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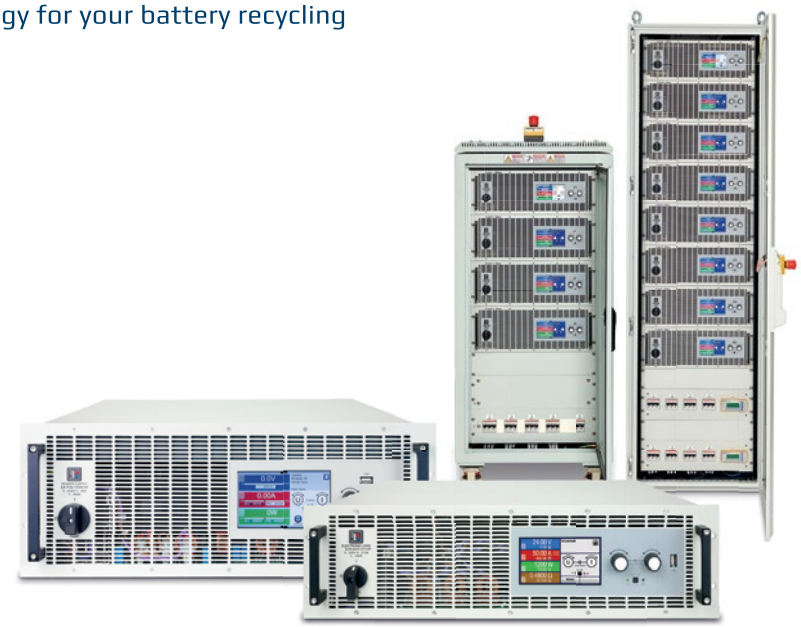

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EDITOR'S NOTE

HARDWARE IS AWESOME

We tend to forget this shiny happy software-oriented world is built on a foundation of hardware.

Beyond the societal issues of the mundane world, we actually live in a very cool time. The technical renaissance fomented by the ability for electronics to enhance processes is still ongoing, with no real end in sight. Our industry is full of cool terms that reflect the impressive pervasive wireless world we live in. Cloud-enhanced, IoT-driven, software-oriented—the modern landscape is full of functional promise.

Unfortunately, there is some disquiet in the industry, as software takes a stronger and stronger hold and influence over hardware design and development. Many in the public think that software is a new replacement technology that will sweep all before it, converting everything into the Internet. We'll all be magically connected with smart earrings, or something we haven't thought of yet, through a seamless wireless environment free of cares and worries.

Yet that's not really how it works. For all of the amazing Cloud-based IoT-enabled software-oriented carefree world we see, there is a lot of wiring behind the wainscoting that many don't see. That's the hardware part, the part that without which nothing would function, no matter how slick the software. You can have all the powerful, emission-free, cheap gasoline you want, but if there is no car to pour it in, you are going nowhere.

The fact is that the current advances in software capabilities are grounded in the hardware that runs it. There is no Edge computing without better processors, ditto AI, and all the other enhanced computing solutions being developed. Without the advanced, fast, efficient, and powerful hardware platforms, there would be no capacity or ability to present any functionality to the user.

We covered a variation on this theme recently in an article online called "No Electronics Without Electricity" (evaluationengineering.com/21223150) in which we talked to our old friend Robert Gendron of Vicor, on power's changing role in the industry. One of the things we covered was the aspect of power being ubiquitous, needed, and yet often overlooked or considered in a secondary fashion, when it is the primary foundation of it all. There are truly no electronics without electricity, and there can be no software without the hardware to run it.

To whip this omnibus of analogy further, you cannot sail the seas without a ship, you can't surf the waves without a surfboard. We are all traveling in this new software sea but, in reality, it is the ability of our boats to take us there that is the real journey. We travel to new places and discover new worlds, but the hardware is where we physically interact with the world we live in.

Another perspective can be taken from the mixed-signal space, where analog and digital information leverages one another. Without digital processing, many of the functionalities we realize today would not be able to manifest themselves, but without the analog real world to draw from, there is nothing to process and act upon. (This skirts the whole issue of reality and whether it's important, but they're covering that in the philosophy class down the hall.)

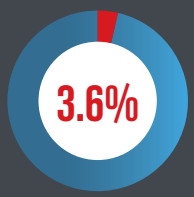
People see software intruding into the hardware space, but it is really the hardware growing with the ability to integrate software. Unlike electricity replacing steam or fossil fuels, electronics aren't being replaced by software, they are being enhanced by it. There is no real dichotomy, it is a false conflict. Hardware and software are Yin and Yang, Warp and Woof, inseparable and complementary. EE

Alix Paultre,
Editor

BY THE NUMBERS

123.1 BILLION

Global Semiconductor sales in Q1 2021

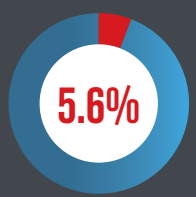


Revenue increase over previous quarter

Source: SIA

23,560.4 MILLION

Predicted market for electronic warfare by 2028

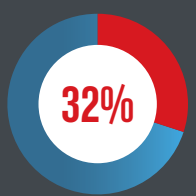


Predicted CAGR 2021-2028

Source: Allied Market Research

3.14 BILLION

North American semiconductor equipment billings in February 2021



Billings increase over February 2020

Source: SEMI

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Figure 1: The Anritsu Field Master Pro MS2090A real-time spectrum analyzer has a frequency coverage up to 54 GHz.

SPECIAL REPORT

SIGNAL & SPECTRUM ANALYZERS EMPOWER ADVANCED WIRELESS SYSTEM DEVELOPMENT

by **Alix Paultre,** Editor

The crowded RF spectrum, compounded by the explosion in application spaces joining the cloud, demands advanced development tools able to provide deeper insights into signals and their measurement.

Our society is in the process of migrating toward a more expansive and extensive Cloud-based, IoT-oriented, and "smart" community where people, things, and the very neighborhood they exist in, are all connected and communicating. The shiny future consumers are growing to expect, however, involves a monumental amount of device and infrastructure development.

The tools needed to create this future are luckily powerful and extremely functional and can make the difference between a relatively easy development process and design hell. For this Special Report we asked some companies about their latest solutions to aid your design, test, and evaluation needs. Signal & Spectrum Analyzers are critical to measuring the performance in wireless application spaces as well as perform standards-compliant wireless measurements.

Interference mitigation

When we reached out to Anritsu about challenges in the RF development space, their first response was that the No. 1 challenge that network managers face is interference mitigation. This can be an extreme challenge, as interference comes from more and more sources and as the spectrum continues to crowd, especially with new 5G bands.

They presented the Anritsu Field Master Pro MS2090A real-time spectrum analyzer (https://www.anritsu.com/en-us/test-measurement/products/ms2090a) as having a level of performance never previously available in a compact, handheld instrument (Figure 1). These features include a frequency coverage up to 54 GHz to cover most popular signal standards, as well as a 110 MHz instantaneous capture bandwidth to support 5G carriers.

There are also 5G and LTE demodulation packages provided for installation and maintenance applications, offering real-time spectrum analysis to capture narrow, intermittent, or signal-on-signal interference with IQ capture and streaming for detailed signal analysis. There is also a pulse analyzer for automated pulse measurements based on IEEE standards, and EMF options up to 40 GHz.

The Field Master Pro is also equipped with a wide variety of features to directly address interference. These include extremely fast real-time spectrum analysis (RTSA), IQ capture/streaming, coverage mapping, direction-finding tools, AM/FM audio output, and interference-hunting PC tools.

When it came to the question of the trends they are seeing in the area of Signal & Spectrum Analyzers, Anritsu said that on the premium end, analyzers continue to expand in frequency coverage and analysis bandwidth to match growing wireless signals. Viewing the spectrum isn't enough, though. Instruments need to provide solutions to help track and analyze wireless signals. Real-time spectrum analysis is becoming increasingly valuable in the field for finding "signal-in-signal" or intermittent interfering sources.

Among the application areas Anritsu's Signal & Spectrum Analyzers target, the two largest spaces include wireless and cellular customers (operators, regulators, network equipment manufacturers) and general-purpose test in aerospace and defense, satcom, intelligence, and commercial products. Their instruments are used for interference tracking/hunting, spectrum clearing, signal fidelity (i.e. radar measurements), and installation verification.

Capturing elusive signals

When we spoke about development challenges with Paris Akhshi, Product Marketing Manager at Keysight Technologies, she brought up the emergence of numerous high-frequency mmWave use cases, which are increasing bandwidth demands with higher-order modulation schemes, which allow for faster data rates. However, signals at mmWave frequencies are more susceptible to impairments, resulting in significant path loss between test and measurement instruments and the device under test (DUT).

The lower signal-to-noise ratio (SNR) makes signal analysis measurements, such as error vector magnitude (EVM), adjacent channel power, and spurious emissions, very challenging. This limits engineers from truly understanding the performance of their DUT. She explained that engineers need a test solution with the widest analysis bandwidth and highest frequency range available, to help them solve their most difficult test challenges in mmWave applications.

The system must isolate the DUT's measured results from all other measurement setup effects that come from components between a signal analyzer and a DUT, or the test equipment itself. In the past, an external mixer was required to extend the frequency range of a signal analyzer, which due to the lack of a preselector at the front end of the mixer, led to unwanted images in the band of interest and degraded measurement accuracy.

Also, when measuring frequency outside of the mixer's frequency band, engineers needed to reconnect the test signal to the signal analyzer's RF input port or another mixer with a different band. Engineers also needed to change the input source from the corresponding operation interface. These extra steps increased test complexity and measurement uncertainty.

Keysight addresses these issues by integrating a preselector and an RF switch into a high-dynamic-range frequency extender, with a seamless operational interface to the signal analyzer. This enables a wide, unbanded, and preselected swept-power spectrum without managing band breaks and images.

The company's N9042B UXA X-Series, is their latest flagship and is presented as the most powerful signal analyzer available. The N9042B along with a frequency extender deliver a single connection preselected to 110 GHz, with up to 11 GHz of analysis bandwidth, claiming the industry's widest dynamic range and best residual EVM (Figure 2).

The N9042B's latest solution for signal analyzer calibration, the U9361 RCal receiver calibrator, provides up to 10X improved receiver test system accuracy, by removing magnitude and phase errors in measurement setups up to 110 GHz. This proprietary, palm-sized, USB-enabled calibrator can drastically reduce test time, cost, and complexity, eliminating the need for multiple pieces

▼ **Figure 2:** The N9042B UXA X-Series is presented as the most powerful signal analyzer available.

of equipment to calibrate signal-analyzer measurement systems.

The company's recently released millimeter-wave (mmWave) test solution, including the N9042B UXA signal analyzer and M9384B VXG signal generator, supports 4 GHz of corrected RF bandwidth for signal generation and analysis, as well as high-frequency coverage and the speed needed for wideband, high-throughput mmWave communications. Keysight's PathWave X-Series measurement applications address ever-changing measurement requirements for the latest standards with ready-to-use measurements for a variety of mmWave applications.

89600 PathWave VSA software is a comprehensive set of tools for demodulation and vector signal analysis, with support for more than 75 signal standards and modulation types. PathWave VSA software enables engineers to explore virtually every facet of a signal and optimize their most advanced designs, while spending less time on measurement setup and delivering repeatable results.

Addressing mmWave

The use of mmWave frequencies is essential to accommodate more users in an RF spectrum that needs to be free of interference. Proposed LEO-satellite concepts, which orbit 500 to 2,000 kilometers from Earth, offer faster communications, and provide higher bandwidth per user than GEO satellites. In the radar industry, with the increase in vehicle-to-vehicle and vehicle-to-everything wireless communication, automotive radar requires the utmost reliability and performance. Therefore, isolating signals and ensuring EMI/EMC compliance are more important than ever.

Although mmWave technology is the key enabler for all these applications to provide ample margin for performance improvement, it creates challenges such as path loss, tight design margins, complex modulation, and stringent standards. Higher frequency ranges and wider bandwidths enable high-throughput data, range resolution and accuracy, and low latency, but also introduce more noise. The excessive path loss and noise increase test complexity and measurement uncertainties.

Therefore, engineers now, more than ever, need to take extra care to evaluate mmWave components and devices accurately using more advanced signal analyzers, that can deliver the high level of measurement accuracy, in the most reliable fashion. Two main mmWave target applications for N9042B UXA X-Series signal analyzer, are 5G and satellite communications.

In satellite communications, RF engineers need to ensure outstanding system performance through all stages of the satellite life cycle. Once a satellite is deployed, it cannot be called back for a repair. Similarly, testing 5G components and devices per the 3GPP 5G NR standard Release 15 and 16 requires a test solution with higher accuracy, sensitivity, and analysis bandwidth capability.

In mmWave communications, higher frequencies mean greater path loss and a lower SNR ratio, which make it very difficult to make precise measurements. Therefore, components and devices require better EVM performance as the modulation density increases to maintain the communication link. Engineers need to take extra care to design and validate the components and devices accurately, because of the inherent mmWave wideband noise that reduces the SNR and leads to poor measurements.

Keysight's N9042B signal analyzer delivers considerable noise performance by leveraging a highly customized signal-path front end providing what is presented as the best swept-displayed average noise level (DANL) in the industry, down to -174 dBm at 1 GHz, and superior dynamic range for precise measurements of small signals near noise in the presence of large signals. Keysight's latest mmWave test solution supports 4 GHz of corrected RF bandwidth for signal generation and analysis, as well as high-frequency coverage and the speed needed for wideband, high-throughput mmWave communications.

