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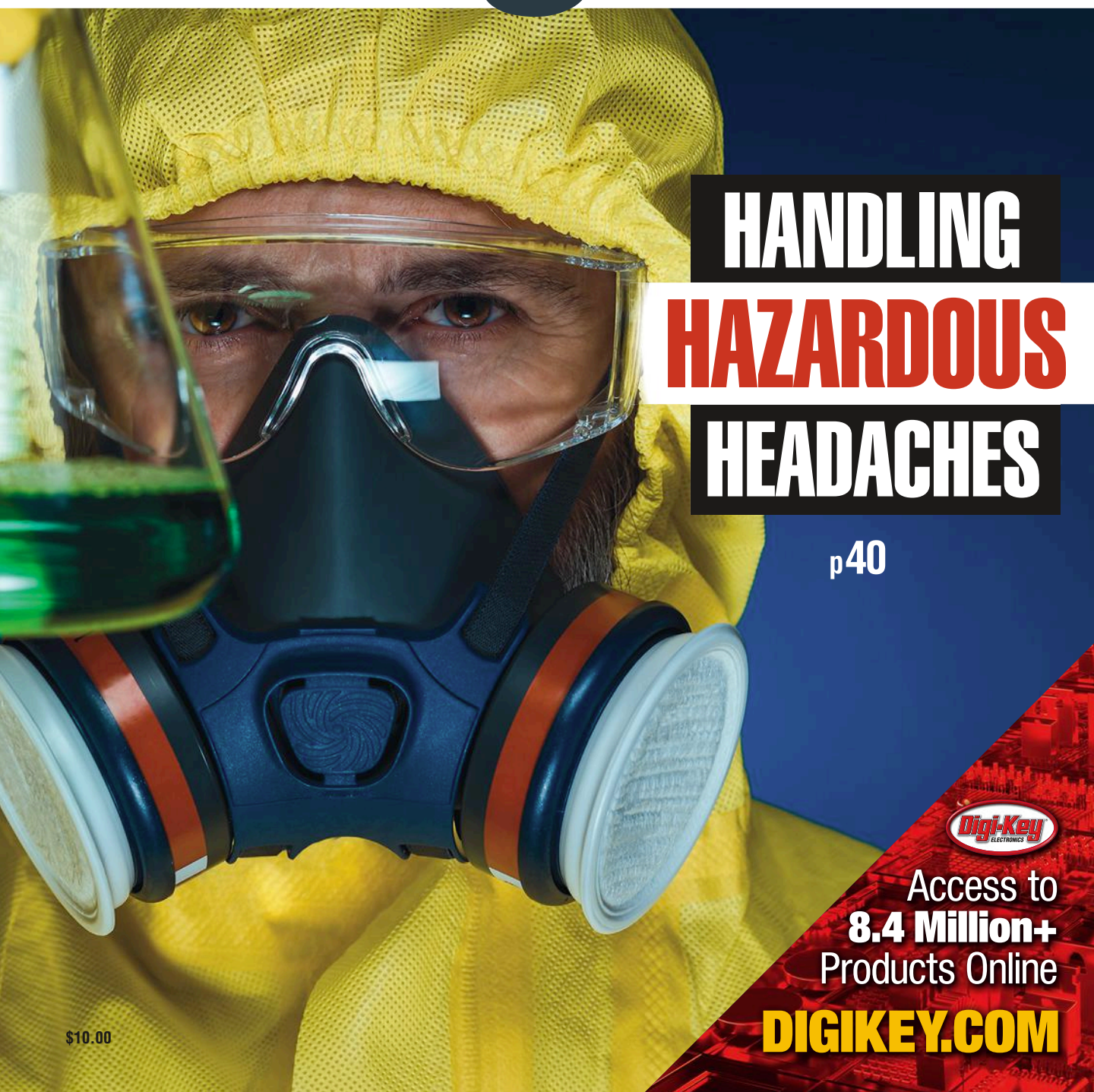

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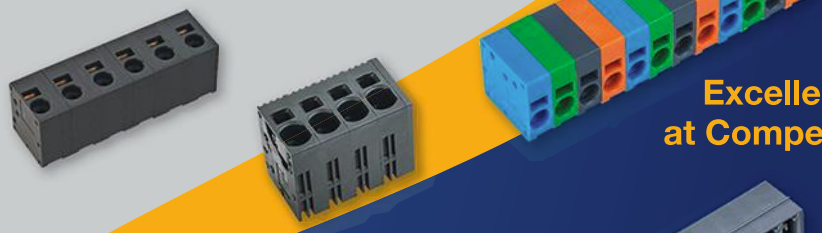

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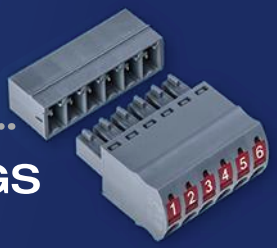

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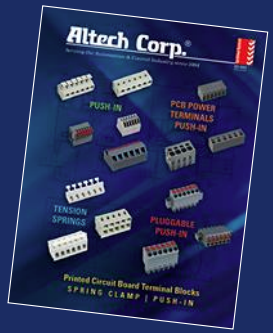

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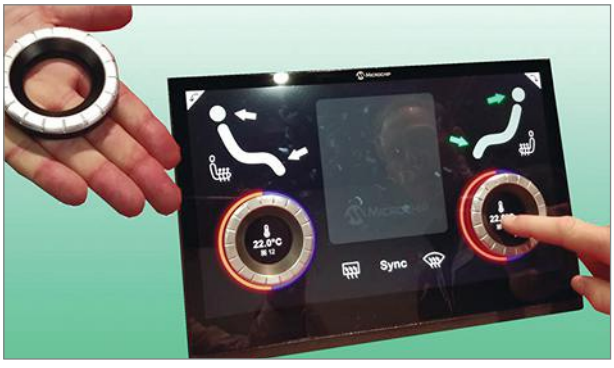
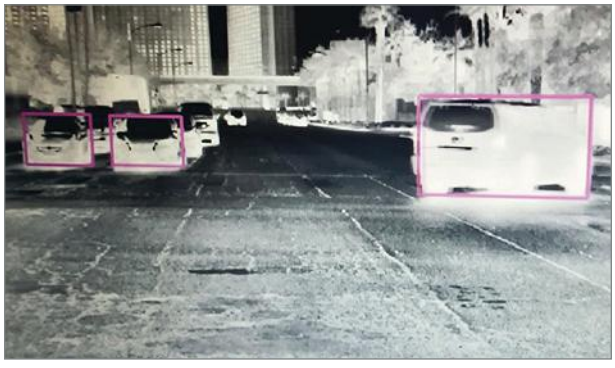


Mechanical Marvels Make Their Mark at CES

The Consumer Electronics Show is all about electronics, but sometime devices need to be a bit more creative mechanically. Senior Technology Editor Bill Wong takes a look at some of this year's standouts.

https://www.electronicdesign.com/industrial-automation/mechanical-marvels-make-their-mark-ces



All Roads Led to CES for the Latest Vehicle Tech

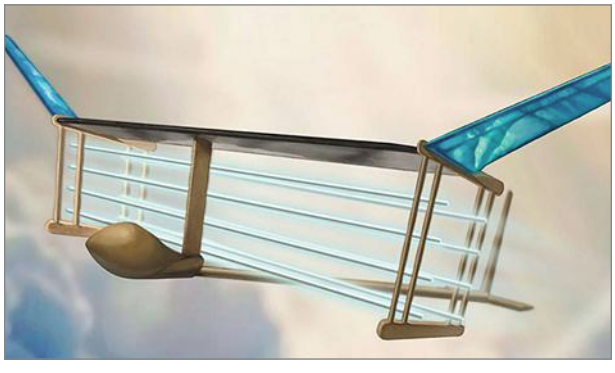
Plenty of new automotive innovations, from thermal imaging to a robotic suitcase, were on display at this year's Consumer Electronics Show, drawing lots of traffic among the attendees.

https://www.electronicdesign.com/automotive/all-roads-led-ces-latest-vehicle-tech

5 Tech Predictions for 2019: Entering the Decade of Disruption

From AI to healthcare to the unleashing of IoT, Screaming Circuits' Duane Benson offers up his take on what will be major technology/market disrupters over the next 10 years.

https://www.electronicdesign.com/industrial-automation/5-tech-predictions-2019-entering-decade-disruption



Ion-Driven Model Aircraft Flies without Moving Parts

Disproving the "it can't be done" conventional wisdom, an MIT team has built and flown an aircraft with 5-meter span that's powered by a silent ion-based sonic wind operating at 40 kV.

https://www.electronicdesign.com/power/ion-driven-model-aircraft-flies-without-moving-parts

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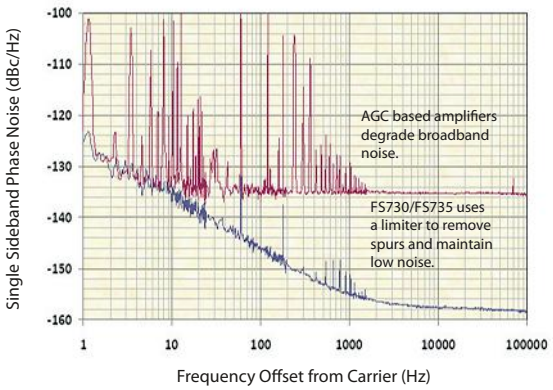

Additive phase noise in 10 MHz Distribution Amplifiers: Limiter vs. AGC Designs

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Editorial

WILLIAM WONG | Senior Technology Editor
bill.wong@informa.com

Addressing the Growing Complexity of Embedded Systems

Embedded-system design has never been more exciting and challenging. New technologies ranging from 5G to PCI Express Gen 5 to the increased use of machine learning (ML) and artificial intelligence (AI) give developers more choice and more decisions to make, let alone learn.

Dealing with new technologies has always been the bane and allure of embedded systems. The problem these days is that other aspects, such as safety, security and privacy, are part of the puzzle as well and can't be overlooked. These aspects are no longer optional or uncommon design issues. Almost every system design must address them. It means not doing dumb things like putting a backdoor in a device or assuming an end-user license agreement (EULA) will protect a company when technology errors occur after products are in the field.

Code quality is also becoming critical to all types of embedded systems, not just those dealing with safety- and security-related products like military, avionics, or medical. There's increased interest in programming languages like Rust and Ada/SPARK for general embedded applications, and C and C++ developers are using tools like static analysis more frequently to improve code quality. This is more arduous, though, because C actually makes it difficult for these tools to provide the level of checking supported by other languages.

Program size and performance are still important, but it's easier and often more cost-effective to buy more memory or performance for most embedded applications. Trying to squeeze the last byte out of storage or use all of a system's potential bandwidth is typically a fool's errand.

Live Planet's virtual-reality 360-degree camera for video conferencing uses NVIDIA's Jetson TX2 to knit video streams from 16 4K cameras.

Developers should also take advantage of improvements in simulation, test, and measurement. Many of these new or improved tools will address new technologies like 5G and PCIe 5, but a host of existing tools are becoming more readily available and economical. Simulation systems can also expose more debugging information that's not available on physical systems.

Platforms like GPGPUs, ML/AI accelerators, and eFPGAs are changing the playing field. NVIDIA's Jetson TX2 enables products like Live Planet's virtual-reality video-conferencing camera that knits together video from 16 4K cameras *(see figure)*. The newer Jetson AGX Xavier includes even more advanced ML/AI acceleration that improves performance by a factor of 10. This represents just one example of the magnitude of performance increase for new hardware.

Performance disruptions aren't the only trend. The growth of RISC-V is disrupting Arm's dominance of the embedded and custom SoC designs even while Arm is pushing into the enterprise and cloud, again.

Unfortunately, this industry has other disruptions that aren't related to technical advances. Political changes, tariffs, and so on are putting a damper on availability and sales. Distribution-chain considerations may now be a bigger part of the design process.

Then again, if dealing with all of this change was easy, then anyone could do it. ed

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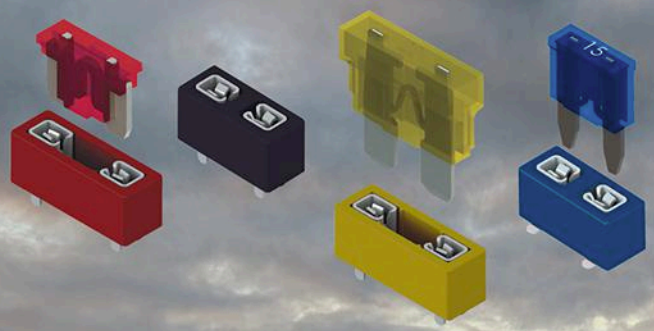

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News

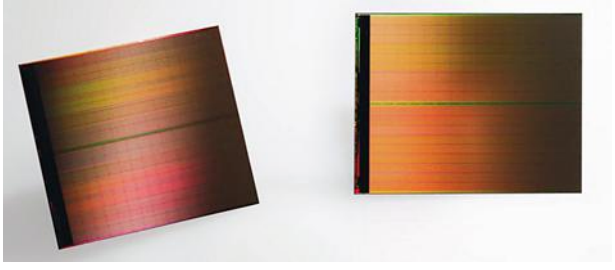
MICRON MOVES AHEAD WITH Plans to Take Over IM Flash Technologies

Micron Technology is moving forward with plans to take over the IM Flash Technologies business it founded with Intel in 2006. In October, the company said that it planned to spend $1.5 billion to buy Intel's 49% stake in the joint venture, which is responsible for the development and manufacturing of 3D XPoint memory chips.

Micron recently announced that it had exercised its right to take over Intel's share in IM Flash Technologies, which currently employs around 1,700 people. IM Flash will continue supplying Intel with XPoint memory wafers for a year after the deal closes. The terms of the agreement mean that Intel can close the deal at any point before January 14, 2020.

"The IM Flash acquisition will enable Micron to accelerate our R&D and optimize our manufacturing plan for 3D XPoint," said Micron chief executive officer Sanjay Mehrotra, adding that it will "provide us with the manufacturing flexibility and highly skilled talent to drive 3D XPoint development and innovation, and to deliver on our emerging technology roadmap."

After building the second generation of the XPoint technology together in the first half of 2019, Intel and Micron plan to stop collaborating on future developments. That also means independently funding future XPoint memory nodes. (Last year, the companies also announced that they would discontinue their joint development of NAND flash memory.



XPoint is designed with thin columns of memory cells stacked tightly in a crosshatch pattern, allowing the cells to be accessed independently, resulting in lower latency and higher endurance versus NAND flash. The memory is also nonvolatile, meaning that it can save information even after power is cut. That contrasts with chips based on DRAM, which is erased without constant power but can be altered and accessed faster than XPoint.

Micron plans to release chips based on 3D XPoint technology in 2019, while Intel introduced its Optane persistent memory product line last year. Intel is building memory controllers into its latest Cascade Lake and Cooper Lake server chips to support Optane, which could challenge DRAM as main memory in data centers. The Santa Clara, California-based company has some high-profile customers, including Google. ■

ENERGY-HARVESTING CHIP Startup Funded by Amazon Web Services

WILIOT, WHICH IS building Bluetooth chips that can be powered by ambient radio frequencies, has raised $30 million in funding from Qualcomm Ventures, Samsung Venture Investment, Avery Dennison, and Amazon Web Services, among others, as it moves closer to entering production. The funding increases the company's total to $50 million since it was founded in 2017.

The chips can be slapped on tags as small as a fingernail, as thin as a sheet of paper and that incorporate sensors. According to Wiliot, the devices can broadcast data such as location, weight, and temperature over Bluetooth. Wiliot's technology lets them communicate with smartphones or other Bluetooth devices using energy harvested from Wi-Fi, cellular, and Bluetooth—no batteries required.

The sensors can be used in all sort of devices unconnected to the Internet of Things, ranging from spare parts in a manufacturing plant to the packaging around consumer goods. The sensors could be pasted on products during production to track them from the factory to the warehouse to the store. They could also replace clothing tags, giving customers the ability to scan for more details.

Wiliot, which has around 40 employees and is based in San Diego, Calif., is the second company founded by the team behind semiconductor startup Wilocity. The company raised roughly $100 million in investment to build chips based on the next-generation WiFi standard—more commonly called WiGig—targeting the PC and peripherals markets. Qualcomm bought it for around $400 million in 2014. ■

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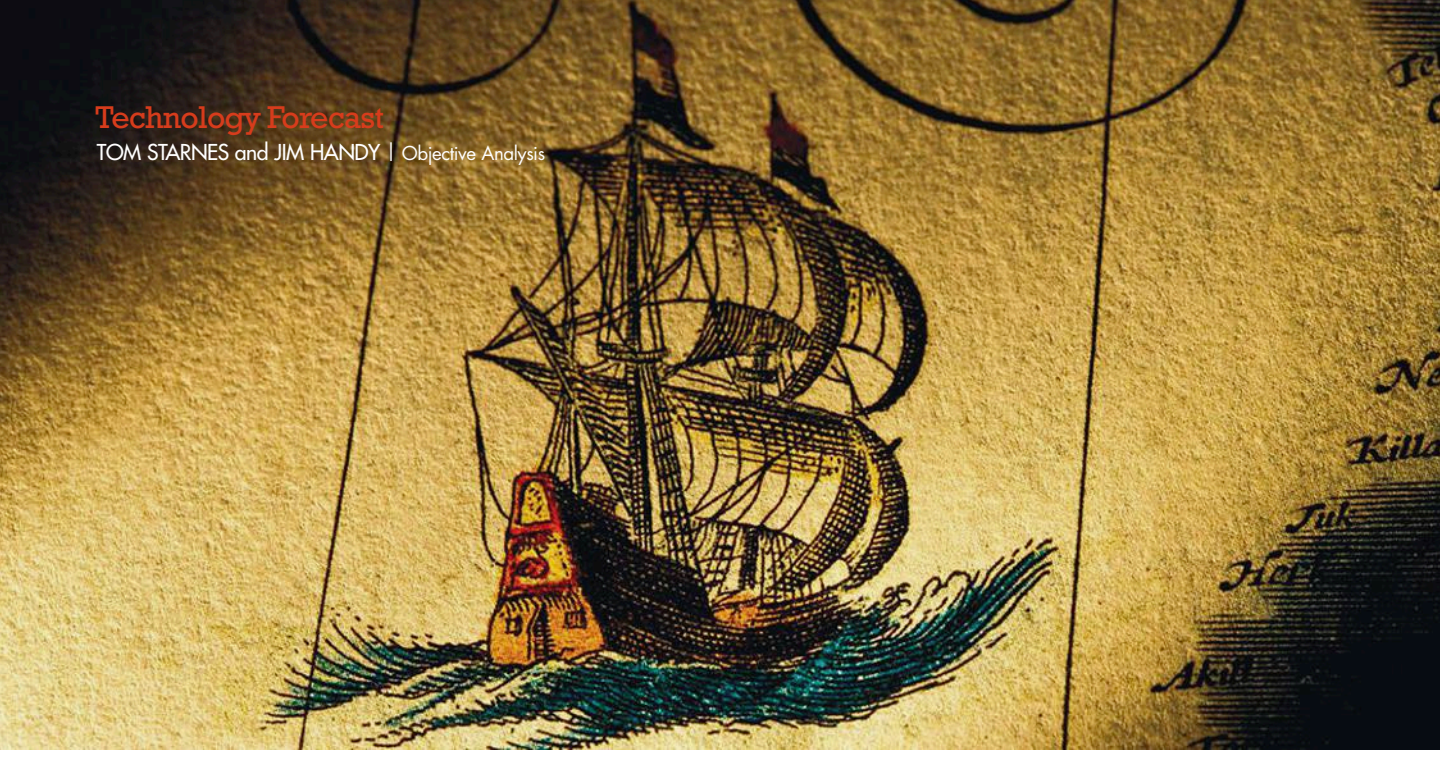


Technology Forecast

TOM STARNES and JIM HANDY | Objective Analysis

The Digital World
Faces Uncharted Waters, Too

How should one operate in the current political, social, and economic climate while keeping pace with technological change? Objective Analysis highlights issues facing the industry as a new year begins and gives a glimpse of familiar basics in a market forecast.

As 2018 came to a close, the economy in the United States continued to be strong (the roller-coaster stock market withstanding). Employment is officially high, but many people are under-employed and salaries and wages generally haven't risen with the cost of living. The U.S. Federal Reserve kept the prime lending rate near zero for seven years to stimulate the economy with low-cost lending, only raising it in December 2015. Through 2017 and 2018, the rate rose to 2.25%, pushing residential mortgage rates to nearly 5% from a prior low of near 3.5%.

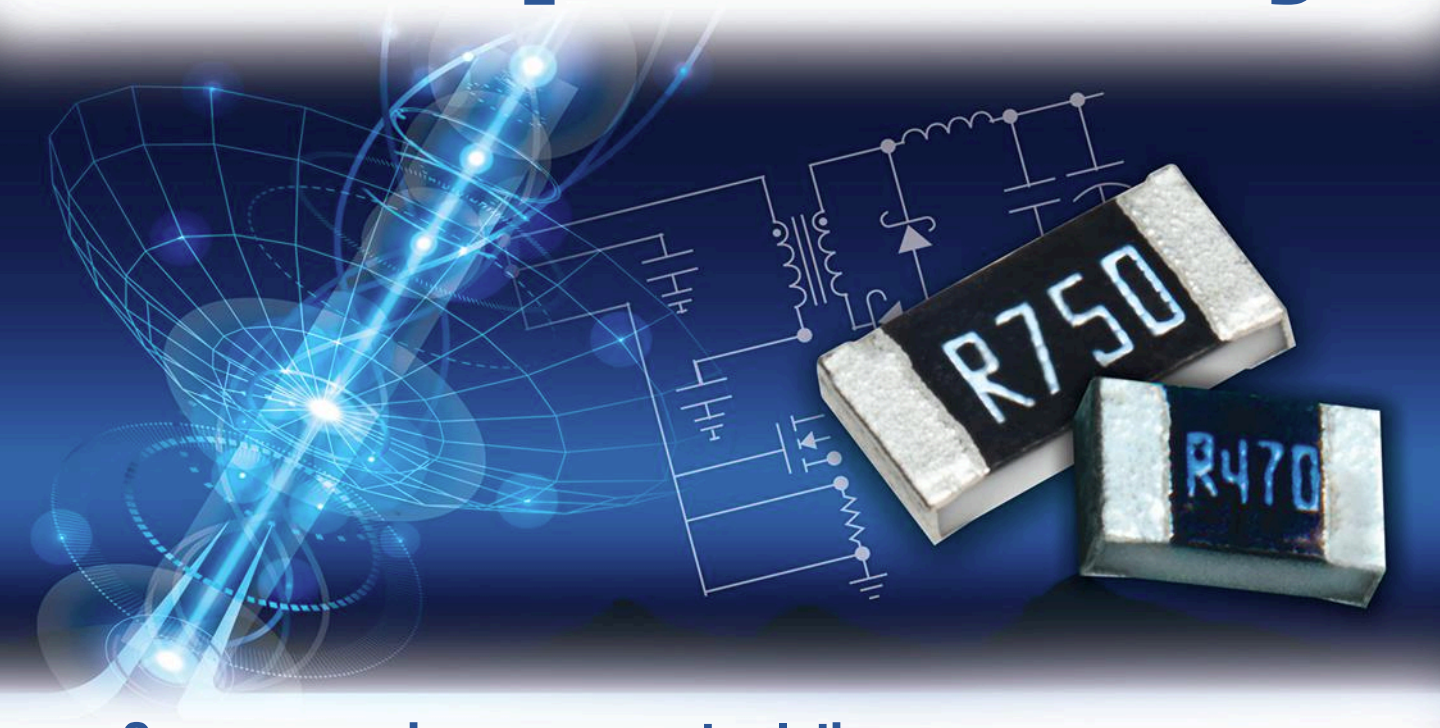
In China, the economy has been strong and growing, although it may be leveling off now. For Europe and much of the rest of the world, some countries have good economies while others are struggling.

While the authors' previous annual outlooks have noted politics *(see "How Will Politics Impact the Semiconductor Industry and Overall Business Climate?" and "IoT Security Getting Well-Deserved Attention" on www.electronicdesign.com)*, in 2018 executive action and policy influences intensified, with various forms of "social responsibility" also causing unforeseen disruption in the digital world.

A surge of "nationalism" has citizens and politicians wanting to topple the established world order. Part of the United Kingdom decided it wanted to "Brexit" the European Union (that doesn't sound very "united"), but that may or may not take place smoothly.

Separately, the Executive branch of the United States is deep-sixing existing alliances and trade agreements, putting up walls against neighboring countries, and threatening stiff tariffs on certain goods from specific countries. This is initiated by someone who fancies himself to be a master negotiator, but may not have a good understanding of how normal business—or Washington—is run. Other countries, many with authoritarian heads of state, are responding in kind. At least Japan—very important in the electronics world—seems to be staying low-key.

From Concept to Reality



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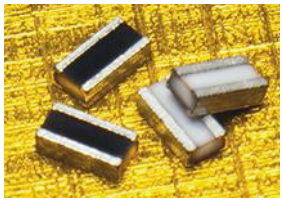

Wide Terminal Current Sense Resistors (WK73R1J)

One signal of the economy's strength is the stock market, which in the U.S. has surged on the order of 30% over the last two years. However, volatility of the stock market has increased significantly, with huge, almost-daily swings, reflective of dramatic changes initiated in the political arena that greatly alter the business environment, especially with trade wars between nations arising in a way not seen for decades. With no resolution of these tensions in sight, corporate leaders must craft their business strategies factoring in greater risk—risk that's outside of their control.

