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WATCH AND LEARN

Wearable technology gives users unprecedented access to information p|20

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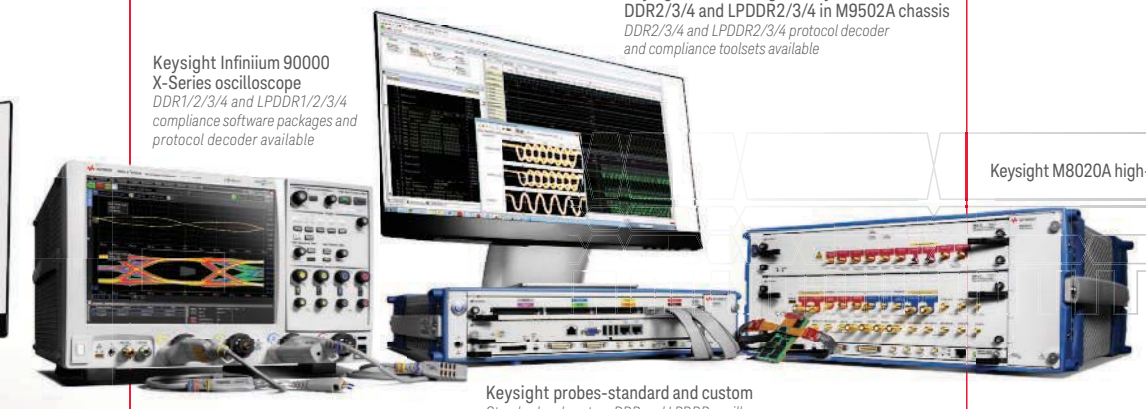

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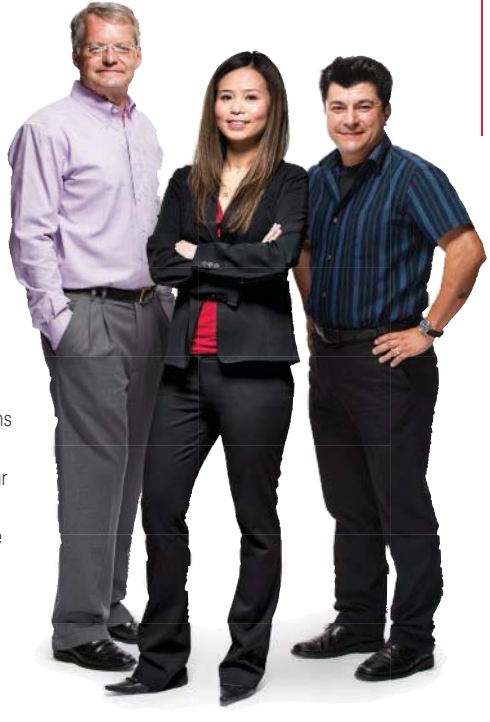

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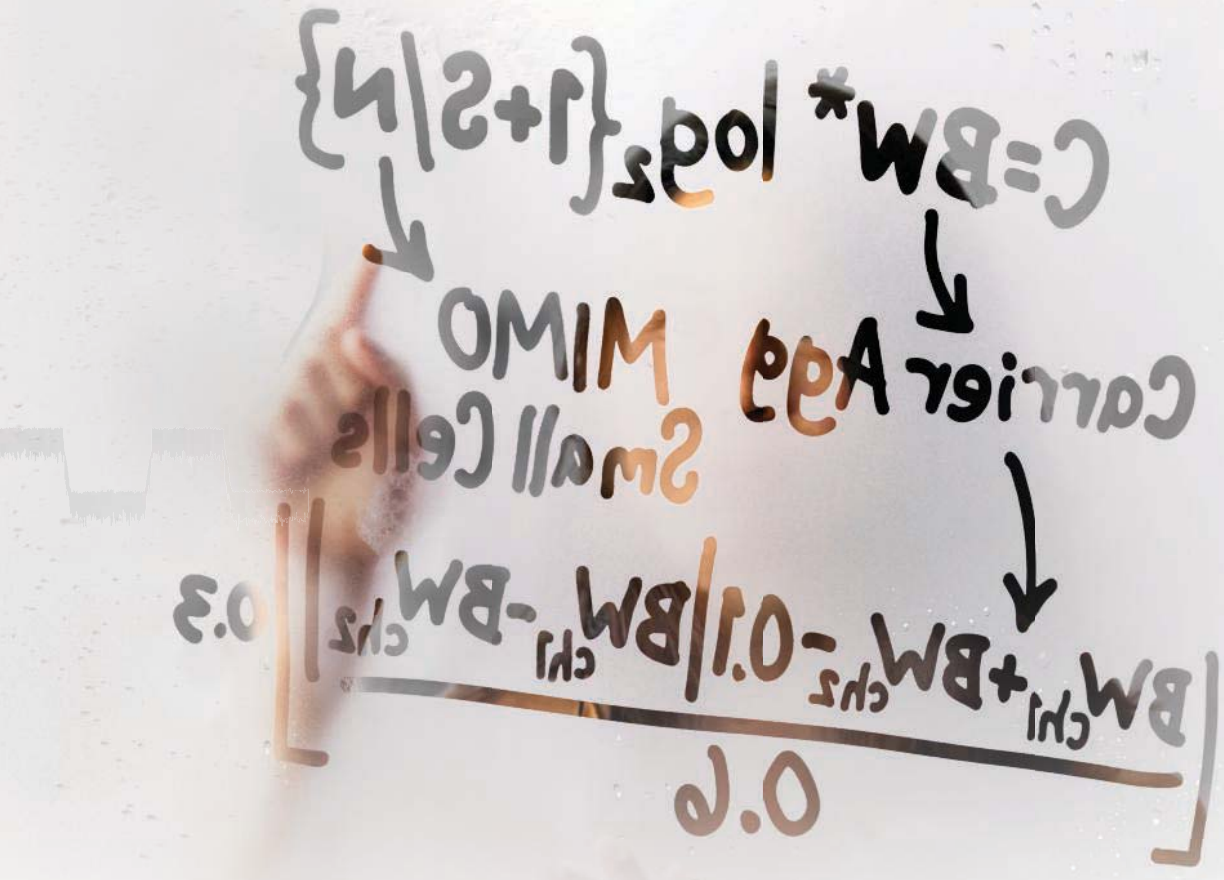

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KEYSIGHT TECHNOLOGIES

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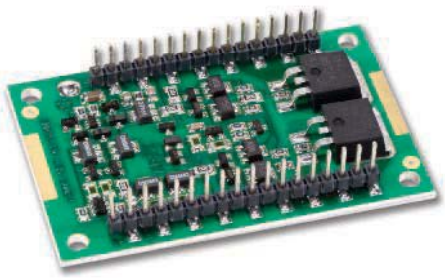

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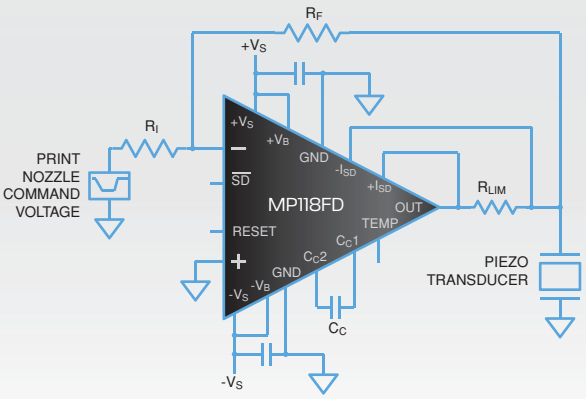

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ISO9001

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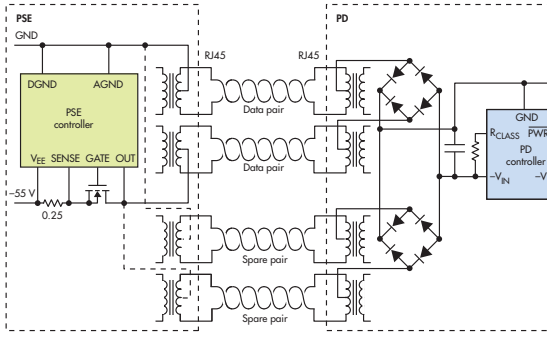

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EDITORIAL MISSION:
To provide the most current, accurate, and in-depth technical coverage of the key emerging technologies that engineers need to design tomorrow's products today.

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THE GOLD STANDARD

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November 2014

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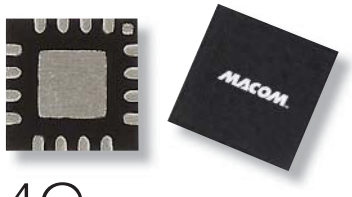

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on electronicdesign.com

2014 ENGINEERING SALARY SURVEY:

ENGINEERING BY THE NUMBERS

Just in case you missed our October issue, be sure to check out the 2014 *Electronic Design* Engineering Salary Survey, offering insights into unemployment, growing salaries, outsourcing, wages, women in engineering, and other trends that affect you.

http://electronicdesign.com/salarysurvey

blogs

PAUL WHYTOCK
ELECTRONIC DESIGN EUROPE

- Boris Will Clean Your Dishes While Bob Checks Home Security

DON TUITE
ANALOG/POWER

- Are CubeSats Adding to Space Junk?

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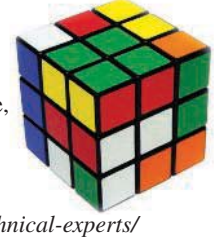
NAKED WITHOUT YOUR WEARABLES

Wearables may be one of the most controversial new consumer electronic product categories to emerge in a long time, but the idea of packaging electronic products to wear on your body is anything but new.

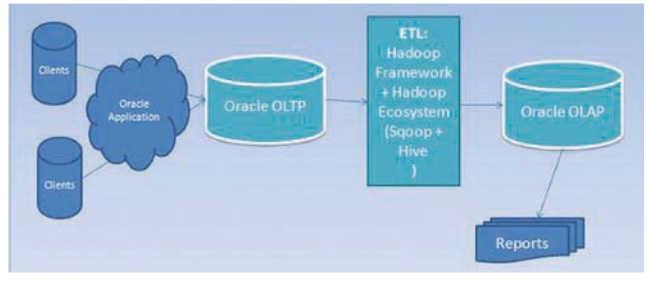
http://electronicdesign.com/blog/naked-without-your-wearables

ALL I REALLY NEED TO KNOW I LEARNED ON THE INTERNET — OR MAYBE NOT?



Vast amounts of information are now instantly available via Wikipedia and Google, but is that really enough to prepare one for lifeís journey — particularly if that journey involves engineering?

http://electronicdesign.com/contributing-technical-experts/all-i-really-need-know-i-learned-internet-or-maybe-not



BLENDING BIG DATA

It isn't hard to see the usefulness of crunching larges amounts of data now available via the Internet, and one of the platforms that is almost synonymous with big data these days is Hadoop.

http://electronicdesign.com/blog/blending-big-data

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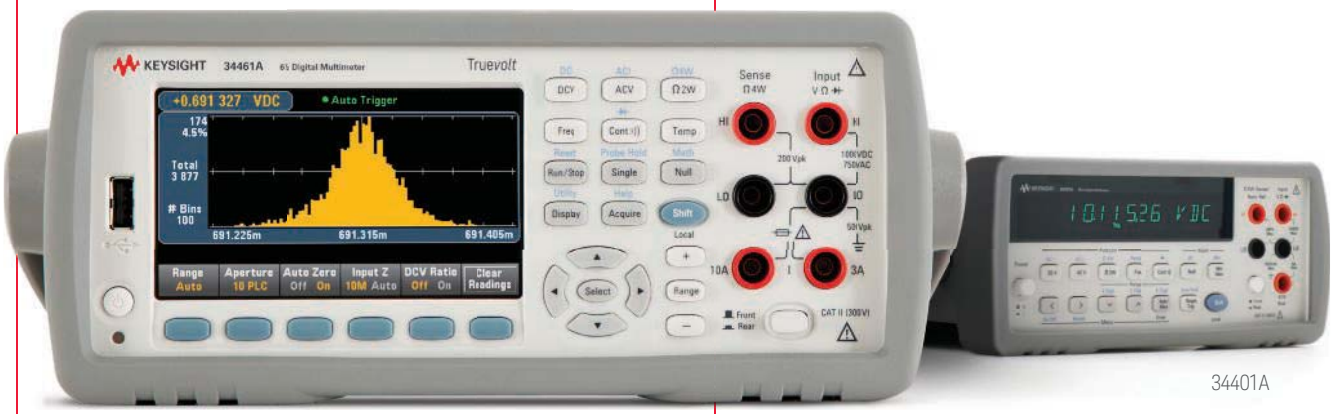

34461A

The next-generation Keysight 34461A Digital Multimeter (DMM) delivers more than numbers, it empowers insights. This replacement to the previous industry-standard 34401A has an easy-to-use, color LCD display and you can now visualize histograms and trend lines. Capturing, analyzing and documenting is simple with BenchVue software and Keysight's Truevolt technology assures accurate measurements. Best of all, the latest thing in DMMs is from the same company that you've trusted for years. Let the insights begin.

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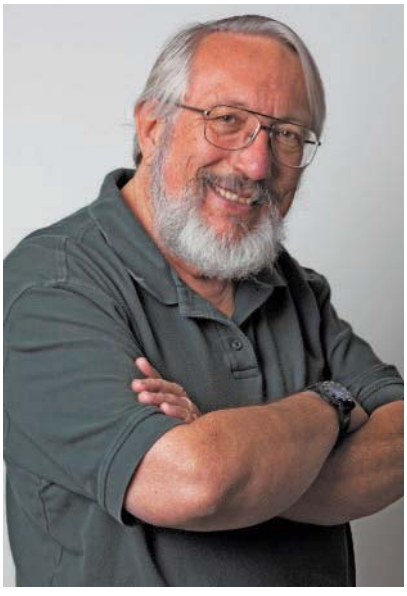


Turn Out Those Lights!

Once again, most of the media missed the point. If you will indulge me, the whole point of Akasaki, Amano, and Nakamura's blue LEDs is that you can turn them OFF and on again fast. It's nice that they have high luminous efficacy. However, regardless of the few watts it takes to squeeze out a lumen, white LEDs are doing their best for the environment when they're dark.

Look at a nighttime photo of the Earth from space. The place looks like a circus midway. Four-fifths of it is covered in ocean, with a heck of a lot of desert. Despite that, the planet positively shimmers, regardless of where the dark side is at any given hour.

The reason for that shimmer stems from the use of so much sodium and mercury vapor lighting – and the fact that we rarely turn those lights off, whether we happen to need them at the time or not. That's because it simply takes too long to turn them on. It's necessary to generate plasma and strike a high-voltage arc through the light in order to make photons. If you turn one off, it takes time to turn it back on. Even with tungsten lamps, you don't want to turn them on and off very often due to added mechanical stress on the filament.

In contrast, with an LED, you're just forward-biasing a diode when you turn it on, so you're not creating much heat in the process. (And you can tune the color-rendering index for a psychologically appropriate value by fooling with the phosphors inside the bulb.)

But the main point is that you can turn area lighting on and off as often as needed without a penalty. If nobody is on the fourth floor of the parking garage at 2 am, the lights can be out. If I come in late to pick up my car, a proximity sensor can turn them on (it turns out the police like the lights coming on, because it tells them where there's "action").

The same principle holds for street lighting. No cars, no pedestrians, no need to burn the juice. Give the sergeant at the local precinct a tablet to turn them on. Give the beat cop an app to do the same thing. There are probably several hundred applications begging to be developed, with interesting engineering challenges in terms of monitoring and security to make them challenging and differentiable. For design engineers, tons of opportunities are lurking, especially on the communications side of the fence.

I have, in fact, been impressed with the rate at which surrounding communities are switching over to LED street lighting. However, it's also disappointing to see it on all night long. That's because turning the things out when there's nobody around would mean somebody's saving my tax money, a consummation to be wished devoutly.

Anyway, at least we're keeping the people on the ISS awake. ed

News & Analysis

GIMBALS ADD FLEXIBILITY to Industrial Exoskeleton

While a real-life Iron Man suit may not yet be in the cards, industrial exoskeletons are emerging as viable work assets. Lockheed Martin recently received a contract through the National Center for Manufacturing Sciences (NCMS) for the U.S. Navy to evaluate and test two FORTIS exoskeletons. The unpowered, lightweight FORTIS increases the operator's strength and endurance by transferring the weight of heavy loads from their body directly to the ground.

FORTIS' ergonomic design moves naturally with the body, providing flexibility without hindrance. This helps operators work longer and more effectively, minimizing fatigue in physically demanding environments such as shipyards. Equipois' zeroG arm makes this possible by including various gimbal types to mount different tools and components. Capable of holding objects up to 36 pounds, the zeroG mechanical arm includes a mounting solution along with a gimbal and tool/payload interface based on the application's requirements.

Although terms of the contract were not disclosed, it marks the first procurement of Lockheed Martin's exoskeletons for use in the industrial arena. The company's research and development into exoskeletons over the past five years covers applications from military to industrial. Beyond reducing fatigue, the technology could also help cut down on injuries and subsequent costs. ■

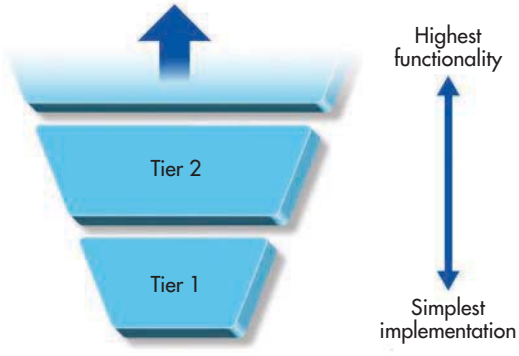
FORTIS is capable of holding objects up to 36 pounds.

(Images courtesy of Lockheed Martin)

Equipois' zeroG arm includes various gimbal types to mount different kinds of tools.

VPX WORKSHOP Tests Latest VITA System Management Standard

VITA COMPLETED ITS FIRST VPX System Management Interoperability Workshop (VSM-IW), which tested VPS product compliancy to the VITA 46.11 System Management for VPX standard. VITA member companies (including Elma Electronic, Extreme Engineering Solutions, Mercury Systems, and Pigeon Point Systems) that build VITA 46.11-compliant VPX chassis and modules came together to systematically test the interoperability of their chassis and module combinations.



The VITA 46.11 architecture defines functionality tiers for both chassis managers and IPMCs to make it easier to adapt the management layer for differing application needs, while preserving predictable interoperability.
(Image courtesy of VITA Technologies)

VITA 46.11 was intentionally modeled on the hardware management layer of AdvancedTCA (ATCA), adapting the management architecture and test plans to the special needs of critical embedded systems. The standard has two main layers: a chassis manager that manages and represents a chassis to upper-level management, and an intelligent platform management controller (IPMC) integrated into each VPX module that represents the module to the chassis manager. The standard defines two tiers of functionality for each layer to enable implementation flexibility.

In preparation for the workshop, the VITA 46.11 Working Group developed a set of test plans for key functional areas of the standard, and then used those plans to guide the testing. The plans highlighted where the draft standard for trial use (DSTU) can be clarified and improved to enhance interoperability between products built to the specification. The workshop tested the interoperability of two independent chassis-manager implementations and four IPMC implementations. Testing included a 16-slot Open VPX chassis filled with modules from various vendors, including both tiers of IPMC functionality. ■

INDUSTRIAL ROBOT Works Side by Side with Humans

SHORT FOR "YOU and me," the YuMi is a collaborative, dual-arm robot designed to meet the flexible production needs of the consumer electronics industry. ABB's YuMi, which will work alongside people performing the same tasks, has enough accuracy to thread a needle, suiting it for thandling delicate and precise electronics components.

The dual-arm assembly solution has the ability to feel and see. Its soft, padded arms use force-sensing technology to ensure the safety of its human co-workers, enabling it to work cage-free. According to ABB, the robot cannot function on its own, but will operate as part of a system. Successful deployment will involve an exact vision, dexterous grippers, sensitive force control, flexible software, and built-in safety features. These factors will collectively allow for programing through teaching, rather than typical coding.

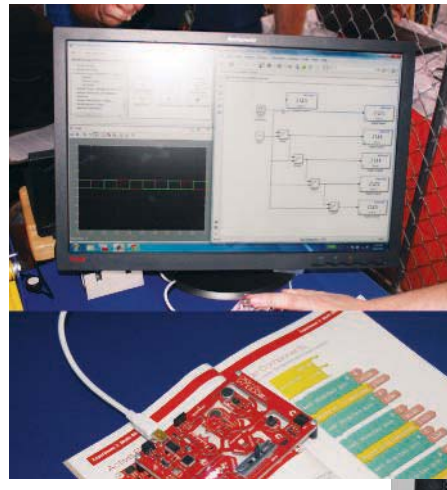
Although its current rollout targets consumer electronics, YuMi will increasingly push into other market sectors. Commercial launch is slated for April 2015 at the Hannover Messe industrial technology fair. For a look at YuMi's collaborative functionality, check out the video at: *http://electronicdesign.com/systems/industrial-robot-works-side-side-humans*. ■

The YuMi dual-arm robot performs with enough accuracy to thread a needle. *(Image courtesy of ABB)*

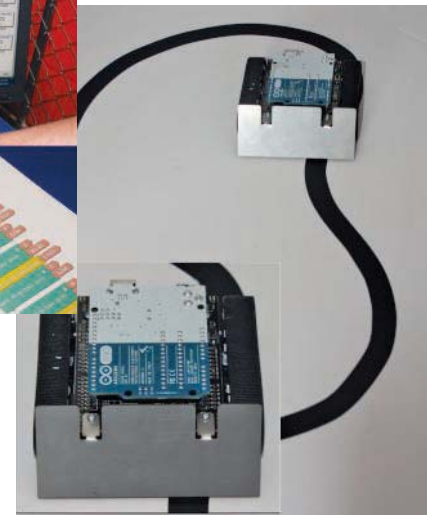
THE FUTURE OF STEM EDUCATION: MathWorks and the Maker Movement

A CORE FOCUS OF the "maker" movement is education, whether for newcomers getting their first taste of science, technology, engineering and mathematics (STEM) applications at school or industry veterans looking to learn something new. At Maker Faire 2014, *Electronic Design* sat down with Paul Kassebaum, who handles Maker community relations at MathWorks, to discuss the company and how it relates to makers.

Maker Faire's "come as you are" attitude and blend of the arts and science was what first attracted MathWorks to the community. The math software development company is home to the well-known MATLAB and Simulink programming environments used for algorithm development, data analysis, visualization, numeric computation, and simulation. Its main mission is to take high-level code and auto-generate low-level code, creating algorithms from a variety of devices such as littleBits, Arduino, and Raspberry Pi. MathWorks partners with teacher trainings and classes at maker spaces to make math more tangible, pseudo-disguising it within fun, hands-on applications.



2. The Digital Sandbox platform can be configured for a variety of applications.



1. Arduino's Uno provides the basis for creating the algorithm to keep the robot on a designated path.

MathWorks had a bevy of demonstrations at its MakerFaire booth, showcasing MATLAB and how easy it is to start coding. For instance, using an Arduino Uno and a few line sensors enables visual creation of an algorithm that keeps the robot on a defined path *(Fig. 1)*. The Digital Sandbox platform *(Fig. 2)* is a learning platform powered by a microcontroller (MCU), which can be used to create algorithms that, for instance, send off delayed alerts to LEDs.

Essentially, the visual experience to a traditionally difficult field such as math involves breaking down complex problems into parts. This breakdown is integral for an introduction into STEM, which often can be intimidating. For younger students, Kassebaum suggests summer camps as a great jumping off point—full immersion in a tech-based, hands-on environment for a limited period of time. For those in college and older, many technical colleges offer introductory one-off classes in specific subjects.

This approach is exactly what the maker movement is about: Give tough subject matter tangibility in order to open up interested individuals' eyes and hopefully to a wealth of new ideas. You needn't thousands of dollars on a dorm room the size of a shoe box. You just have to be open to try something new. ■

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MICROTEK TESTING LAB Receives DLA Mil-Spec Approval

THE U.S. DEPARTMENT of Defense's Defense Logistics Agency (DLA) approved Microtek Laboratories' east coast facility with Laboratory Suitability Status for military standards MIL-PRF-55110, MIL-PRF-31032 and MIL-PRF-50884. With the approval, the laboratory can now perform all applicable Group A, Group B, and Group C conformance and reliability testing, as well as full qualification testing, for those specifications.

The MIL-PRF-55110 specification establishes the performance and qualification requirements for rigid single-sided, double-sided, and multilayered printed wiring boards with or without plated through holes. MIL-PRF-31032 establishes requirements for printed circuit boards and printed wiring boards. And the MIL-PRF-50884 standard establishes requirements for flexible and rigid-flex printed wiring boards with or without plated through holes.

Approval of the standards means the approval of MIL-I-46058, a conformal coating that provides new capabilities for Micotrek in the testing of coatings, such as fungus resistance and full test capabilities for IPC-CC-830. The IPC-CC-830 specification sets the requirements for all electrical insulating compounds. ■

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WEARING YOUR TECHNOLOGY

Direct-digital-synthesizer (DDS) technology can provide the agility and frequency and phase control needed to drive high-performance frequency-modulated-continuous-wave radar systems.

What can you do with low cost, low power microcontrollers and sensors? Strap them on or wear them in a shoe. Wearable electronic technology is everywhere; power remains a challenge, but a plethora of products exist based on currently available hardware.

