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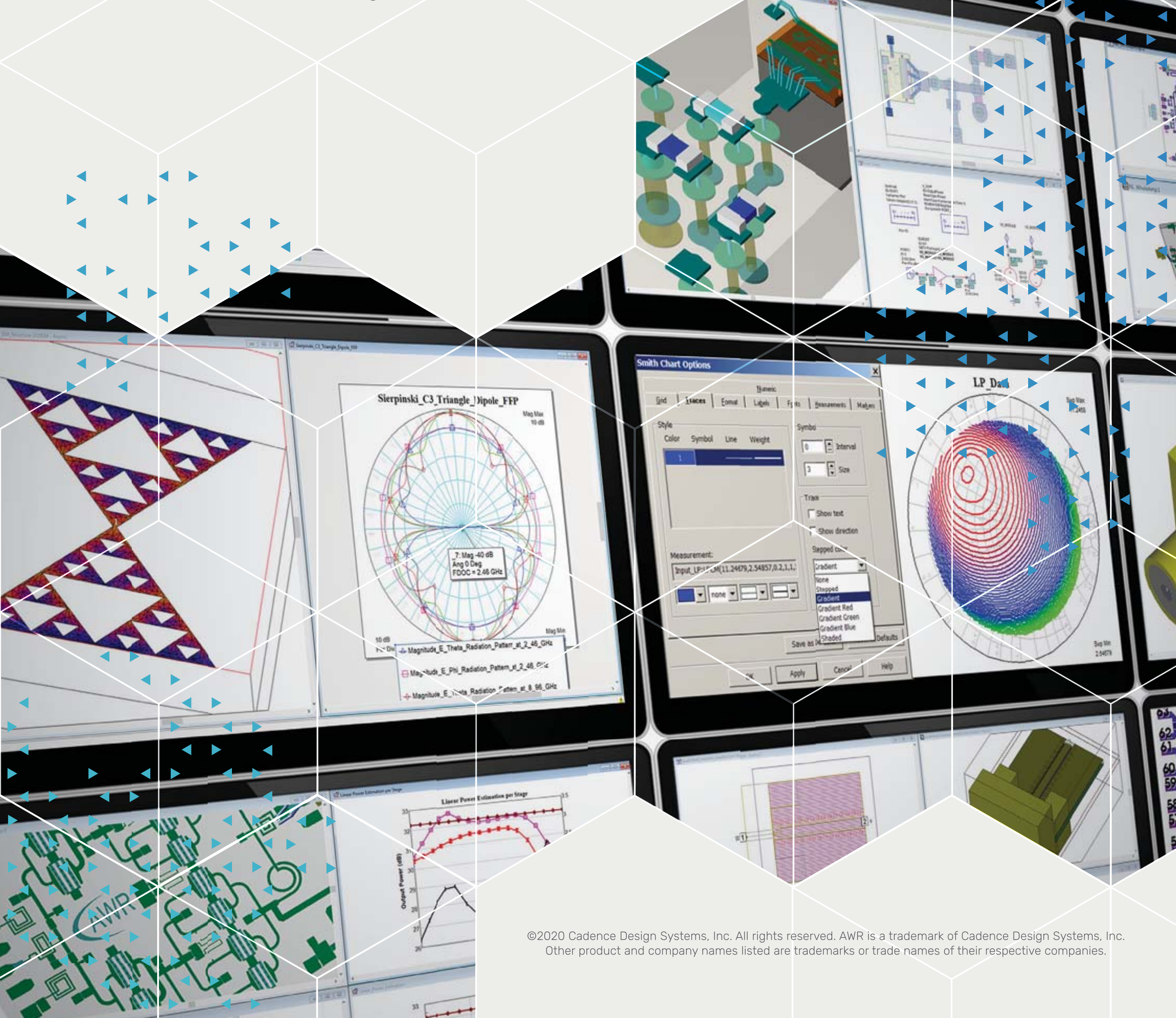

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Microwaves&RF

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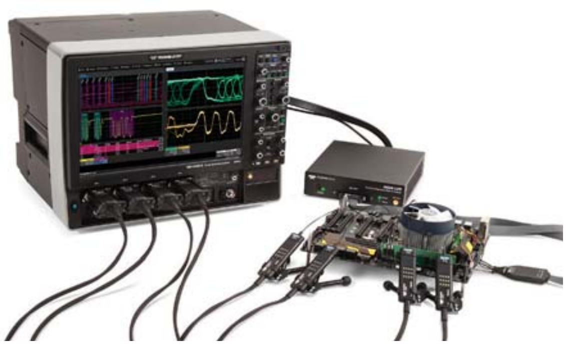

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Editorial

DAVID MALINIAK | Editor

dmaliniak@endeavorb2b.com

To Succeed in IoT, Consider Using Multiple Radios

If deploying either LoRaWAN or Wi-Fi in an IoT application is a winning strategy, why not consider merging them in a multi-radio scheme?

AMONG 2020'S BRIGHT SPOTS (yes, there have been a few) is that it's represented a turning point for IoT adoption. An important factor in the broadening adoption has been reliance on unlicensed wireless technologies like Wi-Fi and LoRaWAN. If deploying one of those technologies is a winning strategy in an IoT application, what about combining them in a multi-radio strategy?

A collaboration between members of the Wireless Broadband Alliance (WBA) and the LoRa Alliance demonstrated that hybrid Wi-Fi and LoRaWAN connectivity increases market opportunities, delivers a strong return on investment (ROI), and offers enhanced network implementations. Adding LoRaWAN to Wi-Fi using network mutualization is a cost-effective approach to deployment using the existing base of Wi-Fi access points. Thus, it presents a significant opportunity for Wi-Fi providers to expand their addressable businesses on complementary use cases that cover both broadband applications and massive IoT leveraging the license-exempt spectrum.

In a new whitepaper, "Wi-Fi & LoRaWAN Trials—An Overview of Use Cases Across Regions Combining Two Technologies," the two alliances provide details on practical trials and proof-of-concept deployments (POCs) representing a variety of uses cases implemented across different geographies and verticals. It builds on an earlier whitepaper, "Wi-Fi & LoRaWAN Deployment Synergies: Expanding Addressable Use Cases for the Internet of Things," comparing the two technologies theoretically and showing how they could effectively support a vast array of use cases.

As two of the most widely adopted unlicensed wireless technologies, Wi-Fi and LoRaWAN address a large proportion of current IoT use cases. Both are disrupting private-public business models and enable participation in the 5G ecosystem and development of capabilities for IoT roaming, using OpenRoaming models. Eleven companies representing both alliances from all global regions contributed to this work, including: Actility, Abeeway, Boingo Wireless, Charter Communications, Cisco, Kerlink, Lacuna Space, Nesten, Simplycity, Skyhook, and Semtech.

Covered use cases include smart buildings, smart city, smart interconnection, smart retail, smart tracking, and smart transportation. The goal is that details on the above use cases will spark inspiration among existing market players that have deployed both Wi-Fi and LoRaWAN, helping them leverage their networks to support innovative new applications.

Moreover, network operators, enterprises, or communities that have deployed either Wi-Fi or LoRaWAN networks can learn ways to extend their offerings by adding the other complementary technology.

In what will hopefully be a model for the wireless industry, WBA and the LoRaWAN Alliance are showing the way toward supporting the rapidly accelerating wireless infrastructure. Homes, cities, transport systems, and retailers all stand to benefit by augmented capacity and coverage and increased ROI. mw

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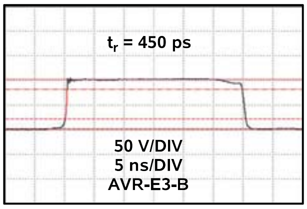

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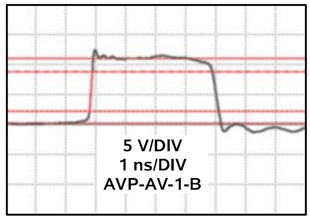

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100 V	500 ps	100 kHz	AVR-E3-B
100 V	300 ps	20 kHz	AVI-V-HV2A-B
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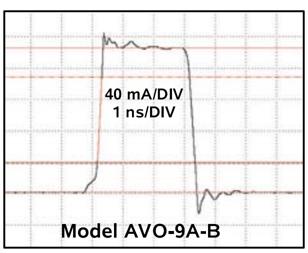

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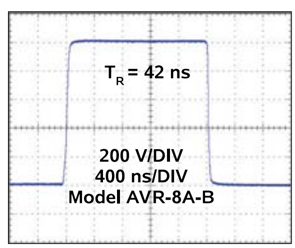

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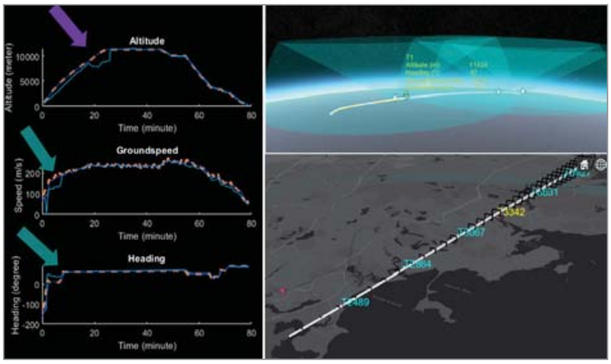


Modeling Air-Traffic-Control Radar Systems

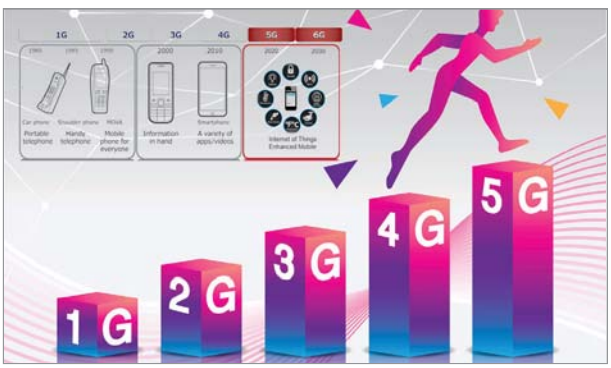
Examples from the previous "Algorithms to Antenna" blog are built upon in terms of air traffic control. Here, we explore information fusion and ways to generate larger data sets to facilitate architecture decisions and improve testing.

https://www.mwrf.com/technologies/systems/article/21148074/mathworks-algorithms-to-antenna-modeling-airtrafficcontrol-radar-systems

Life During the Pandemic: How Are You Connected?

During this unprecedented disruption, RF technology is helping us find a way through the pandemic. Wireless communications enable us to work even as we stay socially distant.

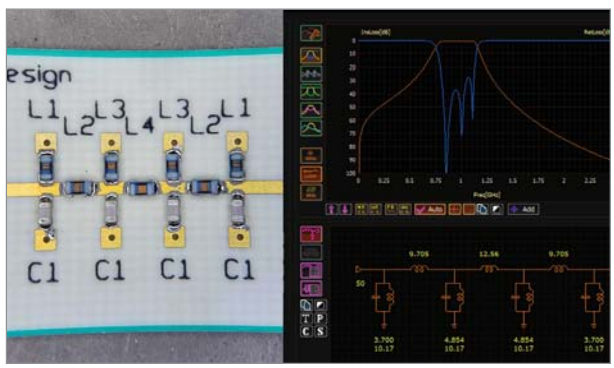
https://www.mwrf.com/technologies/semiconductors/article/21148580/qorvo-life-during-the-pandemic-how-are-you-connected



5G Evolution Supports a New Wave of Wireless Services

Expanding 5G/6G connectivity to include network-to-smart device communications, combined with AI and IoT, will usher in a new industrial wave and offer greater business value for both industry and society.

https://www.mwrf.com/technologies/software/article/21142848/cadence-design-systems-5g-evolution-supports-a-new-wave-of-wireless-services



Accurate Models and Discrete Part-Value Optimization Combine to Improve Workflows

A workflow that combines measurement-based models with discrete part-value optimization can aid designers by automatically adjusting a design's component values to optimal manufacturer part values.

https://www.mwrf.com/technologies/software/article/21135117/accurate-models-and-discrete-partvalue-optimization-combine-to-improve-workflows

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News

Direct Microwave-Synthesis DAC PROVIDES KA-BAND OUTPUT

Teledyne e2v

The space-grade DAC synthesizes signals over 21 GHz without upconversion, and embeds sophisticated digital features.

