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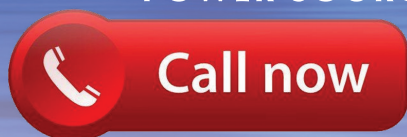
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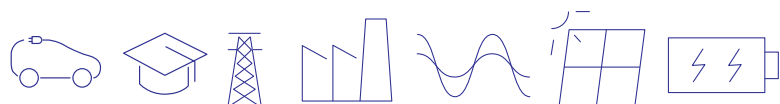
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# EDITOR'S NOTE

## MAKING LEMONADE

It's pretty obvious to even the most casual observer that we are currently living in interesting times. Even before our society was challenged by the latest cultural unrest, climate issues, and a viral pandemic, the electronics industry was and is being rocked by disruptive technologies. Fomented by events, these turbulent situations have merged into a perfect storm of change.

The first thing to do is to recognize times like these as opportunities for positive change. Another thing that should be obvious to everyone is that in every one of these fronts, going forward is the only way to overcome the challenge. From developing more efficient electronics and improved green-energy systems to healthier societal paradigms, we will prevail over the monsters that oppose us.

### Task-based work

We are already beginning to experience the ramifications of the shift to remote work for those who are able. This has fomented many different management styles to address the need to ensure productivity and goal achievement with a widely-spread team. Among the most successful and productive are those focusing on task-based, rather than time-oriented, work.

This approach is well-suited for the electronics industry, which usually has a project-oriented philosophy in the creation of products. Reducing the number of meetings and attend-only events often results in significantly increased productivity, while also allowing workers to use the rest of their time in a more personally-fulfilling manner.

### Web-based collaboration

Team-oriented online collaboration has been around for a while, but has now entered its apogee. While this may be the peak, the ebb will not be large, as web-based tools have demonstrated that effective (and short) meetings and the easy exchange of documents and data are business force multipliers. Telepresence applications have also underscored the unimportance of where

people are. This is freeing in multiple ways, as workers can locate to (or remain in) places with a more favorable cost of living, culture, or climate to them.

The ability to have productive workers living anywhere also expands the ability for companies to grow, as previously the people with the ability to jumpstart new ventures couldn't leave the office long enough to implement them. Now that the value worker can be on-site while still participating in day-to-day operations, companies can do more with less. It is also easier to address remote problems when the raw data can be acquired on the spot.

### Improved web infrastructures

The significant increase in the number of users and volume of traffic online has also exposed the issue of web infrastructures. The best tool in the world is useless if you can't operate it, and the best gathering of minds on the planet can't get anything done if there are bandwidth and latency issues. This nuisance situation creates a strong demand for better and more robust connection and networking solutions, faster and fatter than before.

Next-generation solutions like 5G and WiFi 6 promise to deliver the performance we demand, with the security and reliability we need. There are other things going on in the industry that will also impact Web and Cloud bandwidth and latency, from Edge Computing to the migration of low-information devices to solutions such as Long-Range Wireless (LoRaWAN), Bluetooth Low-Energy (BLE), and Low-Power Wireless Bus (LWB).

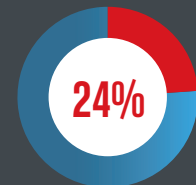
### Smart cities, smart people

This storm has also accelerated the development of next-generation technologies such as smart devices, facilities, and municipalities. These will all be integrated at some level, providing advanced functionalities to everyone. The transition to green energy systems, advanced personal devices and self-driving EVs will also accelerate. The result of this, once we come through the storm, promises to be a better place for us all. **EE**

## BY THE NUMBERS

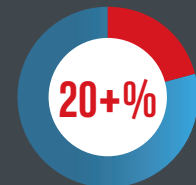
67.7 **BILLION**

Projected global fab equipment spending in 2021



Estimated increase in global fab equipment spending over 2020

Source: SEMI



Forecast increases for global memory market year-on-year in 2021 and 2022

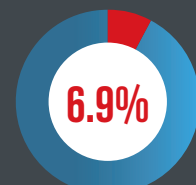
163.3 **BILLION**

Amount the global memory market is predicted to surpass in 2022

Source: IC Insights

104.6 **BILLION**

Worldwide sales of semiconductors in Q1 2020



Estimated year-over-year increase in Q1 semiconductor sales

Source: SIA

# SIGNALING THE FUTURE

> **SASI 240 PROVIDES COMBINED CAPABILITY OF:**

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- Vector waveform analyzer
- Dual-channel oscilloscope

> **APPLICATIONS**

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- HDMI Integrated ATE

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- WRT external 10 MHz Ref: +/- 5 Hz

> **CHARACTERISTICS**  
3U, 19" rack mount

> **FREQUENCY**  
DC to 40 GHz



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Stand alone, fully integrable



Advanced user interface



Ethernet controlled

# RFS 340

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+5 to -100 dBm over 20 to 40 GHz

> **PHASE NOISE**  
Excellent spectral purity, low phase noise

> **SIGNAL**

- Vector signal generation
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> **CHARACTERISTICS**

- 1U, 19" rack mount
- Ethernet Controlled

> **FREQUENCY**  
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## Multimode Seeker Strikes Successfully at Redstone Arsenal

The U.S. Army reports outstanding results for its first open-air testing of an advanced multimode seeker during two days of recent testing at the Redstone Arsenal in Alabama. The new seeker is meant as an upgrade to the Precision Strike Missile system, adding advanced Spiral One signal tracking capabilities. The experimental missile tracking system was operated at 50% capacity, tracking moving targets while mounted on a



pod under the wing of an aircraft. The multimode seeker stems from the Land-Based Anti-Ship Missile program that began in 2015 to help the Army target enemy ships with its long-range precision fires capability. During its development, it was learned that the system was also capable of tracking radio signals from land-based targets as well as ships, such as mobile radars and communications systems on vehicles. The use of multiple sensors makes it possible to locate targets of interest even without good coordinates.

“We think we’re on the right track,” said Brigadier General John Rafferty, director of the Long-Range Precision Fires Cross-Functional Team. Rafferty explains that the Army hopes to field the Precision Strike Missile system in 2023, with the Spiral

# INDUSTRY REPORT



## IMTS is Latest Trade Event to Cancel

The International Manufacturing Technology Show is the latest major trade show to close up shop due to the global pandemic.

The Association for Manufacturing Technology (AMT), which stages the biannual show in Chicago, said late Monday that the 2020 edition of IMTS has been cancelled after show officials said they could not get assurances from state or city officials that the venue would be cleared to open in time for the September show.

“In early May, [Illinois Gov. J.B. Pritzker] introduced a five-phased plan to reopen Illinois businesses. As it reads, the plan specifically states that conventions are included in phase 5 of the plan,” wrote AMT Vice President Peter Eelman in a letter on the IMTS website. “The conditions that must be met for the implementation of phase 5 feature either the availability of a vaccine for the COVID 19 virus or a highly effective treatment protocol, neither of which are expected to occur in the coming months.”

Citing the “difficult and challenging circumstances” around the ability to open the show on time, AMT announced the cancellation. “While this saddens us, the health and safety of our exhibitors and audience remains our top priority,” Eelman wrote.

IMTS is the largest North American manufacturing show and was expected to fill more than 1.6 million square feet of exhibit space at Chicago’s McCormick Place. Hannover Messe USA, the first branded Hannover Messe show outside of Germany, has been co-located with IMTS for the past eight years and brought industrial automation and control systems to be part of an event that already included machine tools and CNC machines.

As has happened with other global trade events affected by the 2020 pandemic, IMTS officials plan to introduce a live-streaming version of its existing IMTS network and a new digital platform, called IMTS Spark, that Eelman wrote would be launched shortly.

One capability integrated by 2025. The functionality will extend the firing range of the Army Tactical Missile System (ATACMS) by more than 500 km. “We’ve got our eyes wide open on the development of this program,” said Rafferty. “We have a small intelligence and targeting team. And one of their primary functions is to make sure that in our approach to developing weapon systems that we have the right targets in mind.” Mike Turner of the Aviation and Missile Center at Redstone Arsenal, added: “We think that’s going to provide significant advantage to us in our long-range fires, rockets, and missiles.”

Miniaturization of multiple on-board processors has made it possible for the seeker system to acquire and track multiple targets within a small housing. Part of the testing will explore operation at full capacity, with testing moving to the White Sands Missile Range in New Mexico during autumn 2020. Rafferty acknowledges that industry partner, Lockheed Martin, can be credited for outstanding safety measures during the testing.

## DoD Adds Sites to Study 5G Technology

Even the U.S. Department of Defense is getting ready for Fifth Generation (5G) cellular wireless communications technology, or at least how to defend against it on a battlefield. The DoD has announced seven more military installations in the U.S. as places to learn more about 5G through experimentation and testing. The locations are part of the DoD’s 5G development roadmap known as “Department of Defense 5G Strategy.” The



U.S. Army

added facilities are Naval Base Norfolk, VA; Joint Base Pearl Harbor-Hickam, HI; Joint Base San Antonio, TX; the National Training Center (NTC), Fort Irwin, CA; Fort Hood, TX; Camp Pendleton, CA; and Tinker Air Force Base, OK. These seven facilities in the second round of 5G study facilities, referred to the DoD as its Tranche 2 selection of research facilities, combine with the earlier five 5G research facilities for a total of 12 locations for 5G research.

The increased data demands of 5G systems compared to earlier cellular wireless communications generations is pushing the use of frequency spectrum well into the millimeter-wave frequency range, at and above 24 GHz. In addition to connecting billions of people via wireless communications, 5G networks will connect many things, many sensors known as Internet of Things (IoT) devices. Military bases selected by the DoD earlier for 5G research chores, as part of the Tranche 1 choice of research facilities, are the Joint Base Lewis-McChord, WA; Hill Air Force Base, UT; Naval Base San Diego, CA; Marine Corps Logistics Base Albany, GA; and Nellis Air Force Base, NV. All the bases feature analysis and testing capabilities in areas needed to

explore phenomena at higher frequencies and wider bandwidths, and the capabilities to explore the performance levels of the latest wireless communications infrastructure equipment.

Although civilian users are looking forward to the availability of 5G systems, it is expected that the technology will play major roles in both military and civilian applications. The DoD is already issuing requests for prototype proposals from industry partners in key areas, including for ship-wide and pier communications at the Naval Station Norfolk, for enhancing aircraft mission readiness at Joint Base Pearl Harbor-Hickam, and for wireless communications for forward operating bases (FOBs) and tactical operations centers (FOCs) at the NTC at Fort Irwin and Fort Hood, TX and for FOBs and TOCs at Camp Pendleton, CA.

### Army Studies Energy Levels for Hot Electrons

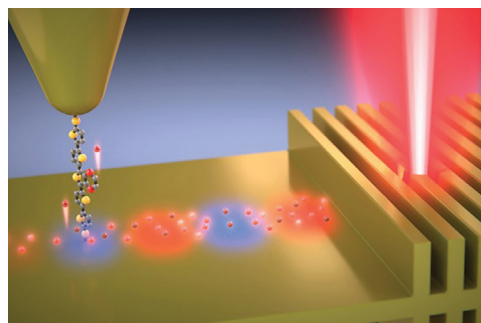
High-energy or “hot” electrons have been of interest for some time in many fields because of their potential for accelerating electronic reactions. But to learn more about how to put hot electrons to work, researchers needed a practical measurement approach to

measure the energy levels of those and other charge carriers. Fortunately, recent studies performed by scientists at the University of Michigan and Purdue University as part of the Department of Defense’s (DoD’s) Multidisciplinary University Research Initiatives program and published in the journal *Science* provided details on the direct measurements of the energy levels and energy distributions of hot electrons.

The energy distribution of hot electrons was measured by a scanning tunneling microscope integrated with lasers and other optical components. Such measurements can provide insights on the efficiencies of different energy sources, such as motion-driven generators and solar panels. The research was

onto a 13-nm-thick gold film with ridges designed to resonate at the frequency of the incident light.

“This multidisciplinary basic research effort sheds light on a unique way to measure the energy of charge carriers,” said Dr. Chakrapani Varanasi, an ARO program manager, who supported this study. “These results are expected to play a crucial role in developing future applications in energy conversion, photocatalysis and photodetectors, for instance, that are of great interest to the Department of Defense.” Dr. Edgar Meyhofer, a professor of mechanical engineering at University of Michigan, who co-led the research along with professors Pramod Sangi-Reddy and Vladimir Shalaev, explained: “If you wanted to employ



U.S. Marine Corps

light to split water into hydrogen and oxygen, you can use hot charge carriers because electrons that are more energetic can more readily partici-

participate in the reaction and drive the reaction faster.” “Measuring energy distribution means quantifying how many electrons are available at a certain amount of energy,” said Harsha Reddy, a doctoral candidate in Purdue’s School of Electrical and Computer Engineering and co-lead author on this paper. “That crucial piece of information was lacking for expanding the use of hot electrons.”

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▼ Keysight technologies 5G NR R&D testbed.  
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**SPECIAL REPORT**

# SPECTRUM OF INTEREST SPANS SUB-6-GHZ CELLULAR FREQUENCIES TO MMWAVE RADAR

By Rick Nelson, Contributing Technical Editor

► Increasing complexity and the need for higher frequencies and bandwidths, multiple channels, low-power operation, and space constraints are placing considerable demands on RF/microwave test equipment. Solutions extend from simulation software to bench, modular, and portable instruments to complete systems, for applications from R&D to compliance test and field service.

“The RF/Microwave test field is witnessing a profound change related to the diffusion of technologies using RF signals (and, in the most advanced applications millimeter-wave signals) to communicate, transfer, and exchange

information,” according to an email message from Keysight Technologies. In the last few months, the company has introduced several hardware and software solutions.

“On the software side, Keysight’s PathWave integrated software suite plays a critical role in 5G and mmWave design, verification, and test methodologies,” the company said. “PathWave software streamlines the entire workflow from system-level modeling to RF/microwave circuit co-simulation and analysis. Companies like Nokia Bell Labs rely on PathWave and the entire Keysight ecosystem to gain the valuable engineering

insights they need to push wireless technology to the next level. Keysight is also collaborating with Nokia on a new software approach that leverages artificial intelligence and advanced data analytics in the company’s 5G base station manufacturing processes, significantly improving test efficiency.”

