed IoT devices will increase sharply over the next few years. Gartner Inc., for instance, published research last year saying that 25 billion connected devices will be installed by 2020. According to ABI Research, sensor nodes and accessories are expected to account for 75% of the growth in the IoT over the next five years.

While technology that combines remote sensing and management will represent a large part of the M2M ecosystem, the Signal and Systems report predicts that multimedia and video applications will account for more than 20% of the revenue generated by M2M and IoT services in 2020. This is due to the widespread incorporation of LTE in M2M modules and gateways.

The 3G Partnership Project (3GPP), the standards organization that developed the LTE specification, is in the process of defining a new release for LTE cellular technology that will target IoT deployments, called LTE Cat. M. The standard occupies a class of low-power wide-area networks (LPWANs) and will replace current 2G cellular IoT system designs.

This attempt to redefine the LTE standard for low-power IoT deployments reflects a growing trend among wireless operators to invest in LPWAN technology, according to the Signal and Systems report. Unlike the consumer-oriented Wi-Fi, ZigBee, and Bluetooth technologies, LPWAN systems target extremely low bandwidth applications in the commercial and industrial IoT. ■

CALL FOR PROJECTS Focused on Improving WBG Semiconductors

IN 2014, THE DEPARTMENT OF Energy established a program to develop advanced manufacturing methods for wide-bandgap (WBG) semiconductors, which allow electronic components to be smaller, faster, and more efficient than semiconductors made from silicon (Si). The program, called the PowerAmerica Institute, recently issued a call for projects to help reduce manufacturing costs and increase the availability of these semiconductors in power electronics.

(Image courtesy of Thinkstock)

The advantages of WBG semiconductors are significant when compared to their silicon-based counterparts. This technology can be used to design power electronics that control and convert electricity at higher temperatures, higher breakdown voltages, and lower frequencies than Si-based MOSFETs.

Led by North Carolina State Univ., PowerAmerica was established as a partnership between academic institutions, semiconductor companies, and the Energy Department. Founded earlier this year, it was granted a $146-million contract. PowerAmerica has partnered with several companies that maintain semiconductor foundries, including APEI Inc., Cree Inc., Monolith Semiconductor, and Qorvo, among others.

The two main WBG semiconductors that are expected to replace Si-based MOSFETs—which are not only inexpensive, but also the foundation of most power electronics systems—are gallium nitride (GaN) and silicon carbide (SiC). French research firm Yole Développement estimates that replacing silicon with SiC or GaN components can increase dc-dc conversion efficiency from 85% to 95%; ac-dc conversion efficiency from 85% to 90%; and the efficiency of dc-ac conversion from 96% to 99%.

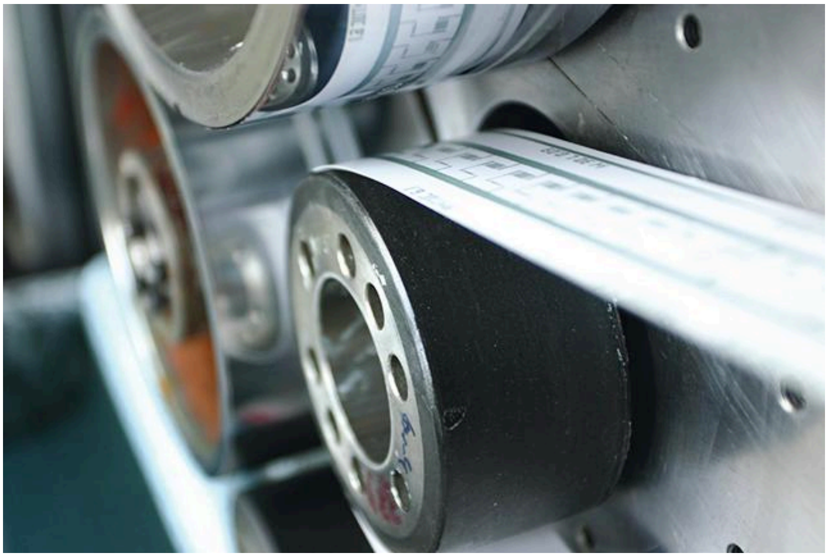
While the advantages are significant, both SiC and GaN process technologies suffer from critical manufacturing issues. For instance, GaN semiconductors have low thermal conductivity and are highly prone to defects. On the other hand, SiC wafers are very costly and have low electron mobility.

Also known as the Next Generation Power Electronics Manufacturing Innovation Institute, PowerAmerica is promoting projects that can significantly reduce the cost and increase the capacity of GaN and SiC foundries. In addition, PowerAmerica is looking to develop new device designs and packaging that effectively exploit the properties of wide-bandgap materials, helping to push them into volume manufacturing.

The call for projects is also focused on filtering the technology into commercial markets. According to statistics from the energy department, the share of U.S. electricity flowing through power electronics

(continued on p.13)

THE FUTURE OF Printed Sensors Depends on Advanced Manufacturing



(Photo by Bystrikt for Wikimedia Commons)

TOWARD THE END OF AUGUST, the U.S. Department of Defense and several private organizations invested $171 million to establish a new manufacturing institute for thin, flexible sensors. Called the Flexible Hybrid Electronics Manufacturing Innovation Institute (FHE MII), it's focused on reducing the time it will take for these unique sensors to be used in the military, industrial, and consumer fields.

Guillaume Chansin, a senior technology analyst with research firm IDTechEx, notes that large investments are pushing printed sensors out of the research phase and toward mass production. While the consumer electronics industry has made progress in the development of printed light-emitting diodes (LEDs) used in smartphone displays, the market for printed sensors is still relatively limited. To date, the only sensors printed on a large scale are those with simple structures. Disposable blood glucose sensors, for instance, which are widely used by diabetics, are covered in reagents to induce an electrochemical reaction with glucose.

According to a recent report from IDTechEx, the market for fully printed sensors will earn revenues over $8 billion by 2025. Chansin notes that the technology will increasingly be used in wearable health monitoring, soft robotics, and sensor monitoring for automobiles and aircraft, in addition to harvesting data for the Internet of Things (IoT). Nevertheless, these sensors will not become more widespread until more advanced production lines can be developed.

Several private companies are in the process of engineering new production lines for printed sensors. In France, for instance, Isorg has begun construction on a new manufacturing process to print optical sensors on flexible plastics. These photodetectors are based on organic semiconductors—instead of silicon ICs—that absorb light and generate an electric current. They can be printed directly over 600-mm^2 plastic sheets, with multiple layers of specialized ink applied in a careful pattern. The production line, which will cost almost $22 million to complete, will become operational in 2017.

In an article about the IDTechEx report, Chansin noted that while the printing process for photodetectors and the glucose test strips might be similar, the equipment is very different: "A factory producing billions of these sensors every year would not be suitable for manufacturing Isorg's photodetectors with decent performances." New manufacturing equipment is necessary for using other materials, such as heat-sensitive polymers and quantum dots.

In the U.S., the FHE MII could make progress in that direction. The institute brings together 96 companies, 11 laboratories, 43 universities, and 15 state organizations. Brewer Science, a member of FHE MII, released prototypes of printed humidity, gas, and temperature sensors. MC10, another member, released a head injury sensor with support from Reebok earlier in 2015.

In addition to integrated packaging and material scaling, the FHE MII has placed an emphasis on developing hybrid systems. This means that printed sensors will also rely on silicon ICs to process information. To create a hybrid system, the ICs will be thinned down, repackaged, and integrated on the flexible substrate. It could result, for example, in a wireless sensor that uses a near-field communication (NFC) chip.

For Chansin, the potential for printed sensors is very high, especially with the growing importance of sensors in building automation and the larger IoT ecosystem. Isorg's photodetectors, for example, could be used to design store shelves that can detect whether an item is still in stock. In a recent interview with Bloomberg, Malcom Thompson, the executive director of the FHE MII, gave an example of an aircraft wing covered in flexible sensors that monitor structural integrity. ■

Call for Projects *(continued from p.11)* is expected to be around 80% by 2030. The Energy Department foresees their rapid uptake in industrial motor systems, for instance, which today consume about 70% of the electricity used in manufacturing throughout the U.S.

PowerAmerica is also looking for projects that advance the use of WBG semiconductors in large data centers, electric vehicles, and converting renewable energy for the electric grid. The greater conversion efficiency and higher operating temperatures of these WBG materials will allow engineers to reduce the size of their cooling systems, according to the Energy Department.

GaN semiconductors are less mature than SiC technology but still progressing steadily. They have seen increased commercial usage in low-power, high-frequency applications, including microwave and RF amplifiers and transistors. Conversely, SiC is finding homes in solid-state lighting and high-voltage devices for switching applications. Despite their technical benefits, however, SiC and GaN are projected to share only 13% of the power semiconductor market by 2024, as indicated in reports from Lux Research.

Si-based power electronics, however, are not going down without a fight. Si-based MOSFETs, which are primarily used in 10- to 500-V devices, are still a cost-effective option in low-power applications. In the 600- and 1200-V range, where WBG semiconductors have the potential to make a significant impact, cost remains an issue. High-voltage Si-based devices—super-junction MOSFETs and IGBTs—are ramping up on 300-mm wafers, making them potentially less expensive than both GaN and SiC.

PowerAmerica is taking a long-term approach to advancing WBG semiconductors, acknowledging that the amount of work to replace generations of Si-based devices will take a significant amount of time. Thus, its call for projects is also focused on developing educational programs and workforce development in the field of WBG semiconductors.

Earlier this year, North Carolina State opened both undergraduate and graduate research programs in WBG semiconductors. For its part, the Energy Department has established a training program through several graduate institutions for power engineering, with its main focus on WBG semiconductors.

"[Power America] is a wonderful opportunity [for students] to get into a new area of technology, but we shouldn't just say that it's just WBG semiconductors," says Jayant Baliga, director of the Power Semiconductor Research Center at N.C. State. "There is a whole technological ecosystem around WBG technology." ■

LOU FRENZEL | Contributing Editor

BEST Communications Product of 2015 Aces the Test

NI's WTS, a more flexible option to ATE, solves high-volume product test problems.

After measuring up all possible candidates for this space, the 2015 Best in Communications was deemed National Instruments' Wireless Test System (WTS) *(Fig. 1)*. It addresses the current and growing necessity of testing thousands, even millions, of wireless devices in a fast and cost-effective manner. The system offers a more efficient, flexible, and affordable alternative to traditional automated test equipment (ATE).

As wireless devices like smartphones and embedded modules have grown in volume and complexity, there's been a corresponding dramatic spike in production test costs. With the sales of smartphones exceeding over one billion per year, test time has become a key manufacturing issue in terms of limiting manufacturing output. The multiple wireless features of a smartphone, such as Wi-Fi, Bluetooth, NFC, GPS, and cellular LTE, in addition to 3G technologies, require manufacturers to meet rigid test specifications for each wireless standard—and that takes time. Add in the need to process thousands of devices rapidly, and production costs skyrocket.

While smartphones still present major test challenges, production engineers are now beginning to deal with test volumes that are several orders of magnitude greater, thanks to the emergence of the first Internet of Things (IoT) products. Though these new devices and modules are small and low cost, they include sensors, an embedded controller, and one of many different wireless technologies.

With projections of IoT volumes climbing to 50 billion devices by 2020, test engineers must find a way to speed up testing while lowering costs. Production test costs simply should not be the major factor in IoT product pricing. So, it's not every day that you can have your cake and eat it, too. But with NI's new WTS, you get shorter test times and lower costs for any device under test (DUT).

THE GENESIS OF WTS

The WTS derives from NI's experience with its successful Semiconductor Test System (STS) announced several years ago. The STS is designed to test and characterize integrated circuits in a production environment. The STS is a platform-based approach to testing built with modular PXI hardware, NI's flagship software LabVIEW, and NI's TestStand software. In one application with chipmaker Cirrus Logic, it produced 30% faster testing results and was less expensive than renting a traditional ATE system.

The WTS is a variation of the STS. It uses PXI modules, LabVIEW system design software, and TestStand, which is NI's test-management and data-analysis software. The resulting system is designed for multi-standard, multi-port, multi-DUT testing for WLAN access

1. National Instruments' Wireless Test System is a multi-standard production test instrument designed to speed up manufacturing test while lowering test cost of high-volume, lower-priced IoT and cellular products.

points, cellular handsets, infotainment systems and IoT multi-standard devices, including cellular, wireless connectivity, and navigation standards *(Fig. 2)*.

Some of the key enhancements to the WTS include a PXI Express Intel Xeon 8-core embedded controller, a PXI Express 24-GB/s chassis using PCI Express 3.0 technology, and NI's popular vector signal transceiver.

