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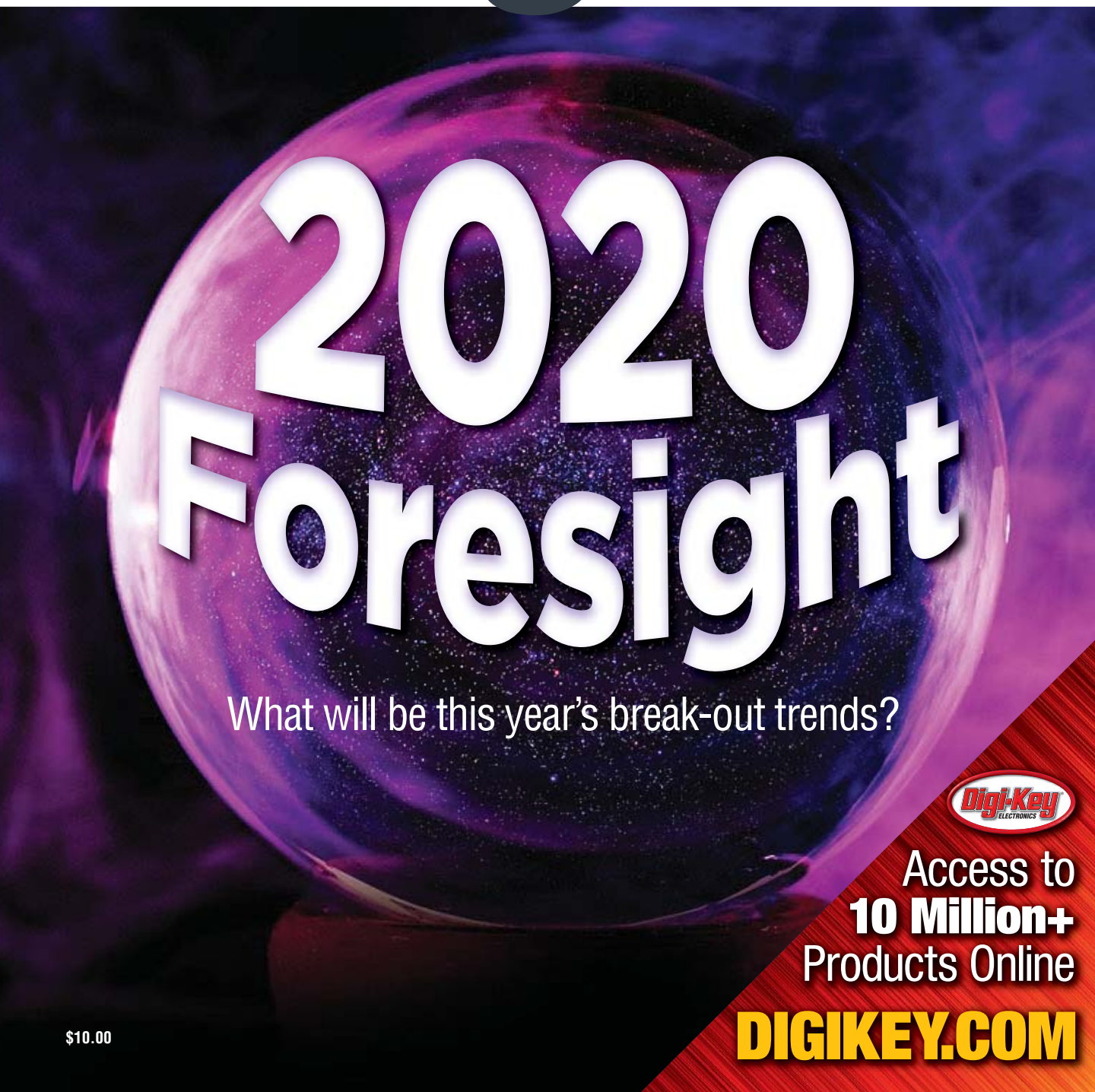

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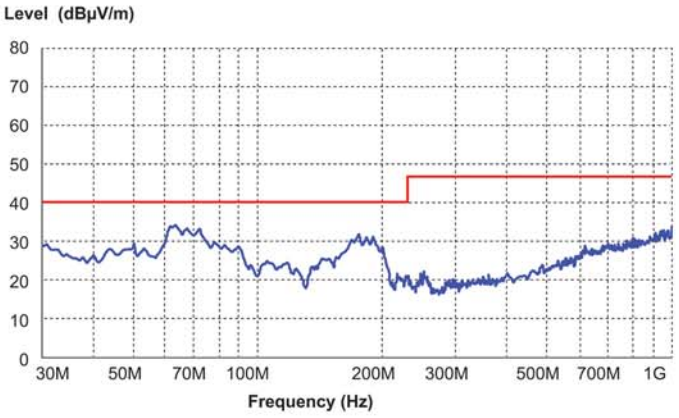

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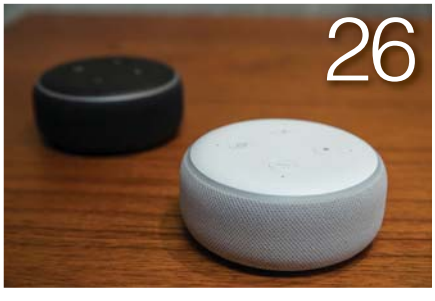

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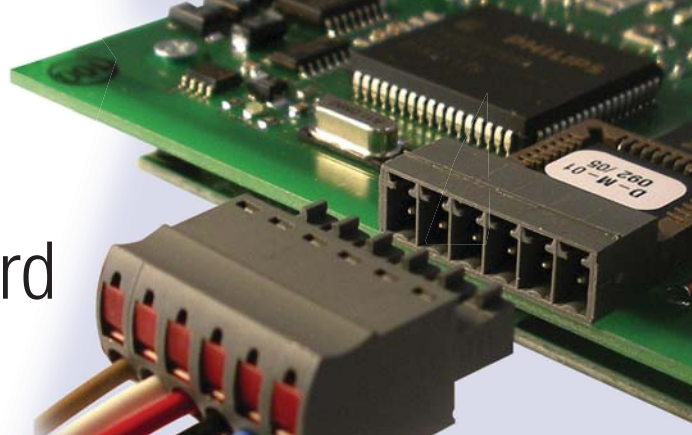

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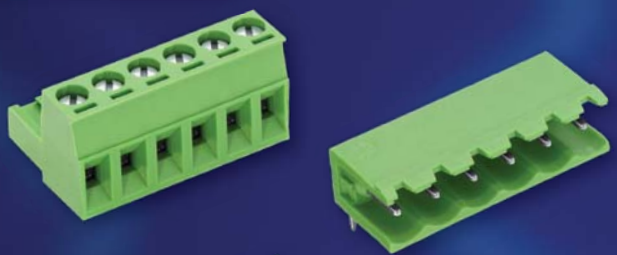

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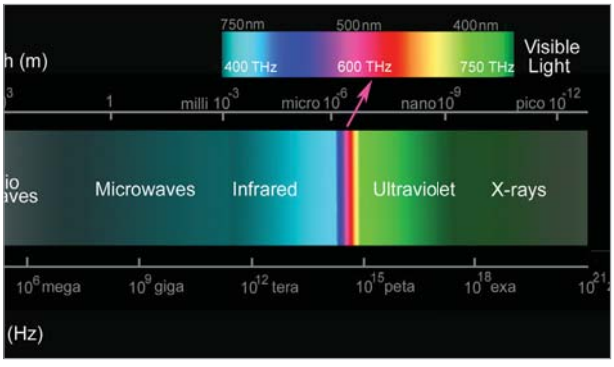


The Existential Threat to Wireless

As we plunge forward into the next generations of wireless—namely 5G and down the road, 6G—one hurdle stands in the way of progress: the very finite amount of spectrum.

https://www.electronicdesign.com/industrial-automation/article/21120231/the-existential-threat-to-wireless

Concept Cars Abound at CES 2020

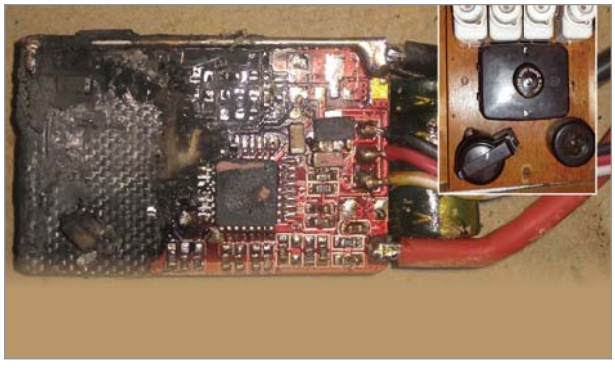
Given the number of concept cars that wheeled into this year's CES, it felt more like an auto show.

https://www.electronicdesign.com/markets/automotive/media-gallery/21120320/concept-cars-abound-at-consumer-electronics-show

Metamaterials Boost MRI Performance without Increased Magnetic Field

Using an array of helical coils formed on a metamaterial core, a research team greatly improved the performance of an MRI machine without having to ramp up magnetic-field intensity.

https://www.electronicdesign.com/power-management/article/21120824/metamaterials-boost-mri-performance-without-increased-magnetic-field



How to Select a Fuse

Picking a fuse for your circuit isn't as easy as it sounds. The right one can protect your users and your circuits.

https://www.electronicdesign.com/power-management/power-protection/whitepaper/21120740/how-to-select-a-fuse

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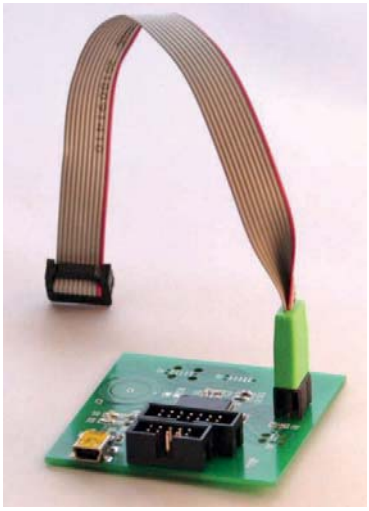

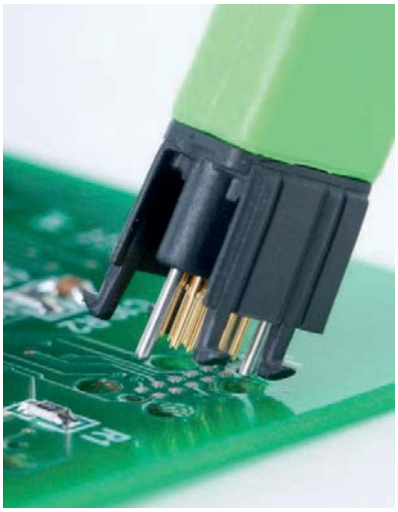

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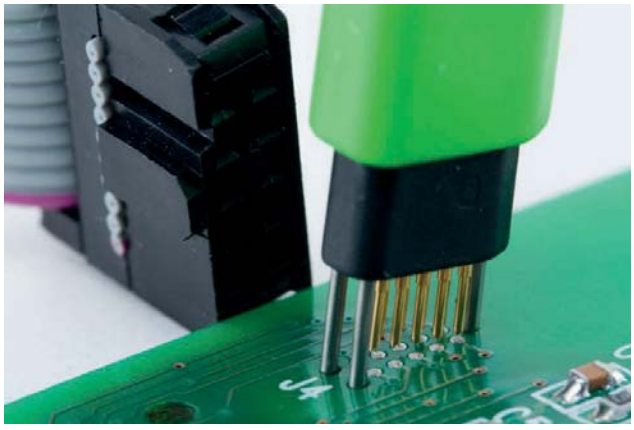

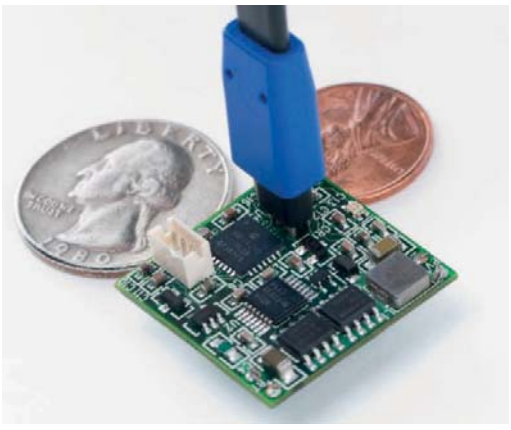

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Editorial

WILLIAM WONG | Senior Content Director
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Machine Learning and Our 2020 Technology Forecast

Machine learning can be useful in forecasting, but for now, Editor Bill Wong is the one gazing into the technology crystal ball.

Machine learning (ML) and neural networks will continue to be a hot topic in 2020. One of its uses is forecasting in everything from when an electric motor will fail to how stocks will perform in the current market. It might be handy to use ML to create this article. However, such forecasting rests in my hands this time around.

ML hardware acceleration for training and deployment will get lots of coverage. I'm more interested in checking out the increased use of ML on standard platforms, though, including applications running on Cortex-M and RISC-V platforms. Most vendors have an overarching approach to artificial intelligence and ML that allows applications to be written to a framework rather than a particular hardware platform. Available performance and capabilities will limit a design and functionality, but not whether ML can be used.

While artificial-intelligence advances will dominate much of the technology discussion in 2020, it's hardly the only new tech that will affect development decisions in the coming year.

The consolidation of RTOSes by vendors and IoT solution providers is making it easier to build IoT applications, but it's also pulling developers into walled gardens. Related support like smart-speaker integration and use of ML in the cloud also requires the use of unique frameworks and tools.

Networking technology will see as many advances as ML, possibly more. 5G will of course be at the forefront as deployment begins, yet changes are blowing in the wind. The IoT aspect of 5G will just be starting to emerge, but plenty of wireless solutions with different characteristics are equally important. This includes technologies like Sigfox, LoRaWAN, NB-IoT, and Bluetooth mesh. These will actually be more interesting to developers because their standards and components are more mature. Though it's fun to look at the latest tech, it's more useful to be able to use it.

Ethernet, PCI Express (PCIe), and other fabrics will see a host of new standards and products in 2020. PCIe is the base for standards like NVMe as well as CCIX and CXL. NVMe has become the desired storage interface for flash drives with M.2 sockets on most motherboards, but SATA and SAS still handle large populations of drives. And hard drives aren't dead yet. Gen-Z's memory-semantic fabric will continue to gain ground.

Power-efficiency improvements for microcontrollers and microprocessors will continue even as the top-end clock speeds remain limited. Multicore is here to stay in a big way with single-core solutions being relegated to microcontrollers. Even there, it's not uncommon to have a dual-core solution with a security or peripheral management processor alongside the primary core.

Security will be getting less lip service and more practical developer support. The standard software development kits will make it easier to take advantage of secure enclaves and encryption acceleration that once required direct interaction with the chip vendor or a security partner. The latter will still be useful as security really needs to be an end-to-end, start-from-the-base design project, not an add-on. Remember, secure boot only guarantees that the booted core is what you thought it was. It doesn't provide protection for security bugs that are part of the system or application.

RISC-V continues to gain steam with some interesting platforms becoming available in 2020. Shifting politics and a desire for a more adaptable platform is driving adoption even as the instruction set continues to evolve.

Keep an eye on FPGAs. The tools are already making it easier to take advantage of their flexibility without needing to be an FPGA hardware expert. RISC-V FPGA SoCs will also be available in 2020. Developers that overlook the tiny, flash-based FPGA solutions are likely to be beaten by their competition that exploit these platforms.

That covered a lot of ground, but it's what we do at *Electronic Design* as we track and present the latest technology for developers. ED

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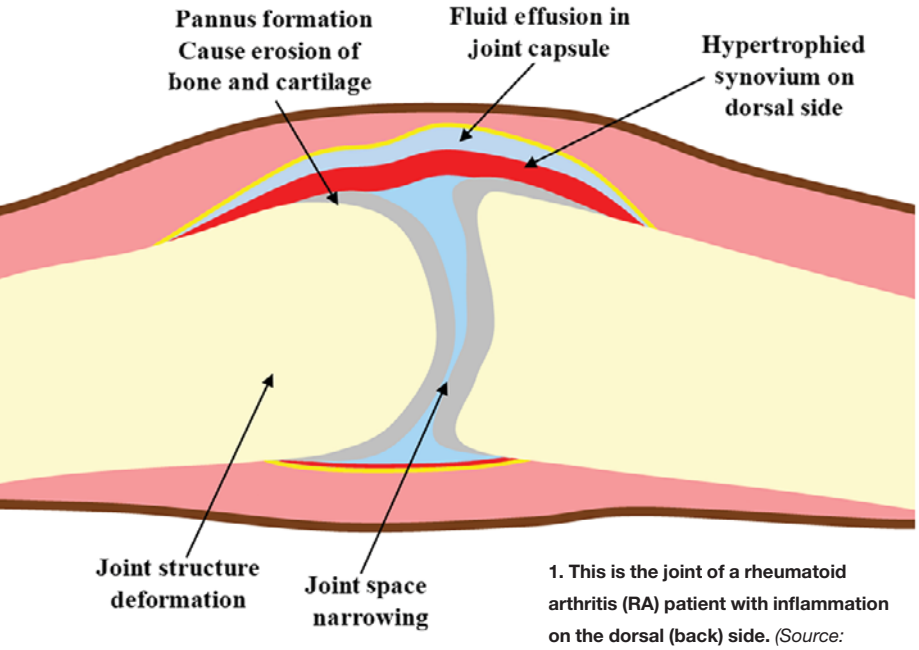
News

OPTICS, ELECTRONICS COMBINE for Non-Invasive, Accurate Arthritis Assessment

BILL SCHWEBER | Contributor



1. This is the joint of a rheumatoid arthritis (RA) patient with inflammation on the dorsal (back) side. *(Source: University of Birmingham – UK)*

You've undoubtedly seen the finger clip-on device that measures peripheral capillary oxygen saturation (SpO_2) in real time, using a pair of LEDs, a phototransistor, sophisticated electronics, and complex algorithms. You can now buy one for about $20 at almost any drug store.

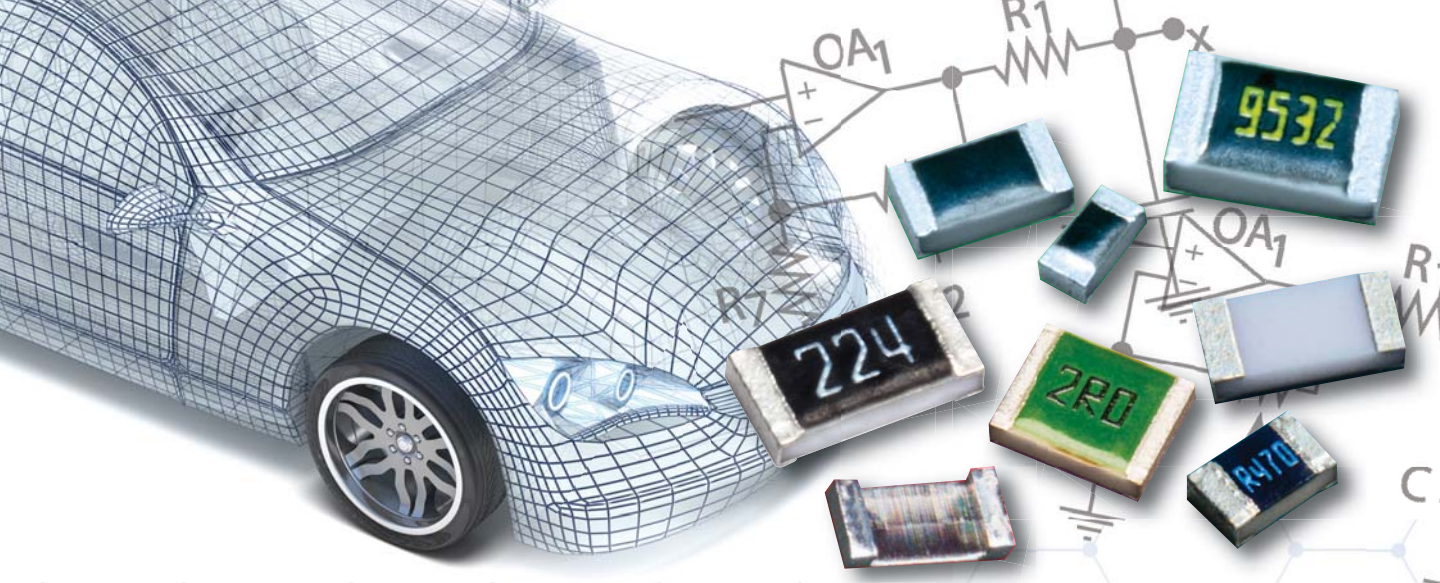
This non-invasive electro-optical unit has completely obsoleted the frustrating, time-consuming, labor-intensive, invasive, and costly previous technique that involved physically taking a blood sample and sending it out for test. It was one of the first devices in the trend to use the synergy of developments in optics, electronics, and computing to provide medical tests that are convenient, minimally disruptive, often non-invasive, yet accurate.

