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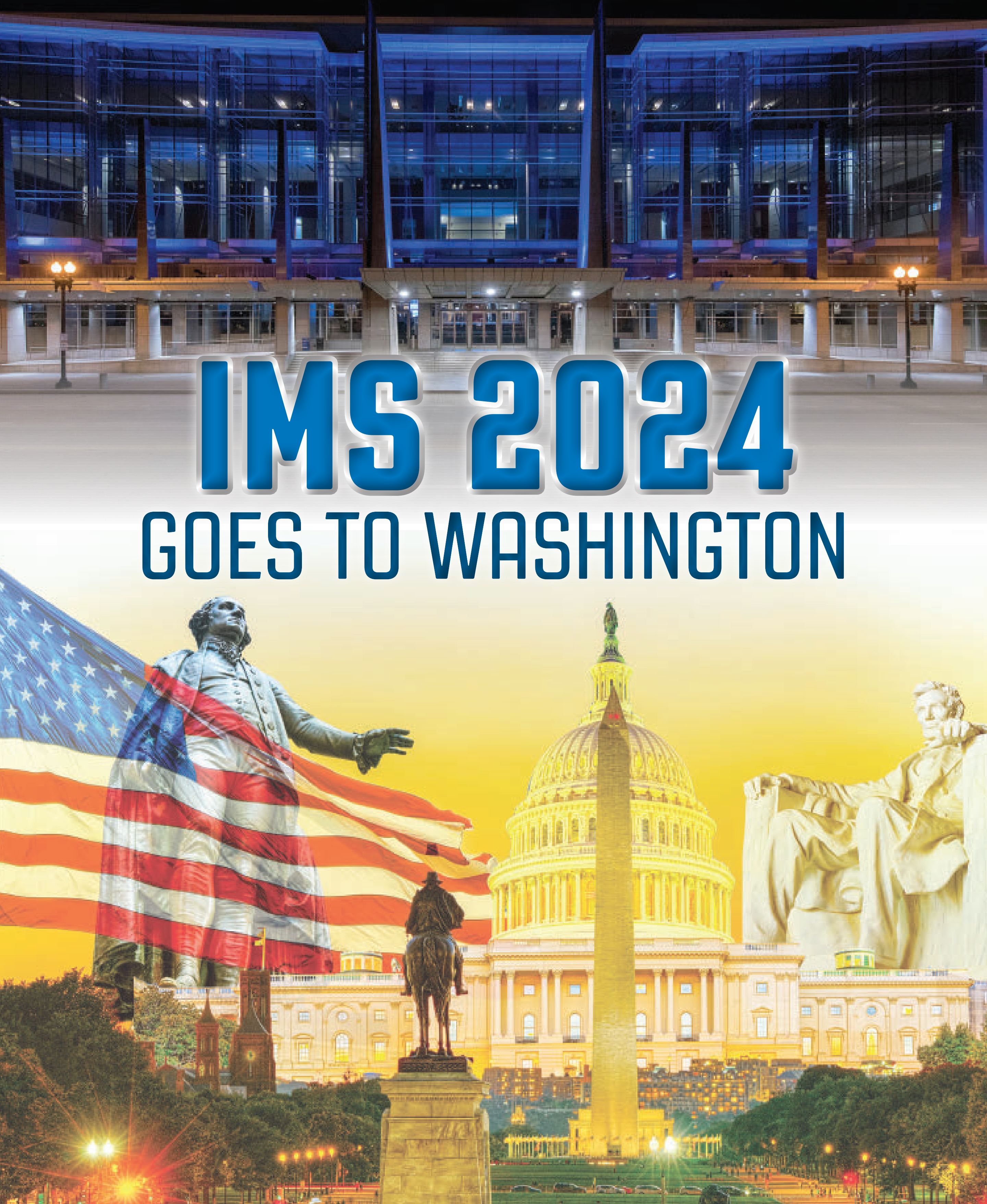

IMS 2024 GOES TO WASHINGTON

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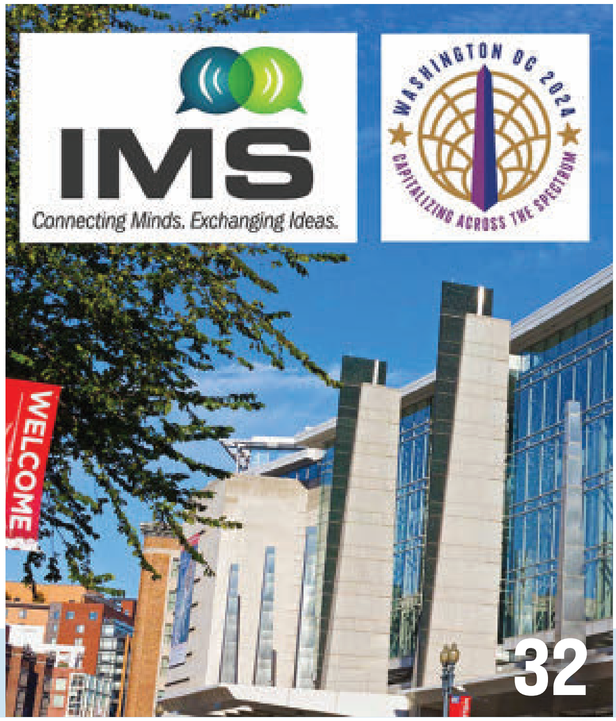

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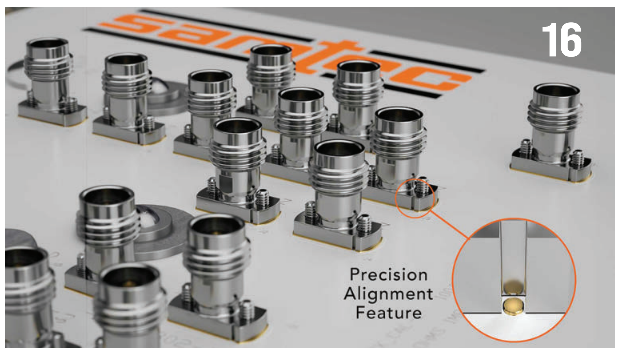

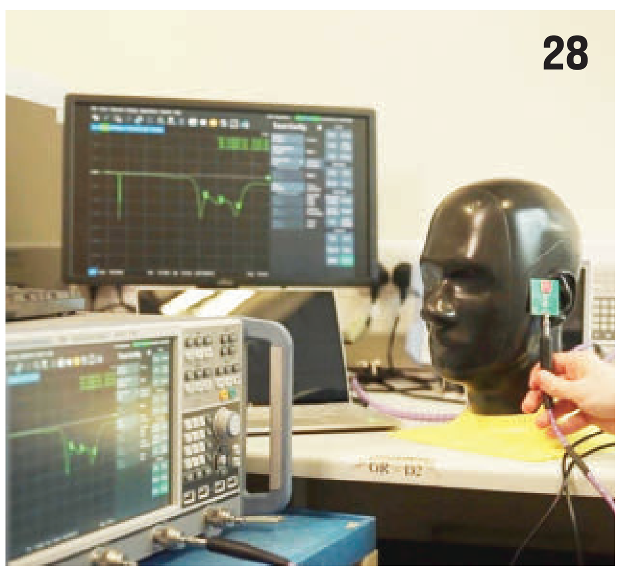

DAVID MALINIAK, Executive Editor

Expanding Your Cranium at **IMS 2024 in Washington**

The annual International Microwave Symposium is poised to deliver its typically stellar technical program, offering an array of educational and career-boosting opportunities to attendees.

AT ANY GIVEN industry convention or trade show, much of the convention center floor space is typically given over to the exhibits. There, you can wander through aisle after aisle of booths in which vendors will tell you all about their latest and greatest offerings.

I'll be doing just that at this year's International Microwave Symposium (IMS, Walter E. Washington Convention Center, Washington, D.C., June 16-21, 2024). In this issue, you can find our IMS show preview article, authored by industry veteran Jack Browne, which provides a teaser of some of what you'll find on the show floor.

But the deeper value of IMS, year after year, is found on other floors of the convention center in the form of the technical program. Whereas the exhibits are where you can learn about the "now," the technical sessions are gatherings where you'll learn about the future. At these sessions, the industry's leading thinkers and movers will provide tantalizing hints to what's coming three, five, and 10 years down the road.

The program also offers several "boot camps" at which you can get caught up on the trends driving the industry. For example, the Quantum Boot Camp explores the ephemeral and still-developing nexus of quantum physics and microwave engineering. You can get a feel for where your skills fit into this emergent and dynamic niche.

In addition, a full slate of workshops will target everything from power-amplifier design to flexible arrays to "chipletization." If you're looking to explore employment opportunities or just make friends with like-minded peers, a number of networking events will take place for groups such as Women in Microwaves, Young Professionals, and Amateur Radio enthusiasts.