In its EV12DD700 dual-channel digital-to-analog converters (DACs), Teledyne e2v takes a step toward its goal of remaking the signal chain. Available now as beta samples, the EV12DD700 DAC is a wide-output-bandwidth (12 or 8 bits) that handles sampling rates up to 12 GS/s. It also has the capacity to generate signal waveforms over multiple frequency bands.

The distinguishing feature of the EV12DD700 is that e2v claims it as the first such device to support operation within the Ka-band (26.5 to 40 GHz). In addition, the device includes a number of features such as direct digital synthesis (DDS) and digital upconversion (DUC) via a built-in 32-bit numerically-controlled oscillator (NCO). These facilitate greater throughput without putting excess strain on the IC's resources.

Another key feature of the DAC is its high-speed serial interface based on the flexible, efficient, and simple ESIstream protocol. ESIstream is an open, highly efficient serial interface protocol based on 14b/16b encoding, with its main benefits being low overhead and ease of hardware implementation. Each DAC core can convert either real data from the 16 high-speed serial lanes (HSSLs) or complex data through their respective DUCs. Each function of the DAC can be controlled through a Serial Peripheral Interface (SPI).

The device can be operated in different output modes with respect to the performance targeted over the full operating bandwidth. The –3-dB bandwidth is 25 GHz for a direct signal synthesis without upconversion stages in the RF front end. The appropriate output mode is selectable to achieve the best compromise between output power and dynamic range. NRZ/RF and 2RF modes are used with a clock frequency signal up to 12 GHz and 24 GHz, respectively. The output gain is adjustable, and the output frequency response can be flattened by the anti-sinc function filter (ASINC).

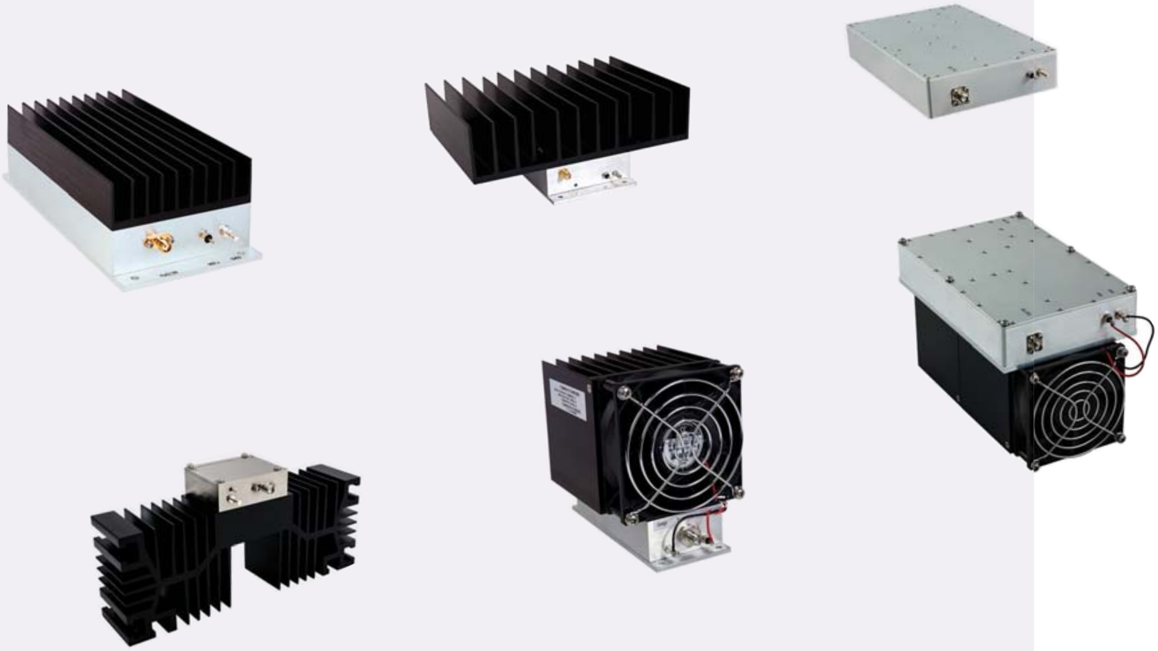
In real data mode (no interpolation), the device synthesizes a very wide Nyquist zone or maximum instantaneous bandwidth of 6 GHz. Sixteen HSSLs at 12 Gb/s per DAC core funnel the digital data to the device.

In complex data mode, interpolation factors (by 4, 8, or 16) can be applied to one or both DAC cores to reduce the overall data rate and reduce the number of HSSLs. Innovative functions are available to control amplitude and phase delays as well as frequency in the digital data path. These functions, configurable through SPI, are beamforming, beam hopping (to hop up to 4 zones), fast frequency hopping, and DDS/chirp.

With EV12DD700 DACs as an option, Teledyne e2v points engineers toward creating next-generation RF systems that have much greater versatility. It will mean that RF system designs can incorporate cutting-edge digital functions such as fast frequency hopping (FFH) and beamforming. The envisaged software-based approach will allow configuration changes directly in code by configuring the DAC, rather than having the inconvenience and expense of making alterations to the hardware. Key applications will include radar, satellite communication, terrestrial network infrastructure, and so on.

Earlier this year, Teledyne e2v announced an EV12DD700-based evaluation board with which engineers could get a look at the device's performance levels. Direct access to samples now lets them evaluate how the device will fit into their designs and begin to plan migration.

The new EV12DD700 DACs will be supplied in a Hi-TCE package format with dimensions of 20 x 20 mm. These robust ICs have a wide operational temperature range of –55 to 125°C. ■



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PLATFORM SLASHES SIX MONTHS OFF Development of Healthcare Wearables

DEVELOPERS OF WEARABLE health monitors can recoup at least six months of development time using the Health Sensor Platform 3.0 (HSP 3.0) from Maxim Integrated Products, Inc. Also known as MAXREFDES104#, this ready-to-wear, wrist-form-factor reference design monitors blood oxygen saturation (SpO2), electrocardiogram (ECG), heart rate (HR), body temperature, and motion. Included algorithms provide HR, heart-rate variability (HRV), respiration rate (RR), SpO2, body temperature, sleep quality, and stress-level information at clinical-grade levels.

Maxim Integrated

The platform allows wearable designers to start collecting data immediately, saving at least six months over building these devices from scratch. Designed for wrist-based form factors, HSP 3.0 can be adapted for other dry-electrode form factors such as chest patches and smart rings.

Compared to its predecessor, Health Sensor Platform 2.0 (HSP 2.0), the HSP 3.0 adds optical SpO2 measurement and dry-electrode capability to the ECG. As a result, it can enable end solutions to monitor cardiac heart and respiratory issues for management of ailments like chronic obstructive pulmonary disease (COPD), infectious diseases (e.g. COVID-19), sleep apnea, and atrial fibrillation (AFib).

Compared to its predecessor, the narrower form factor and enhanced optical architecture of HSP 3.0 improves signal-acquisition quality and uses upgraded microcontroller, power, security, and sensing ICs. The reference design includes complete optical and electrode designs, along with algorithms to meet clinical requirements.

HSP 3.0 or MAXREFDES104# includes the following sensor, power-management, microcontroller, and algorithm products:

- The MAX86176 is a low-noise optical photoplethysmography (PPG) and electrical ECG analog front end (AFE), which offers a 110-dB signal-to-noise ratio (SNR) to add SpO2 saturation capability and over 110-dB common-mode rejection ratio (CMRR) for dry-electrode ECG applications.
- The MAX20360 is a highly integrated power- and battery-management IC (PMIC) optimized for advanced body-worn health sensing devices.
- The MAX32666 is a Bluetooth (BLE)-enabled, ultra-low-power microcontroller with two Arm Cortex-M4F cores and an additional SmartDMA that permits running the BLE stack independently, leaving the two main cores available for major tasks.
- The MAX32670 is an ultra-low-power microcontroller dedicated to Maxim's PPG algorithms of pulse rate, SpO2, HRV, RR, sleep-quality monitoring, and stress monitoring.
- The MAX30208, a low-power, high-accuracy digital temperature sensor, comes in a small package size of 2 x 2 mm. It has 33% lower operating current compared to the closest competitive solution.

The HSP 3.0, also known as MAXREFDES104#, is available with hardware, firmware, and algorithms for $400 at Maxim Integrated's website. ■

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WI-FI 6/6E POWERS Qualcomm's Next-Generation Mesh Networks

IN THESE TIMES OF QUARANTINES, home offices, and sky-high data usage, the basic Wi-Fi paradigm of a single router servicing the entire home seems quaint and, frankly, not up to the task anymore. While Mom's on a work Zoom call, Junior's killing it in competitive e-sports and Dad's downloading 4k videos all at the same time, other bits of bandwidth are going to thermostats, light bulbs, and security systems. There's got to be a better way, and in its Immersive Home mesh Wi-Fi platform, Qualcomm may just have it literally in hand.

Devices built with the Immersive Home platform are designed to deploy low-latency, gigabit-speed mesh Wi-Fi performance to every room in the home in form factors as small as, well, the palm of the hand. Not only that, but they're also expected to be well within consumers' price range, even as they incorporate a new modular architecture, major advancements in network packet-processing technology, and an integration of next-generation Wi-Fi 6 and 6E.

"Not every household has the same requirements," said Bob O'Donnell, president and chief analyst at TECHnalysis Research, LLC. "The beauty of a modular platform is that it lets OEMs and consumers tackle everything from forward-looking massive bandwidth applications using 6-GHz Wi-Fi 6E to tiny mesh extenders that can inconspicuously bring stronger traditional Wi-Fi signals to every room in a home."

To that end, Qualcomm's Immersive Home Platforms offer four distinct product tiers intended to meet the varying needs of consumer OEMs and broadband carriers.

For the most demanding environments, the Immersive Home 310 Series devices represent Qualcomm's Tri-Band Wi-Fi 6 platforms within the portfolio. They are built to simultaneously support IoT-class devices on the 2.4-GHz band and today's legacy media devices on the 5-GHz band. Meanwhile, they also migrate node-to-node backhaul traffic from 5 GHz to the newly opened 6-GHz band while ensuring the network is prepared to support devices supporting emerging 6-GHz applications (VR/XR, live video sharing/streaming, real-time gaming).

The Immersive Home 318 platform delivers:

- 8-stream Tri-Band in a 2x2 (2.4 GHz) + 2x2 (5 GHz) + 4x4 (6 GHz) configuration, for a total available PHY rate of 7.8 Gb/s.
- Multi-gigabit wireless throughput for high-performance clients.
- Support for 160-MHz channels in 5/6-GHz bands
- 4x4 Wi-Fi 6E configuration in the 6-GHz band for enhanced performance, range, and/or client count.

In the Immersive Home 316 Platform, it's 6-stream Tri-Band in a 2x2 (2.4 GHz) + 2x2 (5 GHz) + 2x2 (6 GHz) configuration, for a total available PHY rate of 5.4 Gb/s.

Existing mesh providers can garner performance and cost benefits from the Immersive Home 210 Series. The 216 platform brings 6-stream Wi-Fi 6 in a 2x2 (2.4 GHz) + 4x4 (5 GHz) configuration, for a total available PHY rate of 5.4 Gb/s. Finally, the 214 platform provides 4-stream Wi-Fi 6 in a 2x2 (2.4 GHz) + 2x2 (5 GHz) configuration, for a total available PHY rate of 3.0 Gb/s. Like the 318 platform, the 316, 216, and 214 platforms all support the same 160-MHz channels.