Standards compliance

Dr. Houman Zarrinkoub, Principal Product Manager, Signal Processing & Communications at MathWorks, brought up how ensuring that wireless systems conform to standard specifications is of paramount importance. The effect of RF propagation environments and channels, resulting in signal distortions, must be analyzed and verified at all appropriate frequencies. Base stations and mobile phones must be built and tested at the same frequencies, and this in turn drives the need for up-to-date application tools for analysis and test.

Hardware-based spectral analysis has its own inefficiencies. Configuring RF test equipment like signal generators and analyzers as well as Software Defined Radios (SDRs) to validate 5G and other communications signals over the air (OTA) can take too much time and is often cumbersome to set up. Using a configurable and programmable software environment allows for more repeatable and efficient signal analysis.

To satisfy speed and throughput needs, innovative algorithms such as OFDM, massive MIMO, and beamforming are introduced. This in turn adds significant complexity to the design and verification burden of wireless systems. In turn, the numerous combinations of design options within these systems provide a wide range of spectral characteristics to be adequately analyzed and validated.

To perform better conformance testing at new millimeter-wave frequencies, MathWorks has introduced software-based scopes, such as a spectrum analyzer, into several of their add-on products like DSP System Toolbox and RF Blockset. The spectrum analyzer shows a detailed spectrum of a simulated signal at a wide range of frequencies including millimeter waves. This enables specific measurements associated with the development of individual system components.

Since these spectrum analyzers are software-based, we don't need to wait for RF circuitry necessary to transmit and receive millimeter-waves to be ready before we can test them. Using software models of radio-frequency frontends, power amplifiers and digital pre-distortion (DPD) units, we can perform simulated measurements. Measurements provided by the spectrum analyzer include channel power, occupied bandwidth, frequency offset, harmonic distortion and SNR, to

name a few. The scopes also enable the design of custom measurement tools that can be used on live or prerecorded signals.

App-enabled analysis

Waveform generation is an important requirement for testing any design, and MathWorks' Wireless Waveform Generator app makes the testing process easier and more interactive. It supports a wide range of wireless standard waveforms such as 5G, Wi-Fi, and Bluetooth, and integrates spectral analysis within the waveform generation environment. This, for example, enhances 5G NR testing by characterizing in both time- and frequency-domains in the app.

The app also supports off-the-shelf testing signals specified by standard documents including test models (NR-TM) as well as fix reference channels (FRC). As of release 2021a, it also includes custom 5G waveform generation in the app, which enables engineers to specify any arbitrary set of parameters and to generate all types of 5G signals.

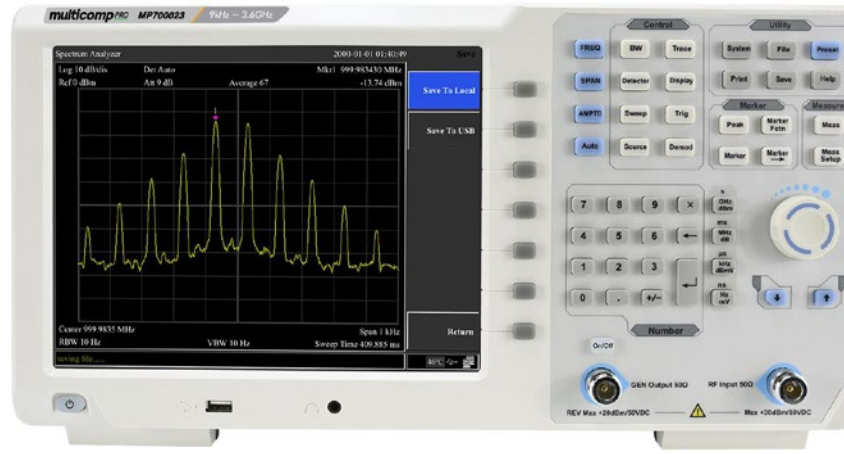
Signal and spectrum analyzers are evolving to support emerging trends and application areas, including requirements such as expanded support for mmWave frequencies, expanded signal bandwidths for enhanced broadband mobile applications, and support for analysis of low-delay transitory signals encountered in IoT and smart-industry applications.

MathWorks' products are used for waveform analysis, algorithm design, and system development across a diverse mix of application domains and signal types. Notable examples include wireless communications, radar and sonar, audio, and noise and vibration. In the wireless area, the products are used to design and test wireless signals for low-power IoT applications, delay-sensitive vehicle-to-vehicle communication, and high-throughput cellular base-station applications.

What are your thoughts on market and industry trends in Signal & Spectrum Analyzers?

As 5G and other high-speed wireless connectivity standards get introduced, there's been an increase in the number of companies providing wireless testing products and services in the market. These new companies, small or large, are vying for market share in this competitive testing market and are customizing their offerings to distinguish themselves from the competition. Many of them use software solutions provided by companies like MathWorks to ensure that their solutions are compliant with standards specifications. This use case of such tools as a reference for design verification is an area that the company provides added value to the signal and spectrum analyzer development market.

Dr. Houman Zarrinkoub concluded by commenting that technology waves in mmWave applications, including 5G, satellite communications, and aerospace defense, are occurring at a faster pace. Advancements in frequency and bandwidth, in mmWave spectrum, and the surging demands in corresponding applications, is pushing demands to generate more advanced and powerful spectrum and signal analyzers, that can overcome mmWave measurement and testing challenges, in base station test, amplifier test, satellite communications, and automotive applications, to name a few.



▲ **Figure 3:** The Multicomp Pro MP700023 US Spectrum Analyzer operates between 9 kHz and 3.6 GHz.

Cost-effective test

The explosion in Cloud-based solutions has placed a lot of pressure on small developers and individuals in the area of test. To address this, Newark offers the MP700023 US Spectrum Analyzer from the company's own brand, Multicomp Pro. This benchtop spectrum analyzer operates between 9 kHz and 3.6 GHz, and features 160dBm displayed average noise levels, 1.5dB total amplitude accuracy, excellent phase noise performance of 80dBc at 30KHz and a large 10.4" TFT LCD display. As the engineer's choice, Multicomp Pro offers a complete product range of high-quality components, tools and equipment.

Many customers are interested in portable, rugged handheld analyzers that can be used in the field to track down interference in the field as well as demanding better connectivity, higher data rates and larger capacity. The challenge to customers is finding these features at an affordable cost. For these customers, they offer the Aim-TTi PSA6005USC, a small handheld spectrum analyzer, well-suited for use in the field. Other trends driving the market for spectrum analyzers is the demand for multitasking features.

Newark also offers a range of Vector Network Analyzers from Pico Technology. PicoVNAs are all-new, professional USB-controlled, laboratory grade vector network instruments of unprecedented performance, portability and value for money. The PicoVNA 106 and PicoVNA 108 have a frequency range of 300MHz to 6GHz and 8.5GHz. Their simple outline, small footprint and low cost make them suitable for engineers working with limited bench space or budget, yet these Pico instruments boast a Quad RX four-receiver architecture to minimize

the uncorrectable errors, delays and unreliability of internal transfer switches.

For excellent value in a high-function handheld 6 GHz Spectrum Analyzer, the Aim-TTi PSA6005USC Handheld 6 GHz Spectrum Analyzer combines small size with light weight for true portability, making it useful for field-testing of RF Signals. It operates between 10 MHz and 6 GHz, with resolution bandwidths from 300Hz to 10MHz (1:3:10), and zero span mode with AM and FM audio demodulation.

Multidomain analysis

When we talked to Amr Haj-Omar, Market Segment Leader at Tektronix Wireless, he emphasized that their SignalVu-PC offers a single-user interface supporting all signal acquisition hardware (benchtop or portable) from DC to 70 GH. Spectrum analyzers and oscilloscopes with SignalVu-PC allow you to view "live" spectral content, perform analysis in the frequency, time, and modulation domain, all at the same time. Tektronix wideband AWGs allow you to generate and simulate any test signal in an unlimited number of wireless/RF environments.

Tektronix' SignalVu and SignalVu-PC software analysis platform includes application-tailored support for 5G NR measurements and other wireless standards, including LTE, WLAN, Bluetooth, APCO P25 and flexible OFDM. SignalVu wireless modulation features EVM (Error Vector Magnitude), ACPR (Adjacent Channel Power Ratio), SEM (Spectral Emission Mask) and DPX (RSAs only).

Among the applications addressed by the company's SignalVu and Spectrum View software are vector signal, spectrum, and modulation analysis using Tektronix oscilloscopes and spectrum (signal) analyzers. Spectrum View is available on the 4/5/6 Series MSO Oscilloscopes, transforming these instruments into multichannel signal analyzers with fully time-correlated and simultaneous analysis in both frequency or time domain on each channel.

For needs beyond basic spectrum analysis or RF vs. Time analysis, SignalVu/-PC offers the same UI across instruments, with EMI and Field Testing, in powerful, compact, and cost-effective packages. DPX spectrum and spectrogram displays reveal transient EMI, with an advanced EMI precompliance and troubleshooting application option (EMCVu) which automates the process of duplicating standards based measurements for Radiated/ Conducted emissions.

▲ **Figure 4:** Spectrum View is available on the 4/5/6 Series MSO Oscilloscopes, transforming these instruments into multichannel signal analyzers.

Dylan Stinson, Tektronix Product Manager for RF Products, pointed out their RSA5100B offers up to 165 MHz real-time bandwidth from 10 Hz up to 26.5 GHz, and is presented as the only fully preselected real-time instrument in its class. The RSA7100B provides up to 800 MHz real-time bandwidth, with hours of I/Q recording capacity on a terabyte drive and a high-speed controller. The RSA306B, RSA500, and RSA600 Series Real Time Spectrum Analyzers offer up to 40 MHz real-time bandwidth from 9 kHz up to 18 GHz, with a USB interface and battery capability.

Tektronix also addresses validation of commercial wireless physical-layer modulation types and standards with SpectrumView on 4/5/6 Series MSO Oscilloscopes, using DDCs (Digital Downconverters) for separate signal path for time & frequency, and phase-matching between channels, which is critical for beamformer calibration. It's a one-box solution that can also analyze digital and analog/RF simultaneously, to analyze latency requirements.

There is a need to analyze digital, analog, and RF to be able to address latency requirements, phase measurements for the beamformer, and MIMO. Hence, the 1-channel solution, with the spectrum analyzer, with its limited bandwidth, is creating an unmet need and trend toward scopes to address these concerns based on a 1-box solution, such as the 6 Series B MSO. DDCs (Digital Downconverters) on each channel allow

for separate RF paths, allowing for independent time and frequency measurement.

Spectrum analyzer customers are putting more emphasis in the software and applications that support the instruments, with 5G applications driving new testing scenarios over-the-air (OTA) using multiple channels or time-correlated RF. The Tektronix MSO Oscilloscopes with dedicated DDCs on each channel and SpectrumView and SignalVu-PC software, is a new/alternative way to test for RF that the traditional RF engineer would have previously not considered, and offers benefits for analyzing both time, frequency, and code domains simultaneously across multiple channels.

No connection, no solution

KRYTAR specializes in the manufacture of ultra-broadband mmWave, microwave, and RF components and test equipment. The company's product line includes directional couplers, directional detectors, 3 dB hybrids, MLDD power dividers/combiners, detectors, terminations, coaxial adaptors and a power meter, covering the DC to 110.0 GHz frequency range.

For example, the company's latest directional coupler, Model 1500110010, offers some of the widest frequency coverage used on the market. This directional coupler maintains a flat 10 dB coupling across a wide 100-GHz bandwidth, and lends itself to wireless designs and many test and measurement applications for emerging mmWave and 5G markets. (Figure 5).

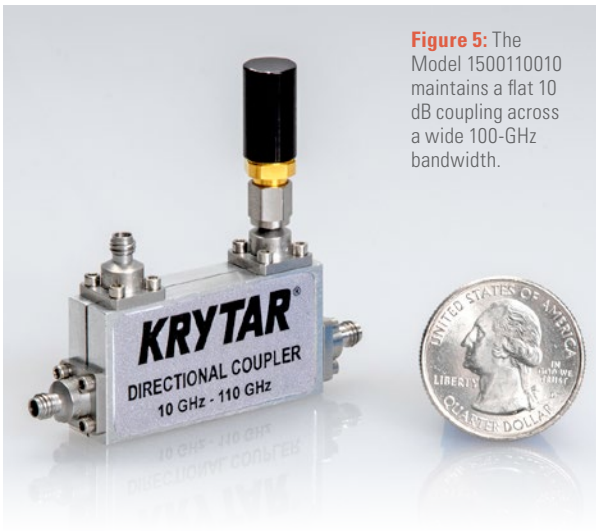


Figure 5: The Model 1500110010 maintains a flat 10 dB coupling across a wide 100-GHz bandwidth.

KRYTAR components support 5G Test & Evaluation solutions, including Sub 6 components in the frequency range from 410 MHz up to 7.125 GHz, and mmWave components from 10 to 50 GHz. It can be a challenge to design microwave stripline broadband components that can cover the entire FR1 or 1st 5G frequency band. However, KRYTAR can design a unit that stretches the frequency down to 5Gs, with a start frequency at 410 MHz that can cover up to 7.125 GHz. EE

5G Test & Evaluation must address the latest RF performance requirements. *Element Materials Technology*

SPECIAL REPORT

EMPOWERING 5G INFRASTRUCTURES WITH EFFECTIVE SYSTEM DEPLOYMENT

by Alix Paultre, Editor

There are many aspects of 5G systems that need monitoring, evaluation, and management beyond the RF spectrum issues.

This important wireless space is on everyone's mind, as the infrastructures and devices to serve the 5G application space are being created and fielded. The 5G infrastructure is growing in leaps and bounds, with more and more capability being added to the system. However, the effectiveness of the solution is strongly based on how well the solution is evaluated, calibrated, and validated. Here is an update on some of the advances in the 5G test, evaluation, and infrastructure space.