Bottom line: There's something for everyone at IMS 2024, whatever your interests or proclivities may be. If you're not registered, it's never too late—until June 22. ■

An Overview of the IMS 2024 Technical Program:

- IMS Plenary Session
- IMS Closing Session
- Technical Sessions and Interactive Forum
- Workshops
- Panel Sessions
- Tutorial Preview Series
- Quantum Boot Camp
- AI/ML Boot Camp
- WPT Boot Camp
- RF Boot Camp
- MicroApps Seminars
- Industry Workshops
- Future G Summit
- Women in Microwaves
- StartUp Program

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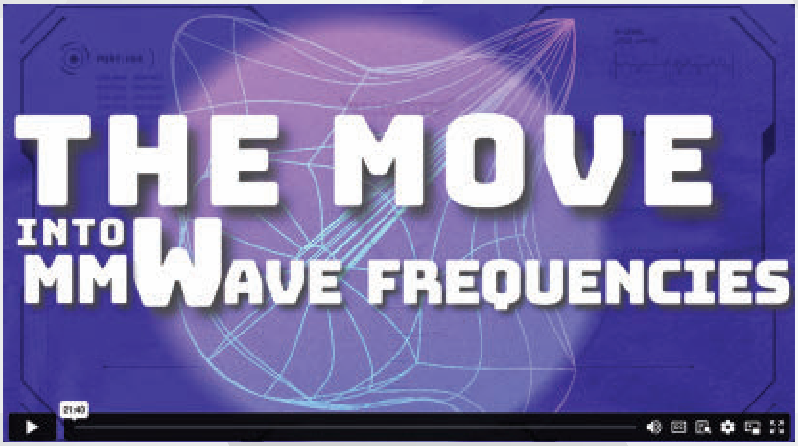

Video ▶ The Move into mmWave Frequencies (Part 1)

In this first of a series of three videos exploring the arena of mmWave system design, Giorgia Zucchelli, product manager for RF and mixed-signal at MathWorks, will cover the topics of frequency dispersion and interfering signals and how they impact the performance of wideband receivers. She discusses the consequences of those signals, such as saturation and desensitization, and examines filtering techniques that are commonly used to mitigate their effects.

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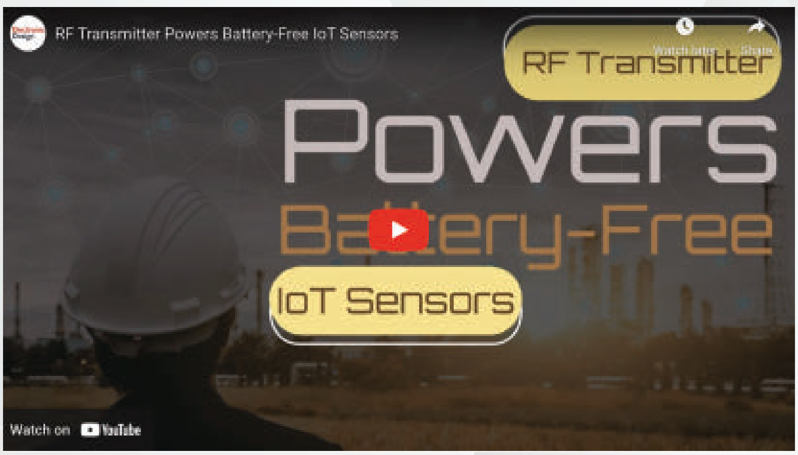

Video ▶ RF Transmitter Powers Battery-Free IoT Sensors

Energous' PowerBridge is designed to send RF energy over the air and to devices with matching chips from the company that can store the energy for use by the device. In this video, Kero Basilios, Energous' Director of Application Engineering and Customer Support, shows the system in action.

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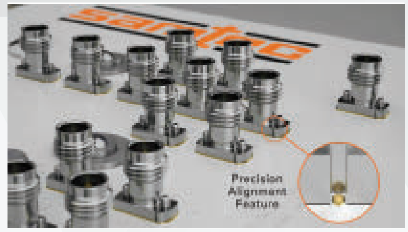

Simplifying Deployment of 5G Open RAN Radio Units in Greenfield Sites

Despite the advantages of O-RAN's openness, the disaggregation facilitating that openness is a double-edged sword that can bring concerns over compatibility, management, and security. Learn more about how important it is to thoroughly test deployments, both in isolation and at the system level.

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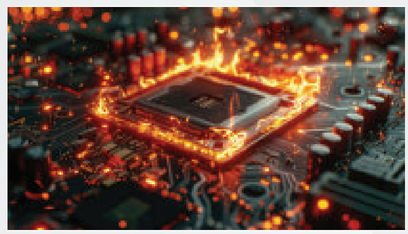


Improve RF System Reliability by Understanding Thermal Analysis

This article looks at the basic concepts of thermal behavior in semiconductors and how to practically measure and analyze temperature and thermal properties. It also covers some of the fundamentals that design engineers should understand to ensure they can create reliable systems.

www.mwrf.com/55019383

Revolutionizing Vehicle Safety: The Role of UWB in Modern Automobiles

While UWB's applications are vast, this article focuses on its critical role in lifesaving vehicle applications, offering a glimpse into the future of safer and more interconnected driving.

www.mwrf.com/55016850

LATEST NEWS

Stable Structures Morph with Hypersonic Conditions

Andres Arrieta and his research group at Purdue University are experimenting with electronic systems capable of morphing to meet the requirements of changing hypersonic operating conditions.

ELECTRONIC SYSTEMS OPERATED within hypersonic vehicles, such as missiles, must withstand rapidly changing operating environments, placing tremendous stress on many components.

To better prepare electrical and mechanical components for these harsh operating environments, researchers at Purdue University are experimenting with morphing systems capable of adapting to changing environments. They're researching the materials and structures required for successful and reliable performance under stressful operating conditions within hypersonic missiles.

At Purdue (West Lafayette, Ind.), Andres Arrieta, associate professor of mechanical engineering, and Rodney Trice, professor of materials engineering, are designing aircraft systems with multistable structures *(see figure)*. They're exploring combinations of materials and physical structures capable of adapting to changing operating conditions. They're also considering the requirements of different applications, such as the need for lighter-weight materials and structures for achieving longer flight times in aircraft and missile systems.

The structures they seek can morph in shape and in weight in response to external forces. These structures function through a combination of mechanical and material interventions that not only make morphing hypersonic systems possible, but may also reduce weight and complexity. The technology is based on data from advanced sensors and structures programmed to respond to changes according to localized sensors.

According to Arrieta, "Current mechanisms that help aircraft maneuver, like the aileron or tail, create noise and drag. These mechanisms are also chains of various parts, and each of these parts is joined by a joint. The more parts and joints you have, the more complex your system becomes."

As the solution, he explains, "So if we have a structure that is just one big part but is also capable of deforming, then there is potential to reduce not only complexity, but also failure, maintenance costs, and weight — which is the most important consideration in aviation." The Purdue researchers are attempting to develop surfaces that can take on a variety of shapes for optimum performance over a range of aircraft speeds. ■

Researchers at Purdue University are experimenting with electronic systems capable of morphing to meet the requirements of changing hypersonic operating conditions. Purdue University

RF Timing Solution Enhances Wireless Infrastructures

Courtesy SiTime

SITIME released the Elite RF precision timing platform, intended to enhance the timing architecture in wireless infrastructures. Like all members of the new class of MEMS-based temperature-compensated crystal oscillators (TCXOs), its Elite RF Super-TCXO is purpose-built to withstand extreme environments in which 5G radios are deployed, while delivering the phase noise, accuracy, and resilience demanded by the application.

The single, highly integrated device also meets the performance requirements specified by the IEEE 1588v2 timing synchronization protocol. Offering a higher reliability than legacy mini oven-controlled crystal oscillators (OCXOs), the Elite RF Super-TCXO provides a reliable timing platform, consuming less power and board space, without additional components like jitter cleaners and VCXOs for generating RF-capable clocks.

"To enable new services, radios are expected to deliver 10X the bandwidth of previous generations with significantly lower latency," said Piyush Sevalia, executive VP of marketing, SiTime. "To achieve these performance goals, next-gen radios must be deployed closer to the user, and all nodes in the network must be time-synchronized. Past radio architectures used separate timing devices for the radio and for synchronization. The SiTime Elite RF platform integrates these two clocking functions, simplifying the radio timing architecture and delivering on the promise of 5G bandwidth and coverage."

TCXO Specs and Features

The SiT5376 and the SiT5377 are ±100-ppb precision MEMS Super-TCXOs with an output that can be digitally pulled by up to ±400 ppm with a resolution of ±0.05 ppt. Both can be factory-programmed to any combination of frequency, voltage, and pull range; are compliant to the GR-1244 Stratum 3 oscillator specifications; and use the company's DualMEMS and TurboCompensation temperature-sensing technology for stable timing in the presence of environmental stressors, including EMI.

Features include a frequency output from 1 to 220 MHz, ±100-ppb stability over the –40 to +105°C operating temperature range with ±0.9 ppb/°C stability over the temperature slope, and ±400-ppm digital control with ±0.05-ppt (parts per trillion) resolution. Typical integrated phase jitter is 100 fs (19.2 MHz, 12-kHz to 20-MHz integration range), with 0.3 ppb/day typical daily aging. Housed in 5.0- × 3.5-mm ceramic packages, they have a power consumption of 144 mW at 1.8 V. ■

UWB PHY Conformance Test Platform Supports FiRa 2.0

KEYSIGHT TECHNOLOGIES unveiled a test tool validated for the FiRa 2.0 Certification release. It covers physical-layer (PHY) conformance testing for performance and interoperability test requirements targeting ultra-wideband (UWB) device conformance. FiRa 2.0 Certification establishes additional testing for UWB devices involving compatibility and functionality across diverse applications.

Support for FiRa 2.0 test cases comes in the company's UWB Test Solution, a validated test tool for the new specifications. The complete toolset covers the design lifecycle from R&D to certification to manufacturing.

The UWB Test Solution performs RF validation to ensure that the device under test (DUT) meets performance requirements, providing angle-of-arrival (AoA) measurements to verify that the DUT measures signal angle correctly to ensure precise positioning. It also provides time-of-flight (ToF) measurements to establish that the DUT reports signal flight time as expected for accurate distance calculation.