On the hardware side, Keysight in 2019 introduced what it calls the first single-box multichannel solution for wideband mmWave measurements. “Based on the UXR-Series of oscilloscopes, it delivers fast, affordable, coherent analysis for wideband measurements up to 110 GHz. This solution accelerates the development



of next-generation mmWave communications, satellite communications, and radar applications,” Keysight said.

### Characterization to production

Rohde & Schwarz is addressing various aspects of RF/microwave test, including characterization, network rollout, automotive radar, and cross-channel measurements, according to Markus Lörner, market segment manager industry components, research and universities.

For network rollout, Lörner said, 5G operators can employ the R&S TSME30DC drive-test scanner. “Networks anchored in LTE, or making use of dynamic shared spectrum (DSS) to transmit 5G-related data using part of the LTE spectrum, or with separate networks utilizing FR1 and FR2 frequencies, can scan both frequency ranges simultaneously to save time and effort, by using the R&S TSME30DC with a suitable drive-test scanner,” he said, adding that frequencies from 450 MHz to 6 GHz and 24 to 30 GHz can be scanned simultaneously.

Lörner pointed out that automotive-radar applications are migrating from the

24-GHz band to 79-GHz. “The 4-GHz instantaneous bandwidth greatly improves the range resolution, accuracy, and reliability of object detection, and the higher frequency reduces the device size. The R&S ATSI500C over-the-air antenna test chamber has been designed to meet requirements for 79-GHz automotive radar test, for R&D, validation, and calibration, in combination with the R&S AREG.”

The R&S ATSI500C features a CATR reflector, providing a 30-cm diameter quiet zone—large enough to test the largest automotive radar sensor aperture used for the frequency band, Lörner said, while the R&S AREG100A automotive radar echo generator can include interference while generating up to four echoes simultaneously, all with the in-demand 4-GHz maximum instantaneous bandwidth.



▲ Rohde & Schwarz ATSI500C over-the-air antenna test chamber.

According to Adam Smith, director of product marketing at LitePoint, the company’s product focus for 2020 is in three main areas: 5G, both sub-6-GHz FR1 and mmWave FR2; Wi-Fi 6E, utilizing

the 6-GHz unlicensed band; and Ultra-Wideband (UWB), based on an emerging application space in accurate positioning and ranging.

“LitePoint has recently released new products to address the unique technical requirements of each of the technologies listed above,” Smith said. First, he described the IQgig-5G Model B as “Our second-generation 5G mmWave product focused on scaling 5G mmWave FR2 end-products to high-volume manufacturing. Currently, the IQgig-5G is the only fully-integrated mmWave test system in the market, deployed on manufacturing lines testing up to four devices in parallel. Further, IQgig-5G offers best-in-class error vector magnitude (EVM) performance across all existing and forthcoming 3GPP bands, in a contiguous 23- to 45-GHz range.”

Smith said the IQxel-MW 7G is specifically targeted at testing Wi-Fi 6E products. “The IQxel-MW 7G is a fully-integrated wireless connectivity test solution that addresses the high-performance needs of products launching later this year, operating in the new 6-GHz unlicensed band (6 to 7.125 GHz),” he said. “IQxel-MW 7G is a reference solution at silicon solution providers, backward-compatible with LitePoint’s widely-deployed installed base of IQxel family testers, enabling companies integrating the latest Wi-Fi technology to get to market (and volume) quickly.”

Smith also commented on the IQgig-UWB. “UWB technology introduces some very unique requirements that do not conform to traditional wireless connectivity standards like Wi-Fi or Bluetooth,” he said. “Specifically, UWB operates in a frequency range up to 10.6 GHz at instantaneous signal bandwidths of approximately 500 MHz to more than



▲ LitePoint IQgig-5G Model B second-generation 5G mmWave instrument.

1 GHz. Additionally, instead of metrics like EVM that we have been accustomed to testing in OFDM-based technologies, UWB's performance metric is focused on accurate measurement of timing. IQgig-UWB uniquely includes a precise trigger mechanism to enable accurate time-of-flight (ToF) and jitter measurements for UWB products."

**VNAs and device models**

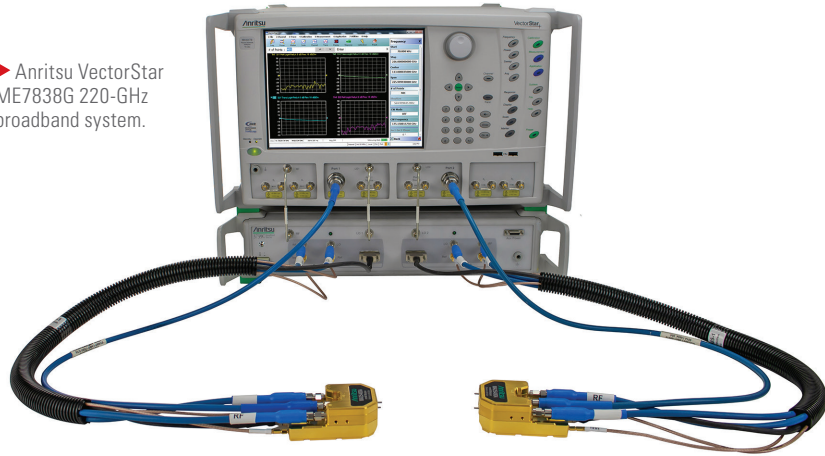
Wayne Wong, product marketing manager at Anritsu, cited a key challenge for RF/microwave test. "Accurate circuit simulation is important for rapid deployment of emerging RF/microwave communication systems because it provides accurate predictions of new designs," he said. "The result is greater chance for first-time design turns. First-time release becomes even more critical when the design cycle includes on-wafer development."

Wong continued, "The key aspect for accurate circuit simulation is precise device models, which are developed using a VNA with as wide of bandwidth as possible. The universal migration of microwave components towards on-wafer media is driven by the need for compact subsystems, economies of scale, and highly-integrated systems for improved performance. The VectorStar ME7838G 220-GHz broadband system performs ultrawide single-sweep frequency characterization for optimal device characterization and accurate circuit simulation."

Wong said the VectorStar ME7838G system primarily supports on-wafer measurements where device characterization is required. "R&D device characterization for circuit simulation during the design phase of communication circuits is the first line of targeted applications, and can also be used in production environments where multiple circuits within wafers need to be verified."

He continued, "the ability to test a wide range of circuits from 5G cellular to D-band radios, means that when the ME7838G system is installed a probe station can be quickly and efficiently transformed for different application measurements. This can be done without having to dismantle the VNA and reconfigure for mmWave waveguide measurements."

▶ Anritsu VectorStar ME7838G 220-GHz broadband system.



Another key test challenge is to continually address higher frequency requirements in a cost- and space-efficient way, Wong said. "Removing the effects of cable and fixturing to achieve more accurate test results becomes more difficult, as frequencies climb and calibration standards become harder to implement on-wafer or in the form factor of the test fixture."

Angus Robinson, Anritsu's product marketing manager, added, "For field testing, we see increased levels of spectrum interference and the need to identify nefarious signals. There is also more passive intermodulation (PIM) distortion in cellular networks. All of this means over-the-air (OTA) measurements of 5G mmWave radios are becoming more important."

In addition to the VectorStar ME7838G VNA, Anritsu offers the MS46131A 1-port VNA, the newest instrument in the ShockLine family. "It is available in three frequency ranges, including to a market-leading 1-port sweep range of 43.5 GHz," Wong said. "It is also modular, with the software on a single PC configuring one or two MS46131A VNAs on a session-by-session basis for excellent test setup flexibility."

The ShockLine MS46131A VNA targets production test of a range of RF and microwave components, Wong said, adding, "The performance supports limited design and verification requirements, and the small form-factor supports portability between test sites."

Wong also cited Anritsu's ONA (Optoelectronic Vector Network Analyzer), describing it as suitable for opto-electronic device characterization

at frequency ranges up to 40/70 GHz for 850-nm/1,310-nm/1,550-nm wavelength devices. "The modular system is built on Anritsu's VectorStar VNA, and users can easily conduct electrical, electro-optical, or optical measurements. "The modular architecture of the ONA systems allows it to be used in all phases of a product life-cycle—from R&D to test verification and through production."

Robinson commented on portability. "The Field Master Pro MS2090A battery-powered handheld spectrum analyzer has been enhanced with IQ capture and streaming with 110-MHz bandwidth, enabling new applications for government agencies needing to monitor secure spectrum. It interfaces directly to the industry-standard Bird IQC5000B record and playback system." He added that the Field Master Pro MS2090A is used for R&D and spectrum monitoring and protection applications.



▶ Per Vices Cyan platform.

According to Brandon Malatest, COO at Per Vices, "Our Cyan platform is our latest release and pushes the limits of RF/microwave test equipment. The flexibility offers an extended operating frequency from near DC to 18 GHz, a customizable

number of radio chains (up to 16), both transmit and receive functionality, with high bandwidths available (1 GHz per radio chain with possibility to extend to 3 GHz), and able to be optimized for high dynamic range or aggressive channel-masking applications as required.”

Malatest said the company’s products have been used in each stage of a product lifecycle. “Where the initial stages of R&D are typically serviced by our stock products, we do work with our customers to ensure we optimize the platforms to meet their specific production or field-test requirements.” This optimization can include the incorporation of additional IP; development of custom radio stages to accommodate noise, filtering, or channel-masking requirements; and mechanical and environmental changes, he said.

### RF/microwave switching

Pickering Interfaces addresses switching. “We have focused on two areas in our product portfolio—first, our 40-88X solid-state switch family has been updated from a 6-GHz bandwidth to 8 GHz,” said Bob Stasonis, technical product specialist. “In addition, our microwave switching family now has bandwidth expanded to 67 GHz. With the expansion of 5G developments and rollouts, this is an important change. Our present PXI offerings feature 420 RF and microwave module choices. In addition, there are presently over 70 RF and Microwave LXI switching systems in our catalog.”

Stasonis commented on applications.

“Our RF and microwave offerings have been used primarily in MIL/aero applications, most of which we are not allowed to discuss, but we assume that a lot of our products are used for testing communications and radar systems,” he said. “In

automotive, our impedance-controlled fault-insertion modules are part of HILS systems testing automotive networks. The addition of the 67-GHz switching products makes Pickering a provider for testing 5G devices. We have also recently been working in the healthcare industry to replace older, obsolete GPIB microwave switching.”

► Pickering Interfaces 40-88X solid-state switch family.



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VTI Instruments, a product line in AMETEK's Programmable Power business unit, also addresses switching. The company recently introduced its SMX-7xxx Series of 15 PXIe microwave switch modules, according to Chris Gibson, senior product manager. "These new modules extend functionality typically reserved for dedicated standalone systems into the PXIe form factor. The 26.5-GHz bandwidth operation as well as single- and dual-slot versions provide the ability to create multiple configurations, including SPDT, SP4T, SP6T, and transfer switches."

He continued, "a pass-through adapter module extends functionality even further with programmable drive lines for controlling attenuators and other microwave devices. Embedded web-browser control further simplifies setup and test debugging, which allows all relays to be controlled independently of application software and device drivers."

### Amplifiers, analyzers, and generators

AR RF/Microwave Instrumentation continually releases updated amplifier models, according to Dale Hauck, applications engineer. "Of particular interest is AR's line of S-series amplifiers, spanning from 0.7 to 18 GHz," he said. "These amps, along with all of AR's amps, offer the widest bandwidth, highest output power, longest life, and best mismatch tolerance on the market."

Hauck added that AR's amplifiers serve in all stages of product life cycle, including R&D, production test, and field test. "AR amps are actively used for each of the stages, whether it's characterization testing, production chip testing, product compliance testing, or radar communications in the field, as well as many other applications," he said, adding that the company serves 5G, Wi-Fi 6, automotive radar, IoT, radar, and EMC compliance. He further noted that AR has formed strategic partnerships with companies including Keysight, Comtest, and Nexio to provide total solutions for customers.

Tabor Electronics has recently introduced two RF/microwave test products, according to Mark Elo, US manager. The

first is Proteus, "...a 9-GHz bandwidth arbitrary waveform transceiver that not only generates directly to RF and microwave frequencies, but also has a receiver architecture with FPGA processing built in. This allows you to generate real-time signals based on feedback from the receiver, which are then processed onboard in the FPGA."

The second is Lucid, which, Elo said, redefines analog signal generation. "This 12-GHz modular instrument has specifications comparable to leading bench/rack instrumentation," he said, adding that it is available in four form factors: a basic brick module, a multichannel unit for R&D and production (available in benchtop or rack-mount models), and a portable version for field support.

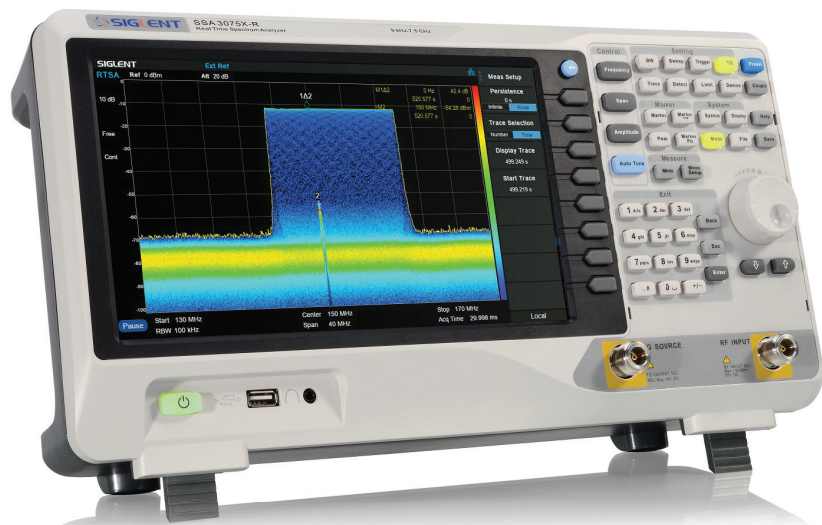
Elo commented on applications. "Proteus focuses on wide-bandwidth applications in the communications, automotive, electronic warfare, and physics verticals, and can generate up to 4.5 GHz of instantaneous bandwidth. This is frequently used in signal-simulation applications for emulating next-generation wireless systems, such as Wi-Fi 6 and 5G, and radar signals for automotive and electronic warfare applications. We also simplify the quantum-physics experiment setup by providing the ability to generate signals direct to microwave, eliminating the need for complex measurement setups."