Qualcomm

In both dual and tri-band series, the platforms deliver Gigabit wireless in a form factor highly optimized for size, scale, and performance. When compared to Qualcomm's earlier IPQ4xxx family (found in most Wi-Fi 5-generation mesh systems), the Immersive Home Platforms can deliver 2.5X throughput per watt, which means smaller, cooler, and less costly end products.

Other key features of the Qualcomm Immersive Home platform devices include:

Broad Wi-Fi technology support: Qualcomm Immersive Home Platforms are built to deliver seamless roaming, band/node client steering, and advanced security safeguards across Wi-Fi 4, 5, 6, 6E, and support many of the industry's leading mesh software protocols including Qualcomm Wi-Fi SON, the OpenSync open-source software, eero's TrueMesh, and the Wi-Fi Alliance's Wi-Fi CERTIFIED EasyMesh standard.

Powerful smart home integration capabilities: Qualcomm Immersive Home Platforms feature advanced Qualcomm Multi-User Traffic Management technologies to balance and support all the Wi-Fi connected devices in a modern smart home, while high-performance Bluetooth integration enables seamless onboarding and integration of advanced applications leveraging either connectivity technology.

Ultra-low latency enabled: Qualcomm Immersive Home Platforms can support, in certain configurations with 6-GHz operation, a new class of emerging latency-sensitive applications like mobile gaming and XR through latency reduction up to 8x in congested environments and wireless VR-class latency of <3 ms.

Qualcomm Immersive Home Platforms are sampling now to customers. For more information about Wi-Fi 6 and 6E products for the home, visit *qualcomm.com/mesh-networking.* ■

SEBASTIAN RICHTER | Vice President of Market Segment ICR (Industry, Components, Research & Universities), Rohde & Schwarz

Quantum Computing in the Cloud—Can It Live Up to THE HYPE?

With the increasing accessibility of quantum computing, Rohde & Schwarz's Sebastian Richter assesses the technology's potential and what needs to happen next.

Quantum computing has earned its place on the Gartner hype cycle. Pundits have claimed that it will take over and change everything forever. The reality will likely be somewhat less dramatic, although it's fair to say that quantum computers could spell the end for conventional cryptography. Clearly, this has implications for technologies like blockchain, which are slated to support financial systems of the future.

While the Bitcoin system, for example, is calculated to keep classical mining computers busy until 2140, brute-force decryption using a quantum computer could theoretically mine every token almost instantaneously. More powerful digital ledger technologies based on quantum cryptography could level the playing field.

All of this presupposes that quantum computing will become usable and affordable on a widespread scale. As things stand, this certainly seems achievable. Serious computing players, including IBM, Honeywell, Google, and Microsoft, as well as newer specialist startups, all have active programs that are putting quantum computing in the cloud right now and inviting engagement from the wider computing community. Introduction packs and development kits are available to help new users get started.

DEMOCRATIZING ACCESS

These are important moves that will almost certainly drive further advancement as users come up with more diverse and demanding workloads and figure out ways of handling them using quantum technology. Equally important is the anticipated democratizing effect of widespread cloud access, which should bring more people from a wider variety of backgrounds into contact with quantum to understand it, use it, and influence its ongoing development.

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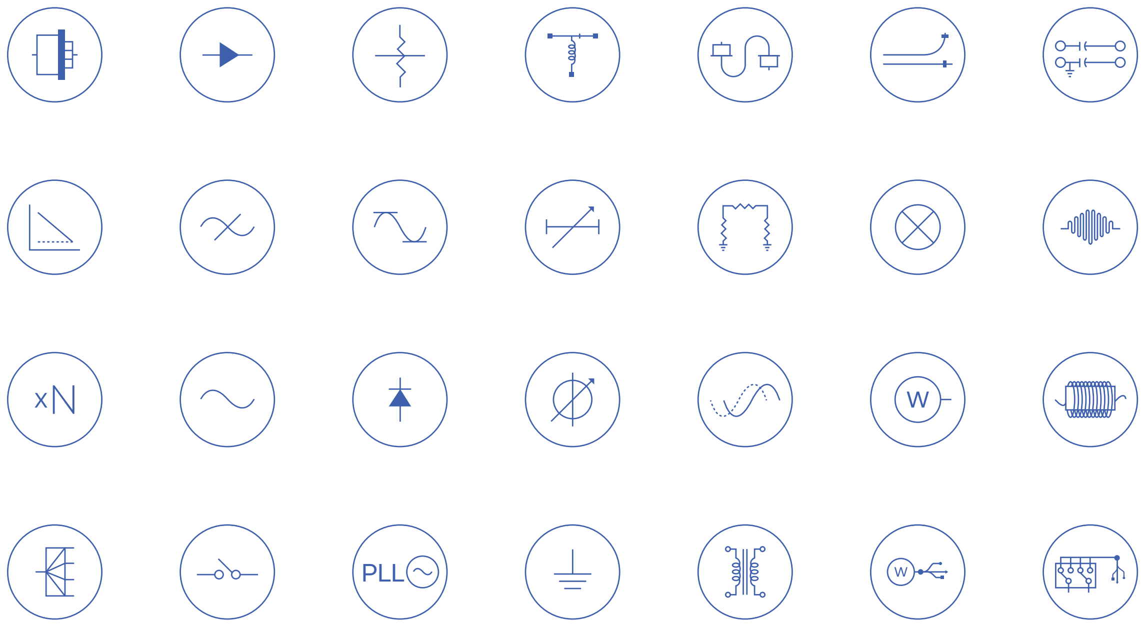

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Although it's here, quantum computing remains at a very experimental stage. In the future, commercial cloud services could provide affordable access in the same way that scientific or banking organizations can today rent cloud AI applications to do complex workloads that are billed according to the number of computer cycles used.

Hospitals, for example, are taking advantage of genome sequencing apps hosted on AI accelerators in hyperscale data centers to identify genetic disorders in newborn babies. The process costs just a few dollars and the results are back within minutes, enabling timely and potentially life-saving intervention by clinicians.

Quantum computing as a service could further transform healthcare as well as deeply affect many other fields such as materials science. Simulating a caffeine molecule, for example, is incredibly difficult to do with a classical computer, demanding the equivalent of over 100 years of processing time. A quantum computer can complete the task in seconds. Other applications that could benefit include climate analysis, transportation planning, bioinformatics, financial services, encryption, and codebreaking.

1. Extremely pure and clean RF sources like the R&S SGS100A are needed in quantum-computing applications.

A REAL TECHNOLOGY ROADMAP

For all its power, quantum computing isn't here to kill off classical computing or turn the entire world upside down. Because quantum bits (qubits) can be in both states, 0 and 1, unlike conventional binary bits that are in one state or another, they can store exponentially more information. However, their state when measured is determined by probability, so quantum is only suited to certain types of algorithms. Others can be handled better by classical computers.

In addition, building and running a quantum computer is incredibly difficult and complex. On top of that, the challenges intensify as we try to increase the number of qubits in the system. As with any computer, more bits corresponds to more processing power, so increasing the number of bits is a key objective for quantum-computer architects.

Keeping the system stable, with a low error rate, for longer periods is another objective. One way to achieve this is by cryogenically cooling the equipment to near absolute zero to eliminate thermal noise. Furthermore, extremely pure and clean RF sources are needed. I'm excited that, at Rohde & Schwarz, we are working with our academic partners to apply our ultra-low-noise R&S SGS100A RF sources *(Fig. 1)* to help increase qubit count and stability.

The RF source is one of the most important building blocks as it determines the amount of errors that must be corrected in the process of reading out the quantum-computation results. A "cleaner" RF signal increases quantum-system stability, reducing errors due to quantum decoherence that would result in information loss.

Besides the low phase and amplitude noise requirements, multichannel solutions are essential to scale up the quantum-computing system. Moreover, as we start to consider scalability, a small form factor of the signal sources becomes even more relevant. We're combining our RF expertise with the software and system know-how of our partners in pursuit of a complete solution.

2. VNAs such as the R&S ZNA help determine properties of material used in quantum computing.

EQUIPMENT NEEDS

In addition, scientists are constantly looking for new material to be applied in quantum-computing chips and need equipment to help them accurately determine the exact properties. Then, once the new quantum chip is manufactured, its resonance frequencies must be measured to ensure that no undesired resonances exist. Rohde & Schwarz has developed high-performance vector network analyzers *(Fig. 2)* for both tasks and can assist in the debugging of the quantum-computing system itself.

Our partners are relying on us to provide various other test-and-measurement solutions to help them increase the performance and capabilities of quantum computers. The IQ mixing is a crucial part of a quantum computer, for example, and our spectrum analyzers help to characterize and calibrate the IQ mixers and suppress undesired sidebands. Moreover, R&S high-speed oscilloscopes *(Fig. 3)* help enable precise temporal synchronization of signals in the time domain, which is needed to set up and debug quantum-computing systems.

As we work with our partners in the quantum world to improve our products for a better solution fit, at the same time we're learning how to apply that knowledge to other products in our portfolio. In turn, this helps to deliver even better performing solutions.

3. High-speed oscilloscopes, for example, the R&S RTP, can be used to set up and debug quantum-computing systems.

While cloud access will enable more companies and research institutes to take part in the quantum revolution, bringing this technology into the everyday world requires a lot more work on "user friendliness." That involves moving away from the temperature restrictions, stabilizing quantum computers with a high number of qubits, and all for a competitive price.

Already, however, we can see that quantum has the potential to profoundly change everything it touches. No hype is needed. mw

PETER DELOS, BOB BROUGHTON, JON KRAFT | Analog Devices

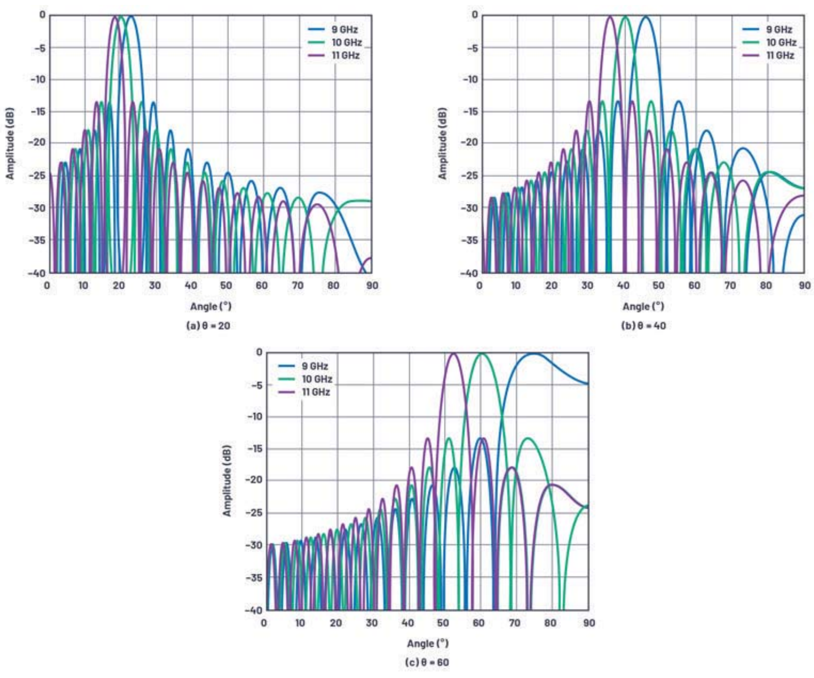
Phased-Array Antenna Patterns (Part 5)—BEAM SQUINT

In Part 4 of this series on phased-array antenna patterns, we covered grating lobes. Part 5 turns its attention to beam squint: changes in beam angle as a function of frequency.

In previous parts of this series, we described how, when a wavefront approaches an array of elements, there's a time delay between elements based on the wavefront angle θ relative to boresight. For a single frequency, the beamsteering can be accomplished by replacing the time delay with a phase shift. This works for narrowband waveforms, but for wideband waveforms, where the beamsteering is produced by a phase shift, the beam can shift direction as a function of frequency. Such a situation can be intuitively explained if we remember that a time delay is a linear phase shift vs. frequency.

