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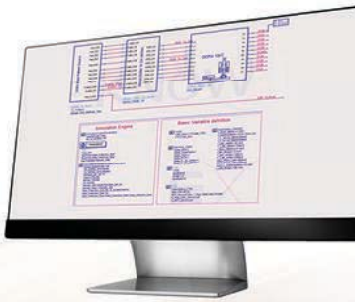

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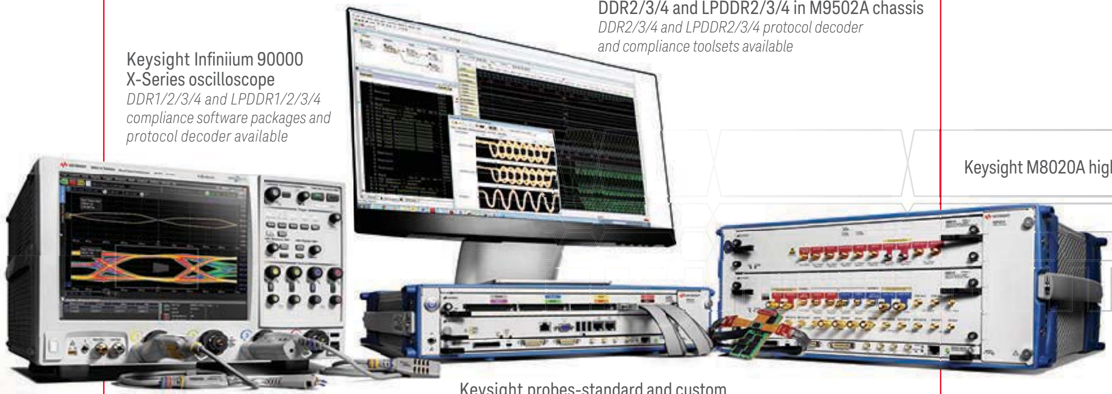

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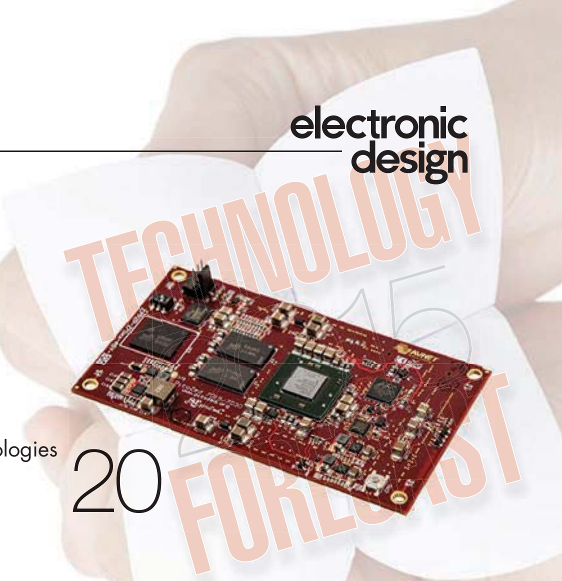

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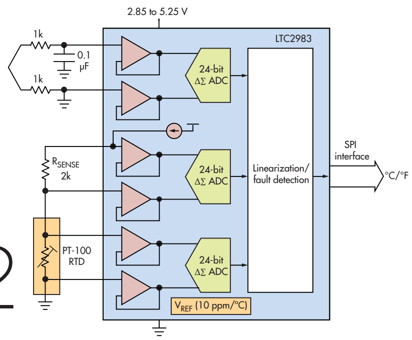

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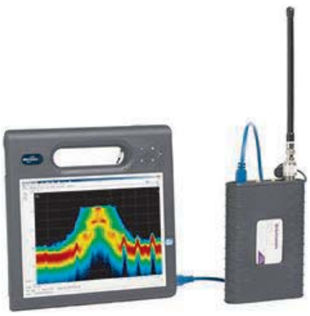

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EDITORIAL MISSION:
To provide the most current, accurate, and in-depth technical coverage of the key emerging technologies that engineers need to design tomorrow's products today.

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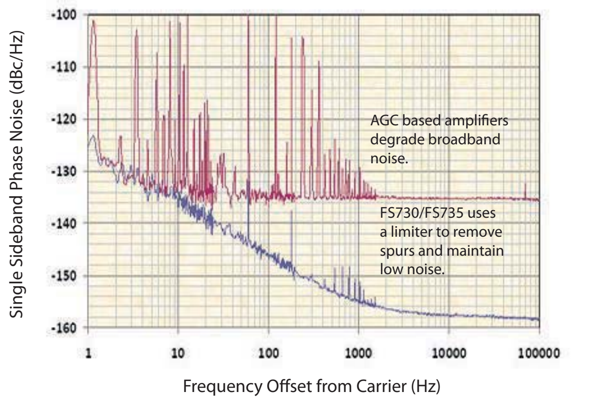

Additive phase noise in 10 MHz Distribution Amplifiers: Limiter vs. AGC Designs

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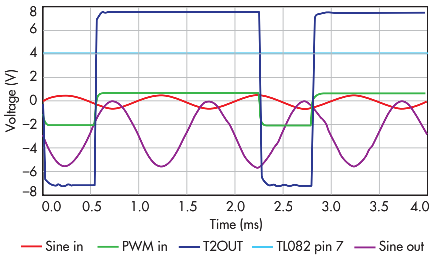

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on electronicdesign.com

DRONES: GOOD NEWS, BAD NEWS

http://electronicdesign.com/blog/drones-good-news-and-bad-news

Like most technological developments, drones have their upside and downsides. Growth of the drone business has been spectacular the past few years and it is now so influential that the government is ready to act to regulate it. Is that a good or bad thing?

VIDEO: COMPUTER-CREATED ART

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Will a robot become the new Rembrandt or Shakespeare? And do we need droids that can paint masterpieces or write heart-melting sonnets?

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A senior applications engineer at ON Semiconductor looks at the typical system architecture of tablets and the types of integrated devices that make it possible to achieve high levels of performance and functionality in very small overall form factors.

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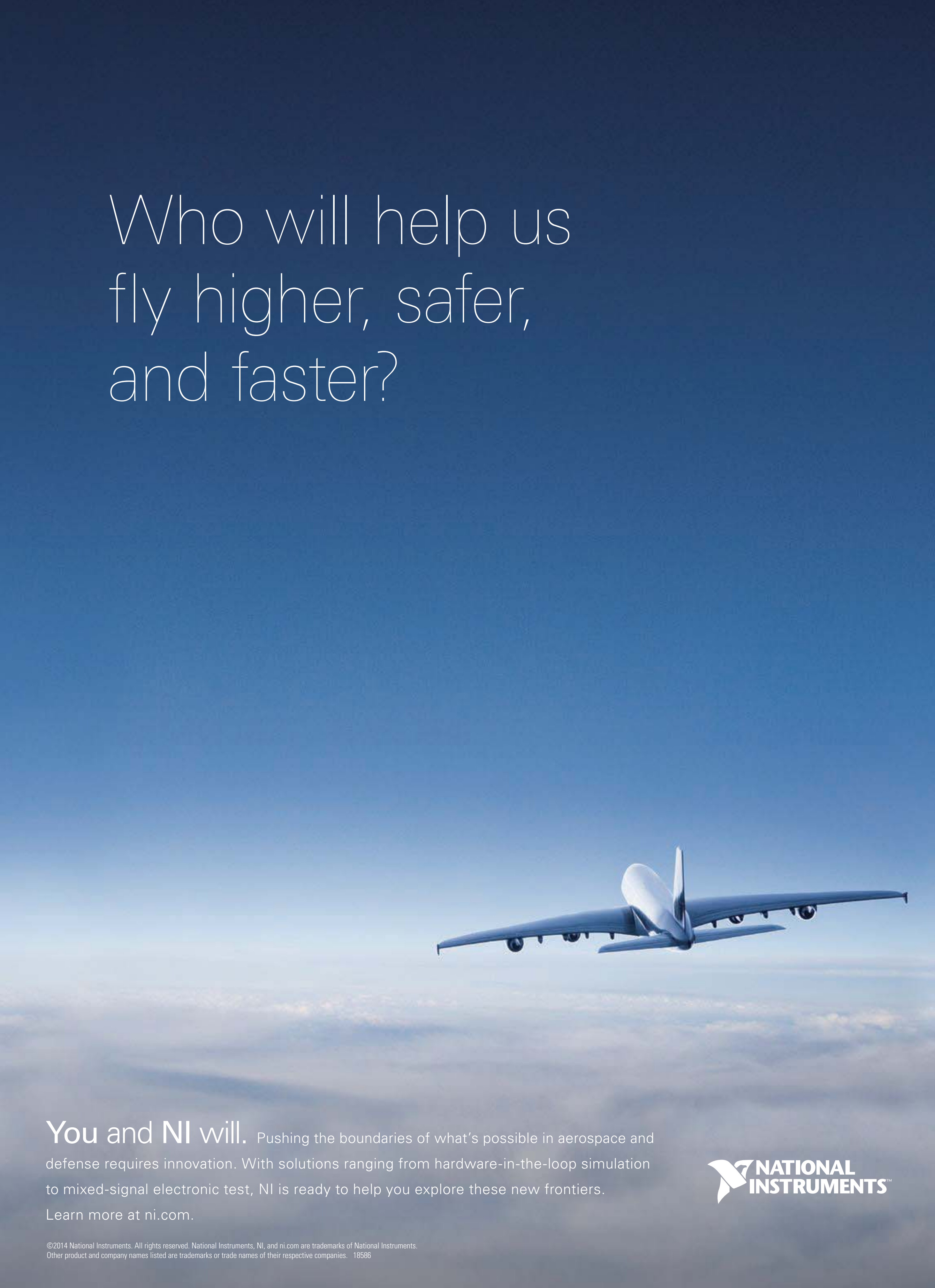

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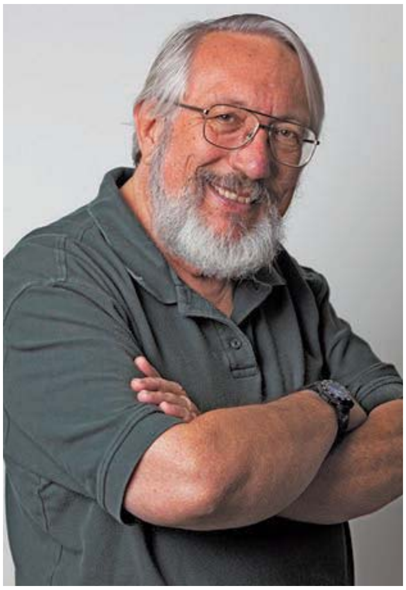

A Look Ahead at Wireless Charging

Just before Thanksgiving, I had the opportunity to attend the fourth annual Wireless Power Summit, a two-day conference held in Oakland, Calif. It was a pretty good mix of "suits" and engineers. The suits got to hear forecasts and updates on how wireless charging is or will be applied, and the engineers attended sessions in which university researchers addressed technical issues. Here are some of my observations:

1. Free charging of smart devices is creeping into consumer services. The free charging lures customers in the door, and the data collected about those customers justifies the free services. Interestingly, at the same time that we were meeting, Starbucks outlets in the Bay Area were publicizing the availability of charging stations built into their table surfaces. There would be no monitoring of the customer's activities, but there is a built-in handshake between chargers and smartphones that does provide a customer's preferences for seating, length of stay, and so forth that will tell the corporation about habits and preferences without breaching privacy.

2. One thing about wearable tech: In general, chargeable wearables present a challenge for coil orientation. Phones have big flat surfaces and users lay them on top of other flat surfaces, so the problem is reduced to two dimensions. Charging somebody's raincoat—one that lights up at night, perhaps—is a lot more challenging.

3. There was some talk about wireless charging of objects in the Internet of Things (IoT), but not much. It was more as if people felt they *had* to say something about the IoT, without actually having anything to say.

4. There was a lot of interest in how wireless charging would be implemented in personal vehicles. I was reminded of a talk I heard last year at Cisco about how cars would become people's personal gateway to the IoT, routing data through the most cost-effective gateways. Obviously, that would only work if driver and passenger phones stayed charged up all the time.

5. Technical challenges are fascinating. Presently, there are two popular approaches, both near-field. The least efficient is simply to create a transformer by bringing two coils into close proximity. A step up from that is to tune the coils to resonance, a la Nikola Tesla. What's still in the university labs involves, among other things, coupling coils between charger and the unit being charged. Essentially, energy is stored in the intermediate tuned circuit. This overcomes some of the problems of an over-large air-gap. ed

News & Analysis

(Image courtesy of Thinkstock)

DUAL-SCREEN VR CHIP
Boosts Bandwidth by 80%

Commercial availability of dual-screen, virtual-reality (VR) head-mounted displays could ramp up significantly with Spectra7 Microsystems' latest chip development. Increasing bandwidth up to 80%, the VR7200 feeds dual ultra-high resolution displays that support resolutions over 500 pixels/in. in deep color at 80 frames/s, and at distances up to 5 m from the source.

Dual-screen VR offers a more immersive, broad field of view. However, it requires about twice the bandwidth of other VR systems and is typically burdened by multiple, thick passive cables. The VR7200 features high-speed, active signal processing and a single super-thin cable/ultra-compact connector combo to combat those issues. VR interconnects built with the chip are capable of dual 2560-by-1440-wide quad high-definition (WQHD) display resolution at 4:4:4 Chroma at up to 80 frames/s per screen. Thanks to Luma or Chroma subsampling, there's no image degradation. A separate, external HMD power connection is not required.

"The recent surge in new VR product announcements underscores the growing need for differentiated products among leading OEMs, and the emergence of Dual Screen VR takes this market to yet another level," said Tony Stelliga, CEO of Spectra7. "Spectra7's VR7200 reduces the current multi-cable requirements of Dual Display VR to a single unified connection with integrated power delivery, delivering a much lighter, more immersive experience for the VR enthusiast."

According to consulting firm KZero, the consumer VR market is expected to reach $5.2 billion by 2018, with an installed base of over 250 million VR-capable game consoles. Dual-screen systems may hold the potential to set an industry benchmark for immersive VR by reducing perceptible latency and delivering enhanced audio fidelity and video resolution. ■

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256-PIXEL LED Shows Promise in Smart Automotive Headlamps

TECHNOLOGICAL ADVANCES in intelligent LED headlamps continue to improve illumination of roads for automobiles while distributing the light to avoid distracting other drivers. In this vein, the team behind a µAFS research project, coordinated by Osram Opto Semiconductors, created a prototype LED chip with an array of 256 pixels. Its development makes serious strides in the mission to formulate technical principles for a new class of energy-efficient LED lamps.

Previous solutions had one pixel correspond to one LED component or chip. In the new prototype, however, one chip contains 256 pixels—all of which can be individually controlled. It was developed with defined light patterns in blue and white, and is thought to be the first step toward the development of light sources with more than 1000 pixels.

Fraunhofer IZM's mounting technology was used to couple the light-emitting pixel chip with the controlling driver chip. Then Osram structured the chip

(Continued at the bottom of next page)

A research team has developed an LED chip with an array of 256 pixels as part of a project to develop more advanced LED headlamps. *(Image courtesy of Osram Opto Semiconductors)*

ALLIANCE EYES IOT with New Industrial-Based Ethernet Standards

ENHANCED SUPPORT for Ethernet standards in the industrial community has prompted the AVnu Alliance to create an industrial market segment. Specifically, standards associated with the evolution of audio video bridging (AVB) into time-sensitive networking (TSN) will be the main focus of the consortium, which welcomes three new members: Belden, General Electric, and National Instruments. Other members include Broadcom, Cisco, Intel, Interval Zero, Marvell, Micrel, Vitesse, Xilinx, and XMOS.

The AVnu Alliance is responsible for guiding the specification for new applications to simplify the design engineer's product-building process. Furthermore, the Alliance will drive interoperability and certification of networked devices to help ensure the deployment of reliable solutions. With the new capabilities defined by the impending standards, high-speed closed-loop control networks could support any Ethernet device using standard IT components.

The standards will help create the necessary foundation for Internet of Things (IoT) integration into industrial production. TSN technology delivers the necessary high-speed data-transfer rates and high-accuracy time synchronization for standard Ethernet communication in industrial applications. The Alliance previously announced support for TSN's use in automotive applications, including drive-by-wire and autonomous driving. ■

(Continued from previous page)
surface and attached the converter to create white light. The resulting prototype demonstrated the feasibility of exhibiting a particularly high resolution, which is necessary for the light pattern to adjust dynamically and with a high degree of precision.

In the next step of the project, Osram will work to transfer the prototype to a light module with electrical, mechanical, and thermal interfaces, focusing on intelligent control and an appropriate connection to the vehicle bus to ensure fine control of the light. Project member Hella will be responsible for optical and thermal-management system development, as well as the design of the complete headlight. Daimler, another member, has already contributed specifications and requirements in regard to the bus connection and optics, and will be responsible for detailed testing of the headlamp in its final stages. ■

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Nonvolatile Storage and 64-bit Arm Cores

Digital technology will take some major steps forward this year with technologies like wearable technology, storage, and cloud computing leading the way.

THIS LOOKS TO BE A GOOD YEAR for digital technology across the board, from memory to compute. Conventional uses from PCs to smartphones continue to push price and performance, but the growing Internet of Things (IoT) trend is being fed by advances in sensors and low power operation.

Wearable technology is one subset of IoT that will see massive growth (*see "What Tech Will You Be Wearing Next Year?" on electronicdesign.com*). It will also place a strain on designers to keep things small, highly functional, and communicating with the rest of the world. Emerging standards like Bluetooth 4.2 provide improved performance as well as delivering direct Internet connectivity.

1. SanDisk UltraDIMM (top/rear, bottom/front) plugs into a standard DDR DIMM socket but it contains flash memory. It can be updated at the row level instead of the block level required for disk storage.

MEETING INSATIABLE STORAGE REQUIREMENTS

If there is one thing developers cannot get enough of, it is storage.

NAND flash steals most of the limelight when it comes to storage. It is available in a mind-boggling array of form factors, capacities, and performance characteristics. The spread includes SLC (single layer cell), MLC (multi-layer cell), and TLC (triple layer cell) that trade off capacity for performance and reliability. In larger systems, various types of flash memory exist in a storage hierarchy (*see "Flash Software Rules in Hierarchical Storage" on electronicdesign.com*).

At the base of the hierarchy is Diablo Technologies' Memory Channel Storage (MCS) architecture, which puts flash right next to the microprocessor in DIMM slots with products like SanDisk's UltraDIMM *(Fig. 1)*. NVMe flash storage on the PCI Express bus is the next level up, with solid-state disks above that.

Flash will also be on the cutting edge of 3D silicon technology with multi-layer 3D NAND chips (*see "Mass Production Underway for 32-Layer 3D V-NAND Flash" on electronicdesign.com*). These address the push for higher densities and performance.

Flash storage alternatives like FRAM and MRAM continue to grow, although they are still addressing niche markets. STT-MRAM (spin-transfer torque) prototypes were shown in 2014, and currently available MRAM has seen growth in demand and capacity (*see "Q&A: Everspin Takes MRAM to the Mainstream" on electronicdesign.com*). Conductive bridging RAM is on the horizon this year, as well (*see "Conductive Bridging RAM" on electronicdesign.com*).

FRAM is starting to replace flash completely in microcontrollers like Texas Instruments' MSP 430 (*see "Low Power Microcontroller Has Up to 128 Kbytes of FRAM" on electronicdesign.com*). The MSP430FR6xx *(Fig. 2)* has 128 Kbytes of FRAM and 2 Kbytes of SRAM.