FEATURES AND SPECIFICATIONS

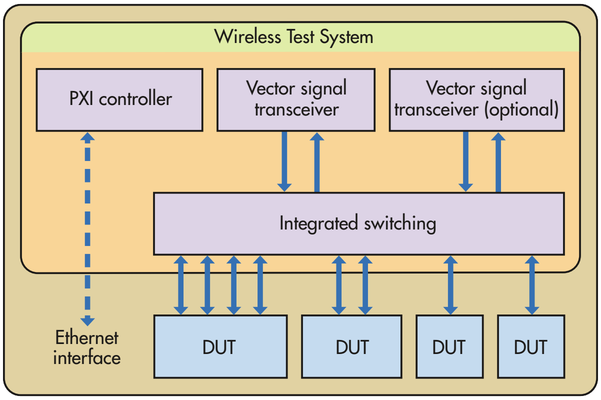
The basic core WTS unit consists of a PXI chassis using the latest and fastest PCI Express bus and an embedded Intel multicore processor. The primary PXI plug-in module is NI's vector signal transceiver (VST)—a combination wideband vector signal generator, vector signal analyzer, and powerful FPGA. The full-duplex RF ports are configured for MIMO, multi-standard, or multi-DUT testing.

The accompanying Wireless Test Module (WTM) provides ready-to-run test sequences for devices from wireless chipset vendors such as Qualcomm and Broadcom. Also included is a Standard Commands for Programmable Instrumentation (SCPI) interface. The SCPI interface, which leverages Ethernet, allows for programming of automated test sequences via the PXI-based system.

The WTS can test almost any standard wireless technology. It supports standards such as Wi-Fi 802.11a/b/g/n/ac, Bluetooth and Bluetooth Low Energy, GPS, FM, and RDS, as well as the cellular variations of LTE/LTE-A/HSPA+/WCDMA/TD-SCDMA/CDMA2000/EDGE/GSM.

Other system features include a frequency range of 65 MHz to 6 GHz, up to 200-MHz instantaneous bandwidth, multiplex or broadcast signal switching configurations, and TCXO or OCXO local oscillator options. NI also offers supporting software tools. For example, its chipset vendor tools minimize the need for new test software development.

If you're planning on developing IoT products in the near future, the WTS could very well be the test solution that best fits the bill, without having to foot an excessive bill.



Note: Ethernet interface connects to PC (not pictured).

2. The NI WTS uses multiple PXI plug-in modules with an embedded controller and integrated switching system that connects to multiple DUTs. The Ethernet interface connects to a remote PC that runs the LabVIEW and TestStand software.

PXI AND THE VST

TWO CHARACTERISTICS OF NI's Wireless Test System allow it to speed up testing while lowering production test costs—the PXI modular system and the NI vector signal transceiver (VST).

PXI, or PCI eXtensions for Instrumentation, is a standard created by NI in 1997. It utilizes the high-speed PCI bus to interconnect measurement modules together, forming specialized electronic test equipment and laboratory instruments. The result is a custom product that's built with special modules to create an instrument for a unique purpose. PXI has become an industry standard supported by a consortium called the PXI Systems Alliance (PXISA), which includes more than 70 companies.

A PXI product begins with a chassis and power supply featuring a Compact PCI bus structure that supports multiple plug-in modules (the faster PCI Express bus is an option). A typical PXI chassis starts with a controller, a PC in a PXI format that usually runs Windows 7. The instrument is then constructed with multiple modules for specific measurements. Some of the possible modules include counters and timers, digital multimeters, LCR meters, digitizers, oscilloscopes, dynamic signal analyzers, digital I/O, RF signal generators, and vector signal analyzers, among many others.

The great benefit of the PXI system is that modules from different manufacturers are fully compatible with the standard. Therefore, they can be mixed and matched to create the specific instrument to fit a particular application's demands. The end result is a low-cost system that can easily be expanded or otherwise modified by adding new modules. Manufacturing test is a typical application.

One of the unique PXI modules available is NI's VST. It combines a vector signal generator, a vector signal analyzer, and a programmable FPGA. The FPGA allows the instrument to be programmed with LabVIEW, like a software-defined radio, to accommodate many different modulation schemes. For example, the VST can test Wi-Fi products using the latest 802.11ac standard as well as cellular handsets using LTE Advanced.

The NI VST comes in several different models, designated PXIe-5644R/5645R/5646R. Basic specifications include a frequency range of 65 MHz to 6 GHz, 80- or 200-MHz bandwidth, 24 channels of high-speed digital I/O, user-programmable FPGA, and optional I/Q interface. The VST is nearly an ideal test instrument for most wireless technologies.

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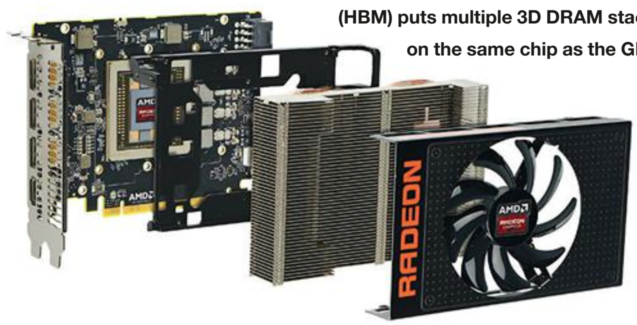
High-Bandwidth Memory Helps GPU Performance

Choosing an *Electronic Design* Best of Award winner always presents a challenge, seeing how there are so many new technologies that show up every year. This year, however, AMD's High Bandwidth Memory (HBM) caught my eye *(see "High-Density Storage" on electronicdesign.com)*. The technology allows multiple 3D DRAM stacks to be included in the same package as AMD's latest GPU *(Fig. 1)*.

AMD has actually been working on HBM for seven years, according to Bryan Black, the firm's senior fellow *(see "Q&A: Taking a Closer Look at AMD's High Bandwidth Memory" on electronicdesign.com)*. The project got its start when AMD realized that GDDR5 was not going to scale to match the growing GPU performance.

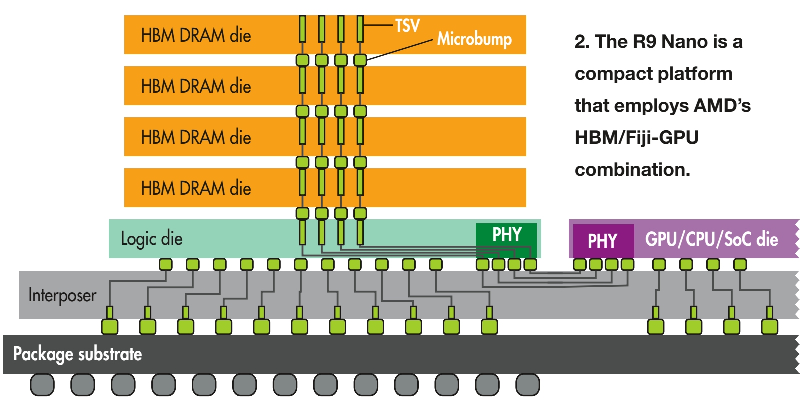


1. AMD's High Bandwidth Memory (HBM) puts multiple 3D DRAM stacks on the same chip as the GPU.

Placing the memory chips on a silicon interposer not only reduces the system footprint, it also significantly increases the memory bandwidth. That's because HBM does not have the pinout limitations of multiplexed off-chip memory. HBM has a 1024-bit bus width versus 32 bits for GDDR5. HBM can deliver 100 GB/s/stack.

There are four stacks in the R9 Radeon Series GPU boards, including the R9 Nano *(Fig. 2)*. The HBM approach is also more power-efficient. Bandwidth per watt for GDDR5 is 10.66 GB/s/W while HBM is over 35 GB/s/W.

Packaging is only part of the puzzle. "The DRAM is only part of the equation," says Bryan. "Building the entire solution required contributions from a number of ecosystem partners in packaging, assembly, and test, as well as DRAM."



2. The R9 Nano is a compact platform that employs AMD's HBM/Fiji-GPU combination.

While silicon interposer use has risen, it has been relegated to high-end solutions like Xilinx's Virtex-7 2000T *(see "10,000 Connections Between FPGA Slices" on electronicdesign.com)*. The interposer can mix chip technologies, allowing optimized designs for each die in the system. In Xilinx's case, it was the addition of SERDES. For AMD, it's the HBM memory stacks.

AMD's implementation is actually more complex because the HBM is a 3D stack of memory dies on top of a logic interface die. These die employ through-silicon vias (TSVs) to provide the vertical interconnects *(see "Setting A New Standard For Through-Silicon Via Reliability" on electronicdesign.com)*.

The R9 Series' 4 GB of HBM basically provides storage for AMD's Fiji GPU. The platform supports Microsoft DirectX 12, Open GL, Mantle, and Vulkan, and can easily handle 4K displays for high-end gamers. The Fiji GPU has 4096 stream processors, 64 compute units, and 256 units. Compute performance reaches 8.19 TFLOPS. The R9 Nano board uses only 175 W of power and plugs into an x16 PCI Express Gen 3 slot.

The R9 Series supports other AMD technologies, including FreeSync, LiquidVR, Eyefinity, and CrossFire. FreeSync synchronizes GPU and CPU gaming operation. LiquidVR assists virtual-reality displays by providing services to reduce motion-to-photon latency to less than 10 ms. Eyefinity provides multiple display support, while CrossFire allows multiple GPUs to be linked for even higher performance. ed

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Create Custom Capes Fast and Easy

Gumstix has taken its Geppetto build-to-order system to the next level. It can now handle platforms like the BeagleBone, as well as standalone microcontrollers and Gumstix COM modules.

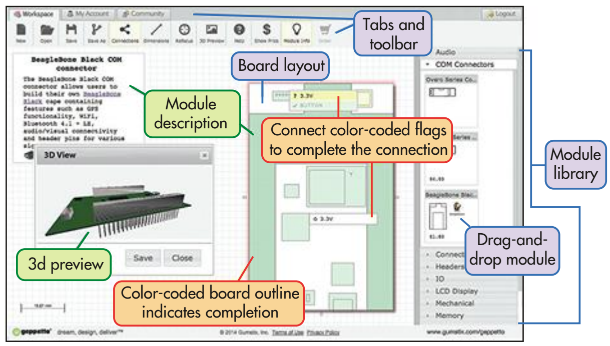
A few years ago Gumstix came out with Geppetto, a web-based designer and build-to-order system *(see "Game Changing Geppetto Builds ARM-based Systems" on electronicdesign.com)*. I was contemplating giving it an *Electronic Design* Best of award, but at the time it was limited to the company's own ARM-based COM modules. This year, Gumstix turned the corner and started supporting third-party platforms such as the popular BeagleBone *(see "Arduino, Raspberry Pi or BeagleBone?" on eletronicdesign.com)*, as well as standalone microcontrollers.

The web-based design tool is the key *(Figs. 1 and 2)*. It is similar to the drag-and-drop interface used by other printed-circuit-board (PCB) design tools for placement, albeit with two major differences. First, there is no routing involved. That part of the PCB design is automatic and hidden from the designer. The other difference is the logical linking between chips and connectors. It is only possible to connect a USB interface on a COM module or processor to a matching USB connector or header. Those can be placed anywhere on the board.

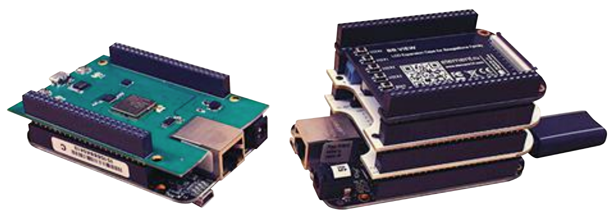
A working board can be designed in an afternoon. Production boards can be delivered within three weeks. This is not a blank PCB: These boards have all the components installed. There is a fixed set-up charge of $2000, and the price of a board is available as the design progresses. Each component also has a price so that a designer can see what it will cost to add a new item.

Components change from red to yellow to green as they are connected. For example, a microcontroller or COM module requires power. Some may also need boot memory and an external reset. The system even tracks power sources and utilization so one cannot skimp on a voltage regulator.

Most systems are designed to run Linux. The system also generates files that work with the Yocto Project tools *(see "Interview: Mike Woster Discusses The Yocto Project" on electronicdesign.com)*, so the proper drivers are configured and ready to work with the customized design.



1. Geppetto is a web-based design system and service tailored for COM platforms from Gumstix as well as third party platforms like BeagleBone.