Thus, for a given beam direction, the phase shift required changes as a function of frequency. Or, conversely, for a given phase shift, the beam direction changes as a function of frequency. The concept of the beam angle changing as a function of frequency is called beam squint.

Also consider that at boresight, θ = 0, there's no phase shift across the elements and therefore no means to produce any beam squint. Thus, the amount of beam squint must be a function of angle, θ, as well as the frequency variation. *Figure 1* shows an X-band example. In this example, the center frequency is 10 GHz, the



1. In this example of beam squint at X-band for a 32-element linear array with a λ/2 element spacing, it's clear that the beam changes direction as a function of both frequency and the initial beam angle.

modulation bandwidth is 2 GHz, and it's apparent that the beam changes direction as a function of both frequency and the initial beam angle.

Beam squint can be calculated directly. Using Equations 1 and 2 from Part 4 of this series, the beam direction deviation, beam squint, can be calculated as:

$$\Delta\theta = arcsin\left(\frac{f_0}{f}\, sin\theta_0\right) - \theta_0$$

This equation is shown graphically in *Figure 2*, in which the f/f0 ratio shown is intentional. The reciprocal of (f0/f) from the previous equation provides an easier way to visualize the change relative to a center frequency.

A few observations on beam squint:

- As the beam angle increases away from boresight, so too does the deviation in beam angle vs. frequency.
- A frequency below the center frequency causes a larger deviation than a frequency above the center frequency.
- A frequency below the center frequency moves the beam further away from boresight.

BEAM-SQUINT CONSIDERATIONS

The beam squint, or deviation in steering angle vs. frequency, is caused by approximating a time delay with a phase shift. Implementing beamsteering with true time-delay units doesn't have this problem.

With the beam squint problem so clearly visible, why would anyone use a phase shifter over a time-delay unit? Typically, this comes down to design simplicity and IC availability of phase shifters vs. time delays. Time delays are implemented in some form of transmission line and the total delay needed is a function of the aperture size. To date, most available analog beamforming ICs are phase-shift-based, but families of true time-delay ICs are emerging, and these may become much more common for phased-array implementations.

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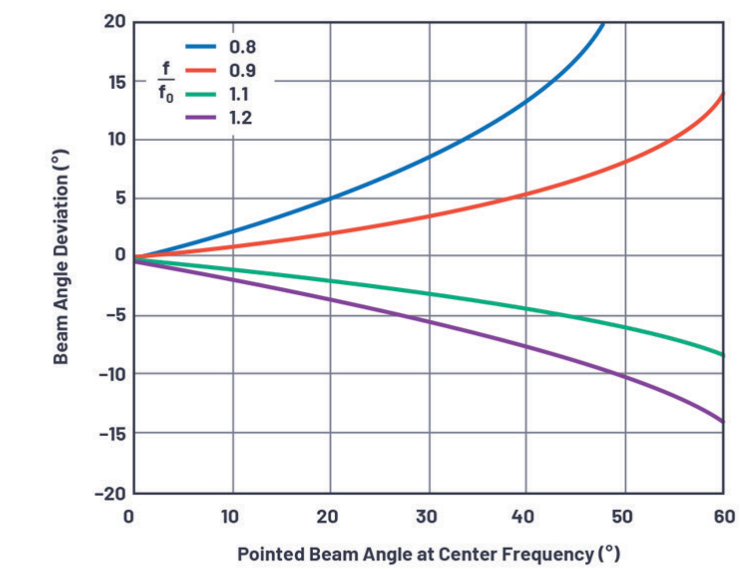

2. Shown are plots of beam squint vs. beam angle for several frequency deviations.

In digital beamforming, true time delay can be implemented in the DSP logic and digital beamforming algorithms. Therefore, a phased-array architecture in which every element is digitized would lend itself naturally to overcome the beam-squint problem, while also providing the most programmability. However, the power, size, and cost of such a solution can be problematic.

In hybrid beamforming, there's a combination of analog beamforming for subarrays followed by digital beamforming for the full array. This can offer some natural beam-squint mitigation worth considering. Beam squint is only subject to the subarray, which is a much wider beamwidth, so it's more tolerant to a beam-angle deviation. Thus, if the subarray beam squint is tolerable, then the hybrid beamforming architecture can be implemented with phase shifters in the subarrays, followed by true time delay in the digital beamforming.

Previously in this series, we introduced beam pointing and the array factor. We then introduced imperfections of grating lobes and beam squint. In the coming articles, we will discuss tapering as a method to reduce sidelobes, and provide insight into the impact of phase-shifter quantization errors. **mw**

PETER DELOS is Technical Lead and BOB BROUGHTON is Director of Engineering for Analog Devices' Aerospace and Defense Group, and JON KRAFT is Senior Staff Field Applications Engineer at Analog Devices.

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Microwaves&RF 2020 Salary & Career Report

DAVID MALINIAK | Editor

Here's an overview of the state of continuing engineering education as revealed by responses to our 2020 Annual Salary and Career Report survey.

CONTINUING EDUCATION

"Technologies are ever evolving, and competent engineers must keep up with the changes that come." That statement from a respondent to our 2020 Salary & Career Report survey sums up the feeling engineers have about continuing their engineering educations. In our survey, we asked you to update us on your current level of education and how you prefer to learn about new technologies and skills. Does your employer encourage continuing education by footing the bill, and if so, in what modes? And how does the coronavirus pandemic figure into the picture? In this article, we'll look at these topics with facts, figures, and anecdotal responses.

EDUCATION LEVELS HOLD STEADY OVERALL

First, let's look at where you stand with your respective highest levels of education and see how that compares with the 2019 survey responses. The leading response was a master's degree (32% vs. 33% in 2019), followed by a bachelor's degree (27% vs. 30%). Last year, 9% of

you reported holding a doctorate; this year, that number jumped up to 12%. Also, the number of respondents who have bachelor's degrees and then followed that up with at least some graduate studies are holding firm at 13%. So, these survey results suggest that the levels of education among you are more or less on balance year on year compared to 2019.

SO MANY WAYS TO LEARN

It's good to see that the general level of education among engineers seems to be on the rise. But we also asked, "What are some of the ways in which you continue your engineering education?" The leading category this year: 65% report relying on engineering/technology publications for keeping up with trends. That's followed by 60% who lean on webcasts and 58% who consume engineering videos.

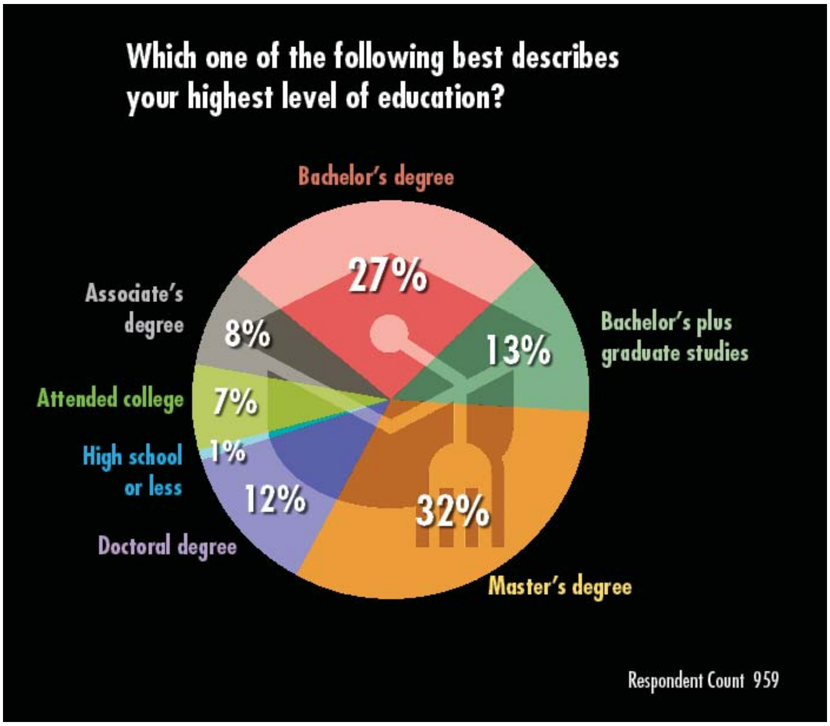
Vendors to the OEM electronics industry have always done a great job at cranking out videos, white papers, and webcasts to educate engineers on their latest and greatest innovations. All of those mediums are free to consume, and webcasts can usually be viewed on demand if you've missed the live events.

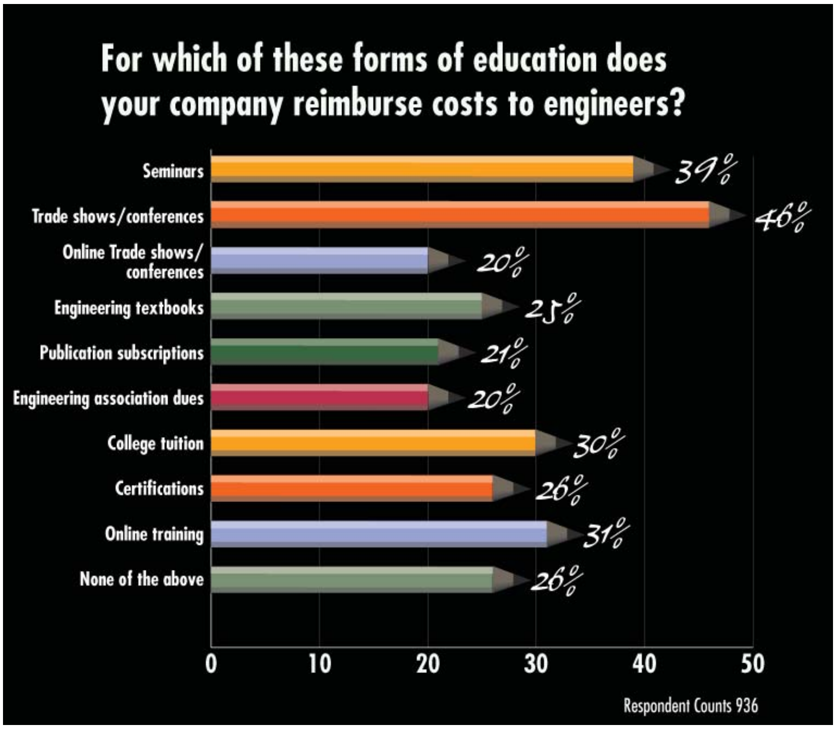
Most in-person modes of continuing education—things like in-classroom college courses, seminars, user group meetings, and meetups—are down a few percentage points from last year's results. Only 26% attended trade shows or conferences, and just 21% have been to engineering association-sponsored meetings.