TECHNOLOGY WILL ADVANCE

High Tech continues to march forward, dependably, as it always has: faster, better, cheaper, higher integration. Today, the advance of technology is one of the few things that can be counted on in a positive light.

The protection of intellectual-property (IP) rights remains vital to the ongoing investment in research and development in high tech. However, IP abuse is contentious and an impediment to fair and open markets.

Corporate consolidation is slowing a bit, with a number of companies in the electronics industry having already merged. Some acquisitions have been blocked, slowed, or otherwise withdrawn. The global nature of our industry can make government approval difficult. Alliances and partnerships between companies are vital, with technology standards benefitting all who make use of them. The reach of Android has grown tremendously. While some parts of the business have disaggregated, many companies pursue further vertical integration, with nearly all engaging more heavily in software.

BE RESPONSIBLE

It may seem far upstream from semiconductors and most electronic hardware, but the proliferation of "fake news," hate speech directed at groups or beliefs, and personal attacks ("shaming") over social networks has revealed a new dark side of the wide-open internet, (electronic) social networks, and the press/media.

This has subjected many companies and their executives to a good grilling by lawmakers/government bodies, the wrath of the public, the initiation of monitoring systems to detect and control nefarious activities, and potential revenue downsides from users and advertisers. On one hand, some governments or corporations might want to restrict—or capitalize on—the content their citizens or users can access over its wires—for good and for bad. On another hand, there's little agreement on who should say what qualifies as acceptable content.

Since the internet is expected to be a real-time network with content that can be anything from simple ASCII text to encoded streaming high-definition video, computers running sophisticated algorithms are the only systems that could possibly monitor all of the traffic, at speed. "Artificial intelligence" would have to be something more than a marketing term for such computers to stay ahead of the moment-by-moment trends, let alone the social media bots that may flood the network.

The exploitation of consumers' rights and privacy has been questioned as more and more data on these end-users has been surreptitiously collected for vague purposes. In May 2018, the European Union's (EU) General Data Protection Regulation (GDPR) became effective, requiring more than a tacit "your use of this site implies…" caution but an explicit agreement by the person on whom the data is collected. The EU acted but few other countries have followed suit. Moreover, corporations drag their feet embracing such policies because of the revenue and marketing value they can derive from the data. Consumers young enough to understand what the word means, might just shrug, "meh."

MEETING DEMAND FOR CONNECTIVITY
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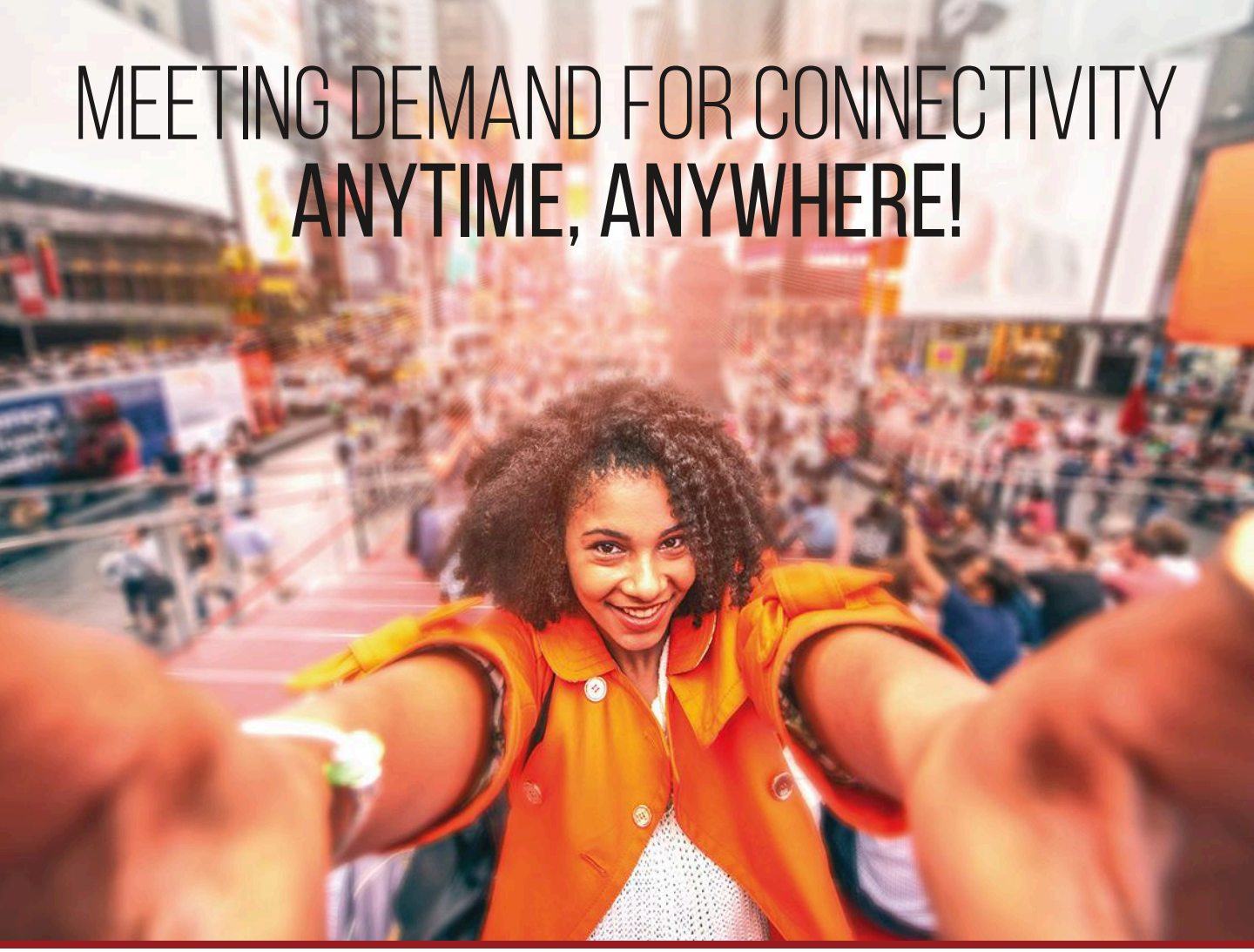

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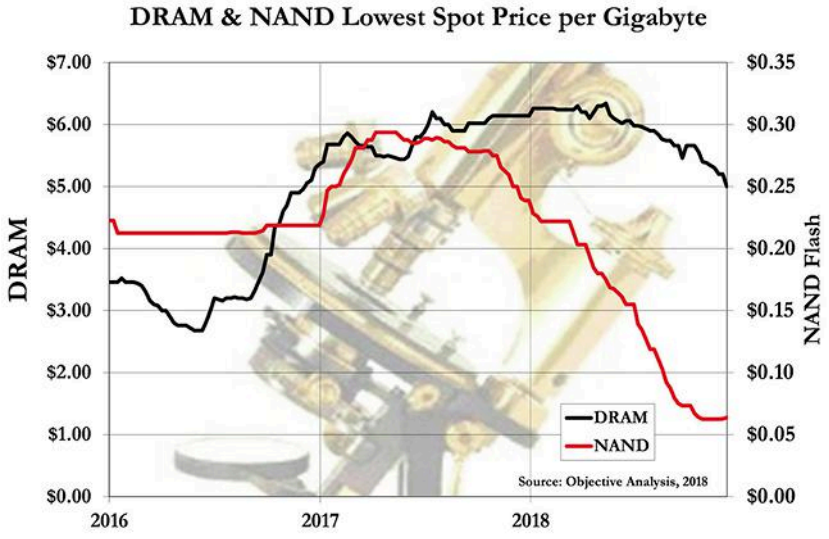

This chart shows the lowest weekly DRAM and NAND flash spot market prices for the past two years, making it clear that NAND flash prices (red line, right axis) have already declined significantly and that DRAM prices (black line, left axis) have just begun their downturn.

A POUND OF FLESH

Ultimately, most of these new social-imposed issues layering over the normal market-driven supply-and-demand factors that impact the next few years' outlook place new burdens on the companies providing the services sought by the user. They consume additional resources, software, and computing power to mitigate this new noise and distraction. The effort and cost add to the overhead of a business, much like the need for a legal team, building maintenance, or an accounting department. However, it also joins issues like security that are likely to become ever-more sophisticated as bad actors try to overcome the defenses that are erected.

It would be hard to say these issues make companies or society more productive, although they will take more manpower (peoplepower) and computational bandwidth to detect and manage infractions. Perhaps these are opportunities for services offered by third parties to handle. However, like security, it's just one more moving target that's difficult to assign an effectiveness or quality number to.

The defense mechanisms likely involve sophisticated algorithms for pattern-matching and quirks of human behavior and therefore could increase demand for computing resources (good for semis). But this isn't likely to support a new fab and is far more nuisance than energizing.

MEMORY LOSSES

An Objective Analysis of the DRAM and NAND flash-memory markets gives valuable insight to how the greater semiconductor market will fare in 2019. When revenues from these two technologies grow or collapse, the rest of the semiconductor market reacts the same, only more modestly, without the extraordinary gyrations suffered by NAND and DRAM.

Because DRAM and NAND flash are undifferentiated commodities, systems can replace any provider's product with any other provider's product, so buyers largely choose suppliers based on price. In a commodity market, an oversupply results in a price collapse, and that's where the market was going late in 2018.

The *figure* shows the lowest weekly DRAM and NAND flash spot market prices for the past two years. Thus, it's clear that NAND flash prices (red line, right axis) have already declined significantly and that DRAM prices (black

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line, left axis) have just begun their downturn.

Spot market prices always have greater price swings than the contract market. The spot market is only a very small (<5%) portion of the overall market, though, so these numbers need to be considered with some caution.

Some industry participants have hypothesized that the DRAM market's consolidation will create an "oligopoly" that will cause prices to "normalize," e.g. stop gyrating the way they always have in the past. While this is a comforting thought for memory makers, there's no evidence that normalization is likely to occur. A reduction in the number of suppliers doesn't naturally lead to a change in price behavior unless only a single company remains, creating a monopoly. Two or more competing commodity suppliers will see price gyrations, known as the "Commodity Cycle."

Collusion between sellers offers an alternate way to prevent a price collapse, but this is illegal so it seldom occurs, and when it does it triggers trade sanctions and even imprisonment for the offenders.

Thus, the current price downturn will become just as severe of a collapse as any that have occurred before, so the next two years are most likely to be profitless for DRAM and NAND flash makers. This is why Objective Analysis expects a semiconductor revenue decline of 5% or more in 2019. A full explanation of our outlook for 2019 appears in a video found here: *https://www.wesrch.com/electronics/wevision-EL1J9YM-memory-market-forecast-2019-with-jim-handy-of-objective-analysis.*

There are two reasons the memory market got to this state:

- NAND flash became oversupplied once NAND makers found a way to efficiently produce 3D NAND. Until early this year, 3D NAND was more costly to produce than older planar NAND. Once NAND fabs started to be used efficiently, they started to produce more flash than the market needed, so prices started to fall. The chart shows a 78% drop from $0.29/GB down to $0.06/GB. Remember that this is the spot market, and contract prices react far less dramatically.
- Once NAND contract prices fell below the production cost of planar NAND (about $0.15/GB), eligible vendors converted excess planar NAND capacity to DRAM manufacture. This accelerated the onset of a DRAM glut that would have happened in early 2019 anyway, thanks to an overabundance of capital spending in late 2016.

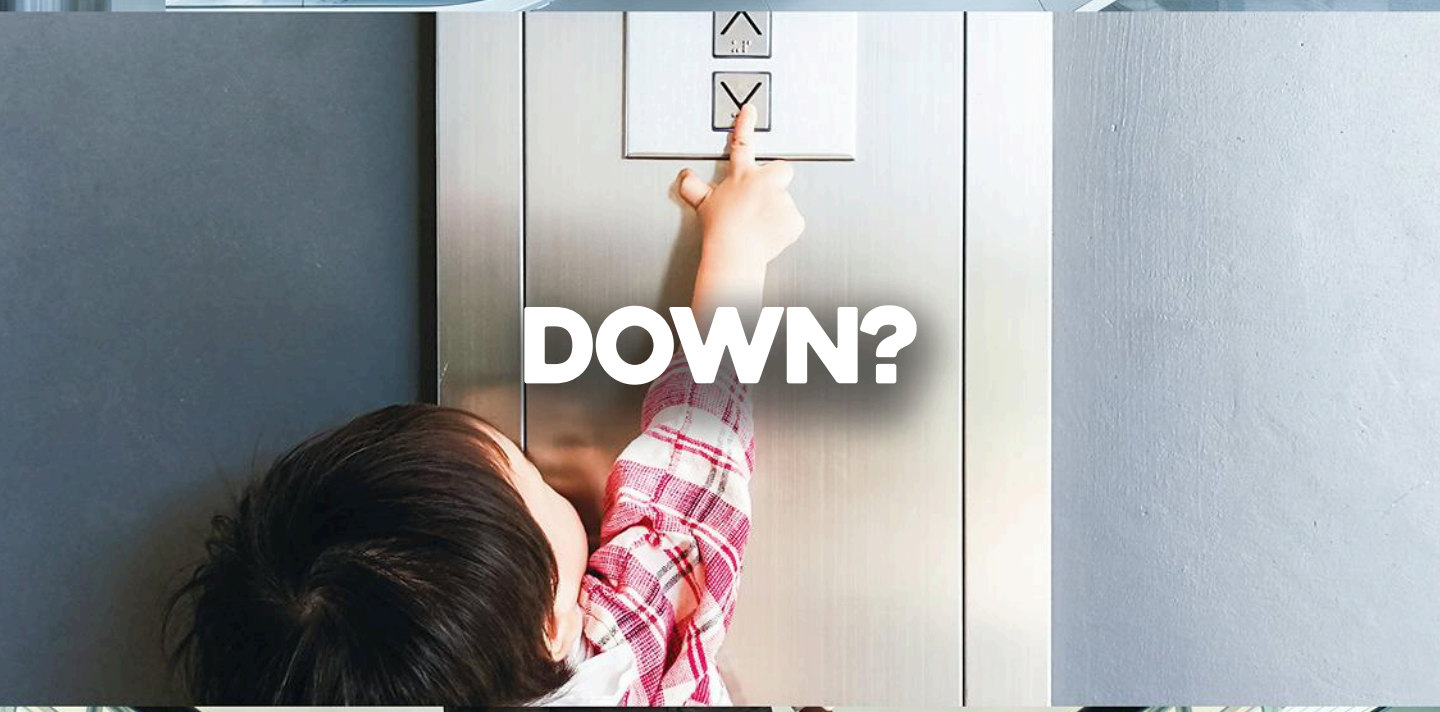
The price collapse may not really help OEMs. These companies have been suffering from chip shortages and high prices for a couple of years, making it a challenge to remain profitable. While a price reduction will lower the OEM's cost of goods, which can lead to higher profits, the wider availability of supply might motivate them all to overproduce, which will hurt their prices.

Another phenomenon that results from a price collapse is the possibility that OEMs who haven't managed their inventory in anticipation of a price reduction, may need to take an inventory write-down against their profits. It's only natural for a company to build a larger inventory than normal during a shortage. If that shortage rapidly shifts to an oversupply, prices collapse and the inventory holder will suddenly find their multi-million-dollar inventory is soon worth half as much.

Objective Analysis clients have been ready for this, so they should be in good shape. Others might be in trouble.

How will this play out over the longer term? Most semiconductor cycles follow a pattern of "Two Years Up, Two Years Down" as long as there are no external factors (like the 2008 Global Financial Collapse or the 2001 Internet Bubble Burst) to influence the cycle. But this time, other factors are at play that might prolong the downturn. ED


GOING UP?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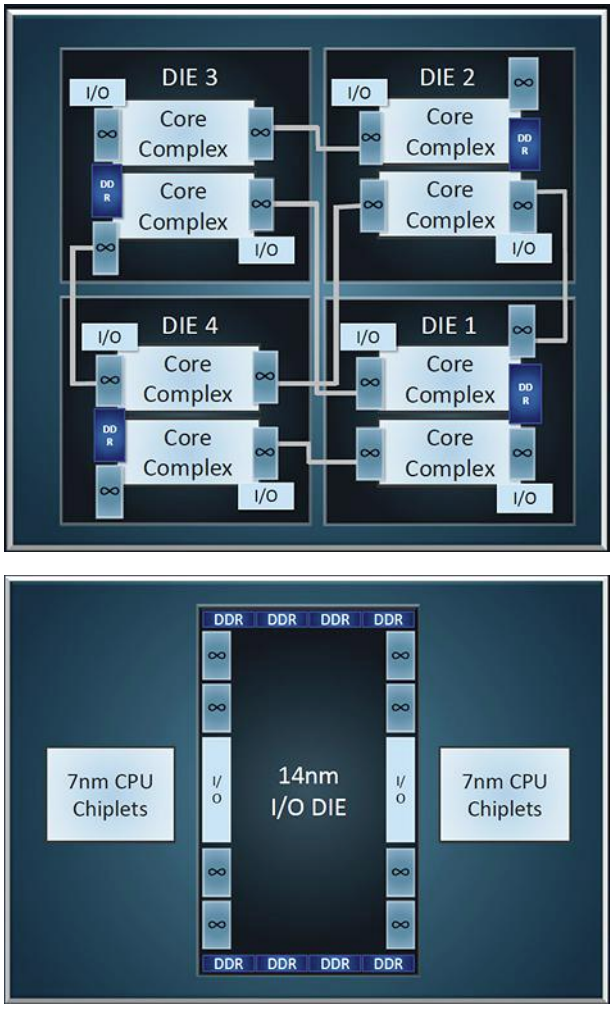
WILLIAM WONG | Senior Technology Editor

For Data Centers, It's All About Cores

The one common theme about the data center from AMD, ARM, Intel, NVIDIA, and Xilinx is the more cores, the better.

The new and old data center may look similar from a rack standpoint, but inside it has radically changed. Multicore CPUs with dozens of cores are now the norm and they often sit side by side with GPUs, FPGAs, and even custom accelerators. The rush to meet the machine-learning (ML) demand has fueled the migration for CPU-only configurations, though that's only part of the drive. It also involves better development and deployment tools and allowing easier use of GPUs and FPGAs for non-ML applications that can take advantage of these architectures.

One should not overlook how the data center is being mirrored in the embedded space, albeit in a smaller, more targeted, low-power solution. Embedded developers have taken up hypervisors and virtual-machine (VM) support common in the data center to tackle the growing complexity of system-on-chips (SoCs) being used in everything from self-driving cars to process control systems.



1. AMD's "ROME" EPYC consists of a "chiplet" collection of 7-nm CPU cluster (top) and a 14-nm I/O cluster (bottom) tied together with a multi-die interposer.

CPUs IN THE DATA CENTER

Intel remains the dominant player in the data center with its Xeon family, but AMD's EPYC is giving Intel some stiff competition. Both processor families include versions that target the embedded space as well.

AMD's EPYC "ROME" uses TSMC's 7-nm transistor technology to double its performance per socket and quadruple its floating-point performance. Architectural advances for the Zen 2 cores include improved branch prediction, better instruction prefetch, an optimized instruction cache, and a larger op-cache. The floating-point support is now built around 256-bit data.

EPYC also supports runtime Secure Memory Encryption (SME) and Secure Encrypted Virtualization (SEC). With SME, data in RAM is encrypted and decrypted when inside the CPU. Data is encrypted before being written to RAM.

SME provides each VM with its own encryption keys. This

allows an encrypted VM to be managed by a hypervisor that doesn't have direct access to data within the VM. As with SME, the support is transparent to the operating systems and applications.

I did mention more cores as being important, and this EPYC chip will have up to 64 of them. These are actually built from eight "chiplets" with eight cores each *(Fig. 1)*. The I/O support is built using 14-nm technology. EPYC also has 128 PCI Express (PCIe) Gen 4 lanes, plus eight DDR4 memory channels to feed the cores.

Intel's Cascade Lake packs in 48 cores built from a pair of 24-core chips in a multichip package connected together using Intel's Ultra Path Interconnect (UPI). Its dozen DDR4 memory channels are designed to support Intel's Optane DC persistent memory DIMMs in a hierarchical storage configuration *(Fig. 2)*. A two-chip configuration connected by UPI provides 24 DDR4 memory channels. Versions of this Xeon family will also support Intel's Omni Path Fabric. Current versions of Cascade Lake use PCIe Gen 3, but PCIe Gen 4 is on the roadmap.

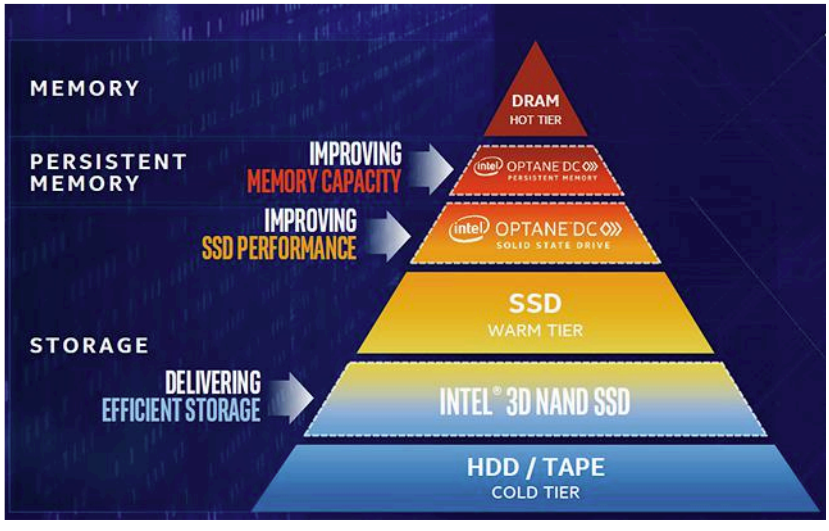
AVX-512, the 512-bit version of Intel's Advanced Vector Extensions, will likely be a determining factor for many developers. It packs 32, double precision floating-point numbers in a 512-bit vector that can be processed in a clock cycle. The system includes a pair of fused-multiply-add (FMA) units.

Both AMD and Intel are tailoring their server support to address AI and ML. Intel's Vector Neural Network Instructions (VNNI) that are part of the AVX-512 support represents just one example. These can be especially important in embedded applications where other ML accelerators may not be available.

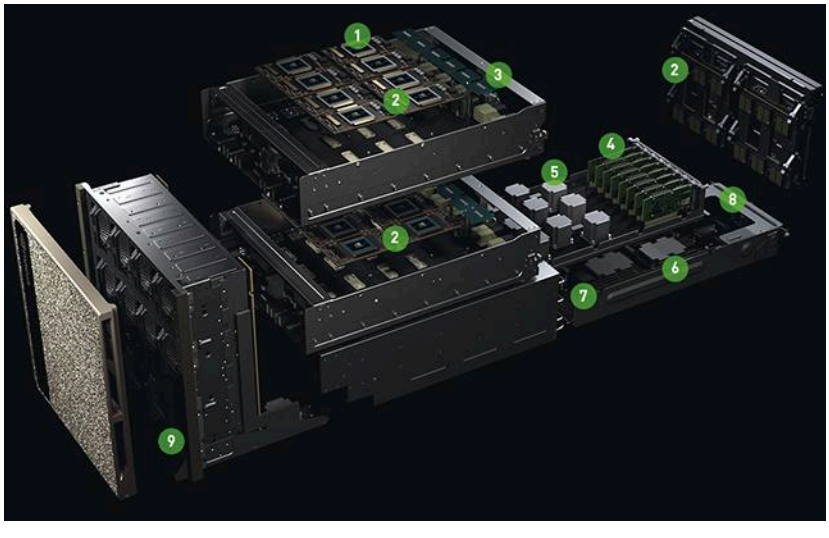
ARM has been helping its partners push into the data-center space, offering solutions that challenge the entry-level and mid-range platforms. Its 7-nm "Ares" Neoverse infrastructure, which targets the cloud and IoT solutions, builds on the Cortex-A76 architecture. The challenge is that AMD and Intel are established players with solutions that include the high end.

GPUs IN THE DATA CENTER

Though 64 cores are a lot for CPUs, the number pales in comparison to the amount of cores in a GPU. Granted, GPU cores are simpler and target more specific applications, but general-purpose GPUs (GPGPUs) are becoming more flexible. Programming platforms



2. Intel's server storage hierarchy includes Optane DC, which involves DIMMs connected to memory channels along with DRAM.



3. NVIDIA's DGX2 combines (1) 16 TESLA V100 GPU modules with (2) a total of 512 GB of HBM2 memory using a (3) dozen NVSwitch chips. It also has (4) eight EDR InfiniBand or 100-Gb Ethernet ports, (5) a PCIe switch complex, (6) two Intel Xeon Platinum processors, (7) 1.7 TB of system memory, (8) dual 10/25-Gb Ethernet ports and (9) 30 TB of NVMe SSD storage.

AMD's Radeon Instinct MI60 compute card *(Fig. 4)* uses AMD's Infinity Fabric, which can connect up to two GPU hives that consist of four MI60 GPUs in a single server. The MI60 is also built on 7-nm technology that takes of advantage of AMD's Vega GPU architecture with 64 compute units and 4096 stream processors.