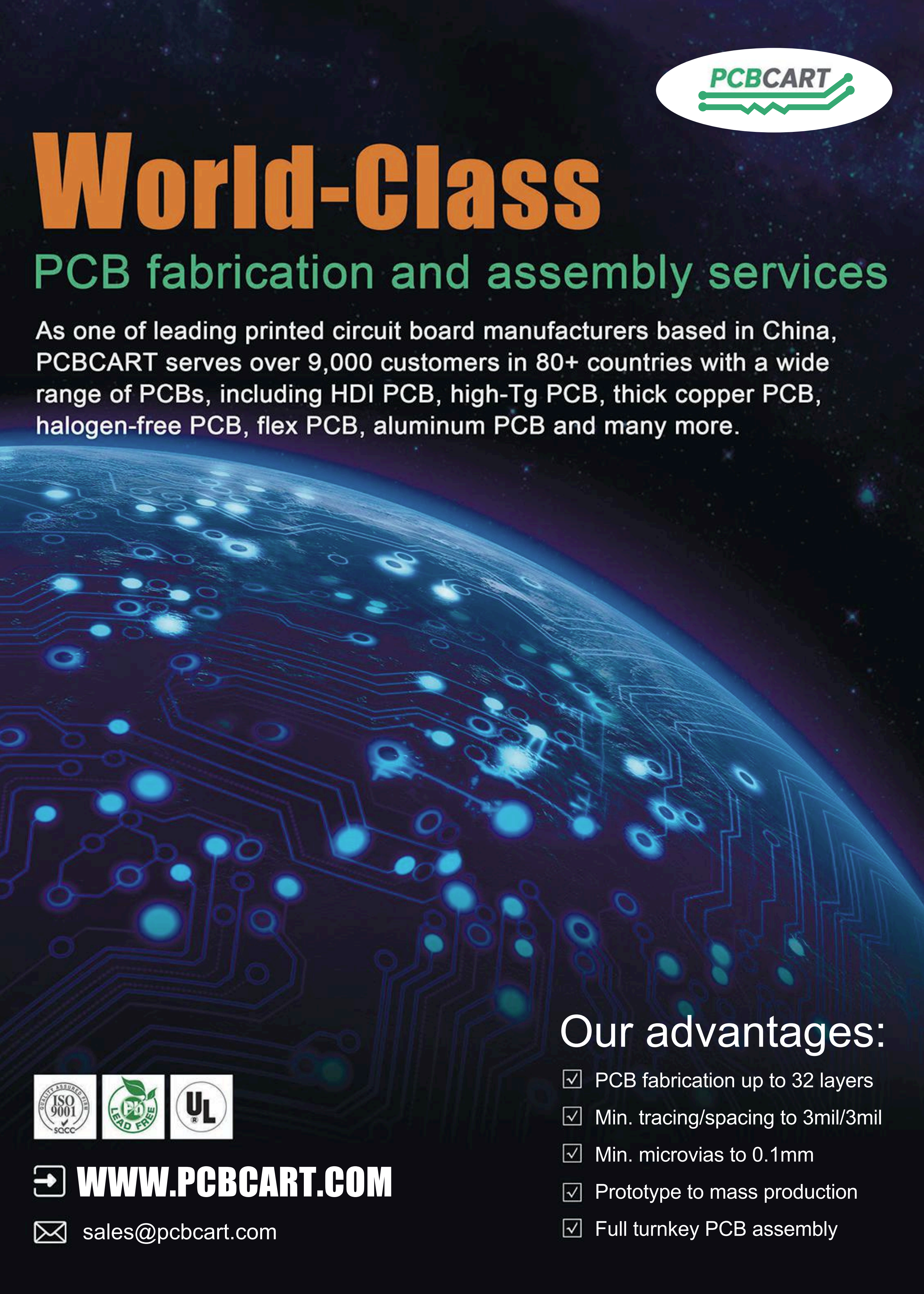


2. These are some BeagleBone capes created using Geppetto stacked on a standard BeagleBone COM module.

Geppetto has many limitations. It cannot be extended except by Gumstix, so a board can only include components in Geppetto's menu. Right now, there is only one GPS and one nine-axis sensor to choose from. There are a number of LCD displays, but only one gigabit Ethernet connector. Still, Gumstix continues to expand the menu of components.

Geppetto costs nothing to use, so it is easy to determine whether the system can complete a design to meet your needs. The set-up charge is for the initial run, and additional boards can be ordered as needed.

Many engineering design companies can help turn just about any design into a product, but it will usually take a bit longer and cost a bit more than using Geppetto. The advantage is the ability to add almost anything to the design. Custom designs make sense when building a million boards, but the dynamics change when there's fewer boards and reduced design complexity.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DON TUITE | Technical Editor

2015 Best of Power Goes to Li-Cell Backup-Power-Management System

Among the slew of groundbreaking product announcements this year, Linear Tech's portable-power-targeted system edged ahead of the rest.

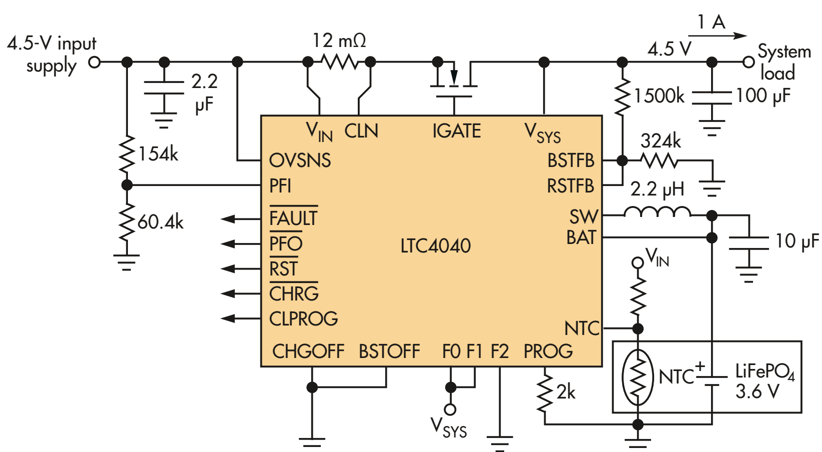
Over the course of 10 months, from January 1 to the end of October (the timeframe we had for choosing the best power innovation), 16 new power ICs were announced by the five largest semiconductor companies: Analog Devices, Fairchild, International Rectifier (now part of Infineon), Linear Technology, and Texas Instruments.

Choosing one product as "Best" was a hard call. Any time chip designers squeeze previously unheard-of performance characteristics out of traditional product types, that breakthrough represents significant effort and further advances process-technology and packaging knowledge. However, I opted instead to look for something new in applications: an innovation that *Electronic Design* readers would consider as a door-opener to other user-product opportunities.

In the end, I chose Linear Technology's LTC4040, which is aimed at portable power. It's a lithium-battery backup-power-management system for 3.5- to 5-V supply rails that must be kept active during a mains power failure *(see figure)*.

The LTC4040 leverages an on-chip bidirectional synchronous converter to provide high-efficiency battery charging as well as high-current, high-efficiency backup power. When external power is available, the device operates as a step-down battery charger for single-cell Li-ion or $LiFePO_4$ batteries while giving preference to the system load. When the input supply drops below the adjustable power-fail input (PFI) threshold, the LTC4040 operates as a step-up regulator capable of delivering up to 2.5 A to the system output from a seamless switchover.

Typical applications for the LTC4040 include fleet and asset tracking, automotive GPS data loggers, automotive telematics systems, toll-collection systems, security systems, communications systems, industrial backup, and USB-powered devices.



The LTC4040 lithium-battery backup-power-management system, developed by Linear Technology, keeps 3.5- to 5-V supply rails active during a mains power failure.

RUNNERS UP

Reluctantly, I had to pass over a number of new devices worthy of recognition. Seven particular standouts (organized by company) got Honorable Mention nods for Best in 2015:

Texas Instruments: In January, TI unveiled its ultra-low-cost C2000 "Piccolo" F2806x "InstaSPIN-MOTION" LaunchPad development kit, which makes it possible to implement control for three-phase motors. The tool controller can tune to a single parameter, which facilitates optimization of complex motion sequences and tracking of desired trajectories across operating ranges. Real-time operation maximizes performance.

Then, in March, TI came out with an 80-V, 10-A, integrated gallium-nitride (GaN) field-effect transistor (FET) power-stage prototype (LMG5200). It consists of a high-frequency driver and two GaN FETs in a half-bridge configuration—all in a quad flat no-lead (QFN) package.

Analog Devices: In August, ADI unveiled an ultra-low-power buck regulator (ADP5301) aimed at extending battery life in portables. In operation, it has a 90% efficiency rating; in standby, quiescent current is a mere 180 nA. Its WLCSP package requires less than 3.1 mm^2 for mounting.

Target apps include wireless sensor networks and wearable devices (e.g., fitness bands and smartwatches) for the Internet of Things (IoT).

Fairchild: In February, Fairchild released a

(continued on p. 22)

DON TUITE | Technical Editor

One Company's Two-Pronged Approach to Enhance Remote Sensing

A video decoder and time-of-flight signal-processing chip, each targeted at remote-sensing applications, combined to take top honors in analog this year.

In what seemingly is the case every year, the slate of analog-related announcements in 2015 was wide and varied. Narrowing down the field for Best of Analog this year was a tough task, but two products from Intersil rose to the top.

FOUR-CHANNEL SURROUND-VIDEO DECODER

The first device from Intersil, the TW9984, is a four-channel analog video decoder with a built-in analog video encoder for around-view parking-assist applications, providing improved safety for drivers and pedestrians *(Fig. 1)*. It's used to create multiple, 360-deg., surround images for advanced driver assistance systems (ADAS).

ADAS is like a rear-view camera on steroids. Typically, four video cameras are positioned around the vehicle. They create real-time images that are combined to present the driver with a 360-deg., top-down, "bird's-eye" view of the surrounding area.

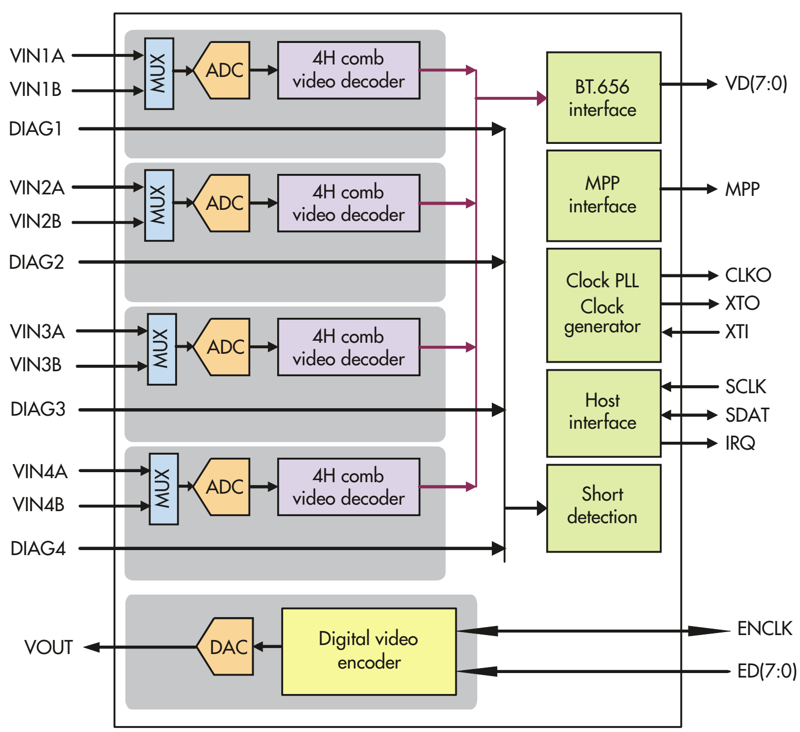
Ultimately, this is more than just a tool for parking assistance and blind-spot detection/elimination. It's an obvious component of future autonomous control. Even today, automotive image-sensor penetration in vehicles is increasing—ABI Research estimates shipments will reach 197 million by 2020.

The TW9984 integrates four high-quality NTSC/PAL/SECAM analog video decoders with 10-bit analog-to-digital converters (ADCs) to support four analog camera inputs simultaneously. Flexibility in the digital output interface makes it easier for system designers to send the images to a processor, which subsequently combines the four images into a single unified around-view image. With the on-chip analog video encoder, the combined video is able to be transmitted as a standard analog composite signal to the head unit display.

Based on Intersil's popular video-decoder technology, the TW8894 is priced at $5 in 1,000-unit lots. It can replace up to nine discrete components with a single chip in many apps.