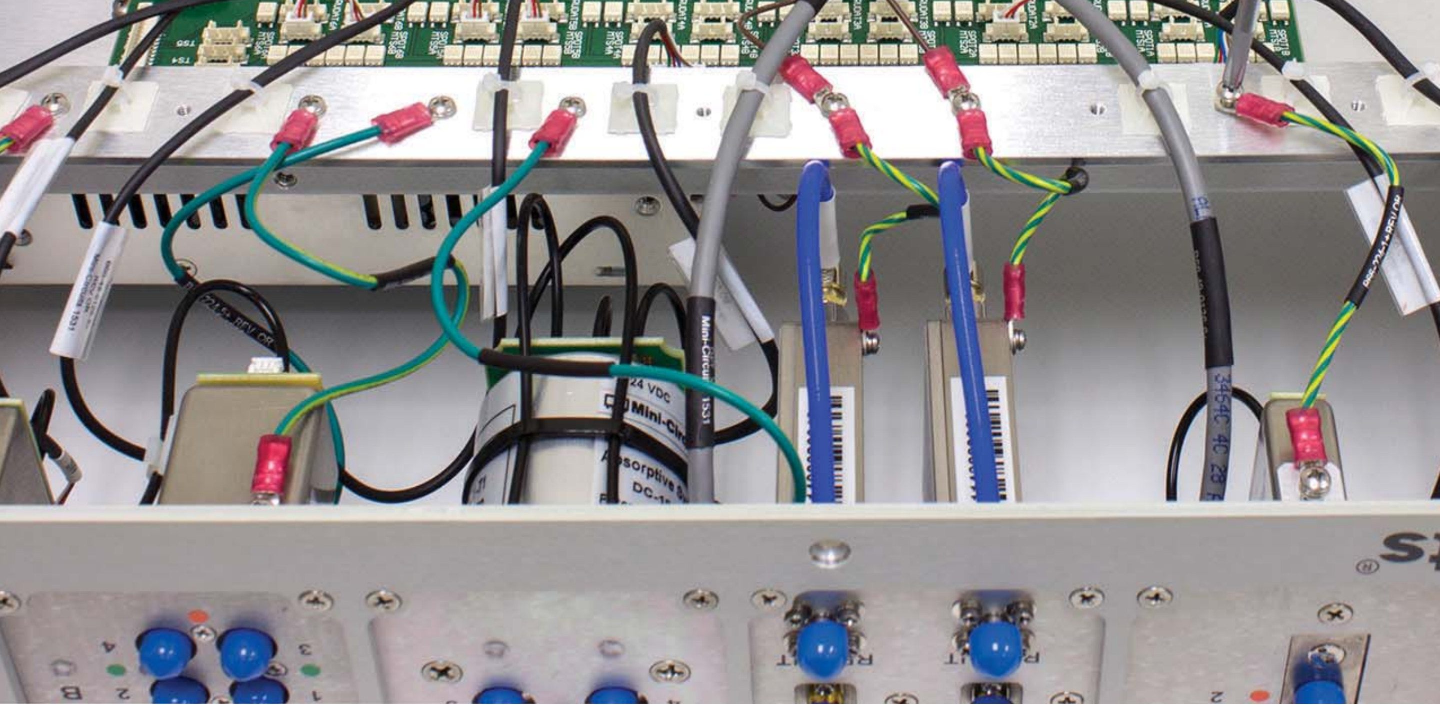
Curiously, online learning is basically on par with last year and even down in some categories. You've been reading fewer e-books (41% vs. 44% in 2019), participating less in online college courses (27% vs 31%), and visiting online engineering discussion forums at a lower clip (18% vs 22%). Given the pandemic's stifling of most away-from-home activities since earlier this year, this is a surprising result. It's even more surprising given that a number of you called out COVID-19 as among the biggest challenges you face in staying current with relevant engineering information.

IMPEDIMENTS TO LEARNING

Yet, the pandemic isn't the most prevalent barrier to gaining knowledge. In their written responses to the question of challenges in maintaining their engi-







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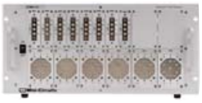

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Vendors to the OEM electronics industry have always done a great job at cranking out videos, white papers, and webcasts to educate engineers on their latest and greatest innovations.

neering educations, far more respondents cited lack of time in various guises: "Too much work, not enough time for self-training and hunting for resources," goes a typical plaint.

This is, of course, not a new finding in the years of surveying our audience on career-oriented issues. Work-life balance is important to everyone, and not everyone wants to take training materials or extracurricular reading home. Lots of you would rather do it on company time, but it's just not possible. "It's hard to balance the intake of new information with working on active projects," according to one respondent.

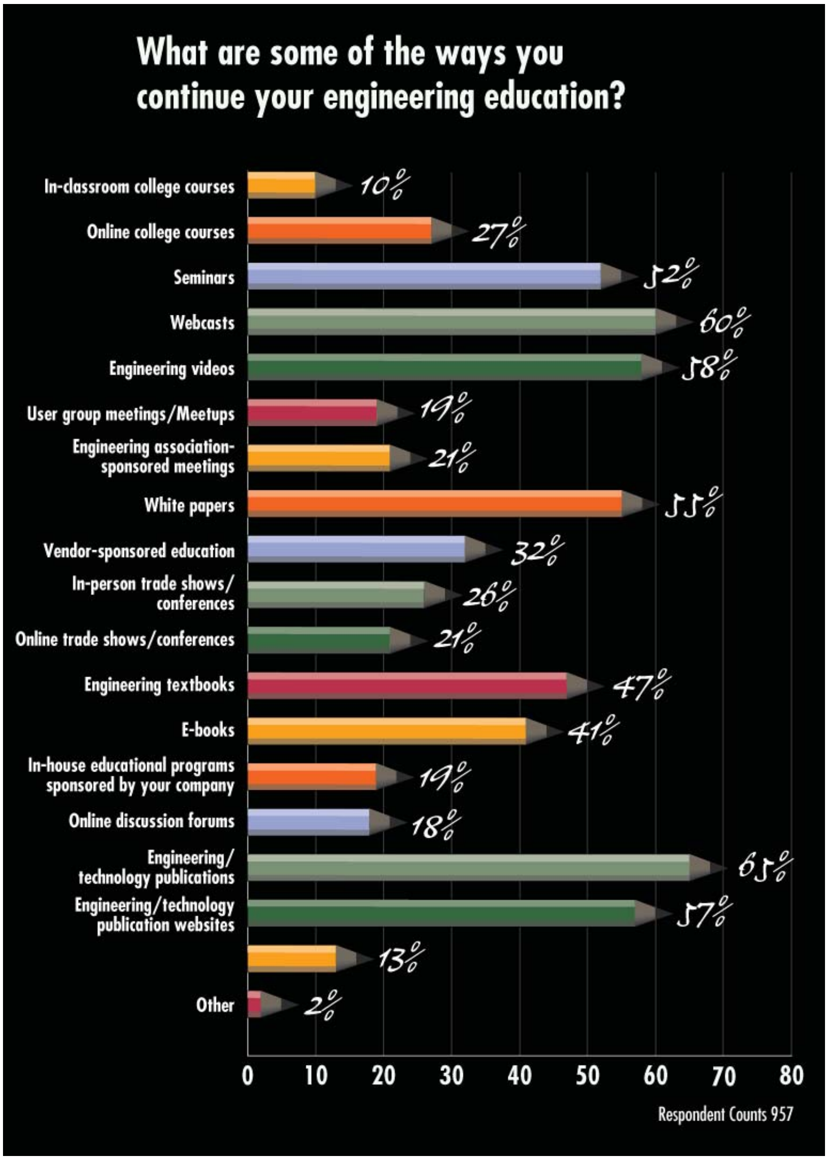
Another oft-cited issue is the sheer volume of material to be sifted through and prioritized. "The problem is focusing on the relevant issues. The available information is vast and overlapping," said one respondent. Meanwhile, another laments that "sometimes the amount of information is too much, and sometimes too little." Still others cite the combination of the pace of change in the industry and the number of topics to keep abreast of.

CONTINUING EDUCATION AS A BENEFIT

Finally, we asked whether your employer invests in its engineering staff by reimbursing you for the cost of continuing education. On this front, the comparison to the 2019 survey results is a mixed bag. More of you report that your employers pick up the tab for things like trade show/conference fees (46% vs. 44% in 2019), professional certifications (26% vs. 25%), and, importantly, online training (31% vs. 26%).

But when it comes to some other avenues of continuing education, employers have become a bit stingier. They're footing the bill less often for seminars (39% vs. 45% in 2019), engineering textbooks (25% vs. 27%), and college tuition costs (30% vs. 32%). More of you say your employers don't cover continuing education costs at all (26% vs 23%). Clearly, in some instances, employers have reined in their investments in employees, perhaps ultimately to their own detriment.

As Henry Ford once said, "Anyone who stops learning is old, whether at twenty or eighty. Anyone who keeps learning stays young." And to that, let's heed the words of Bob Dylan: "May you stay forever young." mw



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Maritime Robot Helps in COVID-19 Studies

A decontamination robot originally designed for shipboard firefighting and maintenance has been modified to battle against the spread of the COVID-19 coronavirus.

JACK BROWNE | Technical Contributor

HUMANS ARE SUFFERING from the global pandemic brought on by COVID-19 virus, but a robot wants to help. A decontamination robot originally designed for shipboard firefighting and maintenance has been modified by university researchers funded by the Office of Naval Research (ONR) to battle against the spread of the COVID-19 coronavirus. The robot *(see figure)* uses ultraviolet C-range (100 to 280 nm wavelength) UVC light to disinfect surfaces without contact. The robot has four wheels and a mechanical arm to maneuver the UV light source over the surfaces to be treated. The robot requires human operators, but the hope is to transform the design into an autonomous health assistant.

"The value of robots to deploy UVC lamps for decontamination is that you can reduce exposure of humans to the UVC light, and the robot can reposition the lamps over surfaces you wish to decontaminate using its arms," said Dr. Thomas

(Continued on page 32)

Defense Department Calls for 5G Experimentation

THE U.S. DEPARTMENT OF DEFENSE (DoD) has long recognized the importance of 5G cellular wireless communications technology to commercial and industrial users in the world. The DoD finally certified that 5G will also no doubt become one of the most important dual-use technologies to be used by military forces. It announced $600 million in awards for 5G experimentation and testing at five U.S. military test sites, the largest such dual-use experimentation on 5G in the world. Each site will include military, industrial, and academic partners to pursue further knowledge of 5G capabilities for mission planning and training of armed forces.

Acting Under Secretary of Defense for Research and Engineering, Michael Kratsios, explained:

"The Department of Defense is at the forefront of cutting-edge 5G testing and experimentation, which will strengthen our nation's warfighting capabilities as well as U.S. economic competitiveness in this critical field. Through these test sites, the Department is leveraging its unique authorities to pursue bold innovation at a scale and scope unmatched anywhere else in the world. Importantly, today's announcement demonstrates the Department's com-

(Continued on page 32)

Maritime Robot Helps in COVID-19 Studies (Continued from page 31)

McKenna, a program officer in ONR's Warfighter Performance Department. "When the robot was designed, there was no COVID-19, but the combination of mobility and manipulation are a good match to this task."

The ONR has been involved in fundamental research on human-robotic interactions for over 20 years, with the help of small companies, universities (including Virginia Tech and the University of Virginia), and the U.S. Naval Research Laboratory (NRL). The research is motivated not only by the desire to remove humans from dangerous situations, but to have robots perform routine tasks so that sailors and Marines can be freed for other assignments. The initial ONR program in the development of humanoid robots focused on shipboard damage control, such as firefighting and shipboard maintenance.

But with the help of Dr. Tomonari Furukawa, a professor at the University of Virginia, manipulators were added to mobile robots to adaptively position UVC lamps for effective decontamination. "The robot can already disinfect by teleoperation. In August, we tested and successfully demonstrated disinfection of a room of COVID-19 at a testing center while teleoperating from a different building," said Furukawa. "We are currently developing the ability to build a 3D map showing disinfected surfaces, and possibly infected surfaces, with which we can next introduce autonomous disinfection. Full completion will need much more work, but we are planning to complete the first installation of the mapping capability by the end of this year." ■

Defense Department Calls for 5G Experimentation (Continued from page 31)


Ericsson

mitment to exploring the vast potential applications and dual-use opportunities that can be built upon next-generation networks."

Test sites include Hill Air Force Base (Utah), Joint Base Lewis-McChord (Washington), Marine Corps Logistics Base Albany (Georgia), Naval Base San Diego (California), and Nellis Air Force Base (Las Vegas, Nevada). Bases were chosen for their mature fiber-optic and wireless communications infrastructures and their capabilities to support new and improved infrastructure requirements. Testing and experimentation will involve dynamic spectrum sharing and exploring the augmented reality (AR) and virtual reality (VR) capabilities of 5G networks for mission planning and other military requirements. Industry partners are extensive and different at each site and include such leading system suppliers as AT&T, Booz Allen Hamilton, Ericsson *(see figure)*, GE Research, and Nokia. ■

The Department of Defense has announced $600 million in awards for experimentation and testing on 5G systems and technology at five military research sites.

Magnetic-Field Navigation as an "Alternative" GPS?

By using measurements of anomalies in the Earth's magnetic field and machine learning to extract data from raw signals, then matching them to accurate magnetic-anomaly maps, it may possible to navigate aircraft with reasonable accuracy independent of GPS.