Part of the wearable trend is based on technology that has come out of the smartphone trend. Compact, low-cost, low-power 3D sensors are found in most smartphones. These can include accelerometers, magnetometers, and gyroscopes. Other sensors include altimeters, pressure, and temperature. Even digital cameras and laser range finders can be found in the mix. Sensor fusion combines multiple sensor information into additional data useful to applications *(see "Sensor Fusion Or Sensor Confusion?" on electronicdesign.com)*.

Wearable technology covers everything from watches to medical devices. While the latest products employ a range of technologies, these are also in reach of the average developer.

WATCHES AND FITNESS SOLUTIONS

Smartwatches and activity trackers are now ubiquitous. Activity trackers started as basic pedometers, having since moved from clip-on fobs to wrist-based sensors. They have also increased in functionality as additional sensors have been added as well as improved sensor integration. For example, some activity trackers can monitor a user's sleep patterns. They can track not only when a person sleeps but also movement. Add a clock to an activity tracker and you have a watch.

Of course, a smartwatch usually has all the sensors found in an activity tracker allowing the smart watch to perform all these function as well as others. The big difference is that a smartwatch usually has a larger, more functional display and its computa-

The Pebble watch originally started as a Kickstarter project that was very successful.

tional power can be utilized by apps, just like a smartphone.

One of the first smartwatches was the Pebble Watch *(Fig. 1)* that was born in a $10 million Kickstarter campaign in 2012. It is now $99, with the latest Pebble Steel version running $199. The latter has a thinner body with Corning Gorilla Glass and metal buttons. They have a 1.26-inch, 144- by 168-pixel, e-paper display *(see "Electronic Paper Provides Design Freedom" on electronicdesign.com)*. The e-paper display is part of the reason the Pebble can run a week between charges. The watch has a waterproof rating of 5 atmospheres.

A USB cable is used for charging but communication is done using Bluetooth 2.1 and Bluetooth 4.0 LE (Bluetooth Low Energy). Typically the watch is wirelessly linked to a smartphone. This allows a user to see incoming calls and messages without looking at the smarthphone. Some question the need for this functionality while others swear by it. A built-in motor provides haptic feedback as well.

The watch includes a magnetometer, ambient light sensors and a three-axis accelerometer. This allows it to act as an activity monitor. It works with Android and Apple smartphones.

Inside is an STMicroelectronics STM32F205RE with a high-performance ARM Cortex-M3 MCU running at 120 MHz *(see "Single Cycle 120MHz Cortex-M3 Delivers 150 DMIPS" on electronicdesign.com)*. It has 32 Mbits serial flash allowing download apps to run on the watch.

The Motorola Moto 360 *(Fig. 2)* is based on more recent technology. It has a Texas Instruments (TI) OMAP 3 processor with an ARM Cortex-A8 core. It has 4 Gbytes for flash and 512 Mbytes of RAM. It runs Google's Android Wear operating system.

The Moto 360 as a 1.56-in backlit color LCD display with a resolution of 320- by 290-pixels (205 ppi). The display is more demanding in terms of power compared to an e-paper display but it provides a more colorful display. This allows features like a background that reflects weather to alerts with sophisticated animations.

The watch links to an Android smartphone via Bluetooth 4.0 LE. It needs to be charged more often than the Pebble but it uses Qi wireless charging that can be very convenient.

The Moto 360 is not the only new smartwatch on the block. There is lots of competition — most notably from the Apple Watch, scheduled to ship in 2015. Apple's product will work

with the iPhone. Smartphone users may be locked into a platform based on their smartphone's OS.

Intel is looking to make a fashion statement with Mica *(Fig. 3)*. At around $1000, it is pricey but stylish. It provides functionality similar to low cost activity trackers.

The wrist is not the only place wearables can be found. Sometimes they may be underfoot.

Moticon OpenGo Sensor Insole *(Fig. 4)* has 13 pressure sensors. It also has a 3-D accelerometer and temperature sensor. This allows the microcontroller to track a user's movement and balance in significantly more detail than the typical activity tracker. It communicates using ANT+ wireless technology. The insoles are matched with an ANT+-enabled flash drive. The system can monitor a user for up to four weeks. In the future, Bluetooth 4.0 LE will be used allowing information to be sent directly to smartphone or smartwatches.

OpenGo is being used to track orthopedic patients after they had received lower-extremity surgery. In theory, it could be used for a host of other medical applications from assisting with rehabilitation of a range of orthopedic problems to balance and load bearing issues for geriatric patients.

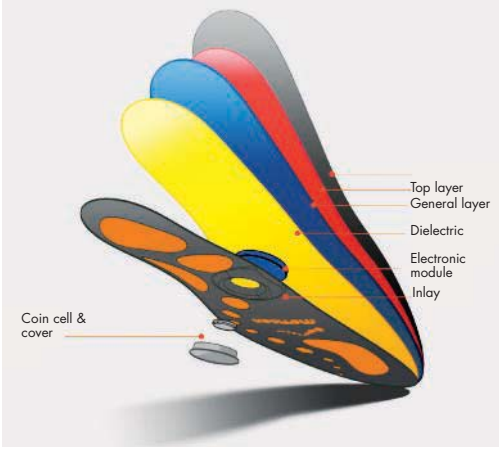
Motorola's Moto 360 runs TI's OMAP 3 processor with a 1.56-in backlit color LCD display that has a 320- by 290-pixel resolution. This display is the winner of Motorola's Design Faceoff competition.

OPTICAL WEARABLES

Google's Google Glass is one of the more prominent optical devices available, but this optical head-mounted display (OHMD) is by no means unique in this space. More expensive OHMDs are used in helicopters and other aircraft. Like smartwatches, Google Glass is typically paired with a smartphone via Bluetooth. Google Glass has

Intel MICA (My Intelligent Communication Accessory) is designed to be biometric fashion accessory.

a small display that can be viewed with one eye. It has a resolution of 640- by 360-pixels and is equivalent to viewing a 25-in display. There is also a built-in camera. Audio support is handled by a bone conduction system. Other sensors include 3D gyroscope, 3D accelerometer, 3D magnetometer, and light and proximity sensors. The processor is TI OMAP 4430 with 16 Gbytes of flash and 1 Gbyte of RAM. It runs Android and has Bluetooth and Wi-Fi connectivity. As with many smartphones, Google Glass is designed to run a day before recharging.



Moticon's OpenGo Sensor Insole incorporates 13 pressure sensors and communicates using ANT+ wireless technology.

Google Glass has raised well-documented privacy and security issues. Some establishments have even banned it although it is simply a more obvious incarnation of the functionality found in the typical smartphone.

Another company that has Google Glass-like technology is Vuzix. Their products range from the M100 Smart Glasses with a single eye display to augmented and virtual reality glasses that target industrial applications.

Google Glass allows a user to view the world as well as its built-in display, but some systems provide a more immersive environment, like 3D goggles. One of the more notable incarnations is Samsung's Oculus Rift *(see "Consumer Electronics Take User Interfaces Beyond Your Fingertips" on electronicdesign.com)*.

Oculus Rift provides a virtual reality environment and blocks out light from the local environment. Each eye has its own 960- by 1080-pixel display with a 75 Hz refresh rate. Some developers have come up with ways to combine the local environment with virtual reality using cameras mounted on the system. Vuzix has a similar product that also incorporates display glasses with cameras.

MEDICAL WEARABLES

Wearable medical technology is moving from big, bulky and obvious to tiny and hidden. Many devices provide medical-related information like a person's pulse, but these are not considered medical telehealth devices. They have not received approval form the Food and Drug Administration (FDA).

Still, this same technology is being incorporated into medical devices. Sensium Healthcare's Sensium Vitals sensor *(Fig. 5)* is a patch that provides real time patient status including heart-rate, respiration and local temperature *(watch "London Calling - Monitoring Patch Checks Vital Signs Every Two Minutes" on electronicdesign.com)*. Other sensor are being employed to provide electroencephalogram (EEG) and electrocardiogram (ECG/EKG) data.

The Continua Personal Connected Health Alliance (PCHA) is an open industry organization that supports collaboration within the healthcare industry. Its standards are based on industry standards like USB, Bluetooth and ZigBee. These standards address interoperability. For example, there is a USB personal healthcare device class (PHDC). FDA approval is a separate but necessary issue.

Sensium Healthcare Sensium Vitals sensor is a patch that provides patient status including heart-rate, respiration, and local temperature.

The challenge for medical wearables is more than just getting a product to work. FDA approval is required for most products in this space and there are legal issues such as the Health Insurance Portability and Accountability Act (HIPAA). Security is paramount, and long-term support and reliability is critical. Solutions will be more expensive than consumer style products but they are likely to be significantly less expensive than older medical solutions.

DIY WEARABLES

Wearable technology is compact and the final form is likely to require a good deal of custom production support but turning an idea into a prototype is within the grasp of most DIY and commercial developers. Development platforms like Freescale's Wearable Reference Design (WaRP) application processing module has an i.MX6Solo with a 1 GHz Cortex-A9 core *(see "It Takes A WaRPed Mind To Design Wearable Tech" on electronicdesign.com)*. The module has Wi-Fi and Bluetooth support.

Intel's Edison module has a dual core, x86 Atom processor plus Intel's Quark microcontroller *(see "How Many Quarks Does It Take To Make An IoT?" on electronicdesign.com)*. The module also has Wi-Fi and Bluetooth built in. Like WaRP, the platform is designed for mobile, battery-based solutions.

Sparkfun's LilyPad *(Fig. 6)* is more than just a module. It consists of a collection of microcontroller modules, sensors, buttons, and display modules. LilyPad was developed in conjunction with Leah Buechley, associate professor at MIT's Media Lab.

The microntroller modules are built around Atmel microcontrollers. This is the same platform found on Arduino modules and LilyPad modules share the architecture and development tools. The LilyPad Arduino 328 Main Board has an ATMega328 on-board. A USB-based FTDI board provides debug support. The ProtoSnap – LilyPad Development Board includes a collection of modules along with conductive thread.

E-textiles — also known as electronic textiles, smart textiles, or smart fabrics — are fabrics that enable digital components (including small computers), and electronics to be embedded in them. Many intelligent clothing, smart clothing, wearable technology, and wearable computing projects involve the use of e-textiles.

The products and technologies presented here are just the tip of the iceberg. Some markets like smart watches have lots of competition with similar products. Medical is where wearable technology will ultimately break new ground, but FDA approval takes a long time. Augmented and virtual reality glasses allow technicians to tap information about devices they are working on.

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The $10 Price Point Will Drive the Next WAVE OF COMPUTING

Before the Internet of Things, wearable electronics, and other innovations gain mainstream success, the semiconductor industry will need to find the best way to support a $10 price point.

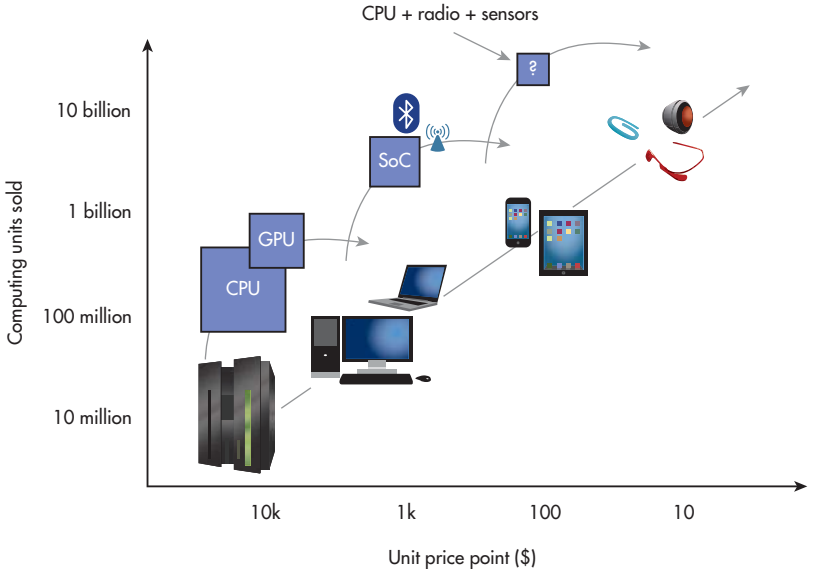
Indeed, this one chart succinctly illustrates how the increasing ubiquity and pervasiveness of computing has driven down the cost structure of the semiconductor industry over decades *(see the figure)*.[1] Otellini noted that an aggressive drop in the price per unit has enabled the equally exponential increase in the number of computing units sold over time.

Starting from mainframes that cost tens of thousands of dollars each and shipped only in thousands of units per year, the industry evolved to shipping well over 300 million PC units at less than $1000 per unit. Smartphones and tablets are on track to ship well over 3 billion units at less than $100 per unit. As is evident in market trends, we are on the cusp of a new wave that will further proliferate the ubiquity of computing by shipping over 30 billion units at less than $10 per unit.

Known as the Internet of Things (IoT), this new wave of computing will be powered by ultra-cheap, ultra-low-power, and highly integrated chips connected to a cloud or a network and embedded in virtually every physical object around us. Many analysts expect this market to range well over 20 billion units by the end of the decade.[2]

The semiconductor industry has enabled successive waves of computing by re-architecting silicon technology for each wave. Companies that have embraced the new architecture early have been able to support the aggressive reduction in price point and establish leadership. On the other hand, incumbents that have failed to quickly adapt have lost ground to disruptors and have struggled to recover. This observation also holds true in the software industry, where a re-architecting of the operating system (OS) and application software has enabled each wave of computing *(Table 1)*.

For the first time in the history of the semiconductor industry, the next wave of computing will not be driven by the most advanced transistor node, but instead by a lagging transistor



Each wave of computing is enabled by a re-architecting of silicon technology.[1] System- or chip-level integration of the CPU, radio, and sensors is likely to become the hardware enabler for the IoT computing wave.

node. "Energy-per-operation" will increasingly become the driving metric for the industry, and chip and system-level integration will become the key enablers. Emerging trends, though, are likely to enable the semiconductor industry to support a $10 unit price point for the next wave of computing.

TRANSITION 1: MAINFRAME TO PC ($1000 PRICE POINT)

The first transition occurred in the early 1980s with the development of a very simple single-chip central processing unit (CPU), Intel's 80286. Operating at just 6 MHz, it continued to be enhanced over three decades through aggressive transistor scaling and a relentless focus on increasing performance (frequency).

Gradually, additional chips such as the graphics processing unit (GPU), memory, and connectivity were added to the system to increase functionality. The CPU-driven hardware ecosystem complemented a mainstream software ecosystem (initially MS-DOS and eventually Windows) and enabled computing on a mass scale (more than 300 million units) with a price point of less than $1000 per unit.

The combination of the CPU and added chips delivered higher performance and more functionality. The CPU and system architecture were designed for performance. Power was a secondary metric. Intel dominated this wave through an aggressive pursuit of Moore's Law and the predominance of x86 architecture while Microsoft dominated through a virtual monopoly of Windows in the software ecosystem.

TRANSITION 2: PC TO MOBILE ($100 PRICE POINT)

The consolidation of functionality on a single chip (SoC) enabled the emergence of the smartphone in the late 2000s. The smartphone and tablet deliver desktop-class functionality with a chipset comprising far fewer chips. This wave of computing established the dominance of the SoC and connectivity solutions and delivered even smaller form factors within a much lower power envelope and much lower cost.

The proliferation of mobile computing was also enabled by dramatically cheaper (eventually free) software ecosystems such as iOS (Apple) and Android (Google) that were specifically designed for mobile (SoC) hardware and not for legacy PC (CPU) hardware. Companies like Apple and Qualcomm dominated the early rise of this wave through the aggressive pursuit of chip-level integration, and the SoC emerged the clear winner over the standalone CPU.

Transistor scaling and Moore's Law helped further enhance the mobile wave by enabling better SoCs and a more compact SoC solution.[3] Companies like MediaTek are driving hard to dominate the maturing mobile wave by offering the entire SoC for under $5 and enabling a unit price point of $100 per unit.

TRANSITION 3: MOBILE TO IoT ($10 PRICE POINT)

Trends suggest that every tenfold increase in unit volume has been enabled by a tenfold reduction in unit price. So what is the right system/chip architecture to enable greater than 30 billion units at a $10 price point? The answer may lie in even higher levels of on-chip integration.

To support the very small form factors and aggressively low power envelopes required for sensor hubs, many system-level functionalities will need to be integrated on a single chip or package, eventually leading to a system-in-package (SiP) or computer-on-chip (CoC). This trend is already evident based on the basic requirements of an IoT chip.

For example, a generic wearable chip may need to deliver a combination of logic computing (CPU), connectivity (radio/bluetooth/GPS), non-volatile memory (flash), and various analog and mixed-signal functions as well as a variety of sensors. The critical technology metric for such an IoT platform will be its total power envelope, which will need to be as much as 10 times lower than that for a mobile SoC platform.

Semiconductor companies looking to establish leadership in the IoT will need to focus their efforts on functional integration far more than transistor scaling. Several companies are trying to establish early leadership in this space, including a combination of fabless and fab-lite (Apple, Broadcom, NXP Semiconductors, Qualcomm, STMicroelectronics, Texas Instruments), integrated

TABLE 1: EVOLUTION OF COMPUTING TECHNOLOGIES

	PC	Mobile	IoT
Hardware enabler	CPU	SoC	Computer-on-chip (CPU, radio, sensor)
Hardware incumbent	Intel	Apple, Samsung, Qualcomm	Still to be established
Software enabler	Windows	iOS, Android	Android Wear, AllJoyn, iOS, others
Software incumbent	Microsoft	Apple, Google	Google, Qualcomm, Apple, others
Unit volume	>300 million	>3 billion	>30 billion
Price point	$1000	$100	$10

device manufacturers or IDMs (Intel, Samsung), and microelectromechanical-systems or MEMS (InvenSense, STMicroelectronics, Texas Instruments). Foundries, too, will need to rapidly adapt their transistor technology roadmaps to enable a silicon ecosystem that will enable such integration.

In addition to a new silicon architecture and ecosystem, IoT computing will rely on cheap, widely available standard software that will enable the hardware to communicate with each other and to the cloud while allowing an independent and robust developer ecosystem to proliferate. Qualcomm is attempting to take an early lead in this space with AllJoyn while Samsung is promoting its Tizen OS. Google recently released Android Wear for developers in the wearable space. Many others are establishing leadership in this emerging market.

TABLE 2: METRICS AND ATTRIBUTES FOR A FRONT-END IoT SILICON PLATFORM

Technology metric	Driving applications	Key attributes
Active power (function of voltage2)	Mostly-on circuits, state monitors (temperature, motion, location)	Supply voltage < 0.9 V, switching frequency 250 MHz or lower
Leakage power (function of transistor design)	Mostly off circuits (wakeup to sense)	Standby leakage << 5 pA/μm
Ultra-low leakage SRAM (on-chip static RAM)	Mostly off circuits that require SRAM data retention	V_{min} < 0.6 V, V_{ret} < 0.4V, cell leakage << 1 pA/cell
Near-threshold computing (voltage just above transistor "turn-on" point)	Ultra-low-power computing at very low performance requirements	Supply voltage ~0.5 V (near V_T), lowest energy/operation
Analog and high-voltage operation	Radio, low-noise amplifier (LNA), power management IC (PMIC), displays	Improved mismatch at 2.5/3.3 V for higher analog precision
Embedded non-volatile memory (flash or other on-chip memory that retains state after power is removed)	Mostly on and mostly off circuits that require microcode or other long-term storage even when power is removed	Compatibility with logic technology

V_{min}: the minimum operating voltage of an SRAM array
V_{ret}: the lowest voltage at which an SRAM cell can retain state
V_T: the threshold voltage of a transistor

TRANSISTOR PLATFORM FOR IOT COMPUTING

IoT broadly describes the entire emerging segment of connected and pervasive computing systems and platforms. These systems will have wide-ranging technology requirements depending on the end application.

Cloud computing and datacenters will form the back end of the platform and serve as the repository of all the data generated by a vast array of connected applications, including consumer, industrial, medical, and environmental, which will form the front end. The front-end devices will in turn have a wide range of performance and power requirements.

Wearable technologies such as Google Glass represent a category of devices that heavily utilize imaging and video and will need high-performance (multicore, gigahertz frequency) and low power. Fitness trackers such as Fitbit and Jawbone's UP represent a category of devices that employ location sensing, motion sensing, and modest (less than 100 MHz) computing. A little sensor that records data in a remote oil field and sends it to the cloud may not need much compute power, but it will need extremely low standby power and very long battery life in addition to extreme temperature stability.

Regardless of the end application, the focus of transistor development over time will shift from "performance-per-watt" to "energy-per-operation." Many of the sensing platforms and devices that will become part of the IoT will need to have battery life on the order of months or years (e.g., remote infrastructure monitoring). Many more will require battery life on the order of weeks or months (e.g., wearable technologies). And yet many more will harvest or scavenge energy and run on no battery at all (e.g., medical patches).

Many of these applications are likely to be single use and replaced upon battery discharge. Since many of them must be off or in a standby state while retaining a sizable amount of data, ultra-low standby power is crucial in addition to low active power. An ideal IoT platform will be able to meet these attributes and provide designers the flexibility to incorporate any combination of them on a single chip *(Table 2)*.

A transistor platform that supports these specifications at the lowest system cost will win in the IoT/wearables space. Unlike CPU technology, the transistors that make up this platform are not limited by geometrical (pitch) scaling. For example, analog and high-voltage (2.5/3.3 V) blocks have not been scaled over several logic technology generations due to very stringent requirements on variability matching.

The most advanced embedded non-volatile memory (eNVM) technology in production today uses design rules that are four times larger than the most advanced logic technology. As a result, chips that are dominated by analog/eNVM do not benefit from the geometrical scaling of logic transistor densities.

Based on these requirements, 40/45/55/65-nm technologies are best suited to support the bulk of the front-end IoT and more specifically the wearable technologies space in the near term (two to three years). The Newton platform by Ingenic Semiconductor is one such integrated computer-on-a-chip.[4]

Applications like Google Glass that require higher performance and can accommodate the higher cost will use 28-nm

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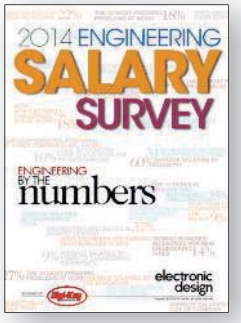

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technology right away. Three to five years out, the high-end IoT space likely will continue to be served by 28-nm planar transistor technology while the bulk of the IoT space will utilize 40-nm technology, provided a suitable eNVM solution can be developed by then.

Given the requirements of cost, power, and functional integration, it is unlikely that sub-20-nm transistor technology will serve the mainstream IoT or wearable technologies space for another five to seven years, if ever. Once a starting technology is in place for such applications, an enhancement roadmap will be driven not so much by geometric scaling, but more by aggressively lowering the power envelope and integration of more functionality.

FOUNDRY IoT TRANSISTOR ROADMAP

Through most of the CPU era, semiconductor R&D programs were driven by a performance-centric roadmap. The roadmap began to emphasize more on-chip integration during the SoC era. The foundry roadmap during the IoT era will be driven by overall power reduction and even higher levels of on-chip integration.

With every successive wave of computing, increasingly more value was extracted from silicon while driving down its overall contribution to the unit bill of materials (BOM). This trend will continue and will move the industry to deliver the "same performance for less cost" or "same power for less cost."

"More than Moore" is used to describe orthogonal scaling as opposed to geometrical scaling of Moore's Law. For example, orthogonal scaling rejuvenates a legacy technology to reduce its total power envelope. Such innovation may also be extended to include enhanced on-chip functionality such as eNVM or enhanced system-level functionality via 2.5D scaling (interposers) or 3D scaling (through-silicon vias, or TSVs).

Judicious investment in these areas will enable foundries to capture a significant projected silicon volume migrating from 130 nm to 28 nm over the remainder of this decade. Continued Moore's Law scaling is likely to serve a limited number of applications and may not lead to high-volume design wins in the IoT space, at least in the near term. Whether very advanced transistor technologies (sub-20 nm) can offer the most effective integrated platforms necessary to succeed in this space is still to be determined.

For the first time in the history of the semiconductor industry, a lagging transistor node will drive the next wave of computing, not the most advanced transistor node. A holistic platform and system-level view suggests that cost, power, and highly disparate functional integration are the key technology metrics for success in the emerging wave of computing.

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PUSHKAR RANADE is vice president, technology development, at SuVolta. Prior to joining SuVolta in 2010, he was with Intel Corp., where he contributed to transistor process integration and development of Intel's 65-, 45-, and 22-nm logic technology. He joined Intel in 2003 after graduating with a PhD from the University of California, Berkeley. At Berkeley, his research was in the area of sub-70-nm CMOS transistor design and involved the integration of novel gate materials and ultra-shallow junctions. He has authored or co-authored over 40 technical publications and holds over 25 U.S. patents.

SCOTT THOMPSON, chief technology officer, is responsible for leading the development of SuVolta's advanced technology platforms. Prior to joining SuVolta, he was a professor of electrical engineering at the University of Florida focusing on advanced transistor technologies. He was also an Intel Fellow, director of logic technology, and responsible for next-generation process integration, technology yield, and transistor design at Intel. He has worked on Intel's 0.35-, 0.25-, 0.18-, 0.13-, and 0.09-µm advanced CMOS logic technologies. In addition, he helped develop a 90-nm strained Si logic technology that is currently in production on 300-mm wafers used to fabricate Intel's advanced microprocessors. He has published 80 papers and holds over 30 U.S. patents. And, he was elected an IEEE Fellow for his contributions to submicron and nanoscale MOSFETs. He holds BSEE, MS, and PhD degrees from the University of Florida.