A recent effort expands on this use of multiple wavelengths of light to determine if a patient has rheumatoid arthritis (RA), an autoimmune disease in which the body's immune system attacks the lining of joints, causing painful inflammation and swelling *(Fig. 1)*.

The work, being done by a team at University of Birmingham (UK) School of Computer Science with various medical institutions as partners, combines 3D digital imaging with infrared spectroscopy. The goal is to create a 3D image of blood content inside a patient's hand and joints that can be used to produce an objective, quantifiable assessment. In theory, this could replace the current diagnosis approach that relies on a complicated combination of physical examinations by a rheumatologist, blood tests, and scanning by x-ray or ultrasound—all of which is time-consuming, subjective, and requires highly trained staff.

Since oxygenated and deoxygenated blood absorb light differently, it's possible to use the infrared imaging to calculate warning signs of RA, such as lowered levels of blood oxygen (hypoxia) and increased levels of blood content in the joint—indications of inflammation. The team used both British and U.S. standards, which differ somewhat, in assessing RA severity.

In their noncontact diffuse-optical-imaging (DOI) system, patients place their hand on the platform of the unit, and a broadband point source of light at five wavelengths (650, 710, 730, 830, and 930 nm) was directed into the joint *(Fig. 2)*. On the opposite side of the joint, optical transmission images of the finger were collected at 14 positions using an air-cooled, charged-coupled device (CCD) camera, with spectral decoupling accomplished via a filter



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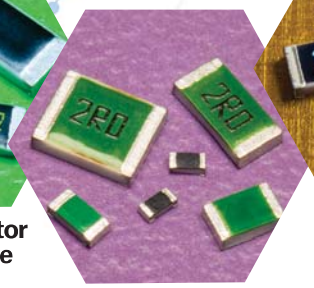

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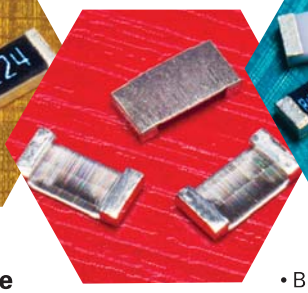

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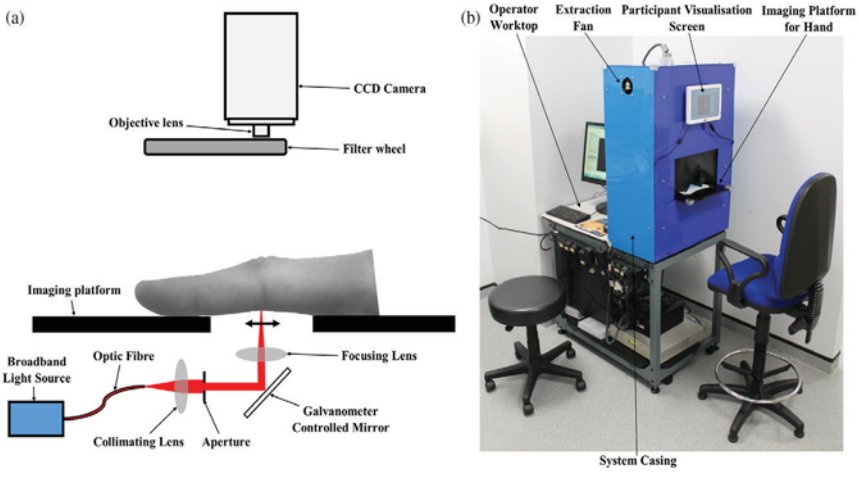
The acquired data requires significant processing to be useful, including data-derived adjustable thresholds, masking, filtering, and fast Fourier transforms (FFTs). All data reduction and statistical analysis is done using MathWorks' MATLAB.

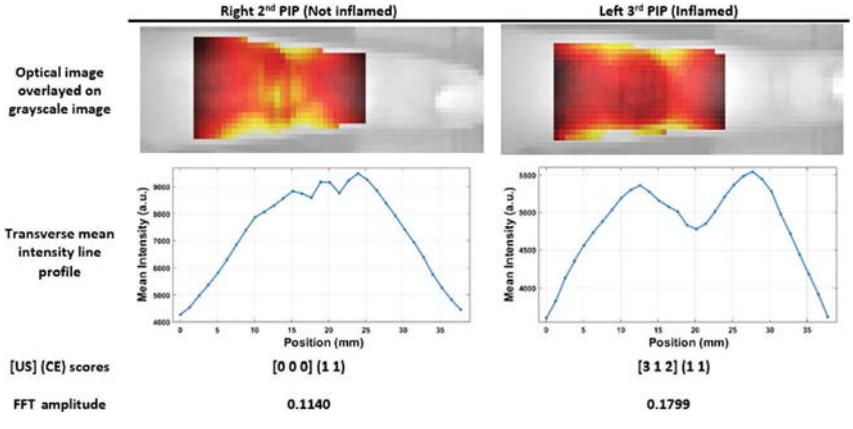
Dorsal (rear) optical transmission images of two fingers of one test subject illustrate the typical optical contrast observed between inflamed and non-inflamed joints *(Fig. 3)*. The left image shows an area of lower intensity at the joint region compared to the immediately surrounding finger surface (and which was clinically inflamed according to U.S. measurements), while the right image shows a peak of intensity at the joint region of a healthy finger.

The test apparatus and associated pilot study data and conclusions are

(Continued on page 15)



2. Shown is a schematic of system for acquisition of dorsal optical-transmission images (a). In the optical-imaging system setup, patients place their hand on the imaging platform and align their finger joint of interest with the source prior to the acquisition of optically created data (b). *(Source: University of Birmingham – UK)*



3. Results of imaging of two finger joints come from the same participant. The top row shows the optical dorsal transmission images at 650 nm when the point source is directly under the joint, overlaid on a brightfield image of the finger. The second row shows corresponding line profiles of the mean intensity in the transverse direction. *(Source: University of Birmingham – UK)*

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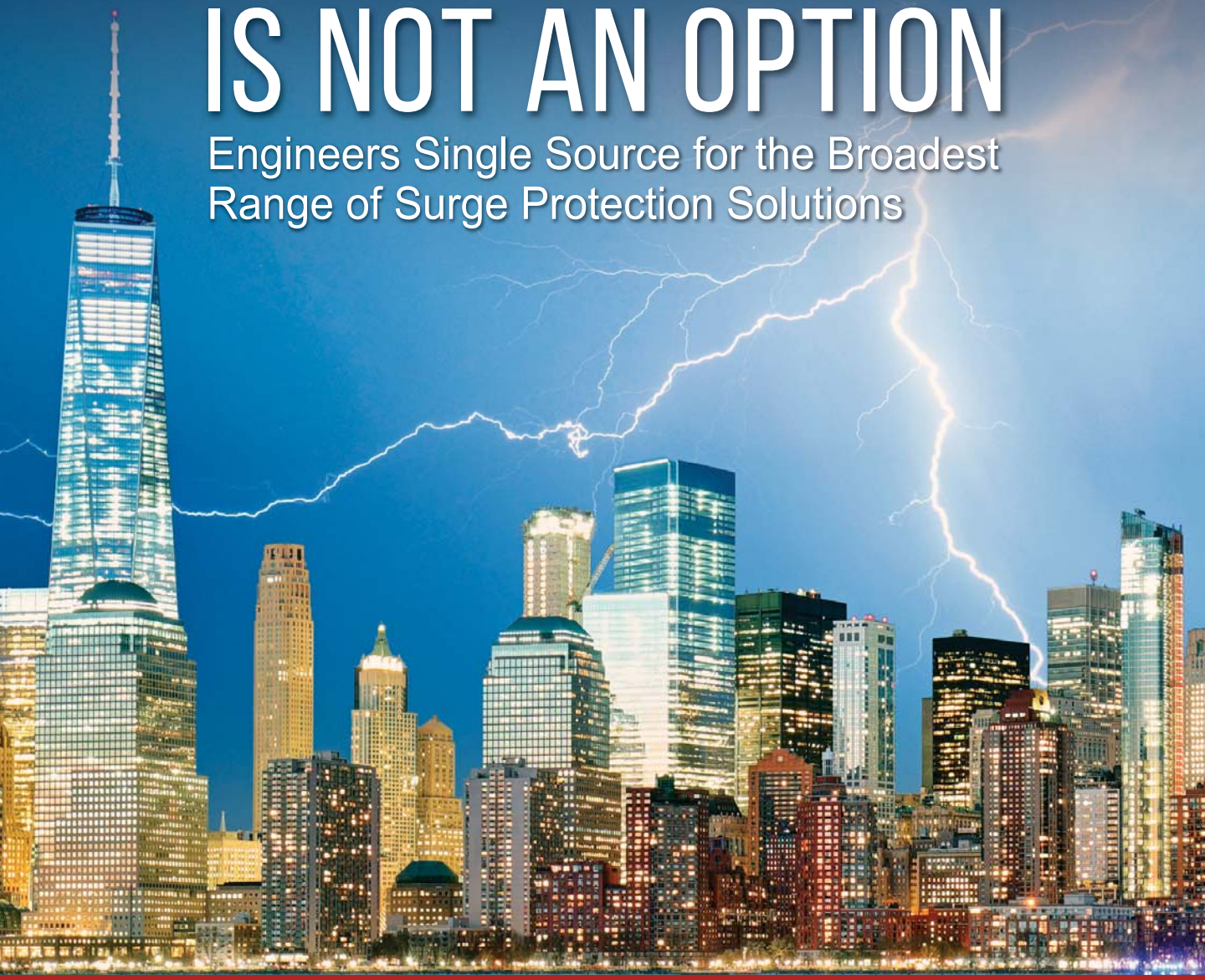

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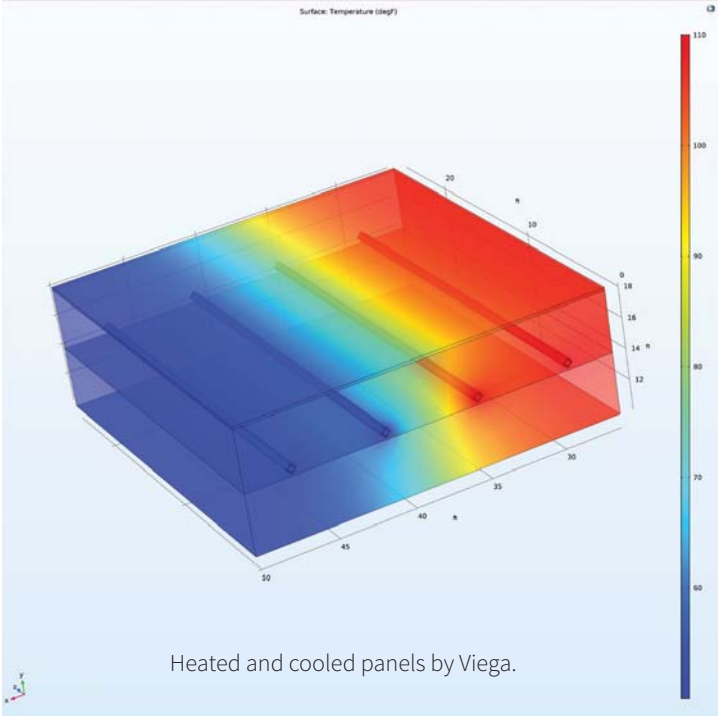
Viega engineers have put specialized applications directly in the hands of their sales force, creating a seamless design process. Several radiant heating and cooling designs will be presented, where applications developed in the COMSOL Multiphysics® software have been used to share design data with customers worldwide for delivering robust and energy efficient systems.

You can ask questions at the end of the webinar during the Q&A session.



Heated and cooled panels by Viega.

SPEAKER: Brett Austin, Manager, Design Services, Viega

Brett Austin is the heating and cooling design supervisor at Viega, where he began his engineering career in 2009. During his time with Viega, Brett has worked on thousands of radiant heating, cooling, and snow melting designs, totaling more than 20 million square feet, ranging from residential bathroom remodels to high-performance commercial buildings. Brett's experience with finite element analysis has been key to the success of the engineering team at Viega. He holds a BS in mechanical engineering from the University of New Hampshire and is a United States Marine Corps veteran.

SPEAKER: Phil Kinnane, VP of Sales, COMSOL

Phil Kinnane is the VP of sales at COMSOL, Inc. He has previously worked within the Business Development, Operations, and Marketing departments. Phil has 20 years of experience with modeling and simulation for all fields of engineering. He earned his PhD in electrochemical engineering from the Royal Institute of Technology, Stockholm.

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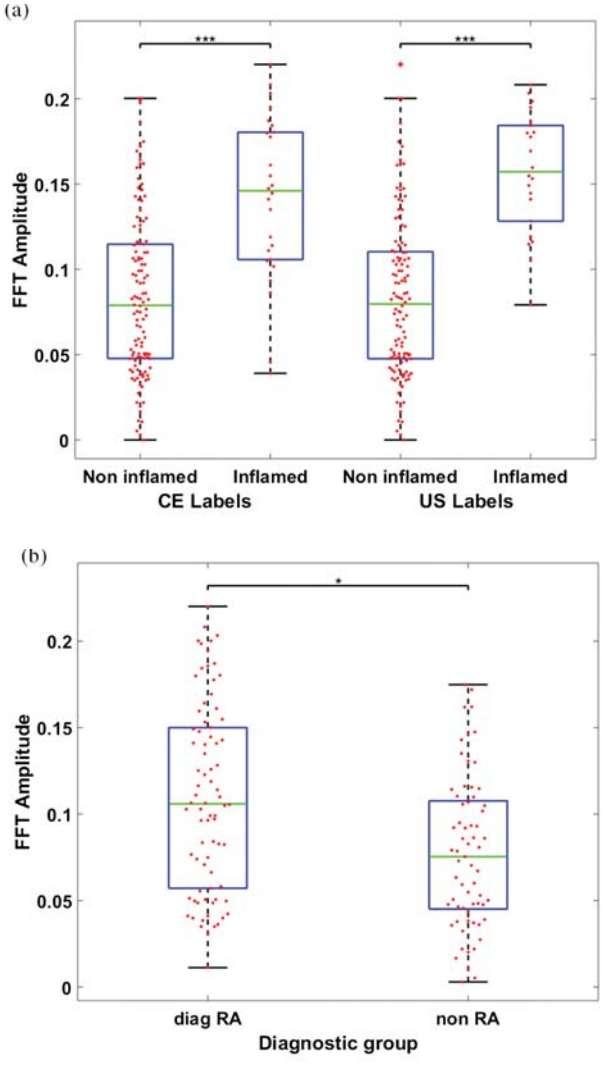
(Continued from page 12)

displayed as boxplots *(Fig. 4)*. This pilot study involved 144 joints from 21 rheumatology patients. There was significantly higher median FFT amplitude for inflamed joints compared to noninflamed joints (with both U.S. and British criteria). The system demonstrated accurate detection of inflamed joints, with results that closely matched diagnoses made using conventional ultrasound and clinical examination approaches.

The full research paper, "Detecting inflammation in rheumatoid arthritis using Fourier transform analysis of dorsal optical transmission images from a pilot study" was published in the *Journal of Biomedical Optics*, a publication of SPIE (the international society for optics and photonics). ■



4. Example boxplots for the FFT amplitudes compare noninflamed versus inflamed joints, labeled using both British (CE) and US RA criteria (a), and joints from the RA patient group with those from the non-RA group (b). *(Source: University of Birmingham – UK)*

BILL WONG | Senior Content Director

Trends for Industry 4.0 in 2020 and Beyond

Greater flexibility, virtual validation, industrial controllers, and edge computing are some of the hot topics and trends that will likely dominate Industry 4.0 going forward.

The fourth industrial revolution, more commonly known as Industry 4.0, holds tremendous potential for manufacturing companies in numerous industries to enable product customization, provide flexibility to meet new demands in real time, and produce more efficient operations.

As factories prepare for 2020 and beyond, I spoke with Philipp Wallner, Industry Manager, MathWorks, about what's driving Industry 4.0 opportunities in 2020, including having enough high-quality data, the need for critical low-latency communication, operations optimization, and performance-management technologies. The following outlines our conversation about future factory trends for 2020 and beyond.

AI has been a buzzword for years. How will emerging technologies impact Industry 4.0 applications next year?

In 2020, AI will become an enabler of flexible production. For the past several years, the automation industry has focused on production lines producing one-of-a-kind goods without encountering extended changeover-times. With Industry 4.0, full individualization in production must be accomplished. This means machines cannot be commissioned, parameterized, and tuned for one specific product produced repeatedly for months or even years. Production lines must be flexible. There must also be an AI that parameterizes and tunes machines according to the next, individualized good manufactured on the line.

Simulation has played a large role in manufacturing. Are there any evolutions in the technology we can expect as the industry transitions to Industry 4.0?

Designing and testing physical machines has become more difficult, if not impossible, due to software complexity and the growing number of possible combinations of modularized software components. To counter, companies will perform virtual commissioning of the software to verify the absence of errors and validate if requirements are met based on simulation models before the physical production line is even in place. Companies, such as Reishauer AG, a producer of high-precision gear grinding machines, are already using multidomain simulation models for virtual commissioning today.

What advances in network communications will take place with the growth of connected machines?

As the industry transitions toward Industry 4.0 and IoT, there will be more emphasis on developing unified standards like OPC UA TSN that will help in ensuring interconnectivity between machines and modules in the factory. To meet these standards, a combination of several technologies that enable data to be transmitted in real-time across manufacturers in compliance with an industry-wide standard will ensure equipment from different vendors interoperates seamlessly.

The emergence of 5G and advanced Wi-Fi will replace inflexible cables— enabling a more flexible factory floor. Machines will not only connect with each other but also to cloud systems where advanced calculation power is running powerful algorithms on business and engineering data.

With this increase in data and machines connected to the cloud, how will companies ensure that the right data will be in place at the correct time to catch critical operations status updates?

Increased calculation power realized by industrial controllers and edge-computing devices, as well as the use of cloud systems, will help achieve a new dimension of software functionality on production systems. Edge computing will enable AI-based algorithms to be better optimized throughout the production line—ensuring notification of faulty operations in time to avoid serious problems while minimizing the consumption of energy. Predictive maintenance will evolve and be able to consider data from multiple factories and equipment from different equipment vendors.

With Industry 4.0, the focus is often on automation and algorithms. But what impact will the industry have on people working in factories in 2020?