Don't forget the passives

One of the aspects of the electronics marketplace is the tendency to focus on the "stars" of the circuit board, the microcontrollers, FPGAs, ASICs, and SoCs; there are a lot of passive components on the board as well. These passives are just as responsible for the success or failure of any design as much as the more glamorous parts on the board. VPG Foil Resistors, part of the Vishay Precision Group, currently offers three power brands: Vishay Foil Resistors, Powertron, and Alpha Electronics.

The demand for precision and accuracy in 5G systems extends to every component, and the performance of the company's Bulk Metal Foil resistor technology is well suited for use in 5G test and evaluation equipment (Figure 1). For example, the FRFS 0402 flip-chip resistor is a discrete, SMT device with a 40% smaller footprint compared to wraparound units, with a TCR of ±2.5 ppm/°C, and a load life stability of 0.01% after 2000 hours. Like

the rest of their Bulk Metal Foil resistor line, it is impervious to electrostatic discharge up to 25,000 V, is low noise, and is virtually noninductive and noncapacitive.

Alpha Electronics' RWs series of SMT chip resistors in 0603, 0805, and 1206 sizes offer a TCR of 2 ppm/°C and load life of 0.005% after 2000 hours. Their CSMxY series, a cost-effective bare metal current-sense resistor currently is available in 2726 and 4026 variations and boasts a TCR of 40 ppm/°C with a current rating of 100 A, well-suited for testing the performance of the power system within any network array.

The challenge for VPG Foil Resistors components is that the parts are not made to be exposed to the data signal. While being unsuited to be incorporated into 5G signals themselves, their parts are well suited for the peripheral systems, providing stable performance no matter the temperature or life span of the product. 5G equipment consists not only of the antennas, which relay the signal, but also measurement and calibration equipment, as well as the power management to create the signal, and the system management to control that power.

By ensuring the transition into the field is accurate and robust, the equipment manufacturers can be assured their systems remain calibrated, accurate, and will withstand the test of time. VPG Foil Resistors components allow those subsystems to be calibrated less often, maintain their calibration throughout the various intended use environments (think Alaska in January and Phoenix in July), and to provide a lower cost of ownership to the ultimate end customer.

Covering the spread

When we asked Joe Dussi, Director of Marketing Communications at Qorvo, about some of the challenges the company is seeing, he explained that one of the challenges facing the industry is maintaining adequate oversampling on waveforms to address wider and wider New Radio (NR) signals. It's important to field hardware implementations that capture the desired data, rejecting unwanted errors.

In addition, the customizability of 5G NR frame structure requires considerable nonstandard waveform generation. 5G NR supports two frequency ranges, using flexible subcarrier spacing derived from the one used in LTE. RF system designers require more power and bandwidth, while optimizing solution size and efficiency, especially when high reliability and performance are critical.

For example, the company's RF Fusion20 portfolio serves major 5G smartphone manufacturers, combining their GaAs power amplifiers, advanced BAW multiplexing, and integrated RF shielding, offering enhanced performance and connectivity. Supporting all major baseband chipsets, Fusion20 modules integrate the receive path and low-noise amplifier, increasing receive performance and connectivity while saving valuable board space.

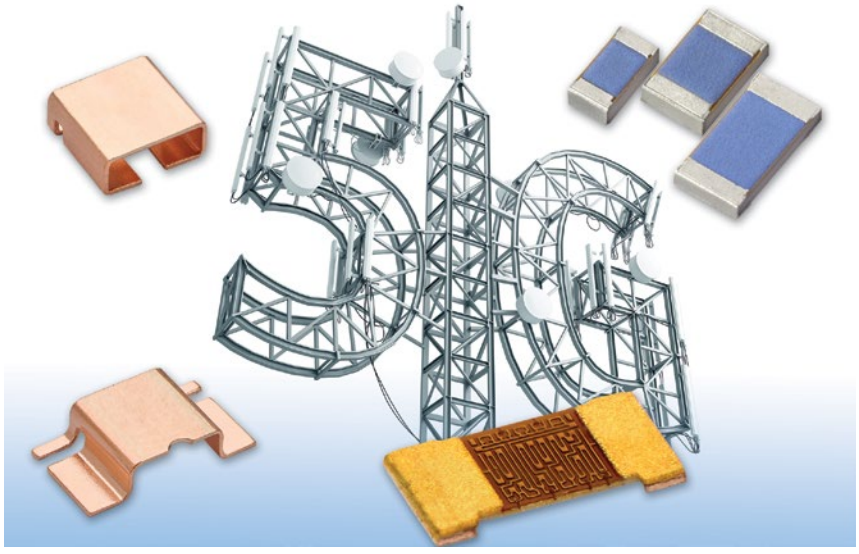
Fusion20 also features Qorvo's innovative MicroShield RF shielding, which minimizes the potential for undesirable interactions between RFFE components. Fusion20 helps support the most stringent 5G bandwidth requirements of up to 200 MHz, leveraging the QM77048 mid-/high-band, QM77043 low-band, and QM78207/208/209 ultra-high-band modules, in regional configurations to meet specific market requirements. Qorvo has optimized Fusion20 as a full 5G front-end solution complemented by Qorvo's Wi-Fi 6/6E modules.

Beaming about beamforming

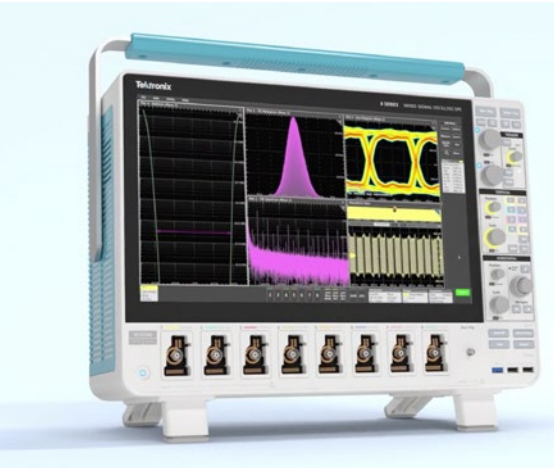
Raajit Lall, Tektronix General Manager of Market Solutions and Software, brought up the two primary challenges they see that instrument vendors and customers face—the bandwidth requirements of 5G and the ability to test multidomain signals. For example, The MSO6B oscilloscope has a digital down converter (DDC) built into the ASIC, which allows for simultaneous correlation of time domain and frequency domain tests (Figure 2).

These tests are becoming critical because beamforming architectures require tight correlation between the digital signals and the phase array antennas in devices. The MSO6B also has up to 10GHz of time domain bandwidth and 2GHz of DDC bandwidth, which allows test engineers to more future-proof their investments, and keep up with the increasing bandwidth requirements of 5G and 6G.

Tektronix has a wide portfolio of products addressing 5G testing, ranging from USB spectrum analyzers for narrow band measurements that apply to massive machine type communications (MMTC) to AWGs and mixed signal oscilloscopes that have the wide bandwidth needed for enhanced mobile broadband (eMBB). The MSO6B oscilloscope is an excellent instrument for wide bandwidth analysis of 5G signals and the AWG70000B arbitrary waveform generator delivers 5G



▲ **Figure 1:** The demand for precision and accuracy in 5G systems extends to every component.



▲ **Figure 2:** The MSO6B oscilloscope can perform simultaneous correlation of time domain and frequency domain tests.

signals with 10GHz of receive and 20GHz of transmit bandwidth each.

In addition, SignalVu-PC is an intuitive software that provides an intuitive UI for 3GPP compliant measurements and a programmable interface for automation of measurements. The newly released Tektronix 8 series sampling oscilloscope provides up to 30GHz of bandwidth for backhaul and datacenter test applications including TDECQ, 400G and PAM4. The 8 series sampling scope provides parallel measurements on up to 4 channels and provides a modular design all in a small form factor.

MIMO and OTA

Two trends accelerated because of 5G and anticipated continuation into 6G technologies are MIMO testing and over the air (OTA) testing. .

Tektronix instrumentation provides a variety of solutions for physical-layer testing of MMTC and eMBB. By using a single software package (SignalVu-PC) for high-channel, narrow-band tests that can be done with USB spectrum analyzers; or wide bandwidth, high-performance spectrum analyzers and oscilloscopes that test engineers can use a familiar interface for all of their physical layer test requirements.

New Radio and mmWave

On industry 5G challenges, Andreas Roessler, Technology Manager at Rohde & Schwarz USA, pointed out that 5G New Radio (NR) is the first standard to use the mmWave frequency region FR2 (i.e. beyond 24 GHz) for highest data transfer rates. The highly integrated front-ends and array antennas necessitate advanced over-the-air (OTA) testing methods and new RF test metrics for assessing current and future mobile communication. Such test metrics include virtual cable calibration (VCC), which is mandatory for reproducible and reliable OTA throughput testing. For performance tests in which fading is emulated the VCC method is crucial to assess defined antenna correlations with minimal crosstalk from the OTA link.

For LTE and 5G NR FR1 tests, conductive testing methods are the norm for MIMO devices. During testing, the antennas of the device under test (DUT) are disconnected from the antenna ports, and the DUT is directly connected to the test system using a coaxial cable. However, for testing UEs in the FR2 bands, this approach is not practical: the large number of integrated antennas on the UE for spatial multiplexing and beamforming requires testing OTA, without cable connections.

The transmitted signal propagating in the OTA radio channel gets distorted by inherent interference due to cross-talk and by the receiver's noise. To have defined and reproducible conditions similar to conductive testing, the effects of the OTA channel must be eliminated. One approach to solve this issue is to calculate the unknown OTA transfer matrix by accounting for the complete OTA environment, including the transmitter and receiver antenna characteristics. This approach is complex and, in most cases, not possible as UE manufacturers are not required to give detailed information about their antenna characteristics (known as the 'black box' assessment approach).

A suitable approach, developed by Rohde & Schwarz, equalizes the OTA channel matrix using only the Reference Signal Received Power per Branch (RSRP-B) feedback parameters, which can be retrieved from an NR UE according to the 3GPP standards. This OTA channel equalization enables having a quasi-conducted or "virtual cable" in an OTA test environment.

The approach lays the foundation for practical 5G UE performance testing, e.g. for maximum throughput. An equalized OTA channel is mandatory for all conformance tests under fading conditions, and it is recommended for all tests that rely on "ideal" radio conditions, such as protocol or application tests. Rohde & Schwarz introduced a high-speed virtual calibration tackling the challenge of noise- and resolution-limited RSRP-B feedback, which provides perfect prerequisites for the challenges of OTA testing.

Space saving

In 5G NR FR2, all measurements are to be performed OTA. In order to reduce the required chamber space, CATR is a hot technology which Rohde & Schwarz has been addressing with compact and portable chambers such as the R&S ATS1800C. Now the next challenge comes along: RRM (Radio Resource Management) testing in FR2. For this, the UE needs to be confronted with two independent base station signals coming from different angular directions.

To accomplish this in a compact OTA setup, Rohde & Schwarz developed an extension of the R&S ATS1800C to create a multireflector setup that addresses this issue. With the R&S ATS1800M there are a total of four reflectors which can create six different pairs of incident angles at the DUT. This fulfills the requirements of the 3GPP RRM spec but allows for even more flexible measurement setups where needed. Since each reflector can create an independent 30 cm quiet zone (QZ), these RRM tests can still be done using a black box approach, keeping the resulting measurement uncertainty low.

Besides RRM with one or two angles of arrival, the R&S ATS1800M can be used for RF conformance, protocol conformance and demodulation tests as well, making it a "one chamber for all requirements" solution which is still only taking up about 5 sqm of lab space. The multi-reflector extension is designed in such a way that it can be added to an existing R&S ATS1800C as an upgrade at any time.

The R&S ATS1800M will be available by summer 2021.

Voice over NR

Voice over NR represents the voice services provided by the 5G RAN, 5GC and IMS. Voice over 5G works in a similar way as Voice over LTE, using IMS as service enabler.

The advantage is that IMS manages (like in VoLTE) the PDU session establishment with the relevant QoS flow for optimized voice quality. The prerequisites for VoNR are support for IMS voice over PS by the UE. In terms of testing voice services in 5G, first implementations and functional behavior is being tested. While the general test setup for VoNR is not that different from the one used for VoLTE, different test areas should be considered.

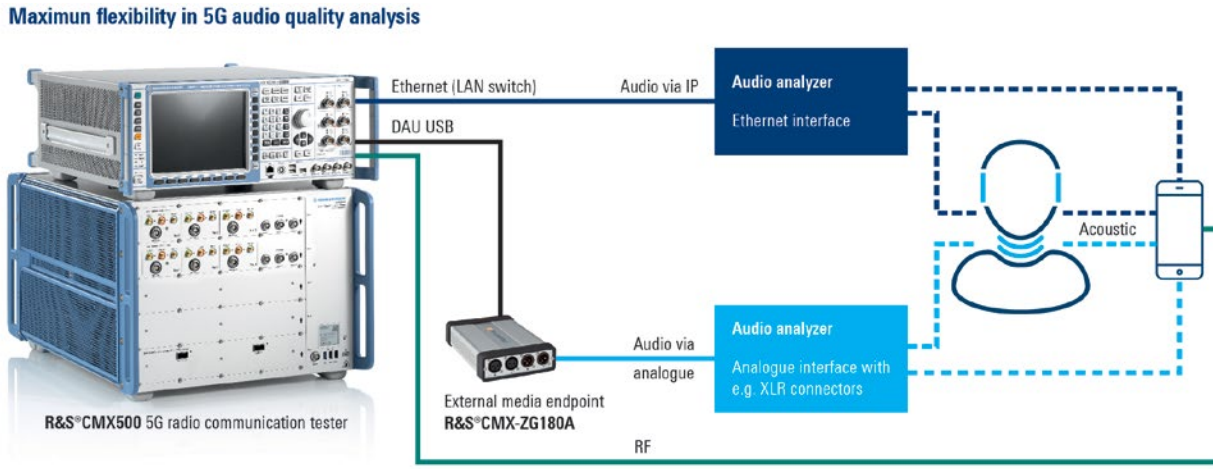
The testing aspects of voice in 5G include scenarios for VoLTE for non-standalone (NSA) mode but also EPS fallback providing a handover during connection setup from NR to LTE, or a RAT fallback if the LTE NG-eNB is connected to the 5GC. And last but not least, VoNR functional tests and audio quality tests have to be performed. From the perspective of speech codecs, a test system for voice over 5G has to support the legacy speech codes AMR-NB and AMR-WB in addition to the EVS codec.