He added that Lucid has broader applications. "It has been used in EMI applications, chamber test (especially with the increase in frequency ranges driven by Wi-Fi 6 and even UWB systems), product RF calibration systems, military field test, multichannel applications such as those required in up-and-down conversion chains, and other applications where multiple channels of coherent carriers are required."

Several companies have recently introduced signal and spectrum analyzers. For example, B&K Precision's 2680 Series spectrum analyzers, offer frequency ranges from 9 kHz to 2.1 GHz, or to 3.2 GHz. "Each model includes advanced measurements such as channel power, adjacent channel power, occupied bandwidth, total power, and third-order-intercept, along with a 2D and 3D spectrum monitor," said Jamie Pederson, product marketing manager. "The standard preamplifier, tracking generator, and 1-Hz minimum RBW round out the list of features," he added.

Siglent's RF development team has been busy this year, according to Jason Chonko, applications marketing manager, Siglent North America. "We announced 7.5-GHz additions to our swept-superheterodyne and VNA product lines, as well as our first real-time spectrum analyzer series, the SSA3000X-R. They all feature solid RF performance, easy-to-use UI, and toolkits that really tailor the instruments for EMI, broadcast, and RF development work."

▼ Siglent SSA3000X-R real-time spectrum analyzer.



In addition, Keysight launched the N9021B MXA X-Series Signal Analyzer to meet the evolving needs of advanced wireless communications design-validation-and-test and manufacturing engineers. According to Lörner at Rohde & Schwarz, the R&S SMBV100B vector signal generator and the R&S FSVA3000 spectrum analyzer provide heavy-lifting RF test solutions for the production line. A subsequent article will provide details on signal- and spectrum-analysis tools.

### USB vector network analyzers

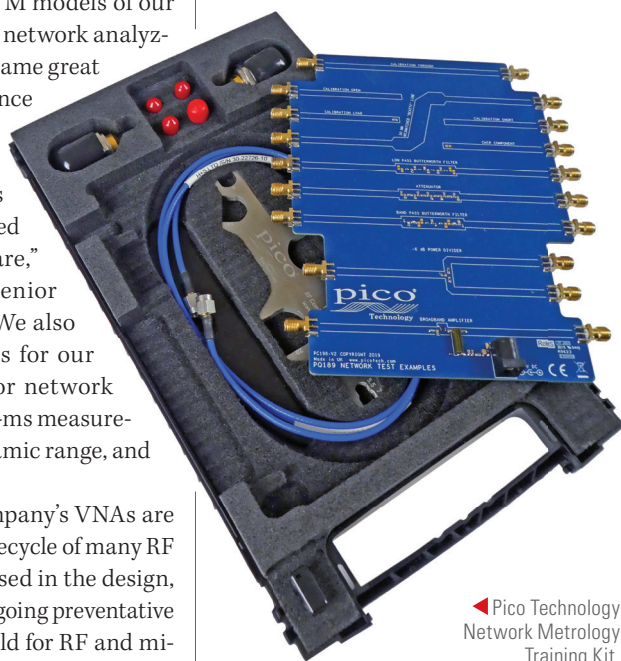
Copper Mountain Technologies focuses on USB vector network analyzers. “We introduced lower-cost M models of our Compact Series vector network analyzers, which provide the same great metrological performance at a very competitive price, as an economical option for engineers who don’t need advanced features in the software,” said Brian Walker, senior RF design engineer. “We also introduced SC models for our Compact Series vector network analyzer series with 16-ms measurement speed, more dynamic range, and higher output power.”

Walker said the company’s VNAs are used throughout the lifecycle of many RF products. “VNAs are used in the design, manufacturing, and ongoing preventative maintenance in the field for RF and microwave products, and is a critical measurement tool for all RF applications. Our customers participate in a wide variety of applications, such as 5G, IoT, automotive, defense, and more. Our VNAs are easy to integrate into a test system, helping them to work seamlessly in many types of industries and applications.”

Pico Technology also offers USB VNAs and has been emphasizing education. “The explosive growth of RF, microwave and ether-borne applications, particularly in the 1 to 6 GHz spectrum, is drawing more engineers, students, technicians, scientists, educators, and even medical professionals, into a field that they have not previously had to master,” said Mark Ashcroft, RF business development

manager. “Training in RF, microwave, and propagation disciplines, whether in design, test and measurement, or field support of RF systems, has needed to spread rapidly to an ever-wider audience.”

He explained, “skills in network, antenna matching, testing, and metrology are of course central to that. Fortunately, the low-cost USB vector network analyzer has brought affordable professional-grade measurements to educators and students alike. This enables unprecedented access to instrumentation and calibration standards to practice techniques and gather real-world measurements in the classroom or on every desk.”



Pico Technology  
Network Metrology  
Training Kit.

Ashcroft continued, “Adding value and flexibility to the highly successful PicoVNA 106 6-GHz Vector Network Analyzer, Pico Technology has recently announced its Network Metrology Training Kit and two important interfaces to major CAD software products. Partnered with the PicoVNA, or indeed any other VNA, Pico’s Network Metrology Training kit provides, in a single carry or storage case, a variety of passive and active test networks and low-cost calibration standards and test leads. A teacher and student need only these to begin the practice of calibration, measurement, and feedline elimination techniques and to

explore and compare errors that can arise. The kit is provided with a comprehensive user/training guide, useful instrument settings files, and typical calibration standard and de-embed data.”

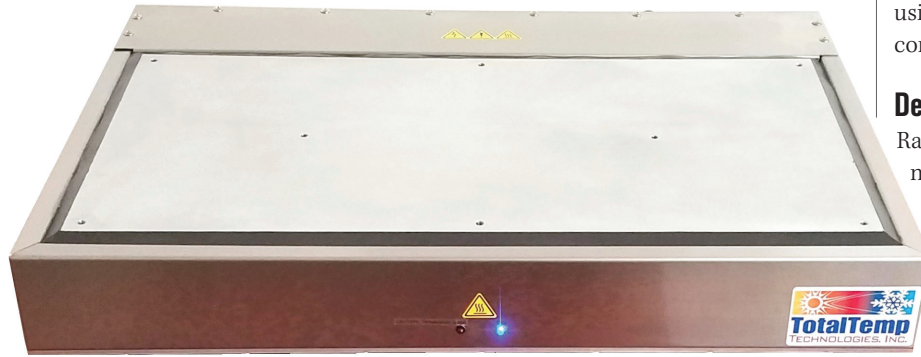
Ashcroft said a trainer can optionally add professional-grade calibration standards, test leads, and verification standards. “Expanding the initiative to cooperation with others, Pico has also become a Cadence AWR Connected Partner by integrating the PicoVNA directly to the AWR Design Environment. A freely downloadable software wizard provides remote control of the PicoVNA and single-touch data transfer from live on-screen measurement directly into your Microwave Office project—perhaps into a comparative plot or as measured data for use in simulation.”

### From chassis to thermal platforms

Pixus Technologies, a provider of embedded computing and enclosure solutions, offers products such as a 6U OpenVPX chassis platform with a mix of VITA 66.4 optical connectors and VITA 67.3 RF connectors. “The VITA 67 standard brings RF capability to OpenVPX open-standard architecture systems,” said Justin Moll, vice president of sales and marketing. “The products can serve in both prototype test and deployed systems, addressing applications including radar and C5ISR.”

“We are working with board vendors for backplane/chassis solutions that are interoperable with their OpenVPX/RF modules,” said Moll. “We’ve also worked with government labs and institutions to provide VITA 67 and OpenVPX chassis platforms for their development. Our open-frame test enclosure provides easy prototyping for SOSA/HOST and other OpenVPX applications utilizing RF. With a wide range of VITA 67/OpenVPX backplanes, Pixus can leverage existing designs for a customized solution for most applications.”

TotalTemp addresses thermal RF test, and the company has recently introduced larger sizes of thermal test platforms. For example, their Model SD288 addresses fast and efficient testing of larger or multiple RF modules, according to John Booher, chief technology officer. The platforms



▲ TotalTemp Technologies Model SD288 cryogenically cooled thermal platform.

serve in both R&D and production test, supporting customers' challenges in obtaining effective heat transfer for their RF modules. He cited an easy-to-use temperature controller with advanced automation and temperature control as a key feature of the platform.

### Ground-vehicle radar

dSPACE addresses the ground vehicle market. "For over 30 years, dSPACE has been delivering tools to the ground vehicle engineering community for developing and validating in-vehicle software," said Vivek Moudgal, vice president of business development, dSPACE Inc., and Andreas Himmler, senior product manager, autonomous driving systems, dSPACE GmbH. "For the community working in the ADAS and AD domains, dSPACE has developed both hardware- and software-based tools to allow the community to speed up their design and verification work and deliver robust and reliable functionality to the consumers."

They added that the company has been integrating best-in-class products into its offerings for automotive radar applications. "In early 2019, dSPACE partnered with ITS and miro-sys and acquired IP, which will continue to be refined to provide the engineering community with the tools they have come to expect from dSPACE." DARTS (dSPACE Automotive Radar Test System) is the company's offering to the automotive radar development and testing community.

"In early 2019, dSPACE released a series of compact DARTS systems (DARTS 9030-M, DARTS 9020-S and DARTS 9030-MS)

with very high capability and performance," Moudgal and Himmler said. "These devices are designed to serve multiple segments of the value chain, from radar chip designers to ECU developers, as well as OEMs for function validation. More recently (at the end of 2019), dSPACE released a new offering—DARTS 9018-D, designed for end-of-line use by Tier 1 suppliers, OEMs, and the aftermarket. Depending on the model, the available bandwidth is 1.2 GHz or 4 GHz with a simple change of the radio front-end (one connection for each RX and TX), the base unit can be switched to work supporting K-band radars to E-band radars or vice-versa. The K-band range supports 23 to 26 GHz, and the E-band range supports 75 to 82 GHz as a standard."

They continued, "Based on application needs, DARTS devices are capable of simulating targets at distances of less than 1 m, all the way to 1,000 m, with 6- or 10-cm resolution over the entire distance simulation range. With the capability to simulate Doppler frequencies of  $\pm 700$  km/h, these devices are capable of being used for all known ground-vehicle applications where relative speed measurement is needed."

They added that DARTS devices can be used in R&D, production testing, and field testing as well as in aftermarket—body shops, Periodic Technical Inspection (PTI), etc.—applications. "Their compact size and ability to be powered by DC power sources makes them extremely portable and easy to package," they said. "Another specialized use case for DARTS is for closed-loop function validation

using a hardware-in-the-loop setup," they concluded.

### Device perspective

Randy Oltman, RF and high-speed instrumentation segment director at Analog Devices, cited two main challenges to the RF test and measurement industry, both related to 5G. "First, millimeter-wave 5G continues to push towards 50 GHz with successful auctions in the 39-GHz and 47-GHz bands," he said. "3GPP defines frequencies above 50 GHz, but band allocations and licensing worldwide for 50 to 55 GHz is less clear. However, test and measurement makers designing new equipment want to be considerate of future needs and look to push frequency coverage as high as possible."

Oltman continued, "Second, OTA methods are not finalized for testing mmWave 5G devices with embedded antennas. Finding an appropriate method that allows rapid testing of mmWave devices in production will be essential to the a mass rollout of mmWave devices."

Oltman said Analog Devices' advanced RF modeling and packaging expertise enables development of novel and higher performance parts. "RF-considerate multichip packaging dramatically reduces parasitics leading to superior broadband performance, highly important for instrumentation," he said. "Further, these multichip devices integrate common functions which are usually discrete, greatly reducing PCB area and simplifying the design through fewer parts."

Oltman cited several recently introduced devices, including the ADPA7006. "This new part joins the recently launched ADPA7002 and ADPA7005," he said. "These 18- to 44-GHz mmWave amplifiers, with of power levels up to 1 W, are available both in SMT and die form. These devices offer a unique novel combination of power and bandwidth, with up to +42-dBm OIP3 and 31-dBm P1dB."

Other recently introduced parts include the ADF4372 16-GHz single-chip synthesizer, ADMV8420/ADMV8416/ADMV8432 tunable band pass filters, ADRF5043 SOI switch, LT3072 dual LDO, and LTM8078 Silent Switcher. With

regard to the LTM8078, he said, "It is one of the lowest-noise switching regulators in the industry. Previously, a designer never would consider powering a VCO or amplifier with a switching regulator. The LTM8078 is the latest in the line of silent switchers that are game changers for applications where greatly improved power efficiency and/or large regulated voltage drops are required."

### Simulation and modeling

Ansys offers modeling and simulation solutions to design RF/microwave and wireless communications devices for a broad range of industries, according to Manohar Raju, their senior product specialist at Ansys. "These solutions are used to compress the number of tests and design cycles," he added.

The company recently introduced key solutions in RF/microwave and wireless communications. "We are the first to offer a novel solution to model antenna arrays used in diverse applications," Raju said. "Significant increase in speed and accuracy as well as decreased memory requirements are the key benefits of this solution in Ansys HFSS/Ansys HFSS."

He continued, "A new product in our portfolio, the Ansys RaptorH employs HFSS to extract S-parameters and parasitics for RFICs with unprecedented speed and accuracy." He explained that S-parameter data is fed to circuit simulators to predict the signal integrity of these components. "Similarly, SI issues for large and dense PCBs and packages are analyzed by hybrid solutions of HFSS and SIwave to take advantage of their best attributes and yield S-parameter data of superior accuracy," he added.