TIME-OF-FLIGHT SIGNAL-PROCESSING IC

Combined with an external emitter and detector, Intersil's ISL29501 time-of-flight (ToF) based signal-processing IC enables low-cost, low-power, and long-range optical distance sensing *(Fig. 2)*. It starts with a current digital-to-analog converter (DAC) that drives an external LED or laser. The modulated light from the emitter reflects off the target and is received by the photodiode. The photodiode then converts the returned signal into current. An on-chip DSP uses that current to calcu-

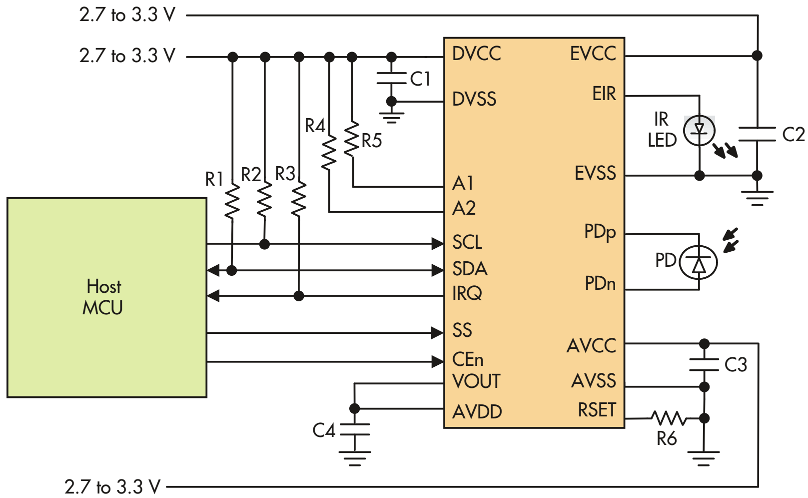


1. Used to create multiple, 360-deg. surround images for ADAS, the TW9984 four-channel analog video decoder improves safety for drivers as well as pedestrians.

late the time of flight, which is proportional to the target distance. There's an I^2C interface for configuration and control.

According to Intersil, it chose to require an external photodiode and emitter so that users could optimize system design for performance, power consumption, and distance measurement range. Since the ISL29501 is wavelength-agnostic, it's possible to match optical wavelengths to applications.

The press release states that 1,000-unit pricing is $4.80. At that price, a potential designer can get a reference design kit for $250, which includes USB cable, software GUI with user's guide, plus system BOM, reference system schematic and layout, datasheet, and applications notes.



2. Intersil's ISL29501 signal-processing IC, based on time-of-flight (ToF) technology, makes possible low-cost, low-power, and long-range optical distance sensing.

Explaining the application focus of the new device, Intersil says the ISL29501 combines "ultra-small size, low-power consumption," and performance that makes the device "ideal for connected devices that make up the Internet of Things (IoT), as well as consumer mobile devices and the emerging commercial drone market."

Positioning the device with respect to drones, Intersil goes on to say, "Traditional amplitude-based proximity sensors and other ToF solutions...perform poorly in lighting conditions above 2,000 lux, or cannot provide distance information unless the object is perpendicular to the sensor."

In contrast, the ISL29501 detects objects as close as 10 cm, and can detect the distance between the ground and drone to provide a soft landing. Placed around and on bottom of drone, the company says ToF would provide better control of landing speed upon detection of the ground. ed

Best of Power *(continued from p 20)*

highly integrated LED controller solution for low-cost and high-reliability dimmable LED lighting solutions from 5 to 30 W. The FL7734 integrates full power-factor-correction circuitry to meet global power factor and total-harmonic-distortion requirements. For current management flexibility, it provides a programmable dimming curve. Also, it incorporates Fairchild's active dimmer driving technology, eliminating visible flicker or shimmer artifacts for most dimmers.

Applications include LED lighting, power supplies for LED televisions and home-theater audio, power adapters, servers, industrial and auxiliary power supplies, and micro solar inverters. The 800-V SuperFET II MOSFET family comprises 26 devices, covering an $R_{DS(ON)}$ range from 4.3 to 60 m Ω.

Infineon/IR: International Rectifier announced several new power devices in 2015. One involved a pair of dual power MOSFETs housed in a small PQFN power block package. The IRFH4257D FastIRFET is intended for 12-V-input, dc-dc synchronous buck applications. IR also introduced a family of rugged, reliable 700-V high-voltage ICs (HVICs) optimized for solar, power-supply, uninterruptible-power-supply (UPS), welding, and industrial drive applications.

July saw the arrival of the high-reliabilityHTB28 series for down-hole applications. IR claimed these were the industry's first hermetic hybrid dc-dc converters rated at 185°C in a 1-inch-wide package. That month also saw a new family of MOSFETs for battery-powered circuits, brushed and brushless dc motor drives, light electric vehicles, drones, and e-bikes.

Linear Technology: In February, the company introduced the LTC7138, a 140-V-input, high-efficiency buck converter that can deliver up to 400 mA of continuous output current while operating from input voltages from 4 to 140 V. A programmable hysteretic-mode design optimizes efficiency over a broad range of output currents from 100 to 400 mA. Fixed output voltages can be programmed from 0.8 V to V_{IN}.

March saw the introduction of Linear Tech's LTC7860, a high-efficiency switching surge stopper with overvoltage and overcurrent protection for high-availability systems. During normal operation, the LTC7860 turns on an external P-channel MOSFET to pass the input voltage through to the output with minimum conduction loss. During an input overvoltage condition, the surge stopper controls the external MOSFET to operate as a high-efficiency, switching dc-dc regulator to protect critical downstream components by limiting both the output voltage and current. ed

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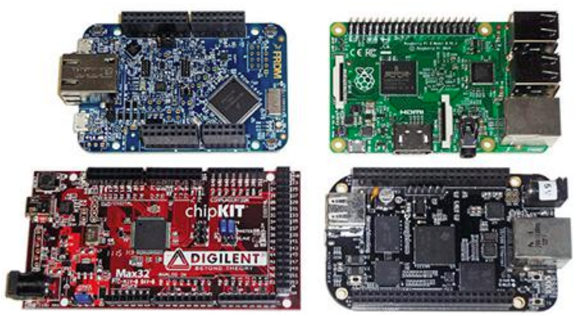
Can Open-Source Modules Move into the Mainstream?

Platforms like Arduino and Raspberry Pi are ubiquitous in the maker movement. The question is whether these platforms can be used in production products.

Platforms like Arduino, Raspberry Pi, and BeagleBone (*see the figure*) are ubiquitous in the maker movement *(see "Arduino, Raspberry Pi or BeagleBone?" on electronicdesign.com)*. The question is whether these platforms can be used in production products. The answer is often yes, depending upon specific application requirements.

Each of these platforms has a large and growing community that encompasses both vendors and developers. The plethora of peripheral expansion boards is key to their success, and many silicon vendors target new products at these platforms. This greatly simplifies deployment while making the product available to a wider audience.



The Freescale Freedom board (top left) and Digilent chipKit Max32 (bottom left) may look different, but they share the basic Arduino pinouts for expansion. The Raspberry Pi 2 (top right) and BeagleBone Black (bottom right) have their own community.

Likewise, microcontroller and microprocessor vendors can deliver boards compatible with these peripherals. Freescale's Freedom boards are compatible with the Arduino platform. Digilent's chipKit Max32 can use Arduino shields (expansion boards), but runs a Microchip 32-bit MIPS-based PIC32 *(see "PIC32 Arduino Modules" on electronicdesign.com)*. The challenge for vendors is determining which platform to select.

There can be challenges for designers especially when it comes to rugged requirements. Most platforms have moved to form factors that allow board stacks to be bolted together. Designers need to take a closer look at boards to make sure they meet interface requirements (such as isolation) that are common on production platforms like PC/104, but often overlooked in the products that target the maker community, where cost or time-to-market is often more critical.

CUSTOMIZING DESIGNS

Many of the platforms are based on open-source hardware. This allows a designer to easily move to a custom solution that can do a number of things, from making a design harder to clone, to providing a more compact solution, to reducing cost. It also means a company can replicate a board if the source becomes unavailable or too expensive.

The challenge facing many developers is the inherent difficulty in moving to a custom solution. There are many design firms that can help turn prototypes into products, but costs can vary. On the plus side, the resulting solution usually provides advantages, such as lower per-unit cost and a more compact footprint.

Still, converting a design to a custom solution can take time and money. There are companies looking into lowering these barriers. Newark/element14 can now deliver customized versions of the Raspberry Pi. This might include chores like removing unneeded interfaces and connectors.

Gumstix's Geppetto can generate custom boards for a fixed $2000 setup fee. The web-based design tool even shows the per-board cost as the board is laid out. It can be used to create boards compatible with popular platforms like the BeagleBone, as well as support COM modules like the Gumstix Overo and select microcontrollers like STmicroelectronics' STM32F427 Cortex-M4.

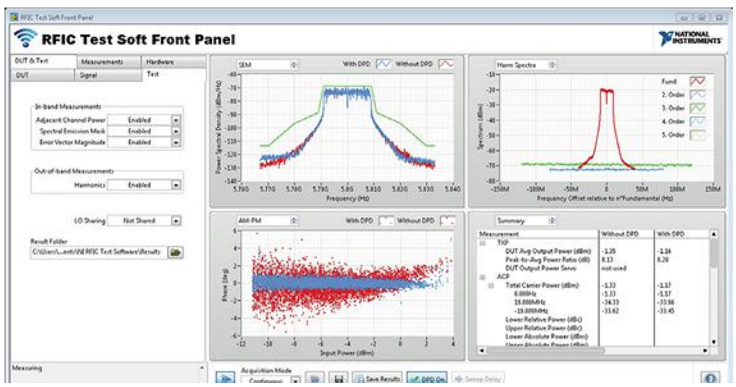
Geppetto differs from other custom approaches because it limits the devices and connectors that can be included on a board. On the other hand, designers only need to layout a board from the component level. The system will only build a board that has met all component requirements. ed

DAVID HALL | Senior Product Marketing Manager
National Instruments

5 THINGS You Didn't Know RF Signal Generators or Analyzers Could Do

A decade ago, innovation in the test-and-measurement industry started pushing the capabilities of vector signal generators and analyzers to wider bandwidths, faster tuning times, and greater signal-processing capabilities. Over this time period, these instruments have evolved from a heavily analog device to a highly sophisticated supercomputer, which also happens to have a killer analog front end.

Given this evolution, I thought it would be worth reviewing several of the applications that engineers are solving with modern RF signal generators and analyzers. Although some of these applications were unthinkable a decade ago, advances in instrumentation technology now make them commonplace.



1. Shown is a typical software application for digital-predistortion (DPD) power-amplifier testing.

IMPLEMENT DPD ALGORITHMS

Digital predistortion (DPD) is a common technique used to correct for nonlinear behavior in RF power amplifiers (PAs) *(Fig. 1)*. It involves digitally modifying a waveform at baseband before upconversion to RF. Because the DPD algorithms historically require intense computation and were embedded on an application-specific integrated circuit (ASIC), testing a PA's performance under DPD conditions required incredibly complex test configurations.

Today, engineers are able to test a PA's performance under "DPD conditions" using off-the-shelf vector signal generators and analyzers. With this setup, the instruments first extract a model of the PA's behavior. Then, using the model, the signal generator's software applies one of several standard DPD algorithms to the baseband waveform. By generating this modified waveform, the signal generator replaces the functionality of the DPD ASIC and allows the engineer to test PA performance under DPD conditions.

RECORD AND PLAYBACK SIGNALS TO AND FROM DISK

A decade ago, the onboard memory of a vector signal generator or analyzer determined the maximum duration of signal that could be generated or acquired by an instrument. Typical onboard memories ranged from tens to hundreds of megabytes, allowing up to a few seconds of waveform generation or acquisition. For longer waveforms, such as the generation of a GPS signal (which often requires several minutes to be useful), you were simply out of luck.

Over the past decade, the evolution of high-throughput bus technology has revolutionized the way that vector signal generators and analyzers can produce or consume data. During this time, bus technology progressed from the days of GPIB delivering megabytes of data per second to today's PCI Express implementations that deliver several gigabytes per second. For example, modern PXI modules using x4 (pronounced "by-4") PCI Express data links are able to stream up to 3.2 GB of data per second from a high-speed hard drive to a PXI module. With complex waveforms consuming 32 bits per sample

(16 bits for I, and 16 for Q), 3.2 GB translates to 800 Msamples of IQ waveform per second.