A test setup for voice and video applications in 5G is depicted in Figure 3, showing the mobile radio tester R&S CMX500 together with the R&S CMW500 supporting LTE and 5G NR for either standalone or non-standalone connectivity testing. The R&S CMX500 supports an internal IMS server allowing a virtual UE emulation and audio loop-back mode for fast and easy functional VoNR testing. The setup can be extended as shown by an audio analyzer connected either via IP "IP forward" or routing of the audio via "DAU USB" to an external media endpoint, the R&S CMX-ZG180A.

To permit audio tests according to IEC 62820-1 or ITU-T P.51 standards, the setup shown can either be used with an artificial head with artificial ear and mouth. For so-called electrical measurements, the DUT might be connected via the speaker output directly to the audio analyzer input, and the microphone output directly to the audio analyzer output. The R&S CMW500 platform, which has been very successful in the market for voice quality analysis for 2G, 3G and 4G, is now being expanded for 5G VoNR applications with the R&S CMX500.

3GPP's Release 16 emphasizes—besides other things—the two market verticals, industrial internet of things (IIoT) and automotive. The second trend is that the hunt for higher data rates will continue. For upcoming Release 17, 3GPP discusses the support of 1024QAM in the downlink direction for the Frequency Range 1 (FR1).

For the extension of Frequency Range 2, often called FR2+, wider bandwidths are under discussion, for instance, up 2 GHz, 2.16 GHz, or even 3.2 GHz. Whatever the standardization body decides on will pose new challenges in designing devices and



▲ **Figure 3:** The R&S CMX500 mobile radio tester and the R&S CMW500.

infrastructure components that support these additional capabilities. Fortunately, the R&S FSW signal and spectrum analyzer supports already today a signal analysis bandwidth of up to 8.3 GHz, which is unparalleled in the test and measurement world.

Rohde & Schwarz considers OpenRAN a technology evolution which incorporates new functions into the RAN, to disaggregate and modularize the architecture and to enable software defined radio, real-time intelligent control, network management and orchestration and networking techniques. In a very simplified way, T&M does not distinguish between traditional RAN and OpenRAN. Most of the test requirements are similar, however, the company's portfolio includes test solutions for emulating the O-DU and test and verification of the O-RU.

Addressing complexity

The kind people at NI told us that some of the key challenges they see are related to working with more complex, high-bandwidth signals, as their customers routinely develop devices that support at least 100 MHz-wide carriers, moving on to 200 MHz, 400 MHz, carrier-aggregated test scenarios with 8x100 MHz signals, and inter-band combinations. To increase the energy efficiency of their RF frontends, for example, they look for techniques such as digital predistortion (DPD) and envelope tracking (ET) to help them achieve their target performance.

But applying DPD linearization on large bandwidth signals is computationally intensive and requires even higher bandwidth instrumentation. Similarly, implementing ET on 100 MHz, 200 MHz, and wider signals is very challenging, if not impossible with current technology.

By taking advantage of the PXI platform, NI can give customers greater data processing capabilities, and they also collaborate with industry leaders like Maxlinear on cutting-edge digital predistortion.

NI is currently addressing three areas of research and development, among others: more capable instrumentation (Hardware), more efficient measurement algorithms and software tools, and mission-ready system-level integration. In terms of instrumentation, NI continues to invest in wideband, high-linearity RF measurements for 5G Frequency Range 1 (FR1, sub 6 GHz) and Frequency Range 2 (FR2, or mmWave) through the Vector Signal Transceiver (VST), an instrument that integrates both vector signal generation and analysis in one. The VST enables validation and test of the latest 5G cellular and early Wi-Fi 7 connectivity front ends, transceivers, and user equipment (Figure 4).

Regarding measurement algorithms and software tools, NI continues to expand the waveform generation and analysis capabilities of its RF measurement experience (RFmx) API, keeping up with the latest advances in the 3GPP 5G standard. RFmx gives validation and test engineers flexibility to create and apply very large combinations of 5G stimulus waveforms to their devices under test (DUTs) by varying multiple parameters, such as waveform bandwidth, subcarrier spacing, modulation scheme, and carrier-aggregation combinations. On the analysis side, RFmx implements multithreaded, parallel-processing technology for accurate measurement results rapidly, compared to more traditional sequential-measurement approaches.

The RF Front-end Validation reference architecture gives validation engineers focused on wideband, RF front ends a tightly synchronized PXI bench with multiple instruments, from DC, to digital, to RF, plus software for cockpit-like control of their benches, access to the latest digital predistortion (DPD) linearization algorithms, and a fast path to automated characterization.

As engineers develop multi-element antenna modules for FR2 mmWave connections, they face the tough challenge of validating and testing their beam-steering performance. Engineers must make their measurements over the air (OTA) in a controlled RF environment inside anechoic chambers (Figure 5). These chambers must also support rotation of the DUT in azimuth and elevation to determine the DUT's 3D spatial radiation pattern, the effective isotropic radiated power (EIRP), total radiated power (TRP), location of beam peaks and nulls, and other measurements.

These OTA measurements also help characterize the DUT's capabilities for beamforming and calibrate the beam direction based on specific DUT control words. To help engineers accelerate development in this area, NI introduced the 5G mmWave OTA validation reference architecture, which takes advantage of NI motion control to speed up 3D spatial measurements 5X to 10X, compared to more traditional methods.

At the semiconductor level, one of the biggest trends is in OTA validation and testing. First, devices keep pushing higher in frequency toward the upper range of FR2 around 48 to 52 GHz. Second, there's a growing need for very reliable and fast mmWave OTA production test solutions

▲ **Figure 4:** The VST enables validation and test of the latest 5G cellular and early Wi-Fi 7 connectivity front-ends, transceivers, and user equipment.

that support parametric testing of antenna modules.

mmWave capabilities will continue to propagate down from flagship devices to more mid-range user equipment. In user equipment, the mmWave configuration relies on multiple sub-arrays to make 3D beamforming possible and to avoid problems with a user's hands covering the mmWave beam. Typical configurations could include three or four antenna arrays on a smartphone, with each array consisting of four antenna elements. This will result in increased demand for faster and more cost-effective mmWave OTA test and evaluation solutions, capable of parametric measurements to indicate potential beamforming problems in the field.

◀ **Figure 5:** Engineers must make their measurements over the air (OTA) in a controlled RF environment inside anechoic chambers.

Accuracy and efficiency

When it came to the question of industry challenges, Dr. Houman Zarrinkoub, Principal Product Manager, Wireless Communications at MathWorks, said that the main challenges they see involve accuracy and efficiency. When it comes to accuracy, designers need to find accurate and reliable signal vectors and cover all the test cases needed to qualify a system to be compliant with 5G-standard. MathWork's 5G Toolbox enables reliable access to these test vectors, rigorously verified by their engineers.

As far as efficiency goes, it takes a considerable amount of time to test the physical layer (PHY) sub-systems of 5G devices, with all their modes, frequencies and parameters.

The company's Wireless Waveform Generator app is designed to make all these three steps more efficient. By generating waveforms interactively, then generating MATLAB scripts that capture the waveform generation process as a test script and then connecting the waveforms directly to the RF instrument, the app goes a long way to address these challenges.

MathWork's 5G flagship product, 5G Toolbox, includes test models (NR-TM) and fixed-reference channels (FRCs) signals defined directly as part of 5G standards documentation. This helps designers to verify and validate their 5G designs accurately. Waveform generation is an important requirement for testing any design.

The recently introduced Wireless Waveform Generator app makes the testing process easier and more interactive. As an interactive and graphical tool for testing, the app generates, visualizes and integrates 5G test signals within its test environment. As a result, any user, even those who are not MATLAB programmers, can easily generate 5G test vectors.

The app supports a wide range of wireless standard waveforms such as 5G, Wi-Fi, and Bluetooth. The app also supports off-the-shelf testing signals specified by standard documents including test models as well as the fixed reference channels. As of release 2021a, we have also included the custom 5G waveform generation in the app, which enables engineers to specify any arbitrary set of parameters and generate all types of 5G signals.

The Wireless Waveform Generator app also directly connects to RF instruments (signal generators) from various vendors. This allows transmission of generated 5G waveform over-the-air with a single click. This feature requires the use of our Instrument Control Toolbox, in conjunction with 5G Toolbox.

5G standards have introduced new frequencies in the millimeter-wave range (above 24 GHz). Due to limited range of millimeter wave (mm Wave) signals, transmissions at these frequencies are usually combined with use of large MIMO antenna arrays that boost the signal and hence increase the range.

Picking up the pieces

The point Jon Semancik, Director of Marketing at Marvin Test Solutions, brought up was that production throughput is critical in mmWave semiconductor device test, and is one of the biggest challenges that most manufacturers are facing. The GENASYS Semi TS-900e-5G is presented as the fastest production test set currently available, with some benchmarks showing an order of magnitude faster execution times (Figure 6). They accomplish this by implementing

a parallel test architecture with up to 20 independent VNA ports per system, resulting in exceptional test efficiencies and test time reductions.

MTS' flagship offering, the TS-900e-5G 5G mmWave test system is part of Marvin Test Solutions' GENASYS Semi suite of flexible, configurable, semiconductor test solutions, well-suited for both wafer probe and package test, with support for most popular production automation and handling tools. The system can support up to 20 independent VNA ports of 44 GHz signal delivery to the device under test (DUT), meeting the throughput requirements demanded by OSAT production.

Additionally, the modular architecture of the test system is well suited to address the evolving needs of mmWave test, with expanded performance to 53 GHz scheduled for late Q2. The TS-900e-5G core system includes Keysight's high-throughput VNAs and ATEasy, Marvin's comprehensive suite of software tools that allows users to quickly develop and easily maintain test applications as well as ICEasy, which facilitates device test development and characterization. The TS-900e-5G core system also includes high-performance dynamic digital I/O with per-pin PMU to support SPI/I2C device communications and DC parametric testing.

The company also provides the ability to upgrade existing big iron test systems with the latest VNA and digital I/O instrumentation utilizing the MTEK (Marvin Test Expansion Kit) Series. The industry continues to move toward higher frequency devices. Just moving from 44 GHz to 53 GHz impacts many areas of the test set starting with the VNA instrumentation but also including cables, interconnects, blind mate interfaces, and of course, system-level calibration. Industry demand for these devices will continue to grow with the proliferation and adoption of 5G, but the demand for mmWave devices extends beyond 5G to other application areas such as military, imaging, and security screening, to name a few.

Supporting the ecosystem

Jessy Cavazos, 5G Industry Solutions Marketing at Keysight Technologies, talked about how they partner with leading chipset manufacturers like Qualcomm and Mediatek, NEMs like Nokia and Ericsson, and leading operators like NTT Docomo and Verizon to stay ahead of the technology curve. They also partner with newcomers eager to innovate like the new entrants in the O-RAN space.

▲ **Figure 6:** The GENASYS Semi TS-900e-5G

Another example can be found in the Keysight Open RAN Architect (KORA), an end-to-end portfolio of solutions for Open Radio Access Network (O-RAN). It enables ecosystem participants to emulate any part of a 5G O-RAN network. Network vendors and mobile operators can verify the interoperability, performance, and security of multivendor 5G networks based on O-RAN standard interfaces. The transition to multivendor RAN networks introduces interoperability and performance complexity.

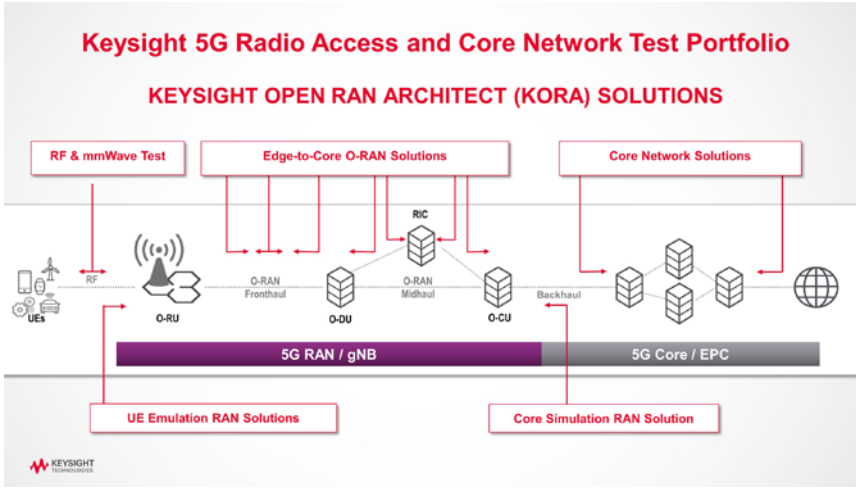
By performing comprehensive testing across a heterogeneous network, network vendors can extend the capabilities of their designs and operators can deliver solutions that support innovative service offerings. KORA provides integrated, software-driven solutions that accelerate the development, integration, and deployment of O-RAN compliant equipment. Each suite is tailored to the needs of participants in the supply chain—chipset makers, network equipment manufacturers (NEMs), mobile network operators (MNOs), and Open Test and Integration Centers (OTICs). KORA includes Open RAN Studio, UeSIM, RuSIM, CoreSIM, DuSIM, CuSIM, RIC Test, ATI Pentest, CyPerf, Breaking Point, Vision Edge, IxNetwork, CloudPeak, Nemo Outdoor, and channel emulation solutions.