Further, Raju said, "Designers of RF components and systems must ensure that their devices do not cause unintended emissions, radiations, or overstep regulatory standards. In-built EMI/EMC 3D components of Ansys HFSS and uniform simulation workflows help achieve compliance faster and economically for electromagnetic impulse (EMP), conducted emissions CISPR25 and CISPR2, and other standards."

Remcom offers tools including XFDTD electromagnetic simulation software,

WaveFarer automotive radar simulation software, and Wireless InSite 3D wireless prediction software, according to Stefanie Lucas, director of marketing. The products support R&D and simulated testing, across a variety of verticals, including 5G, Wi-Fi, automotive radar, IoT, indoor consumer electronics (smart speakers, laptops), mobile device design, and wireless network planning, she said.

XFDTD includes full-wave, static, bio-thermal, optimization, and circuit solvers, and can simulate electrostatic discharge (ESD) testing, enabling engineers to identify potential locations of dielectric breakdown and components at risk of damage. The automotive version of WaveFarer supports drive scenario modeling at frequencies beyond 79 GHz, and Wireless InSite supports the analysis and design of wireless systems for communication, networking, sensors, and other applications in urban, indoor, or rural environments.

MathWorks offers a range of tools for wireless and radar system design. "These tools are built on our platform products, MATLAB and Simulink," said Rick Gentile, product manager, RF and signal-processing systems. "The tools cover RF, antenna, and phased-array design and analysis. They also cover the signal-processing and data-processing system components."

Gentile said modeling building blocks, algorithms, and system simulators are available for standards-based wireless systems including 5G NR systems. "We also support broad workflows for multifunction radar design," he added. "System developers use our tools to ensure architectures and designs will work at the earliest point in the project life cycle. The unique aspect is that MATLAB and Simulink as platforms span such a broad range of disciplines and a broad range of workflows (requirements analysis through deployment on hardware). This enables a development environment that eases system-level integration across diverse teams at the very earliest stages of a project." Building on that foundation, MathWorks' most recent solutions are available in the company's R2020a release, which became available for download in March.

Gentile cited a challenge that faces test vendors and customers across the RF/microwave arena. "We see the rise in system complexity as the main challenge," he said. "This complexity is driven by many external factors such as the need for higher bandwidth, lower power systems. The RF spectrum is crowded, and the chance for interference is greater than ever. Systems that previously were focused on a few key functions now need to perform a more diverse set of tasks. Today's systems also get deployed in ways that were never possible in the past."

Gentile noted further that system development teams may be smaller today than in the past and are likely to be spread out across the world. "All of the challenges described above add risk," he said. "Our goal is to make it easy for system developers and integrators to model and simulate their systems before they build them. Finding issues early in a project greatly reduces the cost in fixing these issues. We want to help reduce risk. We also want to help system developers leverage all of their modeling work by making it easy to deploy code directly from models. System reliability is critical, so we work to make it easy to verify designs directly from the modeling results as well."

### Markets and challenges

EE asked contributors to this report to elaborate key features of their offerings and to comment on the markets they serve, and challenges facing the industry. Read on to see what they had to say.

### What are other key features of your solutions you would like to emphasize?

*Moudgal and Himmler, dSPACE:* "Characteristics that describe DARTS devices include ultra-compact, lightweight, low-power-consuming, RUT-modulation-scheme-agnostic, and quick-changeover between K-band and E-band applications. Industry-leading performance makes DARTS a very versatile instrument for a wide range of applications, from radar chip design and calibration to end-of-line testing at Tier 1s and OEMs, to function validation in the lab, and to aftermarket applications."

**Stasonis, Pickering Interfaces:** “Our customers really appreciate the LED switch-path status indicators on our PXI and LXI products. It allows them to visually see if their code is closing the correct switch. Our customers who are configuring a large number of microwave switches and multiplexers into a complex configuration have found that our Switch Path Manager (SPM) signal-routing software makes programming their switching system extremely easy. Once the test engineer has defined the cabling interconnections, all that is necessary is to program a particular test point that is to be connected to a particular instrument, and SPM automatically makes the necessary connections.”

**Gibson, VTI Instruments:** “VTI custom RF interface units (RFIUs) are switch systems designed to meet customer specifications that require integrating the RF source and measurement instrumentation with the device(s) under test. RFIUs allow signals to be routed, attenuated, combined, split, filtered, and amplified. AMETEK provides RFIU customers with a combination of the following services: RF engineering for component selection and system design; control engineering for signal routing management; mechanical engineering for enclosure design, component layout, and temperature control; software engineering for development of both an LXI-based virtual front panel and IVI drivers, and complete documentation and test data for accurate reproduction of the system as needed.”

## “The ShockLine and VectorStar families of VNAs ... achieve higher frequency capabilities in more compact and cost-efficient packages.”

— Wong, Anritsu

**Wong, Anritsu:** “The ShockLine and VectorStar families of VNAs take advantage of Anritsu’s patented Non-Linear Transmission Line (NLTL) technology to achieve higher frequency capabilities in more compact and cost-efficient packages. Many ShockLine models and VectorStar modules are compact enough to direct connect to the DUT or on-wafer probe, thus minimizing cable and fixture losses and maximizing measurement stability.

“ShockLine VNAs also offer Anritsu technology developed for the high-end VectorStar VNA family to de-embed fixtures and probes using partial calibration standards with the Universal Fixture Remove (UFX) option. The NLTL harmonic samplers provide the highest third-order intercept (TOI) performance that enables high-performance measurements of active devices in the VectorStar VNA line.

“The Anritsu ONA solution takes advantage of the NIST traceability (with an in-house calibration lab that characterizes all the customers’ OE modules) for the OE modules for traceable measurements. The flexibility and upgradability in terms of frequency for the VNA, the OE module, and the EO convertor is a considerable advantage to our customers.”

**Raju, Ansys:** “Ansys is the first to offer a novel solution to accurately model antenna arrays for applications such as 5G mmWave base stations and microcells, automobile radars, satellite communications, aerospace, naval, etc. Leveraging HFSS 3D Component, the technique is built upon the HFSS Domain Decomposition method (DDM) for large-scale analysis, and is a breakthrough technology for solving large and complex arrays. It eases the burden of matrix factorization and decreases memory requirements resulting in significantly faster array simulations.”

**Malatest, Per Vices:** “Our products aim to meet the needs of many customers out of the box; however, some customers do have strict requirements that are not met by the stock products. For these customers, we work very closely to leverage the flexibility of our platforms along with our existing IP to help develop a solution to meet their needs. For our existing customers, this has resulted in a more cost-effective solution, faster time to market, and higher performance platform than any alternative.”

**Smith, LitePoint:** “Usually, when we look at the increasing technical requirements of new wireless technologies, it is usually tied to something related to a more advanced modulation technique and a race to higher data rates. However, with the emergence of UWB technology, we find a completely different set of requirements. Instead of jamming gigabits-per-second through the air, UWB technology (specifically the 802.15.4z IEEE standard amendment) uses very short pulses to transmit information that enables a companion device to accurately determine its relative distance and direction.

“The ‘money spec’ in UWB is time, or more specifically, time-of-flight (ToF). ToF is not only useful for accurately determining location, it is more importantly able to provide an additional layer of security to an application by enabling improved location authentication. Other wireless technologies (such as Bluetooth) can be intercepted and rebroadcasted to ‘fake’ the appearance of location (aka, a relay hack). This allows a thief to steal your wireless car key, or even credit-card information, if they can get physical proximity to your transmitted signal. The time-based nature of UWB does not allow for this kind of vulnerability. It is relatively simple to defeat signal-strength (RSSI) authentication methods. It is very difficult to defeat methods that rely on the authentication of a time stamp.

“Accurately calibrating and measuring the performance of UWB devices requires the test equipment being able to very precisely measure and respond to a device in time. For example, in 1 ns a radio signal travels approximately 30 cm. In order to know a location with roughly 10-cm accuracy, the timing precision of the measurement equipment needs to be less than 100 ps. LitePoint’s IQgig-UWB test system has a timing architecture that enables this level of timing and response repeatability.”

**Keysight:** “Modern devices are highly integrated. As a result, wireless and high-speed-digital engineers often test devices with more than four ports. In wireless RF, front-end modules (FEM) for multiband operation and MIMO antennas require

multiport characterization for all their components. Testing high-speed digital technologies like HDMI and USB 3.1 is even more tedious. Not only do digital cables have multiple internal cables and connectors, but each must undergo testing twice—once in the time domain, and once in the frequency domain. The need for multiport test accelerated the development of switch-based solutions for traditional vector network analyzers (VNAs). When switch-based solutions were not adequate to keep up with multiport test, the VNA itself was reimagined and optimized for multiport test.”

### What vertical applications areas do your products serve?

*(Editor’s note: Many contributors to this report provided details on 5G and Wi-Fi 6 test, which will be the subject of a subsequent article.)*

**Wong, Anritsu:** “The VectorStar ME7838G and ONA solutions address the needs of designers developing solutions for 5G, automotive radar, microwave backhaul communication links, opto-electronic markets, and other applications with high-speed data throughput. The MS46131A ShockLine VNA targets 28-GHz and 39-GHz 5G antenna testing, along with other microwave one-port applications.”

**Robinson, Anritsu:** “Field applications, including interference hunting, spectrum protection, and 5G NR installation and maintenance, are where the Field Master Pro MS2090A is used.”

**Malatest, Per Vices:** “Our products are being primarily used for applications in the following markets: radar systems, medical-imaging systems, radio links and mobile base stations, and GPS navigational systems. The specific functionality depends on the markets and the customers; however, the use of our products as test and measurement equipment has been present in each of the above.”

**Gibson, VTI Instruments:** “VTI RF/microwave switch systems serve all the wireless telecommunication and wireless industrial applications. VTI switch systems are not limited to testing a specific wireless protocol.”

**Raju, Ansys:** “For automotive, our tools accurately simulate RFICs and the standalone and installed performance of radar. Engineers virtually recreate dynamic ADAS scenarios involving V2V and V2X communications in Ansys HFSS SBR+. Finally, with Accelerated Doppler Processing capabilities following simulations in Ansys HFSS SBR+, vehicle radar sensors are accurately evaluated. ADP uses high-fidelity simulations to model synthetic

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radar signatures from automotive radar sensors with unmatched speed and efficiency. It's difficult and costly to test and measure active safety scenario corner cases, such as an autonomous-car driving scene involving a pedestrian crossing the road. Using Ansys simulation tools is economical and faster to study regular, corner, and edge cases. Moreover, simulation also be used to consider cases involving potential loss of life and property damage."

**Gentile, MathWorks:** "Our customers work across a broad spectrum of applications across all industries. Wireless technology is ubiquitous and enables connectivity across the board. This standards-based wireless connectivity including 5G, Bluetooth, and WLAN. We also enable radar system development for commercial (for example, consumer, automotive radar) and aerospace/defense applications."

**Moudgal and Himmler, dSPACE:** "The current line-up of DARTS is specifically designed to support the K-band (24 GHz) and E-band (77 GHz) automotive radar programs. In the future, if other frequency bands are needed, the DARTS devices are easily upgradable by switching out the radio front-ends to match the frequency band of interest."

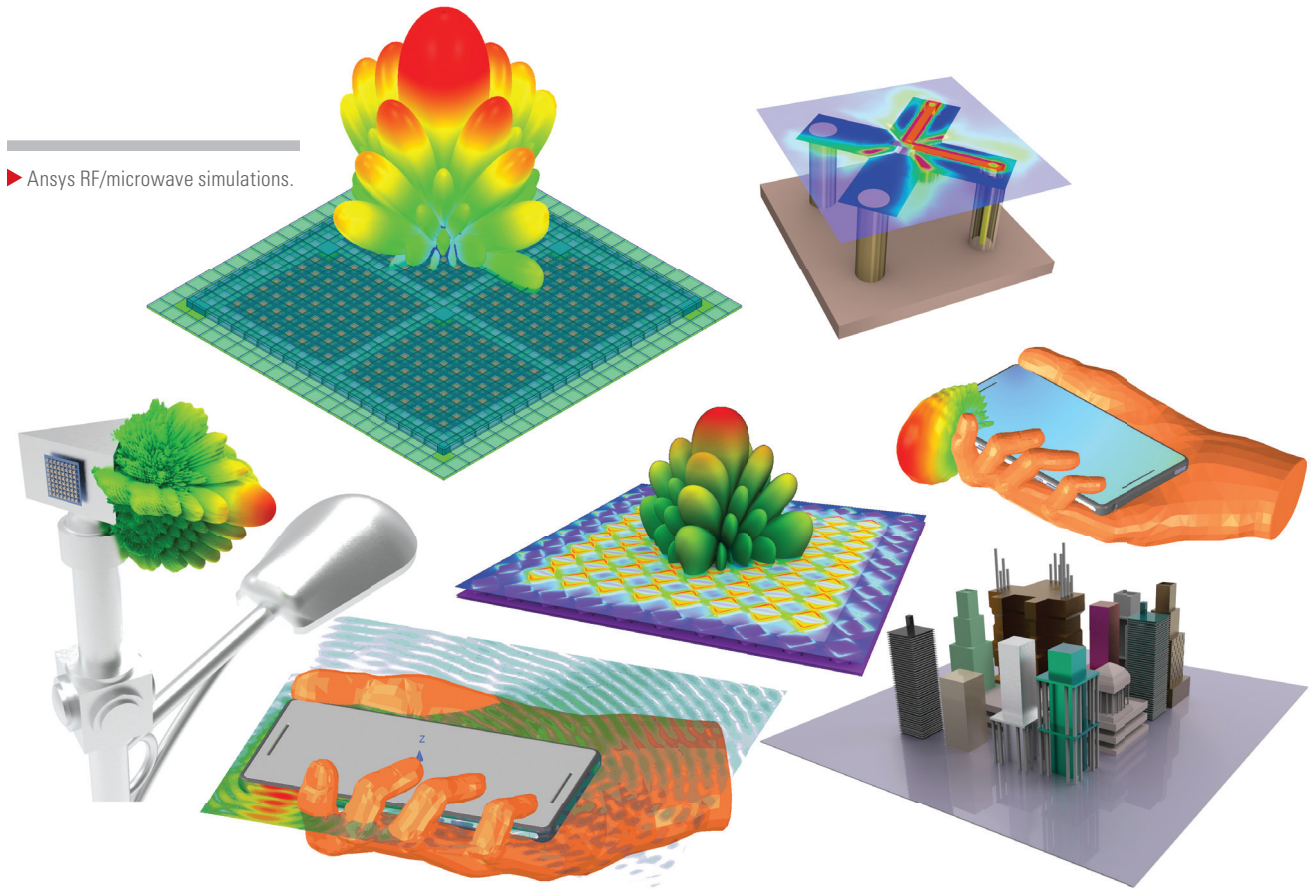
**What do you see as key RF/microwave test challenges?**

**Chonko, Siglent:** "I think that a key area of development is knowledge, and the gap between new engineers and folks

that have been in the industry for a long time. Over the past 10 years, the interest in RF has ballooned, but I'm not sure that the number of engineers with practical experience has matched the need. Many experienced engineers are retiring, and this may leave a significant gap in what we can do today vs. where we go tomorrow."