Embedded MMC (eMMC) flash will continue to deliver in the embedded and mobile space. Capacities will be up as well as throughput. Much of this push is due to things like 4K video capture support found in high-end smartphones.

There is also the bursty nature of these applications, including IoT applications where fast flash storage is needed, but long term storage needs higher capacities. Hybrid flash with chameleon-like properties will bring the speed of SLC with the capacity of MLC and TLC, allowing designers to arbitrarily choose the boundary between the two based on application requirements.

DDR4 is starting to reach full stride. DIMMs are available in a wide array of configurations and it is the interface found on all high-performance processors and motherboards. Intel's Haswell supports DDR4 and the forthcoming Intel Skylake architecture will support DDR3 and DDR4.

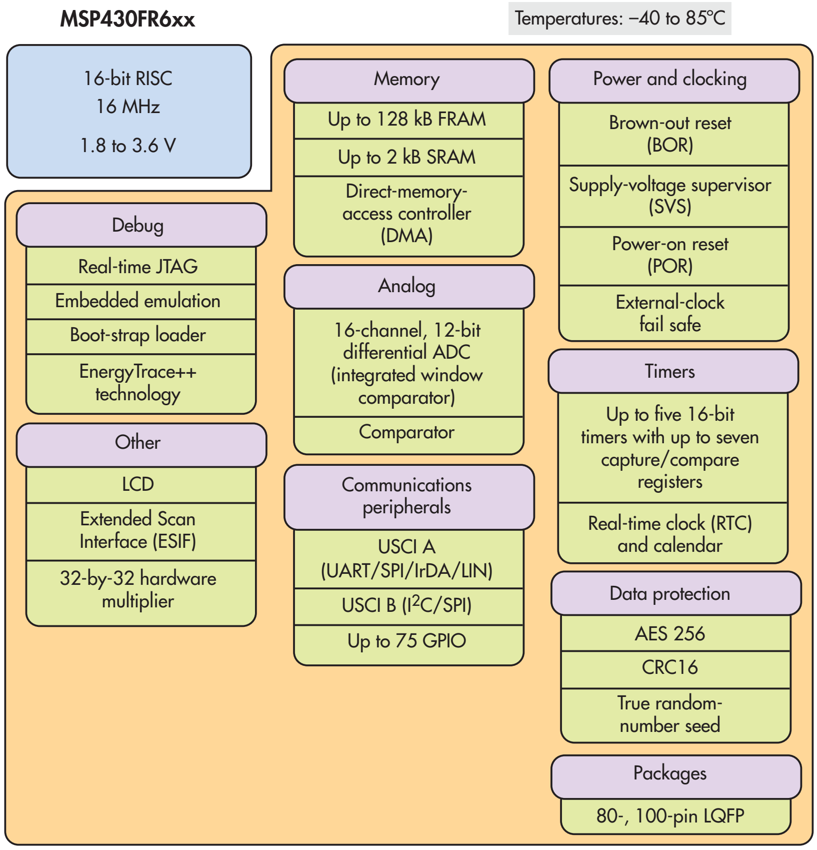
DDR4's premium price is dropping and its advantages over DDR3 are significant. It uses 20% less power and can run at 1.2 V. Performance tops out around 3200 MHz, although 4000 MHz could be available in the future. Enterprise solutions will push the capacity per DIMM as high as possible.

This year we may see new high-performance systems that utilize technologies like the Hybrid Memory Cube (see *Hybrid Memory Cube Shows New Direction for High-Performance Storage on electronicdesign.com*). This is also a 3D silicon technology, but targeting DRAM.

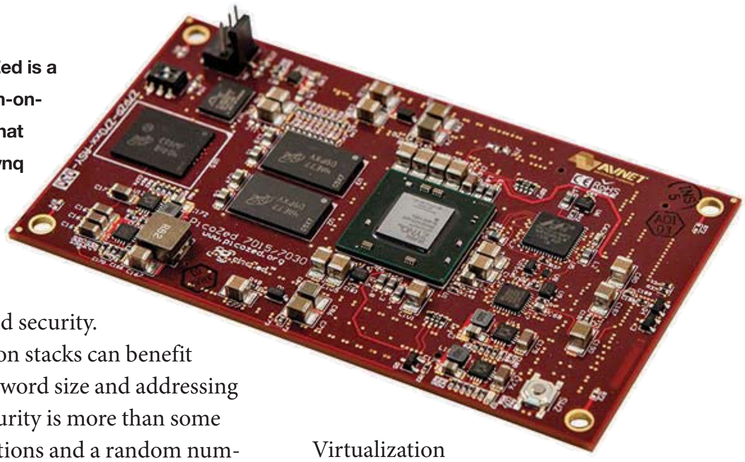
FASTER, USING LESS POWER, AND MORE SECURE

Have no fear: 8- and 16-bit micros have not gone away. They will continue to be challenged by 32-bit solutions, primarily built around the ARM Cortex-M0+ architecture, that continue to push down into the low power space. At this point, vendors with a mix of 8-, 16-, and 32-bit micros have unified their I/O structure and development tools simplifying migration, although most developers tend to stick with one platform.

IoT is one reason for the push to 32 bits, and a lot of that has to do with com-



2. MSP430FR6xx has 128 Kbytes of FRAM and 2 Kbytes of SRAM. SRAM still has a performance edge, but FRAM is used for code and data storage.



3. Avnet's PicoZed is a compact system-on-module (SOM) that holds a Xilinx Zynq FPGA with dual Cortex-A9 cores.

munication and security. Communication stacks can benefit from the wide word size and addressing capability. Security is more than some crypto instructions and a random number generator (RNG). These are necessary, but features like secure boot and storage tend to be part of the mix these days. The challenge for developers is that homes and sites may have hundreds of IoT devices, thereby greatly increasing the attack surface. Making these devices more secure helps mitigate the threat.

Intel's Broadwell-K and Skylake platforms are due in mid-2015. Skylake is the "tock" in Intel's tick-tock release cycle that refines the Broadwell architecture with improved performance and reduced power requirements. Intel has announced its synthesizble Atom core that should be seeing more traction in 2015 with partners like Rockchip. Mobile solutions will begin the transition from 22-nm to 14-nm.

ARM partners continue to challenge Intel across the board from the 64-bit ARMv8 Cortex-A50 series, which will finally see major shipments this year through the mid- and low-end space where ARM has been dominant. The announcement of the Cortex-M7 (*see "Cortex-M7 Takes Aim at the IoT High Ground" on electronicdesign.com*) in 2014 pushes the microcontroller solution into the Cortex-A space in terms of performance, challenging many proprietary digital signal controller (DSC) architectures.

Cortex-A53 and Cortex-A57 will be showing up in everything from high-end smartphones and tablets to cloud and communication servers. Cavium's ThunderX family now packs 48 ARMv8 cores into a single CN88xx chip.

Virtualization will continue to make inroads in deeply embedded. It provides a way to integrate legacy systems onto a single platform as well as providing isolation for functionality and security reasons. Virtualization already dominates in the cloud and the enterprise, where network function virtualization (NFV) is bringing networking closer to the applications.

FPGAs AND HIGH-PERFORMANCE CHALLENGES

Hard or soft cores in an FPGA are the norm these days. Soft cores are even suitable for many of the low-power, flash-based FPGAs that provide the flexibility of an FPGA with the functionality of a microcontroller, with fewer product lifetime issues.

Modules like Avnet's PicoZed *(Fig. 3)* system-on-module (SOM) and Digilent's Zybo (see *"Hard-Core FGPA Provides A Flexible Development Target" on electronicdesign.com*) are providing compact delivery and development support for Xilinx's Zynq-7000 FPGA, with dual Cortex-A9 cores capable of running operating systems like Linux. Hard-core processors allow more flexible communication support for an FPGA solution. Altera's 14-nm Stratix 10 can include a four-pack of ARM Cortex-A53 cores.

Translating OpenCL design to FPGAs moves from the lab to the mainstream. Altera and Xilinx provide OpenCL support as alternatives to their conventional FPGA design tools. FPGAs can also be incorporated into a server using Intel's

> NAND flash steals most of the limelight when it comes to storage. It is available in a mind-boggling array of form factors, capacities, and performance characteristics."

QuickPath Interconnect (QPI), but this is only one approach available to users looking for higher performance.

GPGPUs are commonly found in supercomputers and racks where high-performance computing is needed. This year adds more power-efficient cores to the mix. Intel Knights Landing Xeon's Phi continue the use of lots and lots of x86 cores designed to work with Intel's Silicon Photonics optical interconnect.

Keep an eye out for some of the new compute platforms from massively parallel CPUs to Micron's Automata Processor (*see "Making a New Type of Parallel Processing Possible" on electronicdesign.com*). Parallel processing is cropping up in in unexpected places.

FPGA prototyping will be key to shortening ASIC development times as EDA vendors deliver improved verification productivity and early software bring-up. All levels of simulation continue to be very important as the cost of generating silicon rises. The challenge will be the transition between these levels.

Increasing functional consolidation into a single SoC is pushing ultra-large designs. Mary Ann White, director of product marketing, Galaxy Design Platform for Synopsys, notes, "While 16- and 14-nm FinFET technologies become a reality by moving into production for high-performance applications, the popularity of the 28-nm node will persevere, especially for mobile and IoT (Internet of Things) devices." A significant number of designs are approaching 1 billion transistors.

CONNECTIVITY FOR IoT

Wired and wireless connectivity is the hallmark of IoT devices. Devices will have one or more connections such as the latest Bluetooth 4.2 or USB 3.

Bluetooth 4.2 will be the target for integrated designs. It provides faster throughput, IPv6 support, and improved privacy. For example, a smartphone implementation could allow selective connections to local beacons based on user preferences.

USB 3 adoption will be helped by the new Type-C connector (*see "USB 3.1 Type C Connector Is Reversible" on electronicdesign.com*). The reversible design is akin to the style used with Apple products like the iPhone.

Adoption of USB's advanced power management is on the rise. USB has long since stepped past the 2.5 W for the USB 2.0 standard. USB 3 systems can deliver up to 100 W at 20 V.

PCI Express (PCIe) Gen 3 remains the primary high-speed interconnect. An x16 configuration can support 40 Gbit/s Ethernet, but 100 Gbit/s Ethernet is on the map along with software defined networking (SDN). SDN switch chips like Cavium's XPliant and Broadcom's StrataXGS Tomahawk Series (*see "Chips Make Software Defined Networking Work" on electronicdesign.com*) were announced in 2014. They will provide a flexible platform for 100 Gbit/s Ethernet as well as various combinations of lower-speed Ethernet incarnations.

Gigabit Ethernet is common now, but 2.5 Gbit/s Ethernet and even 5 Gbit/s Ethernet may be on the horizon for device connections. These speeds also lead to higher-end links like 25 Gbit/s Ethernet.

Many of the new multicore chips are designed for the 40 Gbit/s and 100 Gbit/s Ethernet space. They are designed to support NFV with connections to SDN switches to create a software configurable environment. This approach is turning from theory into the norm in 2015. ed

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The Impact of Embedded... in Everything

Embedded designs make their presence felt across all technology sectors, from wearable computing to cloud clusters.

THE EMBEDDED COMPUTING REALM continues to expand even as embedded devices shrink. At one end of the spectrum are the "stylish" devices, where wearable computing meets fashion *(Fig. 1)*. At the other end is the cloud, where massive clusters utilize as much power, performance, storage, and communication bandwidth as can be delivered by designers.

WEARABLE COMPUTING

Depending on who you talk to, the current crop of wearable-computing products *(see "Wearing Your Technology" on electronicdesign.com)* garner responses ranging from "the greatest thing" to "clumsy renditions of real fashion." In any case, the trend is clear and designers are doing their best to meet demand by reducing size and power requirements while increasing functionality. It's not an easy task, though.

Improvements in sensors and sensor fusion technology will make a big difference. The drive for sensor enhancements is being fed by a number of sources, including smartphones and tablets. There's also a move to asymmetric multicore mobile solutions to optimize power utilization *(see "Hierarchical Processors Target Wearable Tech" on electronicdesign.com)*.

Wireless communications is almost always a requirement. The new Bluetooth 4.2 standard provides a range of new features, including more robust location support and selective beacon connections. The latter, for instance, could let a smartwatch receive advertisements from a nearby local establishment that's preferred by the wearer while ignoring others.

Wearable is also headed into the wireless-charging arena. USB connectors are getting smaller, but they detract from the system design and collect dust. Wireless charging eliminates the connector and provides a more convenient solution.

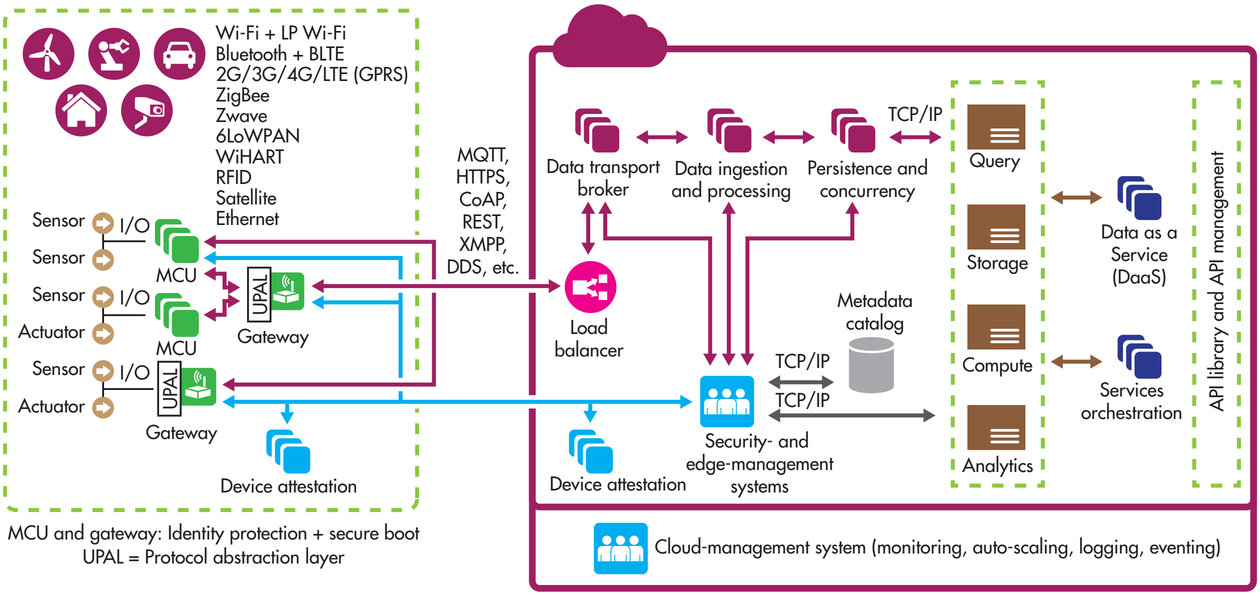
However, wearable technology represents just the tip of the iceberg when it comes to the Internet of Things (IoT). IoT is designed to simplify information exchange, but the underlying infrastructure is very complex *(Fig. 2)*. IoT support can be a challenge, because most solutions tend to be from one or a pair of solution providers. The Open Interconnect Consortium will be worth watching on this front. It's working on an open connectivity framework that will include IP protection with certification and branding.

Security is one key aspect of IoT receiving more action these days, especially given the rash of security breaches in other areas. The large number of future IoT devices opens up to an ever-expanding area of attack. Tools like firewalls help, but application developers will need to consider—if they haven't already—security as a natural part of application design and implementation.

SMALL SCALE

Stackables like PC/104 still have a role to play in embedded applications. They remain a solid solution


1. Intel's MICA (My Intelligent Communications Accessory) bracelet (left) provides a stylish platform for messaging while Motorola's Moto 360 (right) hides its functionality behind a clock face.



2. The Internet of Things (IoT) is designed to simplify information exchange, but the underlying infrastructure is very complex. *(Courtesy of Intel)*

because of the plethora of products available and the ability to combine them easily. The PCI Express variants now offer a better complement of peripherals, and some applications are pushing the bus bandwidth into this space.

Another issue that's become more acute is the lack of ISA support in processor chips. It's easy to design an ISA peripheral, but PCI Express (PCIe) bridge chips add more complexity to the motherboard.

One alternative is computer-on-modules (COMs); expect more options this year. Still, the challenge remains the variety of incompatible options available. A number of COM standards, such as PICMG's COM Express standard, have made adoption easier and provided developers with a growth path.

SMARC (Smart Mobility ARChitecture) from the Standardization Group For Embedded Technologies (SGeT) is one of the latest on the scene. There are full-size SMARC systems like ADLINK's LEC-iMX6 *(Fig. 3)* and half-size systems like Kontron's SMARC-sXQU *(Fig. 4)*. The SMARC-sXQU, based on Intel's Quark X1000 series, has 1 GB of DDR3 DRAM. With a power envelope under 6 W, SMARC can target small-form-factor applications. In addition to SMARC, SGeT hosts the Qseven module standard.

In general, x86 platforms have dominated C/104 and COM Express, while ARM processors dominate the compact COM space. Two emerging processor platforms to watch in this sector are Intel's Quark and ARM-based Cortex-A50 processors.

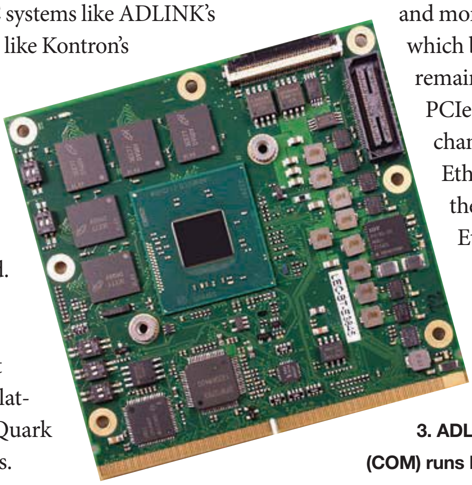
MEDIUM SCALE

Mid-range, board-level system designs include standards such as VME, VPX, CompactPCI, CompactPCI Serial, SHB Express, AdvancedTCA, and MicroTCA. ISA has effectively disappeared from this space due to new designs utilizing high-speed serial interfaces like PCIe, and Ethernet becoming dominant. Still, parallel bus architectures like VME and CompactPCI have a long-term installed base in medical, military, and avionic applications, and they continue to undergo improvements in processor and peripheral support.

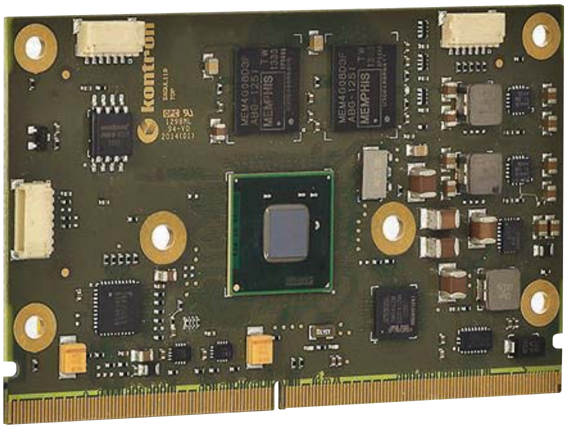
Of course, speed is a significant requirement for many applications, and 10 Gigabit Ethernet and PCIe Gen 3 are commonplace. For VPX, as well as InfiniBand and Serial RapidIO, 40 Gigabit Ethernet is the goal for 2015.