4. AMD's Radeon Instinct MI60 compute card is based on AMD's Vega GPU architecture.

like OpenCL have pulled GPGPUs into the programming mainstream and they were the initial workhorses in the rise of AI/ML applications. They remain the preferred training platform in the cloud. NVIDIA and AMD are the main players when it comes to high-performance GPGPUs, with ARM, Imagination, and Intel providing integrated offerings that show up in CPU/GPU SoCs.

NVIDIA has taken the high ground when it comes to GPUs. Its NVLink connection is supported by its 16-port NVLink NVSwitch and Tesla V100 GPUs that have a half-dozen NVLink connections. This allows them to build the DGX2 *(Fig. 3)* with 12 NVSwitch chips and 16 GPUs that act like a single system in much the same fashion as a CPUs. It has 512 GB of HBM2 high bandwidth memory, 1.7 TB of system memory, and 32 TB of NVMe SSDs; a pair of Intel Xeon CPUs provide management support. The DGX2 is designed for the data center where multiple DGX2s are likely to reside side-by-side.

The Tesla V100 GPU uses the Volta architecture that's also found in the Jetson AGX Xavier. Targeting embedded applications, this single-chip solution incorporates multiple ARMv8 cores and accelerators, including two NVIDIA deep-learning accelerators (NVDLAs).

AMD's Radeon Instinct MI60 compute card *(Fig. 4)* uses AMD's Infinity Fabric, which can connect up to two GPU hives that consist of four MI60 GPUs in a single server. The MI60 is also built on 7-nm technology that takes of advantage of AMD's Vega GPU architecture with 64 compute units and 4096 stream processors. The chip incorporates 32 GB of HBM2 memory with ECC. The HBM2 has a bandwidth of 1 TB/s. In addition, a x16 PCIe Gen 4 interface supports the ROCm Open Ecosystem. A single board delivers 59 TOPS of INT8, 29.5 TFLOPS of FP16, 14.7 TFLOPS of FP32 and 7.4 TFLOPS of FP64.

The Instinct family includes the MI60, MI50, MI25, and M8. The M8 is a half-length card has only 4 GB of memory and foregoes the compute units to target embedded applications that need floating-point acceleration.

NVIDIA's Volta and AMD's Vega, like most GPGPUs these days, incorporate deep-learning support. This usually includes the ability to munch 8-bit integers (INT8) along with 16-, 32- and 64-bit floating point. The INT8 support is typically used with neural-network training and inference while floating point is used for more conventional computation.

FPGAs IN THE DATA CENTER

One of the biggest changes coming in the data center is the use of FPGAs like Intel's PSG Stratix 10 *(Fig. 5)* and Xilinx's Alveo *(Fig. 6)*. Part of the change is due to hardware, but the biggest change is in the software.

The PSG Stratix 10 is a member of Intel's Programmable Acceleration Card (PAC) series. It has an FPGA with 2.8 million logic elements, 32 GB of DDR4 using four memory channels, and x16 PCIe Gen 3. The Stratix 10 FPGA is based on Intel's Hyperflex FPGA architecture using Intel's 14-nm Tri-Gate process. It has a pair of QSFP28 network interface sockets.

Xilinx's Alveo U280 is the top-end board with a 16-nm Xilinx UltraScale FPGA. It has 8 GB of HBMS2 memory with a 460-GB/s bandwidth. The boards have a x16 PCIe Gen 4 interface that supports CCIX. CCIX is a cache-coherent protocol that runs atop PCIe hardware in parallel with the PCIe protocol.

FPGA boards have been available for decades, although mostly for embed-

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Xilinx and Intel are adding a standard system software layer between the application and the hardware. This allows developers to treat the FPGA more like a black box with a standard API. Developers can build or buy the IP that's used in the black, making the hardware more independent of the application.

ded applications. The tools for creating the IP that works with an FPGA have improved significantly, and it's even possible to turn software written for frameworks like OpenCL directly into FPGA IP. Embedded developers typically handle the loading of this IP onto the FPGA, and it's often tightly integrated with the application software.

Xilinx and Intel are adding a standard system software layer between the application and the hardware. This allows developers to treat the FPGA more like a black box with a standard API. Developers can build or buy the IP that's used in

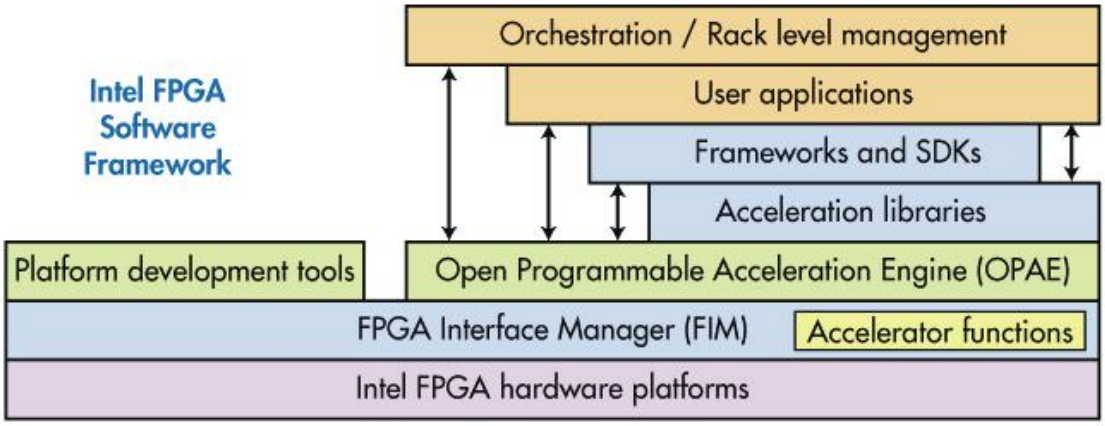
5. Intel's PSG Stratix 10 employs a Stratix 10 FPGA based on the company's Hyperflex FPGA architecture.

6. Xilinx's Alveo U280 can deliver 24.5 INT8 TOPS and has one million LUTs.

the black, making the hardware more independent of the application.

For example, Intel's Open Programmable Acceleration Engine (OPAE) runs on top of the FPGA Interface Manager (FIM) to manage its PAC FPGAs *(Fig. 7)*. The software manages FPGA configuration and data movement to and from the FPGA and application. It needn't be concerned with the hardware configuration as long as the IP fits in the FPGA available to the system. The OPAE is responsible for managing the use of the FPGAs in the system that can change over time as new applications are started.

Other major factors are affecting the data center and embedded servers from persistent memory technology to the upcoming PCIe Gen 5 and CCIX. But that's for another article.



7. The Open Programmable Acceleration Engine (OPAE) runs on top of the FPGA Interface Manager (FIM) to manage Programmable Acceleration Cards (PACs).

WILLIAM WONG | Senior Technology Editor

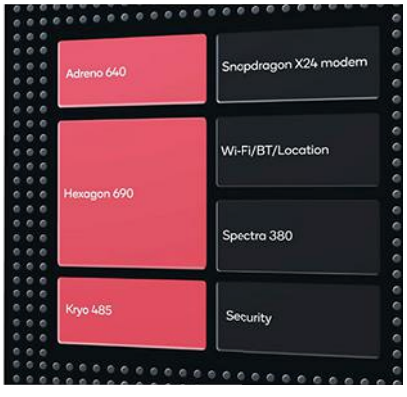
Your Next SoC Will Probably Include AI Acceleration

It may be possible to get an SoC without AI acceleration, but the trend is to provide mainstream machine-learning support.

System-on-chip (SoC) solutions continue to get more complex as more specialized hardware is added to optimize the SoC for new applications. Qualcomm's latest Snapdragon 855 *(Fig. 1)* highlights this change. The 855 includes a number of blocks including the Snapdragon X24 cellular modem and wireless Wi-Fi, Bluetooth, and GPS support from the Adreno 640 GPU, the Hexagon 690 DSP, the Kryo 485 processor cluster, and the Spectra 380 image signal processor (ISP).

EThe 64-bit Kryo 485 includes one high-performance "Gold Prime" 2.84-GHz core with a 512-kB L2 cache, three 2.42-GHz cores with 256-kB L2 caches, and four 1.8-GHz cores with 128-kB L2 caches designed for low-power operation. The Gold Prime core targets single-threaded, user-interface applications like web browsers.

The Hexagon 690 DSP is where the most change has occurred. It includes a Tensor accelerator and new vector extensions with support for INT8 and INT16 datatypes. The enhancements highlight the machine-learning (ML) support of the 855. The Kyro 485 also includes new dot product instructions with INT8 and single precision floating point that can also be useful with ML applications. Many chip designers are enhancing the DSP with ML support since DSP architectures already lend themselves to ML applications.



1. Qualcomm's Snapdragon 855 SoC includes the Adreno 640 GPU, the Hexagon 690 DSP, the octal core Kryo 485 processor cluster, and the Spectra 380 image signal processor, along with wireless communication and security support.

The 855 targets premium smartphones and other high-end applications while its sibling, the Snapdragon 8cx, targets laptops with a higher-performance GPU. ML is playing a part in applications like image processing and computer vision for facial-recognition support. The ISP is designed to provide data to ML image applications.

Seth DeLand, Product Marketing Manager of Data Analytics at MathWorks, notes that "Companies will increasingly use machine learning algorithms to enable products and services to 'learn' from data and improve performance. Machine learning is already present in some areas: image processing and computer vision for facial recognition, price and load forecasting for energy production, predicting failures in industrial equipment, and more. In the coming year, it can be expected that machine learning will be increasingly present as more companies are inspired to integrate machine-learning algorithms into their products and services by using scalable software tools, including MATLAB."

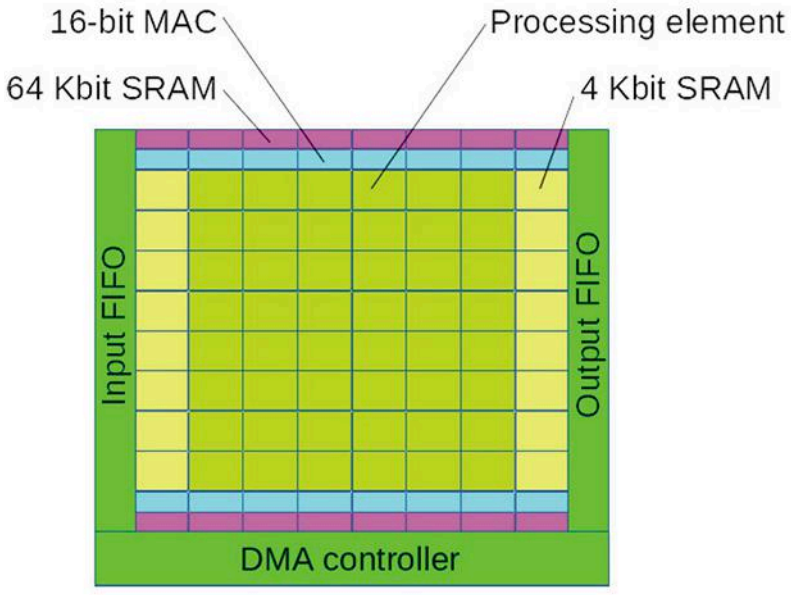
MORE MACHINE LEARNING

ML support is showing up at all levels. MediaTek's Helio P70 is built around an octal core big.LITTLE configuration with four 2.1-GHz Arm Cortex-A73s and four power-efficient, 2-GHz Cortex-A53s. There's also a 900-MHz Arm Mali-G72 GPU and a dual-core AI processing unit (APU). The APU is designed to handle chores like human pose recognition in real-time as well as augmentation to still images and video. It can deliver 280 GMACs.

Moving further down the scale is Renesas' RZ/A2M with DRP. It's designed to support human machine interfaces (HMIs) including systems with cameras. It has an Arm Cortex-A9 along with Renesas' Dynamically Reconfigurable Processor (DRP) that provides ML support. The DRP is programmable in C and has optimized DMA support to minimize data movement *(Fig. 2)*. The DRP is designed to be reconfigured every clock cycle, allowing for implementation of innovate algorithms.

ML hardware acceleration is becoming the norm. However, it's possible to run more functionally constrained ML applications on microcontrollers like the Cortex-M7 that have no ML hardware acceleration. It helps to have DSP-style support.

Many platforms, like Renesas' RZ family, include incarnations without ML acceleration. More often than not, though, ML will be an option available to developers. Much of this support targets image and video processing, but the hardware tends to be applicable to almost any ML inference application. ed



2. Renesas' Dynamically Reconfigurable Processor includes an array of processing elements, MACs, and memory blocks. Streams of data are moved to and from main memory by the DMA controller.

WILLIAM WONG | Senior Technology Editor

5G will obviously make an impact in 2019, but how much of one depends on what you're doing.

Higher bandwidth…lower power…sub-10-ms latency—these are the promises of 5G wireless. Its smaller cell size is a challenge, though, since more cells and matching equipment are required to cover an area. Piggybacking 5G on 4G towers requires additional nodes throughout the area.

5G smartphones will be the driving factor for technology. However, IoT devices and other applications such as augmented and virtual reality (AR/VR) will be taking advantage of 5G's features.

Test tools and precision timing measurement and support will be key to creating 5G products. Many of these tools are already available, but refinement and updates will bring about compliance for the final standards.

Sean D'Arcy, Director of Aerospace and Defense at Analog Devices, says "Before 5G becomes available on a global scale, RF technologies will meet critical checkpoints in performance. Of great importance is the availability of spectrum, whether it be low-, mid-, or high-band. In sub-6-GHz, the coverage layer will be built on massive MIMO using existing infrastructure followed by densification. Small-cell deployments will be more critical to 5G rollout taking advantage of the higher frequencies."

Piyush Sevalia, Executive Vice President of Marketing for SiTime, notes "In 2019, we will see growing interest in 5G timing advances in tandem with the growth of 5G deployment. Therefore, MEMS timing solutions will proliferate as they bring unique benefits that are not offered by traditional timing solutions. In particular, the 5G and communications, automotive, and IoT markets will greatly benefit from the size, reliability, and performance of SiTime's MEMS timing solutions.

"In networking and communications, timing and synchronization is essential to the entire system. The resiliency of MEMS timing provides unfailing performance that is critical for the deployment of 5G as it rolls out into less-controlled, harsher environments. The same need for reliability and dynamic performance is driving the growing use of MEMS resonators in automotive, where systems must operate dependably in challenging conditions. In IoT, MEMS timing provides small size, low weight, and low power."

While 5G offers opportunities and new features, it will be existing 3G and 4G/LTE technology that will drive IoT, IIoT, and Industry 4.0 solutions in the coming year. LTE-M and NB-IoT support is available now with modems that handle multiple protocols. Cellular licensing is also becoming more flexible.

Cellular solutions provide many benefits, including wide coverage, but there are many alternatives that may be more suitable for a range of applications. These include long-range, low-power, unlicensed band wireless solutions like LoRaWAN and Sigfox.

The majority of IoT applications don't require high-speed connectivity. LTE-M can deliver 1 Mb/s while the other available options are much slower. 5G will allow significantly higher throughput, opening up new applications.

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Don't Do It!

WILLIAM WONG | Senior Technology Editor

Disabling SELinux

Implementing SELinux can definitely improve the security of a system—but only if you actually use it.

These days, security is one of those things everyone talks about and in this arena, many actually do something about it. Using mandatory-access-control (MAC) systems like SELinux and AppArmor can significantly improve the security of a system, but only if they're used. For this discussion, we concentrate on SELinux. However, the ideas are applicable to most access-control systems.

Security-Enhanced Linux or SELinux was initially developed by the US National Security Agency (NSA). It's standard fare on Red Hat Enterprise Linux (RHEL), the community version called CentOS, and Fedora Linux. It works many other incarnations, although it's not always installed or turned on by default.

Disabling SELinux is easy. Just run *setenforce 0*. Turning it off permanently is done by setting *SELINUX=disabled* in the /etc/selinux/config file for CentOS or Fedora.

JUST DON'T DO IT.

Too many "tips" on the web tell readers to do just this when a particular application will not run with SELinux. It's usually because they're too lazy to figure out why. While this will typically get an application to run also turns a relatively secure system to a relatively insecure system.

The reason most of these tips arise is that there are few good presentations of SELinux, or other access-control systems, that can be easily found and readily available. Some of the good books on SELinux also tend to be rather daunting; the excuse for not reading them is that security is not important, not my job, etc.

Unfortunately, getting things to work under SELinux is actually not that hard. Still, there are many cases where it can be more challenging. More on that later.

So, before you disable SELinux completely, take a look at some of the less severe changes that will likely get your application to run.

```
# ls -Z /etc/*.conf
-rw-------. root root system_u:object_r:etc_t:s0       /etc/aide.conf
-rw-r--r--. root root system_u:object_r:etc_t:s0       /etc/asound.conf
-rw-r--r--. root root system_u:object_r:etc_t:s0       /etc/chrony.conf
-rw-r--r--. root root system_u:object_r:dnsmasq_etc_t:s0 /etc/dnsmasq.conf
-rw-r--r--. root root system_u:object_r:kdump_etc_t:s0 /etc/kdump.conf
-rw-r--r--. root root system_u:object_r:krb5_conf_t:s0 /etc/krb5.conf
-rw-r--r--. root root system_u:object_r:etc_t:s0       /etc/ld.so.conf
-rw-r-----. root root system_u:object_r:etc_t:s0       /etc/libaudit.conf
-rw-r--r--. root root system_u:object_r:etc_t:s0       /etc/libuser.conf
-rw-r--r--. root root system_u:object_r:locale_t:s0    /etc/locale.conf
-rw-r--r--. root root system_u:object_r:etc_t:s0       /etc/logrotate.conf
-rw-r--r--. root root system_u:object_r:etc_t:s0       /etc/nsswitch.conf
-rw-r--r--. root root system_u:object_r:net_conf_t:s0  /etc/ntp.conf
-rw-r--r--. root root system_u:object_r:net_conf_t:s0  /etc/resolv.conf
-rw-r--r--. root root system_u:object_r:rsync_etc_t:s0 /etc/rsyncd.conf
-rw-r--r--. root root system_u:object_r:syslog_conf_t:s0 /etc/rsyslog.conf
```

1. The ls -Z command lists SELinux labels for files and directories.

```
# semanage fcontext -a -t my_app_var_t '/etc/test(/.*)?'
# restorecon -R -v /etc/test
```

2. The restorecon application changes file and directory labels based on the saved file context (fcontext). The semange program is used to manipulate SELinux contexts.

First off, one needs to understand what SELinux is up to. Really providing a good SELinux overview does take at least a chapter or two of a book, so this will be a bit abbreviated.

Essentially all items that SELinux is protecting, including files, directories, ports, etc., have a label for the form user:role:type. Listing the labels for files and directories is built into ls *(Fig. 1)*. The labels are used by SELinux to determine what security profiles apply to the item.

The label can be changed using the *chcon* program, but it's better to use an SELinux context managed using the *semanage* program along with the *restorecon* program *(Fig. 2)*. Typically, an application that has been configured for SELinux will include a profile with contexts that define how labels will be set for files, directories, etc. used by the application.

What often happens is that a user will create or edit files associated with an application such that the labels are incorrect. Of course, SELinux then prevents the application from using these files, as it should. Running *restorecon* on files and directories where errors occur should be the first step to getting an application to run properly under SELinux.

SELinux AUDIT TRAIL

The file /var/log/audit/audit.log *(Fig. 3)* in CentOS and Fedora is where SELinux errors and actions are logged.

```
# grep denied /var/log/audit/audit.log
type=AVC msg=audit(1544038090.937:59987): avc:  denied  { getattr } for  pid=26327
comm="bconsole" path="/root/.bconsole_history" dev="vda3" ino=1394009
scontext=system_u:system_r:httpd_t:s0 tcontext=unconfined_u:object_r:admin_home_t:s0
tclass=file
type=AVC msg=audit(1544038090.978:59988): avc:  denied  { write } for  pid=26327
comm="bconsole" name=".bconsole_history" dev="vda3" ino=1394009
scontext=system_u:system_r:httpd_t:s0 tcontext=unconfined_u:object_r:admin_home_t:s0
tclass=file
type=AVC msg=audit(1544038090.978:59989): avc:  denied  { append } for  pid=26327
comm="bconsole" name=".bconsole_history" dev="vda3" ino=1394009
scontext=system_u:system_r:httpd_t:s0 tcontext=unconfined_u:object_r:admin_home_t:s0
tclass=file
```

3. The file /var/log/audit/audit.log can be filtered using tools like grep to display actions that have been denied by SELinux.

Actions that are denied can be found by filtering the file using tools like *grep*. The log entries tend to be cryptic, but they provide information that can be used to address applications that aren't working with SELinux.

Keep in mind that SELinux can run in one of three modes: off, permissive, and enforcing. The former has SELinux doing nothing. Permissive and enforcing have SELinux watching the system. However, permissive simply adds entries to the audit log file while enforcing prevents applications from using an item. We always want SELinux to be enforcing, but we also want applications to run.

The typical recommendation after *setenforce 0* is to run SELinux in permissive mode so that it will hopefully generate an audit trail with denial that can then be used to generate a security profile that allows an application to run. The profile can be generated using the log entries and the *audit2allow* program.

While grep and similar tools are useful for filtering the audit log, SELinux comes with the *ausearch* program that's often preferable for use with audit2allow *(Fig. 4)*. It can filter entries based on many criteria from hosts to process ids. Check out the main pages for *ausearch* and *audit2allow* as with most of the SELinux-related programs mentioned here, since they have many options not covered in this article.

The challenge with *audit2allow* is that it will create a profile that enables an application to do more than it could without the profile. However, it may not be sufficient to allow the application to run all of the time. This is because the audit log will only have problems related to what the application did during the period of the log. The profile may be sufficient if all of the application's actions were tested. However, if some were not, then it's possible that the generated profile would let the application run for some time but then fail or have errors at some point when encountering actions that weren't tested. Running SELinux in permissive mode again would allow the new denied actions to be recorded so that a new profile could be created.

```
# ausearch -c 'httpd' --raw | audit2allow -M my-httpd
# semodule -i my-httpd.pp
```

4. The *ausearch* application can filter the audit log so that *audit2allow* is able to generate a profile that's added to SELinux using *semodule*.

```
# getsebool -a | grep httpd
allow_httpd_anon_write --> off
allow_httpd_bugzilla_script_anon_write --> off
allow_httpd_mod_auth_pam --> off
allow_httpd_nagios_script_anon_write --> off
allow_httpd_squid_script_anon_write --> off
allow_httpd_sys_script_anon_write --> off
httpd_builtin_scripting --> on
httpd_can_network_connect --> off
httpd_can_network_connect_db --> off
httpd_can_network_relay --> off
httpd_disable_trans --> off
httpd_enable_cgi --> on
httpd_enable_ftp_server --> off
httpd_enable_homedirs --> on
httpd_rotatelogs_disable_trans --> off
httpd_ssi_exec --> off
httpd_suexec_disable_trans --> off
httpd_tty_comm --> on
httpd_unified --> on
```

5. A list of SELinux variables and their values can be obtained using *getsebool*.

Using an *audit2allow* generated profile may provide an application with more access than one may prefer, but this is still better from a security standpoint than allowing all applications free reign within a system. It's true that the basic Linux security mechanism would still be in play; still, these are more liberal than the confinement provided by SELinux. As noted, the challenge with the *audit2allow* approach is knowing whether the generated profile is sufficient.

I do recommend that you examine the filtered audit log that will be used with *audit2allow* first to see whether changing labels will fix the problem. Often setting a file or directory context using *semanage*, mentioned earlier, will let a program run.

SELinux VARIABLES

Expanding the security limits of an application using *audit2allow* may be necessary for applications that don't have SELinux profiles already defined, but many applications come with profiles that include SELinux variables. These variables can be used to change the security limits in a controlled fashion. They're often handy when trying to get two SELinux-enabled programs to work together, such as the Samba file server and the Apache web server (httpd).

SELinux variables are manipulated using *setsebool* and *getsebool (Fig. 5)*. Typically, these booleans greatly expand the limits of particular aspects of the associated security profile. For example, the Apache web server will normally be limited to what ports it can use. Setting the *httpd_can_network_connect* variable *on* essentially lets the application use any port. This is often done if the port required is unknown or would change in an unknown fashion. It would be better to create a profile that allowed a specific port or range of ports. Nonetheless, at least using the variable doesn't open other areas where the web server may be limited to.

As noted, these variables are sometimes employed to allow two SELinux-enabled programs to work together. This

Design Note

One IC for Multiple DC/DC Topologies: Dual Output Step-Down IC can also be used in SEPIC and Boost Applications

Victor Khasiev

Introduction

Industrial systems designers and automotive manufacturers are significant consumers of power electronics, requiring the full array of available DC/DC converter topologies, including buck, boost and SEPIC in a variety of combinations. In an ideal world, each new project would be performance-optimized with its own specialized controller or monolithic converter IC, but this is unrealistic.

The reality is that each new chip used in an industrial or automotive setting must be qualified via extensive testing before it can be utilized in these demanding environments. Implementing a different IC for each application is time consuming and cost prohibitive. It is far better to have a tested and verified IC on the shelf that can be used in multiple topologies, allowing it to be reused across a variety of applications. As an example, this article will show how to use the LTC3892 step-down controller for SEPIC (step-up and down) and boost applications.