Thanks to modern bus technology, onboard memory size no longer determines the maximum waveform size in a modern RF signal generator or analyzer. Instead, it's determined by the amount of hard-drive space one can assemble. In fact, today's engineers can create or acquire waveforms that are literally tens of terabytes in size. The dramatic increase in waveform record sizes has introduced new applications for instrumentation. One of the most common is to record RF spectrum off the air using an antenna and then play it back to a wireless device in the lab.

MEASURE S-PARAMETERS

Similar to how we're beginning to see modern vector network analyzers (VNAs) with spectrum measurement capabilities, we're also seeing vector signal generators (VSGs) and analyzers (VSAs) evolve with S-parameter measurement capabilities. Historically, network analyzers measured S-parameters through a stimulus signal combined with a tightly controlled arrangement of directional couplers and receivers.

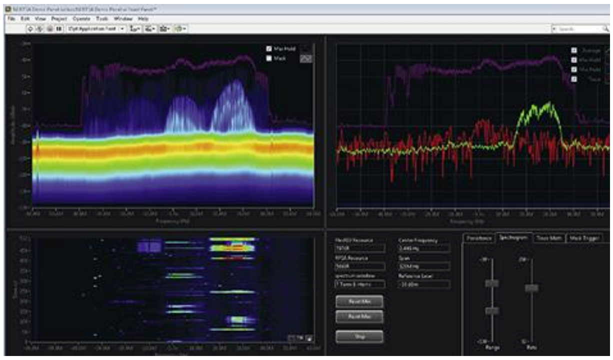
Although a high-end traditional VNA is still the preferred method to perform the most accurate S-parameter measurements, it's not always the most economical. Now, more engineers are adopting a VNA architecture that combines a vector signal generator and analyzer with a "port module," especially in high-volume production test applications for semiconductor components. The port module provides a series of directional couplers, along with signal-conditioning hardware, to turn the VSA/VSG into a VNA. The port-module approach typically results in significant cost savings for engineers that are already performing vector or spectrum measurements.

PROCESS SIGNALS IN REAL TIME

April 19, 2015 marked the 50th anniversary of Moore's law, a simple observation from Gordon E. Moore that transistor density would double every two years. Over the past 50 years, the reliability with which new processor performance has tracked Moore's prediction has made his observation famous.

The last 50 years of exponential processor performance growth has created a scenario where the modern RF signal generator or analyzer now possesses the computational capabilities of a supercomputer. In fact, it's worth noting than in 1965, a state-of-the-art IBM 7904 computer was capable of performing 100,000 floating-point operations per second (FLOPS). Today, the iPhone 6 literally has a million times this processing performance, and a modern RF instrument offers tens of million times this performance.

The end result of such immense signal-processing capabilities on today's RF signal analyzers is the ability to process signals in real time. Not only can today's advanced RF signal analyzers perform spectrum measurements in real time as part of a real-time spectrum analyzer, they can also execute other signal-processing algorithms as well *(Fig. 2)*. For example, engineers use the LabVIEW-programmable FPGA on PXI RF signal analyzers to implement algorithms such as demodulators, multichannel DDCs, and more.



2. Real-time spectrum analyzers can analyze signals without gaps in the time domain.

SYNCHRONIZE FOR MIMO AND MULTICHANNEL APPLICATIONS

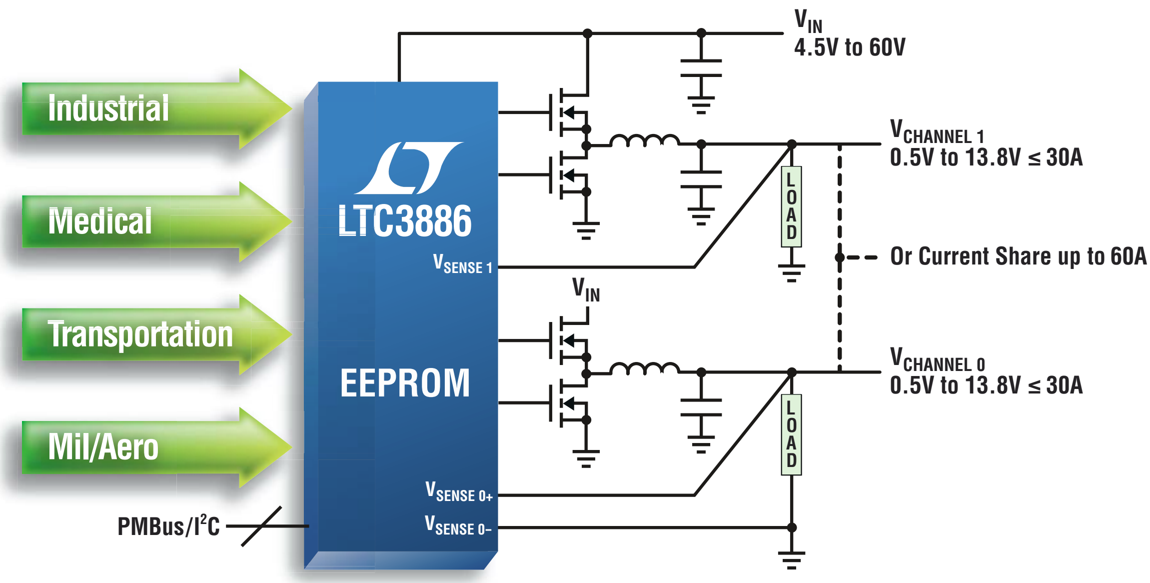
Another capability of modern RF signal generators and analyzers that's progressed significantly over the past decade is the ability to synchronize multiple instruments for multichannel applications. Historically, synchronizing multiple signal generators or analyzers was tricky—if not impossible—due to the relatively closed architectures of the instrument. Today, however, many VSGs and VSAs are designed such that multiple instruments can share their internal local oscillators (LOs).

As a result, engineers can synchronize four, eight, or even more RF instruments for phase-coherent signal generation or acquisition applications. With the emergence of multiple-input multiple-output (MIMO) antenna technology in standards such as IEEE 802.11ac and LTE Advanced, the ability to synchronize multiple instruments has become a substantial asset for engineers testing MIMO transceivers. In addition to these applications, engineers are using multichannel instruments for a wide range of electronic-warfare applications ranging from phased-array radar prototyping to direction finding.

CONCLUSION

No doubt, that old signal generator or analyzer in your undergraduate electrical-engineering lab is substantially different than today's instruments. In fact, the emerging capabilities of these instruments are empowering engineers to use off-the-shelf instruments in an ever-expanding field of applications that were once solved by designing one's own custom instrument. Thus, if you have a crazy signal-generation or acquisition need, and thought you'd have to design your own hardware, think again. No matter how extreme your need might seem, it just might be possible to solve it with an instrument.

60V I²C Programmable Power



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- Input Voltage Range: 4.5V to 60V
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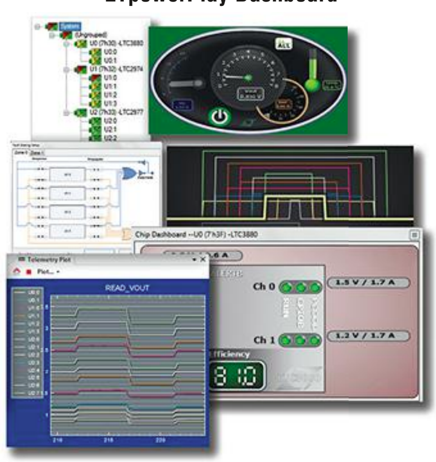
- PMBus/I²C Complaint Serial Interface
- Programmable Control Loop Compensation
- Internal EEPROM and Fault Logging
- Accurate PolyPhase® Current Sharing for Up to 6 Phases
- LTpowerPlay Power Development System

LTpowerPlay Dashboard



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Distributors Eye Economic, Legislative Issues

Taxes, health care, and economic issues, including overtime pay, continue to raise concern as 2015 comes to a close.

VICTORIA FRAZA KICKHAM | DISTRIBUTION EDITOR
JOE NOWLAN | CONTRIBUTING EDITOR

SLOW ECONOMIC GROWTH is the overriding concern of most business leaders throughout the supply channel, but a host of other issues remain on the back burner and are likely to continue to simmer in the upcoming election year. Health care, tax reform, and proposed changes to overtime rules and regulations are a few issues business owners—and small-business owners, in particular—are watching carefully.

Economist Scott Brown, of Raymond James Financial, predicted a mixed bag of economic growth heading into 2016 when he spoke to manufacturing and distribution leaders from the electronic components channel at the recent Executive Conference of the Electronic Components Industry Association. Brown points to ongoing uncertainty in the global economy, coupled with longer term issues here at home, as problems going forward.

Many business leaders at the ECIA event said they were experiencing flat conditions overall, with the exception of the large catalog houses—some of whom predicted near-double-digit growth for the year. Mouser Electronics, for instance, predicts revenue growth of between 9% and 11%. Digi-Key Corp.'s Dave Doherty says 2015 has been a challenging year, but that he's "bullish on 2016" for a variety of reasons (steady design activity, in particular).

"Companies tend to innovate their way out [of difficult times]," says Doherty, who was promoted to president of the Minnesota-based distribution company earlier this year. "There are some strong roads ahead."

Avnet Electronics Marketing's Ed Smith agrees that business continues at a sluggish pace, though he notes that Avnet started off strong in 2015, not feeling the effects of the current slowdown until mid-August. A positive book-to-bill ratio in September fueled a solid outlook as the company entered the final quarter of the calendar year.

Smith, who is president of Avnet Electronics Marketing Americas, says much of the good news is driven by returning military and aerospace business. But he cautions that the soft economy continues to bring pressure from customers and suppliers, as average selling prices fall and customers seek further cost reductions across the board. Abundant inventory throughout the channel is also a factor.

When they are ready, however, Smith indicates the inventory situation is a boon to companies like Avnet. "We haven't cut back on inventories," he says. "If you have the inventory…they buy from you."

SMALL-BUSINESS HURDLES

Business leaders are watching a handful of legislative issues carefully as well—despite being skeptical that anything will be done about them.

"I'm just disgruntled with the way the whole Washington situation works," says Joe Gallagher, president and COO of Gallagher Fluid Seals, a fluid-power and motion-control distributor based in King of Prussia, Pa. "They can't get anything done. It is unfortunate."

Topics—many of which arise annually—include the Estate Tax, which, upon the death of a compa-

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ny's owner, can take a large financial bite out of a family business. Another issue is the state of health care—specifically the Affordable Care Act and its impact on businesses paying for employee health insurance.

Keith Nowak is president of MPT Drives in Madison Heights, Mich. It was founded in 1959, and in 2012, Nowak bought the company from his father, Ed. Out of necessity, he says he stays on top of the Estate Tax. "You have to really take care of your estate planning so you don't get slammed so hard with those taxes," says Nowak. "And it's causing some people to move out of the country or take up residence in different places for tax shelters."

Military and aerospace, automotive, and wearable electronics sectors continue to perform well for Avnet Electronics Marketing Americas, says business unit President Ed Smith.

Companies with a succession plan in place can save themselves a lot of trouble and, in the long run, money. Gallagher Fluid Seals is a family-owned business with newer, younger family members starting to take on larger roles within the company. "We're going through a transition now from second generation to third generation," he explains. "We have tried to plan and try to work around some of those issues here…[So] for us it is not a major issue."

In the House of Representatives earlier this year, Congressmen Kevin Brady (R-Texas) and Sanford Bishop (D-Georgia) introduced the Death Tax Repeal Act. And in the Senate, Sen. John Thune (R-South Dakota) filed similar legislation.

Another issue that may come up in Congress is health care, a topic small-business owners in virtually all industries are watching carefully. Although the Affordable Care Act has not been in place for that long, there is some dissatisfaction.

"The bigger issue that we struggled with over the last couple of years is the change in the healthcare plans," Gallagher explains. "We renew every year, and it is a different plan—not the same as last year. And that makes it challenging in terms of trying to find healthcare plans that are competitive for our people and that are good plans."

Business owners such as Nowak are perplexed that their rates have not decreased, but have been rising annually. "I just got my quotes in for the next year and they didn't go down," he says. "When I talk to other people, [their] deductibles are going up. People's co-pays are going up and the employee contributions to that healthcare plan are going up."

Proponents of the Affordable Care Act point to its long-term goal of a healthier population due to more people having health insurance and better medical care. But in the short-term, annual rates have increased in many cases—although not as much as previously, Nowak acknowledges.

"It's going to take a while," he says. "I think in theory that was the right idea, but what we're hearing is that the problem is not enough young, healthy people are buying insurance."