According to Dr. Michael Stark, FiRa's Compliance and Certification Working Group Co-Chair, "The success of UWB lies in delivering seamless user experiences and device interoperability. We're pleased to have Keysight's UWB Test Solution, a FiRa Validated Test Tool, as part of the 2.0 Certification Program."

Peng Cao, Vice President and General Manager of Keysight's Wireless Test Group added, "With the speed of ultra-wideband innovation and adoption accelerating, device makers are looking for proven and validated test solutions that keep pace with the latest FiRa specifications and interoperability standards. Keysight is proud that the UWB Test Solution has been validated into the FiRa 2.0 Certification Program to provide device makers worldwide with the conformance testing tools they need to bring their products to market quickly." ■

Low-Power 4x4 RF Transceiver Handles Up/Down Conversions

The Overview: An Innovative RF Transceiver

SilverWings, a new 4x4 RF transceiver from Arctic Semiconductor, is touted as the first such device to offer multi-stage upconversion and downconversion from digital to RF and RF to digital. The chip integrates high-performance analog capabilities with high-bandwidth digital functions.

Who Needs It & Why: All-in-One RF Transceiver Design

Designers of all manners of wireless systems want to put as much integration in play as possible, reducing costs and printed-circuit-board footprints. SilverWings offers an avenue toward greater integration in a wide range of applications including:

- Wireless radios
- Satellite communication
- Repeaters
- Fixed-wireless access devices
- User equipment
- Medical devices
- Instrumentation

Moreover, designers stand to gain from the device's low-power architecture and digital-IF and high-IF conversion methodologies, which enable programmable and adaptable system designs.

Under the Hood: Seamless RF Transceiver Integration

Within the SilverWings RF transceiver is a complete suite for functionality that's essential to implementing upconversion and downconversion. The receiver sports an RF gain stage for extremely fast automatic gain control (AGC). The device also includes digital predistortion (DPD) on the transmitter, further increasing integration while also helping subdue external power-amplifier nonlinearity.

Arctic Semiconductor

The device provides a quartet of transmit and receive paths with two observation paths. It offers a control interface that runs at up to 400 Mb/s for pinpoint control and brings up to 72 dB of analog-controllable RF gain.

For the power-conscious designer, SilverWings brings a 60% power reduction compared to competitive solutions, it's claimed. It does so even as it integrates RF gain with gain control in both the transmit and receive signal paths.

Efficient Wireless SoC Built for Energy-Harvesting Apps

Silicon Labs

Silicon Labs recently unveiled the xG22E family of wireless SoCs, its first-ever family designed specifically for the ultra-low-power envelope where battery-free, energy-harvesting applications function. The BG22E, MG22E, and FG22E are the company's most energy-efficient SoCs to date.

The devices enable the creation of advanced Bluetooth Low Energy, 802.15.4-based, or sub-GHz wireless devices for devices able to harvest energy from external sources in their environments. Such ambient energy could come from indoor or outdoor lighting, radio waves, and/or kinetic motion.

Silicon Labs Teams with e-peas on Energy-Harvesting Shields

Silicon Labs is partnering with e-peas to release energy-harvesting shields for its energy-optimized xG22E Explorer Kit.

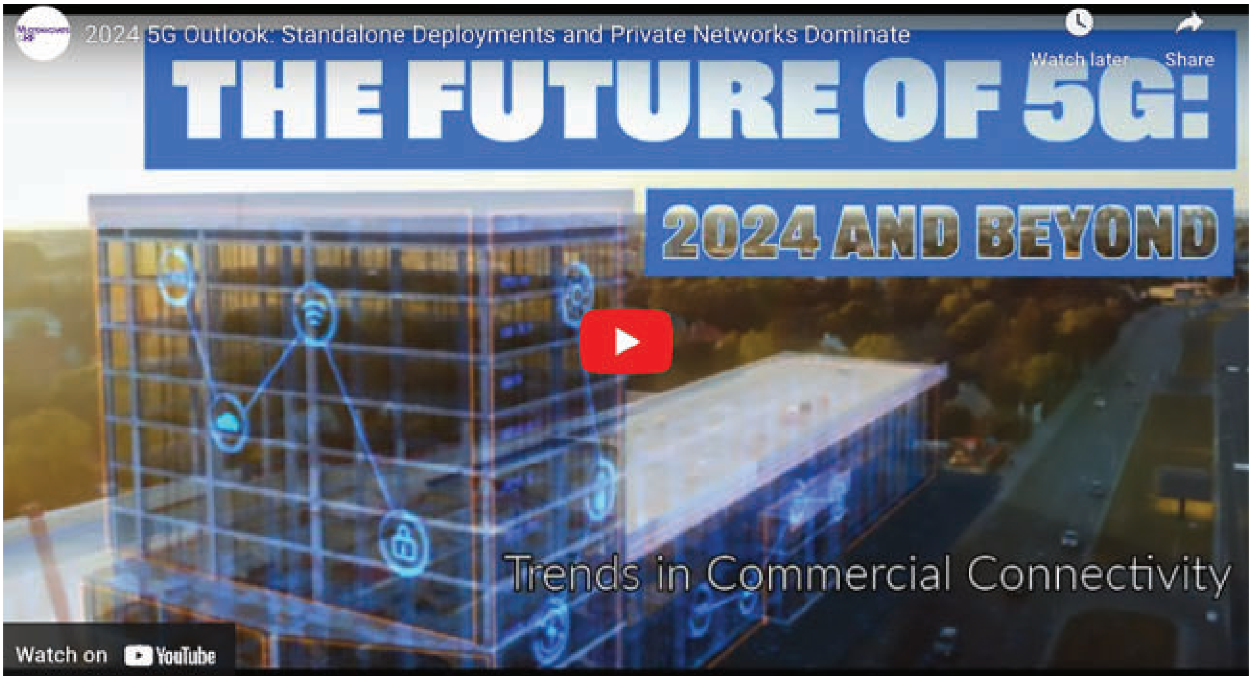
The Explorer Kit makes it possible to optimize peripherals and debugging options to best match the application, with highly accurate measurements to better build application solutions and devices. The shields target different energy sources and energy-storage technologies, and are custom-fit to slot onto the Explorer Kit.

One of the shields uses e-peas' latest AEM13920 dual-harvester, enabling it to pull energy from two distinct energy sources at the same time, like indoor or outdoor light, thermal gradients, and electromagnetic waves, without sacrificing energy-conversion efficiency. The second co-developed shield leverages e-peas' AEM00300 shield to harvest power from random pulsed energy sources.

Energy-Conserving Features of the xG22E Family

The xG22E family offers several features designed to minimize energy use, including ultra-fast, low-energy cold start for applications starting from a zero-energy state to quickly wake up and then rapidly return to sleep. Deep sleep and swift wake-up reduces energy consumption by up to 78% compared to other legacy solutions.

A power-efficient energy mode enables a smooth transition in and out of energy modes by mitigating current spikes or inrush, which can harm energy storage capacity. In addition, multiple deep-sleep wake-up options, such as RFSense, GPIO, and RTC, are well-suited for extended storage.



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2024 5G Outlook: Standalone Deployments and Private Networks Dominate

Spirent's Steve Douglas shares an overview of the company's 5th annual 5G Outlook Report, chock-full of trends such as non-terrestrial networks, open RANs, and the move to standalone 5G infrastructure.

***By David Maliniak,** Executive Editor*

VENDORS OF TEST EQUIPMENT and services are well-positioned to spot trends and areas of growth potential in the industries they serve. To that end, Spirent Communications has released its 5th annual 5G Outlook Report. In a companion video available here, Spirent's Head of Market Strategy Steve Douglas discusses what the company sees for 5G in 2024.

5G Megatrends: Standalone and Private Networks

In the report, Spirent identifies two 5G megatrends, the first being a move to standalone 5G networks. This builds on some commercial deployment momentum that began last year, which was ultimately slowed by both complexity and the need for native cloud environments. In addition, macroeconomic uncertainty caused many to hold back on spending. Yet, Spirent was engaged with more than 30 service providers around the world when testing its new 5G core networks.

That 2023 precursor *(see figure)*, according to the report, provides a strong indication for a breakout in commercial deployments of standalone networks in 2024. Douglas said 2023 test activity went farther than testing the core network. However, it encompassed some of the enhanced services, such as Voice over New Radio and immersive video with network slicing, to ensure those services would be commercially available this year.

A second megatrend Spirent calls out in its report is around the private-network ecosystem. Again, 2023 saw positive momentum for private networks, in terms of an upswing in investment and some validation of how a small-scale automated 5G environment with a few selected use cases could quickly bring value to enterprises. This belies the notion that private 5G networks need to be large, complex, and bespoke.

Emerging 5G Trends: Non-Terrestrial Networks

Spirent's 2024 outlook also identifies some areas in the 5G world with potential for high growth. One that will take off in the latter half of the decade is non-terrestrial networks (NTNs) comprising low-Earth-orbit satellites (LEOs). Douglas cites evidence of the early stages of testing direct-to-device 5G communications. He explained, "At this stage, it's trying to understand the art of the possible in terms of what performance and types of services could be confidently provided."

This is a process that will take several years from the perspectives of both testing and regulatory concerns, the latter meaning sorting out spectrum usage and managing interference. Spirent believes that initial NTN services like IoT and SMS direct to handsets from satellites could commence in 2025. From 2026 and beyond, higher-value services such as voice, data, and mobile broadband are likely.