**Raju, Ansys:** "Designing RF/microwave devices and communications systems to be successful requires ensuring precise signal integrity, accuracy, and fidelity of RF devices, systems, packages, and antennas. With miniaturization, more ICs, SoCs, packages, and wireless systems are being integrated into a single high-speed digital device. This could create interference due to unwanted out-of-band emissions by co-located RF systems (RF cosite) as well as broadband noise and harmonics by digital signals (RF desense)."

**Stasonis, Pickering Interfaces:** "From a switching standpoint, as frequency increases, the interaction with the user interface of switching components we incorporate on our switch modules becomes increasingly critical. For example, extreme care is necessary when cabling is installed on Microwave connectors, as the signal interfaces are quite small and manufactured to precise tolerances. In any case, higher power and bandwidth are always in demand."



► Ansys RF/microwave simulations.

**Malatest, Per Vices:** “The biggest challenge faced by vendors of RF/microwave systems is designing a system with the flexibility to support many customers while still remaining cost-effective. Our products leverage our existing IP and economies of scale to help ensure that the cost remains very competitive and the underlying designs ensure flexibility.”

**Ashcroft, Pico Technology:** “IoT, 5G, WiFi, V2X—has there ever been a bigger market explosion than the use of the antenna, and within very challenging locations? Optenni Lab CAD software simplifies the immense complexity of antenna and array optimization. The package performs real-time interpretation of network measurements to present optimized lumped or line-matching circuits for the measured antenna(s). Already an AWR Connected partner, Optenni has also integrated the PicoVNA into this market-leading CAD software suite.”

**Lörner, Rohde & Schwarz:** “It is not an exaggeration to say that antenna technology for consumer wireless devices is exploding. Firstly, in terms of the number of antennas built into even handheld devices, MIMO really does mean “multiple” these days. Secondly...the techniques used with active beam-forming add performance well beyond the passive multipath propagation initially introduced with multiple antennas.

“While just a few years ago almost all wireless devices included a special interface to connect a cable for test purposes, this is no longer the case. As well as 5G user equipment, there are whole markets for very small inexpensive wireless devices (personal network technologies such as Bluetooth, LoRa, or Zigbee) and of course, the enormous variety of Internet of Things devices, that do not include a test interface from a mixture of cost and space reasons. Then there are more complex devices with multiple miniature antennas where it would be physically impossible to connect a cable.

“Last but not least, with increasing frequency, the mechanical difficulties of making a reliable physical connection also increase out of proportion. Over-the-air test, with all RF communication with the device under test via the antennas it uses for normal operation has introduced whole new complexities to test and measurement, requiring new fields of expertise on our part.”

**Elo, Tabor:** “Bandwidths and frequency ranges are getting higher. Twenty years ago, most systems were less than 3 GHz, and a 1-MHz bandwidth was state-of-the-art. Then 10 years later, most systems were sub-6-GHz with bandwidths ranging from 20 MHz to 160 MHz. Now, we have extended beyond 6 GHz for technologies such as Wi-Fi 6, and standards such as 5G and LTE fiercely contend for spectrum sub-6-GHz and even share unlicensed or military/government spectrum. Finally, mmWave bands opened up by 5G access points and automotive radars have increased the bandwidth demands from MHz to GHz.”

**Moudgal and Himmler, dSPACE:** “Automotive radars are, and will continue to be, a very valuable sensor in most—if not


all—automotive applications. Radars play a very important role in both safety applications (ACC, AEB, etc.), as well as convenience applications (automatic deck-lid actuation). This technology can operate in a wider environmental range, compared to cameras and lidars, and more and more radar sensors are being used in ADAS and AD applications.

“The challenge customers are facing today is with testing production radar ECUs. These ECUs have to be properly calibrated before they can be deployed on vehicles, as well as during end-of-line testing as vehicles come off the production line. These needs are still being investigated and evaluated. A bigger challenge to be faced is with garages and body shops that are expected to realign and recalibrate radar ECUs that are impaired in accidents. To carry out these activities properly will require an investment in specialized equipment and training.”

**Keysight:** “Next-generation wireless systems such as 5G cellular communications, fronthaul and backhaul networks, military and automotive radar, and IEEE 802.11ad and 802.11ay WiGig are targeting a range of new capabilities including higher bandwidth, more connected devices, low latency, and better coverage. To address the wide bandwidth requirements, researchers are exploring higher frequencies in the centimeter and mmWave bands where more spectrum is readily available.”

“Compared to the traditional bandwidths used at sub-6-GHz for cellular communications, the use of hundreds or even several gigahertz of spectrum at these higher frequencies create several challenges. The higher the frequency, the more difficult the design, and the more visible design imperfections become. Imperfections that would be inconsequential at a 5-GHz carrier frequency with 20 MHz of modulation bandwidth could make a 100-GHz carrier with 3.5-GHz wide [modulation bandwidth] incomprehensible. If we look at the components, the request for portable yet multifunction devices or network appliances is strong.

“The semiconductor industry, defying Moore’s law, is pushing component miniaturization further. Commercial 5-nm-node production is ongoing. Compared to 7-nm scale, this technology will enable chip developers to reduce power consumption by 20% or improve performance by 10%, allowing more applications than today’s technology. mmWave technology comes in handy allowing [engineers] to design very small antennas and circuits able to work very efficiently.

“Of course, there is a price to pay: the design and the characterization of those components present unique challenges. Higher frequencies amplify error sources, including cable losses, connector repeatability, and phase shifts that are mostly negligible at radio frequencies. Above 60 GHz, an entire radio structure including a phased-array antenna can be integrated in a single chip, leaving space for other elements and functionality. Multifunction components, however, imply complicated measurement setups to take in account the contribution of the various elements integrated in the circuit under test making repeatable measurements very challenging.” 

## SPECIAL REPORT

# PLANNING AHEAD HELPS ENSURE FULL COMPLIANCE SUCCESS

By Rick Nelson, Contributing Technical Editor



▲ AR RF/Microwave Instrumentation AA18G26-50, part of AR's AA Series of solid-state field generators.

📷 Courtesy of AR RF/Microwave Instrumentation

▶ EMC test is a critical discipline in any electronic product development effort. Full compliance is the ultimate goal, but achieving it quickly and with minimal budget and schedule impact requires EMC debug efforts throughout the design process. These efforts must be combined with effective pre-compliance strategies.

Applicable equipment includes EMI receivers, amplifiers, field generators, and complete EMC test systems as well as general-purpose instruments with applicability to EMC test. Software has several roles to play, ranging from simulation tools to applications that can serve in the test lab. Augmenting instruments and systems are probes and other accessories.

According to Dean Landers, applications engineer at AR RF/Microwave Instrumentation, "We serve every aspect of the EMC test market, providing the total solution for EMC testing. Whether it's design, pre-compliance, or full compliance, we can offer solutions through both test systems and special equipment packages to meet the needs of the customer."

Landers said the company has recently introduced its AA Series solid-state field generators, which he described as a cost-effective solution for testing radiated susceptibility above 18 GHz (18 to 40 GHz) at test levels of up to 50 V/m at a 1-m test distance.

When asked what applications areas AR serves, Landers said the company can assist customers in meeting the

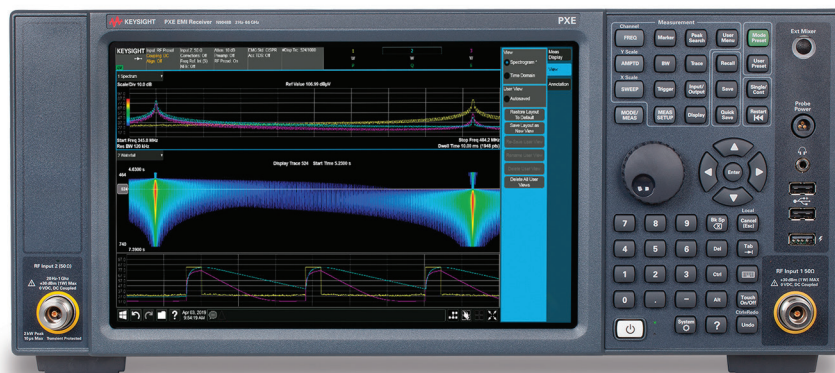
requirements of relevant standards regardless of what market they are working in. “We will also ensure that the equipment provided will be acceptable across multimarket testing agencies, so the equipment can be bought once and used for multiple tests,” he added.

When asked what features customers seek in EMC test equipment, Landers cited reliability. “A test agency or laboratory needs to know for certain that their equipment, on any given day, can be placed into a test setup and work the first time, every time,” he said. “AR provides this level of quality and reliability for each product.”

Landers also pointed out, “Customers are looking for total turnkey solutions, where we not only provide the amplifiers, but the antennas, cables, racks, field probes, etc., all within a single system to test specific or multiple standards.”

Jeff Hu, product manager at Keysight Technologies, said the company addresses full-compliance test with products such as the N9048B PXE EMI receiver, which offers 1-Hz to 44-GHz frequency coverage, and is fully compliant with CISPR 16-1-1:2019 and MIL-STD-461G. Hu explained the instrument offers a “...superior ‘Time Domain Scan’ and even faster ‘Accelerated Time Domain Scan’ measurement speed, with a time-domain scan that supports up to a 350-MHz FFT acquisition bandwidth. He also described an “...accelerated time-domain scan example with a scan time of 5.8 seconds vs. multiple hours using a conventional stepped-scan approach (test conditions: CISPR band C/D, 30 to 1,000 MHz; RBW = 120 kHz; QP + CISPR-average detector; dwell Time = 1 s).”

Hu described a “Real Time Scan” troubleshooting tool, offering up to 350 MHz of bandwidth for gapless real-time signal capture and analysis. The tool allows customers to measure signals with CISPR-compliant quasi-peak, EMI average, and peak detectors simultaneously, gaining a better understanding of signals by displaying them in three windows — frequency domain, time domain, and spectrogram. Customers can also play back and view signals captured in up to 12,000 time slices (for example, 12,000 s recorded time if dwell time is 1 s), and Hu



▲ Keysight Technologies N9048B PXE EMI receiver.  
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added that data can also be exported for post-processing analysis

“As customers (automotive, consumer, communications, medical, etc.) designing electronic devices race to market, they will need better, faster EMC compliance testing of new components, key subassemblies, and whole systems,” Hu said. “For EMC labs, this means greater demand for more testing and troubleshooting in less time, sometimes on short notice, as developers rush to meet looming deadlines. Day to day, the throughput rate of the main test chamber has a direct effect on two key metrics: revenue and customer satisfaction. If demand grows beyond the capacity as we’re seeing now, then the test lab can lose revenue and force customers to go elsewhere. During troubleshooting, delays in assessing failures and suggesting fixes can frustrate impatient customers.”

Hu continued, “Enhancing the lab’s success starts with a compliant EMI receiver that accelerates testing and improves troubleshooting. Equipped with Time Domain Scan, Accelerated Time Domain Scan, and Real Time Scan capabilities, the Keysight N9048B PXE EMI receiver will accelerate throughput during compliance testing and enhance the ability to catch suspect signals sooner during troubleshooting.” He added that the PXE supports many EMC software tools (such as TILE!, Nexio, and Toyo), which can leverage the PXE’s speed during automated testing. The solution also provides capabilities tuned to measurements, reporting, documentation, and more.

Keyvan Yasami, market development manager for Anritsu, talked about their Radio Communication Test Station MT8000A and Radio Communication Analyzer MT8821C mobile network



▲ Anritsu Radio Communication Test Station MT8000A.

emulators. “These solutions are capable of testing EMC for wireless technologies, including unlicensed and licensed cellular technologies, 4G/LTE, 5G New Radio (5G NR), millimeter-wave (mmWave), Wi-Fi, and Bluetooth.”

The MT8000A and MT8221C can help test devices and UE employing 5G NR, 4G/LTE, and legacy wireless technologies, Yasami said, adding, “In addition to ensuring compliance in accordance with FCC rule parts, Anritsu’s solutions simplify test setup and execution and provide reliable test results.”

Yasami said Anritsu solutions enable pre- and full-compliance test and certification for products including mobile phones, handsets, and portable devices. “Our platform provides the capability to ensure these products are compliant with FCC regulations, as well as a variety of other international standards and regulatory bodies.”

According to Tobias Gross, product manager for EMI test receivers at Rohde & Schwarz, the company has a comprehensive portfolio of EMC T&M equipment that ranges from individual devices to custom turnkey systems. “For tracking down interference signals when developing electronic devices, Rohde & Schwarz

offers solutions based on spectrum analyzers and test receivers with measurement software for pre-compliance and certification measurements,” he said.