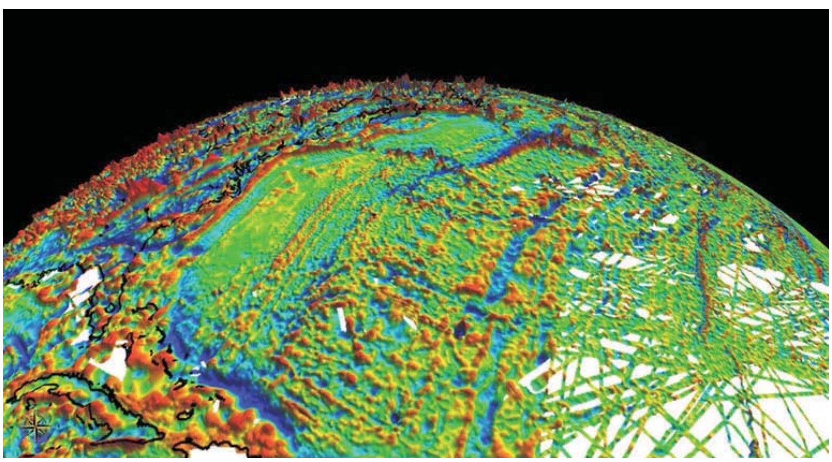
WE TAKE AS A GIVEN that GPS is ubiquitous and available, but that's a suspect assumption. The U.S.-based Global Positioning System as well as other embodiments of Global Navigation Satellite Systems (GNSS) are affected by dead zones, excessive noise, poor signal-to-noise ratio (SNR), deliberate jamming, and even spoofing that can render it unavailable, inaccurate, or even grossly misleading.

But there may be a viable backup alternative, admittedly with less accuracy—the Earth's magnetic field. By using magnetometers to sense this field, as well as accurate maps of the field's anomalies and variations (and there are many), in addition to machine learning (ML), it may be practical to extract useful position and navigation data, even though it's affected by noise and numerous dynamic local and wide-range distortions.

Despite these challenges, the use of this pervasive magnetic field (primarily for flight navigation) is attractive as it's obviously available, worldwide, and nearly impossible to deliberately jam or distort, especially at a distance. While alternative position, navigation, and timing solutions (APNT) such as cameras and computer vision, star tracking, or terrain-following navigation solutions are available, they're limited by the visual environment, weather, and the lack of topography over water. In contrast, a magnetic navigation system collects the available magnetic-field data using magnetometers, then creates and matches magnetic anomaly maps to determine the current location.

The project, which began as a theoretical effort with collaboration between the Massachusetts Institute of Technology (MIT), MIT Lincoln Laboratory, and the Air Force Institute of Technology (Dayton, Ohio), has been underway for several years. It has recently been supplemented by extensive flight tests to create better magnetic-field maps and data capture.

The lead researcher in the project, Air Force Major and Professor Aaron Canciani, acknowledges that GPS offers far greater accuracy, but notes that in many cases, the extra accuracy isn't as important as availability and accessibility. In general, mobile GPS has accuracy on the order of one meter or less, while the magnetic navigation (MAGNAV) approach is potentially accurate to about one kilometer. However, he says that a significant percentage of missions actually don't require GPS-class accuracy.



1. Not your usual map of the Earth, this map shows the magnetic-field variations of part of the globe, as measured at a standardized fixed height above surface. *(Source: http://geomag.org/models/wdmam.html)*

Magnetic anomaly navigation uses scalar magnetometers as sensors to measure differences in magnetic fields. Comparing these measurements with magnetic-field maps can provide information resulting in position determination. Performance depends on the accuracy of the maps of the Earth's field and anomalies—and many such maps exist, with widely varying quality and precision—which have been measured and compiled over the years *(Fig. 1).*

These maps show the highly local field variations due to differences in the Earth's outer crust and under-crust layers as well as deeper causes (literally) from flows of conducting material within the Earth. The anomalies not only change due to geological shifts, but they even have daily and other cyclic shifts for a variety of reasons.

Professor Canciani's 2016 Ph.D. thesis "Absolute Positioning Using the Earth's Magnetic Anomaly Field" established a context for the project. This very readable and intense 265-page thesis begins as an insightful tutorial and established a framework for how sophisticated algorithms can, in principle, be used to extract useful results and, as a result, navigation information from the corrupted, continually changing magnetic-field anomaly signals.

The paper is very clear about the numerous subtle and complex factors that affect this map as well as the integrity of collected data, and the ways these factors can be assessed and understood. He has also posted a clear and informative 17-slide PowerPoint overview on the subject, titled "Magnetic Navigation," which is a very useful introduction. (Note that the Earth's core field—the one that most people recognize, which causes a compass to point north—has very little spatial variation and thus isn't suitable for absolute positioning.)

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2. One test aircraft used by the project team was a Cessna Caravan that's routinely outfitted for geophysical surveying. Here, it carried five scalar magnetometers (one mounted in a tail "stinger" extension) plus three vector magnetometers. *(Source: Sander Geophysics Ltd.)*

Geophysicists and industry have been making magnetic anomaly maps for decades to study the Earth's subsurface. These maps give valuable insight into the locations and types of minerals buried underground and are used commonly in industry to discover resources such as oil and diamonds.

The baseline is the World Digital Magnetic Anomaly Map (WDMAM), a global three-arc-minute resolution grid of the anomaly of the magnetic intensity, at an altitude of 5 km above mean sea level. This map was compiled from satellite, marine, aeromagnetic, and ground magnetic surveys, and is formally updated every five years.

The WDMAM is created by differencing the measured magnetic intensity from a reference field; the most commonly used reference field is the International Geomagnetic Reference Field (IGRF). Most of these magnetic intensity surveys are done with optically pumped cesium-based split-beam scalar magnetometers that have an absolute accuracy of between one and three nanoteslas.

One of the project tests involved flights and data collection using a specialized small aircraft from Sander Geophysics Limited (a worldwide geophysical surveying company) *(Fig. 2)*. It's equipped with multiple magnetometers, plus GPS and an inertial navigation system (INS) for precision three-dimensional position tagging associated with the acquired magnetic data. One scalar magnetometer was positioned on an external tail "stinger" to collect magnetic measurements with minimal aircraft magnetic-field noise. The remaining four scalar magnetometers, as well as the three vector fluxgate magnetometers, were placed inside the cabin of the aircraft. The anomaly-based variations to be measured are on the order of just a few nanoteslas.

Flight data was collected over many carefully defined patterns and altitudes, but that's just a part of the project *(Fig. 3 on page 46)*. To create an accurate map, a very large list of basic and advanced corrections and compensations is needed to adjust the raw data for measurement-zone fringing, flight height differences, aircraft-induced distortions, and numerous other factors.

It would be nice to say the tests were successful and proved the viability of the MAGNAV concept, but that's the simplistic view. The paper has dozens of graphs and tables analyzing the data from multiple perspectives, and this isn't a pass/fail subject.

> The Earth's core field has values ranging from 25 to 65 microtesla at the surface of the earth about 100 times weaker than a refrigerator magnet), while the magnetic anomaly field of interest typically varies by just hundreds of nanotesla, making it about 100 times weaker than the core field.

The Earth's core field has values ranging from 25 to 65 microtesla at the surface of the earth about 100 times weaker than a refrigerator magnet), while the magnetic anomaly field of interest typically varies by just hundreds of nanotesla, making it about 100 times weaker than the core field. The process of extracting meaningful anomaly data is somewhat analogous to determining a minuscule, random-like signal about which some general characteristics are roughly known, but it's obscured by much larger and also somewhat varying dc-like baseline—a classic high-end problem in signal estimation theory.

To further analyze the voluminous data and reduce it to meaningful results, the core project team recently posted a 21-page paper defining a "challenge problem" to be worked by the team as well as outsiders. The paper, "Signal Enhancement for Magnetic Navigation Challenge Problem," clarifies the many issues and establishes objectives for this challenge problem for filtering the noisy, nonlinear, distorted data and applying numerous adjustments. The result would decouple the Earth and aircraft magnetic signals and in turn derive a clean, corrected signal that could be used to perform magnetic navigation.

Baseline testing on the dataset shows that the Earth's magnetic-field anomalies can be extracted from the total magnetic field using ML and a trained neural network.

(Continued on page 46)

DAVID MALINIAK | Editor

What's Trending in Defense and Aerospace Tech?

Microwaves & RF **chats with Rick Gentile about the changing technological landscape in the military and aerospace industries, and the systems, tools, and techniques used to help engineers keep pace.**

RICK GENTILE IS PRODUCT MANAGER for Signal Processing, Radar, and RF products at MathWorks. He's well-known to *Microwaves & RF's* readers as an author of the popular "Algorithms to Antennas" blog. We spoke to Rick about emerging trends in the military and commercial aerospace industries, and the following is an edited transcript of our conversation.

Could you just start by telling me a little bit about yourself?

Sure. I've been at MathWorks for about five years, during which time I've focused on tools that are built on MATLAB and Simulink, particularly those focused on signal processing, RF, radar, and wireless. Before MathWorks, I started off in the radar business in roles at MITRE and MIT Lincoln Laboratory. And in the middle, I was in the signal-processing group at Analog Devices. Here at MathWorks, I've focused on the tools that help customers simulate their systems before they start building them. So, I've had a broad background in terms of RF, microwaves, signal processing, and now system modeling.

What made you want to be an engineer in the first place?

I always was kind of a hobbyist and my uncle was an electrical engineer. I'd see some of the projects he worked on when I was a kid and from then on, I knew that's what I wanted to do.

What are some of the similarities (and differences) between the requirements of military and commercial aerospace customers?

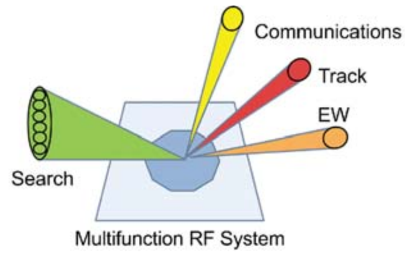
We've seen a lot of convergence in terms of what they're looking for; I think there's a lot of overlap. For example, in the past, some of the mil/aero customers might have started off building radars. Now, they build multifunction RF systems, radar systems with built-in communication systems as well as electronic-warfare functionality, all in the same form factor. So, they now want to squeeze in a lot of different capabilities.

The other similarity is that the systems are much more complex. The requirements their systems must satisfy are a huge step up from previous generations, especially on the aerospace/defense side, where they're building one system that performs multiple roles. That creates a lot of very different challenges, especially as the need for bandwidth and security are balanced with cost, power, and smaller form factors.

We've also seen mil/aero customers adopting fast-moving technologies from areas driven by LTE and now 5G. They had been used to working at a much slower pace in building a mil/aero system, where the technology may have derived from a custom development. Now, they make a conscious effort to adopt new technologies like software-defined radios or more generally using commercially available technology in their designs to stay competitive. They don't have to develop it themselves and, theoretically, it should help them get to market faster.

One big difference is that military-focused development often involves upgrading existing systems, which may add constraints that would be present in a new commercial system.

The military has standardized on a lot of RF technology. What's been the impact of that trend?



1. Phased-array technology provides the flexibility needed to implement multifunction RF systems. *(© 1984-2020 The MathWorks, Inc.)*

Across the industry, this standardization has helped to shorten development time for new systems and for system upgrades. In many ways, it makes it easier to adopt commercial technology at larger scales. It also helped to ensure commonality across systems, which also is more friendly to the logistics and fielding of military systems.

From a MathWorks perspective, we have seen a large adoption of our standards-based products. For example, many of our military customers have adopted our 5G Toolbox. We saw this with LTE as well, where they're using these commercially available standards. Sometimes they're doing it for communications. Sometimes, in passive-radar or signal intelligence systems, they might be using the transmitters for these kinds of systems.

There's more overlap than one would think.

There is overlap.