Circuit Description and Functionality

The LTC3892 [1] is designed as a dual output synchronous buck controller with input-output voltage range 4.5V to 60V—covering the requirements for most automotive and industrial applications. In these environments, the voltage input to the converter can vary significantly, such as those resulting from cold cranking and load dumps in automotive

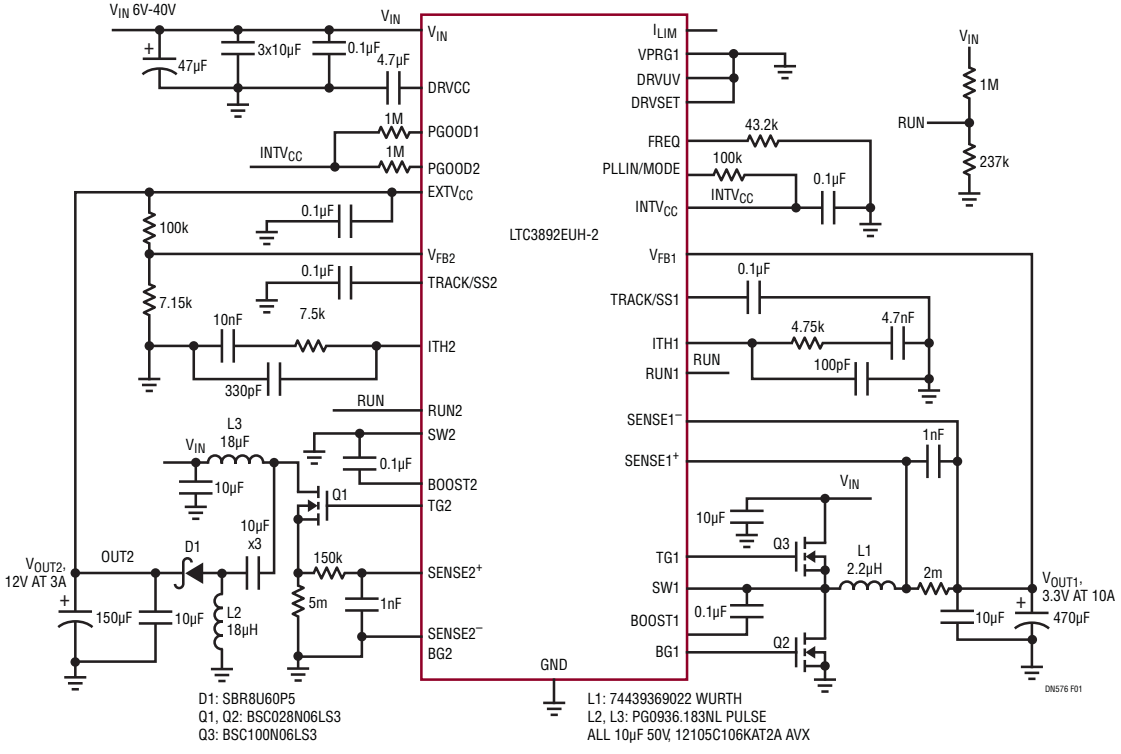

Figure 1. Electrical Schematic of LTC3892 in SEPIC and Buck Applications

applications, or brownouts and voltage spikes in industrial systems when plant machinery is turned off and on. The native step-down topology of the LTC3892 cannot regulate output voltages when the input drops below the output, but a SEPIC topology can.

Figure 1 shows a SEPIC solution that supports two outputs: V_{OUT1} is 3.3V at 10A and V_{OUT2} is 12V at 3A. The input voltage range is 6V to 40V. V_{OUT1} is implemented as a straightforward step-down converter with a power train including L1, Q1, Q2. To reduce number of components, the VPRG1 pin is connected to GND, internally programming V_{OUT1} to 3.3V.

The second output of the LTC3892 is a SEPIC converter. The SEPIC power train includes L2, L3, Q3 and D1. A non-coupled SEPIC, with two discrete inductors, is employed here, expanding the range of the available inductors, an important consideration for cost-sensitive devices.

Figure 2 shows how the converter functions when faced with voltage drops, such as during cold cranking. The rail voltage V_{IN} drops far below nominal 12V, but both V_{OUT1} and V_{OUT2} remain in regulation, providing a stable power supply to the critical loads. Figure 3 shows how the converter functions when experiencing voltage spikes, such as load dumps. V_{OUT1} and V_{OUT2} remain regulated, even as V_{IN} flies far above the nominal 12V input.

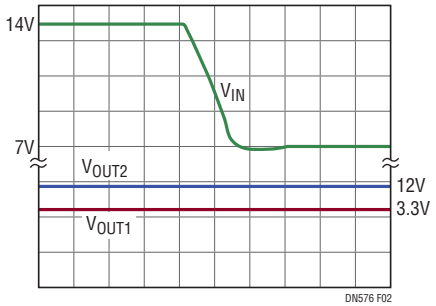

Figure 2. Shows a Cold Cranking Event. The Rail Voltage Drops from 14V to 7V, but Both V_{OUT1} and V_{OUT2} Remain in Regulation. [[CH1 V_{IN}, 2V/DIV; CH2 V_{OUT2}, 5V/DIV; CH3 V_{OUT1}, 2V/DIV; 1ms/DIV.]]

Figure 4 is the demonstration circuit DC2727A [2], a dual output converter described herein. The SEPIC portion of the DC2727A can be easily rewired to a boost topology by removing one inductor L2 and replacing second L3 to an appropriate boost choke.

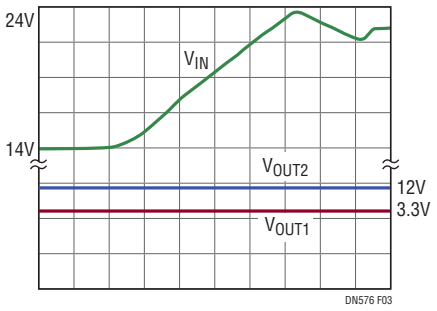

Figure 3. Load Dump Event. The Rail Voltage Rises from 14V to 24V, However, Both V_{OUT1} and V_{OUT2} Stay in Regulation. (CH1 V_{IN}, 5V/DIV; CH2 V_{OUT2}, 5V/DIV; CH3 V_{OUT1}, 2V/DIV; 1ms/DIV).

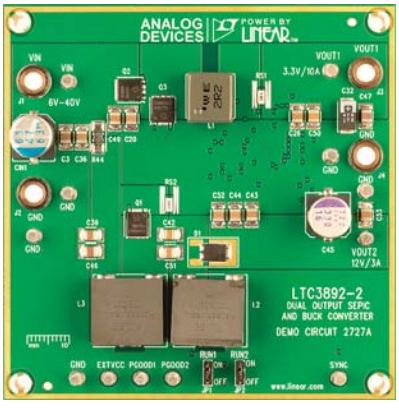

Figure 4. Demonstration Circuit DC2727A. The LTC3892 Controls Two Outputs, a Non-Coupled SEPIC and a Step-Down Converter. [[V_{IN} 6V-40V, V_{OUT1} 3.3V at 10A and 12V at 3.0A.]]

Conclusion

The LTC3892 is a flexible controller that can serve a variety of DC/DC converter needs in automotive and industrial environments. Although it is primarily designed for employment in synchronous buck converters, it can also be used in SEPIC and boost converter applications, simplifying the qualification testing process when these topologies are needed.

References

1. Data sheet, LTC3892/LTC3892-1/LTC3892-2, 60V Low I_Q, Dual, 2-Phase Synchronous Step-Down DC/DC Controller
2. Demo board, DC2727A,
3. LTC3892-2 Demo Circuit - Automotive SEPIC Converter using Single (Non-Coupled) Inductors (10V-18V to 12V at 3A & 3.3V at 10A)

Data Sheet Download
www.mouser.com/LTC3892

Using an *audit2allow* generated profile may provide an application with more access than one may prefer, but this is still better from a security standpoint than allowing all applications free reign within a system. It's true that the basic Linux security mechanism would still be in play; still, these are more liberal than the confinement provided by SELinux.

is because profiles are often designed to give an application access to its resources but prevent other programs from accessing them. That would not be the case if a Samba file share was being used for a website.

There are other ways to enable such sharing to occur, but examining even basic examples is beyond the scope of this article. Suffice it to say that you don't want to disable SELinux and allow for expanded security boundaries using SELinux variables; it's much preferred to having no SELinux support.

PERMISSIVE DOMAINS

Running SELinux in permissive mode allows all applications to run without generating SELinux. However, the problems are still logged in the audit trail. It's possible to provide this support on a more limited basis using permissive domains *(Fig. 6)*. In this case, SELinux runs in enforcing mode, limiting most applications, though ones within a permissive domain will not have these restrictions causing errors. Any denials will still be logged, but the applications will be allowed to continue unimpeded.

Again, using this approach expands the security limits, though it's in a known fashion where a user, manager, or developer can determine whether this scope is sufficient for a system. Likewise, it's more limited than turning off SELinux completely.

```
# semanage permissive -a httpd_t
# semodule -l | grep permissive
permissive_httpd_t      (null)
permissivedomains       (null)
```

6. Permissive domains provide a selective way of expanding a domain's security limitations.

Providing an application without SELinux support if that application is targeted at platforms where it would be available should be verboten. Security has become critical to the proper operation of PCs, servers, and embedded systems, and not providing this type of security is just poor development practice.

SOME MORE SELinux TOOLS

Other tools come in handy when using SELinux. These include:

- aureport – provides a filtered and formatted report of the audit log
- avcstat – shows access vector cache statistics
- sealart – part of the GUI monitoring system
- seinfo – sdf
- sesearch – searches for SELinux policies for a rule
- sediff – displays differences between SELinux policies
- sechecker – checks SELinux policies
- findcon – searches for files or directories with a desired SELinux contenxt

Most of these aren't installed when SELinux is running, as they're often used for status, development, or debugging chores. A system secured using SELinux doesn't require them, but they're invaluable when trying to get an application working under SELinux. For example, try *sesearch -s httpd_t --allow -d*. It lists all of the rules that are associated with files labeled with, or based on, the type httpd_t.

Here are some useful links for more information on SELinux and other security modules:

- https://github.com/SELinuxProject
- http://selinuxproject.org (replaced by https://github.com/SELinuxProject)
- NSA SELinux documentation
- SELinux User's and Administrator's Guide
- Fedora Project SELinux
- Kernel.org Linux Security Module Usage
- AppArmor
- Simplified Mandatory Access Control Kernel (SMACK) – used by Tizen Linux
- TOMOYO Linux

SELinux AND DEVELOPERS

Providing an application without SELinux support if that application is targeted at platforms where it would be available should be verboten. Security has become critical to the proper operation of PCs, servers, and embedded systems, and not providing this type of security is just poor development practice. It's also something that's significantly easier for a developer to include rather than having something attempt to shoehorn an application into an SELinux system after the fact.

Providing support for SELinux, or other access-control systems, requires some understanding of the security environment, which is actually much simpler than most developers might think. Unfortunately, that's an article for another day.

Hopefully this article provided enough impetus to prevent you from disabling SELinux. ed

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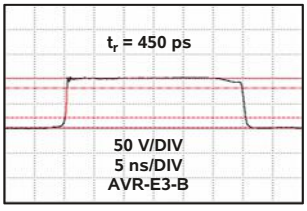

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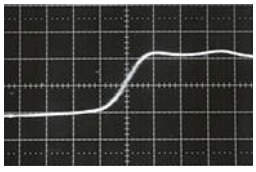

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20 V	200 ps	10 MHz	AVMR-2D-B
15 V	100 ps	25 MHz	AVM-2-C
15 V	150 ps	200 MHz	AVN-3-C
10 V	100 ps	1 MHz	AVP-AV-1-B
10 V	50 ps	1 MHz	AVP-3SA-C
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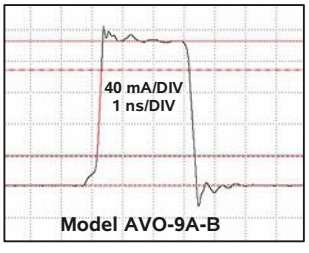

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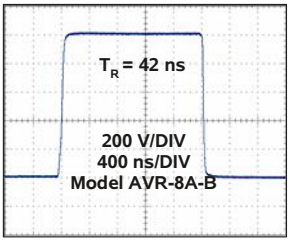

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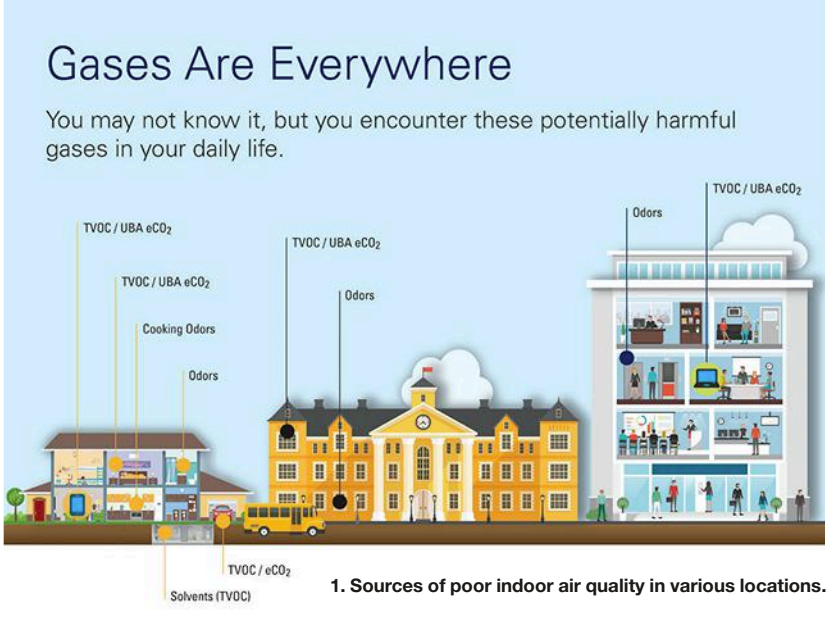
How to Implement GAS SENSORS for Indoor Air-Quality Applications

Recent advances in the types of gas sensors available have created new opportunities for engineering smart products that can consider the air quality and smell, thus providing more information to users as well as directing control over our air quality.

Metal-oxide (MOx) gas sensors, sometimes known as chemiresistors, have been used for more than 30 years in a wide range of products, most notably industrial and safety products. The largest market for these sensors has been in highly specialized, regulation-based applications where requirements are defined by independent governing agencies, and equipment is relatively expensive and intended for use by trained operators.

However, a new range of MEMs-based sensors have hit the market in the past few years, promising smaller sizes, lower prices, and embedded signal conditioners for ease of use and integration. This new class of sensors enables the electronic sense of "smell" to be added to a wide range of consumer-oriented products (including handheld and portable devices such as smartphones), with no special experience or knowledge needed by the end user.



1. Sources of poor indoor air quality in various locations.

With the growing trend for smart objects and the Internet of Things (IoT), the availability of these new sensors is creating a completely new class of applications and customers looking into MOx sensors and applications. One of the most exciting applications is in the area of indoor air quality. This article will describe the application and integration of a gas sensor into consumer products for air-quality detection.

AIR QUALITY: WHY SHOULD WE CARE?

Worldwide, people spend 90% of their lives indoors, which includes our homes, offices, schools, and cars.[1] Modern building methods focus on energy efficiency, which is great for our environment overall. Unfortunately, though, it also results in air quality inside buildings that's less comfortable and occasionally unhealthy because there's an insufficient exchange between indoor and outdoor air. The impact on indoor air quality is compounded by the many different sources of indoor air contaminants that can degrade the quality of indoor air. This includes daily activities (cooking, cleaning), materials off-gassing (furniture, paint), and even our lifestyle choices (scented candles, perfumes, etc.).

Figure 1 summarizes the different sources of poor indoor air quality. Components of air quality include particulates (e.g. PM2.5) and gases, such as carbon dioxide (CO_2) and carbon monoxide (CO), and a wide range of other volatile compounds that are present at trace levels (ppm or ppb).

CO is a highly regulated safety gas, which is colorless, odorless, and tasteless. This article focuses on the CO_2 and those other volatile components of air quality that prevail in our living spaces. These common sources of poor indoor air quality fall into the category of volatile organic compounds (VOCs), while certain activities and locations can have other indoor contaminants like volatile sulfur compounds (VSCs), also known as "bad" smells.

Though information about regional levels of outdoor air pollution can be relatively easy to find (e.g., the site managed by the Environmental Protection Agency), regrettably, it's much more difficult to find information on what's in the air in places where we spend most of our time. With knowledge comes power, and in this case, power includes the ability to change our indoor environments to increase the health, comfort and productivity of our families and ourselves.

Ways to improve indoor air quality can be as simple as turning on a fan or opening a window, especially in a bathroom or kitchen, or could include controlling HVAC systems or air purifiers. Or people could simply make conscious decisions about lifestyle activities and the types of products they use in their personal environments.

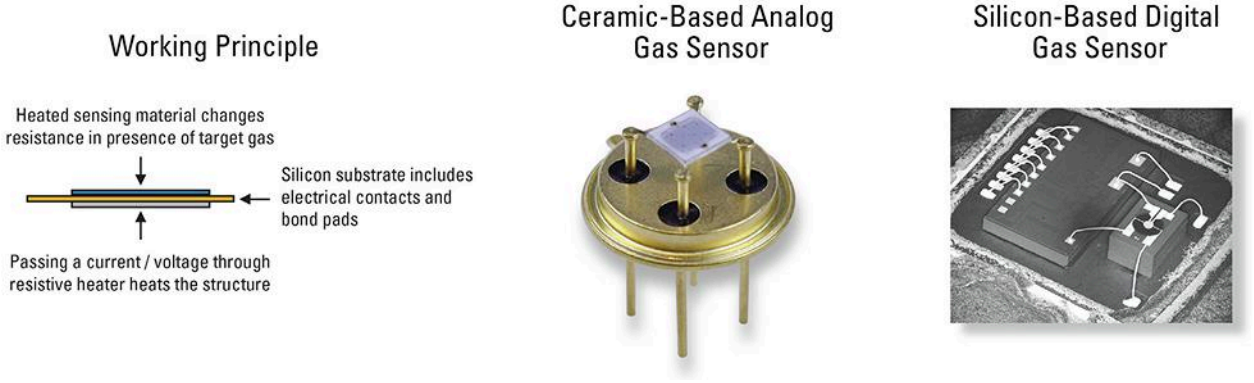
WHAT ARE MOx GAS SENSORS AND HOW DO THEY WORK?

MOx gas sensors, used to detect various gases, are comprised of a heating element, which was traditionally a small ceramic chip. Modern sensors feature a micro hot plate produced in silicon and designed to reach accurate temperatures in the range of 100 to 400°C, while minimizing power use (reducing heat transfer). The sensors also feature a sensing material based on a metal oxide—tin oxide is the traditional choice. A number of other base materials are used, too, and a wide range of additives are available to control the material properties.

Some examples of the design and construction of the sensor element are shown in *Figure 2*. Sensor manufacturers might spend months or even years perfecting a specific MOx recipe and method of manufacturing to achieve detection of the targeted gases and concentrations.

The sensor signal (resistance) is based on (1) the design of the MOx materials, (2) the operating temperature, and (3) the concentration of gases present in the air. The MOx material is heated to the target temperature (or multiple temperatures, in sequence) and the resulting resistance is measured. Resistances can range from a few hundred ohms up to gigohms, depending on the sensing materials selected, electrode design, and the operating environment.

Sensor manufacturers will typically recommend a temperature of operation



2. The basic structure of a MOx sensor (left) and examples of an analog and digital device (right).

Modern energy-efficient buildings reduce the quality of air by limiting exchanges with outside air, lowering energy costs at the expense of employee comfort and productivity. The use case for an air-quality sensor is somewhat similar to a bedroom, and a sensor that was measuring both VOCs and estimating CO_2 would be very helpful. The sensor could be tied into central air-conditioning systems to optimize both energy efficiency and productivity.

(or heater control, e.g. voltage input) to achieve a specific result or set of specifications. Some modern sensor manufacturers will go further in creating an easy-to-use sensor by developing operating methods that can be dynamically controlled with software. Therefore, the user doesn't have to consider operating temperature or how to control it and correct it for environmental variation.

Figure 3 shows a simple example of the sensitivity of a sensor to three different VOCs, which can vary depending on the operating temperature of the sensor. In the real world, air quality is much more complex, and sensor testing includes evaluation of the effect of a wide range of VOCs on the gas-sensor response.

The resistance of the MOx gas material is a function of the gas concentration of the sensor. The mathematical description for the relationship between gas concentration and conductivity follows a power law behavior as shown in the equation:[2]

$$RMOx = A \cdot c^{-\alpha} \quad (1)$$

RMOx = MOx resistance

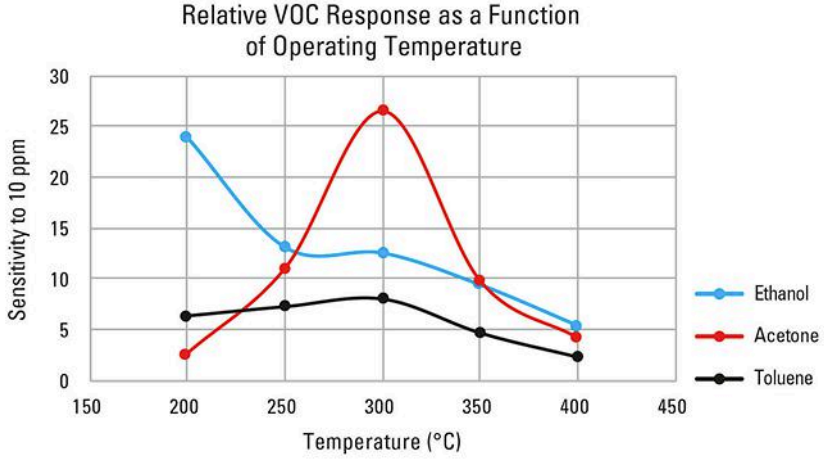
A = constant, based on the MOx material used

c = gas concentration

α = exponent, based on the MOx material used

The change in resistance with changing gas concentrations could range from a few percent to several orders of magnitude, depending on the amount of gas present, the design of the MOx material, and the operating temperature selected. Larger changes in resistance are typically preferred. This is a twist on the classic signal-to-noise ratio consideration: larger response to the gas of interest (signal) compared to sensor drift and response to changing environmental conditions (humidity, barometric pressure, environmental temperature). Together, these comprise the noise. As with other measurement systems, the better the signal-to-noise, the better the result.

While traditional analog gas sensors require user calibration, some manufacturers provide calibrated output and libraries of pre-compiled code with their sensors to make integration easier.



3. The effect of temperature on sensitivity to a target gas. By changing the operating temperature, or method of heater control, the sensor can be tuned to detect different gases.

MEASURING AIR QUALITY WITH SENSORS

Users can integrate sensors in a wide variety of locations. Each of these locations can have different sources of poor air quality, and different actions that could be taken to improve the air quality. Examples of some common consumer products that could benefit from an indoor air-quality sensor are shown in *Figure 4*.

Bedroom Example

The primary source of air quality in bedrooms is furnishings (especially if carpet or paint is new) and humans. When we breathe, we increase both CO_2 and VOCs in the air. A total VOC (TVOC) sensor with optional CO_2 correlation would be very useful—the effects of CO_2 on our sleep and cognitive function are alarming.[3]

Objective measurements of sleep quality improve with reductions in CO_2, as does performance on tests of logical thinking skills. With the informa-

4. These consumer products could benefit from an indoor air-quality sensor.

tion provided by the sensor, a user could decide to open a window, or open a door to the larger area of the house. HVAC and thermostat-control companies could consider the bedroom a zone to be controlled, not just via temperature, but also via air quality, when people are sleeping.

Kitchen Example

Cooking and cleaning both cause short-term increases in VOC levels, which can sometimes reach quite high levels. This information could be really interesting from a user point of view, in order to understand the effect on air quality from cooking and cleaning activities and choices. The information could prompt user actions, such as opening windows, or manually turning on the kitchen ventilation, or keeping the range hood on for longer amounts of time. The method of sensor operation can be tuned to kitchen odors, and an algorithm to turn a fan on or off, and control ventilation speed would be a very useful tool for appliance manufacturers. A cook's life would be significantly easier when the range hood can turn on automatically, and turn off once the levels of VOC are decreased.

Office Example

In many ways, an office is similar to a bedroom, in that the biggest contributor to poor air quality is human occupation.[4] However, because there can also be different products used (dry erase markers, surface cleaners, dry-cleaned clothing, perfumes), as well as people eating at their desks, the level of both VOC and CO_2 can fluctuate throughout the day.

Modern energy-efficient buildings reduce the quality of air by limiting exchanges with outside air, lowering energy costs at the expense of employee comfort and productivity. The use case for an air-quality sensor is somewhat similar to a bedroom, and a sensor that was measuring both VOCs and estimating CO_2 would be very helpful. The sensor could be tied into central air-conditioning systems to optimize both energy efficiency and productivity.

The idea of demand-controlled ventilation has been around for many years, but traditional sensors are expensive to buy, implement, and maintain. In addition, individual employees could take control of their comfort and health with personal and portable air-quality detectors and air purifiers.