Most of the action remains in new processors, better storage, and more features. Interface standards like PCIe, which boards and backplanes are based on, will remain relatively stable for a while. Watch for PCIe Gen 4 looming on the horizon. The biggest change will likely be a move toward 2.5 Gigabit Ethernet from 1 Gigabit Ethernet, along with the matching migration of higher-speed Ethernet based on these.

In some markets, such as communications, the move toward software-defined networking (SDN) and network function virtualization (NFV) will cause some



3. ADLINK's full-size SMARC computer-on-module (COM) runs Freescale's i.MX6 system-on-chip.



4. Kontron's half-size SMARC module runs Intel's Quark X1000 system-on-chip.

shifts in the sand. SDN will have the biggest impact in terms of hardware design, because it utilizes switch hardware that differs from conventional network switches. The result is a more flexible, upgradable system. On the other hand, NFV is essentially a virtual-machine (VM) server; therefore, existing hardware can address this software framework. Though SDN and NFV are often discussed at the same time, they're distinct technologies that can be implemented independently of each other.

SDN and NFV are already major factors in the enterprise, but they will be found in the embedded arena, too. Both will have more influence on large-scale systems, even though they're moving out from the enterprise toward the end nodes.

LARGE SCALE

Racks of 1U servers will continue to support many applications. However, large-scale systems that provide public and private cloud services are looking to split compute, communication, and storage into large collections to be allocated as needed. In this case, compute platforms have minimal communication and storage hardware. It requires a high-speed communication infrastructure that lends itself to large-scale environments and does not usually scale down satisfactorily.

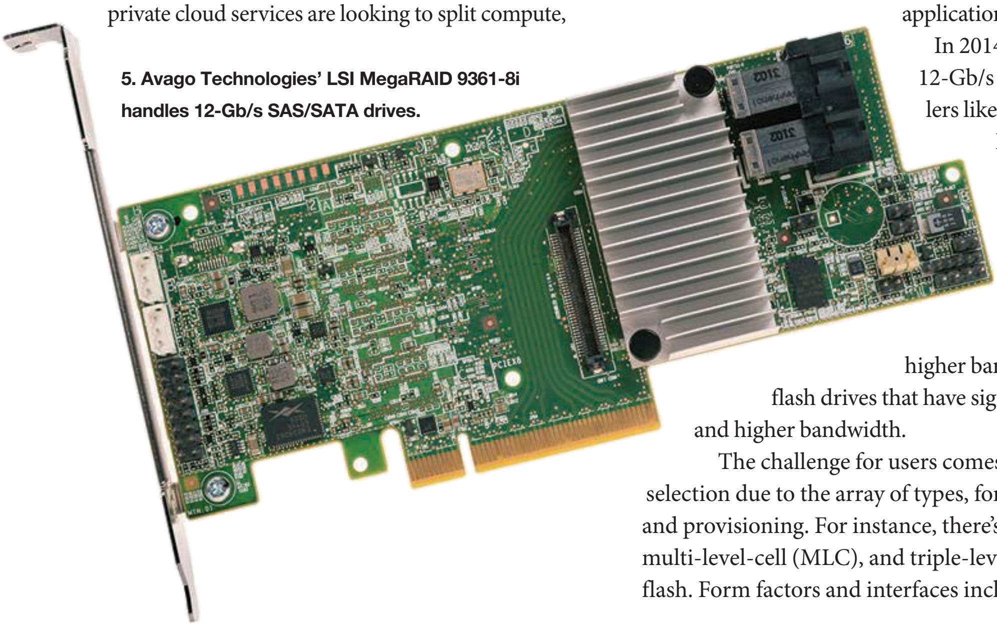
This rack-scale-architecture (RSA) disaggregation approach differs from many blade-style systems that provide a hot-swappable version of 1U servers. These typically incorporate compute, communication, and storage on the same motherboard or blade with a fabric like Ethernet connected via a top-of-rack (ToR) switch.

The major component of RSA is the system interconnect. Fiber appears to be the holy grail for this approach. The latest fiber technology, silicon photonics, provides low-latency, high-speed communication. It also supports transfers over longer distances than copper.

In the end, RSA addresses efficiency using very large resource clusters. It will be useful for companies with large clouds like Amazon and Facebook, and may prove effective in smaller-scale environments down the road.

FLASH-STORAGE IMPROVEMENTS

Regardless of the scale, storage remains a critical factor in embedded-system design. Flash storage continues to influence changes in non-volatile storage, both in its usage and how it's viewed. Rotating magnetic media remains a critical element within many applications, but the storage hierarchy typically has a flash-memory component in the mix. Even hybrid hard-disk drives combine magnetic and flash storage in the same package *(see "Seagate Delivers 2nd Generation Hybrid Hard Drive" on electronicdesign.com)*. Though these typically target laptop and tablet applications, they're applicable to a variety of embedded applications as well.



5. Avago Technologies' LSI MegaRAID 9361-8i handles 12-Gb/s SAS/SATA drives.

In 2014, we saw the release of 12-Gb/s SAS drives and controllers like Avago Technologies' LSI MegaRAID 9361-8i *(Fig. 5)*. They can handle hard-disk storage such as Seagate's 2.5-in., 15K, STM600MX series of 12-Gb/s enterprise drives. Of course, the higher bandwidth will also benefit flash drives that have significantly lower latency and higher bandwidth.

The challenge for users comes down to flash-drive selection due to the array of types, form factors, functionality, and provisioning. For instance, there's single-level-cell (SLC), multi-level-cell (MLC), and triple-level-cell (TLC) NAND flash. Form factors and interfaces include drives like the 2.5-in

Micron M500DC *(Fig. 6)*, which has a SATA interface. The 20-nm MLC enterprise drive with a five-year lifetime can handle three full writes per day *(see "Enterprise SSD Targets Big Data Applications" on electronicdesign.com)*.

NVM (non-volatile memory) Express (NVMe) is another flash interface that's rising in popularity. Based on PCI Express and available in board or disk form factors, it brings flash closer to the processor. Furthermore, it eliminates the need for a SAS/SATA interface.

Diablo Technologies' Memory Storage Channel (MSC) technology moves flash even closer to the processor *(see "Memory Channel Storage Puts SSD Next to CPU" on electronicdesign.com)*. Systems can mix MSC flash and DRAM DIMMs, eliminating even PCI Express interface overhead.

The hardware is finally in place to allow some interesting non-volatile memory storage hierarchies for enterprise environments such as SanDisk's non-volatile memory file system (NVMFS). NVMFS allows low-level atomic writes that can provide a significant performance boost to database applications, since the applications needn't implement a double-buffer scheme *(see "Flash Software Rules in Hierarchical Storage" on electronicdesign.com)*.

6. Micron's M500DC SATA, NAND flash drive targets enterprise applications that need up to three drive rewrites per day.

NEW C++

Developers will be able to take advantage of new services like NVMFS using the latest C++ standard, C++14 *(see "C++14 Adds Embedded Features" in electronicdesign.com)*. The new auto keyword can simplify applications—the compiler is able to determine the data type of a variable rather than the developer having to explicitly specify the type. It's particularly handy for lambdas that were introduced in C++11.

Of course, it may be things like readable literals that will endear C++14 to embedded developers, such as this example:

```
auto mac_address = 0x01'23'45'ab;
```

Sometimes it's the little things that make all the difference. ed

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New Regs for Energy Efficiency
Challenge EPS Makers

Remember the fuss in 2006 when the California Energy Commission imposed a half-Watt Standby Requirement on 'wall-warts'? This time around, power supply makers are ready for and eager to comply with new international standards.

GOVERNMENT DIRECTIVES FOR OPERATIONAL and standby efficiency in external power supplies have represented design challenges to power supply companies since the early 1990s, when U.S. Department of Energy Energy Star standards were released under the Energy Independence and Security Act (EISA). There was a major flap in 2006, when the California Energy Commission (CEC) introduced a half-Watt standard for standby efficiency in the common "wall-wart" ac-dc supplies used to power or charge most home electronics.

According to Gary Bocock, director of engineering, XP Power, today's new regulations come via Energy Star and the CEC in the U.S, the Energy-related EU Code of Conduct (CoC) in Europe, Natural Resources Canada (NRCan), and the Minimum Energy Performance Standard (MEPS) standards in Australia, among others.

For the time being, the limits set in these standards are voluntary, but are more stringent than those required by legislation. Still, it is inevitable that the mandatory requirements will also become more stringent in the future as newer standards are adopted.

TABLE 1: ENERGY START (FEB. 10, 2016)

No load power limits	
Rated power	**No load consumption**
0 W to ≤1 W	≤0.1 W
>1 W to ≤49 W	≤0.1 W
>49 W to ≤250 W	≤0.21 W
>250 W	≤0.5 W
Active mode efficiency, O/P < 6V	
Rated power	**Average efficiency**
0 W to ≤1 W	≥0.517 × Pout + 0.087
>1 W to ≤49 W	≥0.0834 × Ln (Pout) – 0.0014 × Pout + 0.609
>49 W to ≤250 W	≥0.87
>250 W	≥0.875
Active mode efficiency, O/P ≥ 6V	
Rated power	**Average efficiency**
0W to ≤1 W	≥0.5 × Pout + 0.16
>1 W to ≤49 W	≥[0.071 × Ln (Pout) – 0.0014 × Pout] + 0.67
>49 W to ≤250 W	≥0.88
>250 W	≥0.875

TABLE 2: EU CODE OF CONDUCT (JAN. 1, 2014 AND JAN. 1, 2016)

No load power limits		
Rated power	**No load consumption**	
	Tier 1 (1st Jan 2014)	**Tier 2 (1st Jan 2016)**
0 W to ≤1 W	≤0.15 W	≤0.075 W
>1 W to ≤49 W	≤0.15 W	≤0.075 W
>49 W to ≤250 W	≤0.25 W	≤0.15 W
Active mode efficiency, O/P < 6V		
Rated power	**Average efficiency**	
	Tier 1 (1st Jan 2014)	**Tier 2 (1st Jan 2016)**
0 W to ≤1 W	≥0.51 × Pout + 0.085	≥0.517 × Pout + 0.087
>1 W to ≤49 W	≥[0.0755 × Ln (Pout)] + 0.585	≥0.0834 × Ln (Pout) – 0.0014 × Pout + 0.609
>49 W to ≤250 W	≥0.88	≥0.88
Active mode efficiency, O/P ≥ 6V		
Rated power	**Average efficiency**	
	Tier 1 (1st Jan 2014)	**Tier 2 (1st Jan 2016)**
0 W to ≤1 W	≥0.5 × Pout + 0.145	≥0.5 × Pout + 0.16
>1 W to ≤49 W	≥ [0.0626 × Ln (Pout)] + 0.645	≥ [0.07 × Ln (Pout) 0.0014 × Pout] + 0.67
>49 W to ≤250 W	≥0.89	≥0.89

What's happening now is that both Energy Star and the EU CoC have set new, more demanding standards for both energy efficiency and no load power consumption. For example, the EU CoC has introduced a new two-tier load efficiency requirement expressly for applications that spend most of their time using minimal power from the external power supply (such as those with an internal battery) and has two tiers to drive future development.

It was only last year that Energy Star level VI and the EU CoC tier-2 requirements were both introduced, with their voluntary (for now) requirements coming into force in 2016. (See the tables for details and implementation dates.) Note that Energy Star limits now apply to external power supplies with output capabilities up to and beyond 250 W.

The power market is fast moving; customers are keen to design in products that perform to the latest standards and are future-proofed. The first energy efficiency level VI parts are already available, and 2015 will see a significant increase in products released to market offering conformance to the very latest energy efficiency requirements. For example, with its VER & VEL series of 5W wall plug adaptors, XP Power is believed to be one of the first plug top power supplies to comply with the new Energy Star level VI energy efficiency standard. There are two versions: one with a fixed input plug (as required for use in the U.S., UK, Mainland Europe, or Australia), and another with four interchangeable main plugs for the rest of the world.

To get an idea of how the new requirements scale across the spectrum from point-of-load regulators through large internal and external supplies, I spoke with Bocock, Dr. Fariborz Musavi (director of engineering at CUI Inc.), and Patrick Le Fèvre (marketing and communication director at Ericsson Power Modules), asking essentially the same questions of each.

Tuite: As end products shrink in size but the demand for power goes up, what are the challenges power designers are facing in order to achieve increased conversion efficiencies?

Musavi: As the power goes up, several challenges are introduced to power designers. The converters must be designed with not only significantly increased output current and higher efficiency, but also faster transient response, lower output voltage, and tighter output voltage regulation. In addition to these complexities, heat management and board real estate are extremely challenging. To meet these stringent requirements, the power designers must come up with several solutions in order to be able to address them all. This could be a mix of new power topologies, more efficient packaging, advanced control schemes, and improved semiconductor technologies for converting high power efficiently.

Le Fèvre: Over many years, efficiency has largely been related to improvements in switching components and innovative topologies that reduce switching losses. Also, increasing performance of magnetic components has made it possible to store more energy with smaller ferrites. But further major improvements are becoming increasingly challenging. As most regulated dc-dc converters are in the 96% efficiency range, getting closer to the mythical 100% will require improvements in components and better energy management within the switching unit. For example, advanced digital control can optimize energy transferred on a single pulse enabling the flattening of energy performance to an optimum level for either a low or high load.

Bocock: Achieving higher efficiencies is all about the cost, both in terms of the final product cost and the cost to develop a higher-efficiency power supply. Naturally there is a perceived market price for any product, too. We know we could make even more efficient products but even an extra 1% of efficiency could add up to significantly more cost. For example, the humble bridge rectifier is a high-volume, low-cost commodity product. An even more efficient rectification could be achieved with two MOSFETs, an inductor, and a control circuit, but those components could cost up to 10 times that of the bridge rectifier.

TABLE 3: EU CODE OF CONDUCT (JAN. 1, 2014 AND JAN. 1, 2016)

10% Efficiency Requirement, O/P < 6V		
Rated power	10% Efficiency Requirement	
	Tier 1 (Jan. 1, 2014)	Tier 2 (Jan. 1, 2016)
0 W to ≤1 W	≥0.5 × Pout	≥0.517 × Pout
>1 W to ≤49 W	≥[0.0755 × Ln (Pout)] + 0.485	≥0.0834 × Ln (Pout) – 0.0014 × Pout + 0.509
49 W to ≤250 W	≥0.78	≥0.78
10% Efficiency Requirement, O/P ≥ 6 V		
Rated power	10% Efficiency Requirement	
	Tier 1 (1st Jan 2014)	Tier 2 (1st Jan 2016)
0 W to ≤1 W	≥0.5 × Pout + 0.045	≥0.517 × Pout + 0.006
>1 W to ≤49 W	≥[0.0626 × Ln (Pout)] + 0.0545	≥[0.071 × Ln (Pout) – 0.0014 × Pou] + 0.57
>49 W to ≤250 W	≥0.79	≥0.79

Tuite: Is there increasing demand in the market for a more efficient dc-dc conversion process, or is it the same as for ac-dc? What are you experiencing from your customers?

Bocock: Customers will always want more power from a given space. This is especially true for dc-dc converters, which are usually board-mounted. In the main, regarding increasing efficiency, customers have the same needs whether for dc-dc or ac-dc, and regardless of application or market sector. More power from a given space is good. It allows designers to make their end products smaller or to incorporate more functionality in the same footprint.

Musavi: We absolutely see an increasing demand for more efficient dc-dc conversion processes. It is not only to address the increasing cost of energy and meet all of the new energy efficiency standards, but to condition power at higher power rates and smaller sizes; power designers must design their converters more efficiently to be able to package them in such a small real estate.

Le Fèvre: The cost of energy has a direct impact on OPEX, sustainability, and carbon footprint, so the reduction of power consumption is important. Ericsson primarily designs board-mounted products and reducing losses and improving power conversion has driven the portfolio to anticipate customer demands. However, the power conversion ratio has reached a point that now requires new ways of converting power.

Tuite: What power range (low, mid, high-end, etc.) is most in the spotlight for improving power efficiency?

Le Fèvre: The entire power range to an extent, but with bricks now reaching 1kW power levels, clearly this is the area that requires the most attention to avoid a power module becoming a toaster. High-performance computing equipment and routers are integrating

TABLE 4: ENERGY STAR (NOV. 1, 2008) & ERP (APRIL 2011)

No load power limits	
Rated power	**No load consumption**
0 W to <50 W (≤51 W)	0.3 W
≥50 W to 250 W (>51 W)	0.5 W
Active mode efficiency, O/P < 6V	
Rated power	**Average efficiency**
0 W to 1 W	≥0.497 × rated power + 0.067
>1 W to ≤49 W (≤51 W)	≥ [0.0750 × Ln (Rated power] + 0.561
>49 W (>51 W)	≥0.86
Active mode efficiency, O/P ≥ 6V	
Rated power	**Average efficiency**
0 W to 1 W	≥0.48 × rated power + 0.14
>1 W to ≤49 W (≤51 W)	≥ [0.0750 × Ln (Rated power] + 0.622
>49 W (>51 W)	≥0.87

Figures in () are for ErP limits

In addition, Energy Stat power supplies with an input power of 100 W and above must have minimum power factor of 0.9 at 115 VAC 60 Hz.

more strategic processors and some boards will reach 3kW levels, which will mean the use of efficient intermediate bus converters and as potentially as many as 80 point-of-load (PoL) regulators. For boards populated with high-power PoL bricks ranging from 3 to 240 A, all of these components will need to be highly energy efficient.

Musavi: Certainly, low efficiency conversion rates become more impactful as the power goes up. For example, the power loss for a 700-W converter running at 89% efficiency looks very different than a 10W converter running at 89%. However, improving power efficiency is not an option anymore, it is a must, and we are seeing the demand for improvements across the board. Demands for improved cost-effectiveness, higher power density, and effective power management solutions are driving us to develop more efficient power converters, from low-power external adapters, to high-density intermediate bus bricks, in order to meet customer demand.

Bocock: Two categories are certainly in the spotlight at the moment. First, there is a lot of attention for sub 500-W convection-cooled products. Cooling a power supply is always much easier when a forced airflow from a fan is available, but for today's space-constrained designs the use of convection cooling is increasingly a popular choice. The other area relates to external power supplies and the increasing focus on energy efficiency, and no load consumption as required by Energy Star Level VI and EU CoC legislation. Market forces are greatly influenced by such initiatives.

Tuite: Are distributed power architectures or other concepts such as IBA, PoL, and PoE driving more attention to efficient dc-dc conversion, or are industry alliances such as Emerge also responsible?

Musavi: I believe that a number of macro-factors are driving more attention on the need for efficient dc/dc conversion. According to the Ericsson Mobility Report, annual IP traffic will reach 7.7 zettabytes by the end of 2017, up from 2.6 zettabytes in 2012. Video communications, cloud-based services, and the interconnection of physical objects (the Internet of Things) are the primary drivers of this growth. This is placing immense demands on data network power systems, thus driving great awareness on the need for efficient power conversion from corporations and governments alike. The distributed power architecture, IBA, PoL, and digital control are a few of the tools power designers have created over the past few years to try to address these challenges.

Le Fèvre: In ac-dc, industry bodies such as Energy Star have establishing rules and thresholds, whereas in dc-dc, energy efficiency has been inherent in their evolution, driven by market demand. While this has been the situation for many years, as segments such as data centers consider dc distribution, then organizations such as Emerge could drive dc-dc energy improvements in this specific area. But it is unclear that specific actions will trickle down to a single PoL.