One of the key additions to Keysight's 5G portfolio in 2021 comes from the acquisition of Sanjole. Sanjole wireless analyzers are industry-leading over-the-air communication sniffers serving as the source of truth to find anomalies, uncover issues, and quickly identify the root cause of issues in complex wireless systems. These software solutions enable modem, chipset, and RAN makers to perform interoperability testing with communications standards that are validated, debug issues fast, and accelerate their time to deployment.

The range of tools available include the S8708A Advanced Performance Test Toolset and S8709A Virtual Drive Test Toolset, which add real-world radio channel conditions for 5G device performance testing that also include the S8703A Functional KPI Toolset and the S8710A Device Benchmarking Toolset. The solutions consist of software, the UXM 5G network emulator, a PROPSIM channel emulator, and FR2 equipment (chamber, common interface unit, and remote radio heads).

Their P7000 software platform for base station conformance testing provides preconfigured test cases that help NEMs validate their base station performance against the latest 3GPP standards. Compliance declarations are one of the most time-consuming aspects of getting a product to market because of their complexity and constant evolution. With the P7000, R&D and integration and verification (I&V) engineers at NEMs and operators working on small cell, macrocell, and O-RAN testing of disaggregated base station components can interpret the standards and set up complex test cases faster.

The S8825A Satellite and Aerospace Channel Emulation Toolset is a channel emulation solution for 5G nonterrestrial networks (NTN) satellite link testing. Included in the upcoming 3GPP Release 17 (Rel-17), 5G NTN is spurring development activity at cellular and satellite broadband companies to develop the necessary technology in time for the first solution to launch in 2023. Cellular companies need to integrate satellite interlinking and satellite access while satellite companies need to ensure the connection



▲ **Figure 7:** KORA, an end-to-end portfolio of solutions for Open Radio Access Network (O-RAN), enables ecosystem participants to emulate any part of a 5G O-RAN network.

to cellular networks. Keysight's 5G channel emulator, PROPSIM, has been updated to support satellite use cases and help these entities overcome these challenges.

6G researchers require a flexible and scalable testbed to gain insight into their designs' performance while 6G evolves. Determining the level of error vector magnitude (EVM) system performance possible in sub-THz frequency bands and extreme modulation bandwidths is a key area of research. Keysight's testbed measures waveform quality through EVM measurements for the D (110–170 GHz) and G bands (140–220 GHz), with modulation bandwidths of up to 10 GHz occupied bandwidth. But channel characteristics are another unknown. Keysight's sub-THz testbed can perform 6G channel-sounding research with wide bandwidths at D-band. The testbed uses channel sounding signal generation and analysis software with the same hardware setup used for waveform quality EVM measurements.

Networks are becoming increasingly complex with 5G, densification, and more demanding applications. MNOs want to reduce CAPEX while controlling their OPEX and accelerate the delivery of innovative services to subscribers. Disaggregation of the gNB is also necessary to extend virtualization into the RAN. This transition causes significant disruption in the test and validation space. 5G NR continues to evolve. The second release of the standard, 3GPP Rel-16, is unlike any other second release for

a cellular specification by expanding 5G's reach into new verticals, spurring a new wave of challenges in test and validation.

Powerful packages

Brian Walker, Engineering Manager, RF Design at Copper Mountain Technologies, explained to us how their latest 5G Test & Evaluation solutions include vector network analyzers (VNAs) in the millimeter ranges needed to measure 5G components (Figure 8). Their latest compact model, the S5243 operates from 10 MHz to 44 GHz. Its small form factor makes it an ideal addition to the 5G test bench or for embedding directly into a test station.

They also have solutions for measurement of widely separated antennas. Millimeter waves are highly attenuated in long lengths of coaxial cable. The mmWave CobaltFx Frequency Extender System is fed with a much lower microwave signal and produces the millimeter waves directly at the device under test, thus greatly reducing signal loss and improving the dynamic range of measurement. Power amplifier test is another common requirement, and a vector network analyzer is a key piece of test gear for that. It can pulse-modulate our test signal such that a 10W or higher power amplifier may be evaluated with only a few hundred milliwatts of average power dissipation.

Serving the areas of upconverters, downconverters, components, power amplifiers, and antennas among other applications, the frequency offset capability of the company's VNAs allow the user to evaluate the conversion gain or loss of a upconverter or downconverter. Triggered, pulse modulated measurement allows for the measurement of high-power amplifiers at low average power. One-port VNAs can be installed directly on the antenna cable for fast and easy return loss measurements with default factory calibration without the need for an additional test cable.

Compliance testing 5G

Among their recently introduced test solutions, Anritsu's RF Regulatory Test System ME7803NR is a cost-efficient, easy-to-use single solution to conduct ARIB/ETSI/FCC-compliant frequency range (FR) 1 RF tests on 5G NR UE.

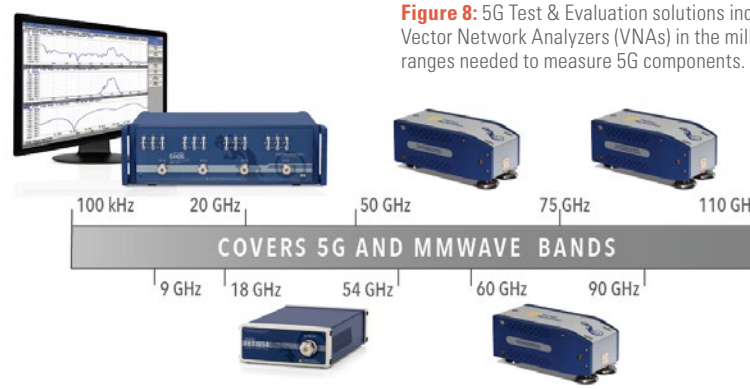


Figure 8: 5G Test & Evaluation solutions include Vector Network Analyzers (VNAs) in the millimeter ranges needed to measure 5G components.

Integrating the MT8000A with other hardware and dedicated software, it supports certified North American, European, and Asian bands, as well as emerging regional bands, including 5G NR bands and 5G non-standalone (NSA) mode LTE bands used as LTE anchors.

Their TRX Test Module MU887002A for the Universal Wireless Test Set MT8000A/MT8872A improves the efficiency of production-line inspection of 5G devices. With 24 RF connectors, the MU887002A supports 5G Sub-6 GHz new radio (NR) RF tests, as well as various simultaneous wireless communications tests, including WLAN, Bluetooth, and Global Navigation Satellite System (GNSS).

The CATR Anechoic Chamber MA8172A supports testing of 5G mobile devices utilizing Frequency Range 2 (FR2) millimeter wave (mmWave) bands in accordance with industry standards (Figure 9). A new Temperature Testing Option MA8172A-010 facilitates previously difficult temperature tests for 5G mmWave UE, helping ensure compliance. The CATR Anechoic Chamber integrates with the Radio Communication Test Station MT8000A and New Radio RF Conformance Test System ME7873NR to facilitate confirmation of 5G mmWave UE RF characteristics in a controlled temperature environment.

The Field Master Pro MS2090A real-time spectrum analyzer is designed for network operator field technicians and national regulators who need to validate the RF performance of 5G base stations as they are rolled out. It has frequency coverage up to 54 GHz to cover all 5G bands currently in use and 110 MHz instantaneous capture bandwidth to support full 5G carriers. 5G and LTE demodulation packages for installation and maintenance are available, and the MS2090A has real-time spectrum analysis capability to capture narrow, intermittent or signal-on-signal interference.

Virtualization and O-RAN create their own set of obstacles. Even though it leverages an open interface, engineers must test to ensure the interface is programmed correctly by the manufacturer. Testing must also be done to verify if an interface is compatible with hardware and software from different vendors. A test solution, such as the MT8000A, must have the protocol stack specifications properly implemented according to the specifications, as well as hardware that is robust and provides repeatable results. This is critical when making latency measurements, as a millisecond delta can be the difference in passing and failing.

Figure 9: The CATR Anechoic Chamber MA8172A supports testing of 5G mobile devices utilizing Frequency Range 2 (FR2) millimeter wave (mmWave) bands.

Fewer countries are requiring full-fledged RF compliance testing during installation of 5G towers. The major need has been with interference hunting after the fact. As network performance issues are reported, test equipment is used to track and hunt down rogue sources of interference including transmitters. New standards from industry organizations such as 3GPP are only a few pieces of the 5G design puzzle.

Ever-changing carrier acceptance and compliance testing are other factors that test solutions must address. The Field Master Pro is targeted at RF testing of physical layer signal characteristics. This is typically useful in installation and maintenance of towers. Anritsu also offers power-level testing for coverage mapping and EMF measurements for safety testing.

Keeping up

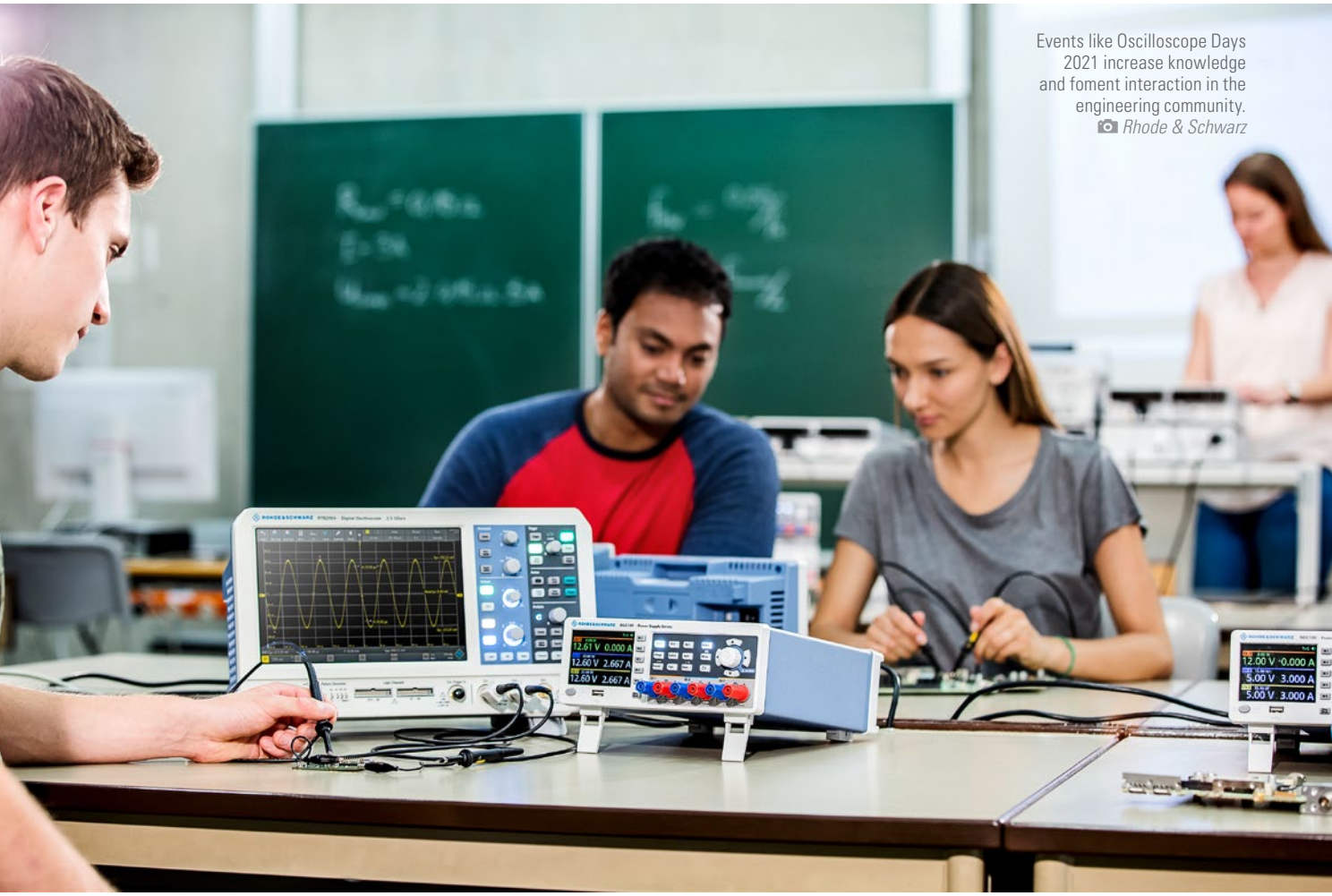
Michael Derby and Steve Hayes from the Connected Technology group of Element Materials Technology explained some of the key challenges their customers are facing is that the R&D cycle time is ever-reducing. They also face challenges involving performing tests and certifying products to regulatory requirements, where new 5G/phone features mean that the regulations are not already in place.

Another issue involves the new features that a given network operator wishes to deploy in their network. The phone, tablet, wearable, or other 5G-enabled equipment needs to be able to support these features, which requires both test labs and the test equipment vendors to constantly update the test plans, hardware, and software in test equipment to validate that the phone or other connected equipment conforms with the new requirements.

When it comes to 5G test & evaluation solutions from the company, they said their test labs are experienced and ready to assess 5G devices for radio transmitter and receiver communications, over the air performance, immunity to EMC phenomena, and safety from hazards, and RF exposure to 5G signals. One major testing trend Element is seeing is an increasing demand for higher capacity at testing labs.