CONCLUSION

Gas sensors have come a long way since they were first introduced. Recent advances in the types of products available have created new opportunities for engineering smart products that can consider the air quality and smell and provide more information to users, as well as direct control over our air quality. ed

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ROGER L. FRANZ | TE Connectivity

Living Without Halogens and Phthalates: THE WHY'S AND HOW'S

More restrictive regulations like those from EU's REACH are pushing companies to produce products free from these substances. What are the implications?

Electronics companies have experienced some chemical reactions in the past two decades. Many will recall the European RoHS Directive (Restriction of Hazardous Substances), which came into force in 2006, that resulted in the need for lead-free components, solder, and manufacturing processes. Changes in electromechanical parts were affected, too, by restrictions on other heavy metals cadmium, mercury, and hexavalent chromium. The same Directive also restricted two classes of flame retardants, PBB and PBDE (polybrominated biphenyls and polybrominated diphenyl ethers). These last two are organic compounds based on carbon, containing one of the halogen group of elements, bromine.

JUMPING THROUGH HOOPS

For several decades now, substances containing halogens have come under scrutiny for various environmental and health effects. There's quite a history not only for the halogen-containing RoHS substances, but others containing either bromine, chlorine, or fluorine. In all fairness, many of these substances do their jobs quite well as insulators, flame retardants, refrigerants, cleaning agents, and so on.

Halogen concerns have risen outside the realm of electronics, notably the use of the chlorinated pesticide, DDT, highlighted in Rachel Carson's book *Silent Spring* (1962). In 1999, there was an incident where polychlorinated biphenyls and the even more toxic chlorinated dioxins were found in livestock feed in Belgium.

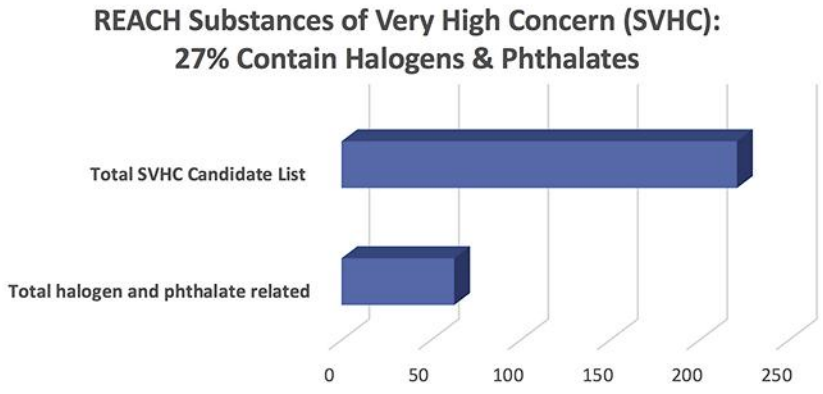
Back to the world of electronics, the Montreal Protocol in 1987 prohibited the use of chlorofluorocarbons used as cleaning agents and refrigerants. Various studies have also shown that improper incineration of discarded end-of-life electronics products could release extremely toxic dioxins to the atmosphere. Finally, the class of polychlorinated biphenyls, which were used widely in large transformers and capacitors, have been classified as one of what have notoriously become known as the "dirty dozen" Persistent Organic Pollutants. You get the picture.

Increasingly, halogenated compounds are also under the watch of the EU's REACH regulations (Registration, Evaluation, and Authorization of CHemicals). In fact, some 18% in the latest list of June, 2018 SVHC (Substances of Very High Concern) are halogen-containing. While presence of SVHC in products does not ban their use, it does bring obligations for reporting that nonetheless burdens the manufacturer.

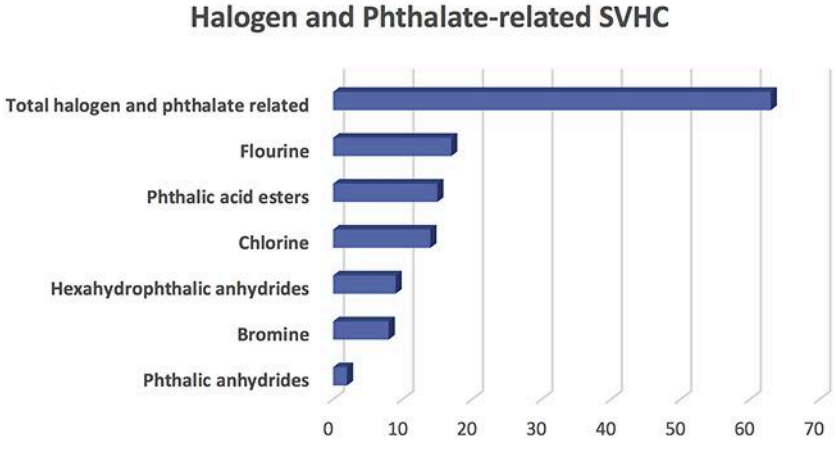
Now add to this scenario another class of substances called phthalates. These compounds are based on phthalic acid, with side chains attached that perform the function of plasticizers and softening agents. Phthalates have been widely added to PVC (polyvinyl chloride), which is inherently rigid as found in PVC pipes, to make it flexible.

PVC is a very common insulator that you most likely have around your home and office.

Combined, these two categories—halogen and phthalate-related compounds—are nearly a third of the REACH SVHC list *(Fig. 1)*. The combined halogen and phthalate-related SVHC are further broken down into more specific classifications in *Fig. 2*. Rather than deal with each substance and category piecemeal, any company currently needing to report SVHC in its products may want to consider a more comprehensive approach.



1. Halogen and phthalate SVHC.



2. Halogen- and phthalate-related SVHC.

TODAY'S CUSTOMER AND REPORTING REQUIREMENTS AND TOMORROW'S SUBSTANCE BANS

Another trend worth noting is for REACH SVHC to be included in updates of the more restrictive RoHS regulation. The four phthalates added to RoHS 2019 are detailed in *Table 1*, along with those that remain, for the time being, under the REACH regulation. *REACH compliance obligations are currently limited to reporting, but as of July 2019, RoHS bans shipping articles with more than 0.1% of the listed phthalates into the EU if above 0.1% by weight.*

While we will leave the science up to environmental chemists and toxicologists, and defer the regulations to the authorities, the bottom line is that companies may wish to take the initiative to move above the sea of regulations and develop halogen-free, phthalate-free products. In the remainder of this article, we provide some guidance on how to do just that. Fortunately, several standards organizations have published criteria that will help guide your work.

STANDARDS TO GUIDE YOU

While a company must be *compliant* to applicable legal requirements, an elec-

TABLE 1: PHTHALATE REGULATIONS: EU REACH TO RoHS

Phthalate Substances	REACH SVHC	RoHS 2015/863/EU Effective date July 22, 2019
Diisobutyl phthalate (DIBP)	x	x
Dibutyl phthalate (DBP)	x	x
Bis (2-ethylhexyl)phthalate (DEHP)	x	x
Benzyl butyl phthalate (BBP)	x	x
Diisopentyl phthalate	x	
Dipentyl phthalate (DPP)	x	
Bis(2-methoxyethyl) phthalate	x	
N-pentyl-isopentylphthalate	x	
Dihexyl phthalate	x	

tive decision to *conform* to a voluntary industry standard may also make sense because doing so brings a broader based acceptance to a specific initiative. *Table 2* lists some of the more prominent industry standards related to halogens. Iodine and astatine aren't included in the standards, nor are they discussed in this article since they're generally agreed to be of no relevance to electronics products.

You may first notice that the different standards cover rather specific usages, i.e. in printed circuit boards, or in polymers (plastics, elastomers etc.), or cables. There's also some disagreement among the various limits in terms of ppm (parts per million), though this isn't significant in most cases because, generally, the current usage levels are well into the percent range. Therefore, products meeting the standards would need a significantly different composition rather than just a partial reduction in the covered substances. The standards also differ in whether a specific limit of halogen Br (bromine), Cl (chlorine), or F (fluorine) or some combined sum of them conforms to the standard.

Various terminology has come to be used by electronics manufacturers in this regard, including: Halogen-Free, Non-Halogen, Non-Halogenated, Low Halogen, Zero Halogen, and Zerohal.

Yet another approach is to combine the definitions more broadly to include all applications, yet separate the types of halogen substances according to industry needs. The application-independent approach is listed in *Table 3* (as used by TE Connectivity).

CUSTOMER REQUIREMENTS

A low halogen product, by these criteria, meets or exceeds all of the industry standards of *Table 2*.

Other classifications that also exceed regulatory requirements may be of interest to specific customers.

For example, some OEMs specify JS709 in the engineering requirements for purchased parts. These applications may include cable-based products where a fluorine-containing cable has the desired properties for the application, and the fluorinated compounds aren't a concern or aren't listed as SVHC.

BFR/CFR/PVC-free products may also be specified. This category is an implied restriction of phthalates commonly used in PVC—unless the supplier offers a suitable substitute for conventional phthalates, an alternate base elastomer will probably have to be used to meet the customer requirement.

While some attempts have been made by industry to develop alternatives to phthalates, they aren't as widely known nor are they considered as effective for their intended function. Moreover, even if phthalate replacement were to be accomplished successfully in PVC, the halogen content would still not be significantly changed due to the inherently high chlorine content of PVC (some 57% by weight). Because of these factors, current trends point to eliminating PVC as a basic material for insulations and jackets when required by the customer.

In the next sections, we discuss some of the available choices in selected commodity types—electronic components, plastics, and cables—and how they can be successfully implemented into products.

TABLE 2: ELECTRONICS INDUSTRY LOW HALOGEN STANDARDS

Document	Applicability	Br (ppm)	Cl (ppm)	F (ppm)	Total Halogen (ppm)
IEC/BS EN 61249-2-21	Printed circuit boards	<900	<900	N/A	<1500 (Br+Cl)
IPC 4101D-WAM1	Printed circuit boards	<900	<900	N/A	<1500 (Br+Cl)
JPCA-ES01-2003	Printed circuit boards	<900	<900	N/A	<1500 (Br+Cl)
JS709 (JEDEC/ECA Joint Standard)	Polymeric materials	<1000 BFR	<1000 CFR	N/A	--
UL QMFZ2	Plastics (non-Cl and non-Br)	<900	<900	N/A	<1500 (Br+Cl)
UL QMFZ2	Plastics (non-halogenated)	<900	<900	<900	<1500 (Br+Cl+F)
ICEA T-33-655	Low-smoke, halogen-free cables	Included	Included	Included	<2000 (Br+Cl+F)

TABLE 3: APPLICATION-DEPENDENT LOW HALOGEN CRITERIA

Low Halogen Classification	Criteria
Low halogen	Cl, Br, and F each < 900 ppm
Low bromine/chlorine	Cl and Br each < 900 ppm (F is allowed in any amount)
BFR/CFR/PVC free	BFR, CFR, and PVC each < 900 ppm
Not low halogen	No halogen restriction

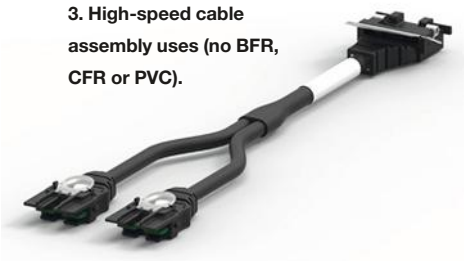
CIRCUIT BOARDS AND COMPONENTS

Flame-retardant thermosets, including the epoxies and similar materials used for laminates, have traditionally contained halogen reacted into the polymer backbone. Device packages like discrete semiconductors, ICs, and molded passives like tantalum capacitors and encapsulated inductors have used similar materials. Only those components that are primarily made of metals and/or ceramics, such as resistors, multilayer capacitors, permanent magnets, and so on, are usually considered to be inherently halogen-free.

Traditional FR-4 epoxy circuit-board laminates have been made using a rather clever chemical reaction, where a bro-

minated flame-retardant monomer, tetrabromobisphenol A (TBBPA), is reacted into the epoxy thermoset polymer backbone of the laminate. This loading of bromine provides significant flame-retardancy properties.

Considerable work has been done by suppliers and industry groups to develop, standardize, and make available halogen-free circuit board materials. One implementation is in the multilayer circuit board that's used in the ChipConnect cable assembly shown in *Fig. 3*. This is an internal faceplate-to-processor cable assembly running at 25 Gb/s. Variations include 1 and 2 ports, with either linear or right-angle connectors available at the linear edge-connector end.



3. High-speed cable assembly uses (no BFR, CFR or PVC).

Circuit boards can be specified to conform to the JS709 standard, with less than 1000 pm each of brominated and chlorinated flame-retardants. Some examples of boards capable of conforming to this standard include EMC-888 (Elite Material Co, Ltd.), TU-863 Thunderclad (Taiwan Union Technology Corp.), and TerraGreen (Isola Group). These are being made in a variety of constructions and thicknesses.

Alternate solder-mask pigments are also available. Typically, these had been based on the compound, phthalocyanine green, chemical formula $Cu(C_{32}N_8Cl_{14})$, which isn't halogen-free. However, there's a chlorine-free alternative that's the same molecule without chlorine, shifting its color to blue, and known as phthalocyanine blue, $Cu(C_{32}H_{16}N_8)$. Additional examples include solder masks in a choice of halogen-free colors.

Following the switch to lead-free terminations, semiconductor suppliers have followed up with halogen-free mold compound for device packaging. A quick survey of the top semiconductor companies finds all to list halogen-free molded packages, as do many other semiconductor suppliers.

The availability of low halogen products from suppliers of molded passive components like tantalum capacitors has evolved similarly. Low halogen developments are ongoing, so the best source of information is web searches and direct contact with your preferred suppliers. While space prevents further

The halogens and phthalates we have discussed here represent an ongoing trend where regulations become more restrictive. REACH Candidate list substances (SVHC) can move under the more restrictive RoHS category, as witnessed by the four phthalates we have discussed.

discussion here, design teams should be aware of the options and inquire about availability. Keywords found in this article may be of benefit in your search.

PLASTICS AND FLAME RETARDANTS

Plastics often need to have flammability protection for their intended applications and be rated by safety agencies. Suppliers have been developing alternatives to classical brominated and chlorinated flame retardants, beginning even before the original RoHS ban on PBB and PBDE. Other types of non-RoHS brominated flame-retardants may still be used (e.g. hexabromocyclododecane (HBCDD). However, its listing as a REACH SVHC is driving the move away from brominated compounds entirely. Some of the most promising replacement substitutes have been based on nitrogen and phosphorous.

TE MATE-N-LOCK is an example of a product line that's low halogen. The 350766-1 plug housing, with a 3-position, 0.25-in. pitch for wire-to-board or wire-to-wire applications, is rated UL 94V-0 *(Fig. 4)*.

4. TE 350766-1 low halogen plug housing.

LOW-SMOKE, ZERO HALOGEN (LSZH) CABLES

Without chlorine, polyvinyl chloride (PVC) would not exist. Achieving viable fluorine-free jacket materials has been challenging for cost-sensitive commercial products. Removing both fluorine and chlorine leaves compounders with few options, except to pursue polyolefin or elastomer-based ingredients, including LDPE, LLDPE, TPE, and TPU materials. In addition to verifying the low halogen content, candidate replacements must pass applicable low-smoke density tests, for example, UL Standard 1685 or IEC 61034. Refer to Low Smoke Zero Halogen High Speed Parallel Pair Cables for more information.

Rugged LSZH cables for the military and marine use are available. For example, Raychem MIL-DTL-24643 Zerohal PROFIBUS cables are 150-Ω twisted pairs available with one or two shields and one or two jackets that can also be water-blocked for marine and ship applications. Other applications include industrial automation.

Another series of low-halogen cables suitable for marine use are the Lightweight Low Fire Hazard Cables according to VG95218 part 28. These low halogen cables are available in a wide range of color-coded conductors and sizes. Lightweight and low fire hazard, these cables are available in a wide range of primary wires and screened cable components in pair, triple, and quad configurations. Additional product offerings, including VG-95218 Marine Cable, may be found in the catalog Wire and Cable: The Industry Standard for Rugged, Reliable Performance.

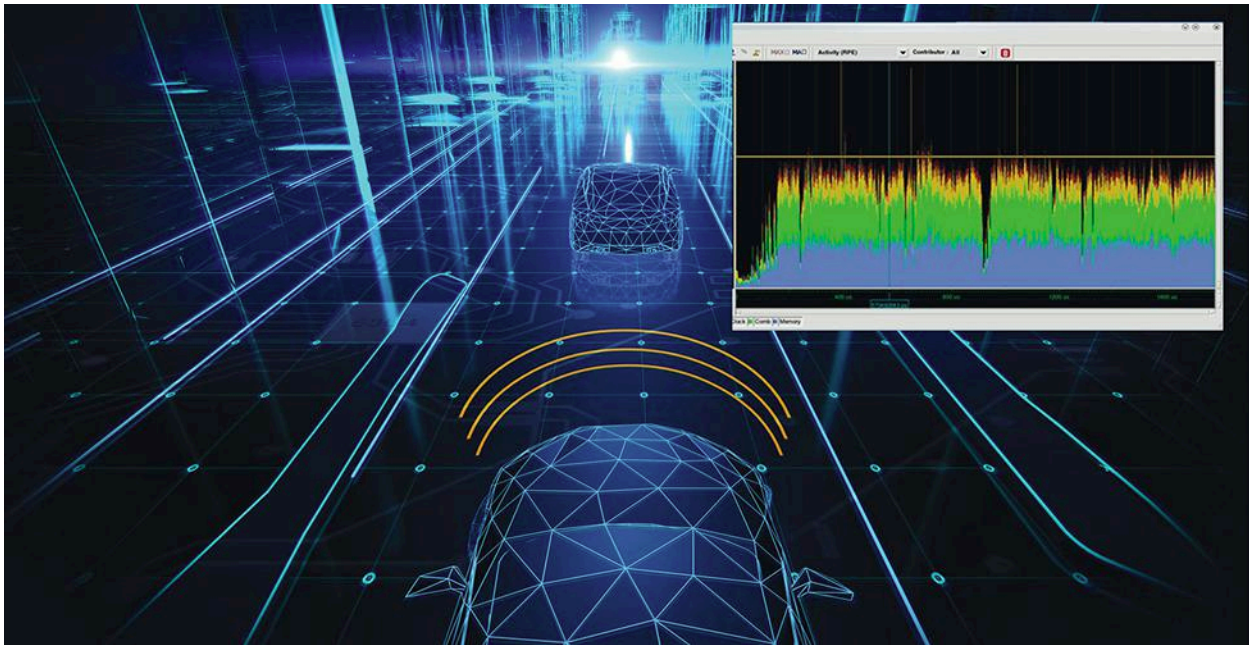
Last, but not least, a non-halogen insulator or heat-shrink tubing may also be needed for some cable assembly applications, including use in commercial and household appliances. Examples include tubing as listed in the brochure SWFR Single Wall, Heat Shrink Tubing Highly flame-retardant, UL VW-1 rated, Zerohal tubing. When a heavier heat-shrink solution is needed, see Raychem Heat-shrinkable Halogen-free, Heavy-wall Tubing ZCSM for Low Fire Hazard Areas. More low halogen types including both flame-retardant and non-flame-retardant grades, low recovery temperature, and fabric tubing are available for selection in Raychem Tubing Products: SINGLE WALL, DUAL WALL, HEAVY DUTY, SPECIAL PURPOSE AND MEDICAL-GRADE.

WHAT NEXT?

We have traced the trend from environmental regulations and industry standards to customer requirements for products without halogens and phthalates. PCBs, molded components, plastic parts, cables, and shrink tubing across diverse electronics industries are all maturing to fill these needs.

The halogens and phthalates we have discussed here represent an ongoing trend where regulations become more restrictive. REACH Candidate list substances (SVHC) can move under the more restrictive RoHS category, as witnessed by the four phthalates we have discussed. Meanwhile, environmental watch groups may also continue to pressure industry to improve the environmental performance and total lifecycle management of electronics products. As has often been the case, adapting high-end, high-reliability solutions for military use can also lead the way to higher-volume, lower-cost solutions for the commercial market. ed

LAURO RIZZATTI | Contributing Technical Expert



Twin DFT and Mission-Critical Safety Apps for Pre-Silicon Design Verification

Combining these Apps with an emulation environment makes it possible to increase fault coverage, increase production yield, and reduce ATE test time and cost.

The design-for-test (DFT) technology was driven by the need to harness the runaway cost of testing silicon chips on the manufacturing floor. This phenomenon eventually became close to 40% of the cost of building the chip. To combat this challenge, the battle cry became "simplify, accelerate, and optimize" the testing of the manufactured chips.

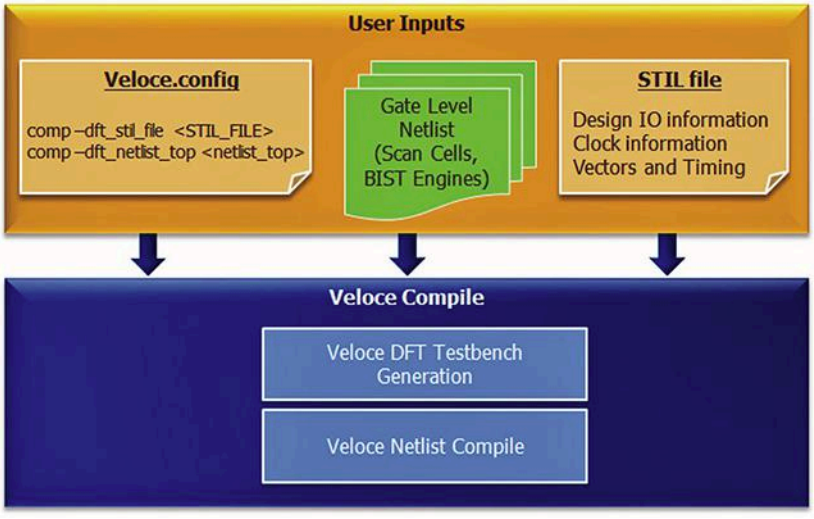
Unfortunately, for all of DFT's benefits, the technology came with a drawback. Inserting DFT logic structures in the netlist of an already tested design forced designers to verify that the design integrity hadn't been broken––easier to say than to do. The added logic on complex designs significantly increased their sizes. And the larger the added logic, the larger the volume of test patterns required to test the design.

Software-based simulation tools barely handled the original design netlists, and the added burden stretched the

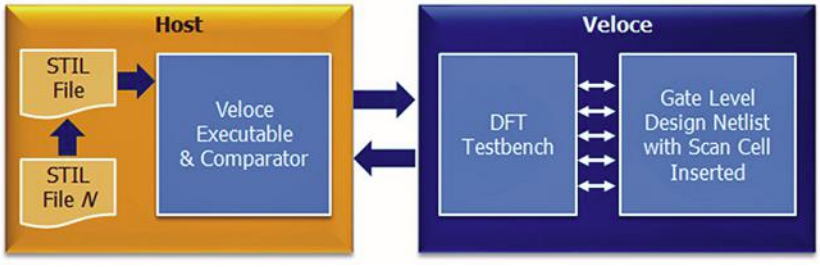
verification cycle to a point beyond the schedule determined by management.

This is where hardware emulation came to the rescue. Its ability to verify multi-billion gate designs at the gate level with performance close to six orders of magnitude faster than traditional software-based simulation tools dramatically sped up DFT verification. The result was higher-quality designs, enhanced production yields, reduced lab bring-up time, lower product and test costs, and faster time to entitlement.

Reflecting on these events, I scheduled a phone discussion with Robert Serphillips, Veloce DFT product specialist at Mentor, a Siemens Business. We talked about twin Veloce Applications: Veloce DFT App and Veloce Fault App. The App/emulation combination accelerates DFT verification for complete validation of test vectors and DFT logic, as well as increases fault coverage prior to tape-out.



A compilation flow for emulation with the DFT App verifies a DFT-modified netlist to accelerate test vector development. *(Source: Mentor, a Siemens Business)*



Single-pattern mode executes one pattern, reinitializes the design, and runs the next pattern. *(Source: Mentor, a Siemens Business)*

DFT APP

The Veloce DFT App and emulation platform verify the DFT-modified design netlist with long sequences of test vectors and accelerate test vector development. By shortening the execution of tests from a few months on a simulator to one or two hours, emulation allows complete validation of test vectors and DFT logic before chip tape-out. This further increases fault coverage and accelerates time to entitlement.

All patterns that run on automatic test equipment (ATE), such as structural, built-in self-test (BIST), parametric, I/O characterization, and functional are fully supported by the DFT App. Based on the Standard Test Interface Language (STIL), the compile flow is straightforward. It reads the design under test (DUT) gate-level netlist instrumented with scan cells and BIST engines, and STIL files, including DUT I/O information, clock information, and test vectors and timing. It generates the DFT testbench and DUT mapping onto the emulator.

The emulation session runs in two modes. In single-pattern mode, the App executes one pattern, reinitializes the design, and runs the next pattern. This mode can be inefficient due to the overhead to reinitialize the DUT and bring the state of the hardware back to time zero.

In a pattern burst mode, similar to running STIL vectors on the tester, the user puts the STIL file into a burst list and runs all patterns in it in one execution, saving time.

For example, 100 STIL patterns in single pattern mode took 45 minutes, but only 90 seconds in burst mode.

COMBINING THE DFT APP WITH THE FAULT APP

By combining the Veloce DFT App with the Veloce Fault App, the user can achieve a powerful pre-silicon fault coverage solution.