(Gary Bocock did not comment because XP Power is not active in this area.) ed

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Faster Hardware, New Apps
Push ADC Boundaries

Higher-speed processors, greater chip densities, and direct downconversion, force analog chipmakers to move beyond the "classic" analog-to-digital converter model.

IN A RECENT ELECTRONIC DESIGN ONLINE ARTICLE titled "High-Speed Converters: What Are They and How Do They Work?" (*www.electronicdesign.com*), David Robertson, vice president of analog technology at Analog Devices, discussed the latest pressures facing data-converter manufacturers. He says that the continuing expansion of broadband communications and high-performance imaging applications particularly emphasizes high-speed data conversion—converters that can handle signals with bandwidths of 10 MHz to more than 1 GHz. He also notes that moving back and forth between the analog and digital domain at high speeds also presents some special signal-integrity challenges for the analog signal as well as clock and data signals.

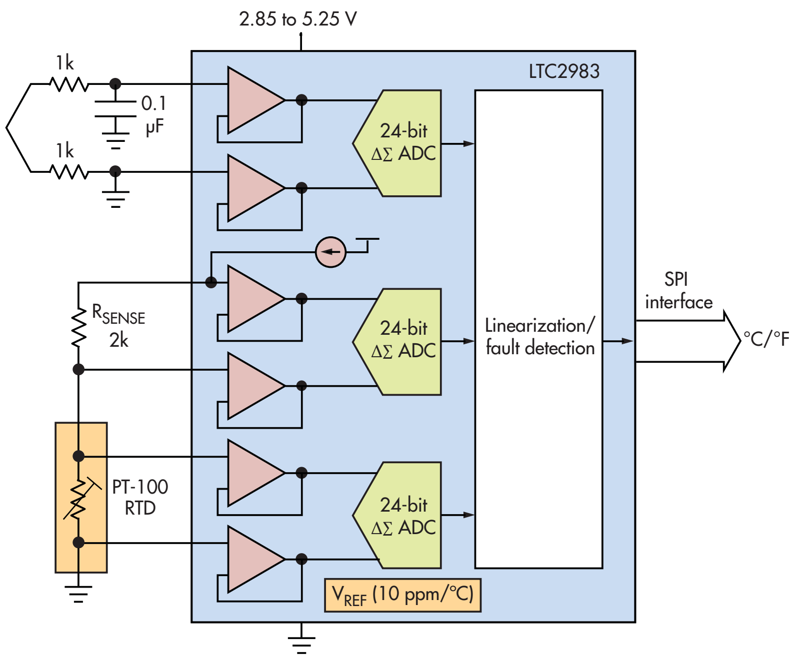
For makers of mixed-signal devices, Roberston says it's created a market with an exponentially increasing appetite for faster ADCs. "A processor running at 100 MHz might be able to effectively manipulate signals with 1 to 10 MHz of bandwidth: Processors running at multiple gigahertz clock rates are perfectly comfortable handling signals with bandwidths of 100s of megahertz."

And, of course, a variety of converter architectures are being used to reach these higher speeds, each with special advantages.

Greater processing power and speed leads naturally to faster data conversion, Robertson says. As broadband signals expand their bandwidths (often to the spectrum limits set by physics or regulators), imaging systems look to handle more pixels per second to accelerate processing of higher-resolution images. System redesigns specifically take advantage of this extreme processing horsepower, including a trend toward parallel processing that may involve multichannel data converters.

Another trending architectural change revolves around "multicarrier/multichannel," or even "software-defined" systems. Conventional, "analog-intensive" systems perform much of the signal-conditioning work (filtering, amplification, frequency translation) in the analog domain; the signal is "taken digital" after careful preparation.

Take, for example, an FM radio. A given radio station will be a 200-kHz-wide channel sitting somewhere in the 88- to 108-MHz FM radio band. Yesterday's conventional receiver would frequency-translate the station of interest to a 10.7-MHz intermediate frequency, filter out all of the other channels, and amplify the signal to the optimal amplitude for demodulation. In contrast, a modern multicarrier architecture would digitize



1. The ADCs are only one part of Linear's LTC2983, a "temperature-to-digital converter" that delivers high-precision temperature measurements from notoriously nonlinear Seebeck-effect and other temperature sensors.

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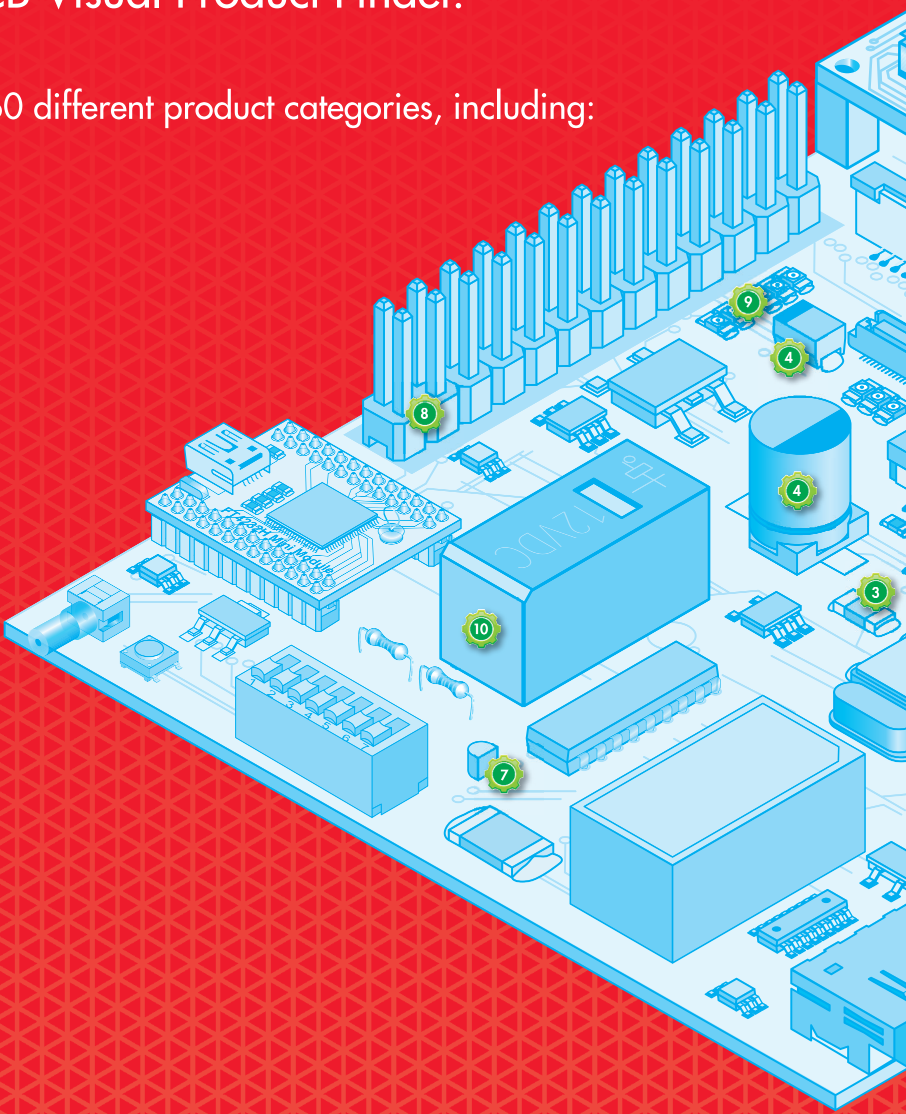

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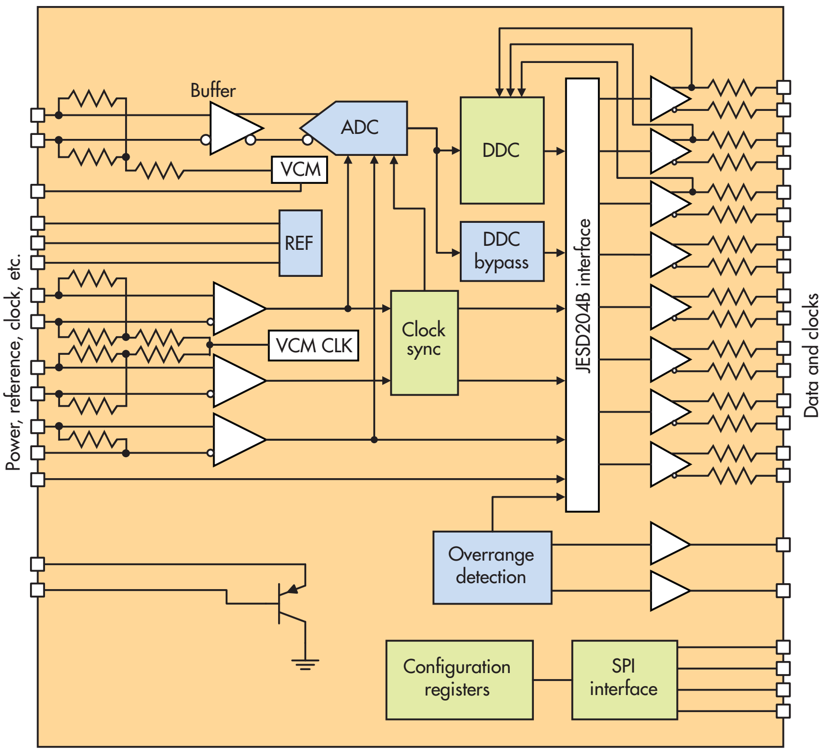
the entire 20-MHz FM band, and digital processing would then select and recover the radio stations of interest.

While the multicarrier scheme requires much more sophisticated circuitry, it offers some great system advantages: the system can recover multiple stations simultaneously, including "side-band" stations. If properly designed, a multicarrier system can even be software-reconfigured to support new standards (*e.g.*, the new "HD radio" stations placed in radio side-bands).

The ultimate extension of this approach is to have a wideband digitizer that can take in all of the bands, and a powerful processor that can recover any sort of signal—otherwise known as a "software-defined radio." Equivalent architectures in other fields include "software-defined instruments" and "software-defined cameras," among others. One can think of this as the signal-processing equivalent of "virtualization." The enabling hardware for such flexible architectures is powerful digital processing and high-speed, high-performance data conversion.

To gauge how it's affecting not just Analog Devices, but all large semiconductor companies that make analog-to-digital converters, it's instructive to look at recent new products. Some of the latest arrivals from the major players include:



2. TI's ADC12J4000 device is based on an ultra-high-speed ADC core that uses an interleaved calibrated folding and interpolating architecture to achieve a high sampling rate, very good dynamic performance, and relatively low power consumption. This ADC core is followed by a configurable direct down-conversion (DDC) block. The DDC provides a range of decimation settings that allow the device to work in ultra-wideband, wideband, and more-narrow-band receive systems. The output data from the DDC is transmitted through a JESD204B-compatible multi-lane serial-output system. Using JESD204B minimizes the number of data pairs required to convey the output data to the downstream processing circuitry.

MAXIM INTEGRATED

Maxim Integrated trotted out both traditional and application-focused ADCs. On the traditional side was the MAX11905, a 20-bit, 1.6-Msample/s successive approximation register (SAR) ADC that the company claimed as having "the industry's highest resolution and fastest sampling rate at the lowest power." The point of the device is to offer an alternative to sigma-delta converters that use less power. The MAX11905 consumes 9 mW versus the typical 100 mW for a classic sigma-delta, even though it incorporates its own reference buffers.

Dynamic specs are 98.3 dB signal-to-noise ratio (SNR) and -123 dB total harmonic distortion (THD). Maxim does acknowledge that classic sigma-deltas used in typical applications such as process control, automatic test equipment, medical instrumentation, and battery-powered devices deliver 24-bit resolution, so there are tradeoffs.

Not all of Maxim's latest ADCs are classic standalone devices, though. For instance, single- and three-phase systems-on-chip (SoCs) were created explicitly for power-line monitoring. This is more than just a case of high precision, like the aforementioned SARs. What's really being sold is time-to-market and a bulletproof design for simple electric meters.

The ZON M3 energy-meter solution integrates four 24-bit ADCs for four-channel data collection and ±0.1% measurement accuracy over a 5000:1 dynamic range. A 32-bit metrology compute engine ensures high-accuracy data, compared to mechanical switches and an infrared-communications interface. (For power transmission and distribution applications, Maxim Integrated also introduced the Petaluma high-speed subsystem monitors, which are described in the Power Forecast article in this issue.)

In other examples of integrating multiple ADCs (keep in mind that last year, Maxim changed its name to Maxim *Integrated)*, the company introduced its MAX11300 PIXI. The device is a configurable, 20-channel, –10- to +10-V high-voltage mixed-signal data converter. Targeted applications include basestations as well as industrial control and automation.

Along with the hardware, designers get a GUI for rapid drag-and-drop configuration. Designers can select an ADC and connect it to any of 20 pins, select a digital-to-analog converter (DAC) and connect it to any pin, or assign a digital I/O to any pin. Its intent is that all of this integration provides a smaller-size, lower-cost, and simplified bill of materials, along with faster design time and time to market.

LINEAR TECHNOLOGY

One has to go back to last February and April to find new versions of the classic type of ADC, which is a surprise for a company that prides itself in introducing a new product every week (LTC has kept up the pace with power products). Nevertheless, the company's latest ADC-like product is the LTC2983 temperature-to-digital converter *(see "The Temperature Digitizer Jim Williams Might Have Wished for 25 Years Ago," www.electronicdesign.com)*, which simplifies the challenge of making high-accuracy/high-precision temperature measurements with a variety of sensor types *(Fig. 1)*.

Essentially, Linear's LTC2983 first interfaces directly with the temperature sensor, which could be a type B, E, J, K, N, S, R, T; thermocouple; two-, three-, or four-wire RTD; 2.25-kΩ to 30-kΩ thermistor; or temperature-sensing diode. Then it outputs the results digitally, via an SPI bus, in °C or °F. The SPI interface works with virtually any digital system, and a comprehensive software support system with drop-down menus facilitates customization. There's no need for amplifiers, negative supplies, or level-shift circuitry.

Inside are three 24-bit sigma-delta ADCs, comparing inputs to an internal 10-ppm/°C reference. (If the application calls for cold-junction compensation, that can be accomplished using any type of external sensor.)

In addition to the ADCs, the chip includes linearization algorithms for all common sensor types. That's where the most challenging part of the design is embodied; thus, an enormous amount of engineering time is taken off the system engineer's plate. (If the designer insists, custom sensors can be linearized with custom coefficients.)

The device even takes care of driving the sensors. Dual programmable excitation current sources feature current-reversal and current-ranging capabilities.

Last winter, LTC introduced a family of SARs, led by the dual 16-bit, 5-Msample/s, simultaneous sampling LTC2323-16, along with its 14- and 12-bit cousins. Dynamic specs are 81dB SNR at 16 bits, 80 dB SNR at 14 bits, and 73 dB SNR at 12 bits.

Linear's latest analog-to-digital converter is the 16-bit, 210-Msample/s LTC2933, which delivers 80-dB SNR. It's intended for the high-performance end of classic communication and instrumentation applications.

TEXAS INSTRUMENTS

In terms of ADCs with classic architectures, Texas Instruments targeted the high end of RF applications with the low-power, 12-bit, 4-Gsample/s ADC12J4000 *(Fig. 2)*. TI says it supports the JEDEC JESD204B standard for data converters up to 8 Gb/s, while consuming 50% less power than competitive devices. With a 10- by 10-mm footprint, the device claims to be the smallest IC in its class. The ADC12J4000 can be used in test and measurement, wireless, and defense applications, including spectrum analyzers, munitions, digital pre-distortion feedback, and radar.

ANALOG DEVICES

Over the course of the last year, ADI did indeed introduce the largest number of high-performance versions of classic ADCs. However, the company also contributed its share of application-focused chips.

Among the new classics was the dual-channel, 1.25-V, 14-bit, 1-Gsample/s AD9680 SAR ADC, which targets the direct RF sampling addressed by Dave Robertson in his article referenced earlier. ADI previously announced the 12-bit, 2-Gsample/s AD9625 converter, also for direct RF sampling. The new devices are interoperable with FPGAs from major manufacturers and come supported with known-good configurations.

For portable applications, Analog Devices previously announced two 18-bit ADCs, its AD7989-1 and AD7989-5 "PulSAR" devices that draw only 400 µW at 100/500 ksamples/s. Dynamic specs include ±1 LSB and 98-dB SNR at 1 kHz. (The PulSAR portfolio includes 18- and 16-bit precision ADCs with conversion rates up to 1 Msample/s.)

In another performance dimension, ADI's high-speed (up to 600-ksamples/s), high-temperature, 16-bit AD8971 ADC is designed to provide error-free operation at temperatures of up to 175°C. Target applications include wide bandwidth sonic and vibration measurement, and low-power pressure and temperature sensing. With respect to the latter, the AD8971 maximizes battery life in harsh environments by scaling power linearly with the sample rate, using only 4.65 mW at full speed and 70 µW at 10 ksamples/s. Dynamic specs include ±0.7-LSB integral nonlinearity and 91-dB SNR.

Beyond its classic converters, ADI also invested in SoCs that incorporate ADCs. One recent example is its healthcare-focused ADuCM350 "meter-on-a-chip" that offers easy connectivity to passive and active sensors of human physiological data. It also supports sensor-fusion functionality, allowing for exceptionally accurate measurements.

The platform combines a 16-bit accurate analog front-end (AFE), which includes a configurable multi-sensor switch matrix, hardware waveform generator, and discrete Fourier transform (DFT) engine. There's also a processing subsystem and an industry-standard software development environment to support a complete product development roadmap. ed

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Test Instruments Just Don't Look the Same Anymore

It's becoming easier to understand what your scope or spectrum analyzer is telling you, and easier to take it to the measurement environment.

PUSHING THEIR SCOPES and spectrum analyzers to unprecedented speeds and bandwidths, instrument makers now look to the user interface for new ideas. This ranges from rethinking the whole look and feel of traditional controls to moving the display from the front of the box to the user's PC or tablet.

DISPLAYS GET A MAKEOVER

Enhancements started with making a friendlier integral display. According to Doug Beck, Keysight usability engineer, when the company visited customers around the world to get feedback about test instruments, issues more often concerned productivity rather than measurement science. This feedback led to the new Version 5.0 user interface for the company's Infiniium oscilloscopes. Improvements include:

- Zone trigger
- Horizontal and vertical scales
- "Grids and windows"
- Spectrum-analyzer-like FFT functions
- Fast and easy documentation
- Offline analysis
- Math and memory controls
- Temporary "handles"
- Gated measurements
- Gated FFTs

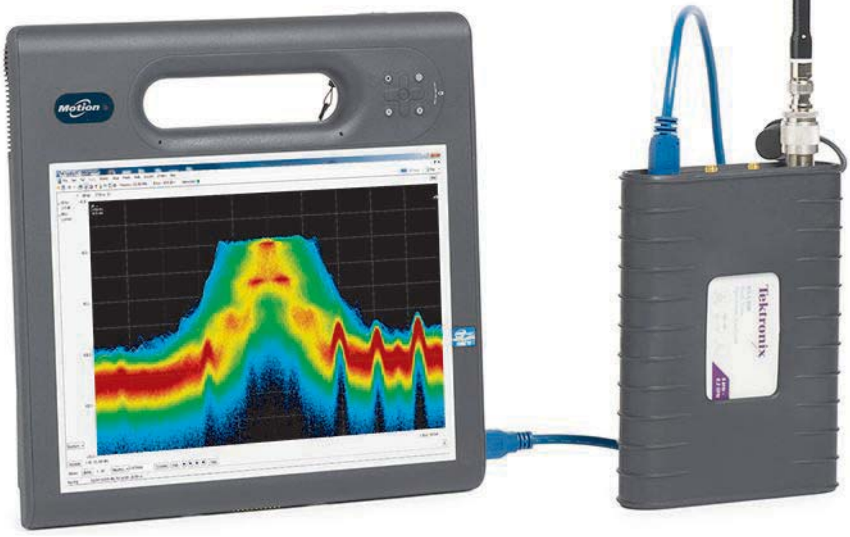
Let's take these in order, starting with "zone trigger." Beck says that while most scope users have no problem triggering on a rising or falling edge of simple waveforms, triggering on anything more complicated presents a challenge. Often, one engineer in the lab is the guru of advanced triggering, and he or she becomes the go-to person for measurement setups that involve "interesting" triggering situations.