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DON TUITE | Analog/Power Editor
don.tuite@penton.com

PoE Max Power Pushes to 60 W and Beyond

Thanks to technological advances such as LTPoE++ and UPoE, Power over Ethernet breaks into uncharted wattage territory.

It had to happen. Power over Ethernet (PoE), once viewed as simply an alternative to powering every electronic device in a worker's cubicle with inefficient "wall-wart" power adapters, but limited to trivial power levels, has matured into a technology capable of delivering 50 and 60 W or more via the same CAT-5 cables that bring the Internet to those cubicles. Driving the technology are applications that few envisioned a decade ago (see "A Long Way from CAT-5 powered VoIP"). As a result, new ICs are emerging from Akros Silicon, Linear Technology, Maxim Integrated, STMicroelectronics, Texas Instruments, and others.

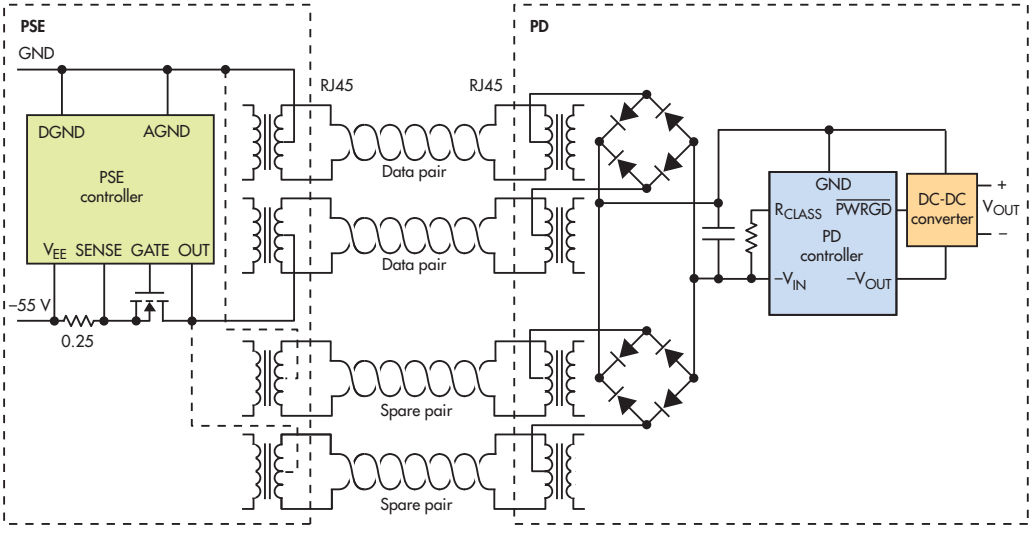
BASICS OF PoE

In PoE nomenclature, the device that provides power to the network is known as a PSE, or power-sourcing equipment, while the device that draws power from the network is called a PD, or powered device.

PSEs are built into either of two types of Ethernet distribution gear: endpoints (typically network switches or routers) that send both data and power; and midspans that inject power on selected ports, but pass through conventional Ethernet traffic from non-PoE endpoints on all ports.

As originally conceived, PoE could use either the data pairs or the spare pairs in an Ethernet cable to carry 48 V dc from the PSE in an endpoint switch or midspan hub to the PD appliance at the other end of the cable. Data pairs were powered via a center tap, while spare pairs were simply paralleled. The sense of the dc voltage didn't matter, thanks to a diode bridge in the PD ahead of the PD controller chip.

Originally, it was never anticipated that every device at the far end of an Ethernet cable support PoE. Therefore, it became necessary to establish a handshake mechanism to ensure that a PSE would not apply power unless a PD was on the other end. It was also desirable that the PD have some way to relay to the PSE its maximum power requirements. The first part of this handshake was accomplished by requiring the presence of a 25-kΩ resistor across the PD chip's input.



1. At all current levels, power over Ethernet uses a power-source-equipment (PSE) device for each Ethernet port in an Ethernet switch, router, or midspan to be powered (midspans are used for retrofitting old, non-PoE switches). Nominal 48-V direct current is supplied to either the data pair or spare pair in a CAT-5 cable via transformer center taps and picked off in the same way. At the powered device (PD) on the other end of the cable, diode bridges maintain the proper sense. A two-level handshake between the PD and the PSE dynamically establishes a maximum current limit at each powered port.

To check for this resistor's presence on the other end of a CAT-5 cable, the PSE would first apply a series of voltages, incremented in 1-V steps at 20-ms intervals, and use the resulting currents to verify the presence and value of a terminating resistor. This part of the handshake was the "discovery" phase.

To verify compatibility between the power

capacity of the PSE and the needs of the PD appliance, the initial standard provided for an optional "classification" phase. Here, the PSE would briefly assert a 15.5- to 20-V pulse on the pair, to which the PD would respond either by temporarily placing a load on the line or by doing nothing. Having a resistor, but not responding to the pulse, was tantamount to self-identifying the PD as "Class 0," and the PSE would supply up to 12.94 W.

To keep the cost of power supplies down, other PD classes signaled that they needed less than the maximum Class 1 demands, to 3.84 W, and Class 2 would need no more than 6.94 W. Class 3 PDs, under 902.3af, signaled that they needed the full 12.94 W.

2. Originally, PoE was conceived as a better source for VoIP power than wall warts. Since then, business phones, such as this "trader turret" for the exchange floor, have evolved into much more sophisticated instruments.

POWERING THE LOAD

Once the PD was discovered and classified, the PSE could apply unregulated 48 to 50 V dc, with current limited as necessary, to the CAT-5 cable. A standard Ethernet cable contains four twisted pairs, though only two are needed to carry data back and forth. Under basic PoE, powering is an either/or situation—but only one pair can be used at a time. This limitation was imposed to enable the use of either new endpoint routers with built-in PoE, or in midspan-bridge-powered legacy systems. In the latter case, midspans would only power the spare pairs, while new endpoint equipment could power either pair *(Fig. 1)*.

Predictably, once the original 802.3af scheme was up and working, there came an immediate demand for higher power levels. Not only was 802.3af

POWER-LIMIT COMPARISON: LTPOE++ PD, PSE VS. 802.3AT

Device			PSE					
	Standard		802.3at		LTPoE++			
		Type	Type 1	Type 2	38.7 W	38.7 W	70 W	90 W
PD	802.3at	Type 1	13 W	13 W	13 W	13 W	13 W	13 W
		Type 2	13 W	25.5 W	25.5 W	25.5 W	25.5 W	25.5 W
	LTPoE++	38.7 W	13 W	25.5 W	38.7 W	38.7 W	38.7 W	38.7 W
		52.7 W	13 W	25.5 W	–	25.5 W	52.7 W	52.7 W
		70 W	13 W	25.5 W	–	–	70 W	70 W
		90 W	13 W	25.5W	–	–	–	90 W

(Courtesy of Linear Technology Corp.)

A LONG WAY FROM CAT-5-POWERED VoIP PHONES

CISCO HAS BEEN a leader in the application of IEEE 802.3. The term for its latest push into higher power is "UPOE," or "Universal Power over Ethernet." The technology embraces not just the evolution of thin clients, but financial trading floors, hospitality, and retail.

On the financial trading floor, for example, Cisco says it's responding to today's traders demands for multiple screens, live video feeds, and conference calls, all serviced at the kinds of speeds necessary to keep up with the various exchanges around the world. "All of these request high availability, multicast, and buffering architecture as the key features for the network."

Powered hardware includes "IP turrets," or "trading turrets," that help traders manage incoming and outgoing call activity with customers or counter-parties via arrays of dedicated point-to-point telephone lines *(Fig. 2)*.

Previously, IP turrets have been powered by wall power with backup UPS. Now, for cost and efficiency the trend is powering via UPOE technology (of course, this transfers the reliability burden to the switch).

Most recently, the company introduced the Catalyst 4500E switch, which provides line-rate unicast and multicast switching with consistent low latency to all user access ports *(Fig. 3)*. On top of that, the switch features full hardware redundancy and in-service software upgrades. Other compatible Cisco switches include the compact 3560C and 2960C. ed

3. Along with the products at the user end of PoE, routers and switches have become denser and more complex.

underpowered for phone systems with video displays, design engineers immediately envisaged a host of new applications. With more power, security cameras could include pan, tilt, and zoom motors. Wi-Fi hotspots could cover wider areas. Security-card readers could self-power the door latches they protected. Almost immediately, the task force began work on IEEE 802.3at, which soon acquired the informal name "PoE+," pronounced "PoE-Plus."

Part of the task force's job was to decide whether the additional power would involve simply increasing the maximum current rating or paralleling the spare pairs with the data pairs. A more challenging part involved expanding the classification scheme so that PDs could negotiate on-the-fly with the PSE for more or less power.

BEYOND JUST PUSHING MORE CURRENT

The above situation unfolded in 2007. Now, at least three makers of PoE PD and PSE semiconductor devices—Linear Technology, Texas Instruments, and Akros Silicon—offer the ability to provide up to 90 W to PDs, while accommodating earlier hardware running at its original ratings. Higher-powered PSEs from one source may not necessarily be compatible with higher-powered PDs from other sources, but the operational fundamentals derived from the 802.3 standards. Thus, the new PDs look like standard PDs to legacy PSEs, and new PSEs are not going to be confused by legacy PDs.

One example of the new generation of PoE devices comes from Linear Technology, with PSEs and PDs that it designates "LTPoE++" ("plus-plus"). Essentially, says the company, "LTPoE++ is a proprietary high-power standard that uses a single CAT-5e Ethernet cable to provide four different PD power levels: 38.7 W, 52.7 W, 70 W, and 90 W."

The concepts are described in greater detail in the company's *Journal of Analog Innovation*.[1] The treatise specifically compares the LTPoE++ technology and the IEEE802.2at standard *(see the table)*.

DEFINE WHAT'S PRIME

Like television's "Star Fleet," LTPoE++ has a "Prime Directive." Actually, it has two of them: "Do not turn on devices that shouldn't be turned on," and "Do turn on things that should be turned on."

Linear Tech's article elaborates: "LTPoE++ PSEs can differentiate between an LTPoE++ PD and all other types of IEEE-compliant PDs, allowing LTPoE++ PSEs to remain compliant and interoperable with existing equipment." More explicitly, that means:

- Conventional Type-1 PSEs will power all Type-1, Type-2, and LTPoE++ PDs with up to 13 W.
- Conventional Type-2 PSEs will power Type-1 PDs with up to 13 W and provide 25.5 W to Type-2 and LTPoE++ PDs.
- When connected to traditional Type-1 and -2 PSEs, LTPoE++, PDs can power up. However, their functionality is limited by current available from the PSE.
- LTPoE++ PSEs will power Type-1, Type-2, and LTPoE++ PDs. The latter are powered to the designed limit of the LTPoE++ PSE.
- When a LTPoE++ PD is identified, it will only be powered up if the PSE power rating meets or exceeds the requested PD power. For example, a 52.7-W LTPoE++ PSE can power either a 38.7- or 52.7-W PD.

TI'S UPOE SOLUTION

Texas Instruments' Universal Power over Ethernet (UPOE) solution, the TPS2378, is an IEEE 802.3at-compliant, Type-2 PD controller. TPS2378 supports high-power auxiliary adapters and provides startup control for the dc-dc converter. Two of them in a dual configuration can support four-pair operation at 51 W.

A TI app note titled "Dual TPS2378 PD for 51-W High Power-Four Pair PoE"[2] presents a typical application. Describing the reference design, TI says a high-power solution meets the basic criteria below:

- Current sharing between both pair sets provides at least 51 W available at the PD power interface.
- No overheating in the PD circuitry.
- A high efficiency dc-dc converter is required to maximize the power available to the load.

The TI note also discusses the importance of PD efficiency and current sharing. Ensuring reliable system-level operation requires a worst-case PD efficiency analysis. The worst-case efficiency includes the input bridge, the PD front-end return switch, any additional series diode, the PoE data transformers, and the efficiency of the dc-dc converter stage. ed

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ANDY PURCELL | SOFTWARE ENGINEER, Keysight Technologies Inc.
Keysight Technologies Inc., formerly Agilent Technologies electronic measurement business

Get Instrument Screen Captures and Data Files Quickly Using USB

Implementing the USB Media Transport Protocol (MTP) helps facilitate file sharing.

Market research shows users frequently need to get files from an instrument to a PC. The file may be a screen capture file or a data file. There is a new technique, available now on some instruments, for making this task easy. A user simply connects the instrument to a PC with a USB cable and the user is prompted with a dialog to start exploring files with the familiar Windows Explorer file browser. A user navigates to the file of interest and then uses copy/paste or drag/drop to move the file. Connecting an instrument to a PC becomes like connecting a phone, camera, or mp3 player.

USER EXPERIENCE: CONNECTING WITH USB

Most everyone has connected a phone, camera, or mp3 player to a PC and seen an AutoPlay dialog box *(Fig. 1)*. If a user wants to get a file, the natural thing to do is click on the AutoPlay "Open device to view files using Windows Explorer". The user then sees information about the instrument storage *(Fig. 2)*.

1. An AutoPlay dialog box such as this appears when connecting a PC to an instrument with USB.

If the user clicks on "Data, Screen Captures and More," the user begins to see shared folders and files on the instrument *(Fig. 3)*. The suggested root folder names help a user navigate to a file of interest:

- "Data" contains data files, such as voltmeter readings or swept frequency response data or whatever is appropriate for the specific instrument.
- "PC Software to control <name> contains informative files and hyperlinks that enable users to get PC software to control the instrument.
- "Screen Captures" contains screen capture files.
- "Settings" contains instrument state files.
- "User Files" is a read-write accessible folder where users can add/delete files.
- Readme.html, when opened, displays information about the instrument and the sharing of files in Internet Explorer.

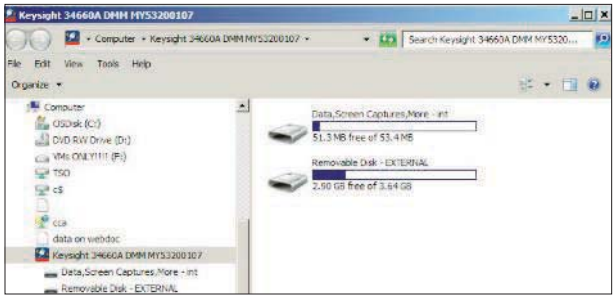
Suppose the user wants to access a screen capture file. The user clicks on "Screen Captures," which results in Figure 4.

If the user wants to get screen capture file "Screen Capture 001.jpg" to the PC, they click on it. The PC operating system (OS) automatically transfers the file content from the instrument to the PC and the OS starts the default application to display .jpg files (Windows Photo Viewer, Paint, etc.) *(Fig. 5)*.

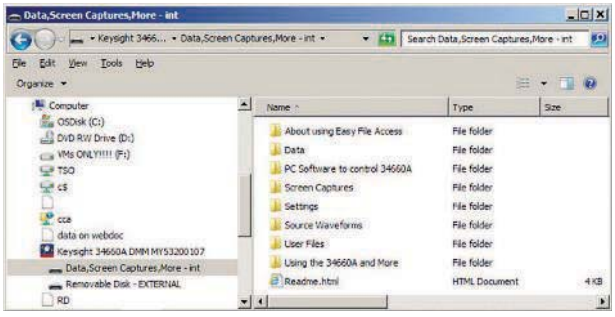
If the user likes what they see, the file can be saved to the PC hard drive or some other storage location. That is all. The user did not have to install any PC software. The user did not need to find a USB flash drive, plug it into the instrument, and figure out how to use the instrument front panel keys to get the file onto the USB flash drive. This is so easy – like getting pictures from a camera. The PC OS does the work to get the content and start the application. The only thing the user had to do was a few clicks of a mouse.

A similar scenario works for getting saved data files. An instrument might save data in a .csv format. When the user clicks on a .csv file, Excel starts and shows the data.

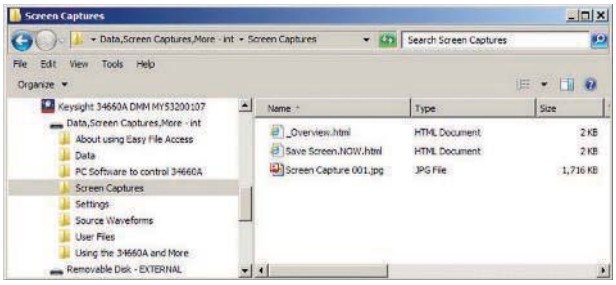
The user can set up an instrument, save the instrument state to a file, and then copy/paste the instrument state file to a location on the PC. The state file can later be moved from the



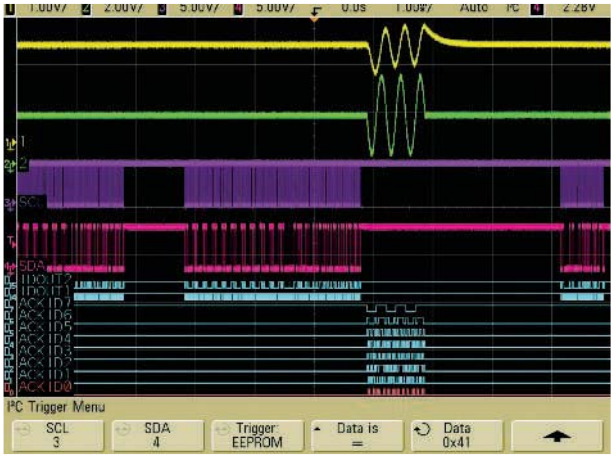
2. Shown is an example of Windows Explorer and instrument shared internal storage and shared external storage.



3. Shown are instrument shared internal storage root directories.



4. Content in a "Screen Captures" folder may appear in this fashion.



5. An example of a screen capture file.

PC to the instrument where it can be used to set up the instrument state exactly as it was before. Files can be moved from the instrument to the PC and from the PC to the instrument.

MTP FILE-SHARING TECHNOLOGY

PC operating systems natively support several types of file-sharing USB devices. Most devices share files using either the USB Media Transfer Protocol (MTP) or the USB Mass Storage Class (MSC). With MTP:

- The instrument can share files and retain the ability to update the file system. The instrument sends MTP defined "events" for communicating when a new file is created.
- The instrument controls what part of the file system is shared. It does not have to share an entire file system. It can share \dir1\dir2\dir3\shared.
- The instrument controls access capabilities. Sharing can be read-only or read-write.
- The instrument can share multiple storage locations. For instance, it could share one location as read-only (RO) and one as read-write (RW).
- The user, at the PC, can also update/change shared files on the instrument. The OS forwards file system change requests as MTP protocol requests to the instrument. Instrument firmware sees the requests and performs the request if it is not also modifying the shared files.

IMPLEMENTING MTP

Instruments can implement MTP as an additional "logical" (not physical) USB interface. Typically a test and measurement instrument implements a USB488 interface to enable PC apps to control the instrument with IVI software. In many cases, instruments can add an MTP interface with firmware modifications only. No new physical connector and no hardware changes. Devices with two or more USB interfaces are common and are called "Composite USB" devices. An example of a Composite USB device is an "all-in-one" printer.

The MTP protocol specification is available from the USB-IF at this location: *http://www.usb.org/developers/devclass_docs/MTPv1_1.zip.*

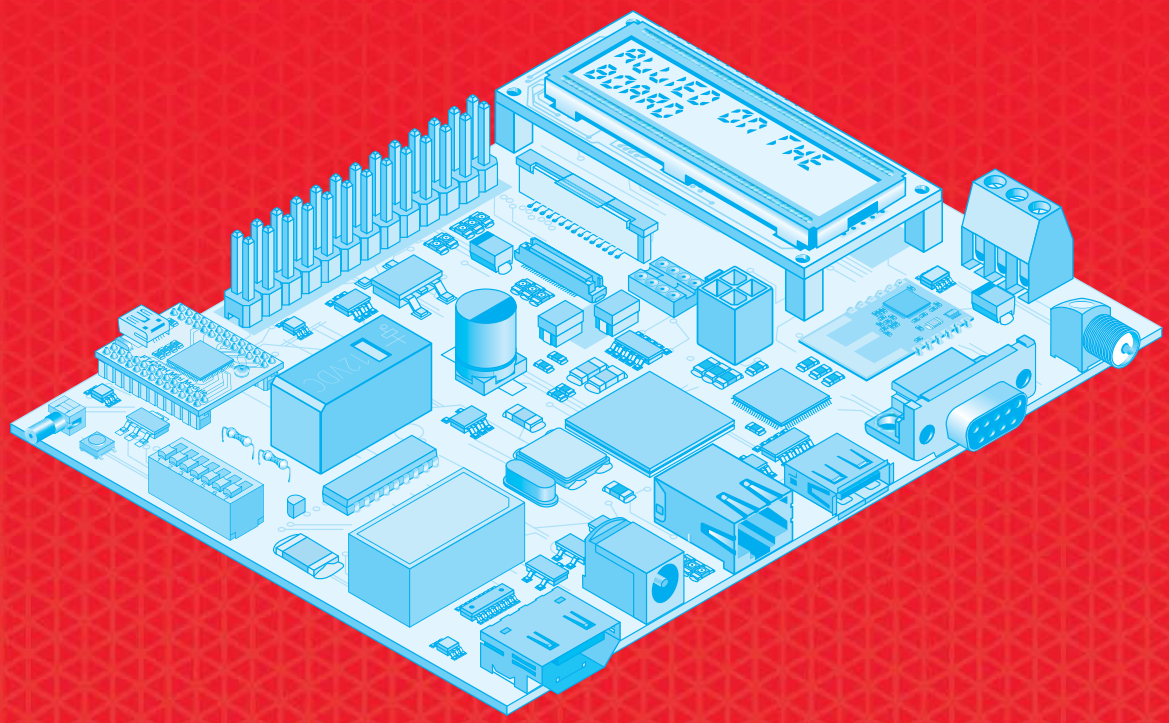
ON-DEMAND

When sharing files with MTP, the instrument retains control of the shared files and instrument firmware knows when files are being accessed by the connected PC. Because of this awareness, MTP enables an "on-demand" feature. If a file is an on-demand file, then when a PC first attempts to read the file, new content is created. In other words, the PC user, by simply clicking on a file, is controlling the instrument, causing it to perform instrument-specific actions. There are several use cases for "on-demand".

A digital voltmeter might share an on-demand file named "Get 100 readings.NOW.csv". The user recognizes that it is an on-demand file because of the ".NOW.". When the user clicks on the file, the OS sends an MTP protocol request to the instrument to read the file. The instrument is notified of the request, takes 100 readings, writes the new data into the file, and then sends the file, with the new content, to the PC. The PC starts Excel to display the new content to the user. This kind of on-demand can be used when the data set is able to be generated within timeout constraints of MTP responses. The data set must also be of unchanging size.

MTP is currently supported on Windows and is known to work on some Linux operating systems. The file-sharing technology is also available for Apple computers; however, it requires the user to install software.

Searching Made Simple



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Suppliers Eye Europe for Continued Growth

North American distributors continue to follow new business opportunities in Europe, capitalizing on the Electronica 2014 exhibition to make new connections.

VICTORIA FRAZA KICKHAM | DISTRIBUTION EDITOR

EUROPE REMAINS AN IMPORTANT target for supply chain companies based in North America, owing to the continuance of the outsourcing trend and companies looking to both expand upon and develop new business opportunities across the continent. The trend has companies large and small focused on expanding their presence with new locations, personnel, marketing programs, and other services aimed at satisfying demand on both the design engineering and production sides of the business.

Texas-based independent distributor Smith & Associates is one such company. Smith has had a presence in Europe for 15 years, and will use the upcoming Electronica 2014 Trade Fair as an important marketing tool. To be held in Munich November 11-14, the 26th Annual Trade Fair for Electronic Components, Systems, and Applications — known as Electronica — is one of the electronics industry's top attractions, held every two years.

"[We are] exhibiting at Electronica Munich with a full complement of sales, purchasing, marketing, and business development staff to offer in-depth views of Smith's global

Continued on Page 40

Supplying the Education Market

Avnet steps into the education arena with Rorke Global Solutions, tying components, embedded systems, and a new slate of products and services together to serve a transforming market.

VICTORIA FRAZA KICKHAM

NEW EDUCATION STANDARDS AND goals are causing school systems nationwide to take bold steps into the world of high technology. Some supply chain companies have decided it's time to walk with them, introducing the education market to a broad range of products and services while simultaneously expanding their business opportunities.

One notable example of this trend comes courtesy of technology distributor Avnet, Inc. Specifically, its electronic components distribution business, Avnet Electronics Marketing, is approaching the K-12 education market in the United States with a business venture designed to anticipate growing demand for solutions that combine hardware, software, consulting, and other services to help schools make the transition to a digital learning environment.

Continued on Page 42

procurement support services," says Mark Bollinger, the company's vice president of marketing. "At Electronica, Smith will highlight our unique and long-standing capabilities that are focused on meeting Europe's high standards for quality and specific regulatory requirements, including RoHS, WEEE, CE, among other regulatory compliances."

Smith is not alone. Other top distributors will use Electronica as a platform to grow and develop business over the next two years. And it's no surprise, as the electronics supply chain becomes increasingly global and Europe plays an important role in the transformation.

"Europe's progressive outlook on automation and energy conservation make it an important market," adds Bollinger, pointing to large-scale municipal and Smart City projects in Europe as well as leading-edge medical device and automotive electronics research, design, and manufacturing as key opportunities. "We view the European market as a growth opportunity, and our strategy is to continue supporting the vital projects of Europe's leading electronics innovators."