Also Emerging in 5G: Augmented and Virtual Reality

A second trend area to watch is augmented and virtual reality (AR/VR). Enterprises are showing interest in how one might use augmented reality within a private-network environment to implement functions like monitoring of assets and remote tech support. Much of the testing in this area focuses on ensuring that users of AR/VR headsets were enjoying sufficient imaging quality.

Open and Virtual RAN

While 2023 was, in Douglas's terms, "an interesting year" for open and virtual radio-access networks (RANs), the market is still in its infancy in terms of commercial deployment. There is, however, a great deal of test activity behind the scenes as network operators plan future implementations.

On the positive side, more than 30 service providers globally are targeting meaningful deployments of open RAN in the second half of this decade. There have been recent major announcements on this subject from the likes of AT&T and Vodafone, and the ecosystem is growing rapidly. There are now over 50 suppliers of radio heads, the new central or distributed units that make up disaggregated open-RAN environments.

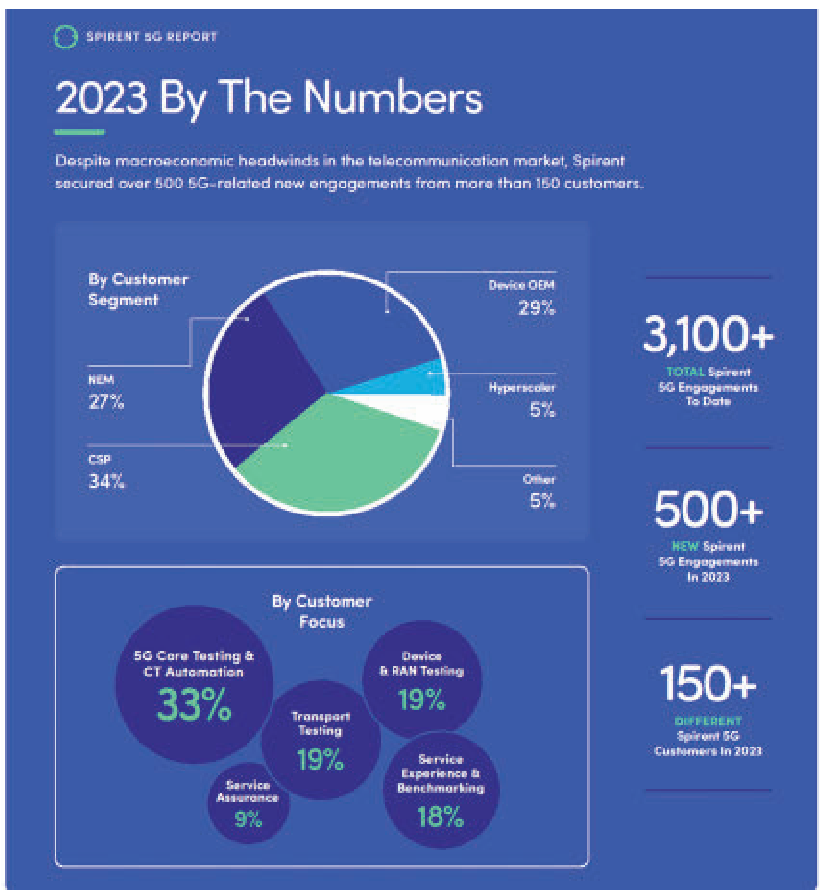
In 2024, we'll see evolution of the test activity toward pilots and trials of open RAN. Network operators will be checking performance, high-level interoperability, resilience testing, and security testing. These aspects are critical in moving from pilots and trials into large-scale commercial deployments in 2025 and beyond.

T&M Opportunities Afforded by Open RAN

The burgeoning adoption of open RAN, with its inherent disaggregation and mixing/matching of hardware and software, presents opportunities for test-and-measurement houses such as Spirent. Open-RAN implementations represent the industry's first efforts at separation of the radio hardware and the associated software stack. This can present challenges in terms of latency performance, especially if elements of the radio stack are geographically dispersed.

It manifests in issues such as standards compliance, proper levels of scaling, and provisions for disaster recovery. There will undoubtedly be more test iterations and more concerns regarding automation of the lifecycle-management end of testing.

Some of these issues arise from the cadence of software updates and releases from suppliers, which happen faster than ever these days. As a result, more effort is expended in revalidating these frequent software drops, which can happen in as fine-grained a span as weekly releases.

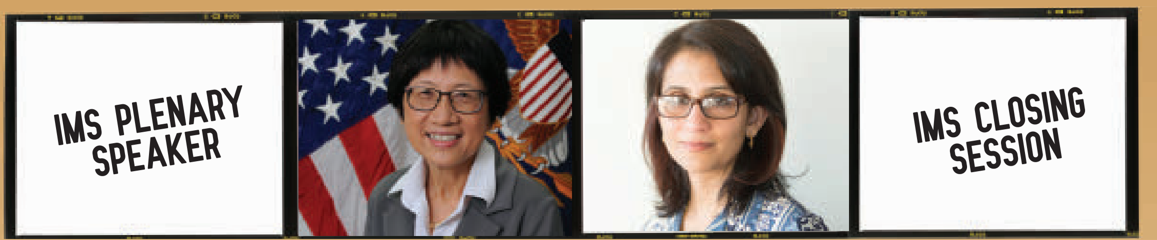


5G by the numbers: A graphic encapsulating 2023 in 5G. Spirent Communications

IMS & RFIC PLENARY SPEAKERS/ WEEK AT-A-GLANCE

Peter Vetter, (Nokia),
President of Bell Labs
Core Research

Prof. Tsu-Jae King Liu,
Dean of the College of
Engineering at UC Berkeley



Heidi Shyu
Under Secretary of Defense for Research and Engineering,
Chief Technology Officer for the Department of Defense

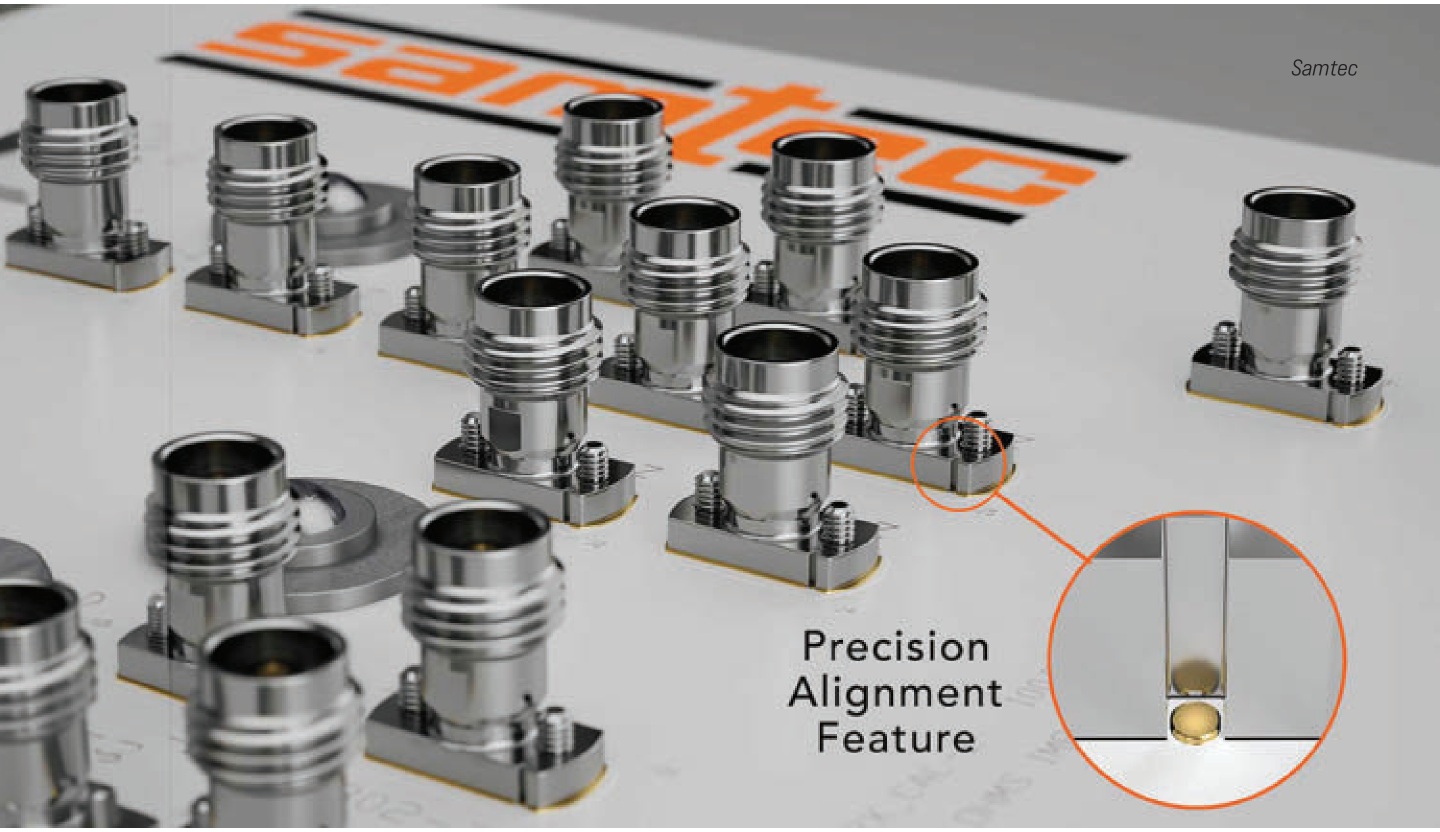
Dr. Monisha Ghosh
Professor of Electrical Engineering, University of Notre Dame, Policy Outreach Director for SpectrumX and Former Chief Technology Officer at the Federal Communications Commission (FCC)