The idea behind zone triggers, he says, is "if you need to trigger on anything more complicated than an edge, just draw a box." To demonstrate, he shows the capture of a complex waveform and, using a touchpad, draws a box around the event he wants to use as a trigger. Users can define up to 10 nested zones.

Beck goes on to talk about "horizontal and vertical scales." Traditionally, a scope user looks at an event on a scope graticule and does a quick mental subtraction—scale value minus offset—to arrive at a measurement value. Essentially, the scope labels the times and amplitude values of selected events on the horizontal and vertical axes of the display.

Next is "grids and windows," which works with those scales. This feature becomes advantageous when looking at multiple waveforms simultaneously. The point is that those words are pluralized.

Up until now, Beck says, all scopes show their results on a single window—a leftover from the days when scopes were analog devices with a



1. Tektronix's RSA3360 6-GHz spectrum analyzer, coupled with a PC or tablet running the company's freeware, facilitate frequency-domain analysis in the field, on the benchtop, or in the university classroom or lab.

phosphorescent CRT screen. When the user separates multiple signals so that they don't overlap, the amplitude and/or time scales of smaller-amplitude signals can be squeezed. As a result, less detail can be observed.

With the "grids" feature, users can view up to 16 full-scale, non-overlapping grids simultaneously, all using the full resolution of the ADCs that are digitizing the individual input signals. It's also possible to overlap the grids.

The "Windows" feature targets sophisticated users who don't want to overlap or stack waveforms. As the name suggests, the feature makes it possible to separate individual signals from multiple inputs and arrange them on the screen in different-sized (or same-sized) windows and stack them (or put them side by side). Users can also add identification tabs to them, or overlay them in whatever order provides the best understanding of what's happening in the circuit under test.


2. Saelig's GDS-200/300 series of battery-powered, two-channel, 1-Gsample/s digital oscilloscopes are controlled from a 7-in. touch-panel LCD.

On top of that, scope waveforms can be sent to a desk monitor that's also displaying a protocol decode, or jitter diagrams, or eye diagrams, to produce a single composite of what's happening in the time, frequency, and digital domains. (If this is starting to sound like "too much information to deal with when you're just peeking at a waveform," Beck points out that "all of these features 'stay out of your way' until you ask for them.")

The Keysight FFT feature represents a "fix" for the problems of contemporary scopes that provide spectrum-analyzer-like displays of analog signals. Beck says they don't necessarily provide frequency-domain displays that deliver information as handily as a real spectrum analyzer.

SHARING RESULTS

The next issue addressed by Beck addresses involves documentation. This is really about sharing results. Once upon a time, a scope could simply hang a special camera on an instrument's bezel, take a Polaroid photograph of the display, type up some notes, paste the photo on the write-up, Xerox the page, and fax it to a colleague.

Considering the information contained in a modern scope display, it may be time for something more 21st century. This isn't a trivial issue, according to Beck. In fact, he says, it's the No. 1 issue brought up by users everywhere. They weren't happy with importing screen captures into PowerPoint.

Such insight led to Keysight's "bookmarks" feature. Essentially, Bookmarks allows users to pinpoint a specific location in time on the display. The bookmark stays associated with that point no matter how one drags the display around. Similarly, embedded markers are tagged with their values and stay with the point highlighted no matter how the user scrolls the screen.

Other features also aim to share data in ways that let other engineers know what they're looking at on the screen captures. For instance, those other engineers can do more than stare at fixed images. If they have the Keysight software, they can actually move around within the captured data, extending the analysis and marking up their interpretations for colleagues.

This, in fact, extends the utility of the scope, which is a fairly expensive piece of capital equipment. With "offline analysis," engineers can use mathematical tools to analyze offline waveforms to an extent, as if they were working on the instrument that captured them, even when someone else in the lab is using the instrument for a different project.

The "math and memory" waveforms feature essentially means that the new scopes always show controls for all waveforms that are ON, regardless of their type. If the user is performing a math function on a waveform, its controls are on-screen, right next to the controls (like the ones that control gain and sweep) for the waveform.

The "temporary handles" feature addresses a common problem with contemporary scopes. When a user tries to grab a marker and misses, he or she winds up moving an underlying waveform instead. That's because most markers, being one pixel wide, are hard to grab. "Temporary handles" resolves the problem by letting the scope user attach labels to markers. Then the labels can be dragged and dropped more easily than having to do so with the markers.

"Gated measurements" make it easy to perform measurements on only selected areas of a trace. Finally, the "gated FFTs" feature allows users to perform an FFT on a selected portion of a waveform and display it concurrently adjacent to the selection in the selection box.

"POCKETABLE" SA TALKS TO TABLETS, GOES TO 6 GHz

Speaking of spectrum analyzers, Tektronix this past November introduced the RSA306, a $3490 "pocket-size" spectrum analyzer with a frequency range from 9 kHz to 6.2 GHz (and 40-MHz real-time bandwidth). It weighs just over a pound. The instrument interfaces, via a USB cable, with Windows 7 or 8 PCs or tablets that run Tek's SignalVu-PC software, which has been proven on the company's scopes and analyzers for a number of years. It previously cost in the $3000 range, but the company has now made it freeware *(Fig. 1)*.

Calling the RSA306 "pocket-size" is a bit of a stretch, but at 7.5 by 5 by 1.5 in. and weighing 1.2 lb, it will fit easily into cargo-pants pockets. That fact emphasizes the virtues of the RSA306 as a field instrument. An open API allows customers to use their own custom Windows-based interface, such as Matlab or Python, to manipulate raw data coming from the instrument.

Tektronix envisions a range of field applications whose users would benefit from an affordable combination of a handheld instrument and potent software running on a PC or laptop:

- *Mobile radio network installation and maintenance:* In the field, having all the capabilities of a real spectrum analyzer provides greater versatility than a dedicated tester.
- *Interference hunting:* For spectrum managers and regulatory agencies, the ability of the RSA306 to spot signal bursts as short as 100 µs is a powerful feature in a handheld tool.
- *University lab classes:* The availability of SignalVu, free on every student's PC or tablet, coupled with a relatively low-cost, high-performance instrument, can help students become better RF and microwave engineers—it gives them hands-on experience, duplicating the performance of the spectrum analyzers they will use after graduation. Vector analysis, frequency and phase trends, and other tools allow educators to teach concepts well beyond basic frequency and amplitude.

ENTRY-LEVEL MULTIFUNCTION INSTRUMENT TARGETS "MAKERS"

National Instruments this past June introduced Virtual Bench, inspired by the company's relationship with Tech Shop, the growing network of technical community resource centers for "maker" type experiences for learning and building.

VirtualBench is an all-in-one instrument that integrates a mixed-signal oscilloscope, function generator, digital multimeter, programmable dc power supply, and digital I/O. Interaction with those tools occurs via software applications that run on PCs or iPads.

Bandwidth on the two-analog-channel scope is 100 MHz (there are 34 digital input channels). Users can add, subtract, and multiply input waveforms and perform fast Fourier transforms (FFTs). The sine- and square-wave function generator is programmable to 20 MHz and 5 MHz, respectively, and the programmable dc supply has one channel that goes to 6 V at 1 A and two that go to 25 V at 0.5 A.

BEYOND THE "USUAL SUSPECTS"

NI's VirtualBench, aimed primarily at educators and experimenters, is a reminder that Saelig Company *(www.saelig.com)*, a test-equipment distributor, has been a source for experimenters and hams since 1988. Most engineers have at least considered investing in one of its PC-connected scopes.

3. **Costing roughly $100, the 25-MHz digital oscilloscope-in-a-pen connects to a PC via USB. It handles input-signal amplitudes ranging from 5 to 50 V.**

In the spirit of "test instruments that don't necessarily look like they used to," consider some recent additions to Saelig's offerings. The GDS-200/300 series of battery-powered, compact, two-channel, 1-Gsample/s digital oscilloscopes have a 7-in. touch-panel LCD that works in portrait or landscape orientations *(Fig. 2)*. The family includes 70-, 100-, and 200-MHz-bandwidth versions. The touch-panel LCD makes it easy to move waveforms up and down and set trigger levels. Two-point touch allows adjustments to amplitude and time settings.

The GDS scopes also incorporate built-in digital multimeters that can simultaneously measure and monitor ac or dc voltage and current, and temperature. It's possible to save and review trend plots over time. Moreover, users can store and retrieve waveform images and raw data via USB, or connect via smartphones to transmit the recorded data to a remote location. A single unit costs $1195.

If that's more scope than necessary, one could instead opt for a $99 USB oscilloscope-in-a-pen *(Fig. 3)*. The Owon RDS1021 "Wave Rambler" comes with its own PC software, much like VirtualBench, but without any box between the probe and PC processing the input signals and running the display. Also, thanks to USB, there's no need for an external power supply.

Is it practical? This scope-in-a-pen handles input-signal amplitudes from 5 to 50 V. On top of that, with the software in the attached PC, it will perform FFTs on captured waveforms.

The horizontal scale can be set between 5 ns and 100 s/div. A trackball is built into the probe top; there's no need for the user to take his or her hands off and adjust the PC.

The Wave Rambler automatically handles peak-to peak, average, and rms voltage measurements, and will calculate frequency, period, overshoot, pre-shoot, rise time, fall time, and duty cycles. It can also show sampled, peak-detect, and average waveforms. Stable waveform triggering is obtainable via signal edge, slope, and pulse triggering.

The instrument measures 5.9 by 0.8 by 0.7 in., and weighs 1 oz. It comes with a ground clip, a protective cover, a CD ROM with the software, a quick-start manual, and a USB cable. ed

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Top 10 Communications Trends to Watch in 2015

Evolutionary leaps in the communications arena seem to be an annual event. "Softwarization" and a ramped-up IoT could be two of this year's paradigm shifters.

COMMUNICATIONS represents the core of electronics. The technology traces back to the dawn of electronics, and still dominates today by weaving its way into nearly every facet of modern life. However, its immense impact on our lives is generally taken for granted. With that in mind, pay attention to these key communications trends in the coming year:

CONTINUED EXPANSION OF LTE

Long Term Evolution (LTE) 4G cellular standards, well established in the U.S. and Asia, haven't hooked on everywhere. Many locations domestically and in most developing nations still rely mainly on 3G technology. In Europe, for example, LTE penetration is only 14%. With the smartphone now the de facto standard handset, there's ever-growing demand for broad and fast LTE coverage. In response, U.S. carriers continue to expand their LTE offerings. Its growth, though, often slows due to lack of available capital and suitable frequency spectrum.

The next big step for LTE involves LTE-Advanced and small cells. LTE-A leverages carrier aggregation and higher MIMO levels to widen bandwidth and boost speed. Modem chips for the LTE-Advanced (Release 10) versions of LTE are just now emerging, so look for LTE-A cell sites and handsets to arrive in… 2016 (most likely not this year). Then download speeds up to 300 Mb/s will be possible under ideal conditions.

1. Ethernet's familiar CAT5/6 cables and connectors will continue to provide the links for new variations of this ubiquitous LAN standard. *(Courtesy of the University of New Hampshire Interoperability Laboratory (UNH-IOL)*

While carrier aggregation will boost bandwidth to increase speeds, the lack of spectrum will still limit LTE-A. It's going through trials and testing now around the world with almost no commercial activity. Carriers like AT&T, T-Mobile, and Verizon are currently preparing for real service in the coming years as chips and other equipment become available.

Despite the capital and spectrum limitations, LTE will still grow significantly. ABI Research estimates that 676 million LTE handsets will ship in 2015, a 50% increase over 2014. Furthermore, ABI estimates 1.89 billion LTE-enabled devices will be in use by 2019. Thus, the burden gets placed on carriers to expedite the LTE infrastructure to support that quantity.

As the LTE infrastructure expands, some of that growth will entail small cells—miniature base stations with limited range and power. These small cells will add to the existing cellular base-station mix to create a heterogeneous network (HetNet) that should boost coverage indoors and out, as well as increase downlink speeds. Few small cells have been installed, but look for gradual deployment in dense population areas.

DEFINING 5G

Even with 4G technology still in expansion mode, fifth-generation (5G) cellular systems are already being defined. We will linger a while longer in the 4G world as LTE continues to expand, LTE-A comes online, and small-cell efforts like Wi-Fi offload and distributed antenna systems (DASs) are implemented. Debates about 5G's future are underway, with further definitions expected this year.

As usual, the goal is to expand capacity, fill in the coverage gaps (especially indoors), ease the spectrum shortage problem, and increase downlink speed. The emerging consensus is that small cells in the millimeter-wave bands can do the job. While physics restricts the range of millimeter-wave signals, high-gain antennas and many small cells should make it workable. At this point, the 28-, 38-, and 73-GHz millimeter bands have been proposed.

While OFDM may be used, newer modulation methods could be part of the new standards. Steerable beam-forming antenna arrays and high levels of MIMO will allow gigabit speeds in dense urban surroundings. Millimeter-wave backhaul will connect everything together. Overall, we're years away (2020?) from 5G, but be on the lookout for ongoing discussions on its progress.

ETERNAL ETHERNET

Ethernet, the ubiquitous local-area-network (LAN) technology, has been with us for over 40 years and continues to morph to keep pace with changing technology. Ethernet has been on the path of increasing line rates by a factor of 10 every few years since its beginning. The original 10 Mb/s soon became 100 Mb/s, then 1 Gb/s, and onto 10 Gb/s. Currently, Ethernet delivers 100 Gb/s in copper as well as fiber forms.

Lately, though, we're seeing a different path taking shape in terms of speed. Instead of reaching for the next decade of 1 terabit per second (1 Tb/s), IEEE 802.3 task forces are targeting 400 Gb/s and even lower-level intermediate speed versions. The idea is to adapt Ethernet to specific needs and niches. A great example is the proposal for 2.5G and 5G versions of Ethernet. This effort is spurred on by the NBASE-T Alliance, an organization dedicated to promoting and developing the 2.5G and 5G versions.

One projected problem is that the LAN infrastructure needs to support the forthcoming 802.11ac Wave 2 wireless hotspots capable of multi-gigabit speeds. With most access points stuck at 1 Gb/s, existing cable installations can't handle the extra speeds achievable with the wireless access points. The most common CAT5 and CAT6 cabling *(Fig. 1)* installations don't support the 10-Gb/s version of Ethernet, so we need another solution. We can look forward to some new versions of Ethernet with modulation methods that can handle 2.5G and 5G speeds on standard unshielded twisted pairs up to 100 meters.

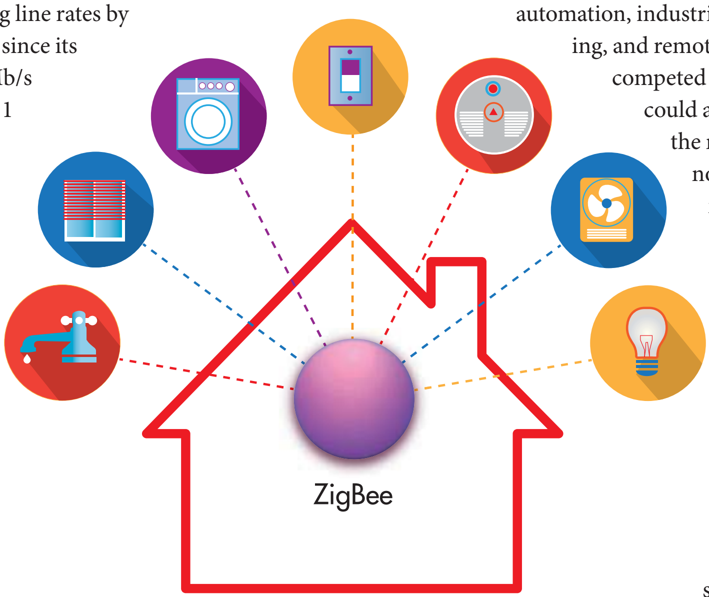
Another similar effort now underway comes via the 25G/50G Ethernet Consortium. This group wants new versions of Ethernet that will run at 25G and/or 50G on copper cables and backplanes. The impetus is to provide lower-cost interconnections of servers and storage units in data centers to support growing cloud, video-data, and wireless-traffic needs.

We needn't worry about Ethernet. Forthcoming new versions for 2.5G, 5G, 25G, 50G, and 400G will keep us happy in the years to come.

NEW SHORT-RANGE WIRELESS OPTIONS

Now almost two decades old, Bluetooth and ZigBee have each carved out a niche in the short-range wireless market. Bluetooth became successful with its wireless headsets, hands-free automobile kits, and wireless speakers. Basically, it's in every smartphone. ZigBee made great strides with home automation, industrial mesh sensor networking, and remote controls. They rarely competed with each other. That could all change, though, given the new versions of these technologies aimed at the Internet of Things (IoT) market.

The Bluetooth SIG's latest version 4.2 improves privacy and security, boosts data speeds, and adds Internet connectivity. The greater security ensures that users of beacons can't be tracked. Data speed jumps by an x2.5 factor over the 4.1 version, improving capacity. In addition, Internet connectivity via IPv6 and 6LoWPAN now make Bluetooth a candidate for IoT applications. And don't forget Bluetooth Low Energy is continuing to penetrate into beacons and wearable products. Bluetooth being combined with near-field communications (NFC) for seamless pairing makes it even more popular in consumer devices.



2. ZigBee's new version 3.0 will make this standard ever more popular for the Internet of Things in terms of home monitoring and control. *(Courtesy of the ZigBee Alliance)*

ZigBee's new 3.0 version has become more attractive than ever, too—it now combines all features of many ZigBee applications into one specification. That includes home automation, lighting, energy management, security, sensors, and healthcare monitoring *(Fig. 2)*. Based on the popular ZigBee PRO specification, version 3.0 is still a great choice for IoT mesh networking and Internet connectivity.

Needless to say, IoT developers now have two more excellent choices at their disposal.

NFC PROGRESS...AT LAST

Near-field communications, another nearly two-decades-old short-range wireless technology, doesn't compete with Wi-Fi, Bluetooth, or ZigBee. Rather, it's found a niche or two in transit payment, secure entry, and posters. Its biggest challenge has

3. IQnfc, developed by LitePoint, is a production line tester for NFC wireless devices. Shipping volume of the tester has spiked thanks to increased NFC usage in smartphones.

been to become the wireless payment method in smartphones, replacing or at least supplementing credit-card payment methods. It was incorporated into some Android smartphones to implement payment schemes like Google Wallet and others. Overall, though, adoption by retailers and consumers was poor.

However, Apple put NFC into its new iPhone 6 models and implemented the Apple Pay system, which seems to have reignited interest in NFC and smarphone pay methods. In fact, LitePoint's VP Curt Schmidek has seen a boost in sales of its IQnfc NFC production test units (*Fig. 3*). He believes that NFC will come into its own this year. With the shift in liability for corrupt hacking charges shifting from bank insurers to merchants, retail outlets should finally invest in NFC payment terminals simply because the systems offer far more security. With the transition expected to happen late this year, look for 2016 to be the year of NFC and increased use of smartphone pay systems.