Mark Bollinger, Smith & Associates

OUTSOURCING DRIVES GROWTH

More than 60% of North American electronic component buyers say their companies outsource manufacturing and design services to other regions and that Europe remains a key attraction, according to *Global Purchasing*'s 2014 Profile Survey of nearly 800 purchasing and supply chain professionals. Released in October, the report showed that 16% of companies outsource design and manufacturing services to Europe, making the region fourth in outsourcing to other locations behind the United States (72%), China (32%), and Mexico (16.5%). Europe came in just ahead of India (14%) and Canada (12%).

NORTH AMERICAN OUTSOURCING TRENDS

To what regions is your company outsourcing design and production work?

OTHER LOCATIONS IN THE U.S.	71.6%
CANADA	11.9%
MEXICO	16.5%
SOUTH AMERICA	4.4%
EUROPE	15.5%
PACIFIC RIM	10.9%
CHINA	32.3%
INDIA	14.1%
OTHER	6.1%

Source: Penton Media DE&S Group

Another U.S.-based distributor capitalizing on the trend is Minnesota-based Digi-Key Corp., which has developed a new footprint in Europe over the past two years, focusing on the region's production business. Digi-Key used Electronica 2012 as a launching pad for its new presence in the region, and has big plans for this year's show as well, according to the company's corporate communications director, Michelle Gjerde.

"This is our fifth Electronica, and we're going all out as we typically do," explains Gjerde, pointing to marketing and promotion efforts aimed at attracting attendees to Digi-Key. The distributor will raffle chances to win a 2014 Tesla and is sponsoring hourly iPad giveaways, for instance. Celebrity look-alikes, interactive games, and special student-targeted promotions are also planned. Digi-Key will give away two Vespas and 10 laptops during the exhibit's Student Day event.

"We can really point to impressive growth in the region," says Gjerde, noting that Germany, the United Kingdom, and other regions of Europe represent Digi-Key's largest growth in recent years—upwards of 30%. The firm will use the four-day event to announce new Web and e-commerce initiatives, as well as a slate of new design tools that are part of its recent partnership with software provider Mentor Graphics.

Other distributors that already have a strong foothold in Europe will also be making waves at Electronica. Avnet Electronics Marketing EMEA, for instance, will introduce its MSC Technologies division during the show as part of the Embedded Platforms Conference. Avnet acquired the European business in 2013, expanding its presence across the region and substantially growing its embedded technology business.

"We focus on intelligent embedded and display solutions for various industrial applications — everything from a single source," according to Wolfgang Eisenbarth, director of communications at MSC Technologies. In doing so, the company promises scalable processor technologies, advanced communications interfaces, and maintenance-free system solutions, especially for future markets such as home automation and energy technology, Eisenbarth added.

50 YEARS OF ELECTRONICA

Electronica Munich turns 50 this year, and will celebrate with more than 2700 exhibitors and a slate of programs focused on automotive, embedded systems, medical electronics, lighting, security, and energy efficiency. The event remains one of the largest in the electronics industry: In 2012, the Trade Fair hosted more than 73,000 attendees.

"I am looking forward to celebrating half a century of electronica with our exhibitors, visitors and partners," Exhibition Director Anke Odouli said earlier this year. "In the context of the anniversary, we are planning various events and activities, in which we don't just want to look back, but more importantly, look forward to the next 50 years.

For more information on the Electronica 2014 event, visit http://electronica.de/en/home. For similar coverage from *Global Purchasing*, visit *www.globalpurchasing.com.* ■

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Continued from Page 39

Avnet's Rorke Global Solutions, which was folded into Avnet EM Americas in 2013, is the key point of entry, making a splash over the summer with the launch of its 1:1 Learning System Chromebook and following up this fall with its Wi-Fi 1:1 Learning System for Windows. Both systems help teachers and administrators integrate technology in the classroom and meet new demands for a more streamlined, high-tech education environment. Through partnerships with publishers, software providers, and other technology companies, RGS aims to create demand for these new solutions in the fast-growing education marketplace.

"RGS gives [Avnet] an opportunity to address a whole new market," explains Scott MacDonald, vice president and general manager, RGS. "It's a chance to say, 'How can we change lives? How can we help make a better life?'"

PUTTING TECHNOLOGY FIRST

Technology is the common thread that holds Avnet EM and RGS together, says MacDonald, emphasizing the natural connection between the electronics industry and the education market. RGS is providing technology solutions to public and private schools nationwide, and as a business unit of Avnet EM's Embedded Technology group is tapping into products, services, and capabilities that will help educators create more technologically "connected" schools and help both teachers and students get "a bigger and better learning experience."

"[RGS is a] market solutions company focused on education," explains MacDonald. "Being that partner that helps schools make the digital transformation — that's our goal. We're putting the technology behind it."

Both the 1:1 Learning System Chromebook and the Wi Fi 1:1 Learning System for Windows offer educators technology systems that address four areas: technology infrastructure (the device or other hardware used to deliver content), content/curriculum (through partnerships with publishing companies, software providers, and others), professional development resources, and management/support services.

The approach emphasizes the idea that digital education is about more than just giving kids a laptop.

"You can give a child a laptop or tablet, but it's really about… how you use technology, make it interactive, and foster an environment in which people want to learn," MacDonald says. "That's really the market opportunity. We can deliver the whole suite of services. Being part of Avnet gives us an amazing, unique opportunity to change the face of education and create a lot of value."

RGS' 1:1 Learning System Chromebook with Wi-Fi includes hardware, digital content from educational publisher Houghton Mifflin Harcourt, and strategic services that address professional development, technical support, and asset life cycle management. RGS' Wi-Fi 1:1 Learning System for Windows includes a device, accessories, and supporting services for setup, warranty management, and call center support. Devices for the latter are available in two forms: traditional laptop and 2-in-1 tablet with detachable keyboard. Users can access supplemental content through a learning management system or directly from a number of digital content publishers.

Both systems meet the content requirements of the Common Core State Standards (CCSS), Smarter Balanced Assessment Consortium (SBAC), Partnership for Assessment of Readiness for College and Careers (PARCC), and the Children's Internet Protection Act (CIPA).

MacDonald adds that both systems represent an entry into the digital education market, which he expects to be a key growth area for RGS and Avnet over the next few years.

"It's an exciting time in education and technology," MacDonald adds. "There's a lot of buzz in the market talking about this digital transformation. We think it's more of a learning transformation than a digital one — and having one of the global leaders in technology behind it is really a great opportunity for the education market." ■

Distributor to Sponsor Bitcoin St. Petersburg Bowl

SEMICONDUCTOR AND ELECTRONIC component distributor America II will be an official sponsor of the Bitcoin St. Petersburg Bowl. The Bowl will be held on Friday, December 26, at 9pm at Tropicana Field in St. Petersburg, Florida. This year, the annual college football postseason game has affiliation with the Atlantic Coast Conference (ACC) and the American Athletic Conference (AAC). America II will be represented during the welcome press conference and the reception for schools participating in the Bowl, held at the Hotel Zamora on St. Pete Beach on Thursday, December 11 from 5-7pm EST. ■

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RS Components Site Gets IoT Area

RS COMPONENTS (RS), the trading brand of British distributor Electrocomponents plc , has introduced an Internet of Things (IoT) area to its online DesignSpark community — featuring software design tools and resources for rapid prototyping and product development. The IoT page, hosted under Design Centres, includes blogs and a series of articles written by partners, DesignSpark community members, and industry experts.

The Design Centre includes an introduction to the IoT area from Onanalytica-ranked IoT thought leader, Alexandra Deschamps-Sonsino of Designswarm. Additional featured articles in the Design Centre include a breakdown of the IoT, its origins, and its future. The site also explores how "Things" connect — from hardware to applications, network infrastructure, and data security.

DesignSpark community manager at RS Components, Pete Wood, says there could be 26 billion devices with unique IDs connected to the Internet by 2020.

RS Components is sister company to Allied Electronics, the North American trading brand of Electrocomponents plc. ■

Eaton Takes New Anti-Counterfeit Measures

POWER MANAGEMENT COMPANY Eaton announced the launch of new laser-etched labels to be featured on its molded case circuit breakers (MCCBs). Laser etching is one of many new technologies companies are using to help combat the counterfeiting of electrical products, and Eaton says its method provides more permanent markings "helping to authenticate each circuit breaker throughout its lifecycle."

"Providing these more permanent markings on circuit breaker labels is part of Eaton's ongoing effort to help prevent unsafe copies from being manufactured and making it into the marketplace," said Tom Grace, brand protection manager, Eaton's Electrical Sector-Americas. "The addition of new laser-etched labels demonstrates Eaton's investment in anti-counterfeit technologies and its commitment to combat counterfeiting worldwide."

Common counterfeit electrical products such as circuit breakers can lead to costly repairs, property damage, and even serious injury or death because they have not been properly manufactured or tested, the company explains.

Eaton laser-etches certain information directly onto each circuit breaker, including ratings, specifications, and product information. With the information included on the label, customers can authenticate the breaker using the company's Circuit Breaker Authentication (CBA) tool, which helps customers detect whether Eaton's MCCBs up to 400 amperes are counterfeit. Customers can access the tool at www.eaton.com/counterfeit.

The new laser-etched labels are in production for 2-Pole, F-Frame, and Series C breakers and will be rolled out to all F-Frame MCCBs, with plans to expand to additional industrial circuit breakers.

The announcement follows other recent anti-counterfeiting news from Eaton. Over the summer, Grace was a featured speaker at an American Bar Association panel discussion on the dangers of counterfeit products. The panel focused on the problem of dangerous counterfeits that pose a heightened risk to human health and safety, addressing possible solutions from policy, legislation, implementation, and legal perspectives. ■

MasterCard and Basware Offer Solution to Improve On-Time B2B Payments

MASTERCARD AND BASWARE have introduced Basware Pay to connect buyer and supplier payment processes and allow working capital optimization. The new process stems from the rate at which businesses admit to delaying payments to suppliers. In the past 12 months, 57% of surveyed international businesses have actively paid suppliers late, according to the companies' recent research. Basware Pay helps buyers manage their cash flow and suppliers get paid sooner.

Basware Pay adds to Basware and MasterCard's existing relationship and offers a new solution to optimize working capital. The system prolongs the value of the purchase-to-pay process by using a global e-payment solution — connecting buyers' and suppliers' payment process through the Basware Commerce Network. Suppliers' invoices are sent through the Basware Commerce Network, are approved by the buyer, and then become available for payment through a virtual MasterCard account number. The supplier receives an early payment, while the buyer usually has extended payment terms.

MasterCard and Basware surveyed more than 1000 strategic decision makers for its "Creating Payment Energy" study. The top findings showed that 88% of respondents agree that suppliers should be paid promptly. However, 74% of decision makers think late payments will always happen, although 90% acknowledge that payment delays have greater repercussions for businesses. Only one in four businesses reported having an automated process to manage payments. ■

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ideas for design

Build Your Own RC-Programmable, Wide-Bandwidth Bandpass-Filter Comm Apps

JOHN R. AMBROSE AND VAN VANE | MIXED SIGNAL INTEGRATION CORP. johna@mix-sig.com, vanna@mix-sig.com

MANY COMMUNICATIONS AND SENSOR applications require a bandpass filter with wide bandwidth. This filter typically requires precision resistors and capacitors to obtain an accurate filter position and response.

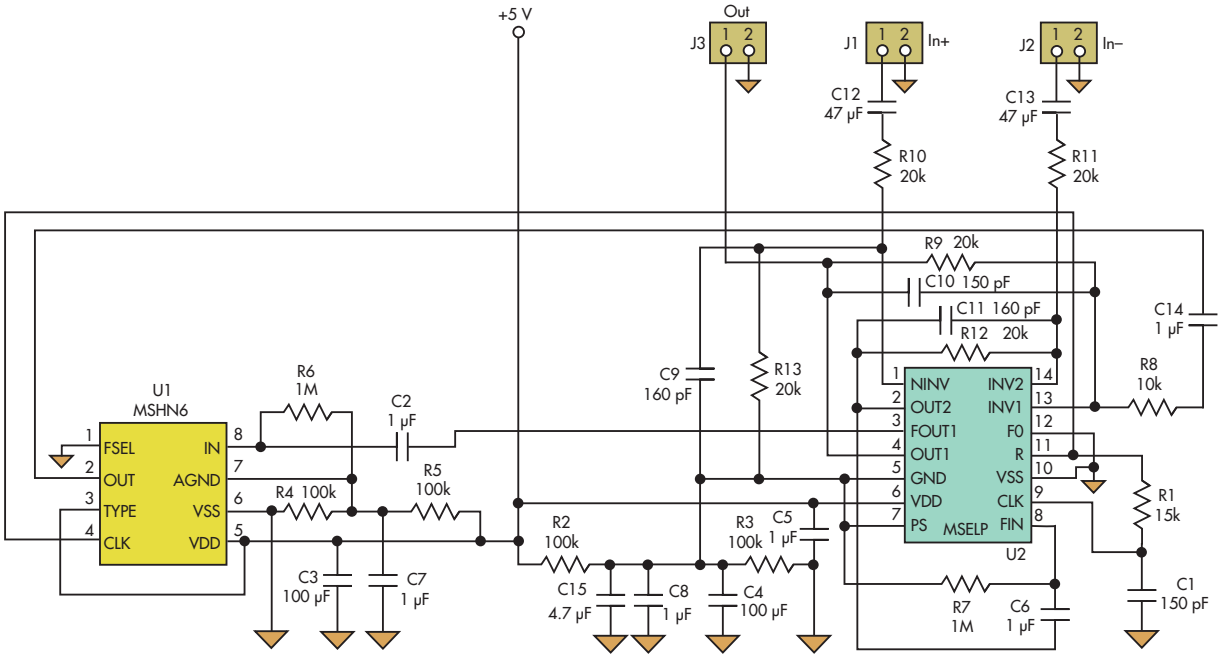
Switched-capacitor filters eliminate the need for precision components, but require a clock from a microcontroller to set the center frequency. With the limited number of outputs and timers on popular low-cost microcontrollers, there may not be a clock timer or digital output to dedicate to the filter's clock function.

The solution is to use a filter with a built-in clock oscillator, such as the MSELP fifth-order elliptic low-pass filter from Mixed Signal Integration. Similar ICs like the higher-current (5 mA) LMF60 are available from Texas Instruments, under the legacy National Semiconductor designation.

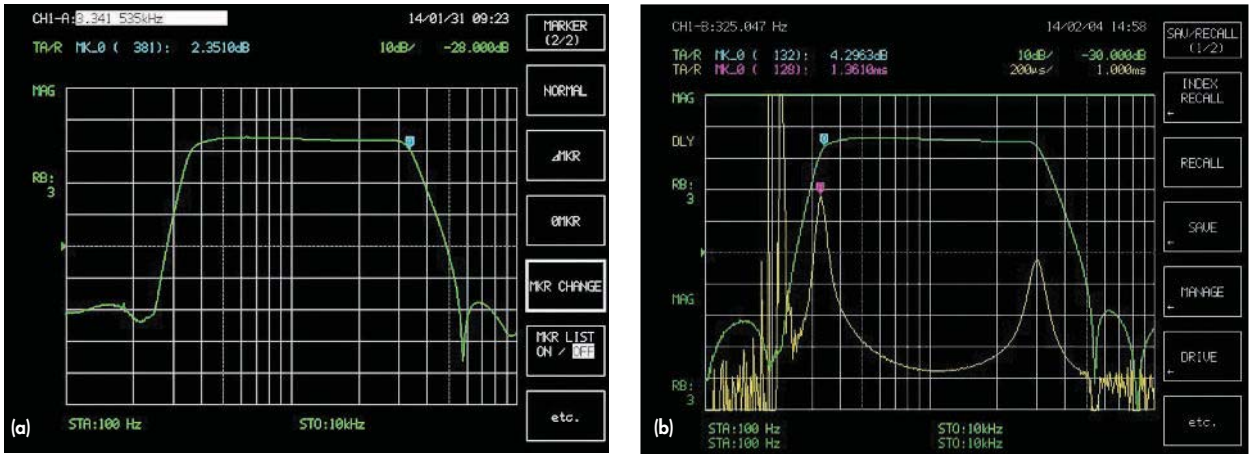
With the selectable 50:1/100:1 clock-to-corner-ratio pin and two uncommitted op amps, the clock-oscillator IC provides both an anti-aliasing filter and a reconstruction filter. Furthermore, the clock output of the MSELP can drive another switched-capacitor high-pass filter. Armed with a clock-to-corner frequency ratio of 1000:1, the MSHN6 sixth-pole high-pass/notch filter puts a decade between the corners of the bandpass filters.

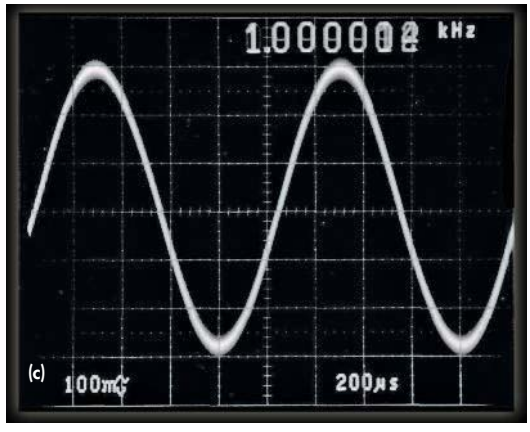
The circuit of Figure 1 is a 330-Hz to 3.3-kHz bandpass filter for Family Radio Service (FRS) radio or telephony. FRS radios are low-power, low-cost, point-to-point units providing direct voice links between users without the need for an intermediate basestation or control node. They are especially useful in remote areas that lack cell-signal coverage or cell towers.

The corner of the reconstruction filter and the anti-aliasing filter is set for approximately 50 kHz. The design uses both anti-aliasing filters and reconstruction filters. The MSELP's op-amp input provides both positive and negative inputs to the



1. This circuit provides a wideband bandpass filter optimized for FRS applications, with a 10:1 ratio in its corner frequencies.





2. The network analyzer output shows the filter's 3-dB points, roll-off, and attenuation through the anti-aliasing filter, two switched-capacitor filters, and the reconstruction filter (a); the amplitude (green trace) and group delay response (yellow trace) (b); and the reconstructed time-domain filter output at 1 kHz (c).

filter input. The MSHN6 and MSELP work down to 2.7 V dc. The circuit draws less than 1 mA. R1 and C1 set the oscillator frequency. With a 5-V supply, the frequency is:

$$F_{Clock} = 1/(1.42 \times R \times C)$$

For a 312-kHz clock, R1 equals 15 kΩ and C1 is 150 pF (3.12-kHz low-pass and 312-Hz high-pass corners).

Figure 2a is a screen capture of the network analyzer showing the complete response through the anti-aliasing filter, two switched-capacitor filters, and the reconstruction filter. Figure 2b shows the amplitude and group delay response. Note that due to its group delay response, this filter would not be suitable for telecom use, but it is a fit for radio and telephony applications. Figure 2c is the filter output at 1 kHz in the time domain. Clock feed-through is minimal, as seen at the reconstruction filter output.

JOHN R. AMBROSE and **VAN VANE** are with Mixed Signal Integration Corp., San Jose, Calif., where John is vice president of applications and systems engineering .

Accurately Determine Steady-State Output for a Periodically Driven RC Filter

KENG WU | SWITCHING POWER INC. kengchi.goah@gmail.com

A RECENT IDEA FOR Design showed a graphical technique for determining the output of an RC filter driven by a pulse-width modulation (PWM) pulse train.[1] It requires the manipulation of infinite series with a limit. Therefore, it does not yield steady-state results with confidence.

A better approach uses the concept of continuity of states and steady-state "wrap-around" to eliminate this shortcoming, since current and voltage values in a real circuit cannot change instantaneously. Current and voltage are variables with continuous values in time, from moment to moment. For a circuit structure that is switched periodically among several states repeatedly, the end state of one structure serves as the starting state of the next.

Using the same RC filter, periodic-input pulse train, and designations as the referenced Idea for Design, Equation 1 shows the filter output when the driving source V_A is non-zero:

$$v_a(t) = [V_{0a}e^{-\frac{t}{\tau}} + V_A(1-e^{-\frac{t}{\tau}})][u(t)-u(t-D\cdot T)] \quad (1)$$

When the driving source drops to zero, the output will be given by:

$$v_b(t) = V_{0b}e^{-\frac{t-DT}{\tau}}[u(t-D\cdot T)-u(t-T)] \quad (2)$$

In Equation 1 and Equation 2, the two starting conditions V_{0a} and V_{0b} are yet to be determined. A gating function with unit steps is also employed. At steady state and at the switching boundaries, t = DT and t = T; therefore Equations 3a and 3b must hold:

$$V_{0a}e^{-\frac{DT}{\tau}} + V_A(1-e^{-\frac{DT}{\tau}}) = V_{ob} \quad (3a)$$

$$V_{0b}e^{-\frac{(1-D)T}{\tau}} = V_{oa} \quad (3b)$$

This indicates that the end state of active duration with non-zero driving source must act as the starting state, V_{0b}, of the inactive duration with zero drive. Similarly, the end state of the inactive interval must return to the same starting state, V_{0a}, of the active segment. Using these facts and Equations 3a and 3b, it results in:

$$V_{0a} = \frac{V_A(1-e^{-\frac{DT}{\tau}})e^{-\frac{(1-D)T}{\tau}}}{1-e^{-\frac{T}{\tau}}} \quad (4a)$$

$$V_{0b} = \frac{V_A(1-e^{-\frac{DT}{\tau}})}{1-e^{-\frac{T}{\tau}}} \quad (4b)$$

In other words, cyclic starting states are actually known functions of driving source V_A, duty cycle D, pulse period T, and time constant RC = τ. The steady-state output in one cycle can be written as:

$$v_1(t) = [V_{0a}(V_A, D, T, \tau)e^{-\frac{t}{\tau}} + V_A(1-e^{-\frac{t}{\tau}})][u(t)-u(t-D\cdot T)] \quad (5)$$
$$[V_{0b}(V_A, D, T, \tau)e^{-\frac{t-DT}{\tau}}][u(t-D\cdot T)-u(t-T)]$$

where the multiple-cycle output is given by:

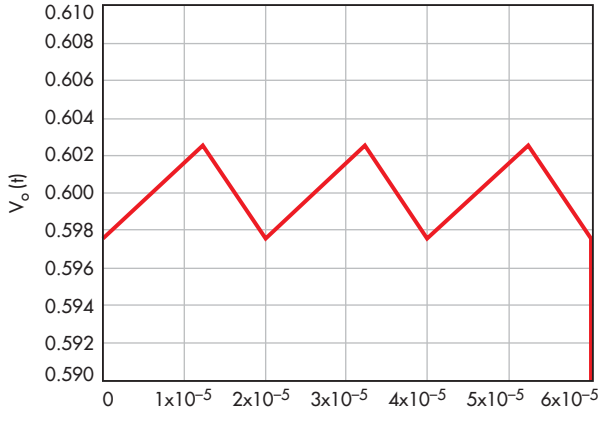
$$v_o(t) = \sum_{n=0}^{m} v_1(t-n\cdot T) \quad (6)$$

Using the example of the previous Idea for Design, with V_A = 1, D = 0.6, T = 20 µs, and τ = 50T, produces the steady-state results of the figure. The output dc level *(Equation 7)* is obtained by taking the average of Equation 5:

$$V_{DC} = \frac{1}{T}\int_0^T v_1(t)dt = 0.599999632129 \quad (7)$$

and confirms Equation 16 of the previous approach.

The approach presented here gives the true steady-state output in compact, closed form with a high degree of confidence. The technique can be extended to a number of other second- and higher-order circuits that are switched periodically among multiple states.[2, 3]



Analysis shows that the steady-state output of this RC filter, when driven by a 50-kHz, 1-V, 60% duty-cycle PWM wave, is also periodic and stays within a narrow amplitude band.

REFERENCES
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2. *Switch-mode Power Converters*, Keng Wu, Elsevier, 2005, ISBN 13:978-0-12-088795.
3. *Power Rectifiers, Inverters, and Converters*, Keng Wu, Lulu.com, 2008, ISBN 978-1-4357-2023-7.

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

LINEAR TECHNOLOGY

DESIGN NOTES

High Efficiency 100mA Synchronous Buck Converter with Wide Input Range from 4V to 150V

Design Note 532

Charlie Zhao

Introduction

The wide 4V to 150V input range of the LTC®3639 step-down DC/DC converter allows automotive, avionics and distributed power systems to:

- Cover extensive transient requirements
- Enable multiple wide-ranging input power sources, such as a high voltage DC bus with a low voltage battery backup
- Create a universal power supply to cover a variety of input sources, thereby reducing inventory and the cost of design and manufacture

The LTC3639 converts at high efficiency with internal high side and low side power MOSFETs. It can support up to 100mA output current and features a programmable peak current limit. Its output voltage range is also broad, from 0.8V to the input voltage. The integrated high side MOSFET can work at 100% duty cycle for low dropout operation. High efficiency is achieved across the wide input and output voltage ranges. Burst Mode® operation and low quiescent current are also features of this synchronous buck converter. The loop is inherently stable without compensation because of the hysteretic nature of the control architecture, resulting in a simple easy to use application circuit.

4V to 150V Input to 3.3V Output, 100mA Buck Converter

Figure 1 shows a 3.3V output, 100mA maximum load current synchronous buck converter, with wide input range from 4V to 150V. The LTC3639 has three programmable fixed output voltages 1.8V, 3.3V and 5V. These fixed outputs use an internal feedback resistor divider and can be simply selected with the V_{PRG1} and V_{PRG2} pins. For 3.3V output, just connect V_{PRG1} to ground and tie V_{PRG2} to the SS pin. The V_{FB} pin is directly connected to the output without using an external resistor divider. Efficiency curves with different input voltages are shown in Figure 2.