There will be more opportunities for smart engineers. More technology and tools like MATLAB will enable engineers and scientists (not just data scientists) to work with technologies enabling Industry 4.0, such as AI. Engineers will be required to build models, deal with large data sets, and handle the respective development tools to best address the trends outlined above. Companies will be looking for skilled engineers to prepare for a future in which Industry 4.0 reflects just the beginning of factory evolution. ED

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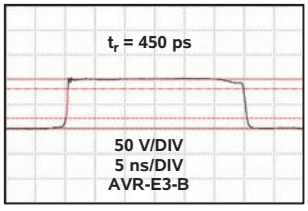

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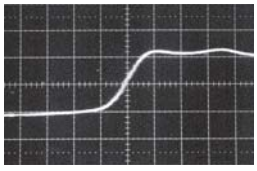

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15 V	100 ps	25 MHz	AVM-2-C
15 V	150 ps	200 MHz	AVN-3-C
10 V	100 ps	1 MHz	AVP-AV-1-B
10 V	50 ps	1 MHz	AVP-3SA-C
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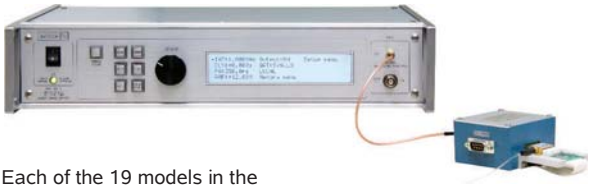

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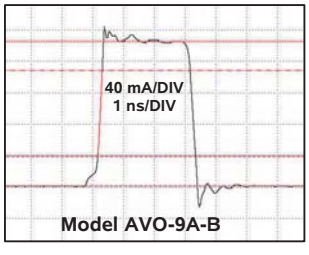

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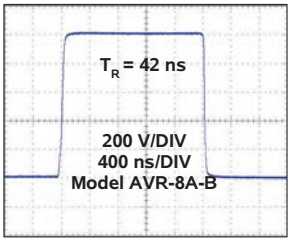

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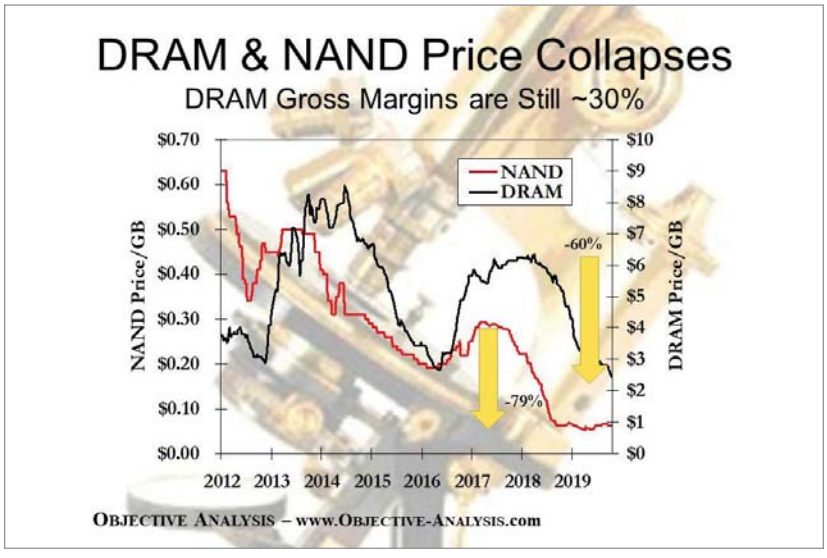
JIM HANDY | Objective Analysis

2019 Was Down!
Will 2020 See a Chip Recovery?

2019 was a very difficult year for the semiconductor industry. Will 2020 be any better?

We can look back on 2019 as a year that was very difficult for the semiconductor industry, particularly for manufacturers of NAND flash and DRAM. The big question for these companies is now: Will 2020 be any better? Let's have a look at what the current market conditions and what a lot of chip history can tell us about how the year is likely to turn out.

Don't get me wrong. Although chip makers are suffering, the market's not bad for everyone. Those OEMs who suffered from sky-high DRAM prices in 2018 were thrilled to get some price relief in 2019. These OEMs also need to know the 2020 outlook: Will today's respite from high prices last, or are chip prices about to return to unbearable heights?



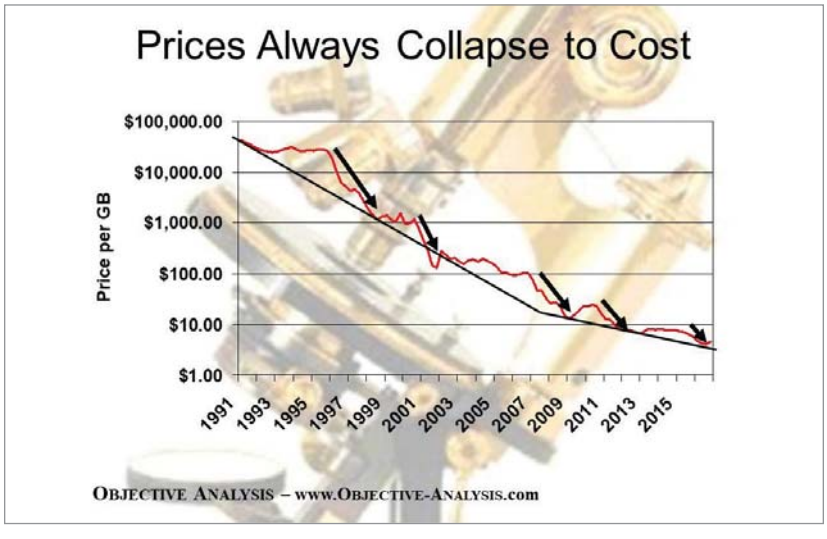
1. NAND flash prices began to tumble in early 2018, and by the middle of this year they had dropped 79% from their 2017 peak to flatten out at cost. DRAM revenues are likely to be down by 41% once 2019 has been tallied up.

2019 AT-A-GLANCE

The chart in *Figure 1* illustrates spot market prices for DRAM and NAND flash for the past couple of years.

These prices are important to anyone in the semiconductor community, even those who neither make nor use DRAM or NAND flash, because they are the drivers of the market's notorious revenue swings. (More on this later.)

NAND flash prices, shown with the red line and measured on the left vertical axis, began to tumble in early 2018, and by the middle of this year they had dropped 79% from their 2017 peak to flatten out at cost. DRAM prices, illustrated with the black line, and measured on the right vertical axis, climbed in 2018 but began to collapse late in the year. By December they had fallen 60%.



2. DRAM price per gigabyte (red line) and approximate cost (black line) show a profitable market when the shortage price and cost diverge. The arrows on the chart show the collapses of past cycles.

The net result of these price falls is that 2019 DRAM revenues are likely to be down by 41% once 2019 has been tallied up, and NAND flash revenues will be found to have fallen by 18%. These two are big contributors to the 12% total semiconductor revenue decline that 2019 is likely to be remembered for once the year's books have been closed.

A SOLID METHODOLOGY

How can we use this kind of information to predict future market trends? Objective Analysis employs a relatively straightforward methodology to predict semiconductor market upturns and downturns. Although length limitations prevent my providing all of the details in this article, our model essentially predicts the timing of shortages and oversupplies based on the capital spending that occurred two years prior, and predicts prices based upon historical price behavior and a production cost model.

This has been the basis for our forecast for the past 12 years, and it has allowed us to deliver the most consistently-accurate semiconductor forecasts in the industry. Our prior forecast performance can be reviewed on our website at *http://Objective-Analysis.com/forecast-accuracy.*

LOOKING FORWARD

Where does the market go from here?

If we look back at DRAM prices over the past 29 years, we can see a pattern that should repeat itself during the current downturn. The chart in *Figure 2* compares DRAM price per gigabyte (red line) to an approximation of cost (black line) since 1991. When there's a shortage, price and cost diverge, making the market profitable. Once the market turns from a shortage to an oversupply, then prices collapse to cost.

NAND flash prices have already collapsed to cost and DRAM is currently involved in the later stages of its own price collapse.

DRAM prices, though, have not yet reached cost—they still generate about a 30% gross margin. Objective Analysis expects to see further DRAM price decreases that will bring prices down to costs by the end of 2019 or early in 2020. We estimate that the production cost of a gigabyte of DRAM is around $1.80, and today's lowest spot market price is around $2.45.

CAPITAL SPENDING'S ROLE

Something interesting always happens when there's a shortage and semiconductor manufacturers are profitable: They all simultaneously invest in additional production capacity. This phenomenon happened when DRAM prices were high in 2018, and when NAND

flash prices peaked in 2017. The market's profitability drives semiconductor cycles. Here's how.

The relationship between capital expenditures ("CapEx") and market profitability is pretty tight: Two years after a CapEx surge the market enters an oversupply and prices collapse to cost. Profits vanish and CapEx is cut. Two years after a CapEx cut the market enters a shortage, prices stabilize, and profits return.

We illustrate this relationship in the chart illustrated in *Figure 3*. The chart plots a black "Capital Shortage" line (measured on the left axis) over a red "DRAM Profit Growth" line, measured on the right axis.

The "Capital Shortage" line is derived from CapEx two years prior.

While there's a clear relationship, the reader can easily find points where the two lines don't move in tandem. As a general rule, though, the black line is a pretty good indicator of where the red line is headed. The fact that the black line increases in 2020 indicates that DRAM profits should return and that the Objective Analysis 2020 semiconductor forecast could rationally predict growth for 2020.

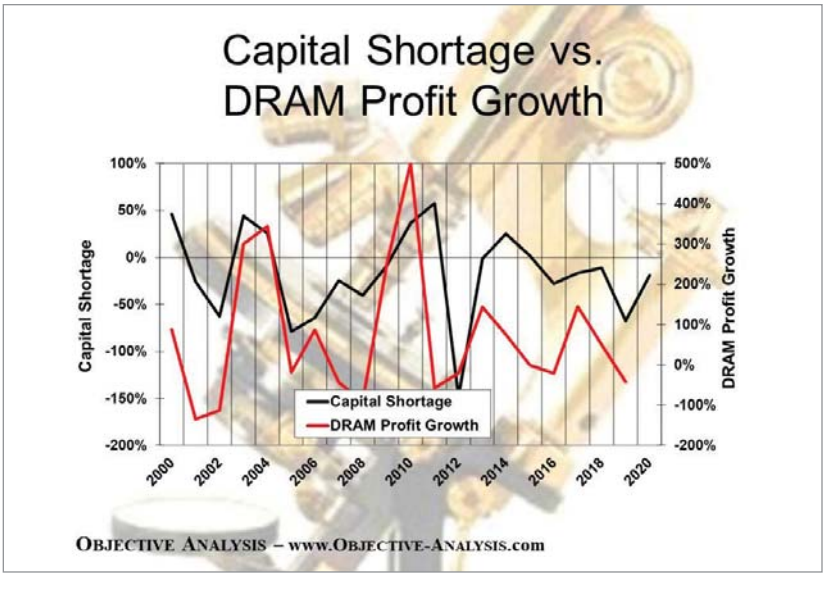
There are times, though, when a forecaster must look at other factors to determine how the market is most likely to evolve. This is one of those times.

There's still a significant NAND flash and DRAM oversupply, and the industry gives us no reason to expect for that oversupply to abate over the course of 2020. 2018's CapEx was so extreme that it's unrealistic to expect for a shortage to return that soon. This drives our outlook to be flat to negative for 2020.

OUR 2020 FORECAST

Objective Analysis predicts that total semiconductor revenues will see zero growth at best, with the strong possibility of a mild revenue decline. Although NAND flash revenues should grow about 5%, based upon an assumption of stable bit growth and prices following cost, DRAM revenues are most likely to decline by 25% as prices continue their collapse and bit growth runs at a slower pace than that of NAND. Although other semiconductors will see modest growth, their growth will be insufficient to offset DRAM's decline.

We provide a more detailed forecast to our regular clients. Please contact us if you would like to learn more.



3. As a general rule, the capital shortage is a pretty good indicator of where the DRAM profit growth is headed.

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TECHNOLOGY PREDICTIONS from a [Precision] Electronic Test Thinktank

What does a [Precision] Electronic Test Thinktank expect to unfold in 2020? From new test tools, to the 5G outlook, to digital twins, to the "Interaction of Things," many potentially transformative advances loom on the horizon.

NEW REALMS OF MEASUREMENT WILL GROW IN IMPORTANCE IN 2020

Measurement-based tools of many kinds are key enablers for the technology-based products and solutions we incorporate into our daily lives, and it will transform as disruptive technologies come into play.

- In 2020, advanced applications related to 5G will explode, using higher frequencies and smaller geometries. To support this growth will be:
  - New classes and labs for design and simulation, over-the-air testing, antenna systems, and measurements will be incorporated into the core engineering curriculum.
  - New measurement science (hardware, software and calibration) will be developed and made part of mainstream offerings.
  - Developers of new electronic products and solutions will use different tools, specifications, and terminology to specify and validate their designs.
- Use of software for implementing technology will remain prevalent in 2020, especially in networking and position or navigation-based smartphone applications. As a result, software-on-software measurement will see a strong surge and, therefore, so will emphasis on interoperability among software tool chains. New standards and certifications will be created, impacting development processes, as well as the marketing required to ensure consumers are aware of what a software-centric product can and cannot do.
- In 2020, expect a substantial rise in specialized processors, such as GPUs and chips, which implement artificial-intelligence (AI) architectures that determine how a network processes and routes information and maintains security, privacy, and integrity. Quantum computing and engineering will continue to be in an aggressive hype phase in 2020, but the ability to control, measure, and error-correct quantum systems as the number of qubits grows will be important from the start.
- As measurement and operation of the computer blends, those interested in building practical quantum computers will require knowledge about measurement technologies and techniques before quantum computing goes into the mainstream.

DATA SILOS WILL BE CONNECTED TO EXTRACT DEVELOPMENT INSIGHTS

Leading companies collect data but typically store it in functional silos: R&D design, pre-production validation, manufacturing, operations and services.

- In 2020, companies will start connecting these silos of data using modern cloud architectures, such as private on-premises clusters, or public sites like AWS or Azure. With the data centrally available, teams will correlate performance through the development process, from early design to manufacturing to field deployment, and close the loop back to design. The benefits for these teams include the rapid collection and reformatting of data, faster debugging of new product design, anticipation of manufacturing issues, and improved product quality.
- To achieve these gains, teams will invest in a computing infrastructure, determine how to store the data (including file location and data structure), as well as choose analytic tools to select and process data to identify anomalies and trends. In addition, teams will change the way they work to shift attention to data-driven decisions.

5G AND THE DATA CENTER

New 5G capabilities in 2020 will put pressure on networks, revealing new data-center and network chokepoints.

- Industrial IoT applications will escalate access requests and mobile automotive IoT applications will stretch latency demands. Edge computing will become more important to process the increased access requests and meet stringent latency requirements.
- Higher data speeds will create more demands for faster memory, faster data buses, and faster transceivers in the data center. Meeting the speed and flexibility demands will be one reason, but customer traceability through the network for application monetization will be the main driver to upgrade to the latest standards.
- In 2020, we will see advanced design, test, and monitoring capabilities that ensure networks and products deliver the performance and failsafe reliability expected. The industry will experience closer collaborations between chipset and product manufacturers, software companies, network carriers, cloud-hosting companies, and international standards organizations to build tomorrow's networking infrastructures.

CHALLENGES WILL ABOUND TO GET 5G TO MATURITY

5G represents technical evolution and revolution on many fronts, creating new technical challenges that span many domains.

- In 2020, the industry will move from a small group of early-movers that have commercialized initial 5G networks, to a global community in which multiple operators in every continent and many countries will have commercial 5G networks.
- The early adopters will add scale, and those who launch in 2020 will quickly resolve issues in their initial deployments. Second-generation devices and base stations will be added to the market, and the standards will have another new release in 3GPP's Rel-16.
- Key technical challenges for the industry in 2020 will be to ensure performance in mid-band (3.5 to 5 GHz) frequencies, moving millimeter-wave (mmWave) to mobility, transition planning to a full standalone (SA) 5G network, and resolving architectural decomposition and standards for centralized radio area network (RAN) and mobile-edge computing (MEC).

THE "INTERNET OF THINGS" WILL BECOME THE "INTERACTION OF THINGS"

IoT will rapidly move into the mainstream with widening commercial acceptance, increasing public-sector applications, and accelerated industrial deployments.

- In 2020, we will see an increased level of "smart" experiences when the "Internet of Things"—a collection of devices connected to the internet—becomes the "Interaction of Things"—a collection of things that are communicating and working effectively and efficiently with each other.
- Powerful devices will work with other powerful devices to act quickly and efficiently in the background independent of direct human intervention. Mission-critical applications, such as remote robotic surgery in the area of digital healthcare or autonomous driving in the area of smart mobility, will feel the impact of this shift.
- While these applications will benefit from the "Interaction of Things," new solutions will be developed to ensure they don't suffer from the "Interference of Things," especially when communication failure and network disturbances can bring about devastating or life-threatening consequences. The same will be true of Industry 4.0 applications and smart city applications. Uptime will not be optional.

DIGITAL TWINS WILL MOVE TO THE MAINSTREAM

Digital twins, or the concept of complete replicate simulation, are the nirvana of design engineers.

- In 2020, we will see digital twins mature and move to the mainstream as a result of their ability to accelerate innovations. To fully realize the technology's benefits, companies will look for advanced design and test solutions that can seamlessly validate and optimize their virtual models and real-world siblings to ensure that their behaviors are identical.

2020 WILL NOT BE THE YEAR OF THE AUTONOMOUS VEHICLE: ACTIVE CRUISE CONTROL, YES, BUT WE HAVE A COUPLE YEARS TO GO FOR AUTONOMY

The quantity and sophistication of sensors deployed in vehicles will increase in 2020. However, fully autonomous vehicles will require more ubiquitous 5G connectivity and more artificial intelligence. Here's where we see the industry on each of those areas:

- The ratio of fleets sales with EV or HEV powertrain will grow from single-digit percentage ratio to double digits in 2020, tripling the shipped units compared to last year.
- The first C-V2X network will hit the streets in China, but they will be operating on an LTE-V network until 5G Release 16 evolves the standard.
- The technical advances for sensors and in-car networks will continue to evolve on a fast pace, needing faster in-vehicle networks. In 2020, Gigabit-Ethernet-based in-car networks become a reality and significantly improved sensor technology enables AI developers to hit new performance levels.

SYSTEM-LEVEL DESIGN, TEST, AND MONITORING WILL EXPERIENCE A DRAMATIC TRANSFORMATION

The connected world will force a shift in how performance, reliability, and integrity are evaluated.

- In 2020, realizing the full potential of sensor systems connected to communication systems connected to mechanical systems will require new ways to test at the system level.
- Today, tests are available for radar antennas and a radar transceiver module. However, testing a multi-antenna radar system integrated into a car will require a different testing approach. The same is true for data centers, mission-critical IoT networks, automobiles, and a wide range of new, complex, 5G-enabled applications.
- This year, the electronics industry will emphasize system-level testing as the definitive, final step to assure end-to-end performance, integrity, and reliability across the increasingly connected world.

EDUCATION WILL SHIFT TO PREPARE THE NEXT GENERATION OF ENGINEERS

Universities will adopt holistic, integrated, and multi-disciplinary curricula for engineering education.

- Academia will tap into industry partnerships to keep up with the accelerating pace of technology and incorporate certification programs, industry-grade instrumentation, and automation systems into teaching labs to train students on current, real-world applications.
- To address IoT, universities will combine methodology from basic electronics, networking, design engineering, cybersecurity, and embedded systems, while increasing emphasis on the impact of technology on society and the environment.
- To address AI, automation, and robotics, universities will mainstream currently niche topics like cognitive science and mechatronics into required learning.

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2020 AND HINDSIGHT: Nest, Ring, or Echo?

Analyst Tom Starnes gives his take on the current state of smart speakers and voice assistants as we embark on a new decade.

The 2020 calendar looms over us. Analysts are asked "what really matters?" It has been 20 years since Y2K cast its false shadow on the new millennium, but many old technologies have evolved and found new life. For 2020, it may be appropriate to include a little hindsight when considering the new year.

THE TREASURED HEART OF THE HOME—NEST, RING, OR ECHO

Long ago, the kitchen might have been the heart of the house, where family members gathered to eat, socialize, and coordinate. Later, the radio, and then television, brought outside events, world news, and entertainment to the family. That evolved to become the cable box—more properly the set-top box (STB). But multiple TVs and video games soon splintered the home's central gathering spot.

Cable TV, phone, satellite, internet, and cellular service providers plus security and utility companies have fought for years to be the provider of a multitude of services to the residential home—as well as apartment and commercial buildings—through a central electronic hub, which often comes down to the modem, routers, or that STB.

More recently, Nest thermostats and Ring doorbell products, although expensive for the function they offer, have carved a decent market for themselves. And they started to expand their footprints to be the hub for other IoT functions around the house.

Meantime, voice input has taken on a far more visible role. It's perhaps driven most by Amazon's Echo products, which have broken open a prime spot in the living room, dining room, and eventually any other room, allowing the "couch potato" to sink to a new level of lazy. The automobile may soon follow, enhancing safety by enabling the eyes and hands to stay on the road and wheel.

VOICE BOX

Utilizing natural language, interpreted by voice-response software like Amazon's Alexa, Microsoft's Cortana, Apple's Siri, Google's Assistant, and the HAL 9000, a seemingly friendly, interactive computer can give humans the answers to stupid questions, monitor timers and sensor inputs, and perform physical operations with certain connected devices. And it all can be done on a schedule or at the command of its master's voice, through the internet, local network, or a personal area network (PAN) like Bluetooth.

Like the original iPod, iPhone, and iPad, and Macintosh (Steve Jobs really was genius), these voice-command devices aren't necessarily bringing brand new or unique functions to the user. Rather, they're blending together—integrating—a number of existing functions into a new form factor or use model that makes it easier for the user to do things—and maybe they're a little more natural, intuitive, and fun.

Note, however, the magnitude of the companies behind the voice-command products/services. These behemoths aren't going to let "the other guy" win the battle for the heart of the home; there's too much at stake in products, services, databases, modeling, and insight.