IMPROVED WI-FI, AND MORE OF IT

Where would we be without Wi-Fi? It's almost ubiquitous, with expectations of it being everywhere and free. This year will see even more Wi-Fi with greater speeds, improved coverage, and even new uses.

First, adoption of the latest 802.11ac standard should be substantial. It has taken some time for this faster 5.8-GHz-only version to come on line, but with new chips available along with improved routers and access points (APs), look for faster links everywhere. Use of 80- or 160-MHz-wide channels and modulation methods up to 256QAM has boosted data rates into the gigabit region.

You will also see the emergence of 802.11ac Wave 2 products. These offer multi-user multiple-input multiple-output (MU-MIMO), which allows one access point to handle more than one user at a time. This will provide greater access as well as near-gigabit data rates.

What's not so clear is the path for the superfast 802.11ad version of Wi-Fi, known as WiGig. This 60-GHz-band wireless standard with active high-gain beam-forming antennas offers speeds to 7 Gb/s over short distances. Its most likely application is uncompressed video transfer. Chips are now available, but few end products. What will 2015 bring?

Major WLAN provider Ruckus Wireless offers up a variety of predictions for Wi-Fi. In addition to its "2015 is the year of 802.11ac" forecast, Ruckus expects wider adoption of the Wi-Fi Alliance's Hotspot 2.0 (Passpoint) with the 802.11u standard, significantly improving the ability of Wi-Fi users to automatically connect to an AP and roam seamlessly from one AP to another. Another major prediction concerns the incorporation of virtualization into the WLAN via network function virtualization (NFV).

Ruckus also looks for wireless operators to increase use of Wi-Fi offload in order to increase capacity. Wi-Fi-calling, or VoIP over Wi-Fi, continues to gain popularity—it allows voice calls from cell phones from locations unreachable with a cell site, but with a nearby Wi-Fi access point. This very popular feature could kill off the femtocell solution for poor cellular coverage. In addition, Wi-Fi offload should slow the adoption of LTE small cells. While small cells will soon become common, many of those small cells will be Wi-Fi access points.

Finally, we may see some progress in extended-range Wi-Fi with coverage out to one kilometer. One development called White-Fi, or Super Wi-Fi, involves application of the 802.11af standard to the white-space spectrum. White space represents the unused TV channels in the 54- to 790-MHz VHF and UHF range. These 6-MHz-wide channels permit longer-range communications than the current 2.4- and 5.8-GHz bands of Wi-Fi. Using cognitive radio methods, the 802.11af standard will greatly extend the range of Wi-Fi in rural areas and those with difficult terrain.

Another longer-range option is the 802.11ah standard designed for the 902- to 928-MHz U.S. unlicensed band. With channel bandwidths to 16 MHz, it can potentially deliver rates topping 300 Mb/s over its extended range.

IoT BECOMES REALITY

Connecting everything to the Internet seems like a nutty idea. Yet, the idea of linking "things" to other "things" and/or to humans via the Internet has not only generated lots of interest, but a surging number of new products. With Internet security becoming an increasing problem, you have to wonder about the implications. Yet new applications will produce substantial benefits in terms of convenience and time/cost savings.

A spokesperson for Broadcom Corp. offered up this view of IoT: "IoT is a significant growth engine, as it has the ability to connect anything. Today, there are approximately 1.75 billion smartphone users worldwide and an average of five to seven connected devices per home. Experts predict that by 2020, 50 billion devices and objects will be connected to the Internet. What's perhaps most exciting about this market is the low barrier for entry. There's an opportunity for anyone with a brilliant idea to quickly test ideas and then bring them to market. For example, Broadcom offers a $20 Wireless Internet Connectivity for Embedded Devices (WICED) development kit, called WICED Sense, that gives developers access to the technology needed to quickly and affordably test an idea and create a prototype."

IoT will exploit a variety of wireless methods. Broadcom's WICED and Texas Instruments' SimpleLink products are two examples. But with new standards, Bluetooth and ZigBee also become candidates for IoT products. Furthermore, cellular remains an option for some applications.

A CRIPPLED INTERNET

The government wants to regulate the Internet. Though it's tried to do so on several occasions only to lose in court, the people in power aren't giving up. The latest efforts include FCC Chairman Tom Wheeler's hybrid plan and President Obama's suggestion to categorize the Internet as a utility under Title II of the Communications Act of 1934.

The idea is to keep the Internet open and fair. Of course, today the Internet is open and basically fair without regulation. Some argue that the carriers will throttle the Internet and raise fees unfairly. Others argue that regulation is necessary to ensure that all traffic coming from large and small organizations be treated the same.

While some regulation seems practical to thwart potential abuses, the effect of any regulation always seems to raise taxes and costs, as well as put restrictions on innovation and investment. So, it appears as though some regulation is inevitable. No decision has been made yet, but look for a resolution sometime during 2015. Hopefully it will be reasonable and not cripple the best technological development of the century.

On top of the predictable forthcoming regulation, another possible government decision threatens to further cripple the Internet. In September, the U.S. Commerce Department's contract with the Internet Corporation for Assigned Names and Numbers (ICANN) will end, terminating U.S. control over the Internet. The current administration wants to turn control over to some international organization.

With individual governments able to make decisions on the Internet, we can possibly expect to see severe restrictions on a country-by-country basis. ICANN has tried to stay fair and neutral under the U.S. influence. Let's hope the government changes its mind and keeps ICANN in its fold. Otherwise, 2015 could be a disaster of a year for the Internet.

SPECTRUM SHORTAGE SOLUTIONS

Some claim that there's no spectrum shortage, but the wireless carriers say otherwise. The lack of usable spectrum is the main limitation to boosting 4G capacity and speed. A couple of approaches are being taken to solve this problem. The first revolves around spectrum auctions—a recent spectrum auction generated over $40 billion. The FCC freed-up space in the AWS-3 spectrum in the 1700- and 2100-MHz range for cellular usage, most of it going to major carriers like AT&T, Verizon, T-Mobile, and Dish Network.

More auctions are on the way. In 2016, the FCC will ask TV broadcasters to voluntarily give up their channels and either go out of business or move to another location. This spectrum is worth billions and many TV station owners are seriously considering it. With only about 10% of the population getting over-the-air TV, and with increased competition from cable and Internet TV, it's expected that some stations will participate. The FCC hopes to free up an additional 100 MHz and generate about $45 billion in the process.

Spectrum sharing is another technique employed to ease the spectrum crunch. The best example is the 2.4- to 2.5-GHz unlicensed band used by Wi-Fi, Bluetooth, ZigBee, and even some cordless phones. It works because of the limited range, low power, and some special coexistence techniques.

We can look for more spectrum sharing that leverages cognitive-radio techniques. The TV white-space spectrum now uses these for unlicensed data transmission.

Another solution is to move to the higher frequencies in the millimeter-wave bands. These frequencies are already seeing increased usage as the latest semiconductors emerge to make them practical. You will no doubt see cellular systems adopt the millimeter bands for 5G.

THE "SOFTWARIZATION" OF NETWORKING

So far, networking has been more or less a balance of hardware and software. Now, though, we're seeing a gradual shift to the software side. With the meteoric rise in Internet traffic (especially video), growing cloud needs, and the potentially overwhelming Internet of Things, current networks find it harder to scale systems to handle the capacity and speed demands. The proposed solution revolves around a new software-based paradigm for networking.

One solution—software-defined networking (SDN)—replaces some hardware with software. SDN separates the data and control planes of the network. The Open Networking Foundation (ONF) defines SDN as "an emerging network architecture where network control is decoupled from forwarding and is directly programmable." OpenFlow is one example of SDN-related commercial software.

Another software approach is the aforementioned network function verification, or NFV. Its goal is to migrate network operations from dedicated hardware to multiple virtual machines running on common servers. This should lead to improved utilization of existing resources while lowering costs. Expectations are that NFV will be used in conjunction with SDN to further improve network performance and efficiency.

SDN and NFV have yet to be widely implemented, but the movement is underway and migration will take years. ed

VICTORIA FRAZA KICKHAM | DISTRIBUTION EDITOR victoria.kickham@penton.com JANUARY 2015

Image courtesy of Thinkstock

The Year of Connectivity

2015 represents the start of something big as the connectivity trend ramps up, creating new opportunities in industrial, automotive, and wearable technology markets.

VICTORIA FRAZA KICKHAM | DISTRIBUTION EDITOR

SUPPLY CHAIN LEADERS anticipate modest growth in 2015, with the overall economy set to grow moderately and the trend toward connectivity across all markets promising even better growth patterns down the road.

Economist Daniel Meckstroth, of the Manufacturers' Alliance for Productivity and Innovation, offered a positive outlook to manufacturing and distribution leaders at last fall's Executive Conference of the Electronic Components Industry Association (ECIA), noting that the economic

Continued on Page 46

Sensor Market Heats Up

Sensors drive growth for supply chain companies in 2015, with wearable electronic devices leading the way.

VICTORIA FRAZA KICKHAM | DISTRIBUTION EDITOR

SENSORS ARE AMONG the hottest technologies in the electronic components market these days, as the drive to connect everything from industrial systems to health monitoring equipment to the Web creates new demand for sophisticated products that incorporate a higher number of sensors. This is especially true in the wearable electronic devices market, where sensor shipments are expected to increase nearly seven-fold between 2013 and 2019, according to a recent industry report from researcher IHS Technology.

IHS predicts that shipments of sensors for wearable electronics will hit 466 million units by 2019, up from 67 million units in 2013. Sensor shipments will rise more quickly than the market for wearable devices themselves, the researcher added, forecasting wearable devices shipments will increase to 135 million units by 2019, compared to 50 million in 2013.

"Wearables are a hotbed for sensors, with market growth driven by the increasing number of these components in each product sold," said Jérémie Bouchaud, director and senior principal analyst, MEMS & Sensors, at IHS. "The main factor propelling this phenomenon is a transition in market share away from simple products like pedometers and toward more sophisticated multipurpose devices such as smart watches and smart glasses. Instead of using a single sensor like the simpler devices, the more complex products employ numerous components for health and activity monitoring, as well as for their more advanced user interfaces."

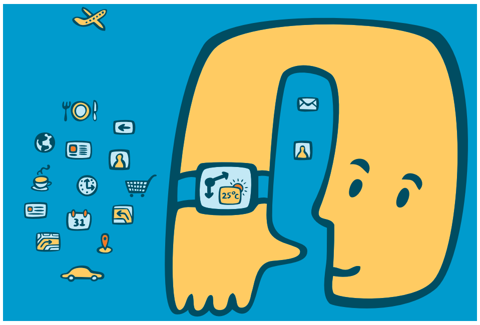


Image courtesy of Thinkstock

The average wearable device shipped in 2019 will incorporate 4.1 sensor elements, up from 1.4 in 2013, according to IHS. The researcher also expects components such as humidity sensors and pulse sensors to move from handsets to wearables, further boosting sensor sales. Smart watches from brands such as Samsung and Apple are just one example.

RAMPING UP IN 2015

Many industry-watchers say 2015 will mark an acceleration point for sensors. IHS points to a doubling of wearable sensor shipments next year. Sensors were also a key topic at October's Electronic Components Industry Association Executive Conference, as manufacturers and distributors discussed their potential across industrial, automotive, health, and fitness categories. "We think it's a big growth opportunity," said Lew LaFornara, vice president, supplier marketing and product management, for electronics distributor TTI, Inc. "And it plays into everything being connected."

LaFornara pointed to Honeywell's new line of thermostats that can be controlled by an iPhone as one example. He also noted that recent acquisitions in the sensor manufacturing market—TE Connectivity's purchase of American Sensor Technologies is one example—are helping distributors add or expand sensor lines to take advantage of the growing market.

And in a presentation on the sensor market during the ECIA event, Dr. Janus Bryzek explained that sensors have the potential to change the global economy. He said sensor usage by mobile devices increased by more than 200% from 2007 to 2012, and that demand will surge into the trillions over the next decade. He cited the digital health market—which is predicted to be a $50 billion market by 2018—as one of the greatest opportunities for makers and sellers of electronic components. ■

Year of Conductivity

Continued from Page 45

uncertainty that had characterized the economy since the 2013 fiscal cliff has substantially declined and that the electronic components outlook, in particular, is upbeat.

"There are no signs of a recession any time soon," Meckstroth told attendees at the meeting, held in Chicago in late October. He pointed to information technology, industrial markets, transportation equipment, and medical manufacturing as key growth areas in 2015.

The need to upgrade or replace aging equipment in many of those markets bodes well for components suppliers—a factor other industry leaders echoed as well. Dale Ford, chief analyst and head of electronics for industry researcher IHS, pointed to the Internet of Things (IoT), wearable technology, and the cloud as important technological advances for those markets. IoT, in particular, holds promise for industrial markets, as the need for building automation, advanced communications, and better lighting solutions—all of which can benefit from connectivity trends—ramps up.

"If you didn't think today that you're supplying the automotive industry, think again," says TTI's Michael Knight, pointing to growing demand for "connected" cars.

"Industrial is the biggest opportunity," Ford said. "The key benefits are cost and time savings and efficiency gains."

Ford predicted high single-digit growth in industrial markets this year, adding that industrial electronics will replace wireless applications as the greatest growth opportunity going forward.

He added that demand for sensors in a wide range of markets will spur growth in related electronic components, another boon to suppliers. Their penetration into smartphones and tablets, for instance, drives demand for processors, memory chips, and the like. The same is true of the automotive industry, where demand for sensors is also growing.

INDUSTRIAL MARKETS HEAT UP

Lew LaFornara, vice president, supplier marketing and product management at electronic components distributor TTI Inc., said he expects modest growth in 2015, following a good 2014. Like Meckstroth and Ford, LaFornara pointed to industrial and automotive markets as bright spots, particularly in light of today's demand for "connectedness" across those industries. He added that, in general, TTI is witnessing a need among customers to move more data across their organizations, spurring demand for products related to networking and communications. He said there is also considerable demand among industrial customers for wireless solutions, including radio frequency (RF) products, sensors, and the like.

"Everything is interconnected. And now, all of that is being adapted for the industrial world," he said. "But industrial customers are more concerned about reliability than 'leading edge' [technology]…systems that are not only

IHS predicts that shipments of sensors for wearable electronics will hit 466 million units by 2019, up from 67 million units in 2013.

high-tech and speed the flow of information, but that are durable enough to survive in harsh industrial environments."

LaFornara points to demand for ruggedized and moisture-sealed high-tech components as examples.

Dan Stewart, vice president of marketing for distributor Allied Electronics, concurred with the solid outlook for industrial markets, a key strength for Allied. He points to pent-up demand in the sector as companies look to upgrade equipment and seek opportunities to streamline productivity. He added that the key challenge for distributors is educating customers on the advantages of upgrading (not just fixing) aging equipment.

What's more, Stewart said 2015 may be a turning point in North American manufacturing as some companies seek to build more products here at home. Mexico is a prime example, as it is less expensive for many companies to manufacture in that country compared to China. Although security is a concern, Stewart said the Mexican marketplace represents considerable opportunity over the next few years. Allied launched a Mexican version of its website in 2014 as a step toward capitalizing on the long-term growth potential.

AUTOMOTIVE, WEARABLES UP, TOO

In a nod to the increasingly connected world, the theme of October's ECIA Executive Conference was "Living Connected"— a title TTI's Michael Knight explained has more relevance to the electronic components industry than many of its executives may realize. The drive to "connect" everything from appliances to automobiles is a technological innovation in itself, creating demand for new products, innovation, and productivity gains—all of which depend on electronic components.

"This new trend—what many are calling 'the next great thing'—is most relevant to our industry," Knight told attendees at the ECIA conference, adding that he thinks this new wave of technology will "unleash the next transformation in our industry."

Knight, senior vice president for TTI Americas, pointed to the automotive industry as a case in point, saying that by 2025, 100% of cars will be connected to the Internet in some way, and some automakers expect to have driverless cars on the market in the next 10 years. These trends not only create opportunities to supply components for new vehicles, but open the door to a large aftermarket business for connecting existing cars.

"This is coming," Knight said. "It's right around the corner. If you didn't think today that you're supplying the automotive industry, think again."

Knight pointed to growing demand for sensors as well, echoing Ford's prediction that such demand will spur the need for related components, driving considerable business opportunities. With the automotive outlook in positive territory, both say it's a market the supply chain cannot overlook. Ford predicted that by 2018, the auto industry will generate $5 billion in business just by connecting cars alone. From there, he added, the opportunities are endless.

"What follows are things like smart cities, which will create all kinds of new economic opportunities," Ford said.

Ford pointed to another area the supply chain should not overlook: wearable technology. He characterized 2015 as a "breakout year for wearable electronics," pointing to medical industry products such as contact lenses that monitor blood glucose and consumer electronics such as the Apple watch as some of the greatest opportunities ahead.

"We're moving into a very exciting future," Ford said. ■

Allied Adds 35,000 New Products

VICTORIA FRAZA KICKHAM | DISTRIBUTION EDITOR

ALLIED ELECTRONICS ANNOUNCED further expansion of its product portfolio, adding nearly 35,000 new offerings available at www.alliedelec.com. The move is part of a global initiative begun in 2013 to make the product portfolios of both Allied and its sister company, United Kingdom-based RS Components, available worldwide.

"When complete, more than 75% of our part numbers will be visible around the world," said Frank Cantwell, Allied's vice president of product management. "This initiative began in 2013, when we expanded the product line of TE Connectivity, and advanced even further this past summer, when we added more than 16,000 products from eight suppliers. Now we take another step forward with this, our latest expansion, making more than 52,000 new products available to our customers in 2014."

Suppliers expanded in this latest phase include: Schneider Electric, Microchip, ST Micro, Siemens, SMC, 3M, Bourns, Nichicon, Epcos, Kemet, ABB, and Vishay.

Cantwell said Allied plans to announce additional expanded lines every six to eight weeks.

"Once this expansion is completed, our customers will have access to more of the parts and products they need than ever before," he said. "It's an exciting initiative, and one that will certainly increase our profile as a global company with a local presence." ■

DESIGN NOTES

Surge Stoppers Ease MIL-STD-1275D Compliance

Design Note 534

Dan Eddleman

Introduction

A military vehicle is a tough environment for electronics, where the potential for damaging power supply fluctuations is high. U.S. Department of Defense MIL-STD-1275D sets down the requirements for electronics when powered from a 28V supply, ensuring that electronics survive in the field.

MIL-STD-1275D compliance can be achieved by brute force, shunting high energy levels to ground using bulky passive components. This method does not guarantee power delivery to downstream electronics and can require replacing damaged protection components when they do their job. A more compelling solution is to use high voltage surge stoppers such as the LTC®4366 and LT®4363, which use series MOSFETs to limit the output voltage when faced with input voltage spikes and surges.

A surge stopper reference design for MIL-STD-1275D is available as Linear Technology demonstration circuit DC2150A-C. This board limits its output voltage to 44V when faced with input voltages as high as 250V, while providing 4A of current to the output in all circumstances except the ±7V ripple test, when the available current is reduced to 2.8A. In most circumstances, satisfying MIL-STD-1275D is as simple as placing this circuit in front of a 44V tolerant device. A certification report is available at www.linear.com/demo/DC2150A.