36V to 72V Input to 24V Output, 100mA Buck Converter

The LTC3639 has a very wide output voltage range, from 0.8V to the input voltage. Besides the selectable three fixed output voltages, an adjustable output voltage can be set with an external resistor divider. Figure 3 shows an application example of a 24V output, 100mA synchronous step-down converter. The input voltage range is controlled from 36V to 72V, with the

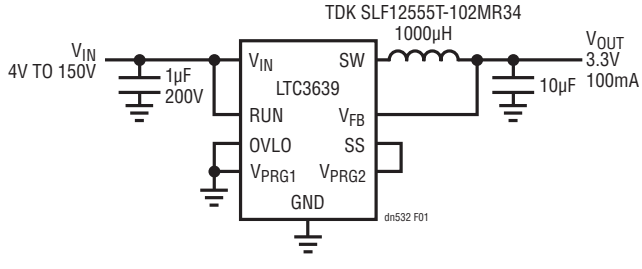

Figure 1. 4V to 150V Input to 3.3V Output, 100mA Synchronous Buck Converter

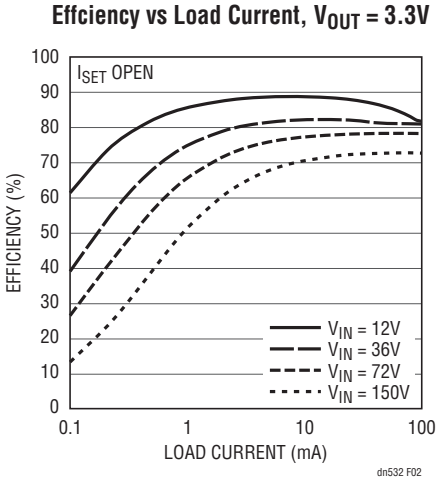

Figure 2. Efficiency Curves of the Converter in Figure 1

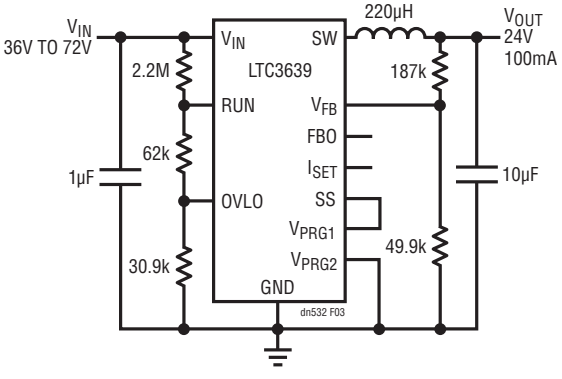

Figure 3. 36V to 72V Input to 24V, 100mA Buck Converter with Input Overvoltage and Undervoltage Lockout

overvoltage lockout and undervoltage lockout features of the LTC3639. The input operating range is easily set with a resistor divider from the V_{IN} to the RUN pin and the OVLO pin, as shown in Figure 3.

Negative Output Voltage Applications

An additional useful application for the LTC3639 is to generate a negative voltage from a positive one. The part's wide voltage range makes even large negative output voltages realizable. Figure 4 shows the implementation of a –15V output regulator from a 4V to 135V input. Since the output is connected to the ground pin, the maximum input voltage is limited to the sum of 150V and the –15V regulated output, or 135V. The maximum output current for the LTC3639 in this positive-to-negative configuration is about 100mA • $V_{IN}/(V_{IN}+|V_{OUT}|)$.

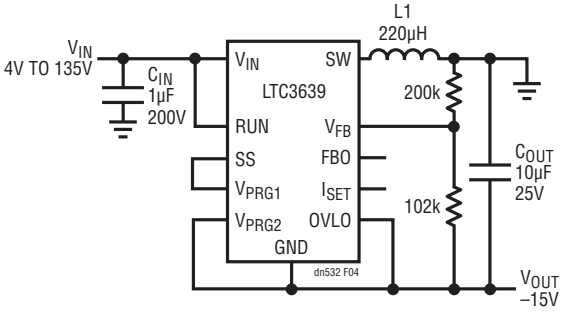

Figure 4. 4V to 135V Input to –15V Output Positive-to-Negative Regulator

Conclusion

The LTC3639 has a very wide input voltage range, very wide output voltage range, integrated power MOSFETs, low quiescent current (1.4µA in shutdown and 12µA in sleep mode) and high efficiency across a wide load current range. Rich features include programmable or adjustable output, adjustable current limit, no compensation required, internal or external soft-start, programmable overvoltage and undervoltage lockout. Additionally, the thermally enhanced small MSE package and simple application circuit offer a high performance, small and cost effective DC/DC converter solution for automotive systems, avionics, distributed power systems, medical devices and industrial control supplies.

Data Sheet Download

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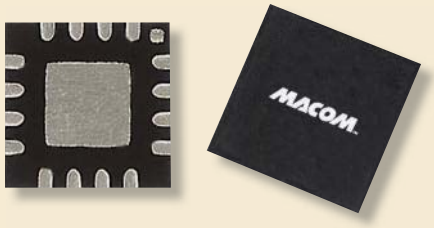
High Power PIN Diode Switch Operates from 30 MHz-3 GHz

THE MASW-011030 from MACOM is a high power PIN diode SP3T switch in a common anode configuration that operates from 30 MHz to 3 GHz. Designed for military and civilian customers who require higher CW and pulsed power operation for radio applications, the device is capable of handling 100 Watts CW incident power at a base plate temperature of 85°C. It is manufactured using MACOM's hybrid process and is delivered in a single 7-mm HWFN 16-lead plastic package. The switch delivers 40 dB isolation at 2 GHz with insertion loss of 0.35 dB and is 1B HBM ESD rated.



MACOM

www.macom.com

Rugged Connector Features Fast Field Termination

THE CEELOK FAS-X connector from TE Connectivity combines rugged reliability with signal integrity to support current and future high-speed protocols. The connector features fast field termination and repair and requires only standard contact insertion/removal and crimping tools. It meets military and aerospace markets' 10 GB/s requirements, as well as other high-speed protocols including IEEE 1394b I/O, fiber channel networks, and Modular D38999 for harsh environment applications. It is also designed for optimal signal integrity with a patented shielding arrangement that helps eliminate crosstalk and isolates each pair through the connector to provide improved impedance matching. The CeeLok FAS-X is designed to maintain high matched 100 Ω impedance and has an operating range of –60°C to +200°C.

TE CONNECTIVITY

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COM Express Mini Module Features ECC Memory

THE CONGA-MA3E, a COM Express Mini Type 10 module from congatec, is based on the Intel Atom E3800 series of processors. The module utilizes error correction code, or ECC memory, to ensure maximum reliability. Unlike traditional RAM modules, ECC modules feature additional functions to check the data flow and adjust as necessary. The Intel Atom single chip design allows for an L2 cache to be shared by multiple cores. The module also includes an ultra-dense design, onboard soldered DDR3L memory with support for up to 8 GBytes and an onboard MLC or SLC eMMC SSD.

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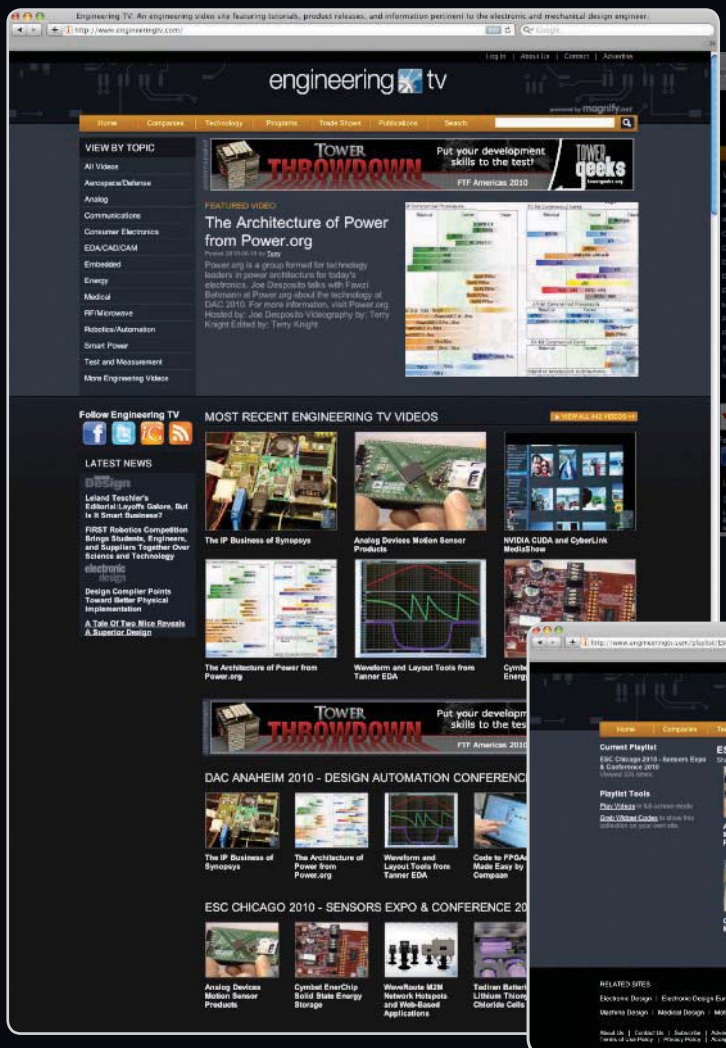

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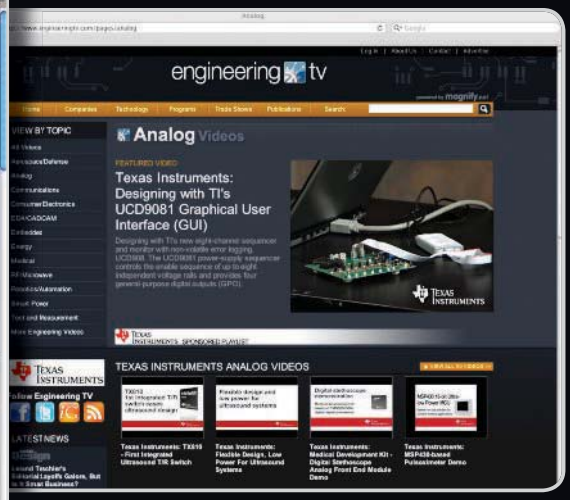

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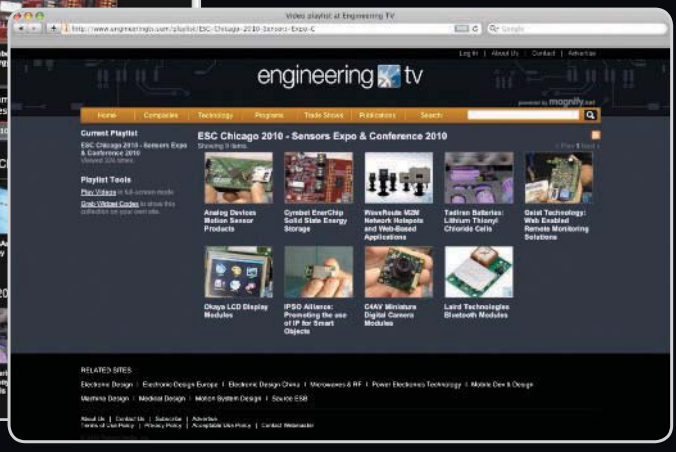

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600-W Programmable Power Supplies Feature 400-V Output

THE BENCH series of 600-W compact, programmable dc power supplies from Versatile Power feature embedded 12-bit D/A and A/D converters to provide accurate controlling and reporting. The devices offer high voltage output up to 400 V, full digital control, SCPI compliant USB with LabVIEW driver and analog control ports, digital encoders for reliability and accuracy, and integral digital remote sense. The BENCH series is ideal for bench and ATE applications and utilize a built-in LCD on the front panel which simultaneously shows both voltage and current readings. The six models measure just 1.73-in (height) × 8.82-in. (width) × 10.30-in. (deep) and weigh 5.6 lbs.

VERSATILE POWER

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DC-DC Converters Feature Remote On/Off Capability

THE SPQ Series of dc-dc converters from ConTech offers 3 Watts of fully regulated output power with a standard SIP footprint. The series offers a 4:1 input range with nominal input voltages of 12, 24, and 48 VDC. Single outputs of 3.3, 5, 12, and 15 VDC are also offered. Dual outputs are ±5, ±12, and ±15 VDC. Operating ambient temperature is –40 to 85°C.

Each unit is encapsulated with a thermally conductive compound potting compound in a non-conductive plastic case. The series also utilizes a remote on/off feature which, when enabled, has a standby current of 2.5 ma maximum. The SPQ series is RoHS compliant and is isolated input to output with an isolation voltage rating of 1600 VDC.

CONTECH

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Dielectric Platform Enables Capacitors for High Temp Environments

KEMET EXPANDED its line of Aximax High Temperature Axial Capacitors with a new axial form factor that enables the technologies to be extended into high vibration environments. Utilizing the X8L dielectric platform, Aximax X8L is a conformally coated device designed to operate in environments reaching temperatures as high as 150° C with capacitance up to 2.2 µF and rated voltages up to 50 V. Based on the X8R dielectric platform, the Aximax Ultra-Stable X8R is ideal for applications sensitive to capacitance changes, such as filters and is available with rated voltages up to 200 V. The dielectric technology exhibits no capacitance loss with respect to applied DC voltage and negligible loss of capacitance as temperatures increase. Typical applications include decoupling, bypass, and filtering in extreme environments.

KEMET

www.kemet.com

Rugged Android Tablet Features 1.5 GHz Dual-Core Processor

THE IMT-1 rugged Android 4.2 tablet from ADLINK Technology integrates a TI OMAP5432 1.5 GHz dual-core ARM A15 processor for enhanced computing power. The IMT-1 features built-in WLAN or optional WWAN connectivity for easy access of information and has an IP54 rating and 1.2 m drop resistance for use in demanding environments. Other features include a 10.1-in. capacitive touchscreen, front and rear cameras, support for 802.11 a/b/g/n protocols, and a data-only model to support 3.5G HSPA+ or 4G LTE cellular connections. A NFC reader/writer enables recognition of RFID tags (13.56 MHz) and a built-in standard secure access module (SAM) slot secures communication of encrypted data.

ADLINK TECHNOLOGY

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ADCs Integrate 20 Active Devices Onto a Single Chip

TEXAS INSTRUMENTS expanded its successive approximation register (SAR) analog-to-digital converter (ADC) portfolio with a new high-voltage family. The 8-channel ADS8688 and 4-channel ADS8684 allow input ranges up to ±10.24 V to be powered by a single 5-V supply. This helps simplify system power requirements. The ADCs feature low gain drift, offset voltage and offset drift, and high precision to enable accuracy throughout the full extended industrial temperature range from –40°C to +125°C. Each device integrates 20 active devices onto one chip including programmable gain amplifiers (PGAs), driver amplifiers, multiplexers, voltage references, reference buffers, and an auxiliary channel input for interfacing.

TEXAS INSTRUMENTS

www.ti.com

Software Enables USB Devices For Internet Connectivity

ENABLING DEVELOPERS to transform low-end stand-alone products into connected devices, SEGGER has released a complete USB to Internet development tool. emUSB-RNDIS allows USB devices to act as virtual network adapters, able to run any TCP/IP-based application including USB-based webservers. With an appropriate application server in the firmware of the USB-connected device, any internet service on a host computer can access it and the host can then allow the USB device to access the LAN and Internet if desired. emUSB-RNDIS comes as a whole packet and contains: generic USB handling, RNDIS device class implementation, a network interface driver which uses embOS/IP as a TCP/IP stack, and a sample application demonstrating how to work with RNDIS.

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Z-COMMUNICATIONS INC.

www.zcomm.com

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Thinking Outside the Box

Thinking outside the box can lead to some interesting solutions. Sometimes the ideas turn out to be really good. Micron, Somnium, and Spansion have technology that fit this characterization.

AUTOMATA RULES

Micron Automata Processor *(see "Automata Processor Piques Parallel Processing" on electronicdesign.com)* is now available featuring the software development kit (SDK) that includes the ANML "animal" (automata network markup language) compiler. ANML provides a more powerful mechanism than the more familiar regular expression that's also supported by the Automata Processor (AP).

The AP now has a 512-vector cache that allows the AP to handle 512 simultaneous input streams. It can process 128 million symbols/s. The chip contains almost 50K state transition elements (STE). It can match over 6000 sequences and there are six independent result regions. The chip has only a 4-W TDP.

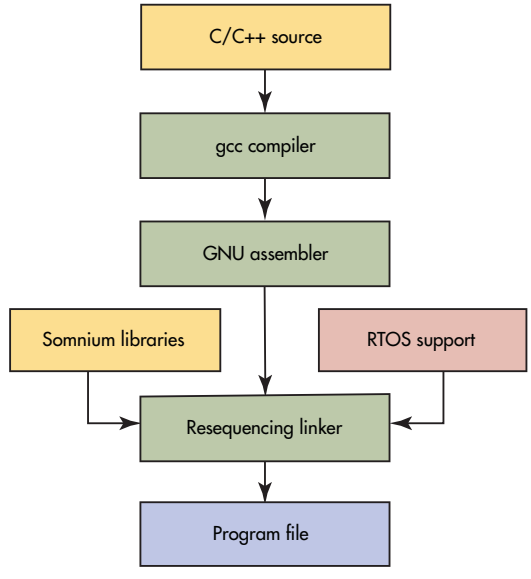
The AP is ideal for packet processing, implementing pattern-based rules, and a host of other applications that are just being developed.

LINKING OPTIMIZATION

Program optimization can take place in a number of areas. The compiler can optimize source code. Code generators can perform micro optimization, and there are global or whole program optimizers. Some just-in-time (JIT) compilers perform multiple optimization passes based on run-time profiling.

Somnium's device-aware resequencing tool (DRT) uses the normal design flow (*see the figure*), but it employs an optimized gcc compiler and linker that perform global optimization. The compiler provides hints to the linker that in turn optimizes the code sequences that wind up in the executable. Hints about the target RTOS as well as Somnium DRT optimized libraries can be mixed with an application to create an optimized executable. The tools are supported with Eclipse IDE plug-ins. Freescale Kinetis and i.MX platforms are the initial target for these tools.

DRT is able to reduce code size up to 25% while providing better performance. DRT also can handle processor interaction with platforms like the Cortex-M7, which may employ a Non Uniform Memory Architecture (NUMA).



Somnium's device-aware resequencing tool (DRT) technology performs global optimization in the linker. The Somnium gcc compiler adds hints for the linker.

HOSTING HYPERBUS

Spansion's new Traveo microcontroller targets automotive HMI (human-machine interface) applications. Based on a Cortex-R5 core, it has plenty of connectivity support like CAN and automotive Ethernet. There is a 2D/3D graphics engine that can take advantage of lots of memory, but like many SoCs, it uses off-chip memory for this aspect of the solution. HyperBus *(see "How HyperBus Delivers 330 Mbyte/s Using a Dozen Signals" on electronicdesign.com)* is one of the interfaces on the Traveo that's available to developers.

HyperBus has an 8-bit data bus that uses about twice the number of signals of quad SPI (QSPI). It also has a bandwidth of over 300 Mbytes/s, compared to QSPI and other alternatives that run under 100 Mbytes/s. Spansion initially delivered flash-based HyperBus chips, but RAM versions are now available.

Traveo and HyperBus fill a niche between microcontrollers and higher-end microprocessor solutions. DDR3 and DDR4 can deliver faster memory platforms but with a higher monetary and power cost.

These three technologies do not take the normal approach, but they deliver better performance, cost, and efficiency compared to alternatives. Sometimes choosing the non-standard solution may turn out to be the best alternative. ed

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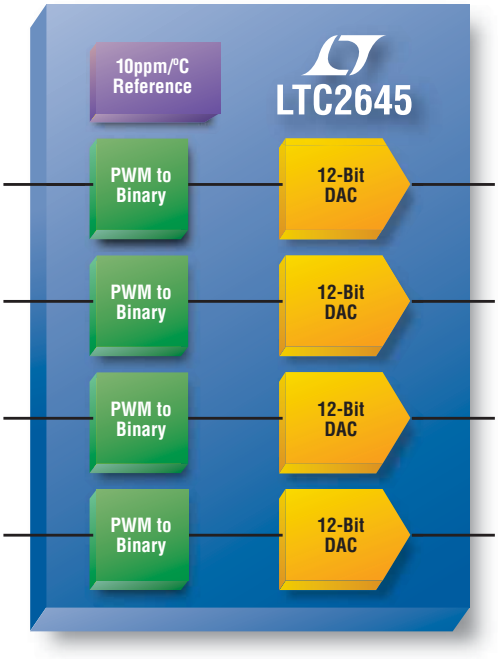

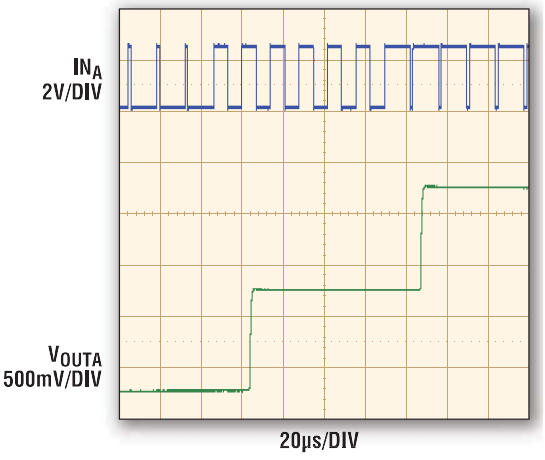

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A Special Section to PENTON'S DESIGN ENGINEERING & SOURCING GROUP 10/11 2014

Recreating simulation environments pIS14

Fighting to keep data secure pIS22

Screening signal generators pIS30

1. The two instruments at the heart of the radar target generator system are the R&S FSW signal and spectrum analyzer (bottom) and the R&S SMW200A vector signal generator (top).

COTS TEST GEAR
Generates Flexible Radar Targets

DARREN MCCARTHY | Aerospace and Defense Technical Marketing Manager
Rohde & Schwarz America, 6821 Benjamin Franklin Dr., Columbia, MD 21046; (410) 910-7800, www.rohde-schwarz.us

DR. STEFFEN HEUEL | Technology Manager
Test and Measurement Division, Rohde & Schwarz, Munich, Germany, www.rohde-schwarz.com

THE COMBINATION of a broadband signal analyzer, vector signal generator, and software—along with additional components—can be used to accurately radar target signals for testing.

Radar systems and technologies serve many different purposes in commercial, industrial, and military applications. In the automotive industry, for example, radar systems have improved vehicular safety by providing collision avoidance, blind spot detection, and automatic cruise control. Military radar systems have long been used for tracking enemy vehicles and missiles and for detecting threats from the land, sea, and the air.

Each radar was developed for a specific application, resulting in a wide range of radar systems with different operating frequencies, waveforms, transmit power, antenna aperture, and other parameters. Such systems must be tested, often with commercial test equipment.

(continued on p. 28)

ALTERA PLANS MIL Temp Specs for 20-nm Devices

ALTERA CORP. (www.altera.com) has announced plans to provide military temperature (Mil Temp) qualification for the firm's latest 20-nm Arria 10 field-programmable gate arrays (FPGAs) and system-on-chip (SoC) devices. By doing so, these offerings will be usable in the temperature extremes (−55 to +125°C) faced by many military electronic systems. Along with the improved temperature screening, the company is also offering guidelines on speed grades, protocols, and external memory interfaces for their FPGAs and SoCs when used in specific applications.

According to David Gamba, senior director of the firm's Military, Aerospace, and Government business unit, "Though not all defense applications operate in the extremes of the Mil Temp range, early notification of these qualification plans allows customers to make valuable platform design decisions now that allow for cost-effective variants and easier design migration later."