Realize that voice-to-text systems have been around for 10 to 20 years; the internet got rolling nicely 30 years ago; Amazon, eBay, and Etsy have been selling products online for a long time; and the concept of a hub in the home has been around nearly 35 years. The home hub may finally be gelling, although the winner is far from obvious as 2020 starts.

The standalone Echo opened an interesting new category.

JOSEPH SAWICKI | Executive Vice President for IC EDA, Mentor, a Siemens Business

EDA in the Era of AI

Artificial intelligence (AI) has proven useful in a range of applications, even in the electronic-design-automation arena. And by the looks of things, AI will have a greater impact on EDA technology this year.

As the adoption and sophistication of artificial-intelligence (AI) technology continues to expand, it's increasingly clear that AI and its many derivatives (deep learning, machine learning, etc.) will lead to profound socioeconomic changes of a magnitude the world hasn't seen since the industrial revolution. While it can sometimes be a controversial topic in terms of its ethical vs. unethical use, and potential impact on global socioeconomics, one thing is certain: AI is, even in its infancy, being effectively deployed to vastly improve and better automate a number of tasks ranging from data collection, communications, robotics/factory automation, automotive design—and to even our own small but mighty industry, EDA, in chip design.

In short (and excuse the mixed metaphor), the genie is out of the bottle, and we need to embrace it. In 2020, we can certainly expect to see continued growth in the design and deployment of AI chips and systems.

To help companies deliver more sophisticated AI technologies, EDA companies such as Mentor, a Siemens business, are doing two things:

1. Developing tools to help companies design AI-accelerators faster.
2. Leveraging machine-learning algorithms to improve IC design tools so that they can deliver better results for customers faster.

Let's take a closer look at these.

TOOLS FOR BETTER, FASTER AI/ML DESIGN

Most AI starts out as a mathematic algorithm. The developer creates the algorithm in a math tool, translates it to C code, and then runs that algorithm on a processor. Inevitably, they'll find that parts of the algorithm run optimally, while other parts run more slowly.

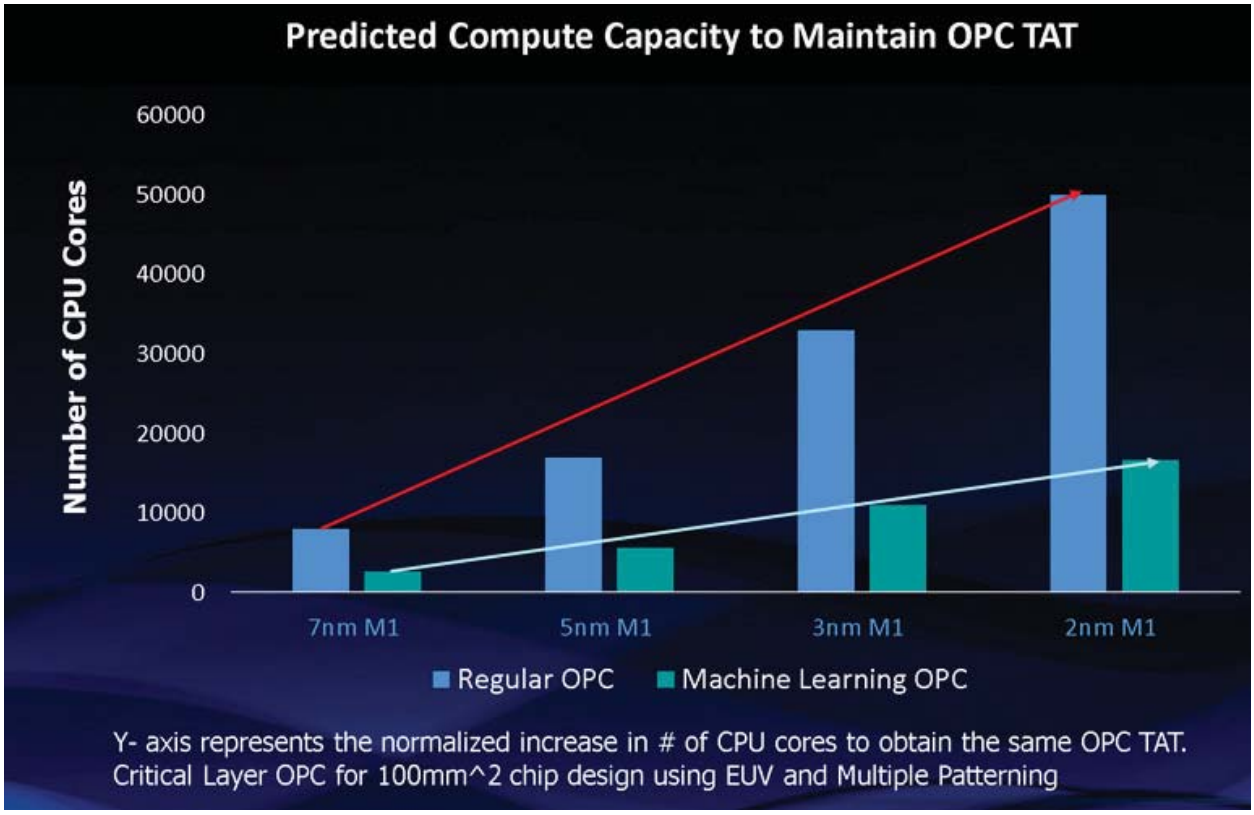
That's why there's a vast rise (and subsequent investment from the venture community as well as from large corporations) in AI/ML accelerator IP and silicon development. Some algorithms can be forced (by tweaking the C code) into running on existing AI ASSP architectures with performance and power compromises, but others (think of mobile devices, for example) require dedicated logic to run optimally.

Developing the right AI architecture for a given application screams for EDA tools that enable companies to work with higher levels of abstraction. We're starting to see increased business in our Catapult HLS (High Level Synthesis) technology for companies developing AI IP accelerators for their system-on-chip (SoC) designs. This enables AI architects to develop their math code, translate it to C or SystemC, and see upfront which parts of their algorithm should be implemented in hardware vs. software. They can then converge on the ideal architecture much sooner than trying to go down to the RT level right away.

When they do converge on the ideal architecture and select the hardware configuration that runs most suitably, by far the best way to test and refine this architecture is to use an emulation solution, such as Mentor's Veloce emulation platform. This enables teams to not only run the hardened chip design on the emulation system and then fine-tune the software emulation, but emulation can also be connected to the end system, with emulation performing overall ML benchmarking.

Many of these AI platforms will increasingly require high-speed connectivity. As such, we believe that most ML SoCs will in fact be mixed-signal SoCs. This will require tools that can more effectively bridge the digital and analog domains, such as our Symphony AMS simulation solution, which is a vendor-agnostic AMS environment.

Because many of the ASSP AI devices that are at the heart of data centers and



Significant reduction in computational demand reduces significantly with machine-learning Calibre OPC in IC design tapeouts.

communications infrastructure require the highest possible performance, I believe we'll start to see increased commercialization of silicon photonic devices that bring photonics directly to the silicon.

ML-ENHANCED EDA TOOLS FOR BETTER, FASTER RESULTS

For the last several years, Mentor's R&D staff has in many ways led the way in integrating ML into our own EDA tools. The company currently has five tool offerings commercially available that leverage ML to help deliver better results, and deliver them more quickly. Allow me to geek out for a moment and talk about ML in the context of improving EDA tools.

As we all know, ML is useless without data. The more data that's produced, the more ML can be called in to sort and develop something meaningful from that data. What's lucky for us is that EDA tools themselves produce an enormous amount of data. Process manufacturing generates a large amount of data, and users can produce their own proprietary data and requirements (for training). So, theoretically there isn't a shortage of data. In fact, when leveraging ML for EDA, the question becomes: What data sets can be leveraged effectively for what tool functions?

So far, we have five tools that leverage ML enhancements, and most of these are in the realm of physical design, verification, and manufacturing: ML for library characterization and simulation, optical proximity correction, lithography simulation, and CMP modeling. This EDA segment is the obvious place to start.

For example, for optical proximity correction, Calibre OPC operates on a physical design database. Each run of the chip produces billions of data points that are available for analysis. By putting ML technology into Calibre OPC, we can collect data around those chips and then use that to produce better results faster for designs.

At 7 nm for a critical layer, customers are using up to 8,000 CPUs running for 12 to 24 hours to perform a single run. By using machine learning, we have been able to drop that by a factor of three and constrain the increase in time that would be necessary to produce each of the advanced nodes coming in the future *(see figure)*.

This is just one example, but we're seeing similar results with our other ML-enhanced tools. We currently have two dozen other projects in the works looking at new ways where AI/ML can leverage a seemingly abundant amount of data to deliver better results faster. You can certainly expect that in 2020, you'll be using more ML-enhanced EDA tools to produce more innovations. ED

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PHIL DAVIES | VP of Sales and Marketing, Vicor Corporation

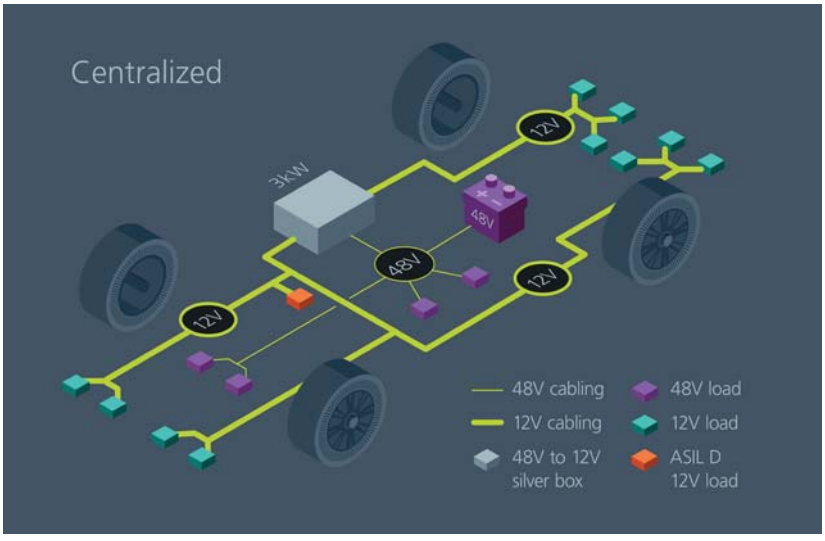
Solve Auto Electrification Challenges with a Decentralized 48-V Power Architecture

For nearly a decade, billions of dollars have been spent annually to meet automotive CO_2 emissions standards. This new approach to electrification could be the next big breakthrough.

Manufacturers of cars, trucks, buses, and motorcycles are rapidly electrifying their vehicles to increase the fuel efficiency of internal combustion engines and reduce CO_2 emissions. There are many electrification choices, but most manufacturers are opting for a 48-V mild-hybrid system rather than a full-hybrid powertrain. In the mild-hybrid system, a 48-V battery is added alongside the traditional 12-V battery.

This increases power capability by 4X ($P = V \times I$), which can be used for heavier loads, such as the air conditioner and catalytic converter at startup. To increase vehicle performance, the 48-V system can power a hybrid motor for faster, smoother acceleration while saving on fuel. The additional power can support steering, braking, and suspension systems, plus add new safety, entertainment, and comfort features.

Introducing a 48-V mild-hybrid system has tremendous upside once designed-in. Overcoming the hesitancy to modify the long-standing 12-V power distribution network (PDN) may be the biggest challenge. Changes in power delivery often require new technologies that need extensive testing and may require new suppliers to deliver on the automotive industry's high safety and quality standards.



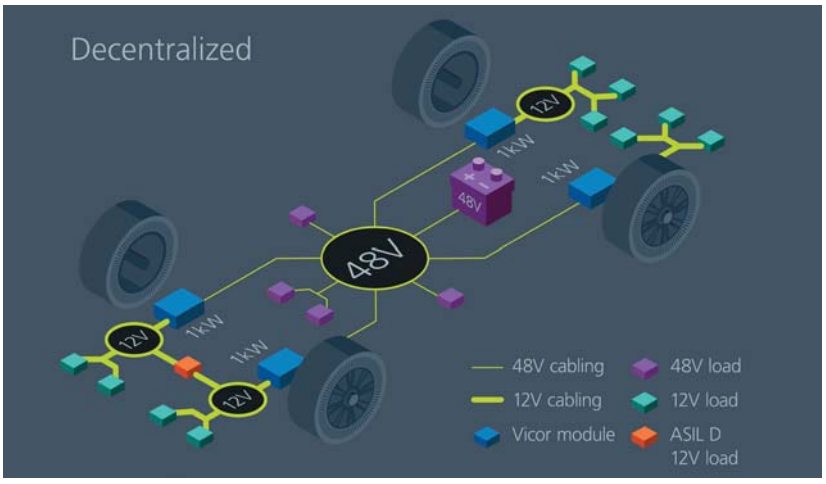
1. Most centralized 12-V architectures are large, heavy, and present a single point of failure.

But the advantages far outweigh the conversion cost, a fact that's being discovered by the data-center industry as it moves to a 48-V PDN. For the automotive industry, a 48-V mild-hybrid system provides a way to rapidly introduce new vehicles with lower emissions, longer range, and higher gas mileage. It also delivers new and exciting design options for higher performance and features while still reducing CO_2 emissions.

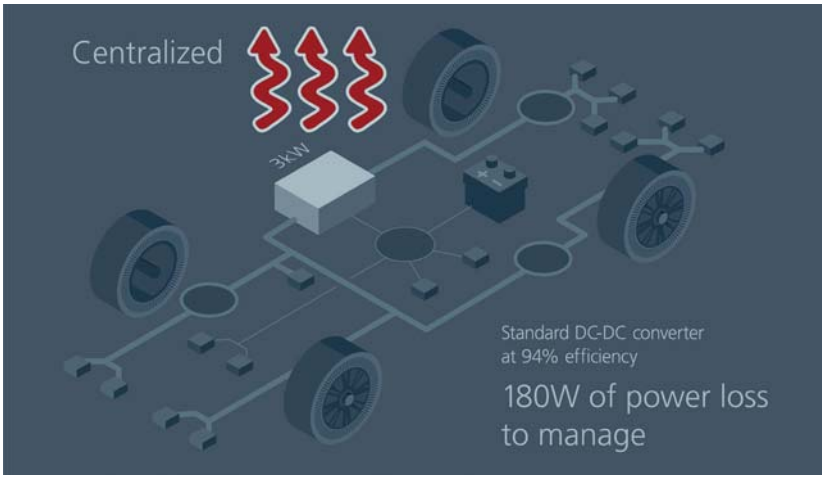
HOW TO MAXIMIZE A 48-V PDN

Adding a 48-V battery to power the heavier powertrain and chassis-system loads provides options to engineers. Now there's a choice of adding systems that can deal directly with a 48-V input, or to retain legacy 12-V electromechanical loads such as pumps, fans, and motors and instead convert the 48 V to 12 V via a regulated dc-dc converter.

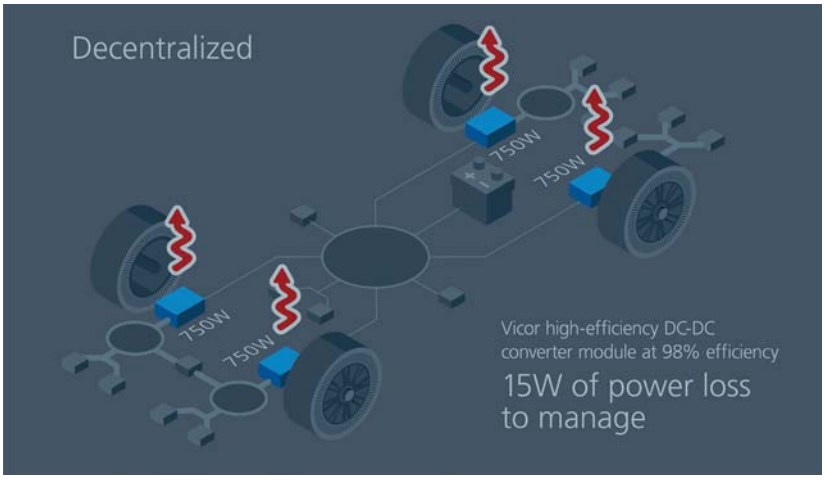
To manage change and risk, existing mild-hybrid power-delivery systems are slowly adding 48-V loads, but they still use a large centralized multi-kilowatt 48- to 12-V converter that feeds 12 V around the vehicle to the 12-V loads. However, this centralized architecture doesn't take full advantage of a 48-V PDN, nor does it utilize the benefits of available advanced converter topologies, control systems, and packaging.



2. A decentralized 48-V architecture places multiple smaller, lower-power converters closer to the 12-V loads.



3. Higher currents in the traditional centralized architecture create greater losses; standard converters are about 94% efficient.



4. Decentralized 48-V architectures reduce losses by distributing lower currents and generating less heat; Vicor has developed converters that are 98% efficient.

The vast majority of these centralized dc-dc converters *(Fig. 1)* are bulky and heavy, since they use older, low-frequency switching PWM topologies. They also represent a single point of failure for many critical powertrain systems.

A different architecture to consider is decentralized power delivery *(Fig. 2)* with modular power components. This power-delivery architecture uses smaller, lower-power 48- to 12-V converters, distributed throughout the vehicle close to the 12-V loads. The simple power equations $P = V \times I$ and $P_{LOSS} = I^2R$ explain why 48 V is more efficient than distributing 12 V.

For a given power level, the current is 4X lower at 48 V than in a 12-V system and has 16X lower losses *(Figs. 3 and 4)*. At one-quarter of the current, the cables and connectors can be smaller, lower weight, and cheaper. The decentralized power architecture also has significant thermal management and power-system redundancy benefits.

MODULAR COMPONENT BENEFITS FOR DECENTRALIZED ARCHITECTURES

A modular approach to a decentralized power delivery is highly scalable *(Fig. 5)*. The 48-V output from the battery is distributed to the various high-power loads in the vehicle, maximizing the benefits of lower current (4X) and lower losses (16X) and resulting in a physically smaller and lower-weight PDN. Depending on a load power analysis of the various distributed loads, one module can be designed and qualified for the right power granularity and scale to be used in parallel arrays.

In this example, a 2-kW module is shown *(Fig. 5, again)*. As noted, the granularity and scalability are system-dependent. By using distributed modules instead of a large centralized dc-dc converter, N+1 redundancy is also possible at a much lower cost. This approach also has advantages if load power changes during the vehicle development phase.

Design Note

4-Switch Buck-Boost Controller with Pass-Thru Capability Eliminates Switching Noise

David Megaw, Senior Design Engineer
and **Bruce Haug**, Product Marketing Manager

Introduction

A common dc-to-dc converter problem is generating a regulated voltage when the input voltage can be above, below, or equal to the output—that is, the converter must perform both step-up and step-down functions. This scenario is typical when powering vehicle electronics from a nominal 12 V battery, which can vary from engine cold crank (down to 3 V) and load dump (up to 100 V), or a reverse battery voltage from operator error. There are several dc-to-dc converter topologies that can perform both step-up and step-down operations, from SEPIC to 4-switch topologies, but none of these solutions pass the input voltage directly to the output without actively switching—until now, that is.

The LT8210 is a synchronous buck-boost controller that can operate in Pass-Thru™ mode, which eliminates EMI and switching losses, and maximizes efficiency (up to 99.9%). Pass-Thru operation passes the input directly to the output when the input voltage is within a user programmable window. The LT8210 operates over an input voltage range of 2.8 V to 100 V, allowing it to regulate from the minimum input voltage during cold crank to the peak amplitude of an unsuppressed load dump. The LT8210 can operate as a conventional buck-boost controller with pin-selectable continuous conduction mode (CCM), pulse skipping, or Burst Mode® operation, or in a new Pass-Thru mode in which the output voltage is regulated to a programmed window. When the input voltage resides in this window, it is passed directly to the output without actively switching the FETs, resulting in ultralow I_Q operation and the elimination of switching noise.

Pass-Thru Operating Mode

Figure 1 shows a simplified schematic of an LT8210 configured for Pass-Thru operation with the output regulated to be between 8 V and 16 V. The top and bottom voltages of the Pass-Thru window are set by the FB2 and FB1 resistor dividers, respectively.

Figure 2 shows the input/output transfer characteristic of this circuit. When the input voltage is above the Pass-Thru window, the LT8210 steps it down to a regulated 16 V output. If the input voltage drops below the window, the LT8210 boosts to maintain the output at 8 V. When the input voltage is within the Pass-Thru window, the top switches, A and D, turn on continuously, allowing the output to track the input and the part to enter a low power state with typical quiescent currents on the V_{IN} and V_{INP} pins of 4 µA and 18 µA, respectively. In this nonswitching state, there are neither EMI nor switching losses, making efficiencies greater than 99.9% achievable.