The complexity of new network and phone features mean that the capital investment for labs is increasing. Another trend is that it's not just phone manufacturers with an interest in 5G communication. Many people requesting testing for radio products will not be radio experts; they will be experts in their own product, into which they have put a radio.

Element has expertise in FCC, ISED, ETSI, and MIC testing and certification, CTIA over the air (OTA) testing, radio frequency (RF) exposure assessment, specific absorption rate (SAR)/ power density (PD), electromagnetic compatibility (EMC) testing, hearing aid compatibility (HAC), radio testing, cybersecurity, safety testing, conformance testing, TCB/FCB and notified body, PTCRB/GCF, and CTIA. EE



Events like Oscilloscope Days 2021 increase knowledge and foment interaction in the engineering community. *Rhode & Schwarz*

OSCILLOSCOPES EVOLVE WITH THE TIMES

by Alix Paultre, Editor

When it comes to electronic design, test, and evaluation, our fast-moving technological landscape is both a blessing and a curse. On the one hand, there are more solutions to solve and address applications in the electronic space than ever before. On the other, the need to ensure that your test and evaluation solution is better than the system it is testing. Only if the lines on your ruler are closer together than the features you want to measure is true accuracy possible.

Luckily, the latest tools for test and evaluation are well up to the task. For example, the basic oscilloscope, staple of the bench, has grown and evolved over the decades from a relatively smart display that required physical measurement of the traces on the screen to a multifunction logic-driven development tool. Today's oscilloscopes often integrate multiple toolsets and functionalities unthought of a few decades ago.

Among the many examples of the state of the industry in the evaluation tool space, Farnell partnered with Rohde & Schwarz to present their latest tech at Oscilloscope Days 2021. The event presented a series of free technical webinars covering the methodology, challenges and applications of using modern digital oscilloscopes for electronic design and test.

Streamed in three languages, English, German, and French,

the Oscilloscope Days 2021 webinar series combined practical and theoretical learning principles to help electronics engineers overcome real-world application challenges and understand the methodology required for electronic design and test.

Session 1 covered the basics of how to choose a measurement setup. Participants learned how to estimate the required bandwidth of their equipment and how to select the right instrument for specific applications. The operation of VNA, an oscilloscope, SPA and EMI receiver were also covered.

The second webinar focused on the analysis of power integrity and DC/DC converters. Some of the key topics covered in this session included the importance of power integrity, the impact of switching semiconductors on a DUT and how to test a DUT's power conversion and distribution parts. Day 1 concluded with a look at the requirements of using high differential probes and filtering for digital transmission systems.

In the following webinars, Rohde & Schwarz experts went deeper into how to achieve signal integrity and Bus analysis using oscilloscopes. Attention was given to the influence a transmission line, filters and protection circuits can have on signal integrity while learning how to practically apply eye diagrams, protocol decode, and USB trigger and decode. Another session covered how to debug EMC from a device, including what instruments and accessories can be used for EMC debugging and how to qualify EMC during the development cycle using an oscilloscope.

Visit https://www.rohde-schwarz.com/_229356-1048128.html to access the recordings from the event.

Here is some recent oscilloscope news from the evaluationengineering.com website:

DL950 ScopeCorder Empowers Design and Evaluation of Green and Energy-Efficient Technologies

Yokogawa Test & Measurement released the DL950 ScopeCorder to improve efficiency and effectiveness in design and evaluation of renewable and energy efficient technologies. The DL950 ScopeCorder is a combination of a multichannel, mixed-signal oscilloscope and portable data acquisition recorder. It captures both high-speed transient events and long-term trends. Building on the capabilities of the well-established DL850E, the new DL950 ScopeCorder can handle larger amounts of data at a faster sample rate and with a longer recording time. The DL950 is capable of simultaneous measurement of a wide variety of mechanical parameters.

Increasing complexities in electronic systems have resulted in the need to measure a wide range of input signals at fast sampling speeds over lengthy periods. Engineers must often resort to using multiple test instruments to measure several signals under different conditions. That adds complexities with data synchronization, management of multiple data formats and storage locations, and the inability to view all signals in one instrument.

https://evaluationengineering.com/21223795

Rackmount Oscilloscope Targets Demanding Applications

RIGOL Technologies expanded its UltraVision II technology platform with the DS8000-R Rack-Mount Digital Oscilloscope, which provides up to 2 GHz of bandwidth. This version has a typical trigger jitter between instruments of less than 350 psRMS, and accessories to synchronize triggering and minimize timing offset among channels. The device delivers the same jitter and real-time eye analysis, power analysis, and serial decode as the company's MSO8000 Series oscilloscope,

Targeting demanding system and automation applications, the scope's compact design (1U high by ½ rack wide) enables two DS8000-R oscilloscopes to be mounted in the same standard 1U rack space. Providing eight 2 GHz channels in 1U of rack space, the DS8000-R addresses high-speed signal acquisition in a compact footprint. The scope can be controlled locally via HDMI monitor, mouse and keyboard, as well as remotely via local web control, freely available UltraScope PC software, or custom programming using LAN or USB.

https://evaluationengineering.com/21223794

◀ RIGOL Technologies DS8000-R Rack-Mount Digital Oscilloscope

Latest 6000E 4-Channel Mixed-Signal Oscilloscopes Perform Single-Shot Pulses at 200ps Resolution

Saelig introduced 750MHz and 1GHz models to the 4-channel PicoScope 6000E Series, which provide 8 to 12 bits of vertical resolution, and up to 5GSa/s sampling rate with 4GSa memory, allowing these scopes to display single-shot pulses with up to 200ps time resolution. The four new 4-channel models added to the existing 6000E series are the PicoScope 750MHz 6405E and the 1GHz 6406E with 8-bit A/D resolution and the PicoScope 750MHz 6425E and the 1GHz 6426E with 8, 10, or 12 bits "FlexRes" resolution. The screen update rate is 300,000 waveforms per second. An active probe interface on these scopes allows the use of optional matching 750MHz or 1.3GHz Active Probes.

Pico "FlexRes" flexible-resolution oscilloscopes allow the scope hardware to be configured to optimize either the sampling rate or the resolution: a fast (5GSa/s) 8-bit oscilloscope for looking at digital signals, a 10-bit oscilloscope for general-purpose use, or a high-resolution 12-bit oscilloscope for audio work and other sensitive analog applications. All models can operate with an extra 4 bits of resolution with the enhanced vertical resolution software feature. Additionally, these oscilloscopes offer 8 or 16 optional digital channels when using the plug-in TA369 MSO pods.
https://evaluationengineering.com/21223578

Mixed-Signal Oscilloscopes Combine Eight Instruments in One

With its Infiniium MXR-Series mixed-signal oscilloscope, Keysight Technologies offers what is said to be the first oscilloscope with 8 analog channels at 6 GHz and 16 simultaneous digital channels. Thanks to advanced ASIC-driven processing, the MXR-Series scopes embody a highly versatile instrument, encompassing the functionalities of a real-time spectrum analyzer, oscilloscope, digital voltmeter, waveform generator, Bode plotter, counter, protocol analyzer, and logic analyzer. The result is less testbench complexity and a smoother workflow.

Applications such as high-speed digital designs, power-integrity verification, Wi-Fi 6, IoT, IIoT, and gallium-nitride (GaN) semiconductors operate at frequencies between 2 GHz and 6 GHz. Testing such products requires time- and frequency-domain equipment capable of simultaneous analog and digital channels. This is coupled with software-enabled protocols, standards, built-in test assistance, and test team remote collaboration. The MXR-Series scope serves test applications with an extensive suite of software solutions focused on power integrity, high-speed digital test, and verification. In addition, built-in software functionality includes a fault hunter function to speed root cause identification and resolution of rare or randomly occurring errors.
https://evaluationengineering.com/21219336

▲ Keysight's MXR-Series scopes embody a highly versatile instrument.

DL950 ScopeCorder Empowers Design and Evaluation of Green and Energy-Efficient Technologies

Increasing complexities in electronic systems have resulted in the need to measure a wide range of input signals at fast sampling speeds over lengthy periods. Engineers must often resort to using multiple test instruments to measure several signals under different conditions. That adds complexities with data synchronization, management of multiple data formats and storage locations, and the inability to view all signals in one instrument.

Yokogawa Test & Measurement released the DL950 ScopeCorder, a combination of a multichannel, mixed-signal oscilloscope and portable data acquisition recorder. It captures both high-speed transient events and long-term trends. Building on the capabilities of the well-established DL850E, the new DL950 ScopeCorder can handle larger amounts of data at a faster sample rate and with a longer recording time. The DL950 is capable of simultaneous measurement of a wide variety of mechanical parameters.
https://evaluationengineering.com/21223795 EE

IDEA!

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Engineering & Automation

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DEVELOPING ADVANCED EV BATTERY TEST SOLUTIONS

by Grant Smith

With each electric car that is sold today, economic performance and driving range only increase in importance. Squeezing every last joule of energy out of the batteries and the electrical system is mission critical to design engineers. Development of series production-ready high energy per volume solid-state batteries is being pushed by many OEM and Tier 1 suppliers.

During vehicle development, engineers perform energy flow analysis in order to understand energy transfer efficiency and the proportion of energy consumption among various subsystems. This analysis informs the economic performance analysis simulation model, guiding the formulation of reasonable performance indicators. Precise measurement and prediction of vehicle energy consumption are needed for both development and vehicle operation. Development of efficient and EMC emissionless electric components like e-motors, inverters, chargers, and power management systems is in full swing.

Outside the vehicle, intelligent Vehicle-to-Grid energy management, wires for fast and high-power energy flow, and inductive charging solutions are under development. The technology to support these mega-trends is well past the "wish list" stage. As a result, recent electric vehicle developments show a need for current sensors with accuracy classes from 0.1% to 0.01% for accurate power measurements, with short-term peak currents up to 2000 A.

To support the development of today's and tomorrow's electric vehicles, data acquisition developer Dewesoft has developed the SIRIUS XHS-PWR high current and high voltage measurement system. Achieving the combination of high bandwidth and extreme voltage and current measurement accuracy required for these tests, in a small and rugged form factor suitable for the testing environment, were the major technical challenges involved in creating the SIRIUS XHS-PWR.

Core Technologies

For example, the SIRIUS XHS-PWR electric vehicle data acquisition system is based on several advanced core technologies, most notably of which is the DC-CT current sensing transducer. This approach achieves extremely accurate current measurements in the most demanding applications, including measuring very high current peaks and leakage current. The DC-CT current measurement transducer system is built on a single high-permeability core and a zero-flux closed-loop null method measurement principle, with the innovative Platiše Flux Sensor (PFS) (Figure 1).

The DC-CT transducer can be seen as an AC current transformer (CT), where primary and secondary windings couple the transformer for AC signals, down to a few Hertz. Just as with other closed-loop

technologies, the PFS continuously measures residual magnetic flux in the core resulting from the difference between the primary and secondary (compensation) currents. The output from the PFS is proportional to the magnetic flux in the core. It drives feedback control circuitry to adjust the compensation current to restore the optimal zero-flux balance in the core. Therefore the compensation current accurately mirrors the primary current, scaled by the number of primary versus secondary turns.

DC-CT technology with the Platiše Flux Sensor represents the latest current sensing technology with ranges of 100, 500, and 1000 Amps, >500 kHz bandwidth, and high performance. Excellent linearity, precision, accuracy, immunity to external magnetic fields, low offsets, and extremely low-temperature drift are achieved at low power operation. It can also directly measure voltage up to 2000 V peak (with CAT II 1000 V safety), with up to 5 MHz bandwidth.

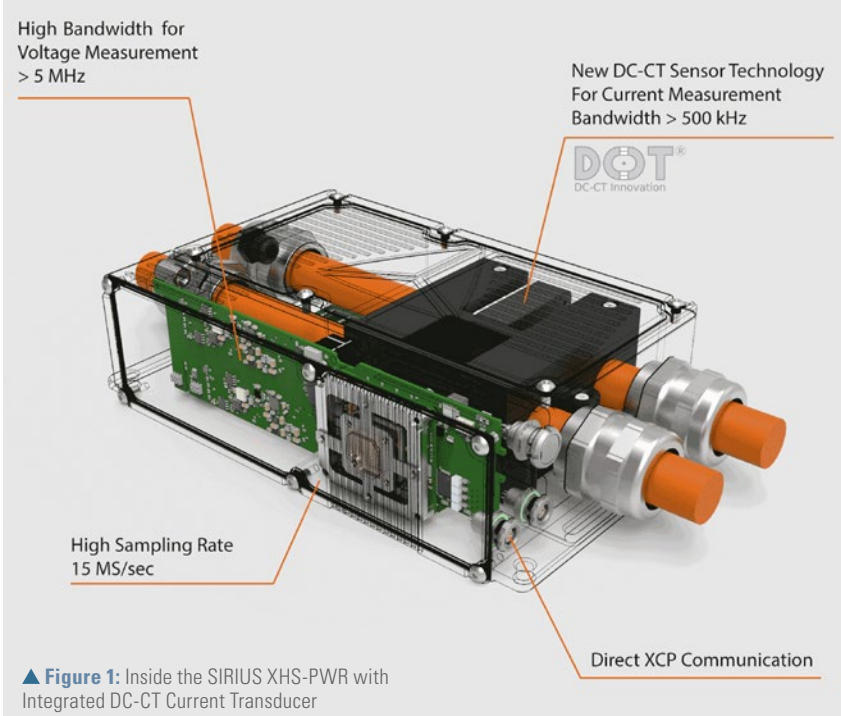
DC-CT technology uses an innovative principle of isolated measurement of DC and AC currents. Within a magnetic core, magnetic flux can only be measured if it is nonconstant (i.e., changing or alternating). Since a DC current generates a constant magnetic flux, the innovative principle redistributes this flux among two or more paths periodically in a single core. If we observe this magnetic flux from one path only it appears alternating and is therefore easily measured by a simple winding whose voltage is proportional to the measuring current.