The company's Arria 10 FPGA and SoC devices feature integrated, IEEE 754-compliant, floating-point operators for fast processing speeds. The hard-floating-point digital-signal-processing (DSP) blocks in the Arria 10 devices facilitate floating point support and help dramatically reduce system development times. The devices are useful in both ground-based and airborne systems, including in phased-array radar and directional-antenna applications. ■

(News continued on p. 8)

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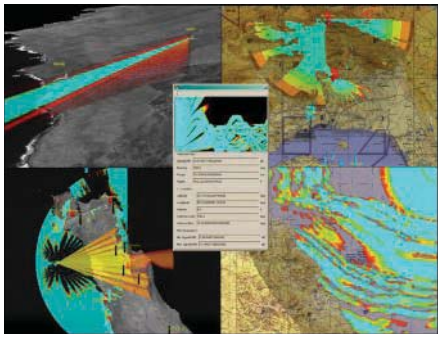

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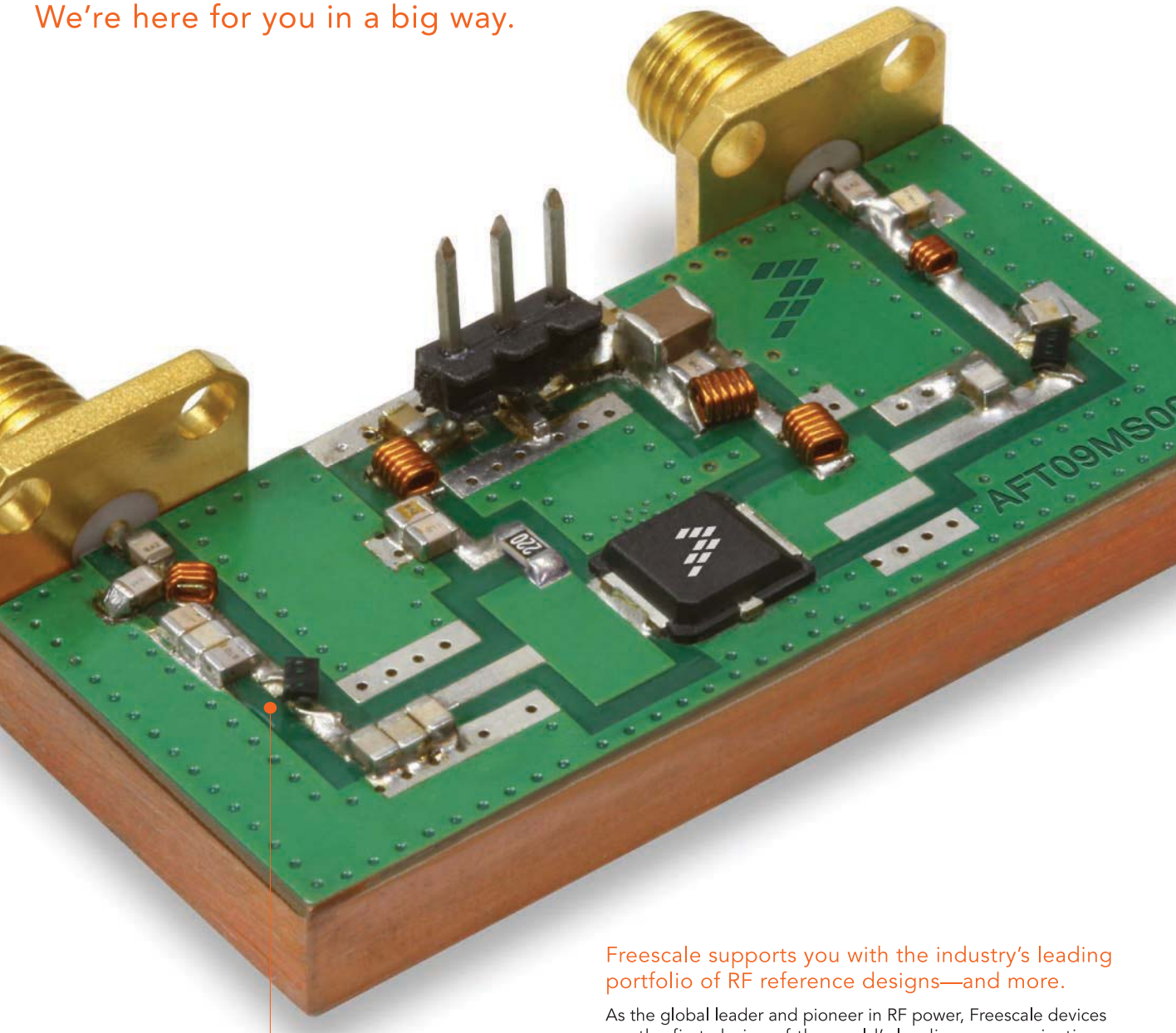

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When Computers are EW Classrooms

COMPUTERS HAVE become a large part of life in commercial and military settings, and they are quickly becoming more akin to teachers than just simple tools. As military users have learned (p. 14), computers are quite effective not only at controlling electronic-warfare (EW) systems, but also in imitating all the things that those systems can do in the form of simulators.

Computers, and in particular their software programs, are also helping design engineers reach new heights in system performance. They provide realistic opportunities to explore how different RF/microwave components behave together in an EW or radar system before they are assembled and, perhaps more importantly, before they are purchased.

One of those software tools that is powering computers (and users) forward in the EW system simulation area is the Visual System Simulator from AWR Corp. (www.awrcorp.com), now part of National Instruments (www.ni.com). AWR has been a dependable supplier of component-level modeling tools, which enable engineers to predict the performance of passive components (such as filters) and active components (such as amplifiers) without actually building the components.

The modeling software works by making predictions based on different component parameters. These include relative dielectric constant for printed-circuit-board (PCB) materials and scattering (S) parameters for transistors used in amplifiers.

The system-level software works with models of the different components in a system, and can tie together many of the firm's other software tools. For example, with circuit and electromagnetic (EM) simulation, it creates models of higher-level assemblies, including EW and radar systems. It can also model the complex signals within those systems, including their modulation characteristics, to help better understand how a system may perform under different signal environments.

Although commonly associated with the simulation of wireless communications systems, the Visual System Simulator (VSS) software is a powerful tool for predicting the interaction of components within an EW or radar system as well as the behavior and performance of the fully assembled system. Since the software's manufacturer (NI) is also a leading supplier of test equipment and measurement software, VSS can be linked to the firm's test equipment for meaningful comparisons of simulated and measured data once an EW system has been fully (or partially) assembled.

Of course, NI is not the only supplier of test equipment that also offers system-level simulation software. Another strong supplier, Keysight Technologies (www.keysight.com), has spent years refining its Advanced Design System (ADS) electronic design automation (EDA) software.

This is a sophisticated system modeling tool that can simulate the finest nuances of commercial and military systems. As with the NI software, it ties together the firm's other software simulation tools, including circuit and EM simulations. It models systems with a wide range of components and signals, including RF, microwave, and digital simulation signals.

Manufacturers of electronic components and systems have used these and other simulators as training tools, to show the effects of combining different components under different conditions. Most system-level software suppliers offer strong knowledge centers on their company websites, which allow users to learn more about high-frequency and high-speed electronics in EW and radar systems. Perhaps most importantly, they also learn about how different components are expected to interact before completing a purchase order for those components. de

JACK BROWNE, *Technical Contributor*

Unmanned Vehicles
Demonstrate Capabilities

UNMANNED VEHICLES can be useful to the U.S. Armed Forces both in the air and on the ground, as Lockheed Martin recently demonstrated. In collaboration with the Army Tank Automotive Research, Development, and Engineering Center (TARDEC), the firm successfully completed a fully autonomous resupply, reconnaissance, surveillance, and target-acquisition test of its Squad Mission Support System (SMSS) unmanned ground vehicle, K-MAX unmanned helicopter, and Gyrocam optical sensor.

The demonstration was called "Extending the Reach of the Warfighter through Robotics" and was performed at Fort Benning, Ga., with the thought that the robotics systems could help resupply soldiers defending a location, such as a village. Once the resupply was completed, the SMSS proceeded to an observation point and raised the Gyrocam sensor to scan for enemy forces. During an actual mission, a remote operator would notify a commander on the ground upon observing enemy forces. This commander would then be able to assess the threat and decide whether further action was warranted.

As Scott Greene, vice president of Ground Vehicles for Lockheed Martin Missiles and Fire Control, notes: "Fully autonomous capabilities as we've just demonstrated will allow service members to focus on important missions and remain out of harm's way." He adds: "This successful demonstration with both unmanned air and ground vehicles shows us that these missions are not only possible, but can be available much sooner than you would expect."

Dr. Paul Rogers, director of TARDEC, also notes: "The synergistic use of unmanned air and ground vehicles will give warfighters a larger operational reach, and allow execution of missions that are currently performed at great risk to the warfighter."

The K-MAX unmanned helicopter is manufactured by Kaman Aerospace Corp. (www. Kaman.com/aerospace) and is capable of lifting 6000 lbs. of cargo at sea level. The Gyrocam 9-in. surveillance sensor, produced by Lockheed Martin, provides constant video surveillance during each phase of the mission. As Dan Spoor, vice president of Aviation and Unmanned Systems at Lockheed Martin's Mission Systems and Training business, explains: "There is significant potential for these types of systems for humanitarian aid, the civilian oil and gas industry, firefighting, and for other military applications." ■

EO/IR Systems Gaining Ground in Military Use

MILITARY EQUIPMENT end-users generally seek any advantages available from technology, and electro-optical/infrared (EO/IR) technologies are answering the call by bringing many unique imaging capabilities to the battlefield.

According to the latest market forecast from research specialist Visiongain (www.visiongain.com), "Military Electro Optical Infra-Red (EO/IR) Systems Market Forecast 2014-2024: Top Companies Enhancing ISR for Ground, Naval, Airborne & UAV Platforms," EO/IR technologies will increasingly be used for intelligence, surveillance, and reconnaissance (ISR), as well as for intelligence, surveillance, target acquisition, and reconnaissance (ISTAR).

These EO/IR systems encompass ground, naval, and airborne applications, both in the form of manned and in unmanned aerial vehicles (UAVs) and unmanned ground vehicles (UGVs).

Visiongain forecasts rising global demand for military EO/IR systems from 2014 to 2024, with established military markets in Europe and North America leading developments in research and technology. The 379-page report predicts that established military markets will achieve lower rates of growth compared to emerging military powers with

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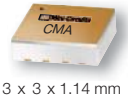

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more aggressive investment strategies.

The increasing affordability of EO/IR systems combined with their mission-critical capabilities will encourage many emerging military countries to invest in these systems and technologies. The report cites a forecast that the global military EO/IR systems market is expected to reach $8.38 billion in 2014. These are systems that employ visible and nonvisible light for imaging purposes in airborne, ground, or naval systems.

Tools include day and night imaging sensors, night vision goggles, laser rangefinders, and IR targeting pods. The report details how the military markets for these technologies have evolved, how they are growing, and what to expect in the future.

In addition to the EO/IR market report, Visiongain recently announced the availability of a new study on expected future commercial avionics markets,. This report is titled "Commercial Aircraft NextGen Avionics Market 2014-2024."

The avionics study covers flight management systems (FMS), air navigation (AN), and satellite tracking technologies, with more than 350 contracts and 150 tables of data detailed in 365 pages. ■

Modernization Plans Bolster Defense Markets

A RECENT STUDY from Frost & Sullivan (www.frost.com) of 10 countries and their defense development plans reveals that, cumulatively, they are planning to spend more than $3.41 trillion on defense spending between 2013 and 2022. Even for countries enduring financial slowdowns and transitioning markets, the defense expenditures will increase at steady paces throughout the studied time period.

The 10 countries featured in the defense-spending study ("Modernization Programs Buoy Defence Industries Across the World") are Algeria, Brazil, Chile, India, Indonesia, Japan, Oman, Poland, Russia and the United Arab Emirates (UAE). As Frost & Sullivan Aerospace and Defence Research Analyst Alix Leboulanger remarks: "Fleet renewal and modernization programs will be among the biggest drivers stimulating defense expenditures among the countries considered."

The report predicts that even with the strong interest in modernization, defense budgets will increase, but only at a moderate pace over those years. However, the improvements and increases in defense spending will continue, backed by political motivations in each of the 10 countries studied. ■

Testing Aims To Achieve Enhanced UAS Safety

UNMANNED AIRCRAFT SYSTEMS (UAS) are becoming a growing part of the national airspace, but it will not take place without strong efforts to maintain safety with piloted vehicles. As part of those efforts, the National Aeronautics and Space Administration (NASA) and Rockwell Collins completed the first in a series of risk-reduction tests meant to create a safer operating environment for UAS in the United States' air space. The data-link waveform tests simulated communications between an aircraft and a ground-based pilot station, with the intent of verifying that the communications made efficient use of the available radio spectrum.

Dave Schreck, director of UAS and Control Technologies for Rockwell Collins, explains: "There are a number of areas where the ability to safely operate unmanned systems in US airspace will provide significant benefits, including public safety enhancements, agricultural solutions, and other applications that are unforeseen today." He cautions: "However, we all agree that there are many considerations that must be thoroughly researched to allow the safe, efficient, and routine operation of unmanned systems in the national airspace."

The testing is part of a project co-funded by Rockwell Collins, which is seeking the development of an open, nonproprietary data-link waveform that may eventually be released as a public resource, and to help in developing a practical set of rules and requirements for unmanned flights. ■

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Raytheon to Develop Laser-Based Weapons

RAYTHEON CO. (www.raytheon.com) is looking to shed some light on drone aircraft—specifically, using laser weapons to defeat low-flying threats such as enemy unmanned aerial vehicles (UAVs). The laser-weapon development efforts are part of an $11-million contract, per an Office of Naval Research (ONR) program to develop vehicular-based weapons for the U.S. Marine Corps.

The laser weapons are being designed and developed as part of the Ground Based Air Defense (GBAD) Directed Energy On-the-Move Future Naval Capabilities program. This program calls for a field demonstration of a short-range laser-weapon system mounted on a Humvee ground vehicle. The laser weapon is expected to produce minimum output power of 25 kW, and will be packaged to meet the Marines' requirements for size, weight, and power consumption.

Bill Hart, vice president of Raytheon Space Systems, offers that keeping things compact is critical: "Raytheon's laser solution generates high power output in a small, light-weight, rugged package ideally suited for mobile platforms." Raytheon relies on its planar waveguide (PWG) technology to maintain small physical sizes for the laser systems while still producing the required output-power levels to stop small aircraft.

Hart notes that the laser design approach can hit higher power levels: "Our PWG laser architecture is scalable. We can achieve increasingly higher power levels with the same compact design we're using for GBAD." ■

Serco Serves on CIWS Applications

SERCO, INC. (www.serco-na.com) has been awarded a single-award indefinite-delivery, indefinite-quantity (IDIQ) contract for installation support for close-in weapons systems (CIWS) on U.S. Navy, Army, and Coast Guard vessels. The contract, with a ceiling of $31 million, features a one-year base period along with two option years. Work on the contract is expected to be performed in Norfolk, Va.; San Diego, Everett, Wash.; Mayport, Fla.; and Pearl Harbor, in addition to several overseas ports.

The CIWS is typically mounted shipboard for naval applications. It is a point-defense weapon for detecting and destroying low- and high-flying, high-speed maneuvering antiship missile threats that have penetrated outer defenses. The contract builds upon Serco's current set of Navy C4ISR contracts, under which the company is providing installation and upgrade support on Navy vessels.

According to Dan Allen, Serco's chairman and chief executive officer, "Serco has a rich history of supporting the U.S. Navy with C4ISR solutions and expertise. This program is a great addition to our C4ISR portfolio, and we are ready to apply our experience to further the United States military and its shipboard defense systems." Serco provides a wide range of services, including maintenance, performance-sustaining engineering, testing, and software development. ■

TeleCommunication Systems Supplies Troposcatter Solutions

TELECOMMUNICATION SYSTEMS (www.telecomsys.com) has received a delivery order from the U.S. Army for nearly $10 million worth of tactical transportable troposcatter (3T) systems. The initial funded value is $5.3 million for the time period from August 2014 through February 2016, with a contract ceiling value (including funded and unfunded amounts) of nearly $10 million.

The 3T system, which is classified as AN/TSC-198 (V3), provides high-bandwidth, low-latency, non-satellite beyond-line-of-sight network transport for existing and future bandwidth intensive C5ISR platforms. The system is a combination of a very-small-aperture-terminal (VSAT) satellite-communications system developed by TCS, and troposcatter technology developed by Comtech Systems (www.comtechsystems.com), a leader in troposcatter technology.

The procurements for the 3T system are being managed by the U.S. Army Project Manager for the Warfighter Information Network-Tactical (PM WIN-T) Commercial Satellite Terminal Program under the Global Tactical Advanced Communication Systems and Services (GTACS) contract efforts. Troposcatter techniques enable long-distance communications by bouncing high-frequency microwave signals off the Earth's troposphere, so that communications can be conducted even in areas of rocky or hilly terrain.

As Michael Bristol, TCS Government Solutions group president, explains: "TCS, in partnership with Comtech Systems, has created a growing market within the Department of Defense (DoD) for deployable troposcatter communication. TCS' 3T system provides the DoD with low latency, high bandwidth beyond-line-of-sight communications between multiple air defense systems. We project major interest over the next three years as the DoD looks to replace legacy TRC-170 systems through the GTACS program of record." ■

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Accurately Recreating EW Signal Environments

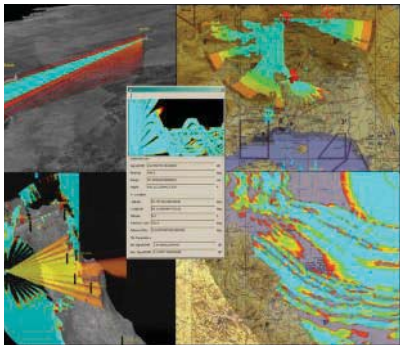
Simulating electronic-warfare (EW) environments requires duplicating these systems and their components across their actual operating frequency ranges.

SIMULATION HAS long been a key part of electronic systems for military use, mimicking the behavior of—and helping with training on—a variety of different systems. Among these are electronic-warfare (EW), surveillance, communications, and radar systems. Military users rely on a wide range of simulation systems but, in particular, electronic gear that recreates EW environments is of particular interest, since EW systems can stand between life and death.

What follows is a brief summary of some of the functions that are essential for EW simulations, along with some examples of the current electronic products that can provide and support these functions.

Simulators of EW functions have grown in sophistication as the EW systems they imitate have developed. For example, EW signal sources have embraced advanced modulation schemes and the use of Doppler effects for direction finding (DF)—with the aid of such technologies as direct digital synthesis (DDS)—and the signals used in many EW systems have grown extremely complex. This enables improved security of these signals in hostile EW environments, but also makes simulation of those signals more challenging.

Receivers of EW signals have also improved with time, gaining in dynamic range and sensitivity as receiver integrated circuits (ICs) and low-noise amplifiers (LNAs) have improved in performance. As the EW systems themselves reach higher levels of performance, the simulators must follow.



1. The Interactive Scenario Builder software tool provides three-dimensional EW system modeling and simulation for government customers. *[Screenshot courtesy of the U.S. Naval Rsearch Laboratory (www.nrl.nav).]*

The different branches of the United States Armed Forces have typically pursued their own efforts in terms of EW system development and simulation. In the case of the Navy, the Naval Research Laboratory (NRL) and its Visual and Systems Integration (VSI) section (www.nrl.navy.mil) have focused on advancements in EW systems and simulation, with the NRL's Tactical Electronic Warfare Division (TEWD) performing a great deal of research on tactical EW requirements. The NRL—in particular, its Advanced Tactical and Environmental Simulation Team (ATEST)—performs three-dimensional EW system modeling and simulation with its Interactive Scenario Builder software tool *(Fig. 1)* for the Navy and other Department of Defense (DoD) customers.

Now in its third iteration, the Interactive Scenarios Builder software combines the effects of terrain, buildings, and signal countermeasures to simulate different military environments. It integrates National Geospatial-Intelligence Agency (NGA) terrain and imagery with Controlled Image Base (CIB) imagery and Digital Terrain Elevation Data (DTED), creating a realistic simulation environment for evaluating different EW equipment.

The U.S. Army Research Lab (www.arl.army.mil) handles the development of EW simulation tools, creating custom solutions and leveraging commercial software where appropriate. Similarly, the Air Force evaluates many different EW simulators at its Wright-Patterson Air Force Base (AFB) in Greene, Ohio. Among these is the Air Force's own Electronic Warfare Evaluator Simulator (AFEWES), which has been used to compare the strengths and weaknesses of different EW systems.

The Navy recently received simulation help from Lockheed Martin (www.lockheedmartin.com) in the form of an advanced maritime test bed, capable of simulating different naval environments, as well as of checking the performance of intelligence, communications, and sensor systems before they are introduced into actual operating environments.

According to Dr. Rob Smith, vice president of C4ISR for Lockheed Martin's Information Systems and Global Solutions business, "The Navy is confronted with unique challenges that require superior, faster intelligence sharing. The Maritime Test Bed provides a cost-effective, risk-reduction platform that can be used for realistic testing to demonstrate what is possible—with the end goal of providing real-time, decision-quality intelligence for the Navy."

Lockheed Martin demonstrated the

2. EW simulators in the EWSIM product line employ physics-based models to recreate aerodynamic models. *[Screenshot courtesy of Electronic Warfare Simulation Corp. (www.ewsim.com).]*

test bed to show how the Navy could combine simulated Aegis radar data with other integrated intelligence, surveillance, and reconnaissance (ISR) sensor data to provide a comprehensive picture of the battle space. The test bed was capable of quickly collecting, analyzing, and processing data and then distributing required portions to simulated naval platforms both on land and at sea. All operating units had access to the integrated ISR sensor data to help with situational awareness and improved efficiency of battle management planning.

The maritime test bed was developed with open standards software infrastructure, which allows it to leverage multiple information sources and databases for testing. For testing highly sensitive technologies, the maritime test bed can be linked to the Secret Defense Research and Engineering Network (SDREN), as well as the Defense Research and Engineering Network (DREN).

From a somewhat smaller supplier, the model RSS8000/CP simulator from EW Simulation Technology (EWST) Ltd. (www.ewst.co.uk) is based on a modular design for flexibility and expansion. The baseline system operates from 2 to 18 GHz in a 4U configuration. It can also be equipped with frequency-extension modules in a larger, 6U package, to provide full frequency coverage from 0.5 to 40.0 GHz. The system, which is suitable for both laboratory and portable use, can be applied to both EW system testing and simulation.

LEARNING BY SIMULATION

Simulators for EW systems also are moving into classrooms. The use of simulated EW signals and entire EW systems provides a more meaningful training environment than software models. In addition, the benefits of training with simulators are reaching well beyond just military EW system users: Law-enforcement and corporate security professionals are looking to suppliers of electronic simulation systems—including makers of EW simulators—for systems that can mimic their own working environments and their various signals (e.g., communications and surveillance signals).

As an example, the Battle Force Electronic Warfare Trainer (BEWT) AN/USQ-T47(V) from Electronic Warfare Simulation Corp. (www.ewsim.com) is just one of their simulation and training tools in the firm's EWSIM product line. The firm also offers simulators and trainers for such applications as communications intelligence (COMINT), signal intelligence (SIGINT), and radar system simulation.

The EWSIM simulation tools are based on a geographic information system (GIS) core for accuracy and use physics-based models to create an Integrated Air Defense System (IADS) that includes aerodynamic models for missile fly outs. The EW simulators *(Fig. 2)* are designed for use with a number of different computer operating systems, including many of the Microsoft (www.microsoft.com) operating systems.

The EW Pro software training tool from RDSI (www.rdsi.com) provides a flexible user interface that enables complete EW scenario creation, including emitter creation and control. In fact, there is no need to create new signal representations of EW threats since the training tool can import emitters from numerous government data bases, including the Navy's Naval Emitter Reference File (NERF) and the ELINT Parameter List (EPL) from the National Security Agency (NSA).

EW Pro boasts a map overlap function that allows maps to be imported into the EW simulation software with complete latitude and longitude displays. During playback, EW Pro creates a realistic emitter environment by considering various factors—including emitter parameters, positions of different platforms, over-the-horizon effects, and emitter visibility—and generates the appropriate audio and video characteristics.

The Joint Man-Portable Air Defense System (JMANPADS) Trainer from DRS Technologies (www.drs.com) is a portable EW training tool designed to counter infrared (IR) Man-Portable Air Defense Systems (MANPADS). It is well suited for aircrew survivability training and allows testing against fixed- and rotary-wing aircraft equipped

3. The CHAMP-WB-DRFM DRFM features high-resolution ADC and DAC circuits for high signal precision. *[Photograph courtesy of Curtiss-Wright Corp. (www.cwcdefense.com).]*

with various missile-warning systems. It includes day and night sensors, digital video recording capability, an internal battery pack, and easy-to-use operator controls, and displays within a single lightweight assembly. Training missions can be recorded in the field and transferred afterward to a personal computer (PC) for storage and analysis.

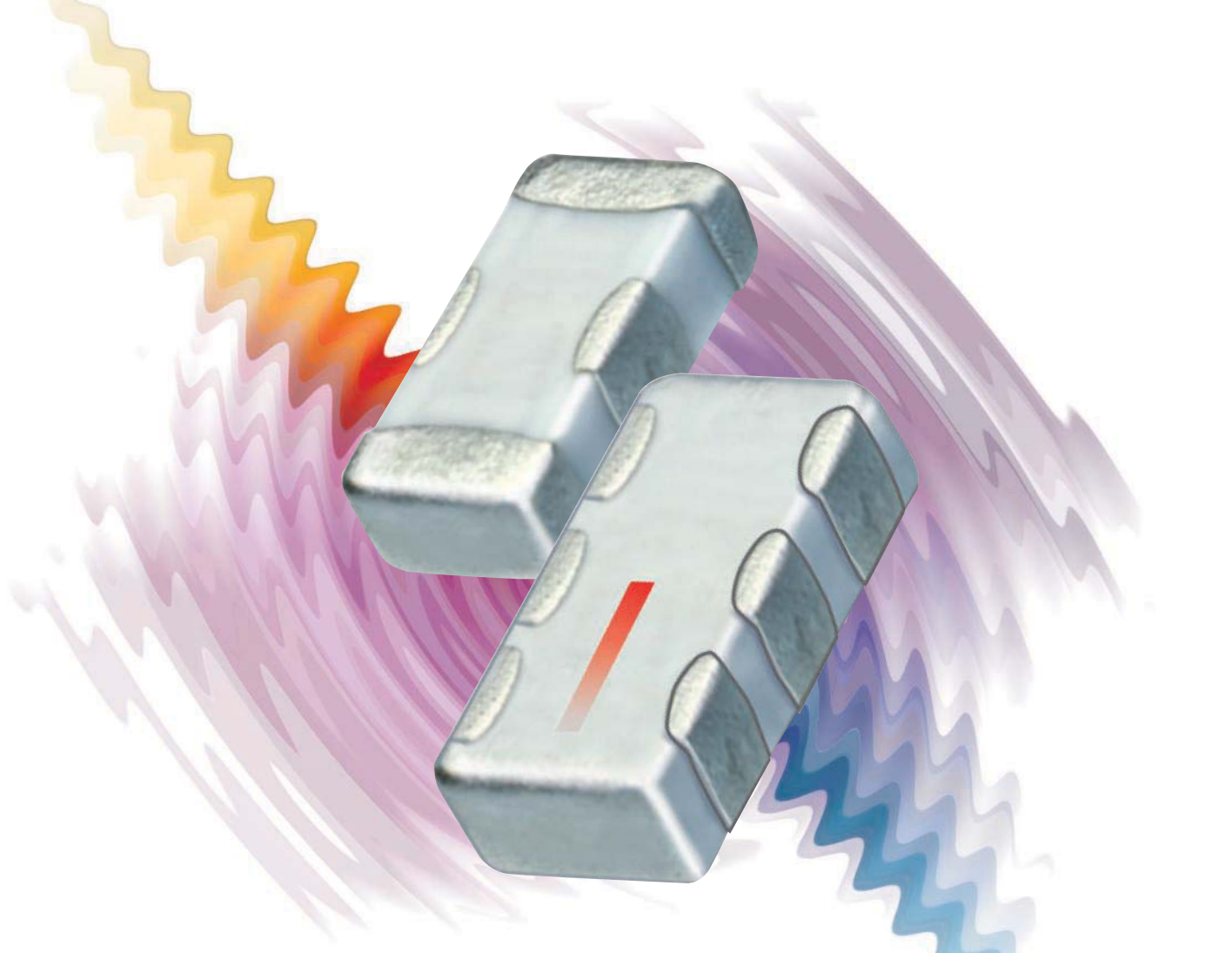
Dynetics (www.dynetics.com) has worked with the US Air Force to develop weapons models for the F22 aircraft combat simulation (ACS). These digital models have included a wide range of systems, including airborne intercept radar, identification friend-or-foe (IFF) system, radar warning receiver (RWR), missile launch detector (MLD), electronic attack system (EAS), fire control system (FCS), and various missile types. The models depend strongly on measurements performed at different military bases to explore different threat system vulnerabilities and create potential EW countermeasures.