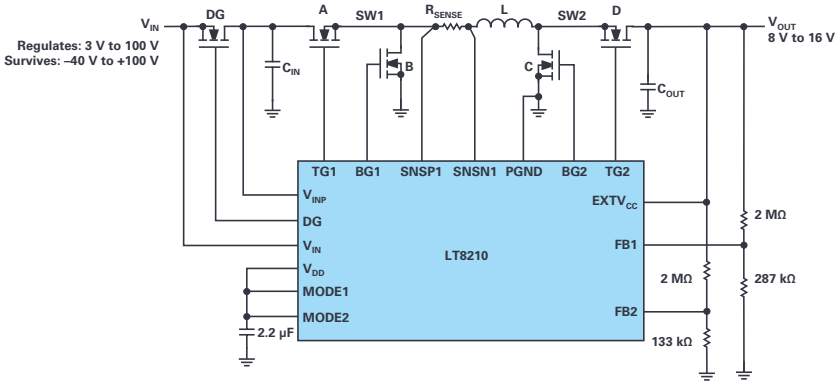


Figure 1. LT8210 8 V to 16 V Pass-Thru regulator circuit.

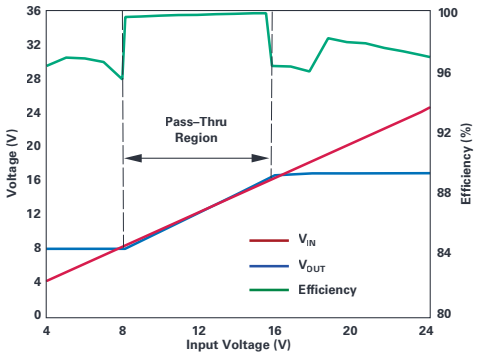


Figure 2. Pass-Thru operation enables 99.9% efficiency in the Pass-Thru input voltage window.

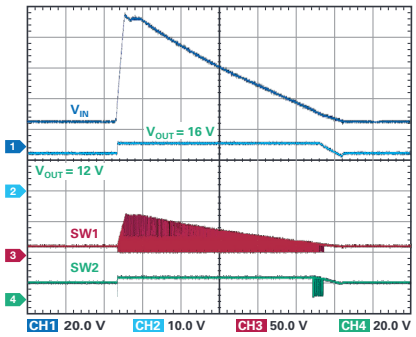


Figure 3. The LT8210 in Pass-Thru mode quickly responds to an 80 V unsuppressed load dump pulse, limiting the output to the programmed 16 V maximum.

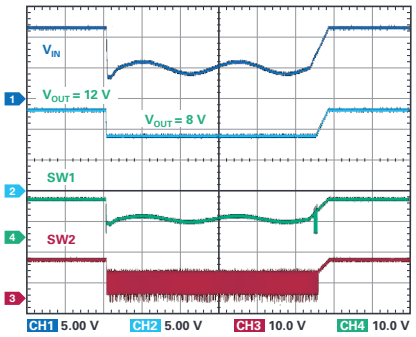


Figure 4. The LT8210 in Pass-Thru mode responds to a cold crank pulse (<4 V) by boosting to the programmed 8 V minimum output voltage.

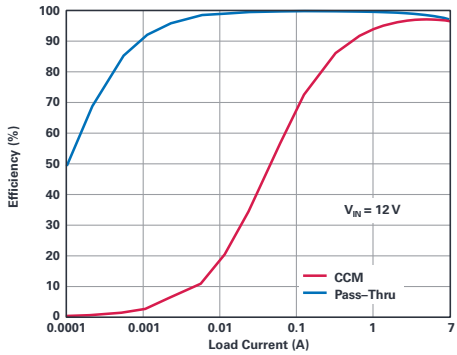


Figure 5. In the Pass-Thru region, efficiency reaches nearly 100%, compared to continuous conduction mode efficiency.

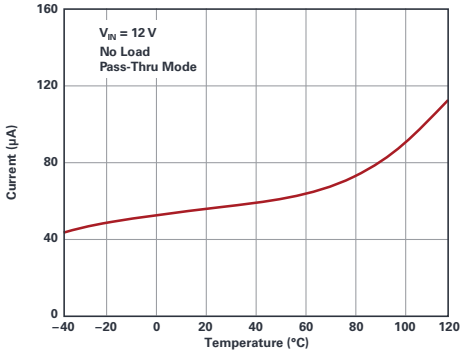


Figure 6. The LT8210 features ultralow quiescent current in the Pass-Thru region.

Conclusion

Automotive batteries and similar wide voltage range power sources are a complex problem for dc-to-dc converter designers, requiring protection features and buck and boost conversion at high efficiency. The LT8210 synchronous buck-boost controller eliminates complexity by combining protection features with a wide input range buck-boost converter and a unique Pass-Thru option. It operates over a 2.8 V to 100 V operating range with built-in reverse voltage protection. Its Pass-Thru mode eliminates switching losses and noise while achieving ultralow quiescent current. In Pass-Thru mode, the output voltage is not regulated in the conventional sense, but is instead bounded by a programmable voltage window.

In the case of pure electric vehicles or high-performance hybrid cars, high-voltage batteries are used due to the high power demands of the powertrain and chassis systems.

Instead of implementing changes to a full ground-up custom power supply, engineers can either add or eliminate modules. Another design advantage is reduced development time as the module is already approved and qualified.

IMPLEMENTING THE DECENTRALIZED ARCHITECTURE IN HIGHER-VOLTAGE BATTERY SYSTEMS

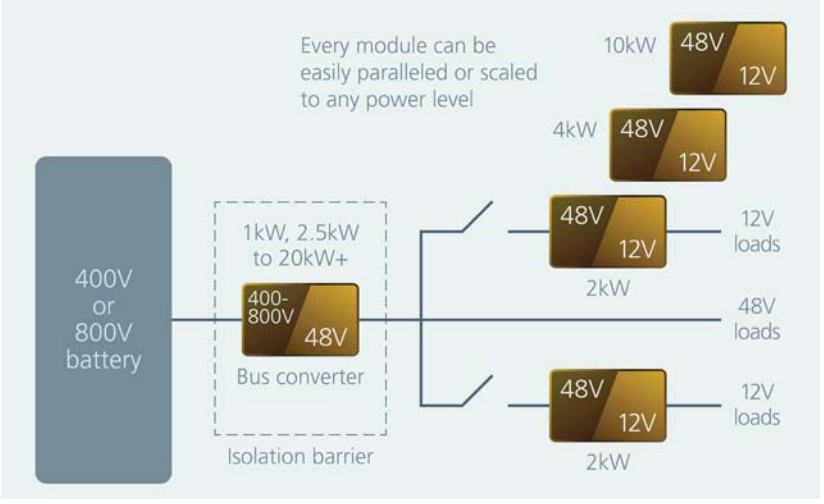
In the case of pure electric vehicles or high-performance hybrid cars, high-voltage batteries are used due to the high power demands of the powertrain and chassis systems. A 48-V safety extra-low-voltage (SELV) PDN still has significant benefits for OEMs, but now the power-system designer has the additional challenge of high-power 800- or 400- to 48-V conversion.

This high-power dc-dc converter also requires isolation, but not regulation. Better voltage regulation is one benefit of decentralizing the placement of 48- to 12-V converters. By using regulated point-of-load (PoL) converters, the high-power upstream converter can employ a fixed-ratio topology. This is extremely beneficial due to the wide input-to-output voltage range of 16:1 or 8:1 for 800/48 and 400/48, respectively *(Fig. 6)*. Using a regulated converter over this range is very inefficient and presents a large thermal-management problem.

It would be very difficult and costly to decentralize this high-voltage isolated converter due to safety requirements in distributing the 400 V or 800 V. However, a high-power centralized fixed-ratio converter can be designed utilizing power modules instead of a large silver-box dc-dc converter.

Power modules of the right level of granularity and scalability can be developed and then easily paralleled for a range of vehicles with differing powertrain and chassis electrification requirements. Fixed-ratio bus converters (BCM) developed by Vicor are also bidirectional, which supports various energy-regeneration schemes. Due to the sine amplitude converter (SAC) high-frequency soft-switching topology, BCMs achieve efficiencies over 98%. They also feature power densities of 2.6 kW/in.^{3}, which reduces the size of the centralized high-voltage converter.

5. A decentralized, modular approach to a 48-V mild hybrid system reduces losses by 16X.



6. Fully electric vehicles can take advantage of the same hybrid-electric modular approach, with only the addition of an upstream fixed-ratio converter.

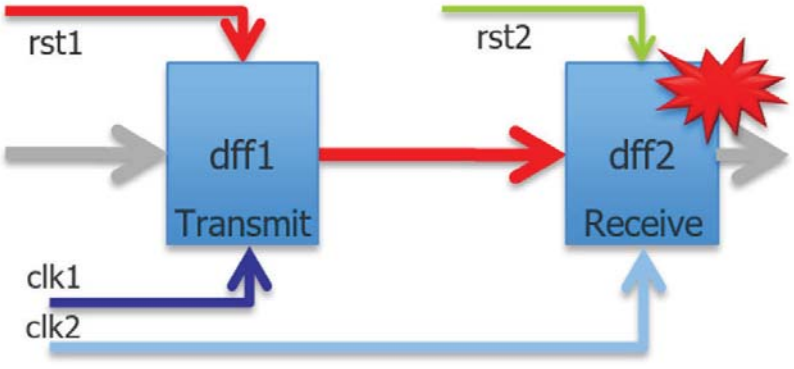
CHRIS GILES | Product Marketing Manager, Mentor, a Siemens Business

First-Time FPGA Success Requires Exhaustive Examination of Clock Domain Crossings

Clock domain crossings are significant sources of field system failures. Despite this fact, designs continue to be released without fully verified CDCs. A false sense of security resulting from incomplete analyses is impacting industry results.

The checkbox is the enemy of a successful ASIC tapeout or FPGA/system release into production. This is counter-intuitive, as the checklist is critical in ensuring that process is followed and that nothing is forgotten or overlooked. All projects should have a good checklist and all good projects have a great one. However, the reality is that checklists alone imbue a false sense of security by shifting the focus from *how* something was done to *if* something was done. The details are lost.

The "CDC Verification Complete" entry in the checklist is one such example of being necessary but not sufficient.



1. The transmission of a signal across an asynchronous clock boundary resulted in metastable behavior at the receiver.

CLOCK ISSUES CONTRIBUTE TO A SIGNIFICANT AND INCREASING NUMBER OF SYSTEM FAILURES

Clocking issues often have to deal with data corruption or signal loss across the boundary between two asynchronous clock domains, known as a clock domain crossing (CDC). As data or control signals transit from one clock domain to another *(Fig. 1)*, those signals have timing characteristics relative to the transmitting clock domain. These signals are eventually sampled in the receiving domain by a clocked element, such as a flip-flop. A flip-flop whose data input changes too closely to the clock edge will enter a transitional, indeterminate state whose duration is probabilistic. This is known as a metastable state.

Many clock-boundary synchronization schemes exist to ensure that control or data signals are transferred accurately despite this metastable behavior. Without such a mechanism, incorrect values on the data or control signals will be sampled and erroneous behavior will result.

These clocking issues are more prevalent than ever in FPGA-based system products heading into the lab or, even more importantly, the market. According to the *2018 Wilson Research Group Functional Verification Study*, clocking flaws are the second-leading cause of production issues in FPGAs, up almost 20% in the last six years, and are on pace to become the leading cause of FPGA production issues *(Fig. 2)*.

Further, the same Wilson Research Group study identified that in 2018, 84% of FPGA designs had non-trivial bugs escape into production *(Fig. 3)*. In the FPGA space, there's a clear need for more verification in general, including more CDC verification.

But it's important to first understand what's causing the escalating trend of clocking errors escaping into production. Otherwise an increase in effort may not address this trend.

We're all aware that designs are always growing in size and complexity. This results in either an increase in the number of clocks or the number of control and data signals crossing the clock domain boundaries—or both. As seen in *Figure 4,* the number of clocks in FPGAs has remained pretty much the same, perhaps slightly increasing, during the last six years. Since the number of clocks isn't substantially increasing, the rising trend in flaws must be due to increased complexity and the number

of data and control signals transitioning between clock domains. In other words, there are more CDCs.

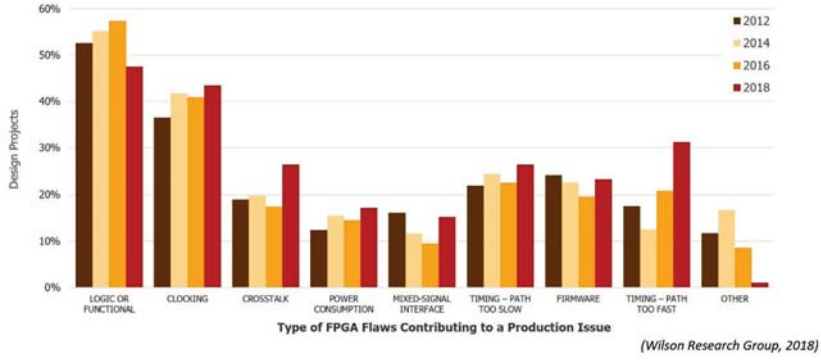
What's needed is not just greater use of CDC verification, but also an increase in adoption of more comprehensive CDC verification methodologies. Such methods should provide an exhaustive analysis based on a complete understanding of all of the potential failure modes for CDC.

COMMON, SIMPLE MEANS TO MANAGE CLOCK DOMAIN CROSSINGS

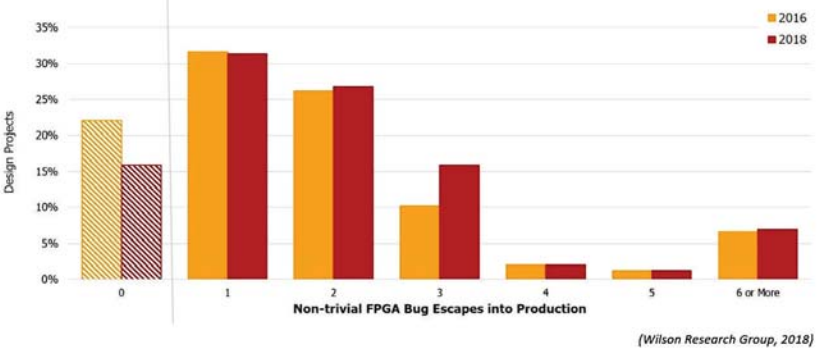
The issues with metastable behavior in designs are well-understood. Most FPGA teams have a methodology to deal with such issues. These methods include adding synchronization mechanisms where these crossings exist (and potentially utilizing a library of pre-approved and reviewed synchronizers), followed by design reviews to ensure that all CDCs are appropriately synchronized. FPGA vendor tool suites are able to perform a clock analysis on the netlist and identify potential CDCs, leaving the team to decide if the CDCs are or are not correctly designed.

If this isn't considered sufficient, teams may rely on simulation to further identify any clocking issues. Clocks may be modeled as asynchronous and the flip-flops in the design may be made sensitive to timing violations such that they generate an unknown output, or "X," during the time of the metastable behavior. In this manner, the team follows a CDC verification methodology that uses proscribed synchronizers to appropriately transition signals across the CDCs, reviews the identified crossings in the tool reports, and then relies on simulation to confirm them.

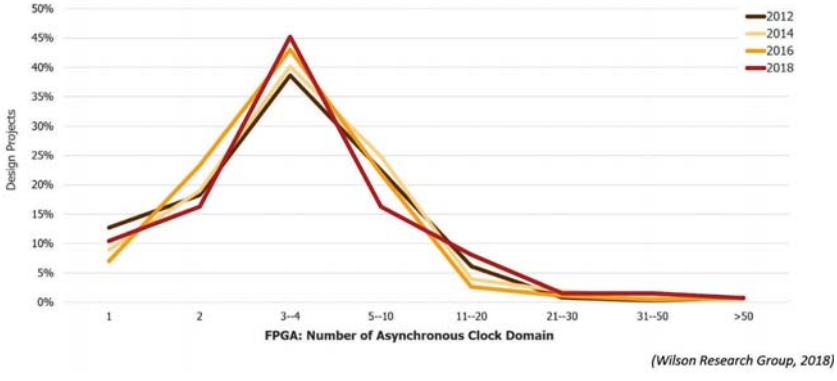
Many teams end their analysis here. Yet why is the increasing trend of clocking issues in production so prevalent? Answer: This level of CDC analysis and verification is insufficient.



2. The bar chart shows the historic trend of causes of FPGA production issues.



3. Illustrated is the historic trend of the number of non-trivial bugs in released FPGA designs.



4. Historic trend of number of asynchronous clock domains per FPGA design.

LIMITATIONS OF REVIEWS

Designers typically feel their code is bug-free until a bug is found in it. The same is true for CDC issues. It's very common for teams to believe (and therefore wager their product's market success on such a belief) that in knowing where their CDCs are, and by following simple rules, clocking issues cannot arise. Reviews are put in place as a cross-check. However, reviews are subject to human error, human limitations, and human assumptions. As such, reviews have limited effectiveness when it comes to functional issues that are common in today's designs. Two such examples are protocol violations and reconvergence.

Protocol Violations

It's not sufficient to simply identify that a synchronizer is located at every CDC. To ensure that the CDC operates correctly, the protocol required for the

synchronization logic must be verified to be met under all conditions.

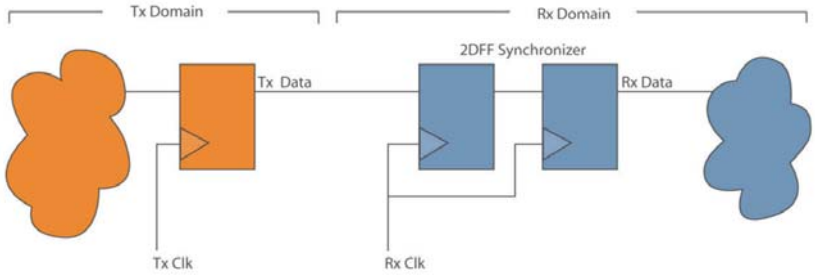
Consider a simple CDC/synchronization interface, such as a simple 2DFF synchronizer on a single control bit *(Fig. 5)*. This type of design is typically found in a library of pre-approved and reviewed synchronizers. It's also a synchronizer with an associated synchronization protocol—that the signal on the transmit side be held long enough to be sampled on the receive side. Reviews may suffice for this simple example, but as the protocols and schemes become more complex and parallel, human error becomes prevalent *(Fig. 5, again)*.

Consider a four-bit data bus. In such circumstances, well-known synchronization techniques, such as the D-Mux synchronizer shown in *Figure 6*, will cause the data to be correctly sampled on the receive side. This requires a different synchronization protocol—that, within the transmit domain, the data is valid before or at the same time as the valid signal and is held until after the valid signal is no longer active. This is still possible to verify in review, but it's becoming more complex.

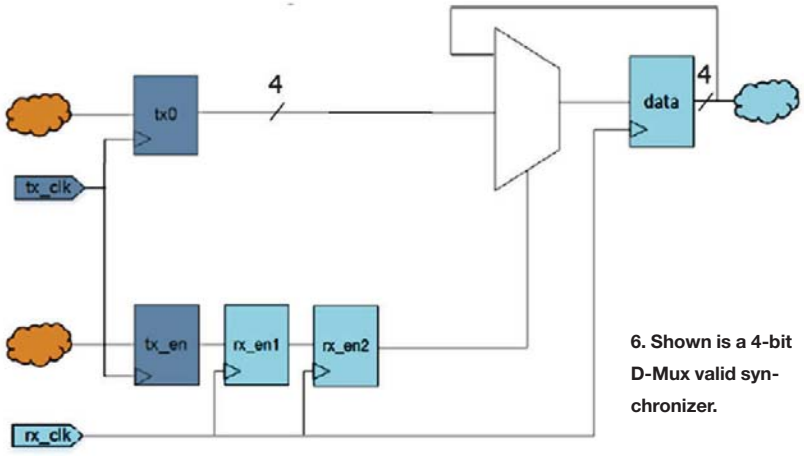
As power, performance, and congestion constraints demand much from the design, latency reductions move CDCs deeper into functionality and into parallel paths. For instance, it's typical for the CDC to run through the middle of a FIFO and across parallel interfaces. A FIFO has a valid protocol (for instance, the FIFO is never written when full or read while empty) that must be verified. This type of CDC synchronization protocol is much more complex to verify by review.