As the wireless community moves to millimeter-wave (mmWave) frequencies, we find them asking for help in areas where mil/aero customers have been working for a long time. For example, mil/aero applications have had large, phased arrays for a long time. Now, we see wireless customers adopting some of

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those technologies that we might have engaged with mil/aero customers in the past. Areas like hybrid beamforming, implementing subarrays, and designing how they're partitioned.

The other big area is that the systems have to coexist in a crowded RF spectrum. This is an area where the overlap must also involve shared algorithmic techniques and resource management to ensure peaceful coexistence when systems operate together.

They seed each other to some extent.

Yes. On one hand, the aero/def industry benefits from the technology that's been driven by the move to 5G. Meanwhile, the wireless folks benefit from years of work the mil/aero industry has helped to drive with systems that implement phased-array systems.

Let's hear more about the newer integrated systems with radar, communications, and so on.

On the aero/def side, especially for new starts or modernizations, a lot of projects are viewed as not just radar, communications, or electronic warfare, but likely to be a multifunction RF system. It's a single system, but the flexibility of having a phased-array front end enables switching between different functions as needs shift while systems are operational *(Fig. 1)*.

Sometimes they might operate as a radar, at another time as a communication system, or in passive signal-analysis mode. But it's not three different systems; rather, it's a system that, because of the flexibility that the phased array provides, has the spatial awareness of what's going on around it. It changes how these systems can operate, and a lot more engineering goes into making them work. It's that upfront design activity that drives the complexity, and that's where we come in to help our customers model and simulate their designs to ensure rework isn't needed at stages later in the project, where it becomes much more costly.

Systems that once did one thing repeatedly now must intersperse these different functions, so areas like resource management become more critical. How do you manage more than one function at the same time? We also see this in a complex system like a 5G base station. You want to achieve the highest possible bandwidth and the lowest latency in a complex, multi-user environment. It's about that layer above the physical layer, where you're managing the system operations.

So, how does that translate into the challenges faced by customers?

Most often, it's coming up with a scalable architecture that meets their requirements. The front end of that process is ensuring their design will work when it's built. That's where our tools start to add value, and it's where we have a lot of our customer engagements. The challenge for the customer is in making sure that what they end up building is the same system that they modeled in the front-end portion. So, we've seen adoption of our tools across those workflows.

Customers also want to be able to generate code from their models to implement in the system. That's made trickier for smaller companies and smaller design teams, which is often the case in recent years. So, there are people who have more than one responsibility and those responsibilities cross disciplines. It's helpful for them to have a technical starting point at each stage of their system design. In the past, there would be specialized engineers for software and hardware, but now the lines get blurred because they have to move from algorithm to hardware much more seamlessly.

I tend to think of MathWorks in that realm of high-level algorithmic modeling. Do you now find yourself being pulled across into the hardware side? Or is it more like creating a bridge that can be crossed from software into hardware?

We're pulled into hardware in the sense that customers use our tools to generate C code, or code for a GPU or FPGA, directly from their models. We also support workflows in which we can connect to software-defined radios and radars, controlling these systems and collecting data from these systems in MATLAB and Simulink. Customers also use our tools to connect to test equipment.

Customers want to ensure the algorithms they have developed match the ones they implement on their end system. The generated code, whether it's HDL, C, or CUDA code, will run on some end processing element, an FPGA, a processor, or a GPU. There's a direct connection into deployment from their algorithms. That starts from the upfront prototyping and requirements analysis.

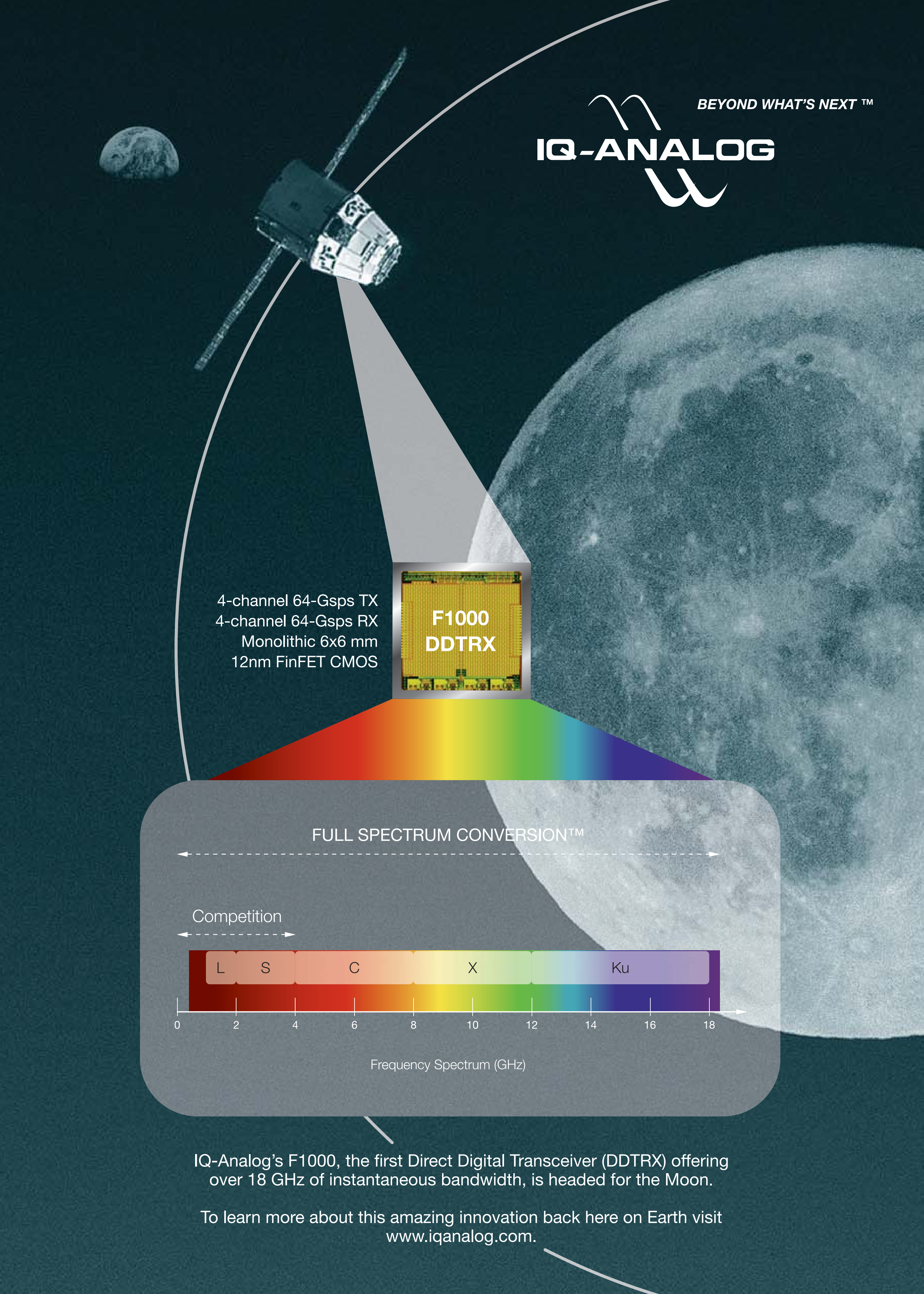
The other connection to hardware that you see is in test and measurement. It's in being able to feed, say, 5G waveforms into a signal generator and into your system, or taking data off the test equipment. Our IMS demos this year were hardware-based, tightly integrated to radios, radars, and test equipment.

Can you envision your tools touching things like electromagnetic simulation?

Well, our solver-based Antenna Toolbox lets you define an antenna or antenna array, and then we can solve those structures for analyzing currents and the resulting near- and far-field patterns. Our solvers also can be used for installed antenna analysis on electrically large structures. Then, after you've done the analysis, one of our workflows directly generates the Gerber files. It's a full design system.

We have customers that then put that design into larger system models to increase the fidelity of their models. We have a set of apps that make it easy to design elements and arrays using solvers.

A design flow like this gives all engineers a voice at the modeling table. The engineer doing the solver-based antenna can use the outputs of that process to get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a prototype built, and then it can be integrated into the system engineers' flow to see that it works together before doing the end integration. They can smoke out problems beforehand. Some customers get data from anechoic chamber tests, from other testing, or from other solvers, and the design environment can bring that information into the model as well to increase the model fidelity.

So, what comes out of the solver can be pulled back up into the higher-level model.

Exactly. The antenna designers can prototype and analyze to determine the best pattern, and that pattern can be brought into the system model where they can steer it. If a signal were in the null of the pattern, they'd see in the system model that their pattern wasn't going to work. It's closing the loop.

Back when I started out, these things would have been done standalone. Maybe we would find such problems in the lab, but most likely we had to bring it out to the site. Today, we have much more insight into whether a design will work, and if it doesn't, we have a model to go back to and tweak until it does.

What about broad trends that you're seeing in aerospace and defense?

There are the multifunction RF systems. Another big one is the broad adoption of artificial intelligence (AI) for things like modulation identification for communication systems or electronic-warfare (EW) systems, target identification, channel estimation, and, more recently, RF fingerprinting, which is the ability for people to use AI to identify trusted nodes.

The other trend is broad adoption of commercially available software-defined radios and radars by the aerospace and defense community. These systems, because they're all moving into the same RF spectral area, must be more efficient and smarter about interference and coexistence. Some people are looking to AI to help with smart spectrum management, avoiding airport radars and things like that.

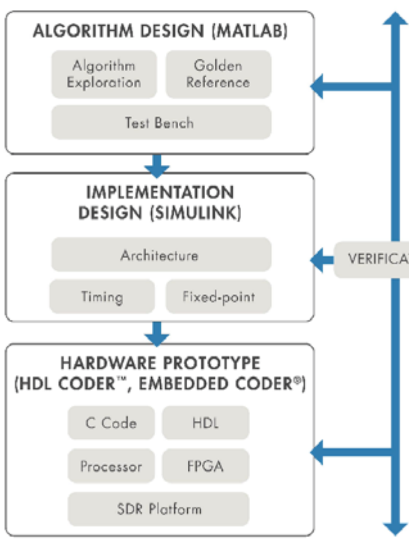
Let's end with an overview of MathWorks' tools and how they support aerospace and defense.

MATLAB and Simulink are our platform products: MATLAB provides a great platform for algorithm development. Simulink is used widely for multi-domain simulation (baseband and RF), deployment, and as an integration platform for diverse engineering teams *(Fig. 2)*.

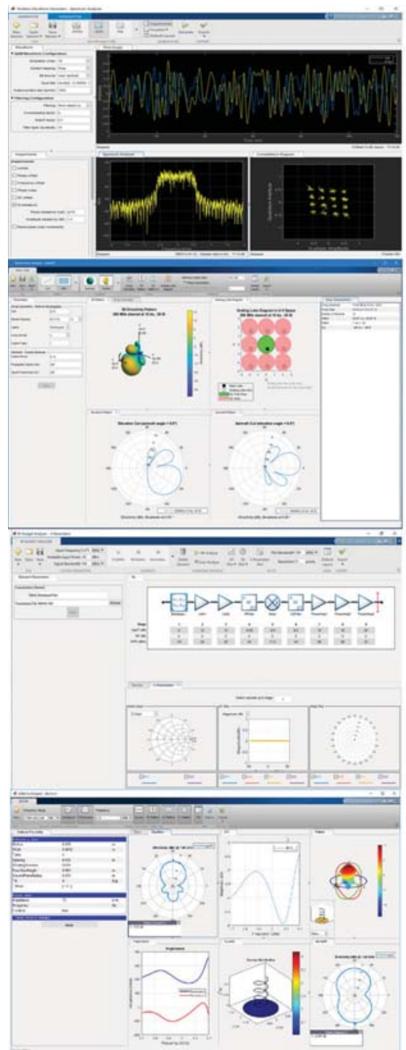
In the case of wireless and aero/defense, we've also seen strong adoption of our toolboxes. On both the commercial and aero/defense sides, our standards-based 5G Toolbox and LTE Toolbox see a lot of use. Collectively, our tools are used to develop the layers of media-access control (MAC) and PHY, where they're building right up from requirements analysis through development and into deployment, putting algorithms on hardware.