WEEK AT-A-GLANCE

	Sunday 16-Jun-24	Monday 17-Jun-24	Tuesday 18-Jun-24	Wednesday 19-Jun-24	Thursday 20-Jun-24	Friday 21-Jun-24
Workshops	■	■				
RFIC Technical Lectures	■					
RFIC Plenary Session, Reception, Industry Showcase	■					
Quantum Bootcamp	■					
AI/ML Bootcamp	■					
RF Bootcamp		■				
WPT Bootcamp		■				
RFIC Technical Sessions and Interactive Forum		■	■			
Three Minute Thesis		■				
IMS Industry Showcase, Plenary and Welcome Reception		■				
IMS Technical Sessions			■	■	■	
Interactive Forum				■		
Panel Sessions		■	■	■	■	
Future G Summit				■		
Exhibition			■	■	■	
MicroApps and Industry Workshops			■	■	■	
Amateur Radio Reception			■			
Young Professionals Reception			■			
Industry Hosted Reception				■		
Women In Microwaves Reception			■			
IMS Closing Ceremony					■	
103rd ARFTG						■

Workshops Technical Lectures RFIC Bootcamp Three Minute Thesis IMS
Panel Sessions Future G Summit Exhibit Hall Activities Focus Groups ARFTG

Improve Alignment of Compression-Mount Connectors in Wireless Designs



Samtec

Take a deeper dive into applying compression-mount connectors in RF and microwave systems, and the crucial significance of alignment.

By ***Zak Speraw,*** *RF Design Engineer, Samtec*

INTERCONNECT DENSITY CONTINUES to intensify in the latest millimeter-wave (mmWave) designs, and as such, manufacturing variations can noticeably impact performance at high frequencies. To conserve PCB real estate, designers are increasingly turning to small compression-mount connectors, particularly in test, prototype, and diagnostic applications. One concern with these types of connectors is the risk of misalignment. Unfortunately, it has historically been difficult to detect.

This article explains how compression-mount connectors are used in RF and microwave systems and why alignment is so important, and then examines the impact of misalignment on performance. The work detailed here shows that a visual indicator of proper alignment can greatly speed up assembly, alignment, and yield in designs using small compression-mount connectors.

The Advantages of Compression-Mount Connectors

In today's wireless designs, it's necessary to scrutinize the performance of even the smallest components. Many mmWave designs, particularly for communication and sensing technologies, incorporate precision, high-frequency test connectors that handle frequencies of 90 GHz or higher. To capture nonlinear and harmonic performance, these components are frequently tested at many times their maximum operating frequency.

Threaded, coaxial compression connectors are growing in popularity for high-precision mmWave interconnect, largely due to their ease of use, reusability, repeatability, and performance. Compression connectors are much like soldered coaxial connectors, except that the center conductor and ground connections are made through precision-designed compression contacts.

Rather than being soldered, these connectors employ mounting screws for fixturing and alignment. Because the design requires only mounting holes on the PCB, they can be used and reused on traces anywhere.

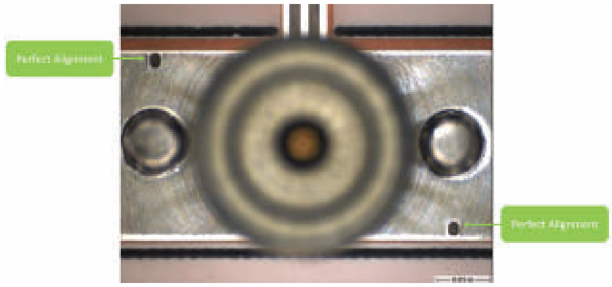
Threaded, coaxial compression connectors are growing in popularity for high-precision mmWave interconnect, largely due to their ease of use, reusability, repeatability, and performance.

Higher-density interconnects require tighter tolerances for connector placement. As a result, proper positioning becomes even more important to ensure reliable, repeatable, high-precision connections between the transmission lines and test leads of the high-frequency test equipment.

Why Alignment Matters for Interconnects

Compression-mount connectors come in a range of sizes, which also means a variety of footprints. Some of the smallest 1.35-mm connectors have a tiny center-pin diameter of 254 µm. Because the trace widths on the landing pads are approximately the same diameter as the center pin, there's significant potential for misalignment at these small sizes.

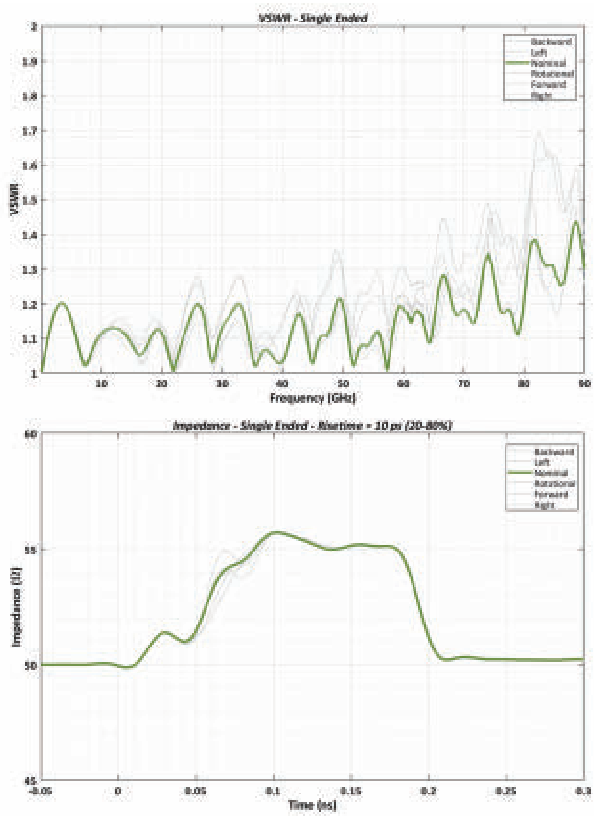
A compression-mount connector can become misaligned in multiple ways, including rotational, lateral, forward, and backward.[1] The analysis performed in this article uses Samtec's compression-mount RF connectors with visual alignment guides machined into the base of the connector housing to assess the impact of misalignment. In this study, performance



1. In this correctly aligned compression-mount connector, both fiducials are fully visible and entirely contained within the fiducial cutouts. Images courtesy Samtec

degraded for each type of misalignment, except for rotational. This doesn't exclude the possibility that rotational alignment can't degrade performance; further study may reveal use cases where there's an impact.

The best way to understand the performance costs of misalignment is through comparison with a well-aligned connector *(Fig. 1)*. Samtec's threaded compression-mount connectors



2. These graphs show the measured nominal VSWR (left) and impedance performance (right) of a correctly aligned compression-mount connector.

have visual alignment guides machined into the base of the connector housing. This approach enables visual indication of a compression connector's alignment/misalignment in reference to the surface metal layer of the PCB.

The PCB fiducials can be specifically designed for the connector alignment guides. This provides visual assurance that the connector center pin and recess for the planar transmission-line trace are aligned with the PCB landing pad (or, in the case of this analysis, will confirm that the center pin is misaligned).

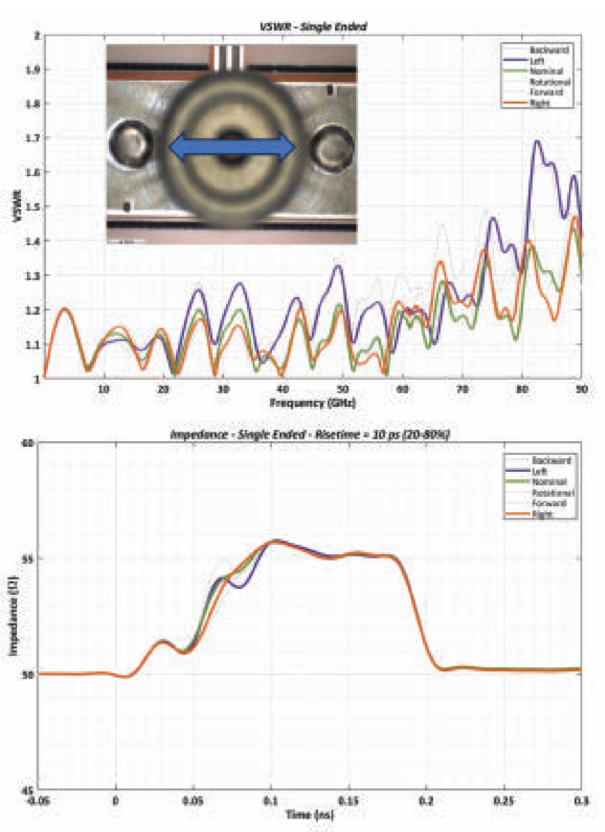
In *Figure 2*, the green trace shows the measured voltage standing-wave ratio (VSWR) and impedance performance of a well-aligned connector (as shown in *Figure 1*, where both fiducials are fully visible and entirely contained within the fiducial cutouts). These measured performance curves will be used for comparison with misaligned connectors later in this article.