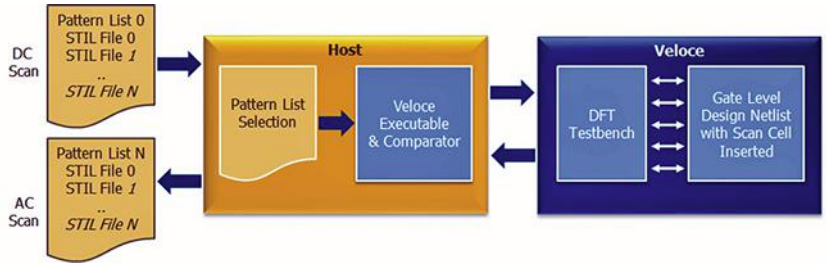
If a user generates 10,000 automatic test pattern generation (ATPG) patterns, AC and DC scans and patterns reached 99% DC coverage and 85% AC fault coverage, the few remaining uncovered faults could be due to several reasons, such as test tools that don't have controllability over the net or no observation. Either way, the user can write BIST patterns, functional patterns, difficult parametric patterns, and IO patterns to cover those untested ATPG faults. Using the ad hoc flow shown below, the user can inject a fault pre-silicon to see if that fault would be covered.

According to Serphillips, the ability to run ATPG, functional, and BIST simultaneously is valuable to the user community.

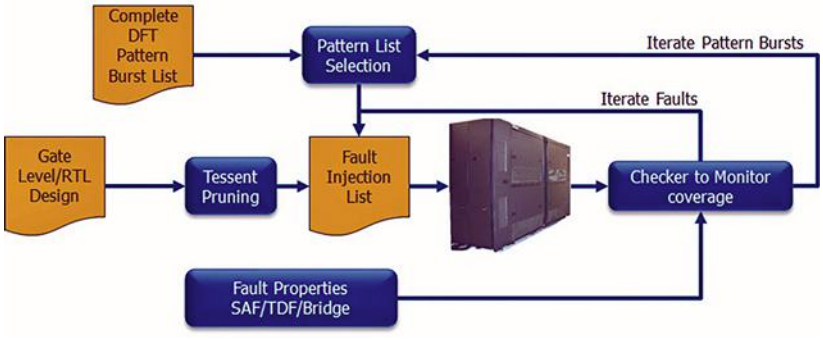
THE FAULT APP

The Veloce Fault App aims to ascertain the fault tolerance of a design that's designed for high-reliability and safety-critical markets such as automotive. While functional verification determines whether a design performs what it's supposed to accomplish, safety verification ensures a design behaves correctly even in presence of hardware faults.

It works in tandem with the emulation platform. At compile time, it generates a fault universe to be injected into the design. Fault types are grouped in four categories: stuck-at, transient, single-event upset (charge particle deposition), and bridge (four-way dominant fault model). The user can inject them into any net or nets of the design in any capacity.



Burst-pattern mode runs all patterns in one time-saving execution. *(Source: Mentor, a Siemens Business)*



Combining the DFT App with the Fault App delivers a pre-silicon fault coverage solution. *(Source: Mentor, a Siemens Business)*

FAULT TYPES SUPPORTED BY THE FAULT APP

Type	Behavior
SA0	Stuck at 0
SA1	Stuck at 1
TF0	Transient 0
TF1	Transient 1
AND1	Bridge fault causing AND, impacted net is FIN net
AND2	Bridge fault causing AND, impacted net is Bridge net
AND	Bridge fault causing AND, both nets impacted
OR1	Bridge fault causing OR, impacted net is FIN net
OR2	Bridge fault causing OR, impacted net is Bridge net
OR	Bridge fault causing OR, both nets impacted
SEU	Charge particle deposition. Remove after first posedge
	(Source: Mentor, a Siemens Business)

COMBINING THE DFT APP WITH THE POWER APP

The number one reason that patterns fail on the tester is due to factual manufacturing defects. Test vectors can only identify a broken part, not fix it.

Sometimes, during testing on the manufacturing floor, physical variations across the process, voltage, and temperature (PVT) may occur. These may be due to internal integrated-circuit quiescent current (IDDQ) events, such as crosstalk, ground bounce, or collapsing voltage rail. The IDDQ events don't happen on all parts under testing. Realistically, they may lead to a 3% fallout on a batch of 10,000 parts.

An IDDQ event typically occurs when the pattern is factored in. In performing embedded deterministic test (EDT) compressed scan, a massive amount of data is scanned into the part, none of it functional. It may be because the power supply doesn't have enough capacity to feed and sustain the switching of all the elements.

In the past, the occurrence was noticed in big networking chips. Today, it affects automotive chips with many megabytes of onboard memory. The DFT engineer may test all memories at

The combination of the DFT App and Power App allows for bursting all ATPG patterns and generating a power profile. If a particular pattern or multiple patterns are generating too much switching activity, it's reasonable to assume that there may be an issue. All testing should be done in pre-silicon before shipping it to the tester.

the same time, but functionally doesn't work like that. The end result is that all of that switching activity causes the collapse of the power supply, leading to an IDDQ event.

The combination of the DFT App and Power App allows for bursting all ATPG patterns and generating a power profile. If a particular pattern or multiple patterns are generating too much switching activity, it's reasonable to assume that there may be an issue. All testing should be done in pre-silicon before shipping it to the tester.

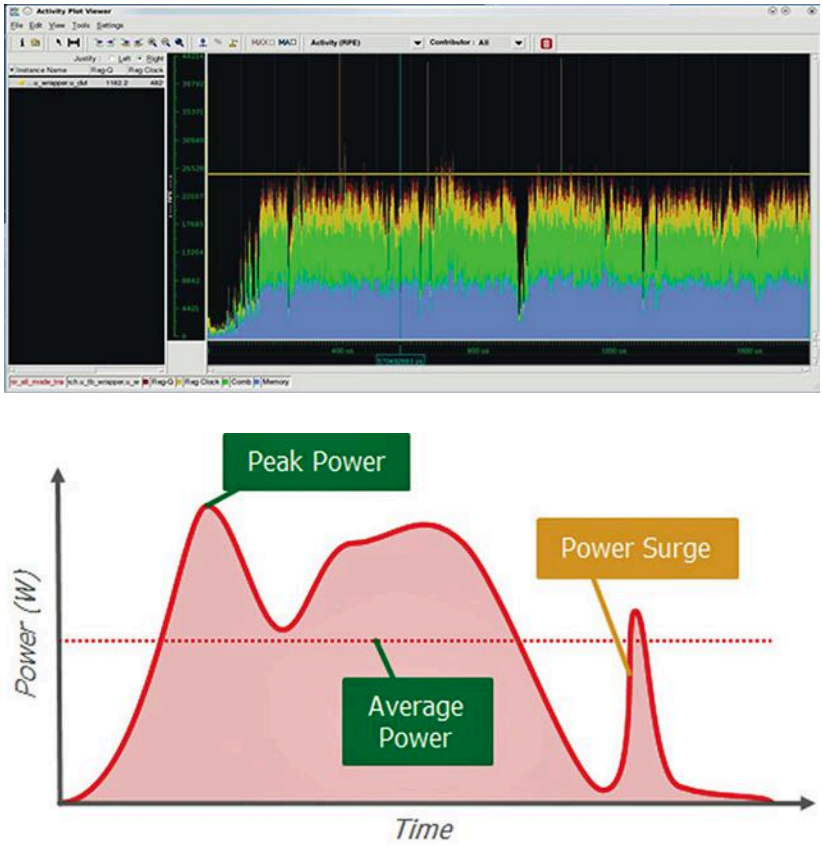
Serphillips recalled a case where BIST patterns were running 200 MHz slower than functional patterns due to an IDDQ event, though there was no visibility on the tester to understand what was happening.

TESTER VS. EMULATOR

The DFT App has an advantage over a tester. A user debugging embedded deterministic test (EDT)-compressed ATPG patterns can substitute an emulator for the tester. When an EDT-compressed pattern fails on a tester, the user can't tell which element on the chain is failing and is forced to go back through the tools that generated the "one hot" and run the test again.

The DFT App enables the user to run the same scenario through emulation and supports both compressed files through a serial style with compression or decompression in the compression or EDT logic. Simultaneously, it supports the EDT internal mode where the user is scanning through the top of the chains individually in an uncompressed manner.

Not supported is parallel or backdoor preload. That's where users shift instead to scan preloaded sequential elements. Emulators in general don't sort backdoor preload because it limits performance. Instead, DFT App users would load compressed EDT-enabled serial and internal uncompressed files.



Combining the DFT App with the Power App enables bursting for all ATPG patterns to generate a power profile. *(Source: Mentor, a Siemens Business)*

CONCLUSION

By combining the DFT App Fault App and Power App with the emulation environment, the user can increase fault coverage, increase production yield, and reduce ATE test time and cost. Ultimately, the user is able to accelerate the design schedule for faster time to market, boosting profits and reducing ATE test escape and increase product returns. ed

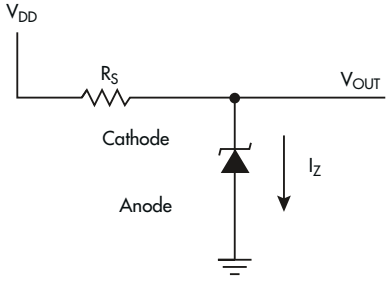
AUTHOR'S NOTE: The emulation apps described here are Veloce DFT App and Veloce Fault App, offered by Mentor, a Siemens Business. These help accelerate DFT verification for complete validation of test vectors and DFT logic and increase fault coverage prior to tape-out. More information can be found at: https://bit.ly/2e0ydhK

ideas for design

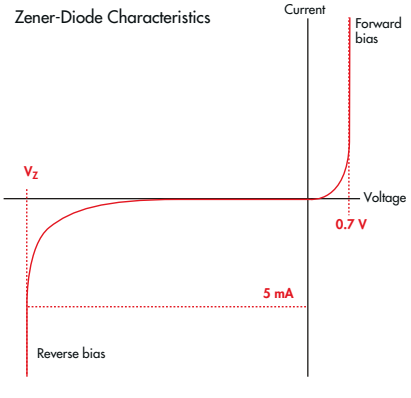
Voltage Reference Bests Zener Diode as Low-Current Bias Source

ROBERT HANRAHAN | Sr. Member of Technical Staff, Texas Instruments

THERE ARE TIMES when you need to bias a low-current load and simply didn't want to add another voltage regulator, or where you need a reasonable level of voltage accuracy, so a simple voltage divider isn't enough. For many years, designers used Zener diodes as simple shunt voltage regulators *(Fig. 1)*. With a single resistor, the device will maintain the fixed voltage which was set during the manufacturing process.



1. In a commonplace arrangement, a single resistor and Zener diode create a simple voltage rail.



2. Zener diodes typically require a more than a few milliamps to reach "knee" voltage V_z.

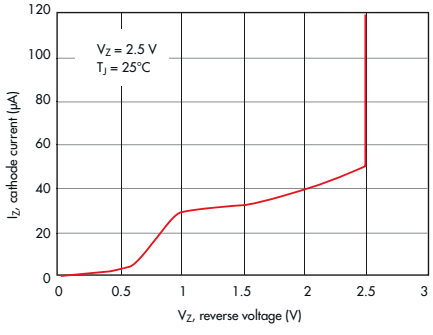
A good Zener diode works well, but when you look closely at the datasheet, you'll see that you need to source more than a few milliamps in order to realize an accurate Zener voltage (V_z). To maintain accuracy, you must choose a low-enough value of series-resistor value to ensure that the Zener reverse-bias current (I_z) falls within an acceptable range. This may be as high as 5 mA, especially with lower-cost, non-temperature-compensated diodes *(Fig. 2)*.

Ohm's law and Joule's law dictate the power losses across the shunt resistor, which affects overall system losses and temperatures. As an example, with a 12-V input, using a 2.5-V Zener diode would require a 1.9-kΩ series resistor to maintain 5 mA (assuming no load current). A 1.9-kΩ resistor carrying 5 mA results in a loss of over 47 mW across that resistor; with 24 V, the losses are over 100 mW.

A voltage reference (also called a bandgap reference) provides the same functionality as a Zener diode, yet requires far less current to maintain a more-accurate voltage. While a Zener diode uses a single p-n junction with specific doping to create a Zener breakdown voltage, a voltage reference uses a combination of transistors and employs a positive-temperature-coefficient p-n junction in conjunction with negative-temperature-coefficient transistors to make a zero-temperature-coefficient reference.

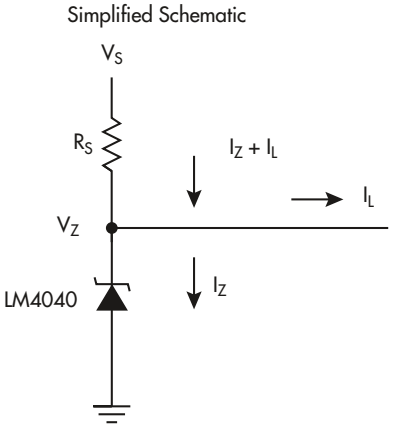
The concept and design of a bandgap reference was introduced back in the 1970s by Bob Widlar, when he was a power IC designer. Although voltage references are often employed because of their voltage accuracy (well under 1%) over temperature and time, advances in semiconductor circuitry, processes, and packaging have brought them into new applications.

Wider-tolerance and lower-cost voltage references (1% and 2%) open up their use in applications where they were never before considered, including applications where you might be using a Zener diode or voltage regulator. Using a voltage reference in place of a Zener diode is about efficiency and simplicity.

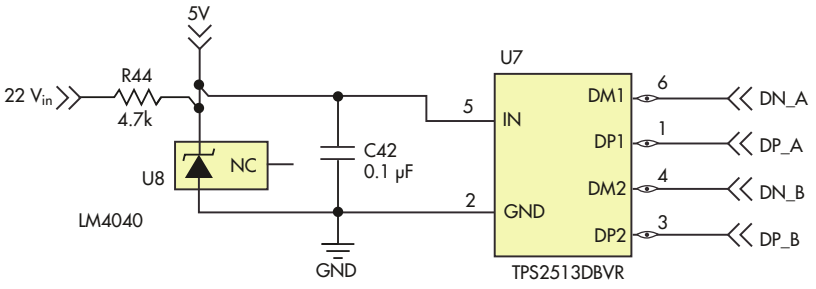


3. The TI LM4040 2.5-V voltage-reference curve shows its high voltage accuracy even when biased well below 100 µA.

The voltage across the voltage reference becomes well-regulated when I_z is only 50 µA. The datasheet shows the characteristics of Texas Instruments' LM4040 at 25°C *(Fig. 3)*, including its superb voltage accuracy when biasing well below 100 µA over ambient temperatures from −40 to +125°C (this is the extended Q-grade temperature version;



4. Calculate R_s to accommodate the worst-case load current while maintaining the minimum Zener current.



5. A simple circuit uses the LM4040 voltage reference to develop a low-current, 5-V bias rail.

the normal industrial temperature range is −40 to +85°C). Some voltage references operate at an even lower current, such as the ATL431 and LM385.

Using the same 12-V example as above, but with 75 µA for I_z instead of 5 mA, you can use a 126-kΩ resistor and maintain a more-accurate voltage. The 126-kΩ resistor also enables keeping the power loss in the resistor under 1 mW, which is well below the 47-mW loss when using a Zener diode.

Of course, when delivering current to a load, it's important to select a lower-value resistor in order to deliver load current while maintaining the needed I_z for regulation over load variations. As shown in *Fig. 4*, simply calculate the current through the shunt resistor R_s where $I_r = I_z + I_{load}$, and then size using Ohm's law, $R = (V_s\text{-}V_z)/I_r$. Be sure to use the worst-case load current and take tolerances into account when selecting this resistor.

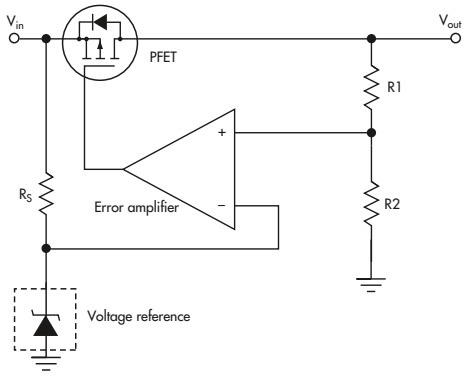
By using a wide-tolerance voltage reference like the 2% LM4040E from TI, you can realize a regulation voltage superior to most voltage regulators at a lower price than a typical voltage regulator and comparable to that of a Zener diode. (These devices are also available in small SC70 packages.) An advantage of using a voltage reference for voltage-regulation applications is its ability to operate over very large voltage ranges; a voltage reference doesn't care about voltage, only current. By choosing the right shunt-resistor value based on the input-voltage range and output current, you can support a very wide range with a simple solution.

Fig. 5 is an example of using the LM4040 to develop a low-current 5-V rail from a 22-to 25-V input to bias the 5-V input to a USB controller IC, which only needs 100-µA worst case. The selected resistor value takes into account additional bias current for a load not shown. This application can use the lower-cost 2% E version of the LM4040-N device. As you can see, the circuit is very simple and small when using 0402 passives.

Because you need higher current, the shunt resistor will need to be larger in order to dissipate the thermal losses caused by the voltage drop. The maximum current through most voltage references is on the order of 10 to 30 mA, which limits applications.

For higher current, you can use the same voltage reference with a bias resistor along with an additional transistor to provide the necessary input-to-output voltage drop. A p-channel FET transistor biased from an error amplifier can supply much-higher current. The error amplifier (note that a single rail-to-rail operational amplifier works well) senses VOUT and compares it to the voltage reference to provide a well-regulated voltage over various changes in load current and temperature *(Fig. 6)*.

By removing R2 (and shorting R1), the circuit will provide a very well-regulated voltage equal to the voltage of the voltage reference. Voltage dividers R1 and R2



6. A voltage reference is at the heart of all voltage-regulator circuits, and can provide higher current with the addition of an external p-channel FET.

provide a means to adjust the output to any voltage equal to or greater than the reference voltage. Although beyond the scope of this discussion, an input and output capacitor isn't shown and would normally be needed.

A voltage reference is at the heart of almost all integrated voltage regulators. You might ask, "If it's this easy, why use an integrated voltage regulator at all?" One reason is that a voltage regulator also includes circuitry to monitor and limit current to the load, and monitors the temperature to protect the device and load during fault conditions. Although designers can and do design discrete voltage reference-based regulators, it's often more practical and cost-effective to use one of the many integrated voltage regulators available today.

Don't jump to a Zener diode next time you need a low-current rail voltage; instead, consider using a voltage reference.

2019 DISTRIBUTION OUTLOOK

What's inside:

- End-market demand drivers for industry growth
- Impact of tariffs and trade
- Growing importance and benefits of e-commerce
- Attract, retain and motivating talent
- IoT and cloud opening non-traditional markets
- Automation of distribution processes
- Biggest surprises in 2018 (Strength of current market cycle)
- Actions to prepare for 2020 and beyond

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Electronics Distribution Outlook 2019:

A Strong Market, Steady Investment, but Uncertainty Over Global Trade

Despite growing volatility in the global trade environment, electronics distribution is on a roll that shows few signs of slowing in 2019. But distributors say they aren't resting on their success. In the midst of a booming market, expect deep investments in inventory and distribution operations, digital infrastructure, and talent acquisition.

"A super cycle," is how Karim Yasmine, Corporate Vice President, Strategic Supplier Development, at Future Electronics, describes the past two years of revenue growth in the electronics distribution industry.

It's an unprecedented run that's expected to extend through this year, fueled by strength in almost every vertical—from automotive and industrial applications to security and mil/aero.

"Many of the core verticals just continue to drive growth," says Yasmine. "For example, if you look at just the basic industrial business, it has experienced strong growth in the last couple of years. If you look at what we would call the traditional automotive business, it too has been on a steady rise because of the increasing amount of electronics content in cars."

As to what's coming next, Yasmine points to numerous new automotive applications such as ADAS, Hybrids and EVs, infotainment, and battery management systems—some which didn't even exist a decade ago--that he expects will drive tremendous business.

Other new technologies and issues are expected to contribute to that growth, including the adoption of 5G technologies, the Internet of Things—with implementations now reaching a critical mass--and cybersecurity. "Right now, the market is being pulled by so many different segments and applications that I feel very positive about what the outlook for next year will be," concludes Yasmine.

Don Akery, President, TTI Americas, concurs. "Business continues to be strong for us. Bookings and billings continue to improve, quarter over quarter." As a case in point, he notes that the third quarter of 2018 was the company's strongest ever.

Layered on top of the strength in the mainstream distribution business, there also is growing demand for distribution services, including design and inventory support, as well as the expansion of non-traditional customers and markets driving new revenue opportunities.

Kevin Hess, Senior VP of Marketing at Mouser Electronics, sees the Internet of Things as one factor that's driving a wholly new customer base. "Nowadays, if you're manufacturing something, you likely want it to be connected. And if your product didn't incorporate electronics before, it now will need to if it's going to be connected in any way," he explains. "This trend is creating a group of innovators—people making modules and boards and building connectivity into their products-- that have never been part of our industry before."

INVESTING IN BRICKS-AND-MORTAR AND DIGITAL INFRASTRUCTURE

To take advantage of a boom market and better serve both existing and new customers, top executives at many of the key distributors say investments in their businesses will continue apace in 2019.

Some of that investment will be in good old bricks-and-mortar, primarily to support an expansion of inventory capabilities and distribution operations, and also to accommodate the increase in business more efficiently.

"We announced last year that we're going to expand our new distribution facility by another 168,000 square feet over the next six to nine months," says TTI's Akery. The company, which moved into a new 800,000-square-foot facility in Fort Worth, TX in 2018, announced at EDS last year that it was committed to taking inventory levels up significantly in order to ensure it would be able meet the needs of its customers.

"We're sitting on inventory that is 40%, 50% more than it was 18 months ago," says Akery. "Even in a market where there's a lot of product that is hard to come by. That's a sign that our guys, our product teams, got ahead of it. "

And all that extra inventory needs to be housed somewhere.

Similarly, Sager Electronics tripled its distribution footprint in Carrollton, TX in 2018. Early this year, it will start replenishing its power and thermal inventory at the new facility. "A year—maybe less--from now we'll have between $20 to $30 million of the bigger, bulkier items in inventory, which is what we set up the facility to handle," says Aruri Faris, Senior VP of Marketing. He notes that the central location of the facility is an advantage for the company.

Six months ago, Premier Farnell, broke ground on a new facility in Leeds, UK. "It will be a fully-functioning, smart warehouse, with automation, mobile robots, shuttle systems, mobile data connections, pick-to-light systems, and more," says Farnell's President, Christopher Breslin. "It is going to deliver two times the existing throughput with much greater efficiency."

Digi-Key Electronics also has started construction on a new 2.2 million-square-ft facility at its Thief River Falls, MN headquarters. "This project was many years in the planning stages," says Chris Beeson, Executive Vice President, Global Supplier & New Business Development at Digi-Key. "It was designed to drive natural productivity gains in our distribution operations, but at the same time we wanted to do more than just make our existing processes more efficient. So, during the design phase we also explored questions such as, 'What don't we do today that we could be doing?' We then looked to incorporate features into the facility design that would allow us to expand our business and take advantage of new revenue opportunities."

For most distributors, it's also about becoming more efficient inside their existing bricks-and-mortar facilities in order to handle the increase in orders.

"The demand for warehouse workers is skyrocketing. And honestly, there are just not enough people out there to fill the jobs," says Dan Stewart, VP of Marketing and Ecommerce at Allied Electronics. "The only way anybody is going to be able to operate effectively moving forward in the future is to add automation to make their warehouse workers more efficient and productive."

Mouser's Hess agrees that it isn't economically feasible to continue to hire more and people as the number of customers and shipments grow, so one of the major things the distributor is doing is adding more automation within the warehouse.

(Continued on page ST 8)

ALL SEGMENTS SHOWING GROWTH

Karim Yasmine,

Corporate Vice President, Strategic Supplier Development; Future Electronics

"What's interesting is that everybody's talking about this cycle we are in and what's going to drive it. Every segment is going to drive growth. Every segment is showing growth. You look at Mil/Aero as well. There are some pretty significant government-sponsored programs that will drive some growth as well. Even IoT, which is a bit of a generic term, at this point because it has become a bit of a horizontal. We're just starting to hit the curve on IoT, and we know that we're prepared to meet our customers' needs."