Many of our customers are using the tools across the different phases of their project lifecycle, so that the antenna engineer, the RF engineer, and the signal-processing engineer all work on a common simulation framework *(Fig. 3)*. It's being able to do quick tradeoffs and what-if analysis.

As you build up, say, the channel model, it gradually expands into something looking very much like what the system will be. You're taking data from the chamber and incorporating that into the system. And each time, you're taking controlled steps in the design and not having big incremental changes. If something doesn't work, you can always dial back to something that's known to work and figure out what you changed.



2. MathWorks tools are used to design, model, implement, and test wireless systems. *(© 1984-2020 The MathWorks, Inc.)*



3. MathWorks provides applications that make it easy to design and analyze antenna elements and arrays and RF systems. *(© 1984–2020 The MathWorks, Inc.)*

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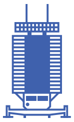
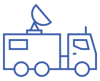


Long-Range Surveillance

Battlefield Management



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MODEL BME1829-50 is a compact solid-state power amplifier (PA) from Comtech Power Systems Technology based on GaN semiconductor technology. The switch-controlled two-band PA provides better than 2 W CW output power from 100 to 500 MHz and more than 50 W CW output power from 800 to 2000 MHz. It incorporates TTL-controlled hot-switchable band control and has enable/blanking time of better than 5 µs. The class A/AB linear PA integrates a wideband dual directional coupler to simplify system integration. The PA is designed for operating temperatures from -40 to +85°C. It measures 5.5 × 4.5 × 1.6 in. *(see figure)* and weighs just 1.9 lbs. while meeting MIL-STD-810F requirements for shock and vibration. High-band harmonic rejection is -12 dBc or better while spurious levels are controlled to below -55 dBc. The conduction-cooled PA is designed for use when connected to a heatsink.

COMTECH POWER SYSTEMS TECHNOLOGY, www.comtechpst.com

Prototyping System Supports FPGA Motherboards with Up to Four Modules

PRO DESIGN recently launched its new series of Intel Arria-based FPGA prototyping systems supporting motherboards with one (uno), two (duo), or four (quad) FPGA modules. The company states engineers can use the systems to scale small to mid-range IP and SoC verification efforts from 8 million to 32 million ASIC gates via the Arria 10 FPGA technology. The proFPGA uno, duo, and quad A10 GX 1150 systems allow different types of FPGA modules to be easily connected and integrated, which provides an extended range of FPGA I/O with up to 24 extension sites on the new platforms.

PRO DESIGN, www.profpga.com

Ruggedized Rack-Mount Servers Handle High-End Defense Requirements

MERCURY SYSTEMS unveiled its new line of ruggedized rackmount RES-XR6 servers, which pack up to four 2nd-generation Intel Xeon Scalable processors and 6 TB of DDR4 ECC memory. The company states the new series offers efficient processing power for applications that include AI, radar, C4ISR, and tactical networking for defense. Advanced features include the ability to scale existing HPE infrastructure from the data center to aerospace, defense and tactical edge applications, and enhanced threat protection with commercially available Trade Agreements Act (TAA)-compliant components, which utilize HPE silicon and firmware. The RS-XR6 series also offers simplified management, deployment and provisioning, leveraging enterprise-grade software from HPE, and extended product lifecycle support for mission-critical operations.

MERCURY SYSTEMS, www.mrcy.com

Field-Installable Termination Systems Save Time and Costs

TIMES MICROWAVE SYSTEMS has debuted its Field Installable Termination Systems (FITS), a new line of LLSB cables, connectors, and tools for shipboard, airborne, and ground-based military interconnect systems. The new FITS can be easily and reliably terminated in the field with no soldering required, saving time and cost on installation. Bi-metal plating ensures corrosion resistance. LLSB-240, 400, and 600 cables pair with the new FITS connectors and have assigned DLA part numbers. The connectors meet numerous applicable military specifications for shipboard applications.

TIMES MICROWAVE SYSTEMS,
www.timesmicrowave.com

Intelligent RF Spectrum Recorder Grabs 1024 Signals

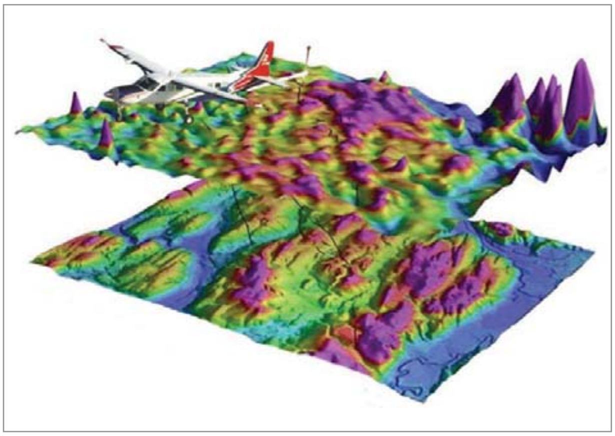
ABLE TO AUTOMATICALLY RECORD 1024 individual wide- or narrow-band signals for after-event analysis, characterization, or archiving, Novator Solutions' ODEN 3001 is an intelligent RF spectrum recorder with 765 MHz of real-time bandwidth. All triggered signals are processed simultaneously and stored in dedicated files, which reduces the time and cost until the data can be further processed. The new intelligent-recording approach is suited for signal surveillance applications such as communications intelligence (COMINT), electronic intelligence (ELINT), or International Telecommunication Union (ITU) spectrum management. The recorder covers a frequency range of 16 kHz to 14 GHz or 26.5 GHz with 765 MHz of instantaneous bandwidth. It provides 128 digital downconverters (DDCs) for the entire instantaneous bandwidth. A 1024-DDC option for an instantaneous bandwidth of 200 MHz will also be available. The system can be ordered with both in-chassis and external RAID hardware, including enterprise-class disks with standard configurations from 4 TB to 184 TB.

NOVATOR SOLUTIONS,
www.novatorsolutions.com

Magnetic-Field Navigation as an "Alternative" GPS? (Continued from page 37)

However, there's much more work remaining, including additional flight tests over different regions to attempt to demonstrate the feasibility of this navigation approach.

Will MAGNAV become a viable alternative or backup to GPS? It's obviously not clear at this time. Nonetheless, there's some historical irony here, as the magnetic compass was among the earliest navigational tools. The possibility of using precision magnetometer measurements of anomalies in the Earth's field along with detailed maps could, in some ways, be considered a highly sophisticated extension of the compass, but by many orders of magnitude.



3. The objective of the first stage of the project is to collect high-resolution magnetic-field anomaly raw data that can be used to create an accurate 3D map. *(Source: Air Force Institute of Technology)*

Latest Aerial Refueler Extends Air Force's Reach

The U.S. Air Force hopes to extend the reach of its forces through the use of its KC-46A advanced aerial refueling aircraft.

GLOBAL REACH FOR THE U.S. AIR FORCE is often a matter of fuel supply, and the new KC-46A Pegasus refueling tanker provides the means of providing much-needed aircraft fuel while still in the air. The high-capacity aircraft displaces the KC-10 Extender while replacing the KC-135 Stratotanker refueling tankers. The KC-46A provides added mobility and capability to aid global missions as well as crisis and contingency operations. It is being developed as part of a multiple-phase construction operation by the Air Force Civil Engineer Center (AFCEC).

The AFCEC provides full-spectrum installation engineering services for the new refueling tanker, especially in the form of infrastructure to support the latest vehicles and equipment. Colonel David Norton, director of AFCEC's Facility Engineering Directorate, said, "The Air Force relies on AFCEC to design and deliver resilient facilities which will accommodate the needs of the KC-46A fleet."

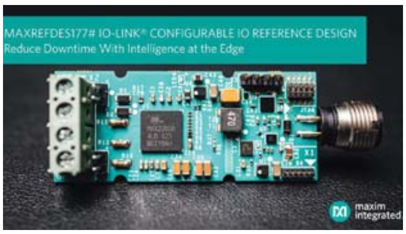
AFCEC is working jointly with the U.S. Army Corps of Engineers and the Naval Facilities Engineering Command on construction efforts to provide infrastructure for the KC-46A aircraft *(see figure)* across the Air Force. "Infrastructure is critical to air power. We work closely with the bases to improve their facilities and ensure they are mission ready," added Norton. The $500 million infrastructure modernization program in support of the new refueling tankers began in 2016 at Tinker AFB, Oklahoma.

Right-Angle Coax Adapter Combines 2.92-mm Connectors

Mini-Circuits' model KMR-KM50+ is a right-angle 2.92- × 2.92-mm adapter with 2.92-mm coaxial connectors and low insertion loss of typically 0.13 dB from dc to 40 GHz. The typical VSWR for the 50-Ω adapter is 1.06:1 to 20 GHz and typically 1.15:1 from dc to 40 GHz. The RoHS-compliant adapter, which can interface with SMA connectors, features passivated stainless-steel construction with gold-plated beryllium-copper center conductor for long-lifetime operation. It has outside dimensions of 0.673 × 0.520 × 0.543 in. (17.10 × 13.20 × 13.80 mm).

MINI-CIRCUITS, www.minicircuits.com

IO-Link Communications Technology Reduces Factory Downtime

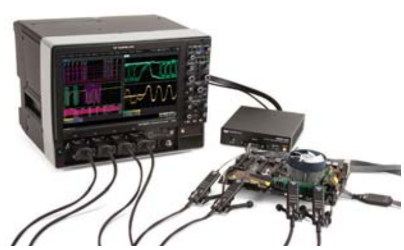


Modern smart factories need to quickly and remotely adjust a sensor's electrical characteristics to minimize downtime and maximize throughput. Maxim Integrated Products' new MAXREFDES177# IO-Link reference design demonstrates the flexibility of the MAX22515 IO-Link transceiver, seamlessly configuring all modes of the MAX22000 software-configurable analog I/O. This chipset provides flexibility with faster reconfiguration to reduce factory downtime. The MAX22000 and MAX22515 build upon the benefits of IO-Link's two-way universal interface. The IO-Link interface allows every IO-Link sensor, actuator, or I/O expansion module to be interchangeable to a standard hardware interface. It also provides software-defined performance parameters and selectable analog input or output performance modes. These software-selectable capabilities are combined and demonstrated in the MAXREFDES177# IO-Link reference design.

MAXIM INTEGRATED PRODUCTS, www.maximintegrated.com

Oscilloscope Software Empowers DDR5/LPDDR5 Debug

Teledyne LeCroy has launched its DDR5 Debug Toolkit for its SDA 8 Zi-B and LabMaster 10Zi-A oscilloscopes. The new DDR/LPDDR5 JEDEC specifications JESD79-5/ JESD209-5A feature faster rates of up to 6400 Mb/s. As DDR5 and LPDDR5 controllers make their way into embedded systems with faster DRAM, the task of design validation and debug becomes even more challenging for DDR validation engineers. The DDR Debug Toolkit now supports DDR5/ LPDDR5 for test, analysis, and debug of the entire DDR design cycle. Both the DDR5 and LPDDR5 Debug Toolkits are backward-compatible with earlier generations of memory. The software is priced at $7500.



TELEDYNE LECROY, www.teledynelecroy.com/ddr/

250-W LDMOS RF Power Transistors Serve 2.45-GHz ISM Applications

Ampleon has rolled out its BLP2425M10S250P, a 250-W RF power transistor for solid-state cooking and industrial, scientific, and medical (ISM) applications in the 2400 to 2500-MHz frequency band. Using Ampleon's tenth-generation LDMOS process, the BLP2425M10S250P operates with 67% drain efficiency, saving energy and simplifying the cooling requirements in high-power systems. Changing from a traditional ceramic to a plastic package makes the device a cost-effective alternative for replacing traditional 2.45-GHz magnetrons. The ability to accurately adjust output power and frequency make solid-state RF amplifiers particularly suitable for industrial applications such as plasma generation, and for the emerging solid-state cooking market.

AMPLEON, www.ampleon.com

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