Impact of Misalignment on Connector Performance and VSWR

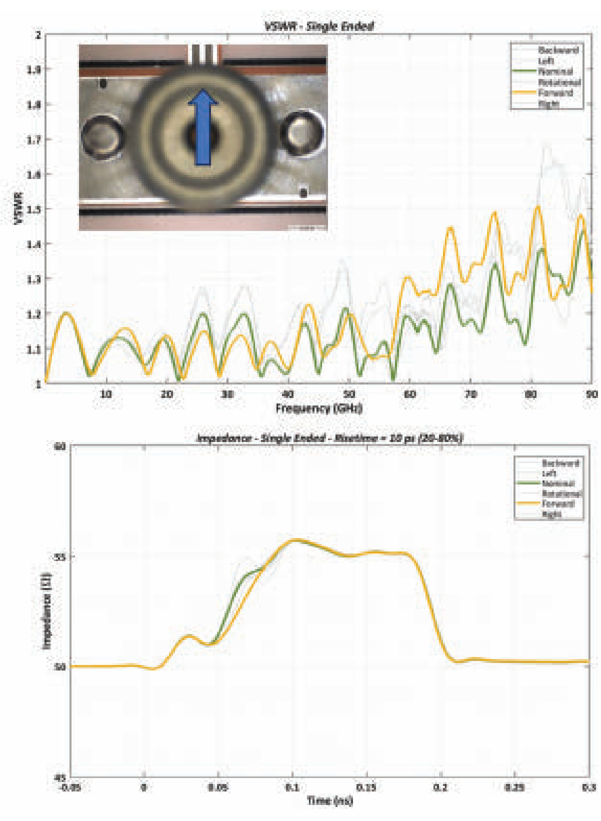
In lateral misalignment, the connector is off-center in a side-to-side orientation, and both fiducials will be slightly covered by the fiducial cutout, indicating poor alignment. *Figure 3* shows the VSWR and impedance performance of left (purple trace) and right (orange trace) lateral misalignment as compared to nominal (green trace).

Lateral misalignment to either side degrades VSWR performance. In this example, one side may be performing worse than the other due to asymmetric PCB mis-registrations, such as tolerance of the hardware drill placement. In terms of impedance, there's some noticeable changes versus nominal. For applications where de-embedding is required, this amount of degradation in VSWR performance could be critical.

Lateral misalignment to either side degrades VSWR performance. In this example, one side may be performing worse than the other due to asymmetric PCB mis-registrations, such as tolerance of the hardware drill placement.



3. Analysis of lateral misalignment of a compression-mount connector reveals significant VSWR degradation and some impedance changes vs. nominal (green trace).



4. Forward misalignment (gold trace) shows a significant impact on VSWR performance vs. nominal (green trace). The impedance trace (right) is slightly more capacitive than nominal.

In cases of forward misalignment, the rear fiducial protrudes from the fiducial cutout *(Fig. 4)*. Backward misalignment is shown in *Figure 5*. Measured results reveal a significant impact on VSWR for forward or backward misalignment, which would lead to degraded connector performance. Like lateral misalignment cases, these types of degradations can seriously affect performance and measurements, particularly as frequencies reach 56 GHz and above.

Probably not surprising, the misalignment with the least impact on performance in this study was rotational misalignment. In this case, neither fiducial is entirely within the fiducial cutout. VSWR performance is only slightly degraded, and there's a minimal difference in impedance *(Fig. 6)*.

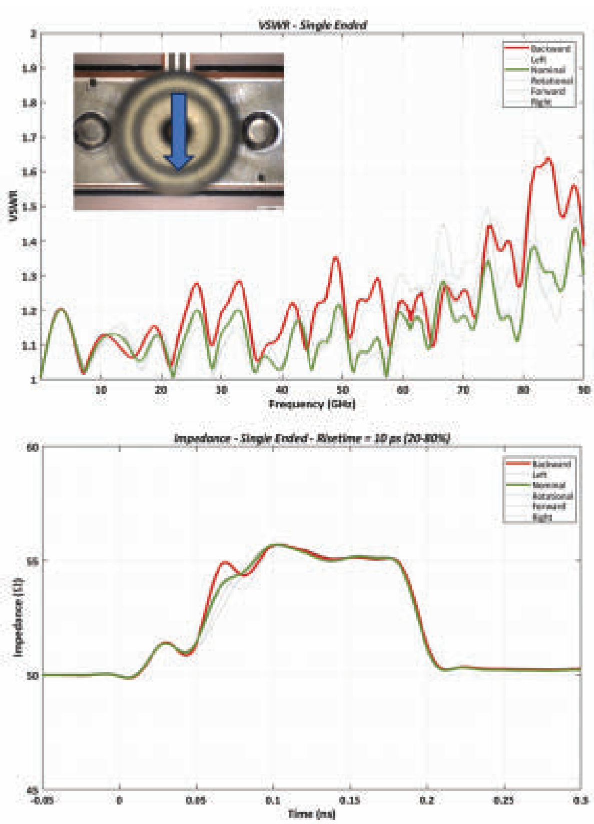
This study showed that a loss in performance occurs for all types of misalignments except for rotational. Forward and backward misalignment demonstrated the largest performance degradation. Unfortunately, this is the most challenging type of misalignment to visually determine in compression-mount connectors that don't have fiducial cutouts.

Misalignment's Effects on PCB Yield and Assembly

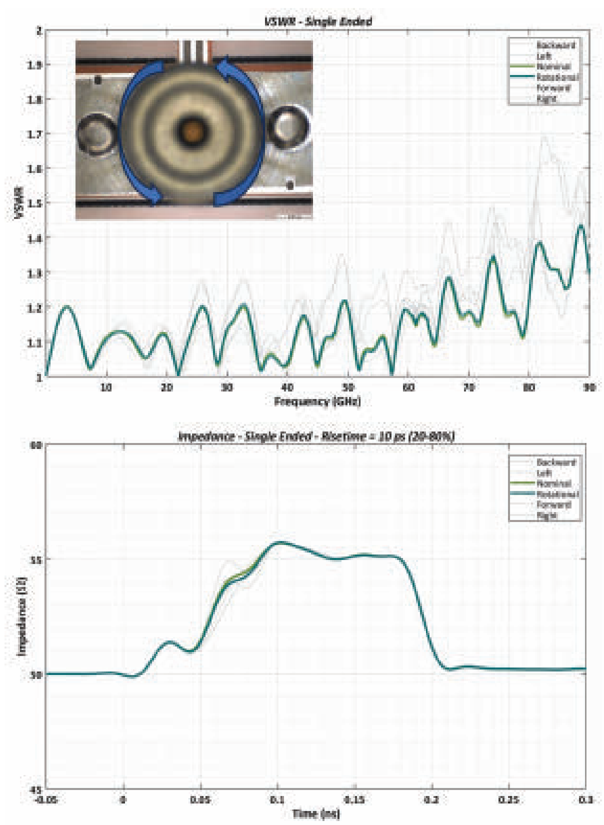
Alignment matters because it may have a dramatic effect on yield, and, because it has historically been hard to determine, troubleshooting can be time-consuming. Before the development of alignment grooves on compression-mount connectors paired with fiducials on a PCB, the methods to ensure alignment were unreliable.

For example, the most common method depended on the screws used to fixture the compression connector to the RF board to ensure alignment. However, it's possible that the "play" between the two screws could allow for undesirable movement of the coaxial connector.[2]

This study showed that a loss in performance occurs for all types of misalignments except for rotational. Forward and backward misalignment demonstrated the largest performance degradation.



5. Backward misalignment also shows a significant impact on VSWR performance vs. nominal (green trace). The impedance trace (right) is noticeably more inductive at the connector-to-board transition.



6. Rotational misalignment (aqua trace) had minimal impact on connector performance in this study.

Without fiducials, the perimeter of the outer housing is the only feature on compression connectors suitable for performing a visual indication of alignment. While some flat surfaces typically exist on the outer housing of these connectors, they're not necessarily machined to the same level of tolerances as the internal features of the coaxial conductors and could prove to be an unreliable method of confirming alignment.

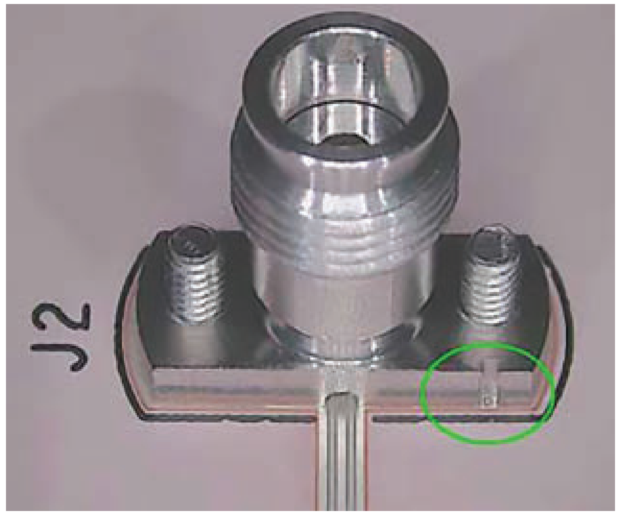
Another common method for avoiding misalignment was to insert alignment pins through a feature on the compression connector body and the PCB. This approach increased the complexity of indexing the PCB during the manufacturing process.[3]

In both methods, relying on a technician to assemble the tiny connectors and notice slight misalignments in relation to screws or pins was difficult. As a result, misalignments typically became apparent during the electrical testing stage. Here, the challenges of troubleshooting could be considerable as they would consider interconnect issues in the other RF hardware, transmission-line defects, and PCB issues.

Fiducials Improve Alignment of Compression-Mount Connectors

Fortunately, alignment grooves on the compression-mount connector combined with fiducials on the PCB can be used to reliably achieve alignment in small-form-factor mmWave connectors. Precisely machined alignment grooves in opposite sides of the base of the compression-mount connector provide a very clear, visual indication of alignment *(Fig. 7)*.