Reconvergence Issues

A CDC may not be isolated to a single bit or single bus crossing between domains. Instead of running just one signal across a boundary, multiple signals may transit across a CDC. Furthermore, signals may be used not only in one receive domain, but also in multiple



5. Reviews may be sufficient enough for this simple single-bit control signal synchronization example.



6. Shown is a 4-bit D-Mux valid synchronizer.

domains. Even more complex, the signals in both domains may be used in yet a third domain. In these scenarios, downstream logic on the receive side(s) will depend on the timing relationships to be maintained as they're defined in the transmit domain. However, the CDC can create a functional bug due to unpredictable delays through the CDC synchronizers *(Fig. 7)*.

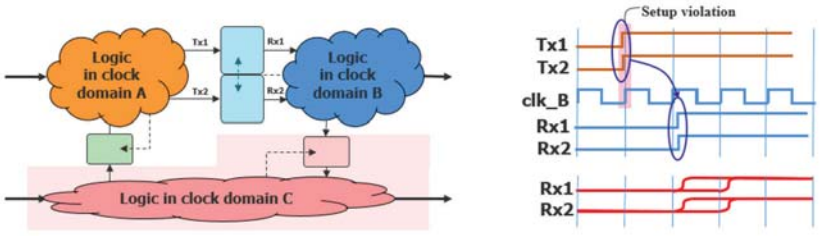
Figure 7 identifies a simple reconvergence scenario. It's not difficult to imagine very complex reconvergence scenarios in which the signals that transit across a CDC aren't actually consumed in the receive domain(s) until many cycles later. Regardless, in either scenario, human review of reconvergence is challenging at best, and very realistically error-prone and likely to miss issues.

LIMITATIONS OF SIMULATION

Is functional simulation an acceptable analysis cross-check that the presence of synchronization on reviewed crossings is correct? The goal of such simulations is to identify when data is corrupted or signals are lost across the CDC. A team may encounter several challenges that can lead them to miss issues.

The first is that digital simulations, by definition, don't handle non-digital behavior well. Thus, the metastable behavior of a flip-flop or other storage element isn't modeled in traditional digital simulations. It can easily be either too pessimistic, injecting an unknown into the simulation that causes a cascade of Xs and unusable results, or too optimistic, missing an issue. As a result, verifying the correct synchronization against the metastable behavior is challenging.

Should a team conquer that issue successfully, it must next ensure that the constraints on the clocks precisely reflect the scenarios on the real clocks in silicon. Only by doing this will the simulations hit the scenario required to create and test CDCs properly. This isn't



7. Reconvergence issues crop up on control signals between transmit domain A and receive domains B and C.

Is functional simulation an acceptable analysis cross-check that the presence of synchronization on reviewed crossings is correct?

easily done exhaustively. For complex designs, it may require more simulation cycles than the team can afford, in order to hit just the right scenario to cause the CDC violation. Constrained-random control of truly asynchronous clocks results in many combinations.

The final challenge has to do with the definition of a passing test. It's possible that a functional test may not actually fail even though data corruption or signal loss occurs through a clock domain crossing. Even if the correct combination of clock constraints is enabled for a test, and the metastable behavior is appropriately modeled, the test must be sensitized in some manner to the path in question. Not all tests focus on all paths.

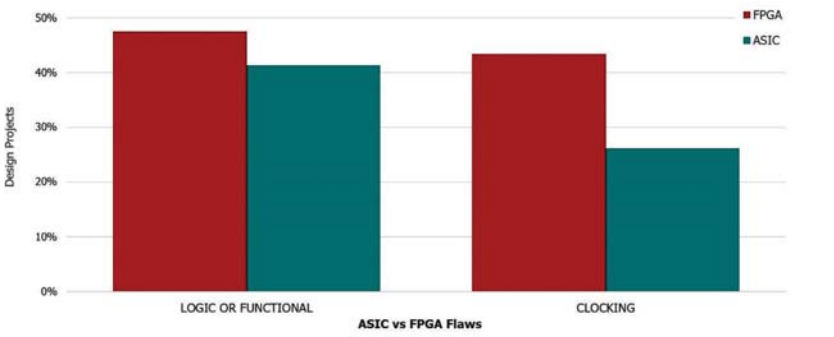
BORROWING CDC TECHNIQUES FROM THE ASIC WORLD

In summary, relying on reviews and functional simulation is at best a very challenging prospect, but at worst is error-prone and will cause a design team to miss key CDCs that exist in systems. Clearly, reviews and simulation aren't enough. What's needed instead is exhaustive, non-simulation-based verification of clock networks and CDCs.

Fortunately for FPGA and systems designers, the challenges of multiple-clock-domain designs are easily addressed by the robust and broad CDC solution spectrum available today and

matured by the ASIC sector for nearly 20 years. These formal-verification-based features are readily applicable to the FPGA and system design space. These tools can easily analyze and identify issues where reviews and simulation fall short. Equally important, these solutions are run on the source code and not the synthesized netlist, identifying issues earlier in the design process when they can be fixed more efficiently and quickly.

The success of the ASIC industry in adopting CDC verification can be seen in the different results between the ASIC community, where robust CDC use is common, and the FPGA community, where it's less common. As seen in *Figure 8*, the Wilson Research Group 2018 survey identified clocking issues as being the root cause of a functional flaw in an ASIC only 26% of the time, compared to 43% of the time for FPGA designs.

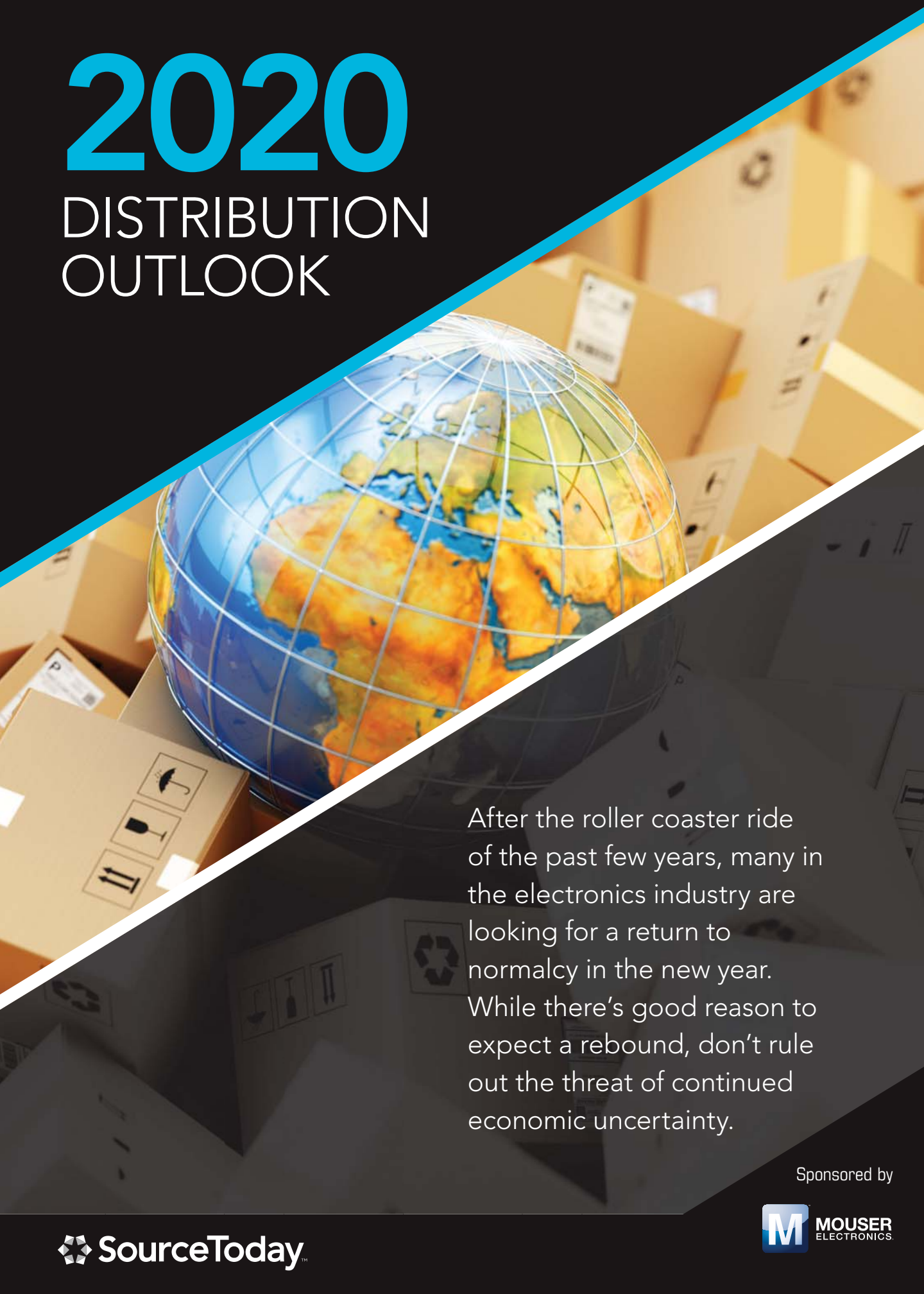


8. The chart compares the differences between ASIC and FPGA verification and clocking flaws.

FPGA designs go into production with a significant number of clocking issues. These issues can be found and addressed prior to production with increased adoption of CDC verification. Moreover, the quality of the CDC analysis is critical to ensuring that designs are clean as they head into deployment. Exhaustive analysis with formal-based tools is a highly effective means of improving results.

CHRIS GILES is a Product Marketing Manager for CDC and RDC tools at Mentor, a Siemens Business. The author of multiple patents, Chris has led the design and verification of IP and SoCs for over 25 years across multiple industries and technologies.

2020 DISTRIBUTION OUTLOOK



After the roller coaster ride of the past few years, many in the electronics industry are looking for a return to normalcy in the new year. While there's good reason to expect a rebound, don't rule out the threat of continued economic uncertainty.

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2020 Market Forecast:

Cloudy Skies with a Chance of Clearing

2018 was one of the best years in recent memory for the global electronics industry in general and the distribution sector in particular. While most electronics companies anticipated 2019 to be a challenging "correction" year following the overexuberance, the expectation by many is that 2020 will see a return to growth and some degree of normalcy.

However, there are indications that challenging times may persist well into the new year. Chief among them is a definitive end to the U.S.-China trade war. A 30,000-foot view of the global economic outlook provides context for what kind of business environment the electronics sector may be facing in 2020.

Recently, both the International Monetary Fund (IMF) and the Organization of Economic Cooperation and Development (OECD) have downgraded global GDP growth due in large part to the impact of the U.S.-China trade war. About 90% of the world's economies grew more slowly in 2019 than in 2018, according to the IMF. As a result, the organization downgraded projected global GDP growth for 2019 to 3%, which will be the weakest this decade. Europe is particularly vulnerable.

In October, the IMF revised its 2020 global growth rate down to 3.4% from 3.5% due in large part to continuing trade tensions between China and the U.S. Still, growth in 2020 is an improvement on 2019, thanks in large part to economic growth in emerging economies such as Brazil and India.

The OECD is a bit less optimistic. It projects global GDP growth to remain at a decade-low rate of 2.9% for both 2019 and 2020, with only a modest increase in 2021 in global GDP growth to 3.0%. Like the IMF, OECD points to trade tensions but also calls out China's slowing economy, climate change, and the devolution of the multilateral order that has dominated the global economy since the breakup of the USSR nearly 30 years ago.

These are structural issues that create a new and troubling kind of uncertainty for manufacturers and their supply chain partners and which cannot be rectified by traditional national fiscal and monetary policy. Indeed, monetary policy is reaching a limit as central banks are pushing interest rates down to zero. And in September, the European Central Bank pushed its benchmark interest rate to negative 0.5% in an effort to stimulate economic growth.

In a September survey report, McKinsey & Co reported that 74% of more than 1,300 business respondents from around the world said global economic conditions are worse now than six months ago, which is the highest percentage since McKinsey began asking the question in 2012. A full two-thirds of survey respondents expect conditions to worsen over the next six months, and about half predict the level of trade will decline over the next 12 months.

A POSITIVE TURN

A significant contributor to the pessimistic outlook has been the trade war between the US and China. To date, the U.S. has imposed tariffs on $360 billion of Chinese goods, which is more than 50% of China's total exports to the U.S.

But there has been some positive news from both the US and China that indicates a resolution to the trade war may be in the works. On December 12, the US announced it had reached an agreement in principle with China on phase one of a deal that would set the stage for negotiations on tariff reductions. Then, on December 23, China responded that as of January 1, it would cut import tariffs for frozen pork, pharmaceuticals and some high-tech components.

The announcement included tariff cuts for 23 other countries including Australia and South Korea. China also announced additional tariffs reductions on some information-technology products and services starting in July 2020.

As part of the trade deal, the U.S. has canceled planned tariffs on $156 billion of Chinese imports that included consumer electronics, and cut in half the tariff rate on $120 billion of goods on the round of tariffs imposed in September.

Importantly, the 25% tariffs imposed by the US would remain on roughly $250 billion in Chinese goods, including electronics.

(Continued on page ST 4)

Digi-Key Electronics, a global Internet-based distributor of electronic components, is an authorized distributor of more than 9.2 million components from 800+ trusted suppliers. The company's reputation extends worldwide as customers continue to choose Digi-Key, gaining access to the widest selection of electronic components in the industry, available for immediate shipment from its award-winning website, www.digikey.com. With this wide range of products, available in both design and production quantities, Digi-Key is the best resource for design engineers and buyers alike.

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Digi-Key has a wealth of online tools and reference materials. The company offers resources such as a range of EDA and design tools, including the new DK IoT Studio; reference design library; on-demand multimedia library; a comprehensive article library; and community websites including TechForum and eewiki.net; among others. Digi-Key also offers numerous Supply Chain solutions such as bonded inventory, just-in-time shipping, and APIs, as well as a newly updated BOM manager.

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(Continued from page ST 1)

IMPLICATIONS ACROSS THE SUPPLY CHAIN

With the US-China trade war as the backdrop, the electronics industry suffered a sharp cyclical correction in 2019. The market correction was triggered in part by speculative component buying in 2018 that stretched out lead times for a wide variety of components and resulted in a severe inventory overhang. As a consequence, monthly semiconductor shipments to the Americas were down 27.1% between October 2018 and October 2019, and 13.1% worldwide, according to Semiconductor Industry Association (SIA) data compiled by Custer Consulting Group. The impact was felt by virtually all the top chipmakers (Figs. 1 and 2).

FIGURE 1

Monthly Semiconductor Shipments
$ Billions (3-month avg in US$)

20191204

	10/18	10/19	% CH
Americas	9.85	7.18	- 27.1%
Europe	3.64	3.37	- 7.3%
Japan	3.41	3.09	- 9.3%
China	14.51	13.03	- 10.2%
Asia Pacific / All Other	10.71	9.92	- 7.4%
Total	42.11	36.59	- 13.1%

SIA www.semiconductors.org/

Source: SIA, data compiled by Custer Consulting Group

FIGURE 2

Top 10 semiconductor supplier growth rates by revenue (in millions USD)

1H'19 Ranking	Company Name	1H'18	1H'19	Growth Rate
1	Intel	32,595	32,027	-1.7%
2	Samsung Electronics	37,840	25,204	-33.4%
3	SK Hynix	17,499	11,419	-34.7%
4	Micron Technology	14,632	10,359	-29.2%
5	Broadcom Limited	8,364	9,068	8.4%
6	Qualcomm	8,135	7,284	-10.5%
7	Texas Instruments	7,604	7,091	-6.7%
8	Infineon Technologies	4,529	4,495	-0.8%
9	nVidia	5,486	4,357	-20.6%
10	STMicroelectronics	4,495	4,249	-5.5%
	Top 10 Companies	141,179	115,553	-18.2%
	All Others	95,415	88,193	-7.6%
	Total Semiconductor	236,594	203,746	-13.9%

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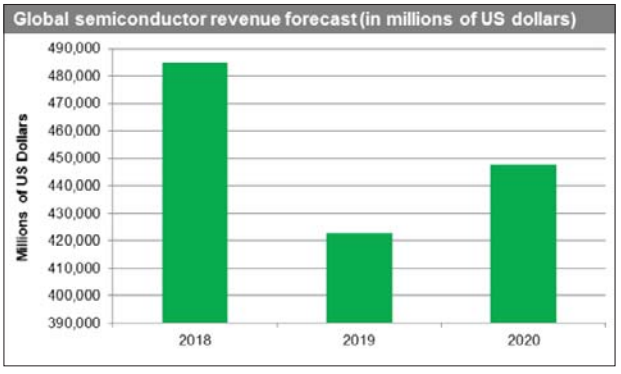
"Semiconductor revenue growth aligns with economic growth, and they influence each other," said Dale Ford, chief analyst, Electronics Components Industry Association. This is reflected in a recent forecast from Informa Tech, formerly IHS Markit Technology, that projects 2019 global semiconductor revenue will decline by 12.8% in 2019 and only see a modest 5.9% rebound in 2020 (Fig. 3).

FIGURE 3



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In a an October survey of component makers by the IPC, the majority of electronics manufacturers indicated they had been negatively impacted by the tariffs, with some reporting lower investment and hiring rates as a consequence. "Many are facing supply-chain disruptions and steeper costs from the tariffs that have been imposed to date, and the impacts will grow as the trade war drags on," according to Shawn DuBravac, IPC's chief economist.

IPC survey results included:

- Tariffs impact 31% of the total dollar value of products imported
- 69% of respondents reported lower profits as a consequence of the tariffs
- More than one-third said they cannot increase prices to cover the cost of tariffs
- 51% of respondents reported they are now sourcing from countries other than China to avoid the tariffs

More recently, IPC's fourth-quarter Pulse of the Electronics Industry survey report published in early December shows a deterioration in sentiment. Based on input from 82 companies from across the global electronics industry, the latest survey pegged average sales growth projections for the fourth quarter of 2019 at 2.6%, down from 3.0% in the third quarter. While the general outlook for the next six months remains positive, "growth is slowing worldwide, and the industry's outlook is less optimistic than in previous quarters," according to the IPC (Fig. 4).

FIGURE 4

Source: IPC

SUPPLY CHAINS IN FLUX

The financial impact of these market challenges is reflected across the electronics industry's supply chain, most notably in the latest quarterly financial statements of the top two electronics distributors: Arrow Electronics and Avnet. These two companies accounted for more than 50% of the total 2018 annual revenue of the top 50 electronics distributors, according to SourceToday. Avnet's top line for the quarter ending Sept. 28, 2019 was down 9%, to $4.63 billion from $5.09 billion in the third quarter of 2018. Arrow's top line fell by 5.5% to $7.08 billion from $7.49 billion over the same period.

Of course, there is regional variability in market growth around the world and different industries. China is unique in Asia in that it is feeling the full brunt of the impact of U.S. tariffs. China's GDP growth fell by 0.2% each quarter in 2019 and is expected to fall below 6% in the final quarter, according to the Berlin-based Mercator Institute for Chinese Studies. Similarly, the IMF is forecasting China's GDP growth to be 6.1% for 2019 but is warning that the growth rate could fall to 5.8% in 2020.

In the U.S., the manufacturing sector's monthly PMI, which gauges sentiment about market conditions, improved slightly in October, but fell in November, according to the Institute for Supply Management (ISM). Sentiment about new orders and production within the computer and electronic products sector were down in November compared to October, according to ISM.

"Customer demand is down, and we are expecting a very soft fourth quarter, without much relief in sight for Q1 [2020]," said one ISM electronics industry survey respondent in October. "Suppliers report the continued rise in labor costs, which are ultimately reflected in the rising product costs."

In Europe, most sectors of the electronics industry were in contraction in the third quarter of 2019, compared to the same time last year, according to the Custer Consulting Group and Eurostat data. Motor vehicle production remained weak, while aerospace output increased.

DISTRIBUTOR OUTLOOK

Of course, there is every reason to expect a strong rebound in the electronics component distribution sector in 2020. However, despite the recent progress made to resolve the US-China trade war, a cloud will continue to hang over the industry until a resolution is finalized, which is likely to positively impact investment and industry growth rates in 2020.

The global state of affairs for many distributors midway through the last quarter of 2019 can be summed up in three words: "Things are flat," said Kevin Hess, senior vice president, marketing, at Mouser. More specifically: "Asia is down, Europe is flat, and the Americas are growing in single digitals," he added.

One market that is bucking the trend and showing strength is the U.S. defense and aerospace market that includes the low-earth orbit satellite market, said Don Akery, president of TTI Americas and senior vice president of TTI Inc. "This is the third year of strong growth for TTI in the defense sector, and the consensus is that the growth will continue," he said.