Gross said they’ve released a turnkey solution for automatically measuring radiated spurious emissions from 5G components in both frequency ranges FR1 and FR2. “For this solution, the R&S ELEKTRA EMC test software has been upgraded with measurement and calibration routines for 5G,” he said. “In addition, the new fast Time Domain Scan (fast TDS) for the R&S ESW high-end test receiver is one of our highlights in EMC testing. Thanks to the doubled scan bandwidth, the measurement speed is nearly twice as fast as with a conventional time-domain scan. This enables previously unattainable fast measurement times for time-consuming tests with a quasi-peak detector.” He added that fast TDS is free with the latest firmware version V1.70 for the R&S ESW.

“And last but not least, we have new EMC test solutions specifically for users in the automotive industry: the fastest CISPR-25 certification with fast TDS, a robust and compact BCI test system, and R&S AdVISE version 5, which keeps a close eye even on vibrating display elements during EMS tests,” he said.

According to Gross, a key customer requirement is for time-saving measuring routines. “That is why we have developed the fast TDS,” he said. “In addition, we have a new option for accelerating product tests on microwave ovens. Typically, test engineers use the log AV method according to standard CISPR 11. With the latest revision of the standard, the new method Multi CISPR APD is applicable as an alternative. This method not only reduces the overall testing time significantly, but also enables a detailed insight in the emission’s characteristics.”

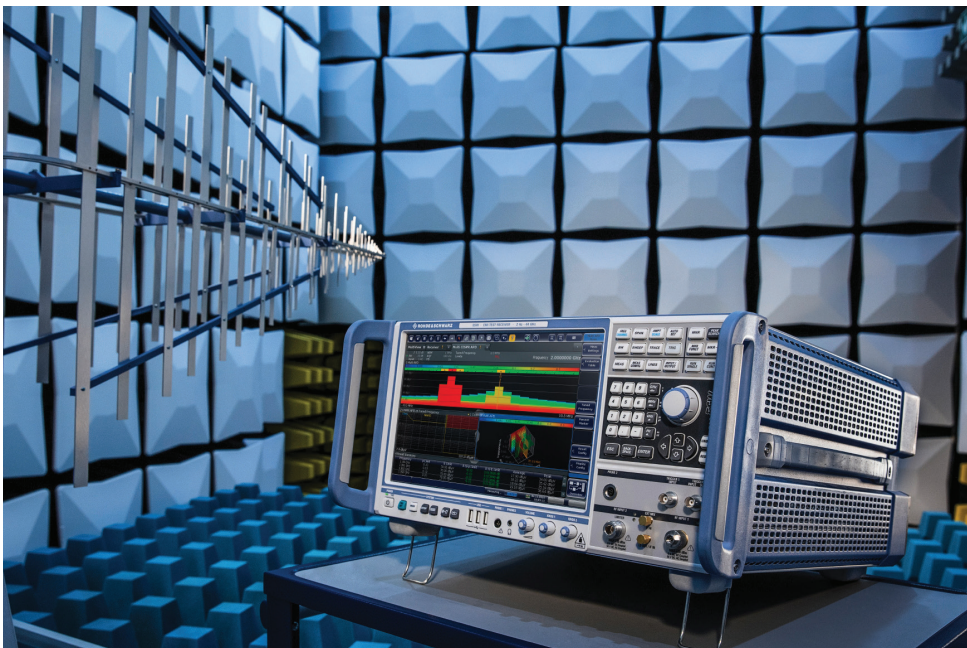
Gross added that the R&S ESW-K58 Multi CISPR APD measurement option for the R&S ESW test receiver simultaneously displays the signal amplitude probability distribution (APD) of up to 67 channels within a specified timeframe. “The option offers numerous analysis and display features, including a 3D view,” he said. “When the method is used in line with the standard for signals with 1 MHz bandwidth, up to 20 channels can be measured simultaneously. APD analysis precisely shows the effects of interference on digitally modulated wireless signals (WLAN, cellular or Bluetooth), and in the future it will also be applied to other product standards.”

Gauss Instruments provides products for full- and pre-compliance EMI testing as well as radiocommunication measurements and 5G measurements, according to Dr. Stephan Braun, CTO. For example, the company offers EMI64k automation software and the TDEMI ULTRA, which enable automated communication and EMI measurements with 685-MHz real-time bandwidth and real-time scanning between DC and 40 GHz (expandable with external mixers in the THz range).

“We serve automotive, industrial, consumer, communication, medical, avionic and military testing,” Braun said. The products cover the CISPR 16-1-1, MIL 461, and DO 160 standards as well as ANSI, FCC, and many other national and international standards.

“With the introduction of the real-time FFT-based receiver in CISPR, ANSI, and MIL461G, customers are looking at solutions that fulfill these standards with large real-time bandwidth,” said Braun,

▼ Rohde & Schwarz ESW high-end test receiver.





## It's not just better software. It's a better solution.

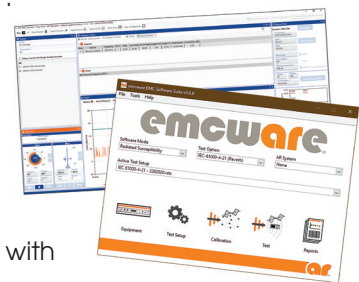
At today's AR, we're not just developing solutions to satisfy one software need. We're working hard to satisfy all your emc software needs, bringing together two great products as part of our commitment to offering a total solution: emcware® 5.0 and Nexio BAT-EMC®.

With emcware 5.0, you get over 500 test profiles, a streamlined user workflow which reduces set-up and training time, and reporting templates to get you up and running faster than ever. In addition, emcware now includes reverb immunity test methodologies.

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We're with you all the way

adding that they also ask for proper automation to enjoy the benefits of the new technology. He added that the company sees more combined equipment like household appliances that need to be tested in accordance with CISPR 14 in combination with Wi-Fi modules that need to be tested for EMC and in accordance with communication standards.

Ophir RF offers amplifiers that serve the area of radiated immunity for all testing standards, according to Edward Davis, vice president, sales and marketing. He said the company has announced "...a new line of solid-state amplifiers designed to replace the traditional TWTAs that have been the industry standard for the last several decades. This product line already has solutions for 200 V/m at 1 m for up to 8 GHz. We are making steady progress in providing the same field strength up to 18 GHz soon."

Herman vanEijkelenburg, director of marketing at Pacific Power, pointed out they just introduced a line of fully-compliant EMC power-line emissions and immunity test systems for harmonics and flicker, to test for compliance to IEC 61000-3 and IEC 61000-4 test standards. "This product compliance is mandatory to place any grid-connected product on the EU market."

Herman explained, "Pacific Power ECTS2 systems range in power levels from 500 VA to 90,000 VA, and are available with either single-phase mode or single-, split-, and three-phase modes." He added that the systems address power integrity and IEC compliance testing of AC-powered products intended for export to EU countries at both the design stage and for full compliance testing to applicable IEC standards.

"These EMC power compliance test systems cover the entire spectrum of AC-



▲ Ophir RF 5RU amplifier.

Davis commented on features customers are looking for. "Today's savvy EMC customers are looking for a company they can depend on—one who has been there in the past and will be there in the future," he said. "They want a solid warranty (five years on SSPA systems), with excellent customer service. They want a provider who does not rest on accomplishments made in the past. They want a supplier who has a pedigree of high-power products used in the harshest military environments, who can take this knowledge and bring it to their commercial products."

powered and grid-connected products including PV inverters and electric-vehicle chargers both on-board or charging-infrastructure-related," he said. "Also covered are DC voltage-

dips test requirements applicable to automotive products. These systems are typically used by independent test labs to test customer products or by in-house labs at larger companies."

### Simulation for EMI/EMC

Ansys focuses on simulation. "Ansys has made key enhancements to its simulation tools to combat EMI/EMC challenges in high-speed electronic and wireless systems," said Juliano Mogni, senior EMI/EMC product manager. "Engineers can leverage readily available libraries of EMI/EMC 3D components and automated workflows in Ansys HFSS to mitigate EMI issues."

Mogni said that companies can use Ansys tools to meet stringent regulatory

standards fast and economically. "Engineers can rely on the unmatched accuracy, speed, and capacity of Ansys electromagnetic 3D and 2.5D field solvers and also dynamically link these solvers to circuit- and system-level tools to predict EMI/EMC performance of electronic devices," he said. "Assessing the overall performance of these designs through a comprehensive analysis leads to interference-free products. Automatic and customizable EMI design-rule checks of printed circuit boards in Ansys prior to running simulations save time and cost."

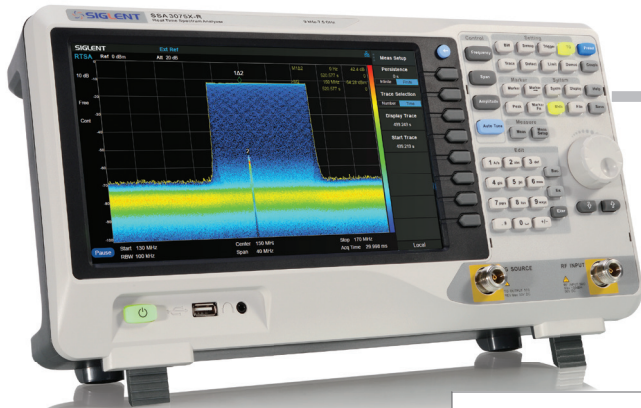
When asked about applications, Mogni said Ansys tools mitigate engineering problems across different verticals including automotive, industrial, consumer, communications, and medical. Mogni added that for electronic and wireless devices, Ansys tools model radiated and conducted emissions, susceptibility, crosstalk, electrostatic discharge, electric fast transients (EFT), and lightning-strike effects. In addition, they can model high-intensity fields (HIRF), radiation hazards (RADHAZ), electromagnetic environmental effects (EEE), electromagnetic pulse (EMP), shielding effectiveness, and other EMC aspects.

"Engineers can use Ansys tools to address the following regulatory standards: electromagnetic pulse (EMP), bulk current injection (ISO 11452-4), conducted emissions locally grounded (CISPR25) and remotely grounded (CISPR2), radiated emissions (CISPR25), electrostatic discharge (IEC 61000-4-2), and radiation hazard (MIL-STD-461-C)," he said.

### From spectrum analyzers to TEM cells

"For EMC, we focus on pre-compliance test and troubleshooting applications," according to Jason Chonko, applications marketing manager at Siglent Technologies North America. The company offers many general-purpose products that serve various industries with tools for design and debug.

Siglent recently announced SSA3000X-R Series real-time spectrum analyzers. "The addition of real-time acquisition is a real benefit for near-field probing applications because it can decrease the time



◀ Siglent SSA3000X-R Series real-time spectrum analyzer.

spent searching for elusive unintentional radiation sources, as well as provide very fast conducted emissions troubleshooting,” Chonko said. “With the optional 40-MHz real-time bandwidth upgrade, you can basically capture the full 35 MHz of bandwidth required by the FCC for conducted emissions in one acquisition.”

EMC test solutions are also available from distributors. For example, Newark offers complete EMC pre-compliance testing solutions, including software, spectrum analyzers, accessories, and probes for ease of use and performance to support customer needs, according to Maureen Lipps, product manager, Test & Tools. She cited as an example Newark’s recently launched Keysight N9000B-503 spectrum analyzer used with N6141C/2TP EMI software.

“Keysight’s EMI measurement application on X-Series signal analyzers allows engineers to perform pre-compliance measurements and diagnostic evaluation of their designs,” she said. “In addition, electronics makers can find and fix problems before they enter the test chamber with the N6141C measurement application on the N9000B CXA signal analyzer with multitouch UI. EMC pre-compliance capabilities include built-in CISPR- and MIL-STD-compliant bandwidths, detectors, and band presets; automated testing to regulatory limit lines with user-selected margins; amplitude correction (for antennas, LISNs, cables, and preamps); and built-in report generation.”

Lipps said Newark also offers the Tektronix RSA306B PC-based spectrum analyzer with SignalVu-PC software used with the EMCVu plug-in. “EMCVu lets designers quickly identify areas of concern to streamline testing and debugging

activities,” she said. “In addition, engineers can quickly analyze suspect frequencies in more detail using a near-field probe to find the source of emission.”

A third EMC test product from Newark, Beehive Electronics 101A EMC probe sets are designed for identifying and fixing EMC problems. “The 100A, 100B, and 100C are loop probes and are sensitive to magnetic fields” Lipps said. “The 100D is

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a stub probe and is sensitive to electric fields. The loop probes have integrated electrostatic shields, providing isolation from common-mode signals. As a result, these probes deliver excellent repeatability. The different loop sizes allow the user to select the optimum probe for a given frequency, providing the optimum sensitivity and spatial resolution.”

Saelig Co. Inc. also offers EMC test equipment from a variety of manufacturers, including spectrum analyzers from Aaronia, Aim-TTi, Rigol, Siglent, and Triarchy; fieldmeters and probes from EMC Test Design LLC; shielded enclosures from Ramsey Electronics; probes, amplifiers, LISNs, and TEM cells from Tekbox; radiation measurement systems from MegiQ; and EMI test enclosures from Select Fabricators. Applications include near-field probing for EMC pre-compliance test<sup>1</sup> and immunity testing using a TEM cell<sup>2</sup>.

As this article was being prepared for publication, organizers of the 2020 IEEE EMC + SIPI Symposium were still planning to hold the live event July 27-31 in Reno. Commenting on the issue, Landers at AR RF/Microwave Instrumentation said, “We plan on attending and will be showcasing our AA Series and other test systems, emcware 5.0, and a full chamber setup from our partner Comtest.”

Anritsu plans to highlight the Radio Communication Test Station 8000A and Radio Communication Analyzer MT8821C. “These solutions enable a range of regulatory and compliance testing, including EMC certification for FCC, ISED, and EU RED, on 5G NR devices,” said Yasami.

Gauss plans to demonstrate its TDEMI ULTRA and its automation software EMI64k, according to Braun. Hu at Keysight said the company plans to highlight its N9048B PXE EMI receiver with its Time Domain Scan/Accelerated Time Domain Scan and Real Time Scan capabilities. Gross at Rohde & Schwarz said the company plans to highlight products including R&S ELEKTRA, the fast TDS function for the R&S ESW, R&S AdvISE v5 with optical character recognition (OCR) for text and numbers as well as image stabilization, the R&S ESW-K58

Multi CISPR APD measurement option for the R&S ESW test receiver, and the R&S FPL1-K54 EMI measurement option for the R&S FPL1000 spectrum analyzer.