OVERTIME AND THE ECONOMY

As 2016 is an election year, it seems unlikely that any Estate Tax or healthcare changes will occur, business leaders agree. It may be just as well that other issues of concern to distributors are those that they, as business owners, are in a position to attack themselves. One is the proposed changes to overtime regulations that came from the Department of Labor in mid-2015.

Under the current rules, employers usually don't pay overtime to salaried employees who earn more than $23,660 a year. The Labor Department's proposals would raise that salary threshold to $50,440. The proposal would also allow for automatic increases—an increase that could be tied to the rate of inflation, although the specifics remain uncertain. As of early November, the finalized version of these changes is expected in early 2016.

The Manufacturers Alliance for Productivity and Innovation looked at the overtime proposals in an August analysis by Les Miller, deputy general counsel at MAPI.

"Companies might start planning for the proposed changes by identifying exempt employees who are at salary levels near the projected minimums. For such employees, determinations can be made as to whether it is more cost-effective to increase some employees' salaries above the exemption threshold where their usual work schedules would otherwise make them eligible for overtime pay…It might also be advisable to consider updating policies and procedures regarding the reporting of hours worked and receipt of authorization to work overtime."

Gallagher joins with many in the supply chain in voicing his concern about the proposals.

"In my opinion, it could be a nightmare…I don't think [the government] understands what business owners face every day when it comes to some of these rules and regulations that they put in place," he says. "It is not something that is black-and-white and pertains to every industry group."

While new overtime regulations can potentially wreak havoc on a company's budget planning, Nowak says he hopes to add talented younger employees to his payroll. But the task is easier said than done."For me to hire a salesman, for example, is very difficult because all the [experienced] ones have jobs," says Nowak. "I'm not big enough to steal from my competitors. I don't have that kind of money. So we are basically forced to hire kids from out of school."

While Nowak is all for youth, many of the potential hires have other, more expansive career plans. "I've been to community college classes promoting industrial distribution," he explains. "I'll talk to kids and ask them about their plans. What do they plan to do? And I hear 'I'm going to be an entrepreneur.'" ■

ADC Function Based on PWM Technique

G. V. KISHORE and K. PALANISAMI | IGCAR, India

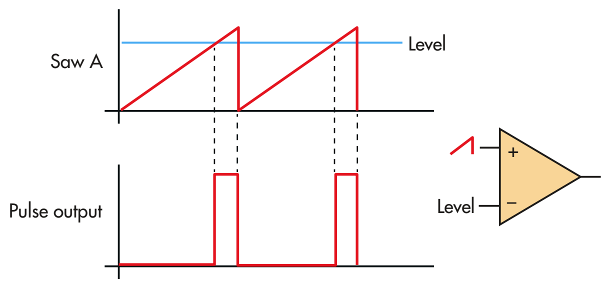
PULSE-WIDTH MODULATION (PWM) is used in applications ranging from controlling valves or pumps to adjusting the brightness of LEDs. In this proposed design, a PWM waveform is the basis for an analog-to-digital-converter (ADC) implementation. The PWM waveform can be easily generated through a comparator using a triangle or sawtooth waveform and variable dc voltage (*Fig. 1*). As the input varies from 0 to 10 V dc, the pulse width changes proportionately. A microcontroller reads the width digitally and displays the corresponding dc input voltage to the user after engineering conversion through the RS-232 port of a legacy machine.

In this implementation of a proposed PWM converter approach, the two inputs to comparator U1 are the sawtooth waveform from an arbitrary waveform generator and the dc input from a precision voltage calibrator (*Fig. 2a*). The sawtooth has a negative offset to ensure that there's a pulse when the dc input is zero; the sawtooth varies from –2 V to 10 V (12 V_{P-P}). The digital circuit must measure the width of the generated output PWM pulse. This circuit is implemented in a CPLD, and consists of a synchronizer, counter, sequencer, latches, and three-state buffers (*Fig. 2b*), and interfaces to U2, a PIC microcontroller, and the RS-232 port (U3 and Conn1) (*Fig. 2c*).

The PWM pulse, which is synchronized with respect to the system clock, serves as an active-high count-enable signal of the 16-bit synchronous counter. The sequencer circuit generates two signals, DRDY and LRST, after the trailing edge of the PWM pulse to latch the synchronous counter output. Then it resets the counter to restart the fresh measurement and acquire new data. After synchronizing, it uses the pulse-width ON time to enable the counter, which is clocked by a fixed 4-MHz source (derived using the clock divider as shown).

The latched output is available through buffers, which are enabled by the microcontroller and subsequently read. EN1 and EN2 are the buffer-enable signals generated by the microcontroller to read the latched counter outputs for downstream processing. When the dc input varies from 0 to 9.95 V, the pulse width is measured with the counter. The sequencer, which is implemented with simple shift register, ensures that the counter output is reset only after latching into the register.

Since the count for 0 V dc is already known (both mathematically and empirically), the result for any value from 10



1. At the heart of the PWM-based analog-to-digital converter is a comparator that has the unknown signal as one input and a known ramping waveform (here, a sawtooth) as the other.

ADC COUNTER VALUE LINEARIZATION

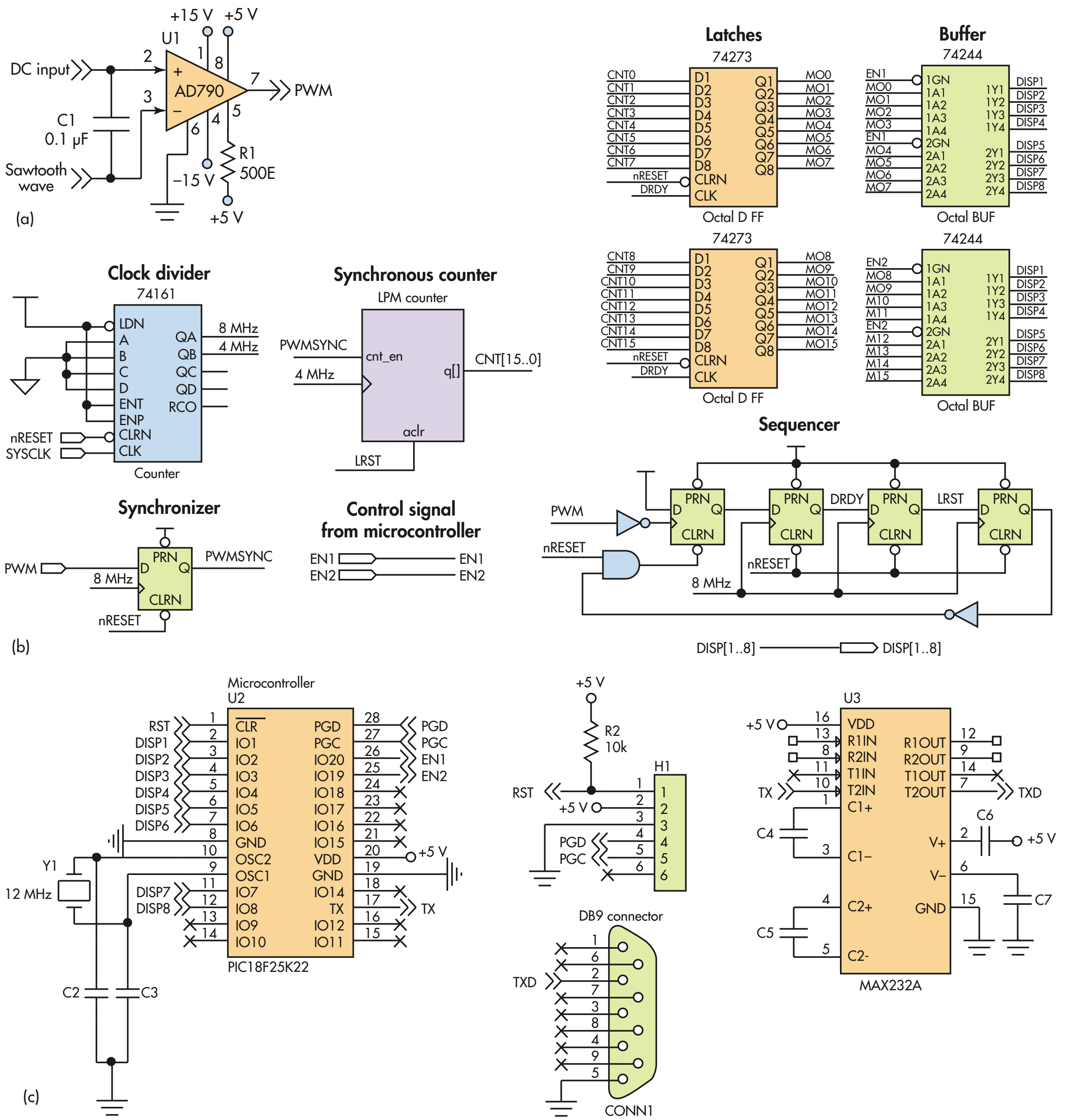
Sl. no	DC input voltage	Normval (V)	Lin Factor ((Int) Normval* 7) mV	ADCVAL (mV)	Error (DC voltage-ADCVAL) mV
1	0.0	0.003	0	3	3
2	0.5	0.504	0	504	4
3	1.0	1.006	7	999	1
4	1.5	1.509	7	1502	2
5	2.0	2.011	14	1997	3
6	2.5	2.514	14	2500	0
7	3.0	3.016	21	2995	5
8	3.5	3.519	21	3498	2
9	4.0	4.023	28	3995	5
10	4.5	4.525	28	4497	3
11	5.0	5.029	35	4994	6
12	5.5	5.532	35	5497	3
13	6.0	6.036	42	5995	5
14	6.5	6.540	42	6498	2
15	7.0	7.044	49	6995	5
16	7.5	7.551	49	7502	2
17	8.0	8.056	56	8000	0
18	8.5	8.565	56	8509	9
19	9.0	9.063	63	9000	0

mV to 9.95 V is computed by subtracting the measured counts with the zero value. The equations for the width of the PWM waveform and factors are:

- $T_W = T_P \times (|V_{Neg\text{-}pk}| + V_{DC}) / V_{P\text{-}P}$
- Synchronous counter output value = $T_W \times T_{CLK}$
- Float Normval = (counter output – count offset) × scaling factor
- Int ADCVAL = Normval – Lin factor

where:

- T_W = pulse width (ms)
- T_P = time period of sawtooth wave
- $V|_{Neg\text{-}pk}|$ is the peak negative voltage, taken in absolute scale



2. Implementing the concept shown in Fig. 1 requires a standard comparator IC and some passive components (a). The complete proposed circuit for measuring the pulse width of a PWM wave is implemented using a CPLD, and requires digital logic for the synchronizer, counter, sequencer, latches, and three-state buffers that interface to the microcontroller (b). A PIC microcontroller interfaces to the digital logic (c).

DESIGN NOTES

Monolithic Converter Delivers High Output Voltages

Design Note 545

Jesus Rosales

Introduction

Industrial, telecom, medical and automotive applications use a wide variety of regulated voltages to operate effectively, including high voltage and negative rails. When the designer is faced with producing industrial power supplies, the job can be simplified by minimizing the parts count, as well as the number of required controller ICs. The LT®8331 achieves both of these goals with an integrated 140V, 500mA switch, programmable frequency, ultra-quiescent current and light load Burst Mode® operation.

High voltage applications are easily accomplished using a simple boost converter, as shown in Figure 1. This application can output 120V at 25mA to 80mA in a straight boost configuration or 240V at 12mA to 40mA as a two stage boost by adding a few components, as shown inside the dotted line. The load can be taken entirely from V_{OUT2}, or a combination of V_{OUT1} and V_{OUT2}.

A high voltage negative output rail can easily be attained by configuring the converter as shown in Figure 2. This converter allows full switch voltage utilization to produce a negative output, by adding a capacitor and a diode. A coupling capacitor, C5, adds input to output disconnect during shutdown, similar to a CUK converter.

Figure 3 shows a CUK converter using the LT8331, and Figure 4 shows the efficiency curve for this inverter with a 12V input. Efficiency for this converter peaks at 84%. Burst Mode operation kicks in when the load drops to about 40mA, which allows the converter to maintain a respectable efficiency level of 73% even with a 1mA load.