4. DRFMs are available with different performance levels and in different package types for use in the laboratory and in the field. *[Photograph courtesy of Mercury Defense Systems (www.mrcy.com).]*

DISSECTING DRFMS

In addition to improvements in various components, such as LNAs and signal sources, EW simulators have gained in power and performance in recent years by means of enhancements to key subsystems, such as digital RF memories (DRFMs). As an example, the CHAMP-WB-DRFM card set *(Fig. 3)* from Curtiss-Wright Corp. (www.cwcdefense.com) is a DRFM with 8-b, 12-GSamples/s analog-to-digital-converter (ADC) technology and 10-b, 12-GSamples/s digital-to-analog-converter (DAC) technology for extremely high signal resolution.

The converters can operate in dual-channel modes and features a Virtex-7 X690T field-programmable gate array (FPGA) from Xilinx (www.xilinx.com) with a generous amount of storage memory for different waveforms. The DRFM card set is typically specified for both commercial and



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military applications, including for EW simulation systems.

The firm also recently announced that its Defense Solutions division has also begun volume production on its model VPX3-530 dual-channel ADC/DAC module which features a 12-b ADC and 14-b DAC both capable of operating in two-channel mode as needed for EW simulator applications. For flexibility, the module is supplied on a single 3U OpenVPX card for installation in a range of different systems, including in radar-warning receivers (RWRs) and software-defined radios (SDRs).

5. The RS-2000 family of compact testers are ideal for radar and EW system testing and simulation through 40 GHz. *[Photograph courtesy of MicroKim (www.microkim.com).]*

Mercury Defense Systems (www.mrcy.com) has developed a number of DRFM solutions, for both the laboratory and the field. The rack-mount versions *(Fig. 4)* provide as much as 12-b quantization with as many as six DRFMs available per rack-mount chassis for a great deal of signal processing power. They can command more than 16 ms signal delay across instantaneous bandwidths of 50 MHz to 1 GHz. These DRFMs are available for use at baseband frequencies or for customer-specified RF/microwave frequencies.

In a slightly smaller package, the RS-2000 family of simulator/test units *(Fig. 5)* from MicroKim (www.microkim.com) are essentially compact testers for radar systems that can also be used for EW simulation and test. They can perform pulse-on-pulse and pulse-on-CW signal simulations with hours of operation on a single battery charge. Different sources are available for total frequency coverage from 0.5 to 40.0 GHz.

Of course, these are just a sampling of the EW simulators currently available. A large number of suppliers are prepared to provide solutions in a wide range of standard frequencies, typically through 40 GHz, or to offer guidance on developing custom EW simulation solutions. de

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YM1003	0.2	1.0 - 12.0	-28
YM1004	0.5	1.0 - 12.0	-10
YM1026	1.0 - 2.0	2.0 - 18.0	-4
YM1027	0.1	1.0 - 18.0	-40
YM1028	0.2	1.0 - 18.0	-33
YM1029	0.5	1.0 - 18.0	-22
YM1087	0.1 - 0.2	1.0 - 12.0	-25

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YOM1518	1.0 - 4.0	20-60	16
YOM1514	4.0 - 12.0	10	15
YOM3719-5	2.0 - 15.0	20	13
YOM1679	2.0 - 12.4	20	13
YOM83	2.0 - 6.0	20	12
YOM137	2.0 - 8.0	20	12
YOM3719-4	8.0 - 18.0	20	14
YOM3719-2	6.0 - 18.0	20	14
YOM3719-1	4.0 - 18.0	20	13
YOM3719	3.0 - 18.0	10	12
YOM3676	2.0 - 18.0	20	15

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YIG BAND REJECT FILTERS

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M104RX	4.0 - 18.0	2.0	8
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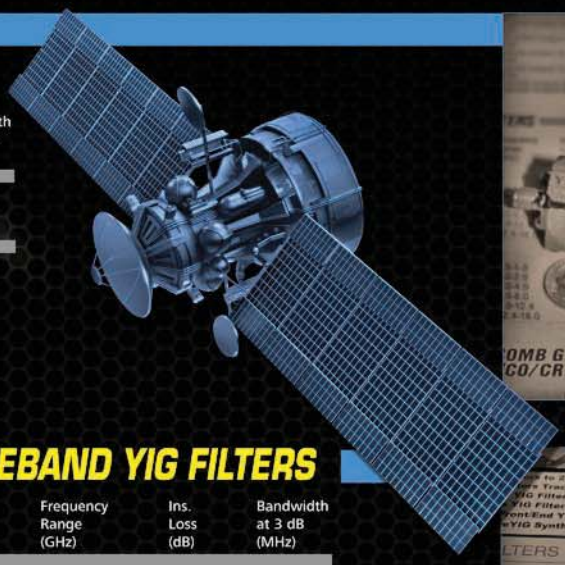

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Omniyig Model No.	Frequency Range (GHz)	Ins. Loss (dB)	Bandwidth at 3 dB (MHz)
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M3064	6.0 - 18.0	6.5	500 min
M2997	6.0 - 18.0	6.0	400 min
M3513	8.0 - 18.0	6.5	500 min

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STANDARD DETECTORS

Omniyig Model No.	Frequency Range (GHz)	k Factor	TSS (dBm)
Zero-Bias Schottky			
ODZ0004A	0.1 - 18.0	1200	-52
ODZ0328A	2.0 - 18.0	1200	-52
ODZ0441A	6.0 - 26.0	1000	-51

STANDARD LIMITERS

Omniyig Model No.	Frequency Range (GHz)	Insertion Loss (dB)	Leakage Power (dBm)
Pin			
OLP2645A	8.0 - 18.0	2.0	+19
OLP2726A	2.0 - 18.0	1.2	+19
PL473	0.5 - 12.0	1.8	+19
OLP2652	2.0 - 18.0	2.5	+20
Schottky Turn-on			
SL048	2.0 - 26.0	2.5	+14
OLD2635A	4.0 - 18.0	2.5	+14
OLD2733A	0.4 - 18.0	2.5	+14

Leakage Power Measured at P(in) = +30 dBm

STANDARD COMB GENERATORS

Omniyig Model No.	Input Frequency (MHz)	Output Frequency (GHz)	Output Power (dBm)
OHG10118	100	0.1 - 18.0	-40
OHG20218	20	0.2 - 18.0	-35
OHG51026	500	0.5 - 18.0	-28
OHG81026	1000	1.0 - 18.0	-18

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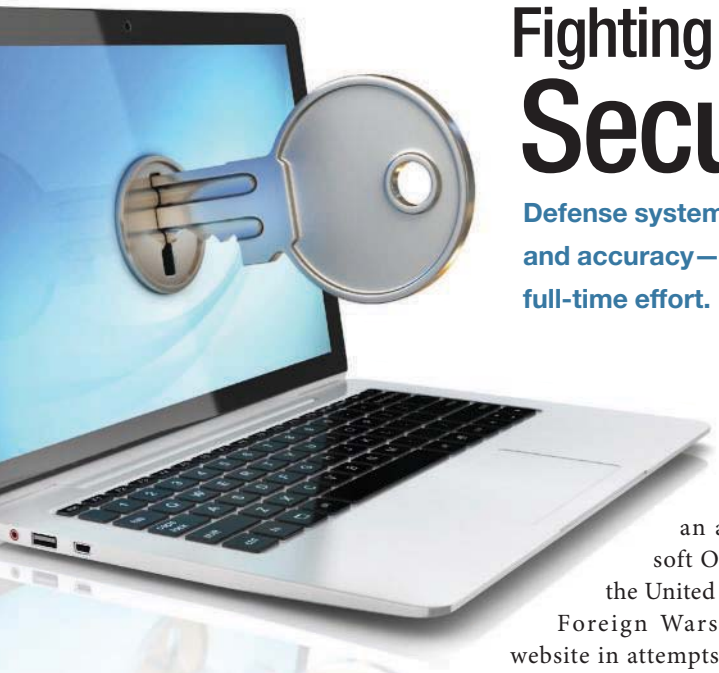

Fighting for Secure Data

Defense systems rely on increasing amounts of data for validity and accuracy—and protecting it from theft and corruption is a full-time effort.

DATA SECURITY is essential for commercial and defense-based systems alike, with one key difference between the two groups of applications: compromising data in a commercial system can mean financial loss, while theft or loss of data in a defense-based system can result in loss of life. The data protection methods used in the two application areas are often similar, but—between the growing sophistication of electronic systems and the increasing amounts of data used by military systems—efforts to protect and preserve this data must be stepped up.

Modern databases and data are synonymous with computers and computer systems, and with software suppliers such as Microsoft (www.microsoft.com). Such software and operating-system (OS) suppliers must constantly check their products for weaknesses. This past September, in fact, Microsoft coordinated a patch release for some of its software.

The firm had addressed a proof-of-concept (PoC) portion of its XMLDOM code, which was first released in April 2013. Unfortunately, vulnerabilities within the software were exploited in an attack on Microsoft OS systems against the United States Veterans of Foreign Wars (www.vfw.org) website in attempts to infect the site and steal data. Fortunately, a security team from Microsoft became aware of the vulnerability in their code and was able to put out a patch to protect against data attackers.

With an ever-growing number of cyber attacks, efforts to protect data may never be sufficient to ensure complete security. According to a 138-page report in 2013 from the Rutgers University Office of Information Technology (www.rusecure.rutgers.edu), assembled by a 33-member panel of civilian and government experts for the Pentagon, the U.S. military is not prepared for a full-scale cyber attack. According to the report, the data security efforts by the U.S. Department of Defense (DoD) are fragmented at best and will not provide adequate security.

In contrast to efforts against individuals and their personal incomes, when data hackers line up government or defense-based targets, they are typically looking for classified data that can be sold to enemies of the government or military. Efforts by the military at protecting data are now typically categorized as part of the U.S. Armed Forces' information security (INFOSEC) programs, and a number of different websites offer support on maintaining INFOSEC services (for example, www.infosyssec.com).

Of course, most of the efforts at maintaining data security with the Armed Forces and government agencies begin with the DoD (www.defense.gov) and the DoD's Defense Information Systems Agency (DISA; www.disa.mil). DISA helps manage the Defense Information System Network (DISN), which offers many online and video educational courses to help maintain data security and provides details on the latest expected threats.

In addition, the DoD's Defense Security Service (DSS; www.dss.mil) provides excellent guidance on data security regarding new and even legacy computer systems. The organization offers white papers and webinars to provide the latest information on threats and how to achieve the highest levels of data security, even for legacy computer systems such as those based on Microsoft Windows XP OS.

RATING SECURITY EFFORTS

The DSS recognizes the efforts of its personnel and contractors by means of different ratings. For industrial contractors, for example, the ratings system helps acknowledge when sufficient efforts have been made to protect data security. The DSS recently gave a "Superior" rating to one of its contractors, a Lockheed Martin (www.lockheedmartin.com) facility in Fort Worth, Tex., for security practices in handling classified data. Earning the rating means those contractors must meet the requirements

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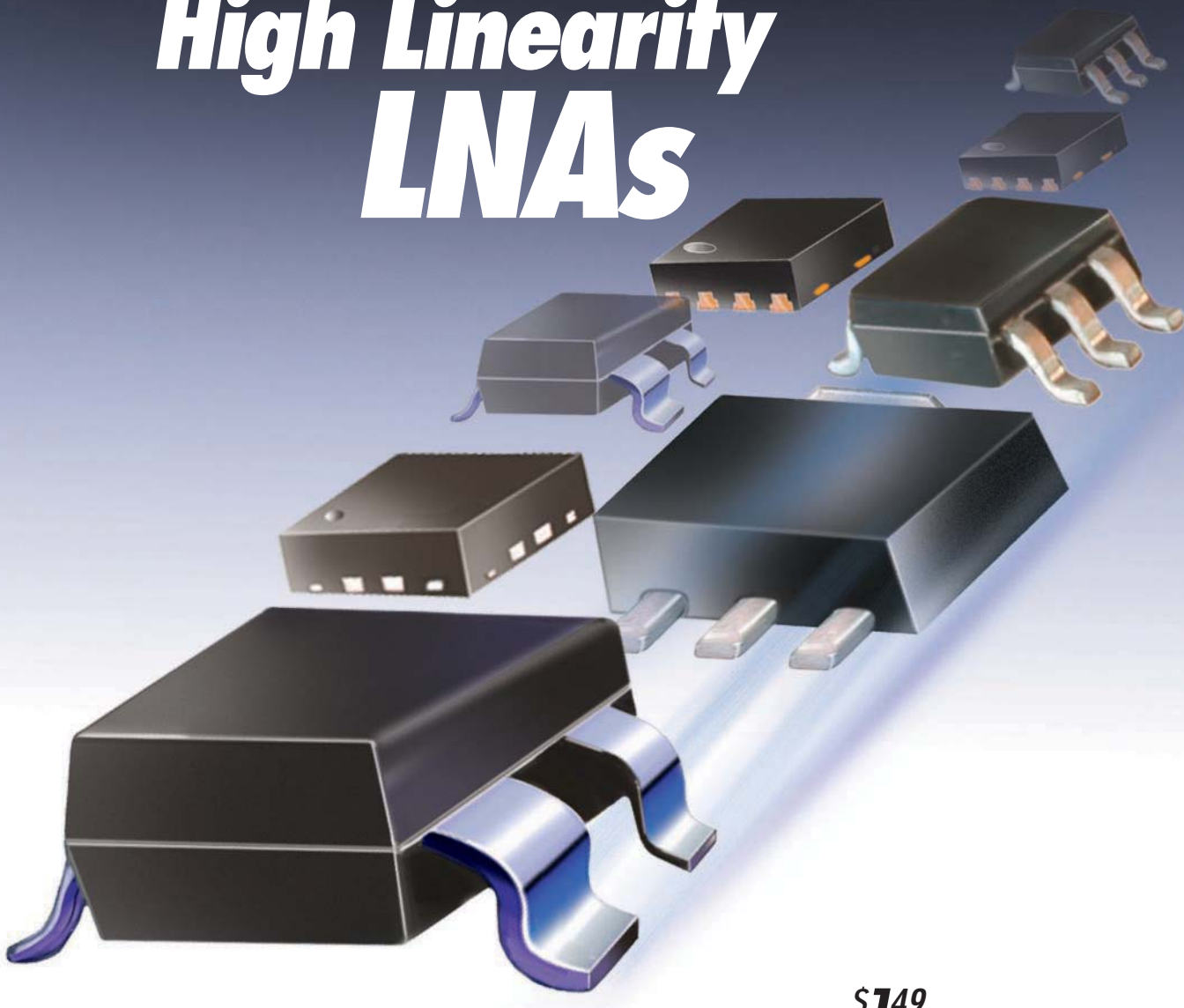

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PSA4-5043+	50-4000	18.4	**0.75**	**34**	19	33 (3V) 58 (5V)	2.50
PMA-5455+	50-6000	14.0	**0.8**	**33**	19	40	1.49
PMA-5451+	50-6000	13.7	**0.8**	**31**	17	30	1.49
PMA2-252LN+	1500-2500	15-19	**0.8**	**30**	18	25-55 (3V) 37-80 (4V)	2.87
PMA-545G3+	700-1000	31.3	**0.9**	**33**	22	158	4.95
PMA-5454+	50-6000	13.5	**0.9**	**28**	15	20	1.49

PSA PMA PGA

Model	Freq. (MHz)	Gain (dB)	NF (dB)	IP3 (dBm)	P_{out} (dBm)	Current (mA)	Price $ (qty. 20)
PGA-103+	50-4000	11.0	**0.9**	**43**	22	60 (3V) 97 (5V)	1.99
PMA-5453+	50-6000	14.3	**0.7**	**37**	20	60	1.49
PSA-5453+	50-4000	14.7	**1.0**	**37**	19	60	1.49
PMA-5456+	50-6000	14.4	**0.8**	**36**	22	60	1.49
PMA-545+	50-6000	14.2	**0.8**	**36**	20	80	1.49
PSA-545+	50-4000	14.9	**1.0**	**36**	20	80	1.49
PMA-545G1+	400-2200	31.3	**1.0**	**34**	22	158	4.95
PMA-545G2+	1100-1600	30.4	**1.0**	**34**	22	158	4.95
PSA-5455+	50-4000	14.4	**1.0**	**32**	19	40	1.49

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of the National Industrial Security Program Operating Manual, including in raising the security awareness of its employees.

With more than 12,000 employees at the facility (which operates production lines for the F-35 and F-16 fighter aircraft), achieving the high security rating was no small feat. As noted by Steve Wheeler, Lockheed Martin's director of security and emergency services, "a Superior rating is particularly meaningful for the men and women who serve in our military and rely on aircraft and other capabilities we develop and produce."

The Deputy Under Secretary of the Navy (Policy) has been designated as the Department of the Navy's Security Executive for data security and other related matters. As with many of the other military branches, the U.S. Navy provides extensive training and educational courses on improving data security, including the Center for Development of Security Excellence (CDSE; www.cdse.edu).

Specifically, the CDSE offers DISA course DS-IA107.06, "DoD Intrusion Detection System (IDS) Analysis Part II." The three-hour course explores how to identify malicious online traffic and how to perform intrusion analysis on raw network packet data. It is aimed at DoD information system professionals and U.S. government personnel and contractors.

> **"With an ever-growing number of cyber attacks, efforts to protect data may never be sufficient to ensure complete security. According to a 2013 report, the U.S. military is not prepared for a full-scale cyber attack."**

The U.S. Army website (www.army.mil) includes a link to the iSALUTE site (www.inscom.army.mil/isalute/) as a means to report counterintelligence information for the full Army community. The link, which does not require a login, helps promote foreign threat awareness as a way to protect against possible espionage and improve government/military data security. The U.S. Army Information Assurance Training Center (www.ia.signal.army.mil) has been established as a centralized site to help with training and awareness concerning cyber threats and maintaining data security under all circumstances.

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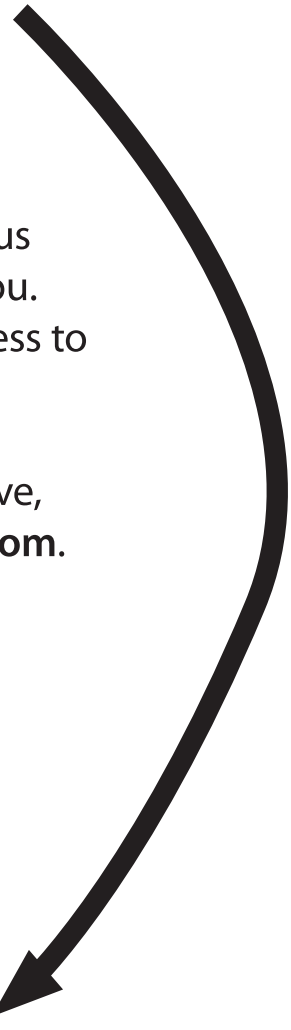

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Also, the Army's Intelligence and Security Command (INSCOM) maintains a website (www.inscom.army.mil) to assist data professionals with security and help maintain the integrity of both classified and unclassified.

The US Army also maintains a public website for its Information Technology Agency (ita.army.mil), mainly to cover unclassified data security topics and keep the general public apprised of news and data-related topics at the Pentagon. Additional sites that are connected to individual branches of the military, such as the INFOSEC site at Fort Belvoir (www.belvoir.army.mil), also offer excellent educational tools and resources on achieving and maintaining data security.

WEBSITE WARRIORS

A growing number of websites are directed towards assisting those tasked with preserving and protecting data. Advanced Security (www.trainace.com) is a training partner to the Army, offering a number of different network security certification classes—such as Security+, Certified Ethical Hacker, and ECSA/LPT—to help improve data security for government and military customers. The firm is approved for use by U.S. Army personnel and has helped improve awareness of cyber threats and methods for achieved improved data security.

The GlobalSecurity.org website is a reliable source of information on data security, as well as military, government, and even aerospace topics. The site includes data security information categorized by separate military branches (including the Army and Air Force), and even provides information on military technologies [such as improvised explosive devices (IEDs)] and overseas activities (e.g., Chinese military activities).

INFOSEC jobs are available in every branch of the military and many federal agencies, including the National Security Agency (NSA), Department of Defense (DoD), Central Intelligence Agency (CIA), and the Department of Homeland Security (DHS). Government INFOSEC professionals may require security clearances and any number of certifications, including such certifications as Security+, CISSP, SSCP, and CAP, along with sufficient educational credentials.

Further information on careers in INFOSEC is available from a number of different websites, including Military.com and the U.S. Army Information Technology Agency (www.ita.army.mil). de

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NEW USB-1SP4T-A18	1 (SP4T)	0.25	1.2	85	2	795.00
USB-1SPDT-A18	1	0.25	1.2	85	10	385.00
USB-2SPDT-A18	2	0.25	1.2	85	10	685.00
USB-3SPDT-A18	3	0.25	1.2	85	10	980.00
USB-4SPDT-A18	4	0.25	1.2	85	10	1180.00
USB-8SPDT-A18	8	0.25	1.2	85	10	2495.00

NEW USB and Ethernet Control Switch Matrices

Model	# Switches (SPDT)	IL (dB)	VSWR (:1)	Isolation (dB)	RF P_{MAX} (W)	Price $ (Qty. 1-9)
RC-1SP4T-A18	1 (SP4T)	0.25	1.2	85	2	895.00
NEW RC-2SP4T-A18	2 (SP4T)	0.25	1.2	85	2	2195.00
RC-1SPDT-A18	1	0.25	1.2	85	10	485.00
RC-2SPDT-A18	2	0.25	1.2	85	10	785.00
RC-3SPDT-A18	3	0.25	1.2	85	10	1080.00
RC-4SPDT-A18	4	0.25	1.2	85	10	1280.00
RC-8SPDT-A18	8	0.25	1.2	85	10	2595.00

*The mechanical switches within each model are offered with an optional 10 year extended warranty. Agreement required. See data sheets on our website for terms and conditions. Switches protected by US patents 5,272,458; 6,650,210; 6,414,577; 7,633,361; 7,843,289; and additional patents pending.

†See data sheet for a full list of compatible software.

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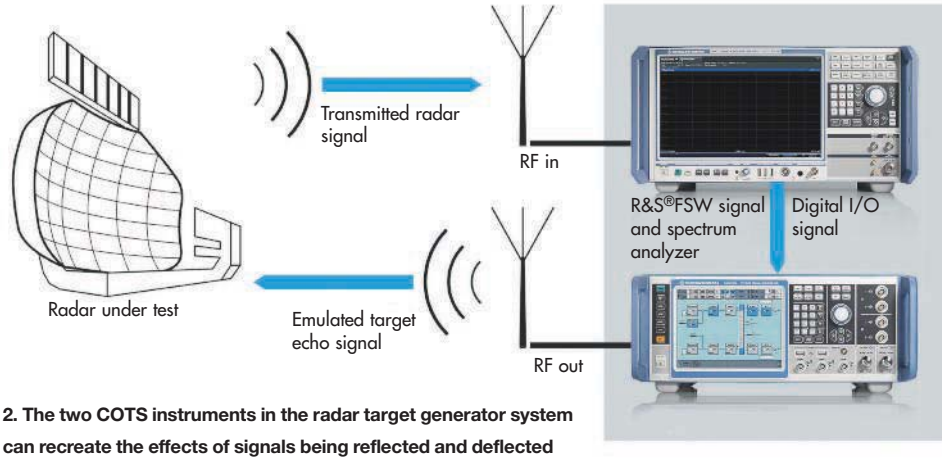


2. The two COTS instruments in the radar target generator system can recreate the effects of signals being reflected and deflected by different objects, essentially creating usable radar test signals.