## Features and challenges

Several contributors to this report elaborated on challenges of EMC test and features that can help engineers meet those challenges. “Many companies are trying to overcome the EMC hurdle without a deep understanding of the physical issues involved, and who can blame them?” said Chonko at Siglent. “Electromagnetics is not trivial, and designs are becoming increasingly complex. Most EMC-targeted instrumentation is also expensive. Since many companies are trying to achieve compliance certification without breaking the bank, Siglent’s goal is to provide tools that get the job done with minimal cost. Quasi-peak detector capability, multitrace viewing, spectrum/waterfall charting, on-screen limit lines, and real-time spectrum acquisition are all features that help lower EMC test time, and Siglent delivers them at affordable prices.”

Gross at Rohde & Schwarz said customers look for easy-to-handle test software for pre-compliance tests during the product development, as well as for automated compliance tests. “To meet these needs, Rohde & Schwarz will successively replace its well-known R&S EMC32 automation software,” he said. “The new R&S ELEKTRA EMC test suite facilitates interactive and/or fully automated measurements for pre-compliance and certification tests for both electromagnetic interference (EMI) and electromagnetic susceptibility (EMS) for all relevant standards.”

Gross also noted that engineers are starting their EMC investigations earlier in the development process, adding that Rohde & Schwarz helps with spectrum analyzers suitable for these tasks. “In combination with the new R&S FPL1-K54 EMI measurement option, the R&S FPL1000 all-round spectrum analyzer measures emissions in line with CISPR and MIL standards and makes fast pass/fail decisions,” he said.

“The spectrum analyzer remotely controls LISNs, and has the corresponding

correction factors built-in. For pure debugging tasks, the R&S FPC1000 spectrum analyzer together with the high-quality R&S HZ-17 near-field probe set and the R&S HM6050-2 LISN is a good choice. This combination allows developers to detect both radiated and conducted interference.” The R&S ELEKTRA EMC test software supports analyzers as well as other instruments and accessories, he added.

Mologni at Ansys commented that the company’s simulation tools are used in the early stages of a development cycle. The tools, “...empower engineers to tackle different problems such as signal integrity, power integrity, EMI, and radio-frequency interference (RFI).”

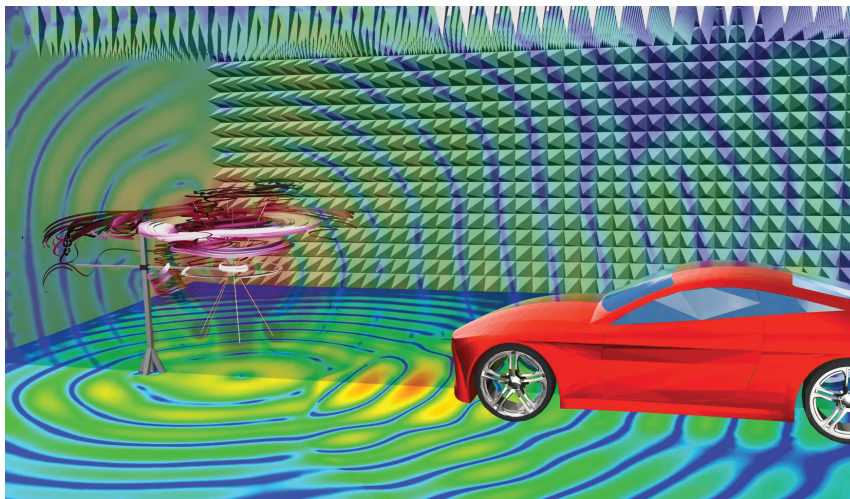
He added that many electrical and thermal issues that affect PCBs—EMI, crosstalk, power integrity, overheating, etc.—adversely impact the overall signal integrity of electronic devices. Automated techniques combine the best attributes of two solvers—in this case, the accuracy of HFSS and the speed and capacity of SIwave—to mitigate SI problems of high-speed data channels in complex and dense printed circuit boards.

“Automatic adaptive mesh refinement techniques in Ansys EM tools accurately model complex PCB, IC, and package designs for DCIR analysis to predict the power integrity of these designs,” Mologni said. “Design-rule checkers in Ansys tools identify potential problems in high-speed electronic systems prior to running simulations, saving time and effort which may otherwise be spent in making costly design changes late in the development cycle. These simulations eliminate errors and reduce PCB re-spins.”


vanEijkelenburg at Pacific Power commented that for final test, full compliance to the applicable standard is of paramount importance. “This also implies that measurements must be both repeatable and reproducible,” he said, adding that other important issues are the ability to test a wide range of products in terms of power level and phase modes with as much sharing of test hardware resources as possible to manage test system cost. “Finally, report generation that documents compliance of the product is important for audit and verification purposes,” he added.

vanEijkelenburg also commented on a growing trend toward the need for ever higher power levels, driven by larger solar installation and thus larger PV inverter sizes. This is coupled with EV charging infrastructure demands for faster charging, and thus higher voltage and power needs. “To meet these growing power needs, our ECTS2 EMC test systems are available up to 90 kVA with higher configurations available as needed,” he said.

Yasami at Anritsu said Test instruments must provide engineers with an overall simple and efficient test process—including ease of use, automation of test cases, and uncomplicated control of the device under test (DUT) without the need to manually configure the DUT or incorporate specific test modes. “5G NR devices and User Equipment (UE) utilize Frequency Range 1 (FR1) and Frequency Range 2 (FR2) frequencies, which include sub-6-GHz and mmWave spectrums, respectively,” he added. “5G NR equipment



▲ Ansys HFSS radiated immunity simulation according to ISO 11451-2.

requires more complex test setup and execution. Engineers must rely on industry-leading technology, such as that incorporated in the MT8000A and MT8821C, to accurately test devices and UE so they can be certified in a timely manner.” 

#### REFERENCES

1. EMC Precompliance Testing: Near Field Probing, Application Note, Saelig Co. Inc.
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# TECH FOCUS

## DC/DC CONVERTERS

DC/DC converters come with a range of capabilities, from low-power devices for IoT and wearable applications to high-power modules that can power servers as well as storage and network equipment. Here is a sampling of some products on the market.



### DIN rail-mount DDA DC/DC converters

TDK (TSE 6762) introduced TDK-Lambda brand DIN rail mount DDA DC/DC converters, using step-down nonisolated power modules using an input range of 9 up to 53Vdc, and a wide adjustable output voltage range from 3.3 up to 24V. The DDA is suited for generating additional low cost, high-current outputs from an existing 24V bus in industrial, semi-fabrication and test and measurement equipment. Three models are available in the DDA series. A single nominal output +12V 20A, a dual output +12V 20A / +5V 20A and a dual output +12V 14A / -12V 8A. Output power is typically 250W for each of the positive outputs and 75W for the negative output. Convection cooled, the overall output power is 250W, which can be increased to up to 500W with forced-air cooling. Positive remote sense, remote on/off and individual power good signals are standard. The DDA series is highly efficient, up to 95%, reducing internal waste heat for reliable operation. The models are 123.4mm high, 115mm deep and have a very narrow 36.5mm width, providing additional space on the DIN rail.

**TDK-Lambda**



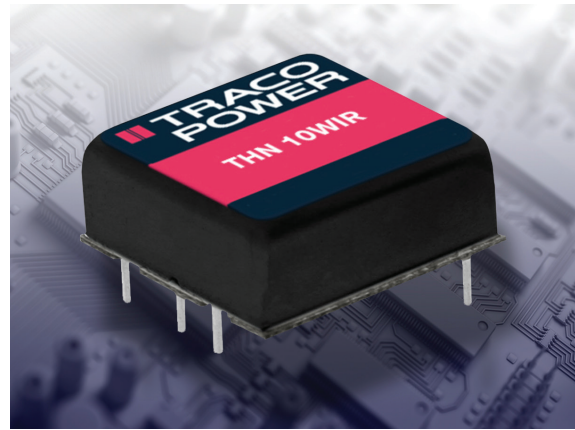
### Industrial-quality DC/DC converter

ABSOPULSE Electronics released the LQC 2K-3U2LC, a liquid cooled, industrial quality DC-DC converter that uses field-proven technology to deliver up to 2000W output power. The unit accepts an input of 600Vdc (400Vdc to 800Vdc range) and provides 24Vdc/80A output voltage. A built-in output separation diode allows parallel connection of several units for higher system output. Custom input/output voltages are also available. The LQC 2K-3U2LC liquid-cooled converter is designed for dense enclosed spaces where heatsinks, fan or pure convection cooling are not feasible. The unit is typically used in vehicles, industrial automation and similar heavy-duty applications. The LQC 2K-3U2LC uses liquid coolant, and the cold plate has an embedded tube running a loop of coolant liquid which ensures a -25°C to +50°C coolant temperature range for full specification. The unit is connected to the external customer cooling system, which provides the liquid coolant. Optional internal temperature sensors can be installed to monitor the liquid coolant temperature. The LQC 2K-3U2LC is equipped with heavy filtering on the input and output, which contributes to low noise. This ensures that the converters can be used in EMI sensitive environments without additional filtering. The input meets EN55032 Class A with wide margins; Class B is available as an option.

**ABSOPULSE**

## 10-Watt DC/DC converter series

The THN 10 WIR series of 10-watt high-density DC/DC converters has an industry standard 1" x 1" footprint and is qualified for rugged industrial and railway applications, and are designed and manufactured for high reliability in harsh environments. The converters have 4:1 input ranges of 9-36, 18-78 and 36-160 VDC with single and dual outputs ranging from 3.3-24 VDC. The innovative design provides high efficiencies up to 90% and enables a full load operating temperature range from -40 to +80°C without derating, with increased resistance against electromagnetic interference, shock/vibration and thermal shock. All models are safety approved to IEC/EN/UL 62368-1 with CB Report and EN 50155 certified qualifying them for harsh environments in industrial, railway and transportation systems and further qualified for fire behavior of components per EN 45545-2. Features include: an internal EN 55032 class A input filter; input under-voltage-lockout; short circuit protection; remote on/off; and output voltage trim. All models offer an MTBF in excess of 2.3 million hours and are supported by a 3-year warranty.




**TRACO POWER**



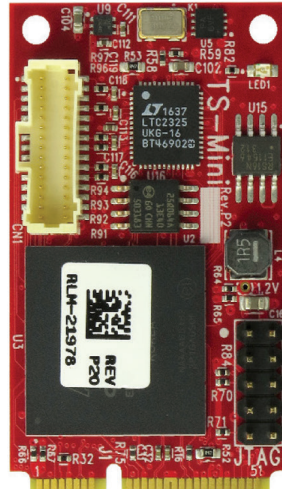
## 80-W DC/DC converter

Cosel has announced the release of a high-reliability 80-W DC/DC converter, the MGF80. Packaged in an industry-standard 2-in. x 1-in. 6-sided, shielded metallic case, the series has been designed with a failure rate below 30 ppm. The MGF80 does not include aluminum or tantalum capacitors. Addressing a range of demanding applications, the series is available in two input voltages: 9 V to 36 V and 18 V to 76 V. A single output version, the MGFS80, is available in four output voltages, 3.3, 5, 12, and 15 V, and can be adjusted within a range of  $\pm 10\%$  using a resistor bridge or potentiometer. A dual-output version, the MGFW80 is available in two factory-trimmed output voltages,  $\pm 12$  V and  $\pm 15$  V.

**Cosel Co. Ltd.**



# Technologic Systems




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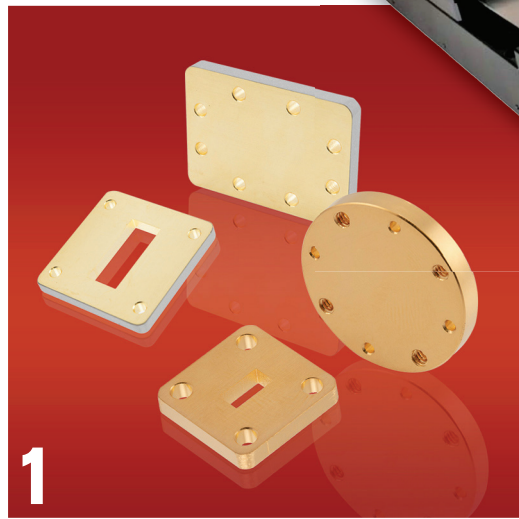
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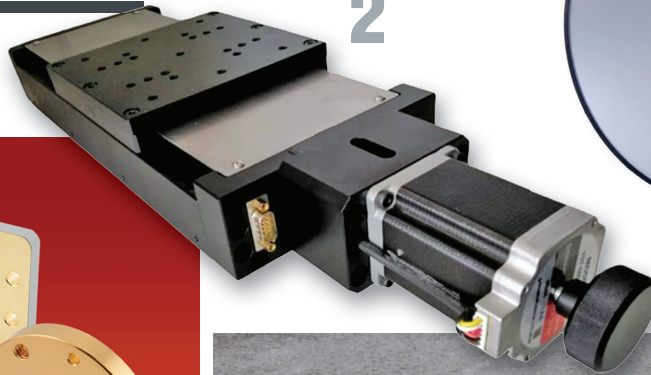


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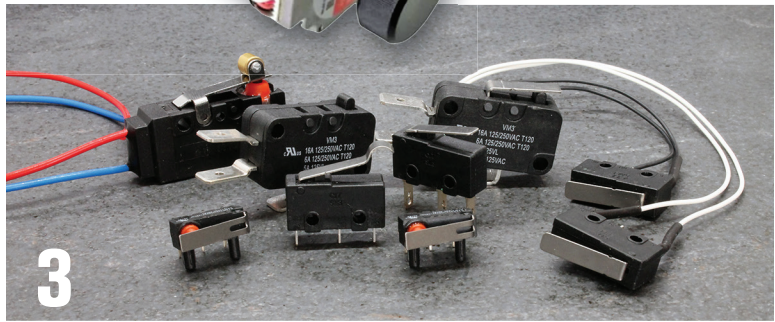
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### 1. Series of Waveguide Shorts and Shims

Fairview Microwave launched a series of waveguide shorts and shims suitable for use in test and instrumentation, wireless communication, satellite communication and radar applications. The series includes 36 models in waveguide sizes from WR-430 to WR-10. These waveguide shims and shorts are compatible with square and round UG cover and CPR-style flanges, and are available in both copper and aluminum versions.