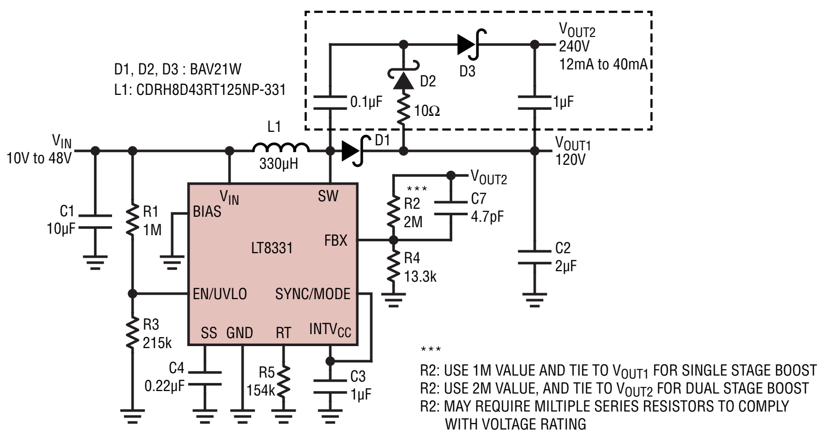


Figure 1. 120V or 240V Output Boost Converter

The LT8331 has very low quiescent current. It features an operation mode where the switching frequency is allowed to decrease progressively when a light load is detected. This mode enables the converter to maintain both high efficiency and low output ripple at light loads. The input current is just 29µA when the output is unloaded and about 11µA comes from the FBX resistor divider. If the converter is turned off by pulling the EN pin to ground, the input current drops to about 1µA for a 5V input, or 2µA with a 12V input. A good portion of the shutdown current is drawn by the EN/UVLO resistor divider.

The LT8331's 4.5V to 100V input range and its 140V rated switch make it an ideal candidate for SEPIC and CUK converters. Coupling capacitor, C5, breaks the input to output DC path, a desirable characteristic in applications where the output must be disconnected from the input. This has the added benefit of removing the current drawn by the FBX resistor divider. The switch voltage in these converters equals the sum of the input and output voltages.

Conclusion

The LT8331 simplifies the design of high output voltage and wide input voltage applications by reducing the number of external components. Its 140V, 500mA internal switch, 100V input, programmable frequency, ultra-low quiescent current and light load Burst Mode operation make it ideal for a broad range of applications.

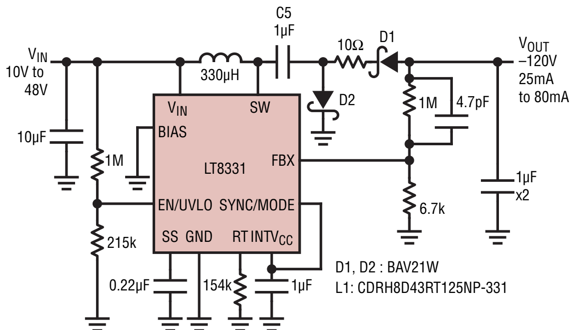


Figure 2. –120V Inverting Converter

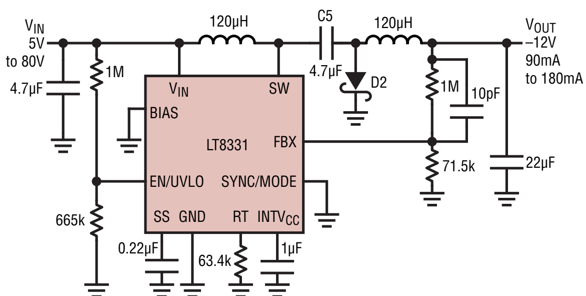


Figure 3. –12V Output CUK Converter

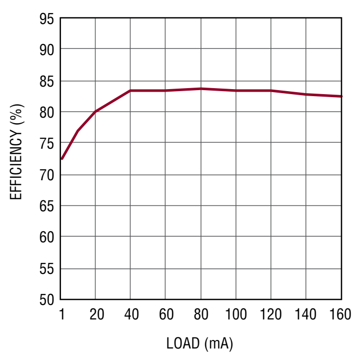


Figure 4. Efficiency Curve for Figure 3 (with a 12V Input)

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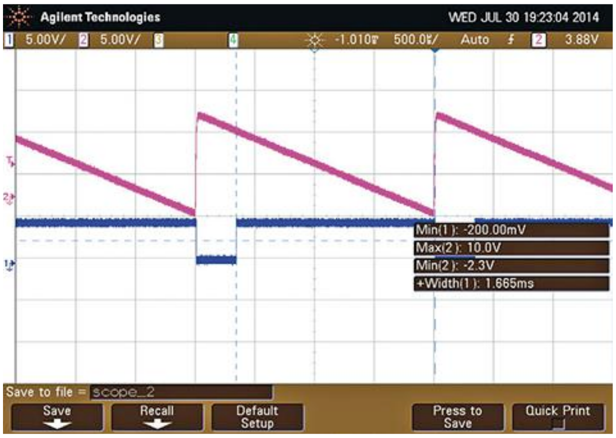
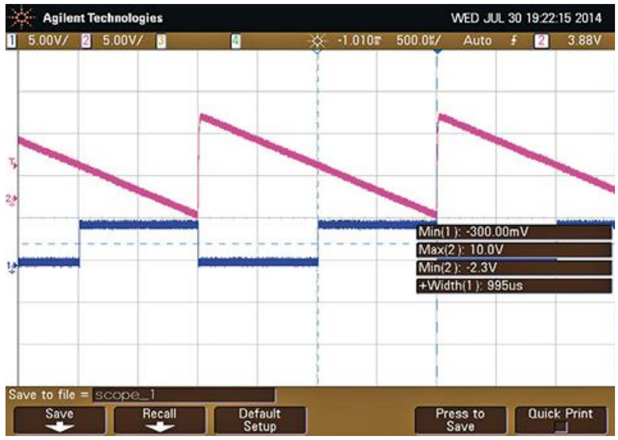


3. The lower trace (blue) shows the width of the output pulse, 1.665 ms, for a dc input of 8 V (horizontal scale is 500 μs/division).



4. The lower trace (blue) shows the output-pulse width of 995 μs, corresponding to a dc input of 4 V.

- V_{DC} = 0-10 V dc input voltage
- V_{P-P} = peak-to-peak voltage levels of sawtooth waveform
- T_{CLK} = the sampling clock to the synchronous counter
- Count offset = the counts corresponding to $V_{DC} = 0$ V
- Normval = a software variable multiplied by appropriate scaling factor
- ADCVAL = a software variable indicating the final ADC count value (in millivolts) after the linear factor correction (Lin factor).

For the proposed design, V_{P-P} = 12 V, $|V_{Neg\text{-}pk}|$ = 2 V, and T_P = 2 ms (500-Hz period) were chosen. This resulted in a pulse width ranging from 333 μs for $V_{DC} = 0$ V to approximately 2 ms for V_{DC} = 9.95 V. The corresponding counter outputs varied from 1,332 (min) to 8,000 (max) count, respectively, for T_{CLK} = 4 MHz.

The scaling factor is evaluated by the formula (8,000 −1,332) × scaling factor = 10 V. Here, the scaling factor worked out to be 1.5 (mV). Linear factor is evaluated after tabulating the measured value of ADCVAL for the corresponding input dc voltage and estimating the slope by curve fitting (see the *table*). The Lin factor was derived as ((Int)Normval × 7) mV.

The scope photos (*Figs. 3 and 4*) show the output pulse widths for dc inputs of 8 and 4 V, respectively. The output results for this PWM-based approach to implementing an ADC shows only minor variations compared to the expected value. The tabulated value indicates that the proposed design functions as a 10-bit ADC.

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Microcontroller Generates Chaotic Lorenz Signals

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CHAOTIC SYSTEMS ARE interesting for a variety of reasons, including their relevance to meteorology, physics, and engineering. A well-known chaotic system is the Lorenz system, described by nonlinear differential equations:

$$du/dt = \sigma(v - u)$$
$$dv/dt = ru - v - 20uw$$
$$dw/dt = 5uv - bw$$

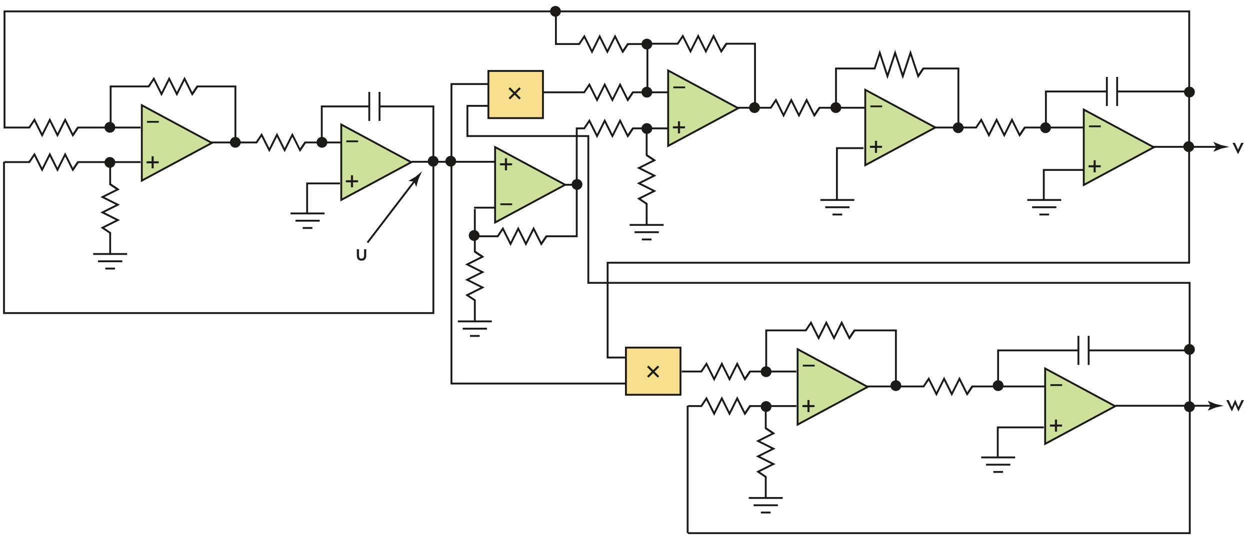
where u, v, and w are the time-dependent variables of the chaotic system and r, b, and σ are the constant parameters that can be adjusted to alter the overall behavior of the system.[1]

This Idea for Design solves the Lorenz chaotic system numerically in a microcontroller, combining a novel approach to generating chaotic signals with the convenience of a simulation and an ability to synthesize real signals when desired.

The analog circuit implements and solves the differential equations of the Lorenz system and generates signals u, v, and w of the system, which then can be observed on an oscilloscope to examine the system's chaotic behavior (*Fig. 1*). These signals can be used to encode an information signal for secure transmission.[2]

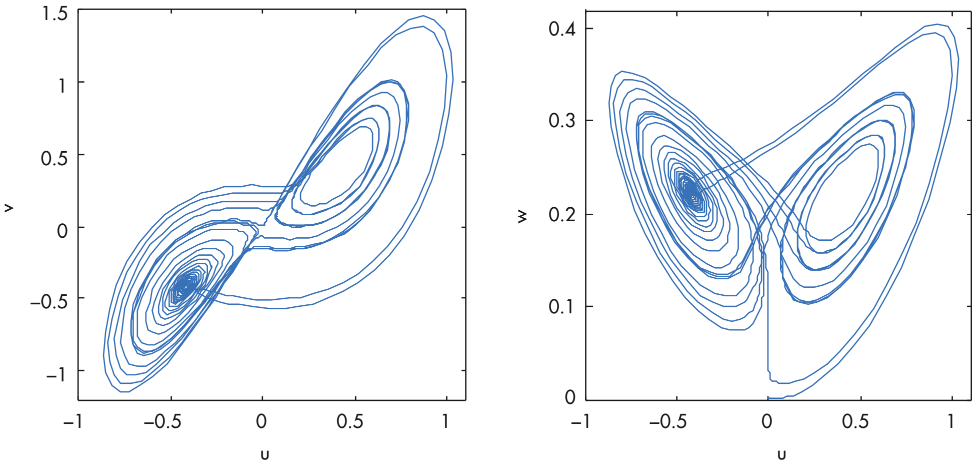
If real signals aren't required, the Lorenz system may be simulated on a computer using one of several numerical methods available for solving systems of differential equations. In the results of a computer simulation with Matlab, these plots are similar to patterns one would observe on an oscilloscope connected to the output of the analog circuit (*Fig. 2*).

The simulation simplifies modification of the parameters and initial conditions, which affect the overall system behavior. Also, the simulation avoids the difficulties encountered with the analog circuit—there's no limitation to the range of signals due to amplifier saturation, nor any compromise or consideration required for the proper selection of component values.



1. The high-level analog circuit for a Lorenz chaos system shows the basic building blocks needed. Reference 1 (Cuomo and Oppenheim) provides details on the construction of this circuit.