Indeed, defense budgets around the world are on the rise—including NATO countries, India, China, Japan, and others—as geopolitical tensions increase, according to Deloitte. In addition to traditional military hardware, there is a growing focus on investment in cybersecurity programs and the militarization of space programs for surveillance, communications, and missile targeting. The investment is led by the U.S., China, and Russia.

In addition, TTI's Akery and other distribution executives see business opportunities in high-growth markets such as industrial IoT and the medical equipment market, which are less dependent on economic conditions to drive growth. The enterprise and automotive IoT markets are projected to grow to 5.8 billion endpoints in 2020, a 21% increase from 2019, according to Gartner. Utilities are expected to be the highest users of IoT technology, increasing usage by 17% in 2020 to reach nearly 1.4 billion endpoints.

(Continued on page ST 8)

TTI – The Electronics Components Specialists

TTI, Inc., is a Berkshire Hathaway company, recognized as a leading specialty distributor of electronic components. The company maintains 1.9 million square feet of dedicated warehouse space around the world containing over 850,000 component part numbers. Paul Andrews, founder and CEO, started TTI in 1971, and today the company employs more than 6,700 people at more than 133 locations throughout North America, South America, Europe, Asia and Africa.

TTI's extensive product line began with the distribution of passive components such as resistors, capacitors, and inductors. The company's success with these critical parts of electronic circuitry lead to expansion into the interconnect business. Today, TTI is an industry leader in connector distribution providing certified military and aerospace connection systems for instrument panels in high-performance aircraft, to the phone charging connection in a jetliner's passenger armrest, as well as on-board and off-board connectors for data, power, media, and control.

Other components ranging from potentiometers, trimmers, magnetic and circuit protection components, wire and cable, wire management, identification products, and application tools, to switches, sensors and electromechanical devices are among TTI's varied inventory. These products are distributed from a broad line of the industry's premier manufacturers.

TTI strives to be the industry's preferred information source by offering the latest IP&E technology and market information through the online MarketEYE Research Center. MarketEYE includes articles, technical seminars, RoHS, industry research reports and much more.

A key element of the many services and value-added offerings TTI provides is the company's supply chain management expertise. TTI Specialists are able to network customer's component demand forecasts with the TTI inventory and ordering systems that reach all the way to supplier production lines. These custom systems are customer designed for each customer's needs and allow TTI to deliver the right parts to the right place at exactly the right time.

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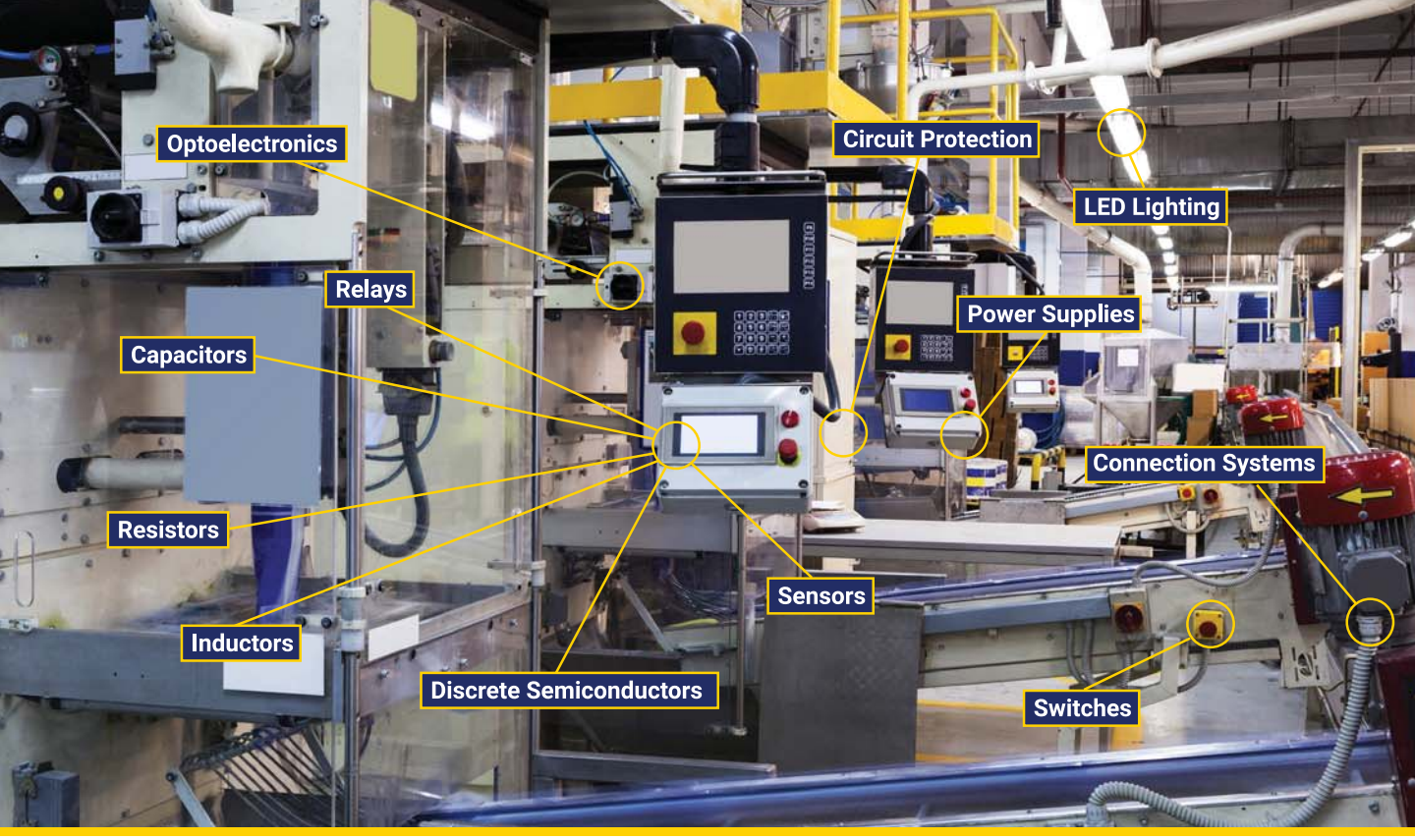
Sensata Technologies smiths interconnect SOURIAU-SUNBANK TDK TE Electronics UNITED CHEMI-CON VISHAY



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(Continued from page ST 5)

Todd Burke
Smith's President, Americas

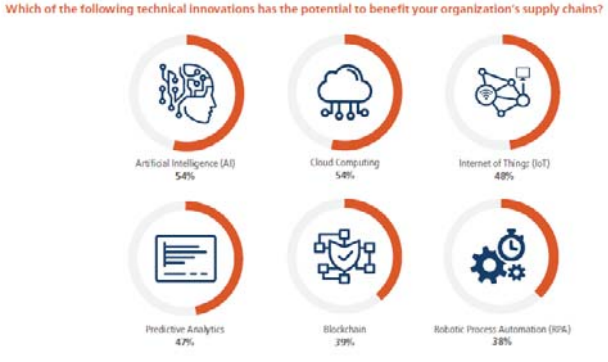
Todd Burke, president, Americas at Smith & Associates, sees an opportunity for growth by expanding services in the cloud computing sector, through data center support and IT asset disposition services.

"We fared well in the first three quarters of 2019," Burke said. "While the slide of memory pricing has been a challenge in 2019, in Q4, we are seeing opportunities with CPUs and SSDs." In addition, the solar market also represents a key opportunity for Smith, said Burke.

A recent survey report by Dimensional Research, sponsored by Jabil, of more than 300 participants reinforces the importance of cloud computing and IoT markets for distributors and component suppliers (Fig. 5). "Keeping supply chains active and efficient while finding cost-savings opportunities are top priorities for many OEM and EMS customers going into 2020," said Burke.

FIGURE 5

Another area that has remained strong through 2019 is



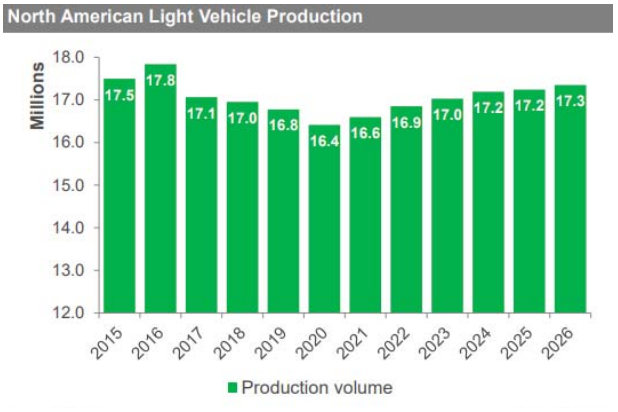
Source: Dimensional Research, sponsored by Jabil

product design activity. The opportunity for component companies and distributors is significant as the design pipeline feeds high-volume component sales to OEMs and EMS providers down the road. "We've seen 2X market growth in design services in all regions except Europe," said Karim Yasmine, vice president of strategic supplier development at Future Electronics.

Similarly, Newark, an Avnet company, has seen an uptick in design activity that feeds the pipeline for component sales, said Umasankar Pingali, Newark's business president. He identified IoT as a strong growth market for design services and component sales. "It is shaping up nicely for us," he said.

At the other end of the growth spectrum is the traditional US transportation sector. TTI is projecting an "okay year" for transportation in 2020, Akery said. Part of the reason is that auto production in North America is in decline and is expected to decline further in 2020, according to IHS Markit (Fig. 6).

FIGURE 6



Source: IHS Markit

Future's Yasmine concurs. "The traditional auto market is still soft if you split out the advanced driver assistance system market," he said.

Like IoT and cloud computing, ADAS is a growth opportunity. MarketsandMarkets estimates the size of the global ADAS market at $30 billion in 2019 and projects it to quadruple to $135 billion by 2027, at a compounded annual growth rate of 20.7% over the forecast period.

The potential of IoT, cloud, and ADAS applications will get a big boost from the introduction of 5G, which will deliver high-bandwidth, low-latency communications that are vastly superior to 4G. 5G rollouts are expected to accelerate in 2020, which is likely to mark the beginning of the next growth surge for the electronics sector. According to ResearchandMarkets, worldwide 5G sales will hit $31.3 billion in 2020 and are forecast to reach $11.2 trillion in 2026.

For most companies, it can't happen soon enough.

By Bruce Rayner, Contributing Editor

Quest offers over $60 million of in-stock inventory of ICs, IP&E components, and electronic equipment among franchised and independent lines; while providing a broad range of services and solutions for OEMs and CEMs.

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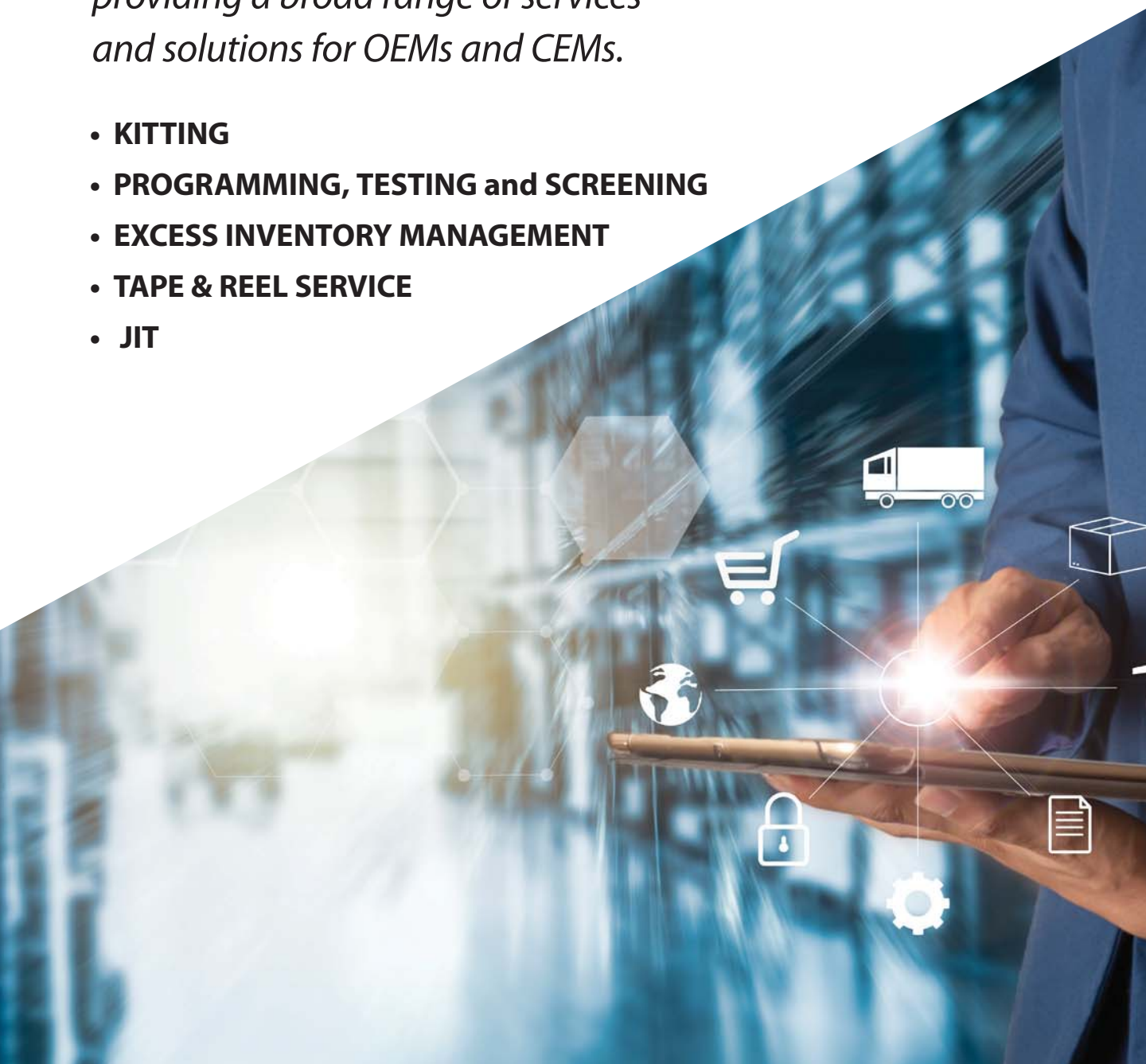

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Peerless constantly assesses its business and has laid the foundation to achieve better business today and in tomorrow's world with its products, procedures and operations always at the forefront.

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While this was taking shape, Peerless has continued to enjoy growth year over year.

Peerless' vision was expanded to modernize its identity, including image and logo modification, positioning and branding, in the same way they were modernizing facilities and capabilities.

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Bill Gallucci
President

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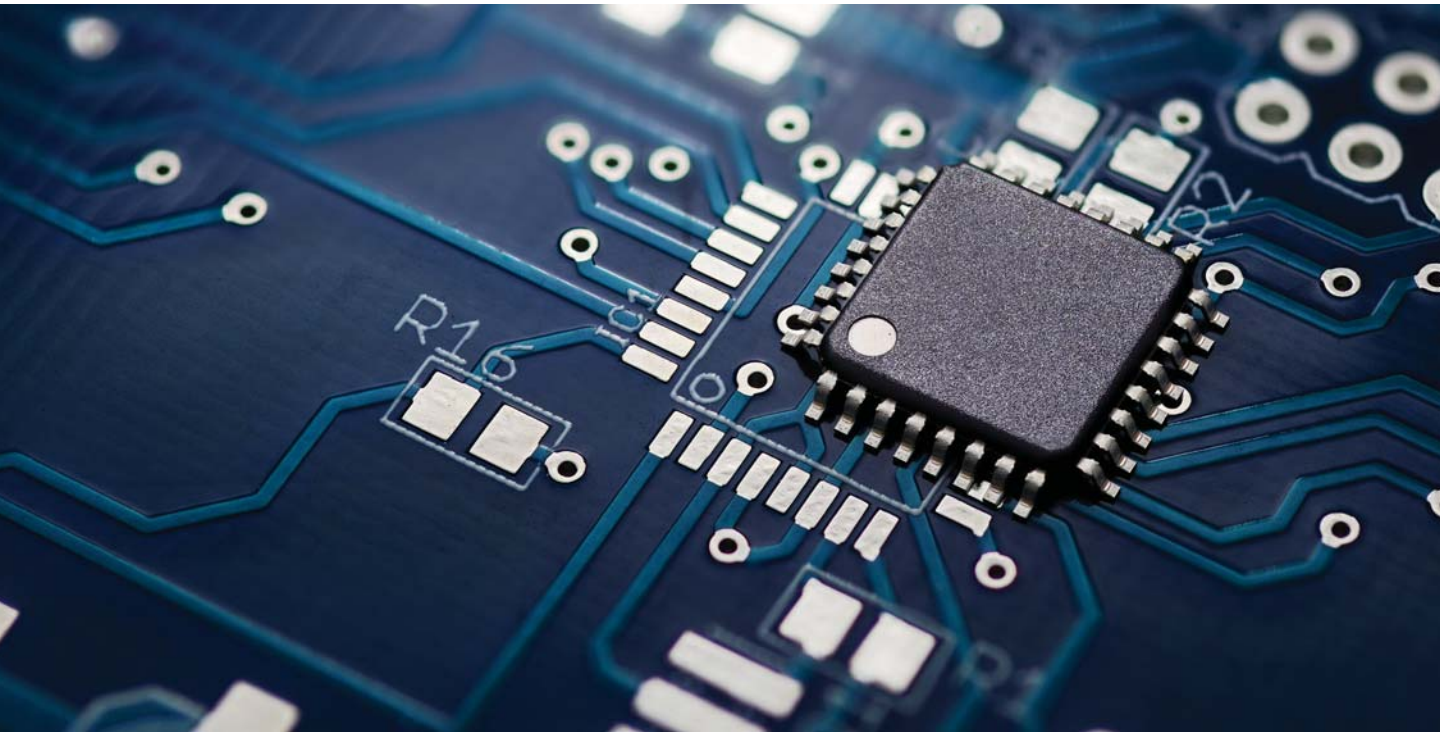

Bullish on 2020:
One-on-One with Karim Yasmine, Future Electronics

What goes up, must come down. That about sums it up when it comes to current conditions in the global electronic component market.

According to recent figures from WSTS, the worldwide semiconductor market growth rate was up 13.7% in 2018, an all-time high, and is forecast to be down 13.3% in 2019, with every geographic region expected to be in negative territory. The Americas are forecast to post the biggest decline for 2019 at 27.3%.

This year's downward slide is comparable in magnitude with the decline during the 2008 Great Recession (see figure). But just as the market bounced back fast and strong in 2009, many industry veterans expect a similar rebound in 2020. Nevertheless, the latest WSTS forecast is not quite as optimistic, putting year-on-year semiconductor growth for 2020 up by 4.8%.

"2019 is a bit of a reset year, coming off a strong allocated market in 2018 where customers loaded up on a significant amount of inventory to protect themselves," said Future Electronics' Karim Yasmine, corporate vice president of strategic supplier development. Layered on top of the cyclical downturn was the imposition of tariffs, which had a multiplier effect on the sales slowdown as OEMs and EMS providers bulked up before the tariffs were imposed, which added to the inventory glut.

The bright side in 2019 has been the amount of design activity, according to Yasmine. Future monitors its customers' new design starts closely—how many new projects have been launched and in what market segments—as they are the feedstock for future component sales. "It's been an incredible year for new designs, so there's an upside to the way the business feels right now," said Yasmine.

(Continued on page ST 14)

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(Continued from page ST 12)

One of the most active areas of new design is transportation, which includes autonomous technologies, battery management, and charging stations. "These days, design is about smart-everything," Yasmine noted. "Artificial intelligence, machine learning, and robotics are all booming.

"We think the chip industry will come roaring back in 2020, and it will be a nice recovery year for the electronics sector. We are well-positioned on the supply chain solution side and on the design conversion side," he continued. "On the design-conversion side, we will continue to outperform market expectations."

In addition to its team of generalist FAEs, Future employs specialist engineers for wireless, security, and other focused applications. The company also has a small number of design engineers specifically tasked with helping customers accelerate design conversion for custom applications.

Today, Future is focused on ensuring the engineering team has the right skills and expertise that will be required to deal with the complexity of product design in the next five years. Yasmine's list of technologies includes the usual suspects: autonomous and electric vehicle technologies, IoT, 5G, AI and ML, and robotics.