Fairview Microwave

### 2. Profile Rail Linear Guide Stages

Optimal Engineering Systems (OES) added five profile single-axis positioning stages to their AQ150 Series. Available in travel lengths of 600 mm (23.622 in.), 700 mm (27.559 in.), 800 mm (31.496 in.), 900 mm (35.433 in.), and 1000 mm (39.370 in.), with either a two-phase stepper motor or with a three-phase brushless motor with a quadrature incremental optical encoder. Stepper-motor-driven models have a resolution of 2.1 microns.

OES

### 3. VM3 Series Snap-Action Switch

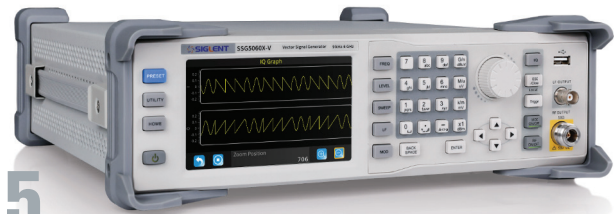
VM3 Series Snap-Action Switches feature 0.187" or 0.250" termination, the VM3 Series offers SPST NO, SPST NC or SPDT functions with operating force from 80gF up to 180gF. This highly customizable switch also offers actuator lever options of pin plunger, roller levers, hinge levers and simulated rollers. Common applications for the VM3 Series include lighting, security, automation, industrial controls, gaming and more. Specifications and materials are dependent upon your choice of options. Lead-time averages 6 to 8 weeks. Volume pricing is dependent on option choices.

CIT Relay & Switch

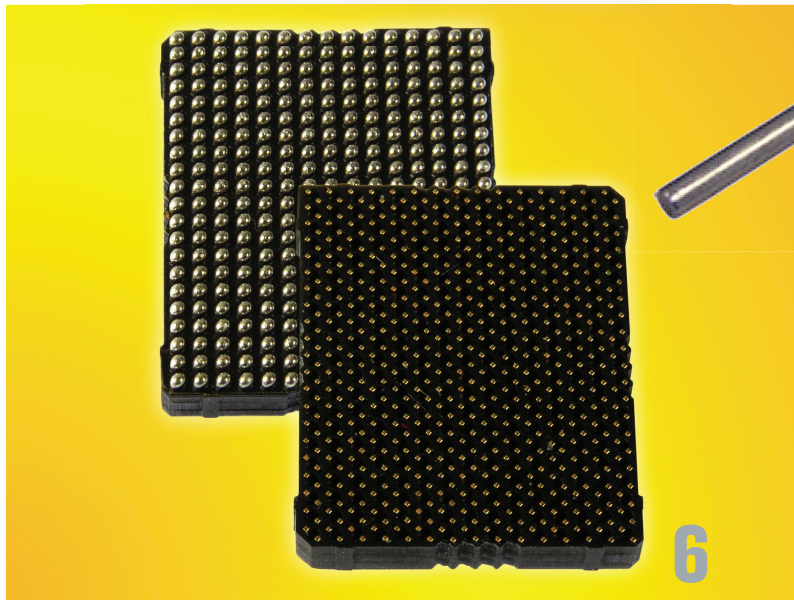
### 4. Point-to-Point Wireless I/O Modules

Acromag broadened their Vertu instrumentation family with the VWB2000 signal wire replacement system. Provided in a rugged NEMA 4X/IP68 industrial housing, the point-to-point wireless signal bridge takes analog, discrete, or Modbus signals at one location and reproduces them at a second. The system consists of two pre-paired transmitter/receiver units with a range of 1 mile outside, or 500 feet indoors, which can be extended using wireless repeater units or high-gain directional antennae. An LCD display provides signal strength and other diagnostic information.

Acromag

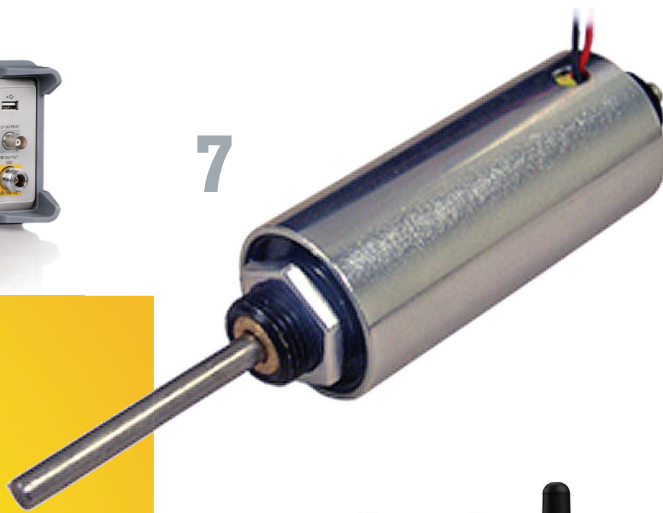


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## 5. Next-Generation RF Signal Generators

Siglent RF signal generators now also cover the NR-5G Band (FR1) between 3.4 and 3.7 GHz. Siglent's Model SSG5000X Series RF Signal Generator can source analog and vector signals up to 4 GHz or 6 GHz. The SSG5000X-V Series Generator features internal IQ modulation with an RF Modulation Bandwidth up to 150 MHz, and an arbitrary waveform playback function. The generators' phase noise is -120 dBc at 1 GHz / 20 kHz offset, with a regulated maximum output level of up to +20 dBm (settable up to +26 dBm), and a minimum output level of -130 dBm (settable down to -140 dBm).

**Siglent**

## 6. LPDDR5 Grypper Test Sockets

Ironwood Electronics GR1032-0001 Grypper socket allows testing of the latest LPDDR5 devices with a 315 Ball and 0.7 x 0.8mm pitch, with speeds up to 6400Mb/s. The LPDDR5 Grypper socket fits to the same location/PCB footprint as the device for development and failure analysis. With a -1dB insertion loss at up to 40.0 GHz, the force required to insert a device is 45 grams per contact. Available in three configurations, including RoHS-compliant versions, pricing for the GR1032-001 is \$594 at qty 4-10.

**Ironwood Electronics**

## 7. Linear Actuators

Moticon has introduced the DDLM-019-044-01 non-commutated linear actuator. This compact, zero cogging, clean, quiet, fully enclosed linear actuator, is just 0.750 in. (19.1 mm) in diameter, with a housing length of 1.750 in. (44.5 mm) long and a stroke of 0.460 in. (11.7 mm). This linear actuator can develop 11.0 oz (3.1 N) of continuous force with a 34.8 oz (9.7 N) peak force. Direct coupling of the actuator to the load results in zero backlash and allows for smooth, high acceleration/deceleration, and high-speed positioning.

**Moticon**

## 8. High-Performance Parabolic Antennas

KP Performance Antennas released 2- and 3-foot antennas with Mimosa B11 mounting kit options to its series of ProLine 11 GHz parabolic antennas. KP's high-performance ProLine parabolic antennas are ideal for high-density, point-to-point backhaul applications or client-premises and operate in the 10.7 GHz to 11.7 GHz frequency range. Offered in 2- and 3-foot diameters, they deliver gain performance of 34.4 dBi and 39 dBi respectively. The antennas are engineered to suppress side- and back-lobes, and reject interference, deliver SISO or 2x2 MIMO, with a 155-mph survival wind speed.

**KP Performance Antennas**

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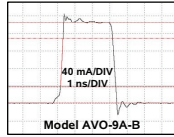


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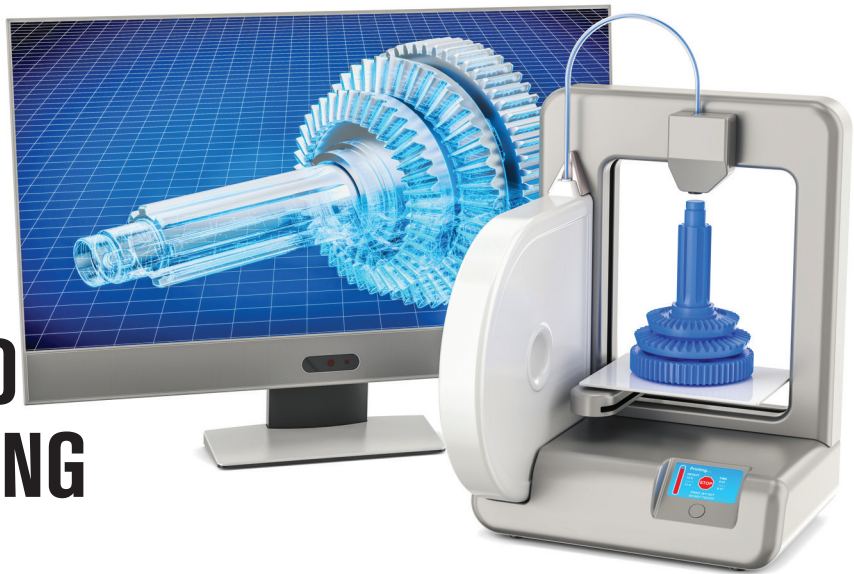
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# 3-D PRINTING MATURES INTO MANUFACTURING

By Ken Cormier, Managing Editor



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▶ 3D printing, also known as additive manufacturing, creates solid objects from a digital file, with the ability to produce complex shapes, including hollow forms. The technology has advanced far from its beginnings in the '90s as a rapid prototyping medium, to a viable cog in industrial manufacturing. Here are a few snippets about recent developments in this rapidly changing technology:

## GE Partners with U.S. Air Force for Printing Spare Engine Parts

General Electric has successfully 3D-printed the sump cover for the F110 jet engine. Initially cast from aluminum, the part, also used on F-15 and F-16 jet fighters, was the focus for this first phase of the collaboration. Engineers at GE Aviation's Cincinnati-area Additive Technology Center (ATC) created the parts from cobalt-chrome powder, using GE Additive's Concept Laser M2 machine. "Part of that process involved how metal additive might replace parts that are either no longer in production, or where we need smaller production runs to keep our platforms flying," explained Melanie Jonason, chief engineer for the propulsion sustainment division at Tinker Air Force Base in Oklahoma.<sup>1</sup>

## Human-Like Ears 3D-Printed Inside Mice


Scientist Maling Gou and colleagues at Sichuan University, China, have grown human-like ears on the backs of mice. The technique could be used to create

body parts for people without resorting to surgery. Up to now, spare human body parts have been printed outside the body, then surgically implanted, which carries a risk for infection. In this experiment, the researchers injected a "bio-ink" into the backs of mice, which was subjected to near-infrared light in the pattern of a human ear, which caused the hydrogel ink particles to solidify and develop, in layers, into human ear structures. Within a month, cartilage cells grew around the structures. The researchers said that the mice suffered no inflammation or side effects. An intent of the study is to create ears for humans born without ears, a condition called microtia. According to Derek Rosenzweig at McGill University in Canada, this printing technique has potential in repairing damaged cartilage in noses, fingers, toes, or elbows. Rosenzweig said that using the technique on hip and deep knee cartilage would be a special challenge, because near-infrared light penetrates only 2 centimeters into the body.<sup>2</sup>

## Coronavirus Spurs Use of 3D Printing

Emergency responders have been faced with finding enough face shields for protection during the COVID-19 coronavirus disaster. Fortunately, major defense contractors such as Raytheon Technologies have been able to contribute what they know in three-dimensional (3D) printing, to form thousands of secure face shields for first responders and other emergency crew members.

"It was unprecedented to bring the entire corporation together to print one single file across multiple processes and materials using somewhere around 100 machines in less than two weeks," said Jesse Boyer, fellow for additive manufacturing at Raytheon Technologies. "To ramp up to that volume that quickly is something that is touted using additive manufacturing, but rarely demonstrated. The opportunity was a great learning experience."

Instead of cutting or molding material, 3D printing, or additive manufacturing, creates a part by building layer upon layer to form the desired shape. This approach can provide extremely efficient shapes and sizes that also work well where space is at a premium, such as in aircraft. "The wild side is to continue to do that, to make very complex, yet optimized structures for areas we couldn't normally do in a jet engine," Boyer said. "We explore methods like bio-mimicry, by looking at the best nature has produced. Additive then reduces the constraints of conventional manufacturing and substantially increases our ability to optimize what we can manufacture."<sup>3</sup> 

## REFERENCES

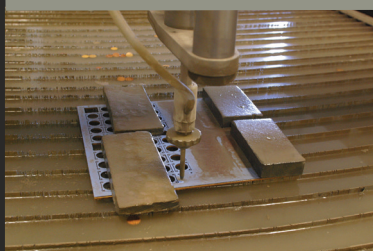
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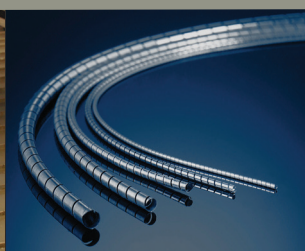
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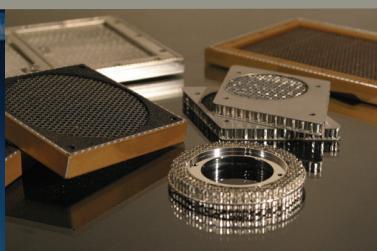
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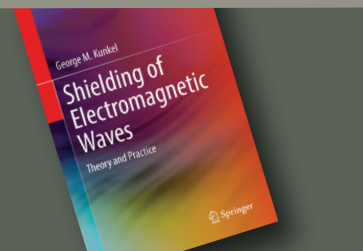
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