These guides are located as close to the connector body as possible and readily visible during assembly. They're also close to the PCB surface to minimize any confusion due to perspective.



7. Shown is a 1.35-mm threaded compression-mount coaxial connector with visual alignment grooves that are machined into the outer housing of the base. Fiducials are etched from the top metal layer of the PCB.

Conclusion

Proper alignment of compression-mount connectors can be critical to performance. Manufacturers using compression-mount RF connectors need to seriously consider the impact of misalignment because it introduces impedance discontinuities, which increases reflections and degrades VSWR performance.

A visual indicator of proper alignment can greatly speed up assembly, alignment, and yield in designs using small compression-mount connectors, because it avoids costly troubleshooting later in the manufacturing process. This article shows the impact of misalignment, and how it can be avoided with alignment grooves on the connector and fiducials on the PCB. ■

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Harnessing the Power of 5G for Better Indoor Connectivity

Growing adoption of 5G mobile technology is disrupting connectivity. But what does this mean for in-building communications, where approximately 80% of all mobile voice and data traffic occurs?

***By Slavko Djukic,** VP of Product Line Management and Technology, SOLiD Americas*

SINCE MOBILE NETWORK operators (MNOs) started rolling out the first 5G networks roughly five years ago, this latest mobile technology continues to experience a meteoric rise. In fact, 5G is on record as scaling faster than any previous generation of mobile wireless technology.

In North America, 5G connections already account for a market penetration of 36% of the population, and worldwide 5G networks are on track to add nearly a billion new connections each year to reach 6.8 billion by the end of 2027.

Despite this obvious success—or perhaps in part because of it—5G technology is still facing several hurdles to be overcome and challenges to be addressed. This is particularly true when it comes to mobile communications that either originate or terminate indoors.

The Rise of 5G

For the most part, the unprecedented scale and impact of 5G is due to the disruptive nature of this technology. Thanks to the ability to deliver higher capacity, faster data speeds, and lower-latency connectivity, 5G enables a wide array of new capabilities, such as:

- *Enhanced Mobile Broadband (eMBB):* More throughput at fast-

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Photo courtesy U.S. Air Force photo/Master Sgt. Kevin J. Gruenwald er speeds for enhanced data rates, expanded coverage, and improved data-sharing efficiency.

- *Ultra-Reliable, Low-Latency Connections (URLLC):* Near real-time interaction and controls enable the network to support new use cases in manufacturing, healthcare, and military applications.
- *Massive IoT and M2M Communications:* The ability to support many more devices per unit of area than 4G/ LTE while enabling longer battery life in connected devices.
- *Network Slicing:* Virtual logical networks, or "network slices," within a single physical network allow for segregation of targeted use cases with varying levels of service and security.

These capabilities, in turn, enable mobile network operators (MNOs), enterprises, and manufacturers to develop innovative services with the power to revolutionize nearly every industry—from healthcare, industrial manufacturing, and retail to logistics, real estate, hospitality, and education.

With 5G eMBB capabilities, virtual-reality (VR) and augmented-reality (AR) technologies can be leveraged to create immersive experiences for telehealth, scientific research, education, and premier guest experiences in the hospitality industry and throughout event venues.

Likewise, capabilities such as massive IoT connectivity, network slicing, and intelligent positioning enable realization of mission-critical Industry 4.0 use cases, including predictive maintenance, manufacturing automation, real-time asset tracking, and occupational health and safety, implemented with high accuracy and low latency.

These 5G advances are due to fundamental network architecture changes made as the technology evolves from 4G, as specified in the 3GPP standards. Although these evolutionary transformations enable significant improvements in mobile network speed, quality, latency, and reliability, they also affect how 5G networks perform indoors.

Challenges	AWS	C-Band	Difference
Pilot Power	LTE 20 MHz -30.8dB	NR 100 MHz -35.2dB	4.4dB
Pathloss	58dB at 30 Feet	63dB at 30 Feet	5dB
Cable Loss	100' ½" Superflex 3.1dB	100' ½" Superflex 4.4dB	1.3dB/100'

1. When upgrading DAS platforms from legacy AWS bands to C-band, overall signal loss can be as much as 20 dB due to channel size, clutter, free-space path loss, and other factors, although these values will vary according to each building configuration. SOLiD Americas

Indoor 5G Access

As more consumers and businesses worldwide adopt 5G, there are mounting expectations of seamless 5G connectivity everywhere, all the time. This includes indoors where roughly 80% of all mobile voice and data traffic occurs. Whether in an office building, hospital, airport, subway, hotel, or stadium, subscribers demand always-on mobile service in today's hyper-connected world.

Moreover, 5G data connectivity has become essential to day-to-day business for many organizations. For example, a growing number of healthcare facilities have adopted a bring-your-own-device (BYOD) policy. This means that to reliably access electronic healthcare records and application data, physicians and staff need secure and reliable connectivity to at least three of the major MNO networks. And in offices or other commercial properties, building owners rely on 5G and the IoT to automatically control building systems such as security cameras, lighting, and smart thermostats.

Yet, even before the evolution to 5G, legacy mobile network service was typically unreliable inside most modern buildings. Energy-efficient Leadership in Energy and Environmental Design (LEED) building materials, congested network traffic, and nearby obstructions that block radio-frequency (RF) transmissions all contribute to spotty in-building coverage and dropped calls.

To address these connectivity issues, many building owners and network operators have traditionally installed distributed antenna system (DAS) platforms to deliver and amplify mobile network signals throughout buildings and campuses. Now the transition to next-generation 5G is creating new in-building connectivity challenges.

5G Connectivity Complexity

As demand for mobile data capacity escalates, the Federal Communications Commission (FCC) continues to make new RF spectrum available to alleviate bottlenecks, including both frequency 1 (FR1) bands below 6 GHz, and frequency 2 (FR2) bands above 6 GHz. However, many of the new frequencies used for 5G are even less capable of penetrating buildings than previous spectrum deployed for 3G and 4G/ LTE networks.

Initial allocations of FR2 mmWave frequencies between 24 and 40 GHz didn't provide an economical solution for wide-area 5G deployment. Because these high-band frequencies offer such poor propagation over long distances, MNOs need to build very dense networks to avoid coverage gaps, making these frequencies impractical outside densely populated urban areas.

However, the 5G mmWave frequencies are also easily blocked by most objects and building materials, including energy-efficient glass. Thus, service can be unreliable both indoors and outdoors in built-up city neighborhoods.

More recently, the FCC made available new mid-band spectrum for 5G, including the C-band (3.7 to 3.98 GHz), Citizens Broadband Radio Service (CBRS, 3.55 to 3.7 GHz), and the spectrum dubbed "Auction 110" by the FCC (3.45 to 3.55 GHz), which is also known as Lower n77. These mid-band frequencies offer an optimal mix of speed, capacity, and coverage.

In turn, most MNOs are taking advantage of them to build out their networks more cost-effectively and enhance wide-area 5G capacity and speed for a better user experience. Plus, because the CBRS spectrum includes some general authorized access (GAA) channels that are unlicensed, other organizations are also using this spectrum to build private 5G networks for a range of enterprise and industrial applications.

Nonetheless, this new mid-band spectrum occupies a higher frequency range than traditional mobile network spectrum, limiting transmission distance and signal strength. As a result, although Tier-1 MNOs are rolling out more wide-area 5G networks using mid-band frequencies across the U.S., these frequencies still can't penetrate building materials, leaving many building tenants, visitors, and employees without ready access to 5G services indoors.

Building Out In-Building Coverage

As network managers and building owners plan their in-building 5G strategy, the first step is to identify whether existing DAS platforms can be upgraded. With a modular, multi-band DAS, support for the new 5G frequencies can be easily added to legacy systems without requiring complete infrastructure replacement.

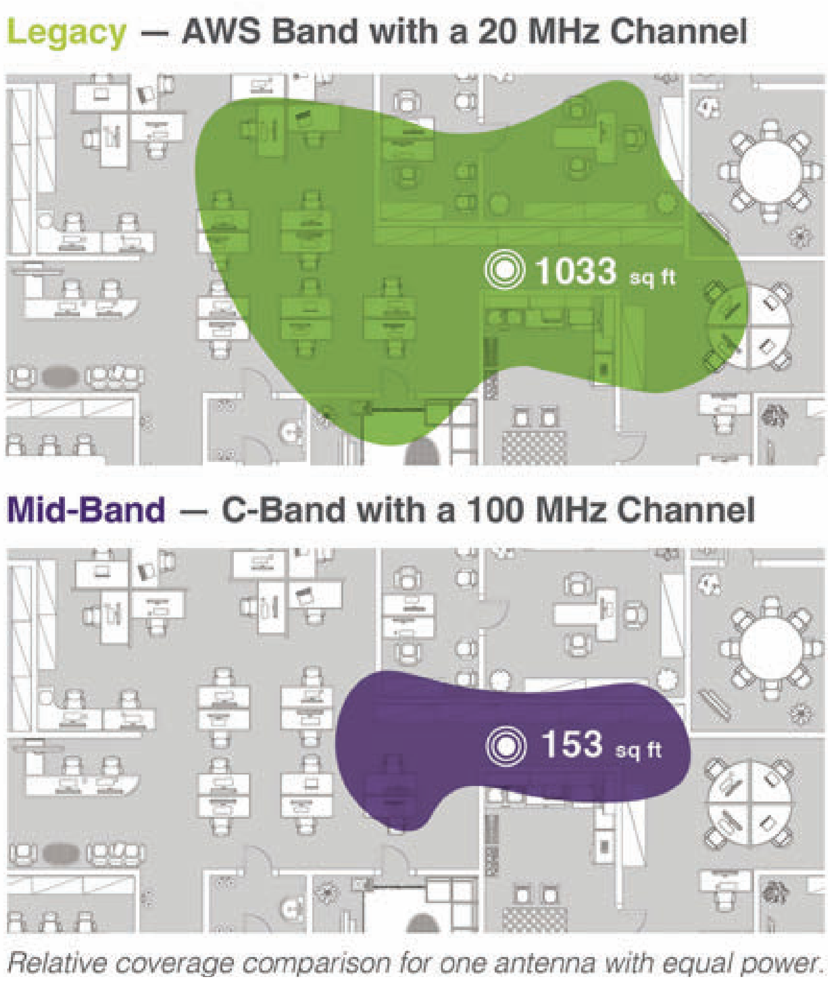
However, the RF characteristics of new mid-band spectrum should be carefully considered when planning upgraded deployments. This may require RF benchmarks, site surveys, updated network designs, and approval from the local mobile service providers.