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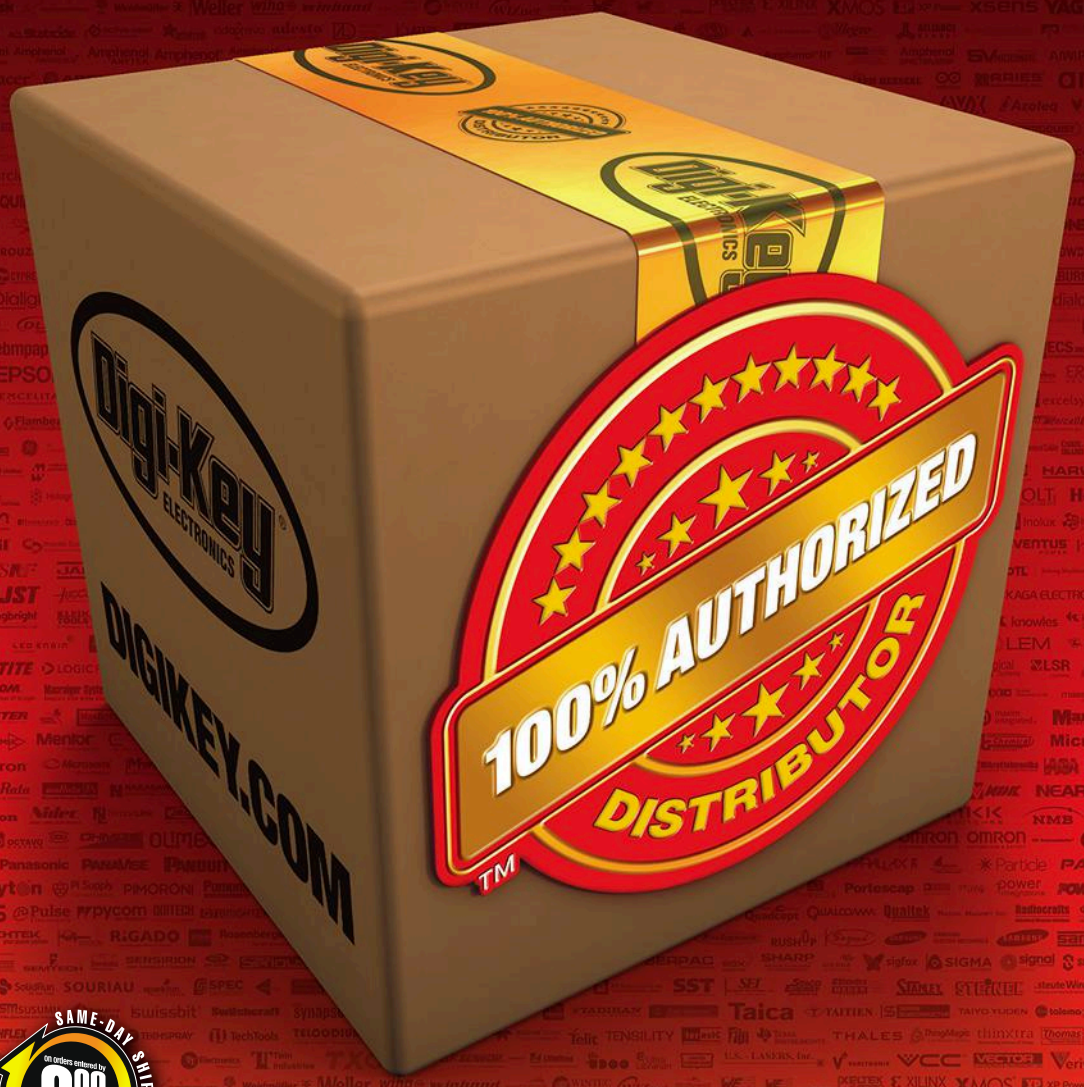

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(Continued from page ST 4)

To that end, Mouser is investing in smart equipment that can communicate to everything else in the warehouse over wireless communications, which will streamline both warehousing and shipping operations. "Bottom line," says Hess. "We're evaluating everything—even the best location for a product to be placed in the warehouse based on its flow—to maximize efficiencies."

Distributors also say there will also be ongoing investments in digital infrastructure, ranging from new capabilities that drive a better customer experience to creating transparency around new tariffs and pricing.

"Improving the customer experience online is a journey that we—as well as other distributors--have been on for some time, and we'll continue to make aggressive investments here," says Allied Electronics' Stewart. "We view it as our job is to make sure that our customers can interact with our site in the way that they want to."

One example he points to is the recent addition of 360-spin images of products, allowing a customer to view a particular product from any angle, something digitally savvy customers will appreciate. Another is the addition of an exploded view of a product, which provides customers with a more detailed look at the specific features or individual sub-components of a product.

"It's changing the way that our customers are engaging with our website," Stewart explains. "In the past, a customer would have to pick up the phone and call tech support with basic product questions. Now, we are making sure that we provide as much information digitally as possible, so now in many cases they don't need to make that call."

Allied Electronics is also using the data on how customers engage with the website to make better decisions. "We can bring these analytics into conversations with our suppliers around topics like inventory and marketing so that we can come out with a very clear action plan grounded in the actual analytics," says Stewart.

Mouser Electronics is focusing on the creation of more educational content for customers and making that content easier to find. "Our non-traditional customers in particular are going to start with a search engine, so we need to make sure our content is discoverable," says Hess. "Then, once they find what they are looking for on Mouser, they need to be able to navigate our website in a highly intuitive way. It's no longer good enough to simply publish a part number and the amount available. A customer may not be familiar with the part they are looking for, so we need to educate people on what they are buying and ideally provide all the content on the same page."

One new feature--designed to address a timely need==that Premier Farnell is working on is providing transparency to its customers around the cost of tariffs. "Rather than simply embedding the cost of the tariff in the total price, we show it as a separate line item for the customer," says Premier Farnell's Breslin. While it takes retooling of the GIS (geographic information system) and other systems reporting, Breslin says that the investment will pay off because of the benefits to the customer.

MAKER MOVEMENT EXPANDING CUSTOMER BASE

Kevin Hess,

Senior Vice President of Marketing; Mouser Electronics

"The innovator movement or maker movement really started more than a few years ago and everybody wanted to reach them. We were all trying to understand how to help these innovators create the next big thing. It's really opened up a market opportunity that is beyond our traditional customer base. I don't know if it's big dollars, but it's a lot of customers, and the hope is that a few customers turn into bigger dollars down the road. We feel things like our no-minimum model, along with our vast product selection, are a plus for this group."

BIG TIME PLANS TO INVEST IN PEOPLE, TOO

Nearly all distributors we spoke too plan to make additional investments in people, particularly in customer-facing roles.

For example, as Sager Electronics becomes increasingly involved in product lines such as power supplies and thermal solutions, it continues to make a substantial investment in electrical and mechanical engineers to focus on those areas. "Our engineers are involved in the process starting from the recommendation of products based on a customer's problems and requirements [which in the case of power supplies is a little more intricate than just recommending a 14-pin connector] all the way in the case of smaller companies to working on the complete design and customizing it, with the help of the supplier" says Sager's Faris. "Our goal is to be trusted advisors in power and thermal."

Future Electronics, too, is making deep investments in headcount to provide technical support to its emerging customer base. "The technical requirements of the products that some of our customers are designing are getting more complex—these days almost everyone wants to connect their product--which means wireless complexities. These designs often require high-touch support," says Future's Yasmine. "So, we've made investments in the physical headcount of our FAE organization. We've also beefed up our Future Connectivity Solutions organization, and in Europe we've opened additional design centers of excellence."

TTI Americas has also been increasing its headcount, with the biggest increase in the number of customer-facing roles in the organization. By the end of the first quarter this year, it expects to have added a total of 233 field sales people in North America since the beginning of 2018. "It's something that we think is unique, based on what we've seen from our publicly held competitors," says Akery

And that's just the tip of the iceberg. There is much, much more that electronic distributors will be investing in because they know even in a boom market that to make money you have to spend money.

SOME CHALLENGES AHEAD

That's not to say that it is all smooth sailing ahead. There's no question that new tariffs and trade treaties and uncertainty around the growing volatility in the global trade environment will have an impact on the distribution business and a ripple effect along the entire supply chain.

Nearly all distributors say that tariffs are a conversation and now becoming a business practice that has created new considerations for the industry. Some go further to say tariffs have no upside and are nothing but a distraction for industry at every level from manufacturers, distributors, and customers to sales reps.

"It is not one of my favorite topics, but it's one that we can't ignore," says Premier Farnell's Breslin. "There's the basic work we need to do, which is to understand the size of the impact and the percent of products that have content from China.

"Our supplier is going to continue to manufacture product in China. Sometimes we have options to do it in other cost-effective geographies. So, we'll do that," Breslin continue. "But beyond that, internally there are a lot of things we have to do just to make sure that we can pass these things along to customers in a way that is not taking advantage of the situation. We also have competitive realities that some of our competitors will pass everything along. Some might absorb some of it and pass along and then have a cost advantage in the market."

(Continued on page ST 12)

RESPONDING TO TARIFFS WITH TRANSPARENCY, FAIRNESS

Don Akery,
President; TTI Americas

"I'd say the China tariff piece of it has thrown a curveball at all of us, and it's taken a lot in order to be able to administer them. But our strategy is to be transparent and fair. We decided that for four months we would absorb the tariffs, and we would start charging on November 1, 2018. One of the reasons we were able to do that was because of our inventory that we had on-the-shelf before the tariffs were put in place. Clearly, we had paid no tariffs on it. We were committed to being transparent with our customers, telling them, 'We're not going to charge you. We're not going to make a profit on this."

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TTI, Inc., a Berkshire Hathaway company, is an authorized, specialty distributor of interconnect, passive and electromechanical (IP&E) components and the distributor of choice for industrial and consumer electronics manufacturers worldwide. Broader and deeper inventory, leading-edge products and custom supply chain solutions have established TTI as the leading specialist in electronic component distribution. Globally, the company maintains more than 2 million square feet of dedicated warehouse space containing over 850,000 component part numbers. Along with its subsidiaries, Mouser Electronics, Sager Electronics, and TTI Semiconductor Group. TTI employs over 6,000 employees and is represented in over 100 locations throughout North America, Europe and Asia. For more information about TTI, visit www.ttiinc.com

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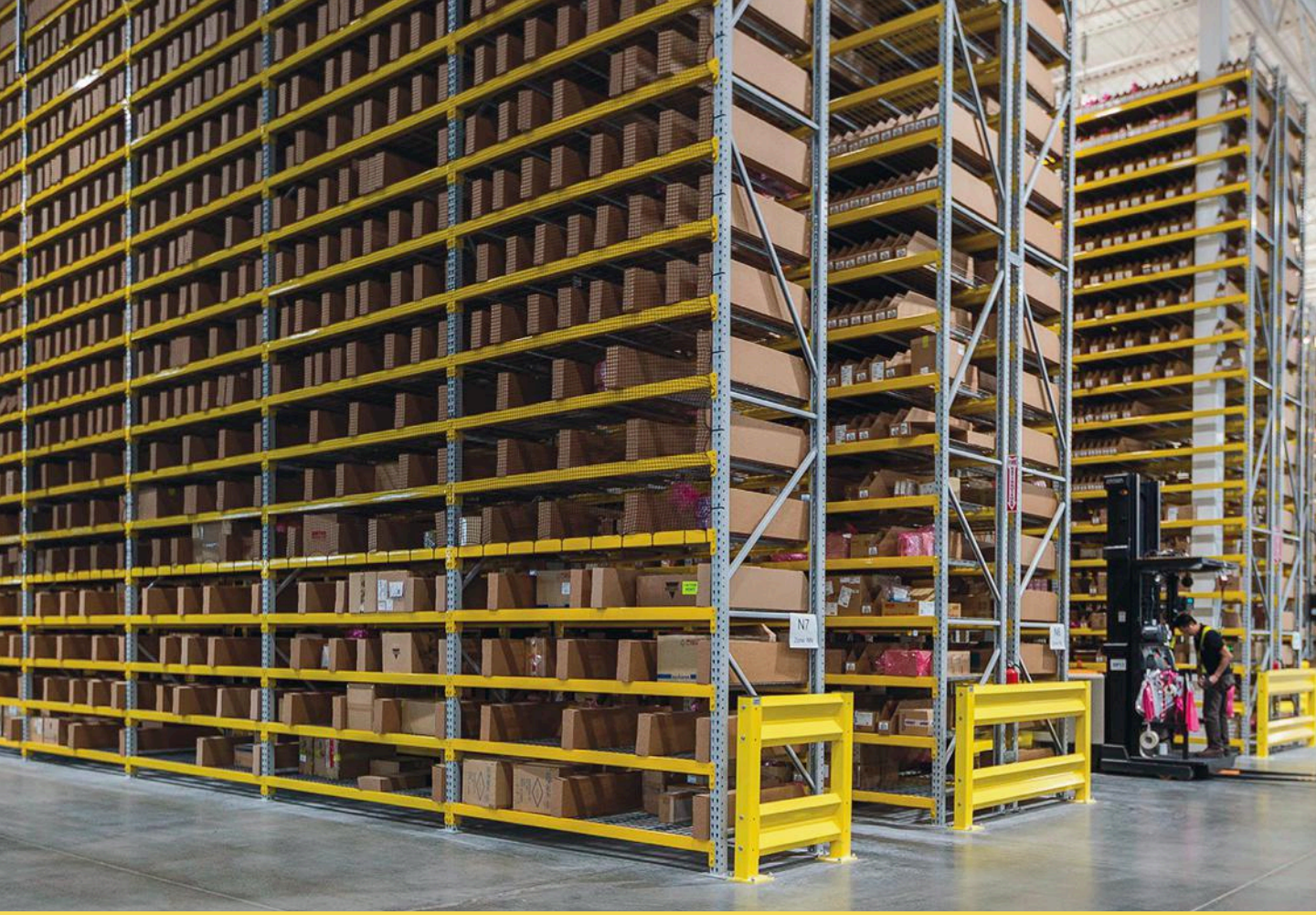

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(Continued from page ST 9)

TTI America's Akery says that his company chose to be transparent and fair. "We're not looking at the tariffs to make any money. We're just administering it. We've invested a lot of money. We've got an advantage in that our warehouse - and it's been this way even before the new one - is a free-trade zone. It's considered a foreign trade zone. That gives us a competitive advantage on anything we import ourselves and export out of the country," he says.

Digi-Key Electronics' Beeson says that it will be challenging to measure the net cost or impact of a lot of the trade and tariff-related activities. But, he also notes that there have been some unexpected benefits. "We've had to look at processes like free trade zones, which overall will be a net benefit. We also are putting a lot of energy into the topic of global trade. Global logistics and trade represent our value to the customer and to our suppliers, especially when you consider we bring these products into the US and export over 50% back out."

Bottom line, distributors agree that it's something they will need to keep a close eye on. "At the end of the day, now that we are as a company fully set up to provide support on a global basis, it's business as usual," says Future Electronics Yasmine. "So, we'll keep pushing on new designs and supporting our customers on their on-time delivery. Moving forward, we're prepared to deal with whatever else comes along."■

FOCUS ON STAYING AHEAD OF THE GAME

Chris Beeson,
Executive Vice President, Global Supplier & New Business Development; Digi-Key Electronics

"We have the luxury of a robust 2018, with growth 40% above the norm. Some of that growth is due to macroeconomic reasons, but we also hope it is related to things we are doing right. So, we ask ourselves questions like 'Why do customers find out website appealing? Why are people reading more of our technical notes? Why are people engaging us for not just more transactions but altering the type of transactions with us?' It's an ongoing process for us as we think about what we need to do in order to stay ahead of the game. We know the importance of new trying things, knowing that some things will pan out, others will not."

Sager Electronics Opens Multifaceted Location in Texas

Distributor of interconnect, power, and electromechanical components expands its existing value-added location in Texas to include a 20,000sf power solutions center and 40,000sf of distribution center space.

For example, as Sager Electronics becomes increasingly involved in product lines such as power supplies and thermal solutions, it continues to make a substantial investment in electrical and mechanical engineers to focus on those areas. "Our engineers are involved in the process starting from the recommendation of products based on a customer's problems and requirements [which in the case of power supplies is a little more intricate than just recommending a 14-pin connector] all the way in the case of smaller companies to working on the complete design and customizing it, with the help of the supplier" says Sager's Faris. "Our goal is to be trusted advisors in power and thermal."

With the goal of positioning its power and thermal products closer to the customers that need those items, Sager Electronics opened a new Southcentral location in Carrollton, Texas this month. A distributor of interconnect, power, and electromechanical components, and a provider of value-add solutions, Sager is currently expanding its power and thermal division and needed a new, strategic location for those operations.

"Our main distribution center in Middleborough (Massachusetts) was at capacity," says Shannon Freise, VP of operations. "We needed to expand particularly for our power and thermal products, which have a much different footprint than, say, traditional electromechanical components."

A large block power supply weighs up to 40 pounds, for example, versus a small switch that weighs a pound or less. "To accommodate this growing part of our business," says Freise, "we needed larger stocking space that could fit more pallet/large bulk goods."

SHORTENING TRANSIT TIMES

Sager Electronics began in 1887 as a single storefront in downtown Boston that serviced the growing interest in radio technology. A wholly-owned subsidiary of TTI Inc., a Berkshire Hathaway Inc., company since 2012, Sager carries products from a variety of global manufacturers.

Headquartered in Middleborough, Mass., the distributor operates a national network of field sales representatives and power systems sales engineers that are located in service centers across North America, plus in its Carrollton value-add operation.

(Continued on page ST 18)

HUGE, NEW WAVE OF CONNECTED TECHNOLOGY

Faris Aruri,
Senior VP of Marketing; Sager Electronics

"Where are we in the cycle now? I could be wrong, but I think we're at the beginning of a new wave in connected technology. It all started with the Alexa. How many products do you see now with Internet connectivity? Smart thermostats, smart cameras, smart lighting—these are all becoming commonplace features in our homes today. I think we haven't even scratched the surface yet. It feels like we're at the beginning of the introduction of a lot of new, innovative products. And we're ready to meet the needs of the people creating those products."

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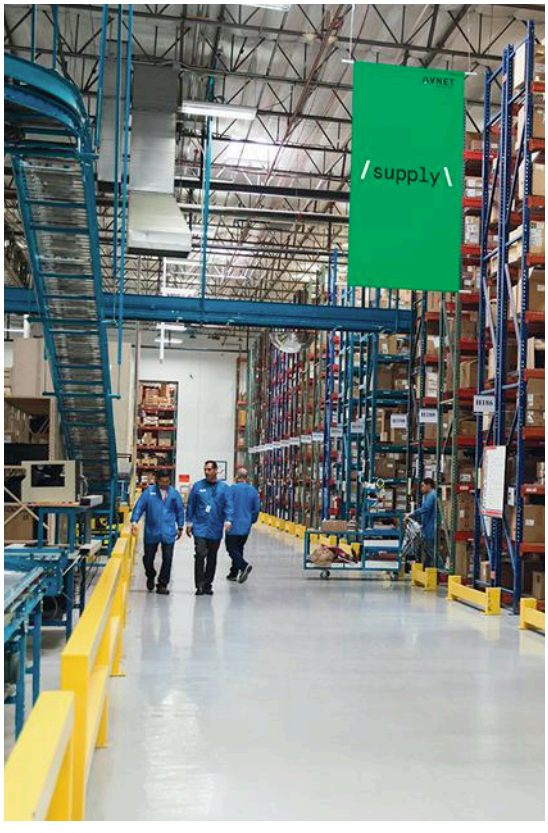

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Along with Premier Farnell, Newark element14 has a history of innovation. We've developed many industry firsts that save precious time, like the first online community for engineers, customizable online catalogue, and the element14 TV engineering video library. This leadership can also be found in our Trust Agenda – a unique focus on driving sustainability through our planet, our people, and our principles.

As a result of our sustainability effort, Premier Farnell has been listed on the FTSE4Good Index and also the Dow Jones Sustainability Europe Index. We continue to work to provide a sustainable future through leadership in packaging, exceeding green standards, providing support for environmental legislation, and more.

(Continued from page ST 13)

Working with supply chain design consulting firm Tompkins International, Sager determined that Carrollton—where its value-add Power Solutions Center was already located—was situated at the geographic center of its customer base.

Freise says Sager's ultimate goal in building out this new geographic footprint was to support efficiencies of distributing larger and heavier-weight products. "Being at the center of customers will reduce a lot of the freight costs of transporting those shipments," she points out.

Previously importing products through Boston, the company can now use Los Angeles ports instead. The company's MEAN WELL products, for example, are made in Asia. "Bringing these goods to California instead, and then trucking them to Texas," says Freise, "will definitely shorten transit times."

A MULTIFACETED APPROACH

Sager's new facility supports three different key functions: a 20,000sf Power Solutions center where value-added manufacturing takes place, a South Central service center (and sales force), and a 40,000sf distribution center. Originally, it was the site of Norvell Electronics (which Sager purchased in 2015), a power products distributor that specialized in design and value-add capabilities.

According to Freise, the Power Solutions Center handles both modular power supply work and custom power projects. She says being able to keep three functionalities (valued-add, service, and distribution) at one location will help Sager make better use of its knowledge workers.

"We didn't want to displace the talent that handles all of our value-added manufacturing," says Freise. "We gained a lot of nice synergies by moving these groups together."

TWO YEARS IN THE MAKING

According to Freise, the grand opening of Sager's new location capped a two-year project. "When we began planning for a new Texas facility almost two years ago, it was our goal to expand our distribution capabilities and create a space that would inspire creativity, innovation, and teamwork," she says.

"Many individuals had a hand in this project, and it was important to Sager to thank each of them for their role in this amazing new building," Freise adds. "We are very proud of what we have accomplished." ■

AUTO, AERO, AND IOT MARKETS STRONG

Christopher Breslin,
President; Premier Farnell

"There are a few, very strong markets that are driving demand today. The military, aerospace, and automotive markets are strong, simply because there's so much electronics content in those applications. But the amount just continues to increase. The IoT has also hit a critical mass, but one of the big differences on the IoT side is the type of customers that we are getting. They are makers and innovators, which is different from our traditional customer base. They benefit from community interaction, and that's where we can really support them with our online community, element14."

A FUTURE GUIDED BY DATA ANALYTICS

Dan Stewart,
Vice President of Marketing & eCommerce;
Allied Electronics & Automation

"I wish I had a crystal ball to look into the future. Any time when things are going well you have cautious optimism. You're optimistic about the future, but you're always cautious because you never know when it's going to turn, because, eventually, it's going to turn. What we do know is that the role of data in our decision making is only going to become more critical. Some 90% of our customers engage with us digitally and when they place an order with us there is a rich set of information on what they want and need. We're leveraging that information to make decisions, develop our strategies and engage with suppliers."

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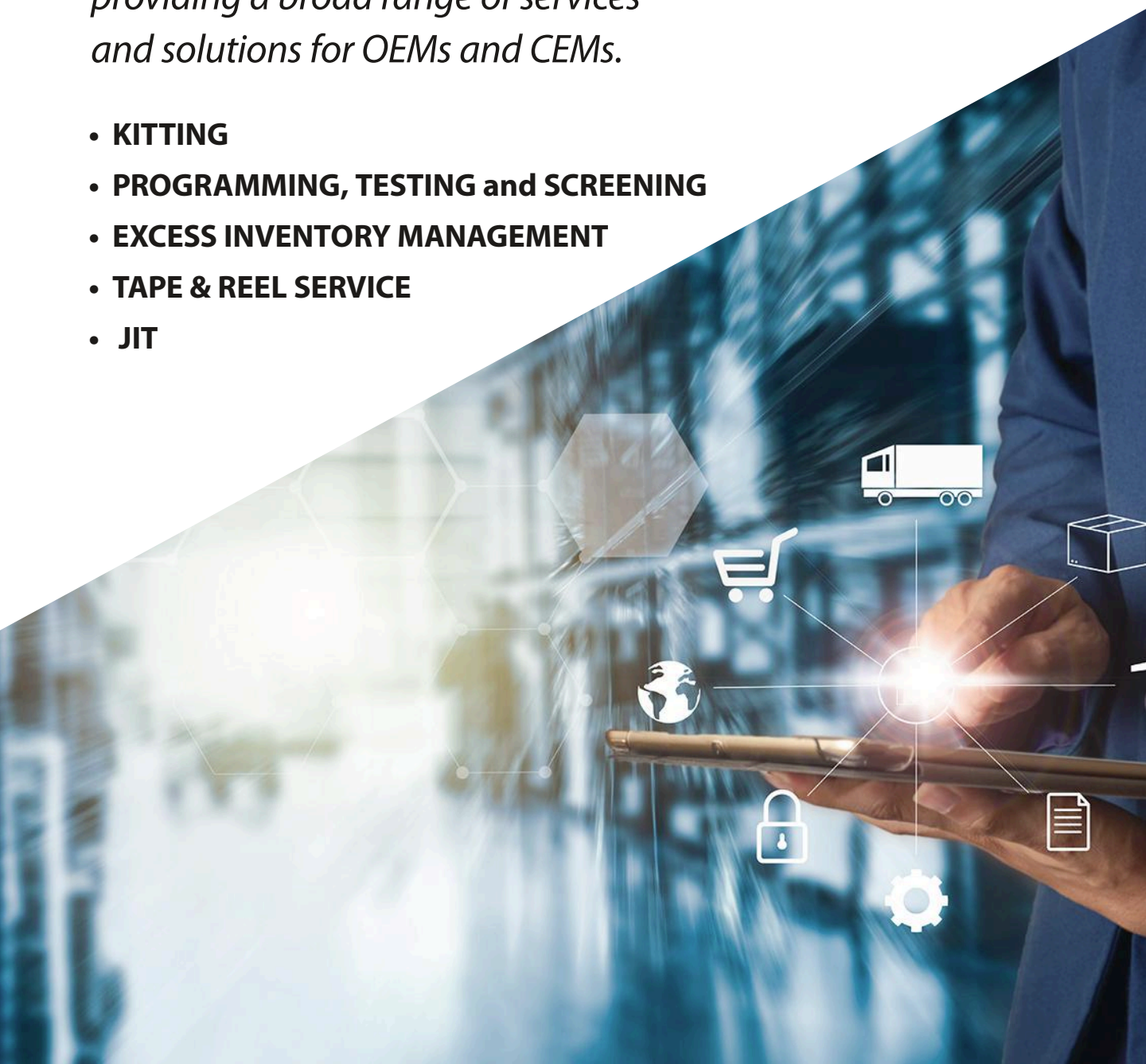

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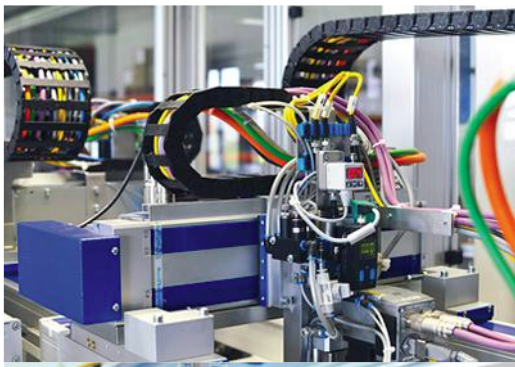

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Q&A with Carleton Dufoe CEO

1. What are the critical demand drivers you see creating continuing opportunities for growth in your business in 2019?

NewPower Worldwide ("NewPower") has grown from zero revenue in 2014 to over 250M USD in 2018. This is impressive growth for any company, but particularly strong when compared to peers in the electronics distribution industry. We have a diverse list of strategic customers that have taken the time to audit and validate our internal processes and procedures. Coupled with an industry leading team of employees, NewPower is well positioned to continue its growth in the upcoming years.