(continued from p. 1)

For example, spectrum analyzers and vector signal analyzers help evaluate radar transmitters, vector signal generators can be used to check receiver performance, and vector network analyzers are often used to characterize the components used in radar systems. Quality measurement solutions for these radar systems and components can often be found in the form of commercial-off-the-shelf (COTS) test gear.

Radar system operators are often interested in quick measurements and an overview covering the main functions of a radar system: target detection and tracking. Exercising a radar system requires the generation of signals that represent targets or the reflection of signals from targets. These target signals must be produced over the entire unambiguous operating range of the radar system.

The target signals should have adjustable properties, such as different radar cross sections (RCSs), so that a radar under test (RUT) is properly evaluated for acceptable detection and false alarm rates. Another important performance factor is radar accuracy, which must be measured periodically as components age and radar system performance parameters (e.g., signal generation and detection) may fluctuate.

This is especially true of older radar systems that may still employ high-powered traveling-wave-tube (TWT) technologies, where performance levels can degrade with age. Ditto for electromagnetic (EM) components such as yttrium-iron-garnet (YIG) tuned oscillators and filters.

Field testing of radar systems has the potential to be expensive, as it can be difficult to configure repeatable test conditions. As an example, airborne radars might be tested under controlled conditions with nearby flying jets and artificial targets deployed, detected, and tracked by the radar under test. The Global Positioning System (GPS) coordinates of a target can then be compared with the radar test data.

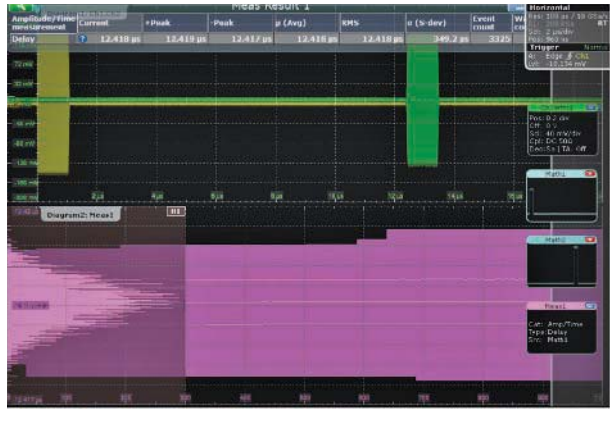
Although such tests can be complex, time-consuming, and expensive, they are necessary to ensure the proper functionality of the radar system and to build confidence in its performance, from the hardware through the detection software algorithms. Fortunately, such testing is possible with COTS test equipment and a radar target generation application from Rohde & Schwarz (www.rohde-schwarz.com).

RADAR TARGET GENERATOR

The radar target generator *(Fig. 1)* captures a transmitted radar signal from the RUT; generates a target range by delaying the received radar signal and introducing a desired radial velocity, owing to Doppler frequency shift; then retransmits the manipulated signal back to the radar. In addition, the generator can set RCS via attenuation of the transmitted signal. The system does not need to know which kind of radar waveform has been transmitted.

The radar target generator essentially acts like a digital radio-frequency memory (DRFM) comprised of COTS test-and-measurement equipment. This allows some of the equipment to function also for its initial purposes, such as a signal analyzer being used for signal analysis and a vector signal generator being used to create test signals for high-frequency component testing. But when the analyzer and generator are used together *(Fig. 2)*, they form a flexible radar target generator capable bring laboratory test quality to the field.

Functioning of the radar target generator system relies on the real-time digital in-phase/quadrature (I/Q) link from the FSW signal and spectrum analyzer and the fading simulator extension offered on the SMW200A vector signal generator. This option for the signal generator was originally aimed at



3. This time-delay measurement was made with an R&S RTO signal processing delay.

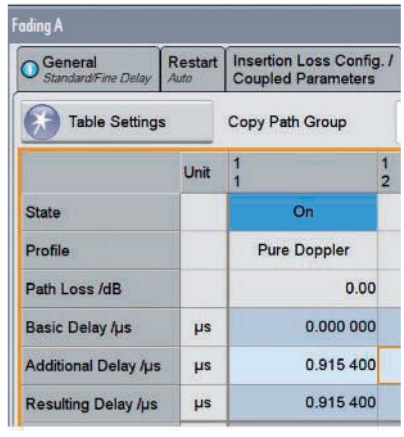
mobile communications testing, but the software offers enough flexibility to manipulate I/Q data within the signal processing chain for use in radar system testing.

The radar target generator system can produce as many as 20 signal fading paths (as many as 40 with a second fading simulator) to mimic as many as 20 targets (40 targets with the second fading simulator) in arbitrary range Doppler cells. The test system provides digital I/Q signal and fading bandwidths to 160 MHz. It can command very high Doppler frequency shifts.

The transmitter carrier frequency can be tuned from 100 kHz to 20 GHz, while the test receiver is locked to the frequency of the RUT. The test system can control maximum time delays to 0.5 s, adjustable in 10-ps steps.

The radar target generator system shown in *Fig. 1* includes an R&S FSW signal and spectrum analyzer and an R&S MW200A vector signal generator. The spectrum analyzer is used for frequency downconversion and digitization of the radar transmit signal. It captures the radar waveform and streams in-phase/quadrature (I/Q) signal components continuously to the signal generator.

An internal block for controlling fading characteristics in the transmission line is used to manipulate the I/Q data prior to upconversion to the desired frequency for retransmission. Each tap in the fader can be individually manipulated to control the delay, attenuation, and Doppler shift of a return echo.



4. The radar target generator system's software features a straightforward user interface for simple adjustment of user parameters.

For accurate radar measurements, the delay through the instruments must be measured. This can be done by using an oscilloscope. By splitting the RF/microwave output power of the R&S SMW200A and the RF/microwave input power fed through the target simulator (the I/Q baseband input port of the R&S FSW), these signals can be combined into the R&S RTO digital oscilloscope. This allows for an original signal and a time-delayed signal to be simultaneously generated and measured immediately *(Fig. 3)*. For this test setup, the measured time delay time 12.418 µs, which results in a minimum target echo of about 1862 m.

With such a radar test system, numerous radar tests can be brought from the field to the laboratory. Basically, an entire radar system can be tested in the laboratory, including the antenna, transmitter, receiver, and all other components. All tests can even be performed automatically using remote commands. It is even possible to test the susceptibility of a RUT to jamming or co-existence tests with other services.

To demonstrate the effectiveness of the radar target generator system, a software-defined-radio (SDR) radar system was constructed using a signal generator and analyzer and signal processing based on MATLAB mathematical software from The MathWorks (www.mathworks.com). Since the radar target generator extends to 20 GHz, the SDR radar system was designed with adjustable carrier frequency range of 100 kHz to 20 GHz and as much as 160-MHz bandwidth.

The coherent processing interval can be arbitrarily configured to match the expected performance of the RUT. In the demonstration system, a frequency-modulated-continuous-wave (FMCW) waveform was implemented with multiple-target resolution capabilities in software. Since this is an SDR-based radar being tested, waveforms can be fully arbitrary.

Using the fixed delay of 12.418 µs previously measured, additional delay of 0.9154 µs results in 2000-m range capability for the experimental SDR radar. Doppler frequency shift of −50 m/s generates −25 m/s radial velocity in the radar, due to the two-way Doppler effects. This echo signal was received by the SDR and processed. The range and radial velocity were drawn in a range-Doppler map and a target list was generated.

To generate a single target for evaluating the performance of the SDR radar, the fading settings path table in the R&S SMW200A vector signal generator was used by selecting the "Pure Doppler" profile and programming the appropriate additional delay (0.9154 µs) and speed (50 m/s). The deviation from the true range and the Doppler frequency-shifted range was very slight. The accuracy of the SDR radar was found to be better than 0.15 m in range and 0.005 m/s in Doppler effect.

Although this example was for a single target, the test gear can be used to generate more complex radar scenarios, including signal environments with jamming and coexistence testing. In addition, a waveform can be arbitrary since the system's waveform parameters are defined by software.

The SDR radar system that was developed to check the radar target generator can be used to demonstrate a variety of tests, including single target generation; radar range and radial velocity resolution verification; radar system resistance to jamming and co-existence testing with other signals, such as those from Long Term Evolution (LTE) and WiMAX systems; testing for minimum detectable signal (MDS); and testing for fixed target suppression (FTS).

In addition, these COTS test instruments can still be used in the field and the laboratory for their initial purposes: signal analysis and signal generation for the purposes of evaluating the performance of RF/microwave components, circuits, devices, subsystems, and systems, including those used for radar systems. de

JACK BROWNE | Technical Contributor

Screening Military Signal Generators

Matching various performance parameters to an application can simplify the task of selecting an RF/microwave signal generator for military and aerospace use.

SIGNAL GENERATORS are among the most versatile of test instruments, owing to their ability to imitate or recreate many of the signals found in modern electronic equipment and systems. Signal generators also come in many forms, to produce continuous-wave (CW) signals, pulsed signals, and analog and digital signals.

In addition, they are available in rack-mount/benchtop forms, as well as in compact battery-powered packages for use in the field. So it should come as little surprise that selecting a signal generator for military-type applications can be a challenging task. Luckily, it is a task that can be made somewhat easier by matching the capabilities of a signal generator with the requirements of a particular application or group of applications.

Perhaps the most essential starting point for selecting a signal generator is frequency range. For many years, signal generators designed for military and aerospace applications assumed that frequency coverage from 2 to 18 GHz was required; additional bandwidth was added at the low- and high-frequency ends to handle applications beyond standard electronic warfare (EW) components and systems.

In addition to frequency range, RF/microwave signal generators can be compared by a list of common specifications that includes output power, spectral purity, frequency stability, frequency tuning resolution, frequency tuning speed, and modulation capabilities.

1. Model MG37020A is a fast-switching signal generator well suited for testing radar and EW components and systems from 10 MHz to 20 GHz. *[Photo courtesy of Anritsu Co., www.anritsu.com).]*

For any RF/microwave test signal source, output power is specified across the frequency range, with an amplitude flatness parameter—such as ±1 dB—that provides details on how much the output power varies with frequency. In most case, the output power will decrease with increasing frequency, although well-designed signal generators can maintain fairly tight amplitude balance even across bandwidths of 40 GHz or more.

For many applications, a signal generator's spectral purity—most notably, its phase noise—may be one of its most important characteristics. Excessive phase noise can degrade a receiving system's sensitivity and hinder its capability to capture low-level and transient signals. Signal generator manufacturers typically provide phase noise referenced to specific offset distances from a carrier, such as 1 Hz or 10 kHz offset from a 1- or 10-GHz carrier signal. In many cases, generator manufacturers will provide full plots from a phase-noise test set to show the signal generator's phase noise at all offsets from a particular carrier frequency.

A signal generator may suffer from other forms of spectral noise, such as harmonic signals and spurious signals, which are typically specified at some decibel level relative to the level of the carrier signal (such as –20 dBc). Harmonic signal levels will decrease with the order of the harmonics, for example, with second-harmonic levels considerably higher than third- or fourth-harmonic levels. As in the case of phase noise, when at excessively high levels, these noise sources can degrade receiver sensitivity and obscure other signals for applications scanning for signals of interest.

Frequency resolution, or the smallest change in frequency that is possible with a signal generator, varies fairly widely across different signal generator models, since fine tuning resolution (e.g., 1 Hz) is not always required for every application. Smaller tuning steps can impact another signal generator parameter: frequency tuning speed. This requirement will be established by an application, with different tuning speed requirements established by applications like radar and EW systems.

Signal generators are also characterized in terms of their amplitude switching speeds, for applications requiring high-speed changes in signal generator output level. High-speed signal sources can generally provide frequency and amplitude switching speeds in the microsecond range.

The number of suppliers for military-grade RF/microwave signal generators is large, and includes Aeroflex (www.aeroflex.com), Anapico (www.anapico.com), Anritsu Co. (www.anritsu.com), Applied Instruments (www.appliedin.com), April Instrument (www.aprilinstrument.com), Berkeley Nucleonics (www.berkeleynucleonics.com), FEI-Elcom Tech (www.elcom-tech.com), Giga-tronics (www.gigatronics.com), Hittite Microwave (www.hittite.com),

2. Model M8195A is an arbitrary waveform generator (AWG) that operates at sampling rates to 65 GSamples/s and is capable of creating a wide range analog output waveforms from DC to 20 GHz. It is representative of the state of the art in AWG signal-generation technology. *[Photo courtesy of Keysight Technologies (www.keysight.com).]*

Keysight Technologies (www.keysight.com), National Instruments (www.ni.com), Noisecom (www.noisecom.com), Phase Matrix (www.phasematrix.com), Rigol Technologies (www.rigol.com), Rohde & Schwarz (www.rohde-schwarz.com), and Tektronix (www.tek.com).

The signal generators offered by these and other suppliers cover a wide range of technologies. These range from traditional sources based on voltage-controlled oscillators (VCOs) that are frequency stabilized by means of a phase-locked loop (PLL) to architectures relying on digital approaches. This latter category encompasses direct-digital synthesizers (DDSs) and signals produced by means of frequency-upconverted outputs from digital-to-analog converters (DACs).

Arbitrary waveform generators are growing in favor due to their flexibility in reproducing the complex signals and their multiple modulation formats found in many military and aerospace applications. Signal generators for military users are available in many shapes and sizes, ranging from traditional 19-in. rack-mount enclosures to more compact, modular VXI and PXI enclosures.

As an example, one signal generator that has gained in popularity for evaluating radar and EW systems because of its stability and switching speed is the model MG37020A from Anritsu Co. *(Fig. 1)*. It covers the broad frequency range from 10 MHz to 20 GHz with typical frequency switching speed of 100 µs to shift from one frequency to another. It is geared for defense applications such as testing radar systems and EW receivers, but also for high-throughput production-line testing and data-intensive applications, such as antenna testing and satellite payload testing.

To meet these requirements, the MG37020A provides pulse modulation (as an option), +23-dBm output power at 20 GHz, and –86 dBc/Hz phase noise offset 10 kHz from a 20-GHz carrier. It can control leveled pulse widths as narrow as 100 ns and unleveled pulse widths as narrow as 10 ns. In terms of programming and interfaces, it provides military users with a wide choice, including IEEE-488, RS-232, Ethernet local area network (LAN), and even Universal Serial Bus (USB) connections.

Signal generators from one of the newest names in test equipment, Keysight Technologies (formerly the test and measurement portion of Agilent Technologies) include instruments based on traditional PLL technologies as well as the latest developments in arbitrary waveform generators (AWGs).

The firm's new model M8195A *(Fig. 2)*, with sampling rates to 65 GSamples/s, provides instantaneous analog bandwidths from DC to 20 GHz, making is as well suited for radar and EW testing as for satellite-communications (satcom), optical communications, and wireless component and system testing. The AWG can be equipped with as much as 16 GSamples of waveform memory and as many as 16 fully synchronous channels in a single, five-slot modular AXIe chassis.

Another high-performance AWG, the

model AWG70000A series from Tektronix, operates at sample rates to50 GSamples/s with 10-b vertical resolution, allowing it to reproduce the most complex waveforms found in modern radar and EW systems at frequencies to 20 GHz. It is available with as much as 16 GSamples waveform memory and is capable of a −80 dBc spurious-free dynamic range.

Of course, some of the better signal-generator solutions for military users come from lesser-known suppliers. As an example, Anapico has successfully combined low phase noise with fast switching speed in its sources. The firm's model APSIN20G signal generator operates from 100 kHz up to 20 GHz with microsecond frequency switching speed and leveled output power from −120 to +13 dBm across the wide frequency range.

The APSIN20G includes numerous modulation formats, including amplitude modulation (AM), frequency modulation (FM), frequency-shift-keying (FSK) modulation, phase-shift-keying (PSK) modulation, and high-speed pulse modulation, and stabilizes signals to an internal 100-MHz oven-controlled crystal oscillator (OCXO) reference. It is available in a single-space rack-mount version and as a portable model with rechargeable battery. It is representative of the signal-generator requirements of the modern military, providing outstanding performance in several different compact and cost-effective package versions.

> "For many applications, a signal generator's spectral purity—most notably, its phase noise—may be one of its most important characteristics."

Also, one of the more compact lines of synthesized signal generators hails from Hittite Microwave Corp. (www.hittite.com), including its model HMC-T2220 with frequency tuning range of 10 MHz to 20 GHz and more than +26 dBm output power at 1 GHz.

The portable signal source features impressive spectral purity, with phase noise of -98 dBc/Hz offset 10 kHz from a 10-GHz carrier and low spurious of −70 dBc at 10 GHz.

The firm offers different frequency ranges with its signal generators, to as high as 70 GHz, all in a portable housing measuring just 12 × 8 × 3 in. (305 × 203 × 76.2 mm) and weighing just 7 lbs. (3.2 kg). de

Digital Board Channels Wide Input Range

MODEL DNX-DIO-449 is a 48-channel, digital input board that can process inputs from 3.3 to 150 V and monitor both AC and DC input signals. It includes built-in analog-to-digital conversion for analog voltage measurements on each input and can provide automatic change-of-state detection with a 200-µs resolution time stamp. It provides internal signal injection for built-in-test (BIT) functions, and can perform self-test and BIT functions without disconnecting field wiring. It supports fully programmable logic high and low levels and hysteresis. The software supplied with the board includes an easy-to-use application programming interface (API) that supports all popular Windows programming languages, as well as drivers for all popular non-Windows operating systems.

UNITED ELECTRONIC INDUSTRIES, INC.

27 Renmar Ave., Walpole, MA 02081; (508) 921-4557, (508) 921-4600, FAX: (508) 668-2350, www.ueidaq.com

GaN Switches Control 0.5 to 6.0 GHz

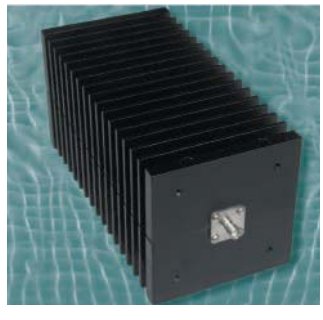
BASED ON gallium-nitride (GaN) semiconductor technology, chip model TGS2354 and packaged model TGS2354-SM switches provides impressive power-handling capabilities from 0.5 to 6.0 GHz. Both switch models can handle +46 dBm (40 W) input power across that frequency range, with better than 50-ns switching speed. Insertion loss is less than 0.8 dB while return loss is better than 15 dB. The switches provide at least 25-dB isolation across the frequency range. The chip model measures 1.40 × 1.58 mm and the surface-mount QFN model switch measures just 4 × 4 mm. The switches are fabricated with the firm's GaN on silicon-carbide (SiC) production process.

TRIQUINT SEMICONDUCTOR

2300 NE Brookwood Pkwy., Hillsboro, OR 97124; (503) 615-9000, www.triquint.com

Fixed Attenuators Handle 100 W Power

HIGH-POWER ATTENUATORS are useful for system and test-and-measurement applications. For use from DC to 3 GHz, the 351-338-XXX line of fixed attenuators from BroadWave Technologies are rated for average RF power-handling capability of 100 W. They are available with attenuation values of 3, 6, and 10 dB with attenuation accuracy of ±0.75 dB; attenuation values of 20 and 30 dB with attenuation accuracy of ±1 dB; and with 40-dB attenuation and attenuation accuracy of ±1.5 dB. The 50-Ω attenuators, which are supplied with SMA female coaxial connectors, exhibit maximum VSWR of 1.20:1 from DC to 1 GHz and 1.40:1 from 1 to 3 GHz.



BROADWAVE TECHNOLOGIES INC.

170 Airport Pkwy., Ste. A, Greenwood, IN 46143; (317) 888-8316, FAX: (317) 888-8593, e-mail: sales@broadwavetech.com, www.broadwavetech.com

Right-Angle Adapters Move Signals to 50 GHz

A FAMILY OF right-angle coaxial adapters from Fairview Microwave has been expanded to serve commercial and military applications through 50 GHz. The adapters allow 90-deg. turns in spaces that might be too small to accommodate bending (and placing strain on) a coaxial cable. The right-angle adapters are available as between-series and in-series configurations—including in 2.4-mm and 1.85-mm coaxial configurations—for frequencies to 50 GHz. Additional configurations include 3.5-mm connectors for use to 34.5 GHz and 2.92-mm connectors for use to 40 GHz. Additional right-angle adapter options include SMA, BNC, TNC, N, 7/16, 10-32, LC, SC, MHV, SHV, QMA, UHF, and mini-UHF connector terminations. Several versions offer a reverse polarity option. The new right-angle adapters are constructed of passivated stainless-steel bodies and coupling nuts with gold-plated BeCu center contacts.

FAIRVIEW MICROWAVE, INC.

17802 Fitch, Irvine, CA 92614; (972) 649-6678, www.fairviewmicrowave.com

Cables Connect Airframe Signals

TO MEET the changing requirements for the aerospace industry, W.L. Gore & Associates has extended its lines of high-speed optical and electrical data cables to support data rates to 10 Gb/s. For example, GORE Ethernet Cables Type Cat 6A support ANSI/TIA-568C.2 specifications to 10 Gb/s. The cables have been tested for reliable performance across runs/distances to 75 m, enabling the aircraft industry to reduce the number of interconnections required for reliable communications in larger aircraft. The Cat 6A cables are constructed with uniquely engineered fluoropolymers that improve durability and simplify routing. In addition, the firm's fiber-optic cables incorporate a dual-buffering system that protects the fiber during installation and service life. The cables are built for

the temperature extremes of aerospace applications and feature a low shrink-back jacket that reduces preassembly temperature cycling. Some of these newer cable products are only being announced and may not be ready for production until spring 2015.

W.L. GORE & ASSOCIATES, INC.

555 Paper Mill Rd., Newark, DE 19711; (888) 914-4673, (410) 506-7787, www.gore.com/aerospace

COTS Modules are Safety-Certifiable Cards

A NEW FAMILY of DO-254 DAL C and DO-178C DAL C safety certifiable commercial-off-the-shelf (COTS) processing modules have been developed by the Defense Solutions division of Curtiss-Wright Corp. for reliable use in civilian and military applications. The modules offer the reduced costs and development risks of COTS electronics to designers of safety-certifiable systems. The first members of the product line are the model VPX3-150 3U VPX single-board computer (SBC) and the model VPX3-718 3U VPX graphics card. The SBC leverages a Freescale P5020 processor running at 1.2 GHz and extensive input/output (I/O) complement to provide advanced processing for embedded military and aerospace applications. It is designed to occupy a 1-in. slot per VITA 65 requirements. Similarly, the graphics module fits within an 0.85-in. slot per VITA 65. It leverages an AMD Radeon E4690 graphics processor unit (GPU) with core clock speed of 300 MHz to deliver dual independent graphics channels with full two-dimensional (2D) and three-dimensional (3D) processing capabilities.

CURTISS-WRIGHT CORP.

13925 Ballantyne Corporate Pl., Ste. 400, Charlotte, NC 28277; (973) 541-3700, FAX: (973) 541-3699, www.curtisswright.com

Synthesizer Tunes from 1990 to 2030 MHz

MODEL PCA2010A-LF is a RoHS-compliant, phase-lock-loop (PLL) frequency synthesizer well suited to satellite-communications (satcom) applications. It tunes from 1990 to 2030 MHz in 1-MHz steps and produces typical output power of +3 dBm into a 50-Ω load. The PLL synthesizer, which can be programmed through a three-wire serial interface, is supplied in a compact housing measuring just 0.50 × 0.50 × 0.13 in. It exhibits phase noise of –100 dBc/Hz offset 10 kHz from the carrier, consuming just 40 mA current when operating from a +5-VDC supply voltage. Spurious levels are only –70 dBc while second harmonics are –15 dBc. The synthesizer, which can also serve microwave radios, can be supplied in tape-and-reel packaging for automated assembly systems.

Z-COMMUNICATIONS, INC.

14118 Stowe Dr., Ste. B, Poway, CA 92064; (858) 621-2700, FAX: (858) 486-1927, www.zcomm.com

Isolators Span 1 to 40 GHz

A LINE OF narrowband and broadband isolators developed by DiTom Microwave covers a total frequency range of 1 to 40 GHz with high isolation and low loss. The components, which are available from distributor East Coast Microwave, include models such as the DMI6018, with 14-dB minimum isolation and 1-dB maximum insertion loss from 6 to 18 GHz, and with 1.50:1 maximum VSWR from –55 to +85°C. Also of note is the model D3I2640, with 14-dB minimum isolation and 1-dB maximum insertion loss from 26.5 to 40.0 GHz, and maximum VSWR of 1.50:1 from –20 to +65°C. For even wider frequency coverage, model D3I1840 is an isolator that operates from 18 to 40 GHz with 9-dB minimum isolation and 2.10-dB maximum insertion loss, and exhibits 2.10:1 maximum VSWR from –20 to +65°C. All of the isolators are supplied with coaxial connectors suitable for their frequency ranges.

EAST COAST MICROWAVE

70 Tower Office Park, Woburn, MA 01801; (800) 786-2576, (781) 279-0900, FAX: (781) 279-9034, www.ecmstockroom.com

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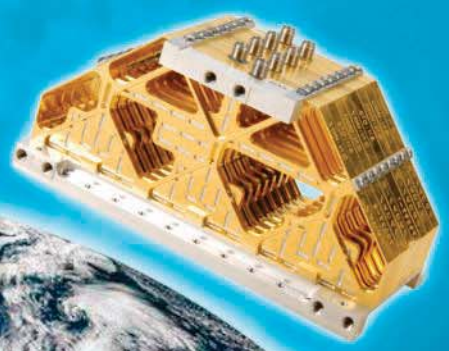

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