As far as where Future is focusing its design engineering investments, Yasmine was less than forthcoming: "We have some conceptual ideas for what we want to do in the next three to five years, but I'll keep them to myself for the time being."

One market of focus for Future is automotive, with substantial growth opportunities in Southeast Asia, including Vietnam, Malaysia, Cambodia, Laos, and Singapore. The primary reason for the optimistic outlook is the migration of manufacturing out of China, according to Yasmine.

Future is closely monitoring the trade battle between the U.S. and China and the dynamics of the Chinese marketplace. Also, it is keeping an eye on new Chinese semiconductor manufacturers that are emerging rapidly. "We are starting to see a lot of customers mentioning Chinese-grown chip manufacturers that are not your run-of-the-mill semiconductor companies," Yasmine revealed.

And then there's the political wildcard. On Future's watchlist is the tariff war between the U.S. and China, the Brexit deal, and tensions between Korea and Japan. Any of these could impact how 2020 unfolds, either negatively or positively.

Still, Future remains bullish on 2020. "We think we've well positioned to outgrow market expectations in the short-term both on the supply chain solution side and on the design-conversion side," Yasmine said.

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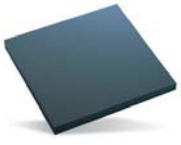

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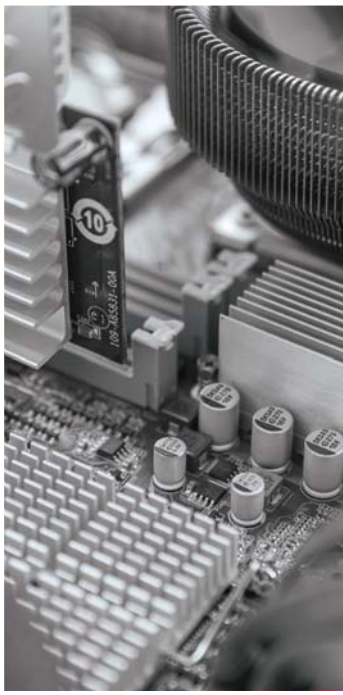

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Relief Ahead on the Tariff Front for 2020

After enduring a rash of new trade war-driven tariffs in 2019, U.S. companies could begin to see some relief in 2020.

After a year of uncertainty over the trade wars and uncertainties, 2019 closed out on a slightly positive note for U.S. companies that were seeking some relief from the international tariffs that hit their supply chains during the prior 12 months.

In December, President Trump agreed to a limited trade agreement with China that will cancel tariffs set to take effect and roll back existing levies on Chinese goods. The WSJ reported that the agreement also secures Chinese purchases of U.S. farm goods.

In the absence of last-minute problems, the primary impact for U.S. importers and exporters will be a more stable business environment as they prepare new orders for 2020, WSJ's Paul Page reports, noting that the deal calls for China to buy $50 billion worth of agricultural products in 2020, along with energy and other goods. "That's far more than China has ever bought in the past, marking a big win for U.S. farmers if the orders come through," Page writes.

At press time, Chinese leader Xi Jinping was calling this phase one trade deal beneficial to both China and the U.S., CNBC reported. "The first-phase economic and trade agreement reached between the U.S. and China is a good thing for the U.S., China, and the entire world," Xi said. "Both the U.S. and Chinese markets and the world have responded very positively to this. The U.S. is willing to maintain close communication with China and strive to sign and implement it as soon as possible."

For this deal, the U.S. will be maintaining 25% tariffs on approximately $250 billion worth of Chinese imports while reducing tariffs on $120 billion worth of goods to 7.5%. CNBC also says that this "phase one" agreement struck between the U.S. and China includes a commitment by Beijing to make "substantial" purchases of American goods in coming years.

GRADUAL ELIMINATION AHEAD?

Here's the bigger news: The plan is to gradually eliminate tariffs on Chinese goods in phases, USA Today reports. According to Wang Shouwen, China's vice commerce minister, the mini-deal represents significant progress in ending the 17-month-old U.S.-Chinese trade war, and will create better conditions between the two countries, the publication adds.

A few days after the two countries announced the phase one trade deal, China unveiled a new list of import tariff exemptions for six chemical and oil products from the United States. The exemptions will be for one year from Dec. 26, CNBC reports.

The tariff waivers will apply to four chemical products, including metallocene high-density polyethylene (HDPE) and a special grade of linear low-density polyethylene (LLDPE), and refined oil products that include white oil and food-grade petroleum wax.

The exemptions on the chemical products could benefit companies such as Dow Chemical, Exxon Mobil, and Chevron Phillips Chemical, according to CBNC, and could see China resume buying more HDPE and LLDPE from the U.S., reversing the trade flow.

"The Sino-U.S. trade war has been a major headache for global policymakers as it slowed economic growth worldwide and chilled business investment and confidence," CNBC adds, noting that there is no specific timetable for these tariff rollbacks.

WE WANT MORE

Some industries applauded the positive news, but also asked for more of it in the future. "While this is a step in the right direction, it means American businesses, American consumers, and American workers are still being hammered at an unacceptably high level by tariffs imposed on U.S. imports from China, and in retaliation, by China's imports from the U.S." Rick Helfenbein, president and CEO of the American Apparel & Footwear Association, said in a statement.

"The administration has imposed one of the largest consumer and manufacturing taxes in American history, most of which remains in place following this agreement," he continued. "Rising costs are already working their way through supply chains and they will still have a negative impact going into next year."

Retail trade organizations also praised the progress while pushing for a rollback of all tariffs, RetailWire reports. "Critics see tariffs raising prices for consumers and undermining long-term planning," the publication points out. "For instance, while some suppliers have significantly reduced their exposure to China, a fear is that new tariffs will be placed on countries they've shifted to."

As we move into 2020, several uncertainties could impact the tariff situation. Not only are more U.S. companies voicing their concerns over the trade war impacts, but it's also an election year. With the U.S. economy still in full swing and showing no solid signs of slowing down just yet, both manufacturers and distributors should keep an eye on these developments.

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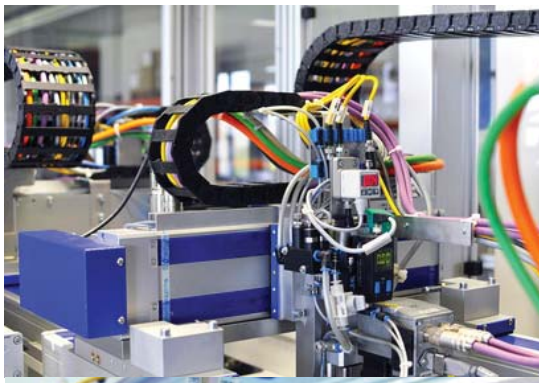

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Q&A with Carleton Dufoe CEO, Jeffrey Hong GM APAC, Matthew Fonstein VP of Trade

1. How has your company fared in the first three quarters of 2019? What were the high and low points?

At NewPower we take great pride in the fact that we've exceeded $300m in revenue in just 5 short years. We've given great thought to diversifying our revenue across a variety of verticals and geographies to sustain us through moments of economic uncertainty. This diversification strategy positioned NewPower extremely well as the first quarter of 2019 was slower than projected largely because of the global economic uncertainties (tariffs) that carried over from 2018.As projected, demand quickly increased shortly after Chinese New Year and NewPower has outperformed its 2019 projections.

2. What are your top 2 or 3 business priorities for 2020? E.g., regional market growth, new end-market opportunities, DC/supply chain operations investments, acquisitions, etc.

From its inception, NewPower has had a relentless focus on technology. Our belief is that technology will set us apart by allowing our team to understand the market and respond to client needs faster and more efficiently than our competition. Our propriety cloud-based trading platform, Scout™, is the heart of our organization and connects our global team with the real-time market data needed to make quick and efficient decisions in today's business climate. Technology has been and will continue to be NewPower's primary area of investment. As NewPower continues to expand international operations, it will be our technology that drives data-driven decisions that ensure our investments in new markets are successful.

3. What is the number one growth opportunity your company is focused on for 2020?

As the fastest growing Independent Distributor in 2018 with 135% YoY growth, NewPower is well positioned to expand and extend our suite of Supply Chain Solutions to more customers globally. With a world-class team armed with cutting edge technology, we are uniquely positioned to be the complete Supply Chain Partner our customers can count on!

4. What are the biggest risk factors that could impact business growth in 2020?

Geopolitical concerns. . . Global Economic Slowdowns. . . etc. . . are all real risk factors to our business but are not in our control. The fact is that NewPower is only supporting 1% of our total available market. Our goal is to penetrate new markets by serving our customers and partners more efficiently than they're currently being supported. Our key differentiator has been and will continue to be technology. We live in a data-driven world and our belief is the information within our Scout™ platform will continue to empower the organization to support new and existing customers regardless of the market or geography.

Carleton Dufoe

Jeffrey Hong

Matthew Fonstein

5. What are your OEM/EMS customers' top priorities for 2020?

NewPower's customers are focused on their business and expect their supply chain partners to continually provide pertinent market information, data points and measurable value. This is a key differentiator when NewPower is compared amongst our peers and we pride ourselves on having our finger on the pulse of the market. People + Process + Technology = Results.

6. What are your component suppliers' top priorities for 2020?

NewPower's supply base is laser focused on meeting the supply and demand needs of their global customers. We have partnered with many of the industries top Manufactures to help their expanding customer base meet their supply needs. As the industry contracts from a supplier base standpoint it is rapidly expanding from a demand perspective. Component manufacturers are witnessing and forecasting exponential growth, but there are real concerns about the ability support the strong forecasts. Many have maxed out capacity and are exploring alternative ways to increase output, but as global demand continues to grow there will be a tipping point. One thing is for certain. . .OEM's will need the support of knowledgeable, experienced, transparent and well-funded independent distributors as a supply and information resource. NewPower and several other top independents are strategically positioned to support the continually changing supply landscape. Call NewPower today to Empower your Supply Chain!

7. How are you integrating new technologies (e.g., AI and ML, augmented/virtual reality, digital twins, etc.) into your business operations? Please provide an example or two.

NewPower was founded because we saw a better way to navigate the Open Market. We have combined our centuries of knowledge, experience, and relationships to put the market data in the hands of the people who need it. Today, our Scout™ platform drives every aspect of our business and it has propelled us to one of the top Independent Distributors in 5 short years. Our investment in technology is what allows NewPower to support an infinite amount of customers while only marginally increasing our footprint, manpower and overhead. NewPower views the supply and distribution space far differently than all other independents. The evidence of this is displayed by our growth. We welcome you to come visit and see how we can change how you view the Open Market.

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Regeneron Sponsors International Science and Engineering Fair

Regeneron has become the named sponsor for the annual event, which is a competition among regional winners comprised of high-school students.

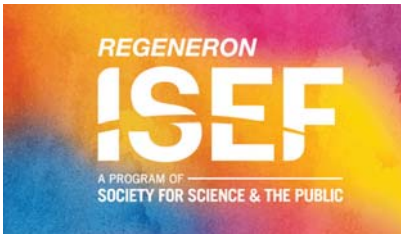
The Intel International Science and Engineering Fair (ISEF) is no more. ISEF is now known as the Regeneron International Science and Engineering Fair *(Fig. 1)*. Regeneron Pharmaceuticals, the named sponsor for ISEF, had earlier picked up the mantel of the Science Talent Search (STS), which was also an Intel-sponsored competition. Intel supported these competitions for over 20 years.

The Society for Science and the Public (SSP) runs these competitions as well as the Broadcom Masters competition for middle-school students. ISEF is for students in grade nine through twelve.

I will be taking the winners of the 2020 Mercer Science and Engineering Fair (MSEF) competition to Anaheim, Calif. the week of May 10th for the 2020 Regeneron ISEF competition. It's one of hundreds of regional competitions that feed into ISEF. The 2019 competition was host to over 1,800 students.

The top winner in 2019 was Krithik Ramesh of Greenwood Village, Colo. *(Fig. 2)*. He received the Gordon E. Moore Award for his project that encompassed augmented reality, machine learning, and computer vision to help orthopedic surgeons achieve greater accuracy for screw placement during spinal surgery.

If you're looking for top talent in science and engineering, then ISEF is the place to start. Many of these student projects are on par with those done by graduate students at top universities. Some may be using duct tape, baling wire, and 3D image sensors to implement prototypes of augmented-reality applications, but they get the job done. This also highlights the determination and creativity possessed by these students.



1. This is the new logo for the Regeneron International Science and Engineering Fair.

It was great news when Regeneron took over the top spot for ISEF, but it's just one of many sponsors. Challenges remain at the local and regional level, though. It's important to get everyone involved—not just for sponsorship, but with support for students, judging, and so on. We continue to find it difficult to round up a sufficient number of judges for MSEF. Even getting students to participate in the fair isn't an easy chore, as many schools don't even let them know about local competitions.

I'm always encouraging scientists and engineers to become involved in their local fairs. Judging takes very little time and is very rewarding to students and judges. It's surprising how many espouse STEM education but don't have a day to help out. We're lucky to have an active team that tries to increase participation of students, judges, and sponsors. Still, we can use help from the technology and educational arenas as well.

Finding local competitions isn't hard, and for ISEF-affiliated fairs, it's as easy as checking the list of fairs on the SSP website. A host of other competitions can use your help, too, such as the FIRST Robotics competition, the Vex Robotics competition, and the Junior Science and Humanities Symposia (JSHS).

STEM education is important and schools are highlighting it, but getting involved with competitions will give students an opportunity to highlight their work. ed

2. Krithik Ramesh received the Gordon E. Moore Award for his project that combined augmented reality, machine learning, and computer vision to help orthopedic surgeons achieve greater accuracy for screw placement during spinal surgery. *(Credit: Chris Ayers/ Society for Science & the Public)*

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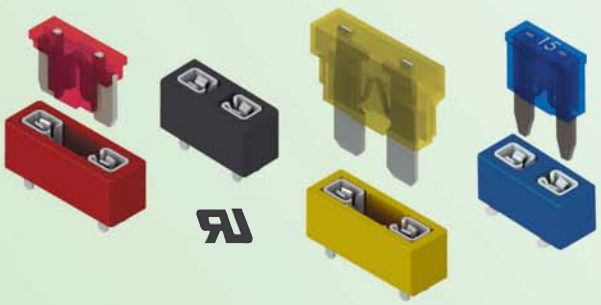

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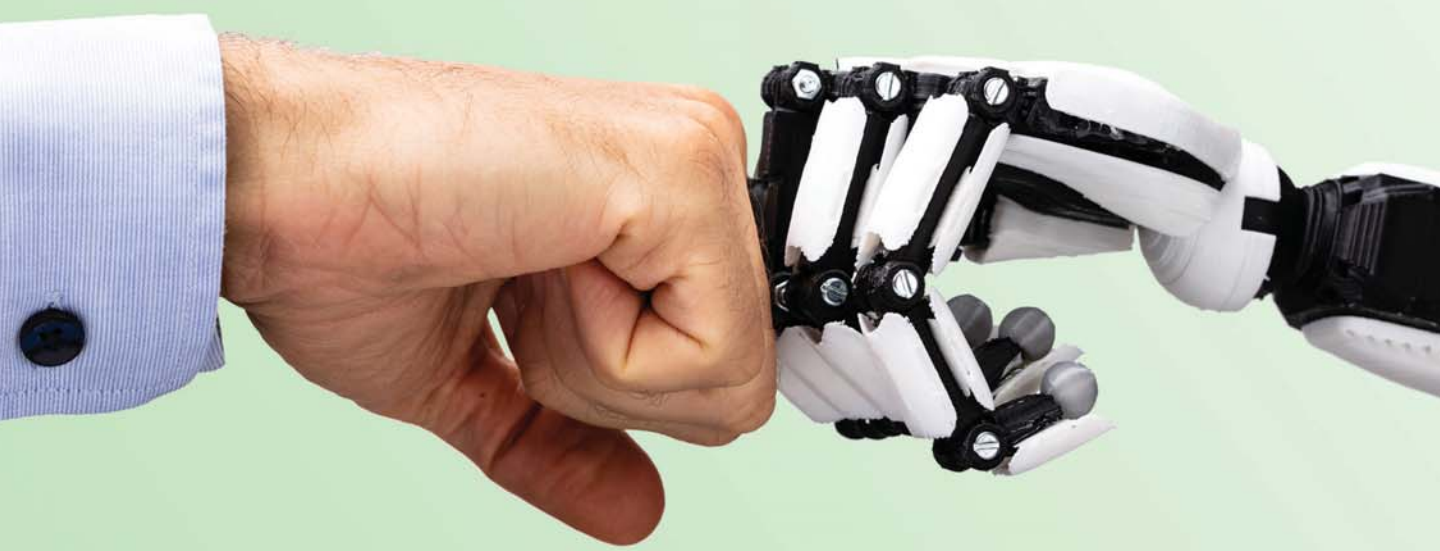

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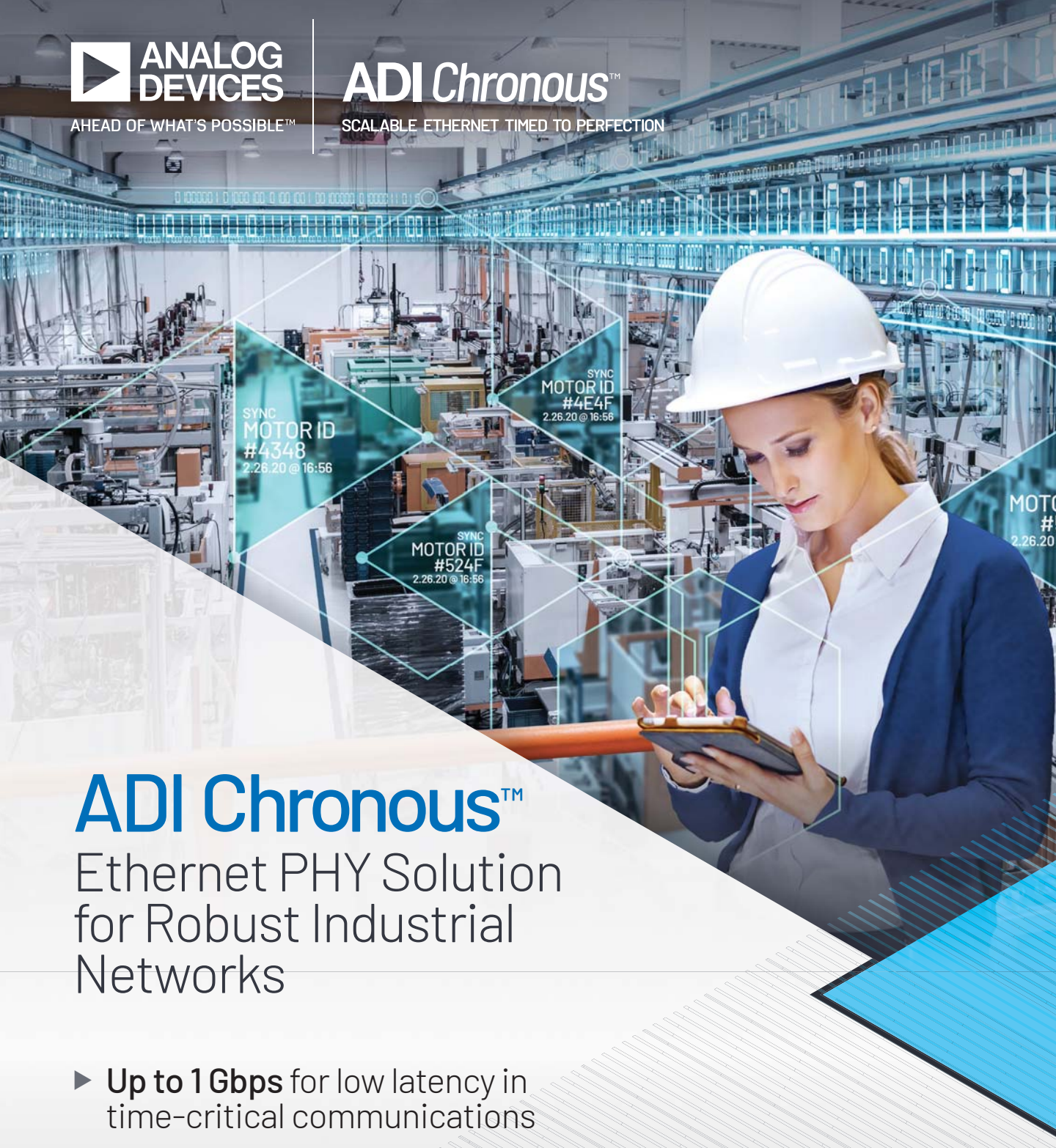

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