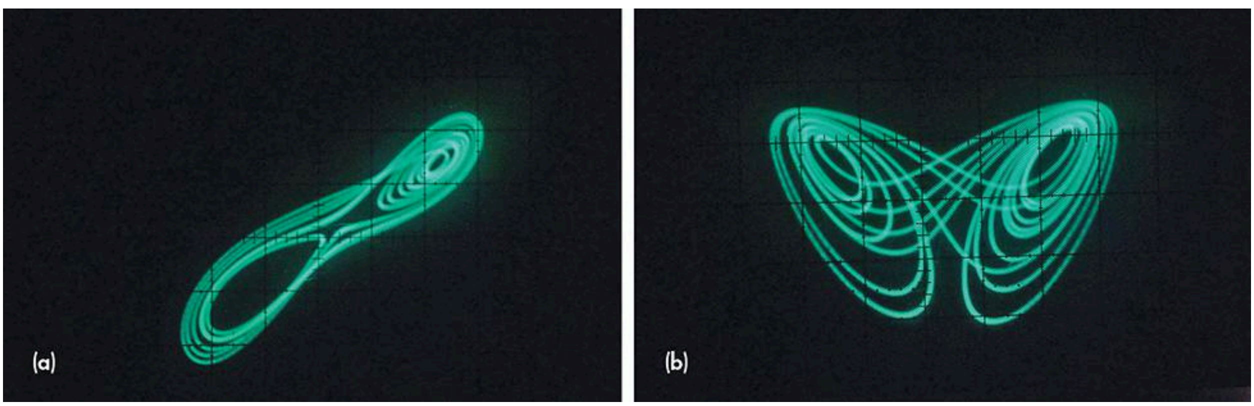
In this solution, we use a microcontroller to find the numerical solutions for u, v, and w, and then pass the results to the pulse-width-modulation (PWM) module of the microcontroller to adjust a duty cycle of one, two, or three pulse trains, depending on the number of PWM signals generated by a given microcontroller. Finally, the PWM signals are low-pass filtered to generate analog signals with behavior that is similar to that observed at the output of the analog circuit for the Lorenz system.



2. Matlab simulation of the Lorenz system captures the chaotic nature of the output, but it's not truly random chaos.

This approach provides a convenient way to generate a set of signals for demonstration and application to the study of chaos systems. In addition, parameters of the system can be easily modified and reprogrammed into the microcontroller to observe their effect on the overall system behavior.

The implementation of this approach is straight-



3. X-Y oscilloscope traces at the output of the low-pass-filtered PWM signals correspond to simulated results: u-v (a) and u-w (b).

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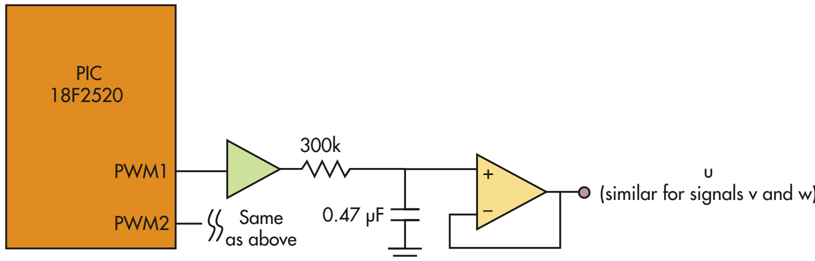

4. This circuit is used to filter each PWM signal that has been modulated with one of three chaos signals of the Lorenz chaotic algorithm.

forward. The Lorenz system is solved with Euler's method, which has been programmed into a PIC18F2520 microcontroller.[3] Parameters r, b, and σ were set to 45, 4, and 16, respectively. Since the range for the numerical solution of u, v, and w is real floating-point numbers, the results need to be offset and scaled prior to being cast as unsigned integers and used in setting the PWM duty cycle.

Figure 3 shows the oscilloscope traces for the output of the low-pass filters used to convert the PWM into analog. *Figure 4* shows the typical implementation of the low-pass filter used to filter each PWM signal. Since the PIC18F2520 has only two PWM outputs, the PIC must be reprogrammed accordingly to view each pair of signals on the oscilloscope.

Available with the online version of this article at www.electronicdesign.com, the microcontroller code is written specifically for the PIC18F2520 using the CCS compiler. It can be easily modified to work with other PIC microcontrollers or other popular microcontrollers, such as the Arduino.

The authors wish to thank Carsten Sewing for his assistance obtaining photographs of the oscilloscope traces included in this article.

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LCR Meters' Advanced Features Include Auto-Binning Capabilities

GW INSTEK'S LCR METERS offer a test frequency range extending from 10 Hz up to 300 kHz with 0.05% basic accuracy. The five models in the series feature a bright 3.5-in. color LCD with multiple display parameters, showing settings, measurement results, and other data. There is a PASS/FAIL output for rapid and convenient testing, as well as automatic binning applications. The resistance display range is from 0.00001 Ω to 99.9999 MΩ, inductance from 0.00001 µH to 9999.99 H, and capacitance from 0.00001 pF to 9999.99 mF. The series also provides the ALC function to satisfy the test voltage requirement of multilayer ceramic capacitors. For inductive component measurements, the series provides an adjustable test current capability and an optional external-bias-current adapter (±2.5 A) . The LCR meters feature an internal ±2.5-V adjustable voltage with an optional external-bias-voltage adapter (±45 V). Ten built-in test functions allow for setting of test parameters either by frequency, voltage, or current.

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Dual/Quad-Core SoCs Integrated on COM Express Module

CONGATEC IS RELEASING its conga-TR3 COM Express basic modules, parallel to AMD's launch of its new generation of high-end embedded processors. The modules with dual- or quad-core AMD Embedded R-Series SoCs boast a more broadly scalable TDP from 12 to 35 W, improved performance per watt, extremely high-performance AMD Radeon graphics, and full support of the HSA specification 1.0. The COM Express modules provide Type 6 pinout and support up to 32 GB of fast DDR4 RAM with optional ECC. The AMD Radeon GPU provides up to three independent 4k displays with 60 Hz via eDP, DisplayPort 1.2, HDMI 2.0, OpenGL 4.0, and DirectX 12. Integrated hardware accelerators allow for energy-efficient streaming of HEVC videos in both directions.

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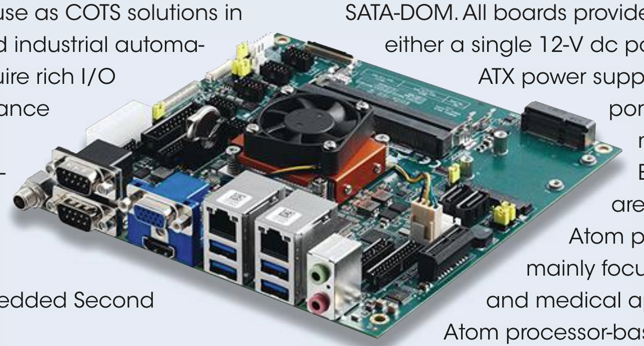
Computing Platforms Follow Form, Fit, Function Design Principle



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Entry level Mini-ITX boards are based on the latest Intel Atom processor roadmap and mainly focus on industrial-automation and medical applications. The new Intel Atom processor-based Mini-ITX embedded boards are also now available in Extreme Rugged versions for operation in –40°C to +85°C conditions.

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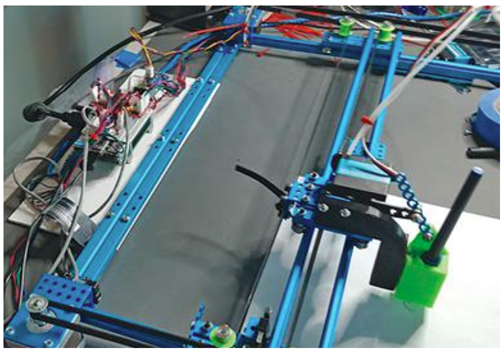
Getting at the Core of Windows 10

Microsoft's Windows 10 Core provides a common platform for all Windows 10 flavors. It provides an ideal platform for embedded applications.

Microsoft Windows has always come in a variety of flavors. However, until the arrival of Windows 10, the variance between instances could be quite diverse. Windows has run on systems like Intel's Itanium, MIPS, and the DEC Alpha. Recently, we had the ARM-based Windows RT. And Windows CE was designed to run on ARM.



That's a Raspberry Pi 2 running Microsoft Windows 10 for IoT Core under the patch board to the left. It controls the custom-made plotter driven by a digital-camera input.

Developers had to use toolsets designed specifically for these different platforms, which was less of an issue when systems tended to operate in a standalone environment. With the Internet of Things (IoT), though, that scenario doesn't make much sense.

Numerous challenges popped up with the various systems, including the way Microsoft split its development and delivery. Visual Studio has been Microsoft's development platform, but a design team within Microsoft would typically take a snapshot and lock it down to provide support for a platform like Windows CE. Unfortunately, that left those developers out of sync with the latest version of Visual Studio and Windows. Windows 10 IoT Core and the latest Visual Studio are designed to change that paradigm.

At this point, Windows 10 IoT Core supports a small but growing number of platforms in addition to the usual x86 platforms targeted by desktop and server versions of Windows. Of note is the Raspberry Pi 2, which is one of the first platforms to support Windows 10 IoT core.

Upon a recent visit to Microsoft, I saw many Raspberry Pi units driving robots to an interesting plotter application that also used a digital camera for input (*see figure*). These were stock units programmed using the latest version of Visual Studio.

Perhaps the biggest change is that the Windows 10 IoT Core is a subset of other Windows 10 versions. It will run on ARM platforms as well as x86 variants like the Minnowboard, which runs an Intel Atom.

A HEADLESS LINUX

Windows 10 IoT Core is not on par with Windows running on a desktop or other platform with a sophisticated user interface. Instead, it's more like a headless version of Linux. It allows Windows 10 IoT Core to be small, suiting it for embedded applications. It also makes the core easier for Microsoft to maintain compatibility between versions.

The advantage for embedded developers is that the languages and tools used for other Windows 10 platforms will be the same for Windows 10 IoT Core. Languages like C++, C#, Python, and Visual Basic can be used on all platforms. There's a single debug interface as well.

Dealing with the subset of services is well-understood among embedded developers. Displays or graphics can be part of the mix, but they will not be standardized at this point. This is generally less of an issue for custom designs that might use something like a 2-line LCD display driven by an I^{2}C interface.

Features like security and communications are common because of the base software. Many management tools also work across the platform, such as remote update and administration. This may not have a huge impact on the maker community, but the features are critical in the commercial IoT space.

Understanding the scope and limitations of Windows 10 IoT Core will be crucial to its adoption. It's not a stripped-down version of the desktop. But that's not what most embedded applications need or what most developers want at this level. ed

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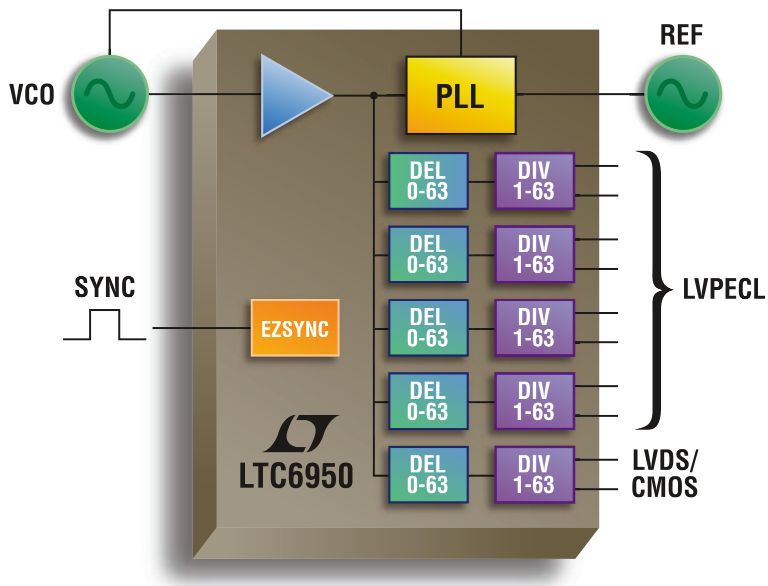

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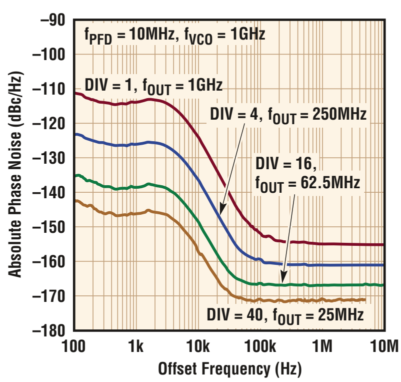

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