What will drive demand into 2019 and beyond? The biggest by far will be global deployment of 5G followed by WLAN, IoT, and Artificial Intelligence (AI). The Automotive, Cloud & Data Centers, Networking and IoT sectors will continue to grow. Worldwide deployment of 5G technology will be a strong source of demand in itself, and will also be the catalyst for the creation of even more technologies and devices. Manufacturers have been making investments in new capacity, but supply constraints will continue in the meantime. 5G will generate exciting new opportunities and increase interest in current market drivers. This combination will keep NewPower's services in strong demand for years to come.

2. What steps are you taking to respond to the growing volatility in the global trade environment? How much and what kind of impact do you think tariffs and new trade treaties will have on distribution?

NewPower is constantly adapting to market conditions. As a young company we are adept at identifying and responding to our customers' needs. By collaborating with customers and suppliers, NewPower maintains a shared knowledge base which generates value for ourselves and our partners. NewPower has multiple warehouses across the globe enabling us to respond rapidly to changes in the market (including tariffs and trade agreements). Volatility is relative, and while it produces challenges it also produces opportunities.

3. What are you doing to attract, retain and motivate your employees in a highly competitive market for workers of all types?

NewPower believes our employees are our greatest asset. We achieved revenues over 250M USD in 2018 with fewer than 55 employees worldwide, and have industry-leading revenue per employee metrics. This speaks volumes to the talent we have inside the company, and our team's dedication to serving our customer base. We maintain an energetic and transparent trading environment. This is supported by training, strategy, and development across all departments and regions. We are a growing company with paths for advancement at all levels and excellent educational/learning opportunities for team members. The bottom line is NewPower knows our employees are our IP.

4. How have your operations benefitted from the adoption of new IoT and cloud technologies? Where are you at in creating a "Smart" distribution operation and what are your plans for the future?

Carleton Dufoe

Jeffrey Hong

Matthew Fonstein

NewPower seeks innovation in all aspects of our business. All of our critical data, information, and communications are cloud-based, from our proprietary trading platform, Scout, to industry standard productivity and collaboration tools. We review feedback from our employees, customers and suppliers in all planning and decision-making. Our customers design, manufacture, and distribute products 24/7/365 and NewPower is there supporting their needs every step of the way. Our job is knowing where the product is before our customers need it and being ready to get that product from point A to point B in the fastest, most economical, and efficient manner possible. Using cloud-based platforms allows our global locations to communicate internally and externally in real-time. Remotely monitoring our facilities' security, as well as environmental conditions in our warehouse and quality lab assures our customers that NewPower provides safe and reliable management of their product and confidential information.

5. What developments are you seeing in the growth of non-traditional customers and markets? Are they having a meaningful impact on your business?

At NewPower our management team has over 200 years of industry experience. We use our knowledge to maintain a diversified, strategic customer base across different industry segments. We are constantly looking to penetrate new segments within Automotive, IoT, Medical, Automation, Computing, Networking, Embedded, and Cloud. Our growth, market knowledge, direct manufacturer relationships, and unwavering commitment to quality have seen the Defense and Aerospace industry engage NewPower directly. NewPower is a new breed of independent distributor and has been changing the status quo since day one. We want to work with customers who share the same core values, and maintain the same commitment to high standards, transparency, and open communication. We welcome all existing and future customers to come and audit us, and see exactly how NewPower can support them.

6. How important are your partners in supporting your customers and delivering differentiated value? What do you do to cultivate successful partnerships?

This question speaks to the core of NewPower and how we have quickly differentiated ourselves from others in the industry. We treasure the relationships we have built within our customer and supplier bases, and work diligently to maintain them. Partnerships and relationships are the keys to success. And whether the shortage environment of the past two years persists or becomes a cost savings-driven market, NewPower has the relationships and partnerships it needs to adapt. NewPower has dedicated sales and purchasing teams across the globe who keep their finger on the pulse of the market, constantly synched through our proprietary trading platform, Scout. We have product managers who are focused on their specific market segments. In these ways, NewPower is "Empowering Supply Chain".

NEWPOWER WORLDWIDE

Empowering Supply Chain

Put our proven industry expertise and strategic partnerships to work for you. Our Certified Global Network of MFGs, OEMs, and Authorized Distributors allows us to deliver traceable, quality product that is not readily available to the Open Market. NewPower Worldwide is a global leader, servicing production and repair needs of the world's top OEMs and EMS providers, a unique position in this demanding marketplace.

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Q&A with Lee Ackerley, Co-Founder and Director

Lee Ackerley

1. What are the critical demand drivers you see creating continuing opportunities for growth in your business in 2019?

Smith's ability to be a strategic partner for our customers through our service offerings – such as vendor-managed inventory, excess inventory solutions, hubbing, scheduled orders, and long lead time part management – will serve as a key critical demand driver in 2019. Smith will also serve our customers' needs for PPV opportunities by offering lower priced parts on many key components.

2. What steps are you taking to respond to the growing volatility in the global trade environment? How much and what kind of impact do you think tariffs and new trade treaties will have on distribution?

Worldwide, our sales representatives have observed our customers strategically redirecting their manufacturing in response to tariffs and new trade treaties. Smith has implemented tariff notifications in its internal, proprietary trading platform to make sales representatives and customers aware of parts affected by the tariff.

3. How is e-commerce changing how you support your customers and achieve customer delight?

Our e-commerce platform allows us to better communicate with our customers and positions Smith as a digital partner for purchasing components. Smith's part search feature allows customers to view available inventory online through smithweb.com. Smith also lists available inventory on many online inventory sites around the globe.

4. What are you doing to attract, retain and motivate your employees in a highly competitive market for workers of all types?

Employee retention and happiness has always been a focus and strength at Smith. Smith invests greatly in employee training and provides employees with the tools for advancement that they need to spend their entire careers at Smith. As evidenced by our average senior management tenure of over 17 years, Smith maintains the best employee retention statistics in the entire industry.

5. How have your operations benefitted from the adoption of new IoT and cloud technologies? Where are you at in creating a "Smart" distribution operation and what are your plans for the future?

Smith's global proprietary trading platform provides our traders around the world with up-to-the-second price trends and order/delivery information for millions of different component part numbers. Smith is adding and developing new technologies that will help automate parts of our operations processes. Smith is also leveraging artificial intelligence in support of our offerings.

6. What developments are you seeing in the growth of non-traditional customers and markets? Are they having a meaningful impact on your business?

Smith consistently serves customers across a broad range of industries. As more and more products are becoming "smart", we are seeing new sectors gaining prominence such as IoT, AI, hyperscale data centers, and cloud computing. Sectors like these are growing every quarter and creating demand for new technologies and hardware in the supply chain.

7. How important are your partners in supporting your customers and delivering differentiated value? What do you do to cultivate successful partnerships?

Smith's partnerships allow us the flexibility and availability of product to navigate the volatility of the electronic component supply chain. Smith works with franchise partners on design in and crossing parts as well as VMI, scheduling, testing, and more.

Questions for All

1. What are the biggest surprises between your expectations and the reality of 2018 for your business and the distribution industry?

For the industry, this year has been a time to adapt, and Smith has stayed at the forefront of change through market intelligence data and its key network of suppliers. Although we anticipated success for 2018, sales exceeded expectations, making 2018 Smith's best year on record in every category.

2. What are the most important initiatives you are pursuing to position your business for success in 2020 and beyond?

Continuing to grow our portfolio of franchise lines will be an ongoing focus in the years ahead. Smith will continue to innovate in support of industries like cloud computing, aerospace and defense, and medical. Continuous growth in our extensive state-of-the-art quality control, software capabilities, IT asset disposition, vendor-managed inventory, and other value-added solutions will also be key.

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It All Started in 1887 as a Small Boston Storefront Selling Speaking Tubes.

Over 130 years later, Sager Electronics has grown into a leading North American distributor of interconnect, power and electromechanical electronic components. Acquired in 2012 by TTI, Inc., a Berkshire Hathaway, Inc. company, Sager continues to operate with the same dedication to its core values – integrity, service and adaptability.

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LOU FRENZEL | Contributing Editor

15 Factors That May Be Delaying Self-Driving Cars

Let's face it, self-driving cars aren't living up to their hype. I've seen hype before and then some. But nothing like that showered upon autonomous vehicles (AVs). They're supposed to solve the world's transportation problems and reduce vehicle deaths and accidents to near zero. Really?

A recent Axios survey indicates that only about 66% of Americans said they feel unsafe around AVs. 80% of seniors fear AVs. An earlier AAA survey identified that 73% of Americans said they're afraid to ride in an AV and 63% said they felt that the road was unsafe with when sharing the road with AVs. It appears that most of the public is still uncomfortable with the idea of self-drivers. Reflecting on this movement, here are my observations and thoughts about this. Some of these may be yours.

1. AVs aren't perfect and like everything else, they never will be. Did the automakers and other developers who have spent billions misjudge the potential given all the hype? Did they underestimate the technological complexity? Or did they ignore what the market is saying? Is it possible that the AV's lack of acceptance is mainly a colossal PR problem?

2. What if the regulations, insurance, etc. of AVs are so strict that adoption will not be in the volume expected?

3. What if cities limit the use of AVs to specific areas or roads?

4. Is it possible that accidents, injuries, and deaths will actually increase with the adoption of AVs? No one really knows.

5. Is it possible that there will be no government tax credits for AVs as there has been for electric vehicles (EVs)?

6. What if the public simply eschews AVs?

7. What if the more rapid introduction of practical and affordable EVs upstages AVs?

8. Does it matter that AVs with internal combustion engines (ICEs) do nothing to improve the emissions and global-warming problem?

9. What do you do with AVs if the public rejects them? Initiate unmanned delivery of goods?

10. Will AV taxis really be viable? Will you ride in one?

11. Will the benefits of AV trucks, including 18-wheelers, actually lower transportation costs and improve safety?

12. Are AV buses viable? Would you let your kids ride in an AV school bus?

13. What is the economic impact on all those millions of truck, taxi, and bus drivers who lose their jobs to AVs?

14. Will the expected initial real-world AV price of over $100,000 seriously limit the sales of AVs?

15. Will AVs ever be able to successfully navigate through areas of road construction or unpaved back roads or in heavy rain, fog, snow, or dust?

CAN WIRELESS HELP PUSH THE AV MOVEMENT?

One helpful addition may be communications. At some point, the government is expected to mandate vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) radios in all vehicles. Cars will be able to talk to one another, exchanging data like precise location, direction of travel, speed, braking condition, turn expectations, and the like to surrounding cars.

Moreover, vehicles will get data from roadside infrastructure units, such as weather and road conditions, traffic updates, and construction issues in advance of encountering these problems. When combined with the improved sensor/fusion processing combinations, certainly this communication should make AVs safer and help them come closer to nirvana.

Two systems are competing for the automotive communications standard. Dedicated short-range communications (DSRC) and cellular or C-V2X. Both use the 5.9-GHz band for two-way communications of data. DSRC uses a version of Wi-Fi technology called 802.11p. It's a proven technology that's been thoroughly vetted in tests. C-V2X is a variant of LTE and uses the existing cellular system for communications. C-V2X also has a direct car-to-car feature called PC5. There's a planned path to 5G for C-V2X once that system is up and running.

C-V2X will probably win this battle. Whatever standard is chosen, though, AVs will be far more intelligent and thereby less likely to have an accident or kill a pedestrian.

If nothing else, some communications capability will make AVs and standard vehicles safer. As ongoing R&D keeps improving the sensor medley and processing power for AVs, perhaps these advances can be added into the current non-AVs with advanced driver-assistance systems (ADAS). With each increment of ADAS improvements using AV technology, vehicles will gradually morph into full level 5 AVs. Then, maybe, the AV goal could be achieved with something like a software upgrade.

Rapid integration of AVs into the real world of driving will also help determine the outcome—success or not. There will still be accidents, collisions, deaths, and other screw-ups along the way. Human drivers will always be better. But for those who passionately want or need an AV, you will eventually get one. Just not yet. ED

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Lab Bench

WILLIAM WONG | Senior Technology Editor
bill.wong@informa.com

Third Time is a Charm with ELVIS III

Technology Editor Bill Wong gives us a bird's-eye view of National Instruments' ELVIS III all-in-one electronics lab.

How I would have loved to have National Instruments' (NI) ELVIS III *(see figure)* all-in-one electronics lab when I was a freshman studying to be an electrical engineer. The closest thing we had at the time was a patch board with RCA jack patch cables that plugged into a small refrigerator-sized box that was the front end for a couple dozen MSI TTL chips. Oscilloscopes were separate and a little smaller.

The ELVIS III Engineering Laboratory Virtual Instrumentation Suite (ELVIS) targets colleges, but it can be very useful in any lab that will be doing prototype work. The rugged base hides the guts of a CompactRIO that runs NI's LabVIEW graphical programming environment. CompactRIO is essentially a PC with an FPGA optimized for control, test, and measurement chores. The complexity is hidden by LabVIEW.

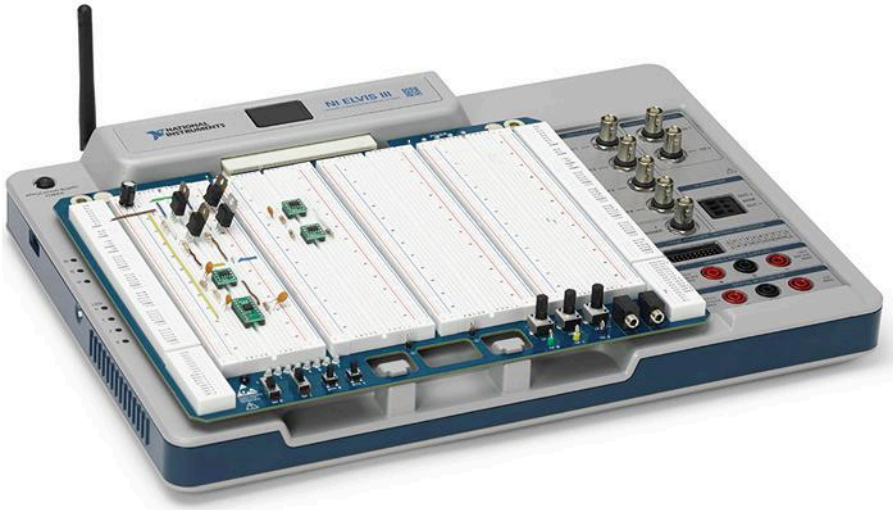
One side of the ELVIS III exposes the connections for a function generator, four-channel oscilloscope, IV analyzer, logic analyzer, pattern generator, variable power supply, and digital multimeter (DMM). These are accessible to LabVIEW applications, but they're usually used in conjunction with web-based apps. A typical environment would have a student with a tablet or laptop viewing the oscilloscope or logic analyzer apps. Yes, ELVIS III has USB, Wi-Fi, and Ethernet interfaces, so its only display is a tiny one that provides information like the unit's ID.

The patch board that dominates the system is removable. Like the base unit, the board has its own unique ID. Therefore, a board can be matched to a student or group making connections to their smartphone, tablet, or PC automatic. The networked orientation makes it easy to control and monitor from multiple computers. This is useful for teacher-student interaction in addition to remote collaboration.

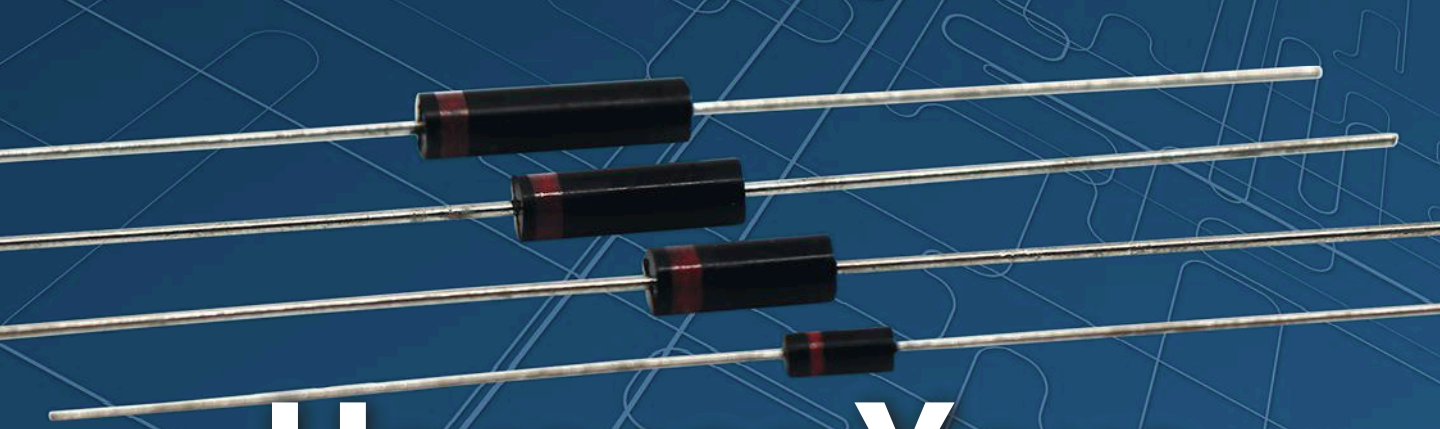
The patch board is only one of many options available for the ELVIS III socket. Plenty more are shown at *https://learn.ni.com/teach*, such as a Control System Design and Analysis platform that works with MathWorks' Simulink. Boards address every electronic and mechanical aspect from power electronics to communication. Most are available from third parties as is much of the educational content.

NI is well-known in the educational community and part of the reason is its attention to integration details. In fact, ELVIS III has a web-based learning and teaching infrastructure built around it that's probably more impressive than the hardware. Most is freely available.

Check *electronicdesign.com* for an upcoming hands-on review article that examines the ELVIS III in more detail. Pricing starts at $2799. It probably can be found in a college lab near you. ed



The ELVIS III all-in-one electronics lab developed by NI is essentially a CompactRIO, oscilloscope, logic analyzer, and DMM in a desktop package.



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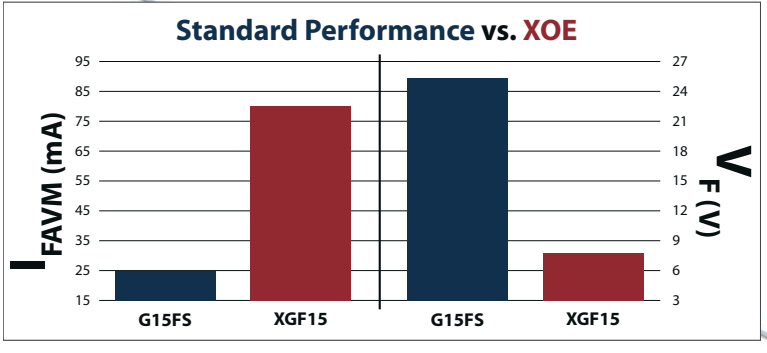

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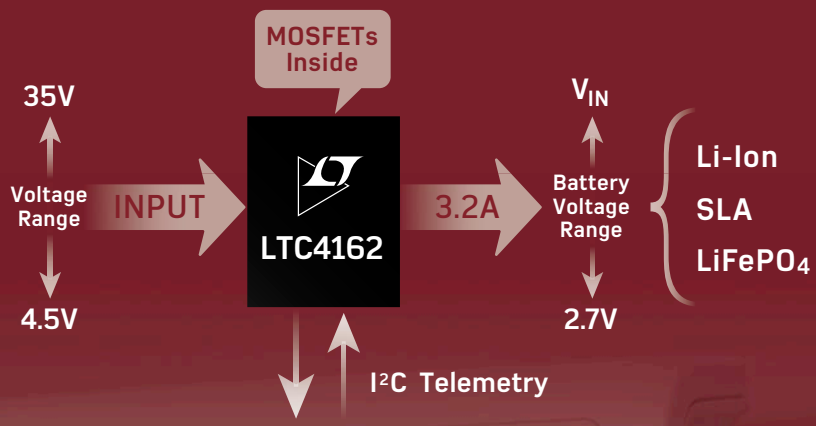

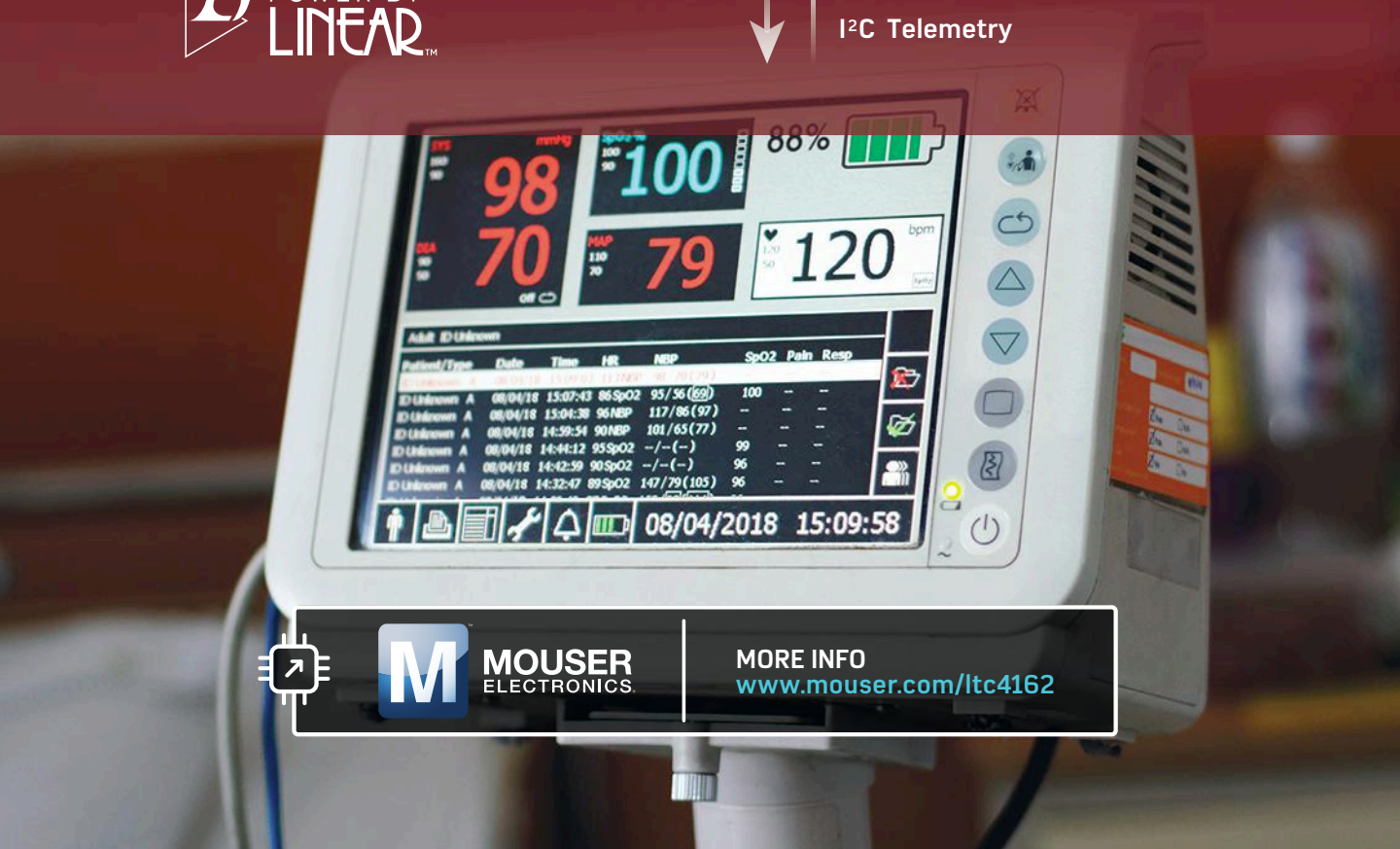

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