This has been achieved by the invention of a current-controlled variable reluctance circuit. This vital component is composed of an "infinity winding" embedded into a gap-less core that retains the good properties of high permeability materials. Comparing this principle to widely used Hall-effect based sensors inserted into a magnetic core, the DC-CT solution does not create any air-gap, retaining very high sensitivity and immunity to external magnetic fields. In addition, the new DC-CT sensing principle is temperature independent.

Let's compare this principle to the most widely used high-end flux-gate transducers, in which a flux-gate adds energy to the core to alternate the flux between the maximum and minimum operational limits of the core, consuming a significant amount of energy. The value of the current can be extracted from the second harmonics, the pulse-width-modulation in self-oscillating solutions, or other methods (Table 1).

High-end flux-gate solutions require up to three cores instead of just one, as in the case of the DC-CT current transducer. Two of them are required for sensing, operating in opposing directions to reduce injected noise, and the third is used to extend the AC bandwidth. Flux-gate sensors reset the core repeatedly, while the DC-CT demagnetizes the core upon request. DC-CT is therefore energy-efficient, compact in size, low noise, high bandwidth, temperature independent, and cost-effective. Existing products are available from 2 A up to 2000 A, with up to 1 MHz bandwidth and target accuracy from 0.1% down to 0.01%.

Other potential uses include replacing DC/AC residual current sensors of class B+. Looking closer at the Platiše Flux Sensor, its conceptual design is based on a magnetic core (B) through whose center runs a wire carrying the current to be measured, also named the primary current Ip (A). The secondary compensation winding (C) Lcomp contains a greater number of turns and is distributed around the majority of the magnetic core. Magnetic material then introduces additional openings, to form a Platiše Flux Sensor (PFS). The PFS is composed of a current-controlled variable reluctance (CCVR) and the Ls winding (D) on the left side of the opening,



▲ **Figure 1:** Inside the SIRIUS XHS-PWR with Integrated DC-CT Current Transducer

	Type	Isolated	Range	Bandwidth	Linearity	Accuracy	Temp. Drift	Consumption
DC-CT®	DC/AC	Yes	High	High	Excellent	Very High	Very Low	Medium
Flux-gate	DC/AC	Yes	High	High	Excellent	Excellent	Low	High
Hall	DC/AC	Yes	High	Medium	Medium	Medium	High	Low-Med
Shunt	DC/AC	No	Medium	Medium	Good	High	Medium	High
Rogowsky	AC	Yes	High	High	Good	Medium	Low	Low
CT	AC	Yes	High	Medium	Medium	Medium	Low	Low

▲ **Table 1:** Comparison of DC-CT versus other current sensor systems

and flux measuring winding Lm (E) on the right side of the opening.

The difference between primary and secondary currents creates a residual or non-compensated flux in the core, and without the presence of the current in the Ls winding, the CCVR portion redistributes quasi equally among the paths (D) and (E). Stimulating the Ls winding (D) with electric current lowers the permeability and thus increases the resistance of path (D). It acts as a kind of a magnetic switch which, with the presence of current, quasi opens; and then the flux which was before distributed quasi equally among the (D) and (E) paths is forced to flow mainly through (E). In the PFS measurement cycle, the Ls winding is continuously switching and chops the residual noncompensated magnetic flux, and continuously redistributes the flux between (D, E) paths and (E) only.

To simplify, let us say that in the first step, each path sees half of the flux, and in the second step the entire flux flows through (E) only, and none through (D). Therefore such a huge flux change dΦ/dt through the (E) path is easily captured by the Lm winding. The rectified (demodulated) output magnitude is directly proportional to the magnitude of the residual magnetic flux, and its phase is proportional to the sign of the flux.

HybridADC Analog-to-Digital System

Another important core technology within the SIRIUS XHS-PWR is the HybridADC data acquisition system. After all, there is no point in putting a high bandwidth sensor into a DAQ system that lacks the bandwidth to handle it. One of two recording modes can be selected for each channel independently, according to the application. There is a High Bandwidth Mode, with more than 5 MHz bandwidth and up to 15 MS/s sampling rate. The SIRIUS XHS-PWR can acquire impulse, step, and square signals without any ringing or overshoot. This mode is perfect for transient recording and power analysis, and uses low-latency SAR ADC technology. There is also a High Dynamic Mode with a sample rate up to 2 MS/s, that can be selected with 24-bit resolution and brick-wall anti-aliasing filtering, meaning that frequencies above the passband are fully rejected. In this mode, SIRIUS XHS-PWR operates with Sigma-Delta ADC technology (Figure 2).

It is important to note that each of the channels can be set to either of these modes: some can be high bandwidth and some can be high dynamic, and all signals are perfectly time-aligned with each other with zero phase shift. Data can be synchronized with other data sources, such as vehicle bus interfaces like CAN (and others), as well as GPS, IMU, video, and more. SIRIUS XHS-PWR instruments can be synchronized using the PTPv2 protocol, IRIG time code, or a PPS signal. Absolute time synchronization can also be achieved using in-house time servers or GPS.

DewesoftX software automatically calculates and stores not only the raw data from the voltage and current transducers, but also all of the power parameters, like P, Q, S, D, Cos Φ, power factor, as well as P, Q, cos Φ for each harmonic, and more. Each parameter can be displayed visually in a variety of time history graphs, FFT graphs, scopes and numeric displays. Power-centric displays like Vector Scope and Harmonic FFT are also included and can be placed anywhere on the screen. Using a computer graphics card as a multi-threaded calculation platform, the DewesoftX power module can calculate all of these parameters up to the top sample rate of 15 MS/sec (Figure 3).

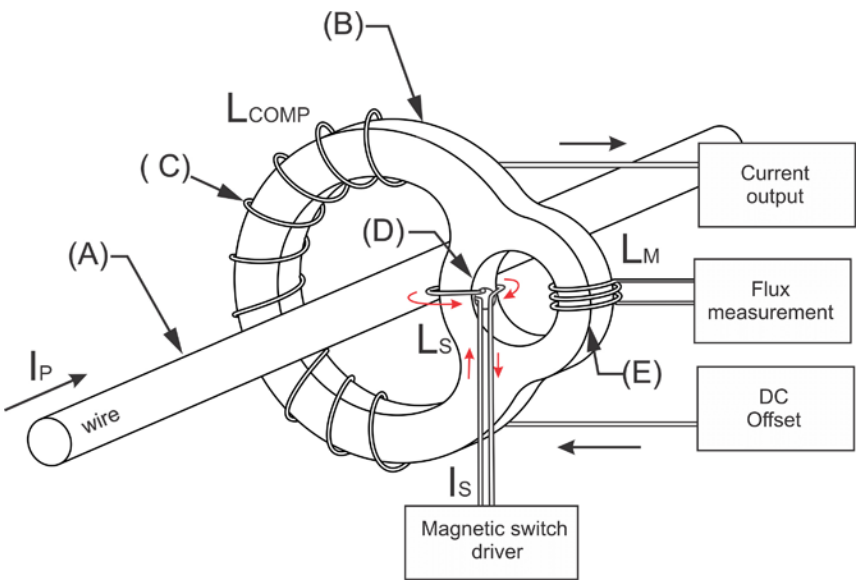
Compatibility with Standard Protocols

In today's world of open tool chain and intercommunication, devices should be compliant with standard protocols. All of these protocols can be used simultaneously with SIRIUS XHS-PWR. OPC UA is more than just an industry standard protocol, OPC UA is a solid framework where the SIRIUS XHS-PWR can be described and set up in any system, including SCADA, MES, ERP, mobile devices, and others.

XCP on Ethernet (TCP/IP) started with version 1.4, XCP, and became a very powerful interface protocol for data exchange in the automotive industry. In this age of e-mobility, sample rates need to be higher than ever, and this 1 Gbit XCP interface allows data transfers up to 1 MS/s. CAN 2.0 and CAN FD monitoring, with measured data from SIRIUS XHS-PWR transmitted over CAN to any third-party CAN interface. Vehicle bus systems can be read through the CAN FD interface while the measured data can be also transmitted through this "golden" standard protocol.

Data can therefore be synchronized with other data sources like CAN, GPS,

▼ **Figure 2:** Schematic diagram of Platiše Flux DC-CT Sensor (PFS)



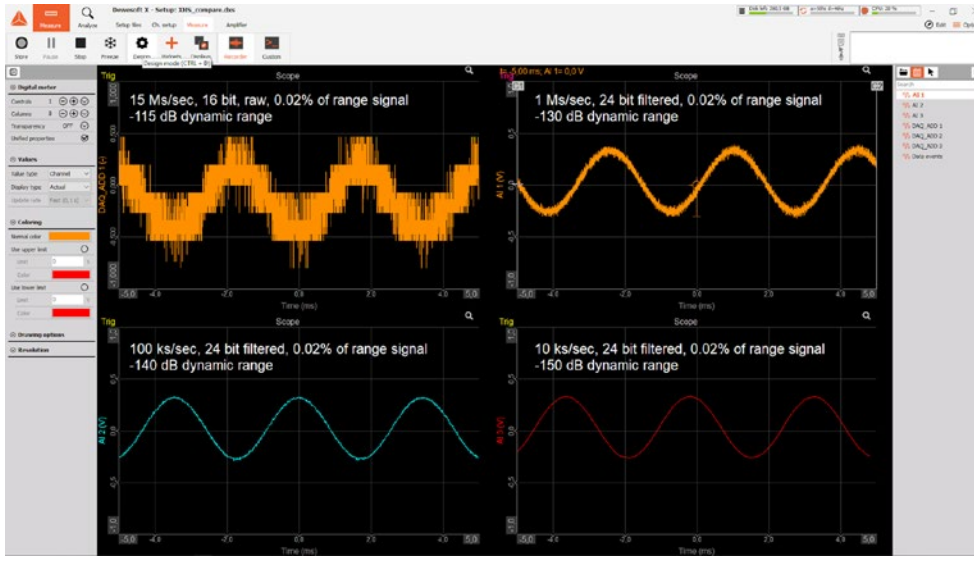


Figure 3: ADC modes of SIRIUS XHS-PWR HybridADC

Figure 4: Typical SIRIUS XHS-PWR ADC display

IMU, video, and more. SIRIUS XHS-PWR instruments can be synchronized using the latest PTPv2 timing protocol (Figure 4). The SIRIUS XHS-PWR is suitable for direct installation into a vehicle. The power lines pass directly through the device, which measures 279 x 151 x 63 mm (10.98 x 5.94 x 2.48 inches). Because SIRIUS XHS-PWR has an operating temperature range of -40 to 70°C (-40 to 158°F), it is also suitable for testing in the most extreme conditions. Its milled-aluminum construction and low mass (typ. 4.4 kg / 9.7 lb.) allow it to withstand rough real driving conditions, and it's sealed against dust and liquids with an IP67 rating.

Looking forward

SIRIUS XHS-PWR is designed to be installed in a vehicle directly on the power lines. Its IP67 protection allows it to work in harsh environments like real drive testing. It's a unique combination of high-bandwidth hybridADC analog-to-digital converters, high accuracy/high bandwidth voltage signal conditioners, high accuracy/high bandwidth DC-CT current transducers—all packed into compact and rugged form-factor with excellent environmental specifications. This system allows electric vehicle test engineers to perform energy flow analysis like never before, and therefore to optimize their designs to achieve the best possible energy performance in today's and tomorrow's electric vehicles.

The world of electric cars is evolving rapidly, and it has never been more important that engineers be up to date on the key e-mobility technologies. Please click the embedded links to learn more about the SIRIUS XHS-PWR, its technical specifications, and more about breakthroughs in electric and hybrid vehicle testing. EE

Grant Maloy Smith has been in the test and measurement industry for 40 years, starting as a technician in 1980 and working his way up as an application engineer, where he put together hundreds of solutions for companies like NASA, Ford Motor Company, and many more. He eventually founded the North American division of Dewetron, running it for 20 years until he retired in 2017. He has a broad range of experience with DAQ applications across the automotive, aerospace, power, and industrial sectors. Today, Grant applies his application knowledge and experience writing about data acquisition (DAQ) technology, both for clients and publications in the worlds of test and measurement and real-time controls.
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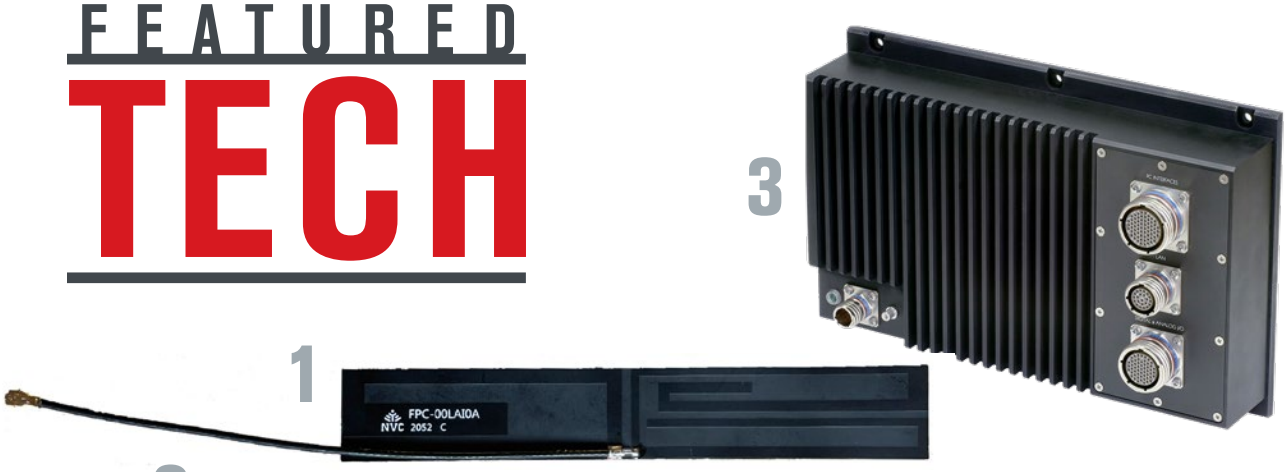
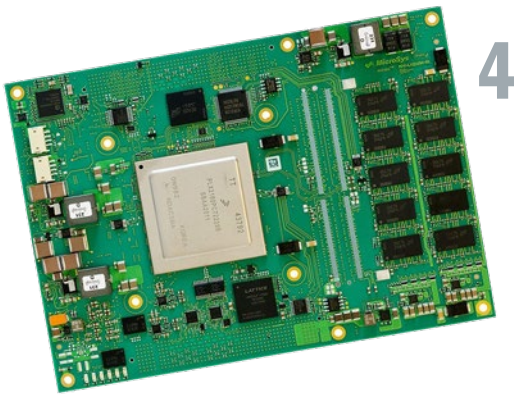
EVALUATION ENGINEERING'S

FEATURED TECH





1. Multi-Channel Antenna Brings 4G LTE to the IoT

Novocomms has announced the launch of its FPCB LTE 4G multi-channel antenna designed for the Internet of Things (IoT). The LTE 4G Bands Flexible PCB features a customizable cable and can be adapted to respond to LB, MB or HB bands. All antennae are designed with 50Ω impedance, and are all available with a customizable coaxial cable. The FPCB LTE 4G antenna is well-suited for medical and wearable devices, and is designed to enable transmission and reception across 4G, Wi-Fi, Bluetooth, and satellite frequencies.