MIL-STD-1275D Requirements

MIL-STD-1275D defines a variety of supply variances, from steady-state operation to starting disturbances, spikes, surges, and ripple, and lays down requirements for each of these conditions in three separate "modes of operation":

- Starting mode: starting and cranking conditions
- Normal mode: nominal, fault-free battery supply
- Generator-only: a disconnected battery leaves the generator directly powering the electronics.

Table 1 compares the MIL-STD-1275D limits for normal mode and generator-only mode. This article focuses on generator-only mode since it is the most demanding.

Table 1. Selected MIL-STD-1275D Specifications in Normal Operating Mode and Generator-Only Mode

SPECIFICATION	NORMAL OPERATING MODE	GENERATOR-ONLY MODE
Steady State	$25V < V_{IN} < 30V$	$23V < V_{IN} < 33V$
Spikes	250V, Max. Energy = 15mJ	Same as Normal Operating Mode
Surges	40V Max., ~500ms, $R_{SOURCE} = 20m\Omega$	100V Max., ~500ms, $R_{SOURCE} = 500m\Omega$
Ripple	Magnitude ±2V	Magnitude ±7V

Steady State

In generator-only mode, the steady-state supply voltage is between 23V and 33V. In the simplified diagram in Figure 1, the LT4363 in combination with sense resistor R_{SENSE} limits the maximum DC current to 4A minimum/5A typical. This protects the system from faults that occur at the output and prevents blown fuses at the input.

Spikes

A spike is generally oscillatory (it rings) and decays to the steady-state voltage within 1ms. The envelope of the worst-case MIL-STD-1275D spike is defined by Figure 2 (for generator-only mode).

In Figure 1, the 250V spike condition is handled by MOSFET M1, rated to withstand over 300V from drain to source. During the –250V spike, diode D1 is reverse-biased, blocking the spike from M2 and the output. (The LTC4366 surge stopper withstands reverse voltages and the –250V spike without additional protection.)

Surges

Surges are transients that last longer than 1ms. Figure 3 shows the limitations for generator-only mode. The recommended test in MIL-STD-1275D specifies that five 100V pulses of 50ms duration should be applied at the system input with a 1s repeat time. The envelope of the surge condition shown in Figure 3 is more difficult to satisfy, as it does not return to 40V for a full 500ms. The solution shown satisfies both conditions.

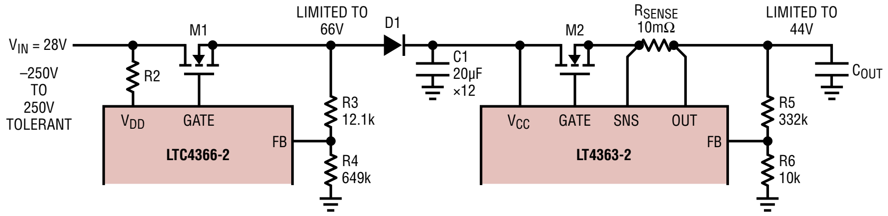


Figure 1. Simplified MIL-STD-1275D Circuit Diagram

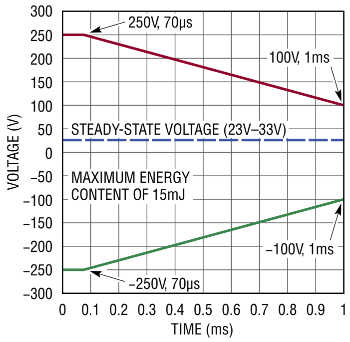


Figure 2. Envelope of Spike in Generator-Only Mode

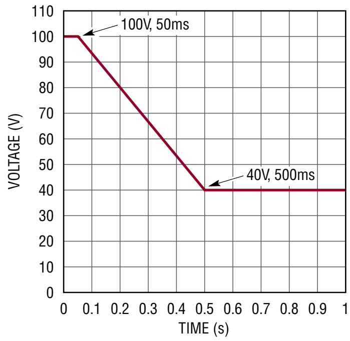


Figure 3. Generator-Only Mode Surge Envelope

During the input surge, M1's source is regulated to 66V by the LTC4366, while M2's source (and the output) is regulated to 44V by the LT4363. Compared to using a single MOSFET, this reduces the power that must be dissipated in the individual MOSFETs and increases power available at the output.

Ripple

Ripple refers to 50Hz to 200kHz oscillations of the supply voltage about its steady-state DC voltage. According to the specification in generator-only mode, the ripple can be as large as ±7V about the DC steady state voltage.

Diode D1 in combination with capacitor C1 forms an AC rectifier that prevents high frequency ripple components from reaching the output. Note that rising edges of the input ripple waveform attempt to pull up the output capacitor, causing the LT4363 to momentarily limit the current through M2. For this reason, the current available to the output load during the ripple condition is 2.8A, less than the 4A available during normal operation. More about the ripple condition and ways to improve this circuit behavior are described in *Linear Technology Journal of Analog Innovation*, Volume 24, Number 1, "High Voltage Surge Stoppers Ease MIL-STD-1275D Compliance by Replacing Bulky Passive Components."

Starting Mode

Voltage variations caused by the starter motor and cranking are described by MIL-STD-1275D starting mode—the supply voltage can drop as low as 6V before recovering to at least 16V within one second and the steady-state DC voltage within 30 seconds. The solution presented here typically functions at the 6V minimum. But it is only guaranteed to work to 8V due to component tolerances, the most significant being the loosely specified threshold voltages provided by MOSFET manufacturers.

Electromagnetic Compatibility Requirements

MIL-STD-1275D refers to another standard, MIL-STD-461, regarding electromagnetic compatibility. Typically, an EMI filter is placed at the input of MIL-STD-1275D compliant systems—while surge stoppers do not eliminate the need for filtering, their linear mode operation introduces no additional noise.

Conclusion

Linear Technology's surge stopper products simplify MIL-STD-1275D compliance by using MOSFETs to block high voltage input surges and spikes while providing uninterrupted power to downstream circuitry. Blocking the voltage with series components avoids the blown fuses and damage that can occur when circuits attempt to shunt high energy to ground with bulky passive components.

Data Sheet Download

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ideas for design

Drive Linear Regulator to 0-V Output with Single Supply

PETRE TZVETANOV PETROV | MICRO-ENGINEERING, SOFIA, BULGARIA ptzvp1@yahoo.fr

MANY ELECTRONICS CIRCUITS begin operation at voltages below 1.25 V. But popular adjustable regulators such as the LM317, LM350, and LM338 can provide output voltages only above 1.25 V, and the L200 minimum is higher at 2.85 V. Fixed-output regulators in the 78XX and LM29xx series start at 5, 3.3, 3.0, 2.85, or 2.5 V.

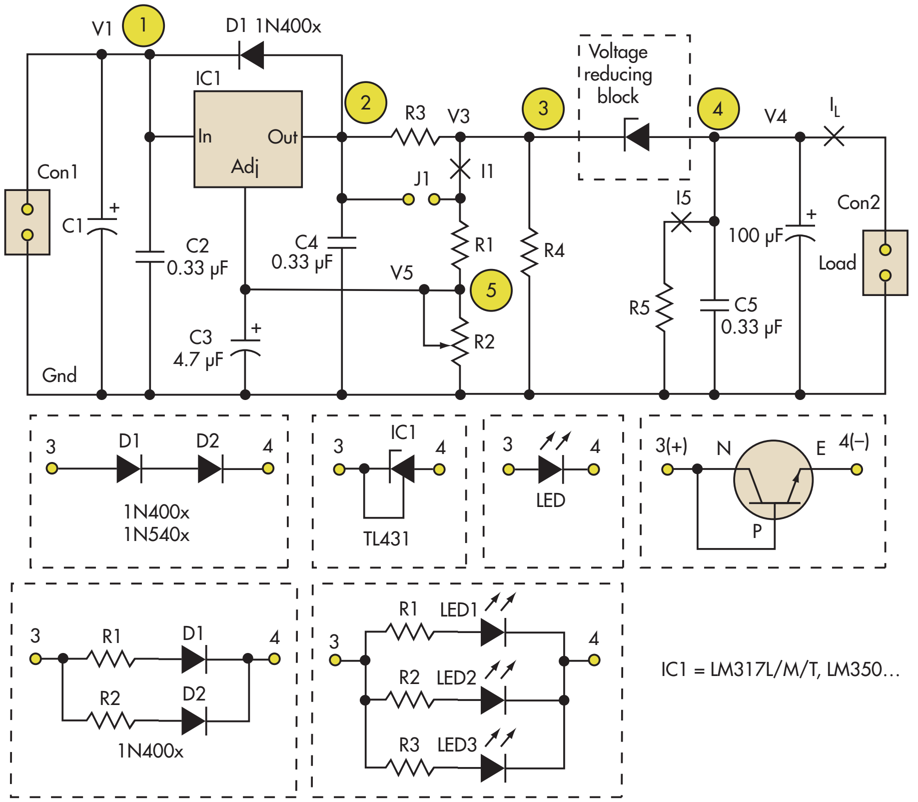
The approaches shown here allow you to provide near-zero and 0-V output (sometimes called "ground-level") from these regulators. There are two ways to achieve this: subtracting a reference voltage from the output of the regulator, or offsetting the voltage adjustment resistors of the regulator.

Figure 1 implements the first approach, where the reference source with voltage to be subtracted via a "voltage-reducing block" is connected between points 3 and 4 of the circuit. The choice is made according the required output current, voltage, and temperature stability. There is no need to subtract exactly 1.25 V or a similar voltage.

Among the components that can be used between points 3 and 4 are: one or more diodes (*e.g.*, 1N400X or 1N540X); one or more Schottky diodes (1N5819, 1N5822); reference diodes (LT1004-1.2, LM385-1.2, TLVH431, TLVH432, LM336-2.5, ADR512, LM4041c12); reference shunt regulators (TL431, LM431); Zener diodes (1.3 W series); LEDs (all colors or combinations, as their voltage drop and current ratings differ); and even transistors used as Zener diodes or as simple diodes.

Each of these solutions has advantages and drawbacks. For example, with the TL431 you can achieve 100-mA output current and good temperature stability. (In that case, voltage V3 at point 3 should start at 2.5 V.) R1 and R2 are standard voltage adjustment resistors for regulators such as the LM317 and LM350.

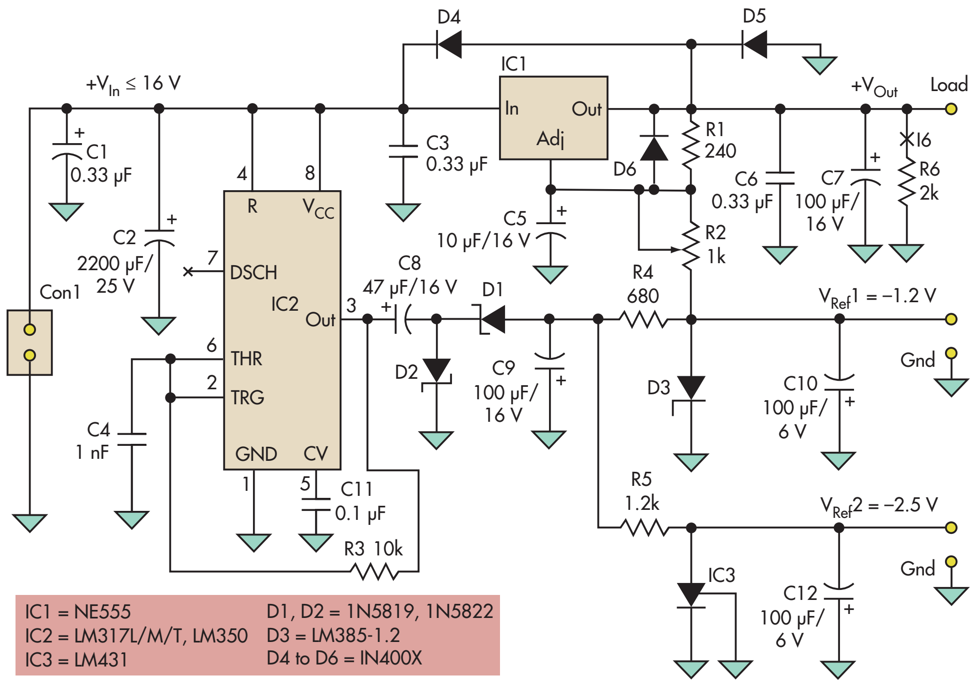
R3, R4, and R5 are optional. R3 is a current-limiting resistor, which can be eliminated if not needed and replaced by a jumper J1. R4 can provide the minimal load current for the regulator IC1. Most often, R1 and R2 provide that current, but that is not required and is not always a good option. R5 can provide the minimal load



1. There are various ways to implement an active "voltage reducing block" at the output of a regulator that subtracts from the reference voltage to bring the output down to ground potential.

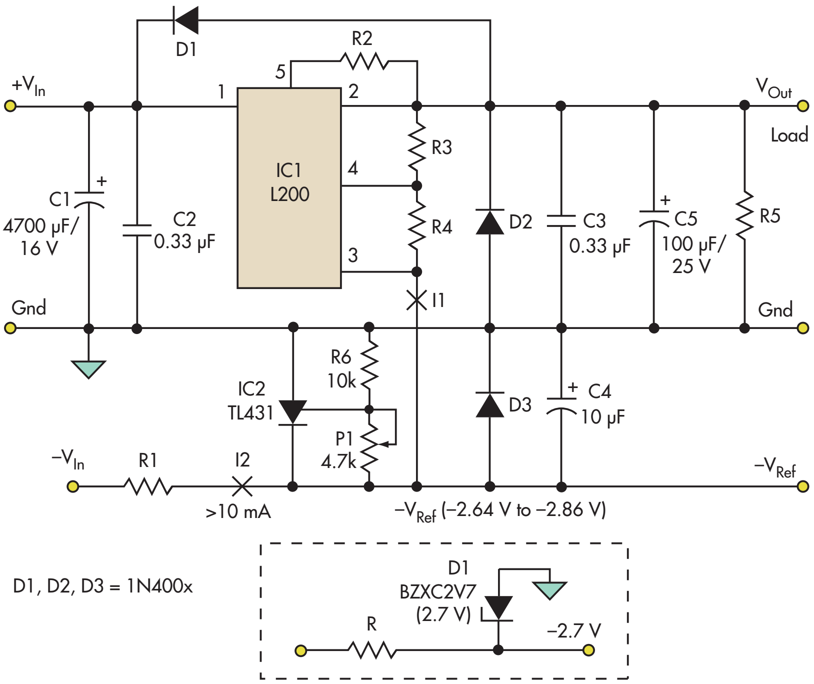
current for the regulator IC1 and/or the minimal current for the subtracting element connected between points 3 and 4.

The second approach is useful where circuits operate from a single power supply, such as 6-V or 12-V rechargeable batteries, and the input power supply is usually limited to around 16 V *(Fig. 2)*. In these cases, you reduce and offset the output voltage of the LM317x by offsetting the voltage-adjustment resistors.



2. For situations where the supply rail is positive and limited, a passive approach using resistors is an alternative to the active techniques from Fig. 1.

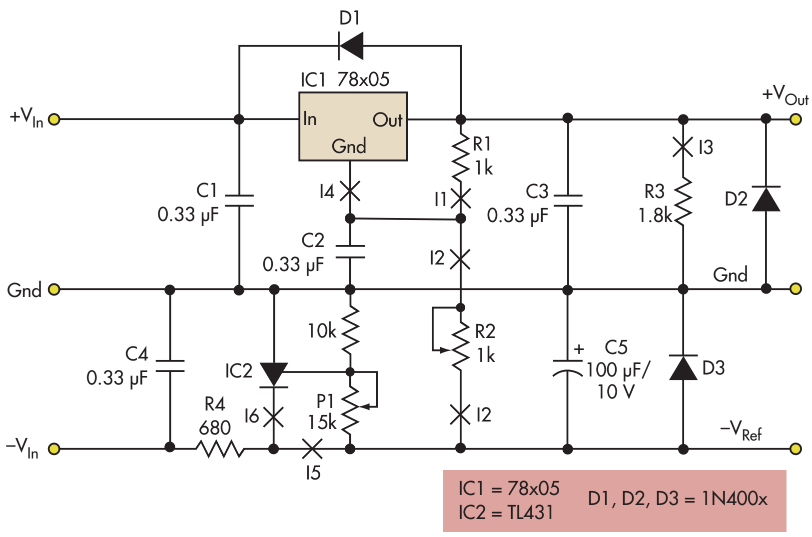
An NE555 and associated components can be used to produce a negative voltage. Here, it produces –1.2 V for the offset of LM317x and –2.5 V for the analog circuits in the system. The working frequency of the oscillator is usually set between 20 kHz and 200 kHz. D1 and D2 should be fast-switching diodes with low-voltage drop such as the 1N5819 or 1N5822. D3 is a voltage-reference or parallel voltage regulator providing the offset, such as the LM385-1.2 V. Resistor R6 is optional. It provides most of the minimal load current for IC1, if needed.



3. For adjustable regulators such as the L200, a shunt regulator acts as an active voltage reducer while a potentiometer allows careful adjustment to the desired voltage value.

In *Fig. 3*, a shunt regulator such as a TL431 drives the output of the adjustable L200 regulator to ground. It should be rated at 10 mA or more to sink the current from the L200. Trimming potentiometer P1 provides appropriate bias voltage for the L200. Also, $-V_{Ref}$ should equal the internal voltage of the L200, which is specified to be between 2.64 V and 2.86 V. Resistors R2, R3, and R4 are calculated according to the datasheet and the application note for the L200.

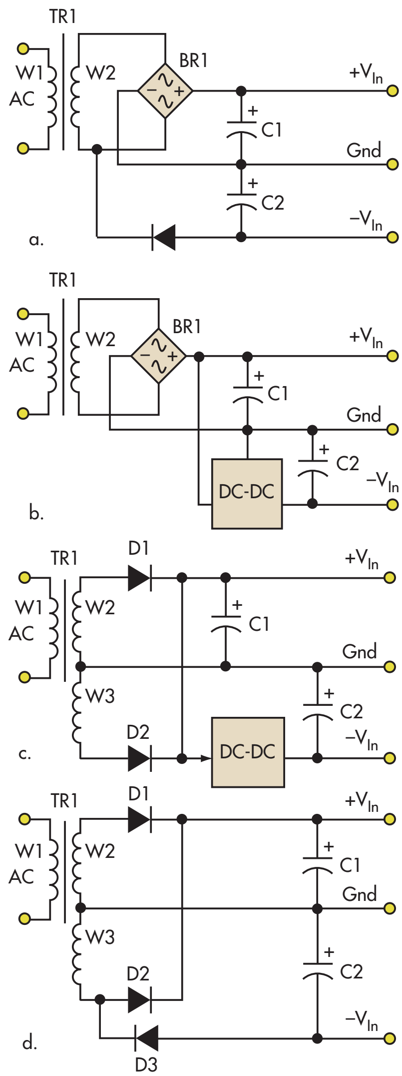
This method also can be applied to adjustable regulators of the 78xx series *(Fig. 4)*. Trimmer P1 is used to make the reference voltage $-V_{Ref}$ equal to the output voltage of 78X05 and thus yield output voltage $+V_{Out}$ close to ground. R2 adjusts output voltage $+V_{Out}$ to the required value between ground and +5 V. For other output-voltage ranges, change the values of R2 and R1. Also, a fixed resistor can replace potentiometer R2.



4. A similar approach works with the 78XX family, but requires a change in the details of the circuit topology.

Figure 5 provides several ideas for generating the negative voltage needed to offset the ground or regulation/adjustment pins of the regulators, using the NE555 or other methods..