Novocomms

2. Radio Test Station Upgraded for 5G

Anritsu's MT8000A radio communication test station now has 5G protocol test functions, using NR (New Radio) Fading software supporting 3GPP TS 38.521-4 B.1/B.2 V15.0.0-compliant 5G NR channel (TDL) model tests. The test station features an integrated internal fader that can support either 2CC 4x4 MIMO tests with one unit or 8CC 2x2 MIMO tests with a pair of units. The MT8000A can cover critical frequency bands used by the first 5G services, such as the sub-6 GHz band (FR1) frequencies of 2.5 GHz, 3.5 GHz, and 4.5 GHz, and the mmWave band (FR2) frequencies of 28 GHz and 39 GHz.

Anritsu

3. Ruggedized Industrial Computer Designed for Data Acquisition in Harsh Environments

MicroMax has designed a ruggedized computer with data acquisition for harsh environments. The M-Max VI-PR7 packs an Intel E3845 (or E3826) quad-core processor, with up to 4 Gb of RAM, an Intel HD Graphics integrated controller and up to 1 Tb of SSD storage. The computer also features a pair of 10/100/1000 Base-T ports, 2X RS-232, and 2X USB 2.0 ports. The M-Max VI-PR7 complies with MIL-STD-810G, MIL-STD461F and MIL-STD-704F specifications, as well as IP66 rated for dust and moisture. The computer can handle vibration up to 2.5G, and is shock rated for 40G.

MicroMax

4. SoM Brings Edge Computing for Commercial Vehicles and Mobile Systems

MicroSys Electronics has launched its new MPXLX2160A, a ruggedized Edge SoM (System on Module) designed for commercial vehicles and mobile systems. The SoM is designed around NXP's QorIQ Layerscape LX2160A processor, with an Arm Cortex-A72 and up to 128 Gb of DDR4 RAM. The board also packs 24X SerDes Lanes with PCIe Gen3 x8, 100GbE/40GbE/25GbE/10GbE, and SATA. Additional features include 2X RGMII, 2X USB 3.0, 2X CAN-FD, UART, I2C, and Flex SPI. The MPX-LX2160A can handle up to 256 Gb of eMMC storage, an interface for external SD cards, temperature sensors, RTC, and a JTAG debugging interface.

MicroSys Electronics

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5. Linear Accuracy Joins Basic Power Supply Class

The R&S NGA100 is available in four models, each providing a choice of single or dual outputs at up to 35 V / 6 A (100 V / 2 A) per output. Single-output models supply up to 40 W, and dual-output models up to 80 W of power. The dual-output models can be combined to provide up to 200 V or 12 A. Rohde & Schwarz has implemented a linear design throughout the output circuits of the R&S NGA100 to significantly improve performance compared to the switched-mode circuits frequently found in basic power supplies.

Rohde & Schwarz

6. High-Res, High Repeatability Alignment Stages

Optimal Engineering Systems', AU200-200x200 Alignment Stages, supplied with a standard 4 mm-per-turn ground lead screw, feature 200 mm (7.874 in.) of travel in both the X and Y axes. These low-profile 80 mm (3.179 in.) high XY stages have a 250 mm x 250 mm (9.842 in. x 9.842 in.) open aperture. Integration of tooling and fixtures is facilitated through a precision series of threaded holes. The stepper motor driven AU200-200x200-01 XY alignment stage features a resolution of 1 micron when using a 20 micro-steps-per-step micro-stepper motor driver and better than 2 micron repeatability.

OES

7. Test Bench for mmWave devices used in 5G apps

Marvin Test Solutions' TS-960e-5G production test system is designed for mmWave devices used in 5G applications and networks. The TS-960e-5G is based on the modular PXIe platform and can be configured with up to 24 independent VNA channels, up to 256 dynamic digital channels with per-channel parametric measurement units (PMUs) and a wide range of digital and analog instrument options. The TS-960e-5G compact test system supports both functional and DC parametric test capabilities. It also comes with 5G software tools and a digital vector conversion utility that supports ASCII, WGL, STIL, VCD, eVCD and ATP vector formats.

Marvin Test Solutions

8. Real-Time Analysis Spectrum Analyzer

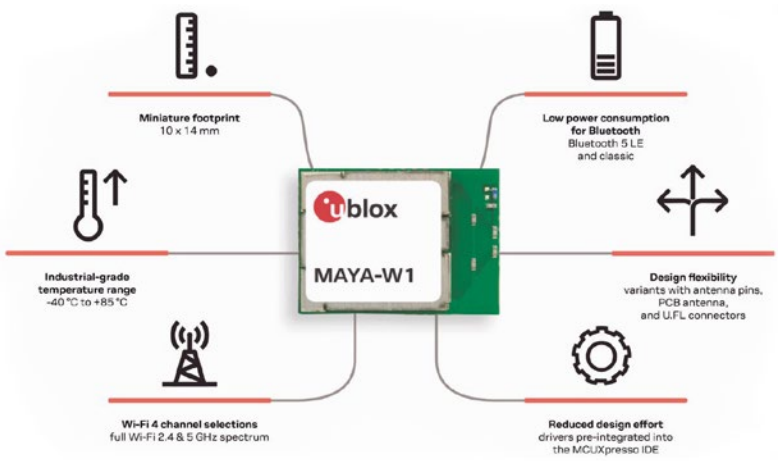
RIGOL Technologies expanded its RF test portfolio with the RSA3000E real-time spectrum analyzer, which combines the power of a high-performance swept spectrum analyzer with real-time analyzer capability. Available in both 1.5 GHz and 3 GHz models, it also comes standard with 10 MHz of real-time analysis bandwidth with seamless capture and a 9.3-microsecond 100% POI. The RSA3000E also can function as a traditional swept-spectrum analyzer with a resolution bandwidth (RBW) of 1 Hz, a noise floor as low as -161dBm, phase noise of -102dBc/Hz, and a full-span sweep as fast as 1ms.

RIGOL Technologies

TECH FOCUS

RF & MICROWAVE

With wireless demand ever increasing, new technological advancements are following suit. 4G is still being implemented in countries worldwide, while 5G and 6G are on the horizon. Wireless plays a crucial role in today's telecommunications platforms and component development for new devices and applications, including robotics, smartphones, and the IoT. In this roundup, we will take a look at some of the new wireless technologies that have been released in 2021.

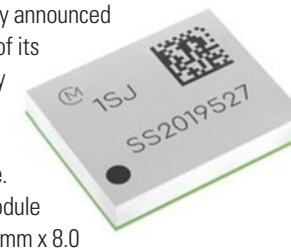


Wi-Fi and Bluetooth Module Designed for EVs, Tracking, and More

u-Blox has released its new MAYA-W1 Wi-Fi 4 and Bluetooth 5 multi-radio module designed for power management, electric vehicle charging, professional appliances, tracking, telematics, and fleet management. The module is designed around NXP's IW416 chip and can operate in harsh environments with temperatures up to 850C. The MAYA-W1 features Access-Point, Station, and Wi-Fi Direct operating modes and offers dual-band wireless (2.4 GHz and 5.0 GHz) and Bluetooth Classic and BLE 5. The module also comes in three variants, including one with a pair of U.FL connectors, another with two separate antenna pins, and a third with an embedded antenna.

u-Blox

Tiny LoRaWAN Modem Solution Reduces Current Consumption



Murata recently announced the expansion of its Type 1SJ family with a new LoRaWAN modem module. The modem module measures 10.0 mm x 8.0 mm x 1.6 mm, making it the smallest in the world. The module operates using a single supply rail with up to 3.9V DC. It incorporates several low-power modes that allow the real-time clock (RTC) to operate while drawing a typical current of only 1.3µA. This allows the modem to run on a single battery for years before it needs recharging. Moreover, the modem module features a resin mold package that allows it to operate in harsh environments at a temperature range of -40°C to +85°C. The Type 1SJ comes preloaded with AT Command controlled modem firmware and a LoRaWAN stack with an AT Command middle layer, which allows for a faster time-to-market and eases design challenges.

Murata

New Microwave and RF Antennas Designed for Satcom testing

Atlantic Microwave recently launched a new series of microwave and RF antennas for Satcom testing and measurement. The range includes horn, patch and spiral antennas that can transmit signals at frequencies that range from 0.5 GHz up to 40 GHz. These Antennas are ideal for applications where cabling testing and signal distribution are not practical or possible with cable or fiber. The new antenna range coincides with the ever-increasing demand for connectivity in all areas, including land, sea, and air.

Atlantic Microwave

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STILL HOOKED UP:
CABLES AND CONNECTORS SEIZE THE DAY

By Ken Cormier, Managing Editor

In an electronics world that is evolving into a wireless future, there still is a need for cables and connectors to channel power and data intact to receiving components and instruments. According to a recent Electronic Cable Market Report[1], the global cable market is predicted to reach $799.5 million by 2025, from $632.6 million in 2021, growing at a CAGR of 6% during the forecast period of 2021 to 2025. The global connector market, according to Allied Market Research, is predicted to reach $98.12 billion by 2027, at a CAGR of 6.7% between 2020 and 2027.[2] Here are some recent news tidbits on what is happening on that front.

CHUYN / iStock / Getty Images Plus

Ethernet Cables Protect Data in Harsh Environments

Electronic designs for the defense sector have their own mobility and portability goals driven by size, weight, and power (SWaP) requirements. Ethernet cables have been one component that has been difficult to shrink without performance sacrifices, until now. TE Connectivity's Raychem single-pair Ethernet (SPE) cables handle the harshest environments in aerospace, commercial, industrial, military, and space environments, providing critical interconnections in such applications as unmanned aerial vehicles (UAVs) and electric vertical takeoff and landing (eVTOL) aircraft.

"The single-pair Ethernet cable allows commercial and defense customers to maintain data rates, while reducing size and weight by up to 75% when compared to existing Quadrax systems," said Lynden Bajus, product manager for TE's Aerospace, Defense and Marine division. "TE's ability to ruggedize an automotive standard to help meet the harsh environment requirements in aerospace, defense, and marine markets has allowed us to focus on improving size and weight parameters for our customers while continuing to maintain critical data-rate needs."

The compact, lightweight construction of the Raychem SPE cables supports 100-Mb/s or 1-Gb/s data rates through single-pair cable assemblies *(see figure above)*. The cables are standardized under the ARINC 854 cabin equipment network bus standard and are available in both AWG 24 and 26 cable sizes. They're designed for operating temperatures from –65 to +150°C. By complementing the firm's 369 shielded connectors, the Raychem SPE cables reduce termination time and simplify maintenance compared to standard eight-wire cables and rectangular connectors.[3]

Report: High-Speed Connector Market Thrives with 5G

A report by Markets and Research values the high-speed connector market at $3,067.65 million in 2019 and predicts that it will grow to $5,658.42 million by 2027, at a CAGR of 8.3% from 2020 to 2027. The report attributes recent growth to the expansion of 5G and related devices in developed and developing countries, which increases demands for high-speed connectors. The report cites the additional high-speed requirements of 4G, VoLTE, and LTE as augmenting market opportunities for speedy connectors, once the fetters of the COVID-19 epidemic are in the past.[4]

Connections in Space

Basic down-to-Earth electronics components such as cables and connectors are also essential and critical items in the dark reaches of Earth orbit at the International Space Station. Such inconspicuous parts of the engineering marvel are subject to consistent inspection and maintenance in the harsh realities of space. NASA, in a brief mention, notes that Commander Akihiko Hoshide, of the seven-member Expedition 65 crew at the space station, checked power cables on the Confocal Space Microscope at the Kibo laboratory module on May 17. With ongoing research at the ISS (which is the length of a football field), cables and connectors play major supporting roles in the success and safety of the long-term mission in the hostile outer reaches of Earth's gravitational influence.[5] EE

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