PETRE TZVETANOV PETROV is an electronics engineer with Micro-Engineering, Sofia, Bulgaria. He has worked as a researcher and assistant professor at Technical University, Sofia, and has been an expert lecturer at OFPPT, Casablanca, in the Kingdom of Morocco.



5. If a negative voltage is needed, there are various common techniques to generate negative dc rails from an ac supply, including a full-wave bridge plus additional diode (a), a full-wave bridge plus negative dc-dc converter and regulato (b), a half-bridge plus negative dc-dc converter and negative regulator (c), and a half-bridge plus diode pick-off (d).

Sound-Card Signal Generator Interface Adds Variable Offset Control

AJOY RAMAN | BANGALORE, INDIA ajoyraman@gmail.com

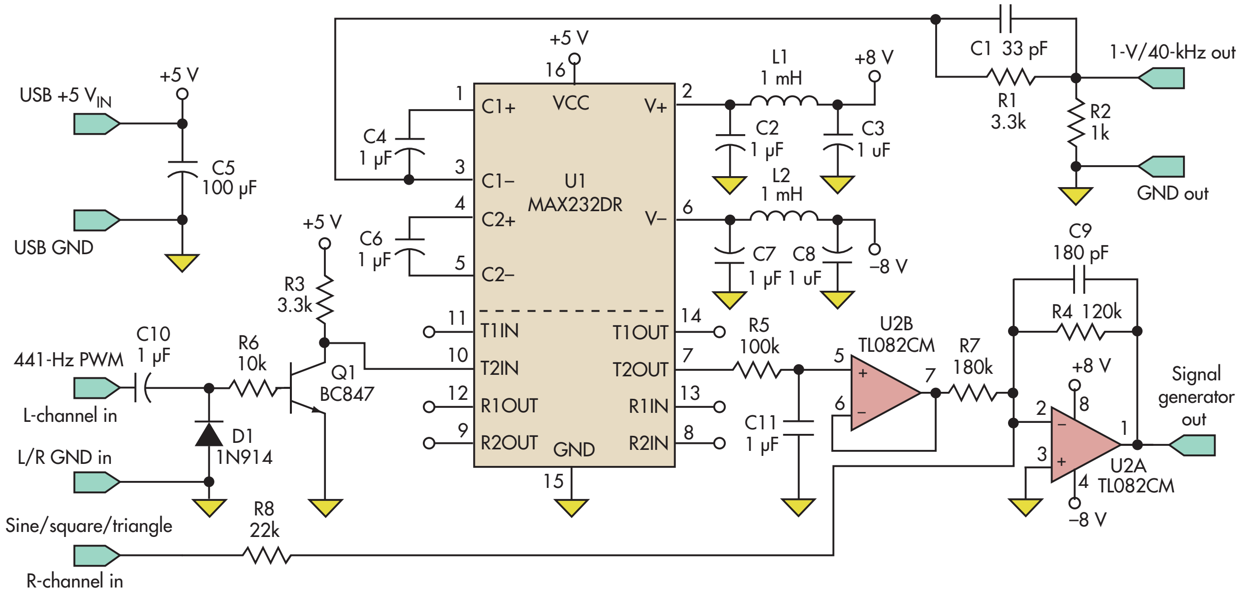
A PERSONAL COMPUTER (PC) sound card can be the basis for a readily available signal generator for testing electronic circuits. The usefulness of these signal generators is limited, however, because their outputs are ac coupled and restricted to ±2 V.

This circuit takes advantage of the two channels provided by the sound card by using one channel to output the sine/square/triangle waveform with a fixed gain while setting up a 441-Hz pulse-width modulated (PWM) square wave on the second channel. This PWM waveform is converted to ±8 V, then averaged and summed with the first channel, to provide an adjustable dc offset that is controllable by the duty-cycle setting.

The circuit provides a variable offset of typically ±5 V at the signal generator output *(Fig. 1)*. It is powered from the PC's USB +5-V supply, which is converted by the capacitive voltage generator within dual driver/receiver IC U1 to ±8 V (typical) to power the low-power dual op-amp U2.

Passive pairs L1/C3 and L2/C8 filter out the ripple on the V+ and V– outputs of U1. The 441-Hz PWM waveform output on the sound-card left-channel is clamped by the C10/D1 combination and fed through R8 to the base of transistor Q1. This produces a TTL-compatible (transistor-transistor logic) square wave at the collector of Q1, which is fed to T2IN of U1.

T2OUT provides a ±8-V PWM waveform that is averaged by filter R5/C11 and buffered by U2B to generate a dc



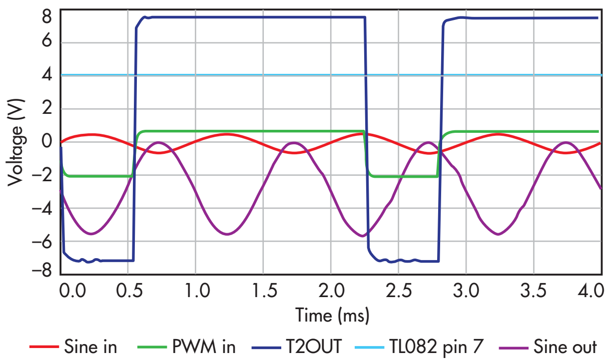
1. By using the second channel of a standard PC sound card to provide a dc offset via a filtered PWM waveform, this circuit overcomes the limitations of using these cards as low-cost function generators.

voltage depending on the PWM duty cycle. This voltage is summed along with the sine/square/triangle waveform output on the sound-card right channel by U2A, forming the signal-generator output.

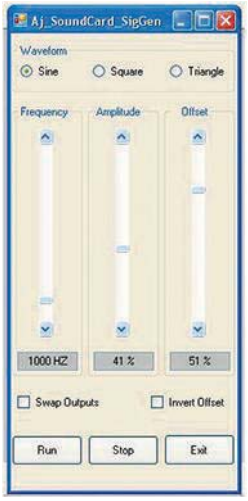
The C9/R4 pair forms a low-pass filter to smooth the quantized signal generated by the sound card. With the values of the components shown, the right channel is amplified by a fixed gain of +5.5 and the dc offset variation is typically ±5 V.

The 75% duty-cycle PWM input signal is converted to typically ±8 V at T2OUT and, when averaged, produces approximately 4-V dc at pin 7 of U2B *(Fig. 2)*. The 0.5-V sine wave is amplified and offset by the inverting summing amplifier U2A to form the signal-generator's output.

This design removes the limitations of ac coupling and the ±2-V signal level limit. It also provides a bonus output by dividing the output at U1 pin 3, using R1/R2 to provide a 1-V, 40-kHz square wave that can be used for step-response testing of analog circuits. Graphical user interface (GUI) software developed in VB.Net is also available with the online version of this article at electronicdesign.com *(Fig. 3)*.



2. Key waveforms in the circuit are the output from one channel of the sound card (here, a 1-kHz bipolar sine wave); the PWM output, also from the sound card; the amplified PWM signal; the filtered and averaged PWM output; and the sine-wave output, now with negative dc offset.



3. The associated VB.Net code provides an easy-to-use PC graphical interface for setting the function generator's critical parameters.

AJOY RAMAN (www.ajoyraman.in) is retired, having 37 years of R&D experience with the aeronautical development establishment in Bangalore, India. He has BTech and MTech degrees in electrical engineering from IIT Madras, India, and now pursues his love of electronics as a full-time hobby, with an emphasis on projects and low-cost teaching aids for students. He has received the Siemens prize for best academic record (M.Tech IIT, Madras), the Dr. V.M. Ghatge Award from the Aeronautical Society of India, and the DRDO Scientist of the Year Award. He can be reached at ajoyraman@gmail.com.

Sensor Dev Kit Features Multi-Hop Network Protocol

ANALOG DEVICES' wireless sensor out-of-the-box development kits enable engineers to establish a working system in as little as 15 minutes to report and remotely analyze sensor data, including temperature, humidity, and motion/vibration. The kits include two multi-sensor node boards, a basestation connector, an emulator platform, and a full-featured software package. The sensor

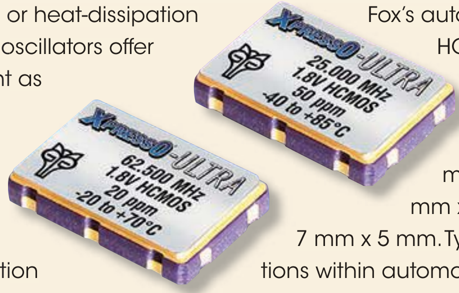
boards include an integrated RF transceiver, an ARM Cortex M3 microcontroller, and a variety of sensor elements such as a triple-axis accelerometer. The software suite includes ADRadioNet, a scalable, low-power, multi-hop wireless communications network protocol with an extremely small code footprint. The kits are ideal for manufacturers of industrial equipment to incorporate IoT connectivity and big data into products.

ANALOG DEVICES

www.analog.com

HCMOS Oscillators Offered in a Variety of Sizes

THE 1.8-V HCMOS XpressO-ULTRA oscillator developed by Fox Electronics can be used in high-component-density applications with limited power options or heat-dissipation concerns. The oscillators offer stability as tight as ±20 ppm, and a frequency range of 0.016 to 62.5 MHz with frequency resolution to six decimal places. They also feature low jitter in highly dense electronic environments. Voltage levels match that of modern chip sets for easier integration. Package size is 5 mm by 3.2 mm, with an operational temperature range from -40 to 85°C.



Beyond the standard size, Fox's automotive-grade HCMOS oscillators now include three additional sizes: 2 mm x 2.5 mm; 5 mm x 3.2 mm; and 7 mm x 5 mm. Typical applications within automotive electronics systems include in-cabin electronics and proximity sensors for backup cameras and parking assistance.

FOX ELECTRONICS

www.foxonline.com

Flexible Interscale Case Platform with Enhanced Schroff Cabinets

SPECIALISTS IN the electronics protection arena, Pentair brought focus to its Interscale case platform and Schroff configurable cabinets at Electronica 2014 last month. Also receiving the top billing were its MicroTCA and AdvancedTCA systems, subracks, and electronics cabinets. Engineers wrangling with non-standardized or small-form-factor designs can take advantage of the

Interscale standard, modified, and fully customized case options. At the show, the company demonstrated its online Interscale M configurator, which facilitates design of individual cases for prototyping and production quantities. In addition, the company made strides with its AdvancedTCA system—its ATCA 450/40 now includes smaller systems with front-to-back cooling. A new 48-V dc version of the two-slot ATCA system unveiled at the show achieves up to 450-W cooling per slot. On another front, upgrades to the Schroff Varistar and Novastar 19-in. cabinet platforms usher in the three-level service concept—standard, modified, and fully customized. Thus, individual cabinets can be configured to satisfy requirement of many applications.

PENTAIR

www.pentair.com

CSR Mesh Utilizes BLE to Network Devices

ATLANTIK ELEKTRONIK'S CSR Mesh aims to place smartphones at the center of the Internet of Things (IoT), allowing for an almost unlimited number of Bluetooth Low Energy (BLE) enabled devices to be networked together and controlled directly from a single smartphone, tablet, or PC.

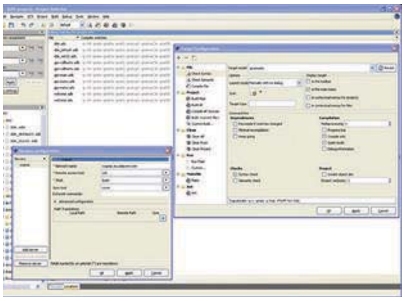
Optimized for smart-home and IoT applications, CSR Mesh doesn't have the limited range or required hub of similar technologies. Its protocol uses BLE to send messages to other BLE-enabled devices in the network, which in turn send them onward. Messages can be addressed to individual devices or groups of devices, and devices can belong to more than one group. The CSR Mesh development kit will include evaluation boards, Android and iOS application source code, and access to binary CSR Mesh libraries.

ATLANTIK ELEKTRONIK

www.atlantikelektronik.de/en/

eXtremeDB IMDS Shows Compatibility with GNAT Pro Tools

MCOBJECT ANNOUNCED that its eXtremeDB In-Memory Database System (IMDS) has been tested and proven compatible with AdaCore's GNAT Pro Ada development environment. AdaCore's tools and the Ada language are suitable for use in real-time and embedded systems that require safety, security, and reliability. GNAT Pro supports mixed language development, which enables programmers to easily interface between Ada and other languages such as C, C++, Java, and Python. The system is used in applications that require low latency, maximum up-time, and predictability. By leveraging eXtremeDB with GNAT Pro, developers should be able to achieve another level of speed.



MCOBJECT

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PCI Express Mini Cards Decrease CPU Loading

THE MPCIE-ICM Series of PCI Express Mini Cards from ACCES I/O Products are designed for use in harsh and rugged environments, such as military and defense applications. The isolated serial communication cards measure 30 by 51 mm and feature four or two ports of isolated RS-232 communications. Their 1.5-kV isolation is provided port-to-computer and 500-V isolation is provided port-to-port on all signals at I/O connectors. Tru-Iso port-to-port and port-to-PC isolation is also included. Designed using type 16C950 UARTs, the cards employ 128-byte transmit/receive FIFO buggers to decrease CPU loading and protect against lost data in multitasking systems. The ±15-kV ESD protection on all signal pins protects sensitive electronic devices from electrostatic-charge damage.

ACCES I/O PRODUCTS

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6-in-1 Oscilloscope Debugs Virtually Any Embedded Design

TEKTRONIX'S MDO3000, a 6-in-1 oscilloscope, includes a spectrum analyzer, logic analyzer, protocol analyzer, arbitrary function generator, and digital voltmeter to test and debug virtually any embedded design. The company also offers the TBS1000B-EDU series of oscilloscopes that feature an integrated courseware system designed to help students learn more effectively. With the courseware, instructors can make their lab exercise content viewable on the oscilloscope. Therefore, students can capture results straight from the instrument.

Recently enhanced with the High Power Interface Panel Model 8020, the Keithley Parametric Curve Trace Configurations on the 2600-/4200-PCT Series delivers results for high-power semiconductor I-V and C-V testing. Adding the 8020 expands I-V and C-V characterization solutions via high power I-V and high-voltage C-V at wafer level. The Keithley Precision Measurement Power Supply 2280S Series offers a large dynamic range, 100-nA current measurement resolution, and a graphical user interface that lets designers test power consumption for portable devices.

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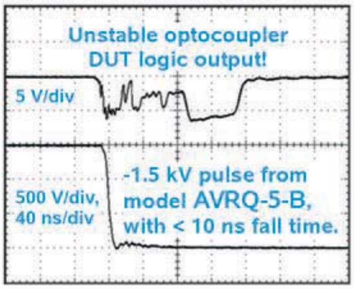

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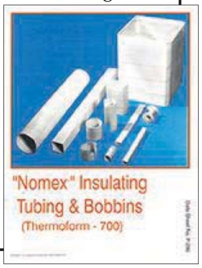

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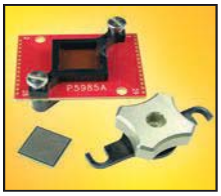

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System Simulation Requires Cooperation

Simulation allows evaluation of a system without having an actual system available. This is becoming more important as system complexity grows and time-to-market shrinks.

Simulation has become a requirement for ASIC development. The cost of creating an actual chip is high as is the turnaround time to make corrections. A chip needs to work the first time. Chip simulation allows designs to be tested before they hit silicon.

The challenge is not just making the transistors work, because the software needs to work as well. Instruction-set simulators can provide cycle accurate simulation that is significantly faster than a low-level simulation. Peripheral simulation is important for embedded applications and the latest crop of simulators makes this possible, taking developers closer to the final system.

WHOLE-SYSTEM SIMULATION

Churning out prototypes is much easier these days with low-cost FPGAs and 3D printers. Still, simulation is faster and cheaper. It is much better to rebuild a simulated device and retest it. Here, the challenge is providing sufficient fidelity so that the simulation provides an accurate rendition of the end environment.

This approach has been used in large projects such as aircraft design. The cost can be justified because in the long run it is significantly more economical. In general, the simulation issues are related to software and the hardware that runs this software. The costs of both are going down as the performance is increasing, making it more practical to use by more designers.

For example, Dura Automotive Systems used Dassault Systemes' Solidworks design tools and the Simulia simulation system to design and simulate sliding French salon doors for a car (*see the figure*). The simulation addressed the mechanical, electrical, and software environments.

The design was a challenge from a mechanical, electrical, and software perspective. The doors needed to be lightweight and have no external tracks. They have a 20% wider egress opening than conventional doors, along with a 40% weight reduction. The system employs a hands-free command system with an advanced obstacle detection system. Dura's aluminum door design includes glass fiber reinforced composites.

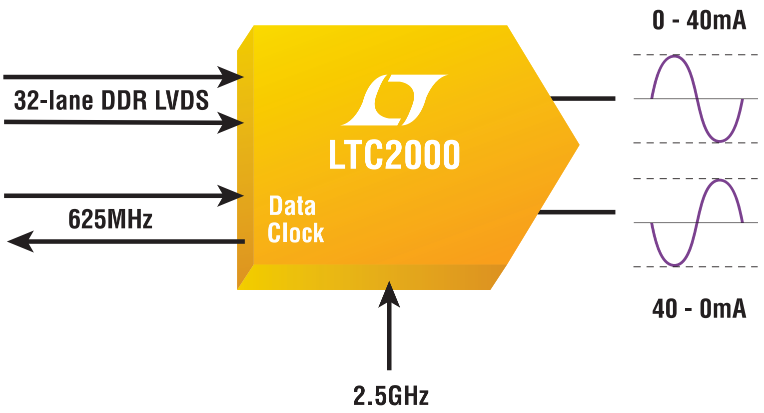
The simulation environment allows testing of the mechanical aspects through the software and sensors that control the door. A simulated person allows repeated obstacle testing. It can guarantee that the system meets consumer and government requirements prior to physical testing.

Physical testing is still required but if the majority of tests can be simulated instead, then costs can be significantly reduced. Simulations can also be faster and done in parallel, thereby allowing more testing.

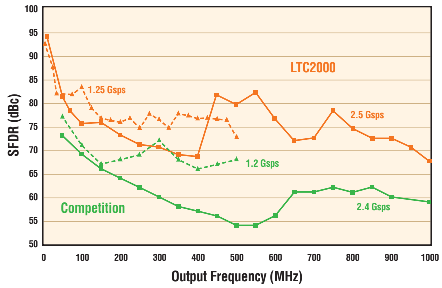
The use of simulation continues to grow as does the range and fidelity of the simulated environment. New embedded application areas like wearable technology will benefit from more robust physical and software simulation. The question will be whether simulation will be sufficient to reduce the amount of physical certification required for products. ed

Dura Automotive Systems used Dassault Systemes' Solidworks design tools and the Simulia simulation system to design and simulate the sliding French doors including the mechanical, electrical, and software environment.

16-Bit 2.5Gsps DAC



LTC2000 SFDR vs Output Frequency



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- 9mm x 15mm 170-Pin BGA Package

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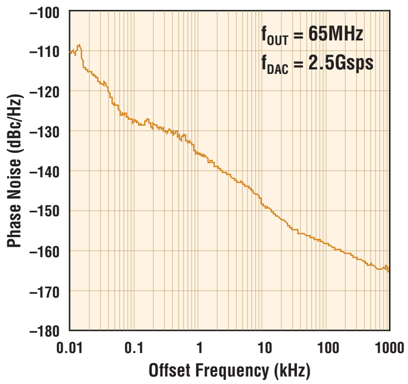

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