Mid-band signals tend to be attenuated by metal, concrete, low-emissivity glass, and other building materials. So, not only are these frequencies less likely to provide in-building service from outside networks, but such transmissions can be impeded by interior walls and furniture as well.

The C-band, for example, offers just one-fourth the signal propagation characteristics of legacy mobile communications bands. *(Fig. 1)* This means that additional reconfiguration of existing in-building network infrastructure is needed to provide sufficient coverage and capacity indoors with mid-band 5G spectrum.

Moreover, although the C-band spectrum offers much greater capacity due to increased channel sizes up to 100 MHz, the wider channels consume more radio power, which drastically reduces the effective coverage area. In fact, indoor C-band coverage per antenna is roughly 15% of what's possible with previous frequencies at the same power level.

That means an antenna providing around 1,000 square feet of coverage for a 4G 20-MHz channel in the legacy Advanced Wireless Service (AWS) band would only cover a little more than 150 square feet with a 100-MHz channel in the C-band, assuming a typical office environment with sheetrock walls *(Fig. 2)*.



2. Relative in-building coverage with C-band is roughly 15% of what's possible with the legacy AWS band, requiring a higher effective antenna output power. SOLiD Americas

As a result, achieving the same indoor coverage with C-band requires a higher effective output power from the antenna, versus legacy mobile communications frequencies. To overcome these obstacles, most existing 4G systems will need amplifiers that provide 4X to 10X more output power for mid-band 5G to match the existing footprint.

Yet, a higher-power configuration may not be feasible if the legacy system already uses high-output power amplifiers. If this is the case, the best practice may be to install a fiber-to-the-edge overlay system to support specific coverage requirements of the new 5G frequencies. In this way, fiber-to-the-edge technology carries voice and data transmissions to the edge of the DAS network, enabling faster speeds, higher bandwidth, and lower latency at each access endpoint throughout a building or campus.

In addition to signal propagation considerations of new 5G frequencies, changes in radio-access-network (RAN) architecture complicate the delivery of 5G connectivity indoors.

Plus, as technology convergence drives more fiber throughout the entire communications network, a common, end-to-end fiber infrastructure offers a scalable evolution path to support more secure and efficient building management systems or IoT applications. Examples include security monitoring, energy management, smart locks, or motion-activated lighting.

This installed fiber also facilitates future communications technology upgrades. For instance, additional DAS capacity overlays enable support for future frequency bands as the FCC releases more spectrum and MNOs turn off previous mobile generations.

Sophisticated link-budget analysis tools and experienced DAS professionals can help network managers weigh the various factors unique to each in-building deployment to enable optimized 5G coverage and capacity. Recommendations to ensure high quality for maximum service availability might include adjusting power output, deploying fiber-to-the-edge, or replacing existing antennas and coaxial splitters.

Timing is Everything

In addition to signal propagation considerations of new 5G frequencies, changes in radio-access-network (RAN) architecture complicate the delivery of 5G connectivity indoors. One of the most substantial transformations from 4G LTE networks is the introduction of the 5G New Radio (NR) air interface standard, designed to enable high-capacity throughput for significantly faster and more responsive 5G mobile experiences.

The 5G NR air interface supports high-bandwidth applications such as streaming video and VR, low-bandwidth massive IoT connectivity and M2M communications, and mission-critical use cases like vehicle-to-everything (V2X) communications and VR-assisted telemedicine, requiring very-low-latency transmissions.

To bring about greater capacity and lower latency, this new air interface enables 5G networks to support a combination of FR1 and FR2 frequency bands, whereas traditional mobile communications traffic primarily used the FR1 bands. Most of these new 5G frequency bands employ time-division duplexing (TDD), rather than frequency-division duplexing (FDD), to provide more contiguous spectrum and support larger channel widths.

The introduction of TDD means that timing synchronization is critical in 5G networks to avoid interference between uplink (UL) and downlink (DL) transmissions. Moreover, because 5G devices can only identify and connect to mobile networks within 3GPP standards-defined delay windows, delay management becomes a key consideration as well.

Consequently, when it comes to managing DAS platforms to support 5G service, failure to properly synchronize timing and minimize delays will result in poor in-building network performance and user experience. On the plus side, the increased scheduling flexibility enabled by TDD bands means that more slots can be assigned for either UL or DL transmissions per channel. This allows network managers to configure the in-building 5G network to meet the specific needs of a venue or service.

Promise of the 5G Future

As 5G adoption continues to accelerate, this disruptive technology is empowering an array of exciting new capabilities. Innovative 5G services are revolutionizing industrial and manufacturing processes, healthcare procedures, scientific research, business practices, and our day-to-day lives.

And the frenetic pace of mobile network evolution doesn't appear to be slowing down anytime soon. In some regions, 5G is just starting to gain momentum, while MNOs in other parts of the world are demonstrating 5G Advanced and 6G technologies. The common denominator is that consumers and businesses alike expect ubiquitous, always-on connectivity everywhere.

New mid-band spectrum presents an ideal blend of frequency characteristics to enhance wide-area-network coverage, capacity, and speed, helping to fulfill 5G's true potential. But when planning in-building DAS deployments, be sure to consider how the new 5G RAN architecture and frequency allocations will impact the effective coverage reach and capacity to ensure optimized quality of service for an ideal 5G experience. ■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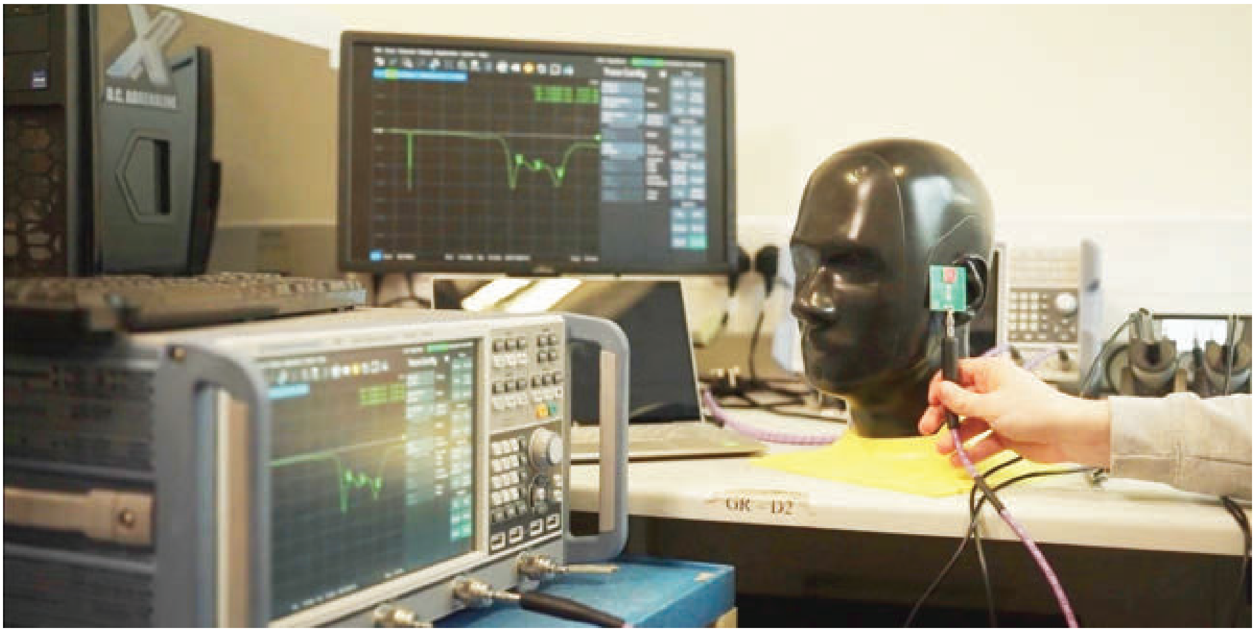


AntennaWare

Optimizing Antenna Selection for **Near-Human-Body Systems**

Placing antennas close to a platform can present many challenges. This article explores what to look for in an antenna to enhance the front-end physical layer of a wireless system under those conditions.

By Dr. Gareth Conway, *CEO/Co-founder, AntennaWare;* ***Dr. Matthew Magill,*** *CEO/Co-founder, AntennaWare*

IN THE WORLD OF electromagnetics, we can't do wireless without antennas, which work brilliantly when mounted away from objects and suspended in free space. Their efficiency is generally only limited to copper and substrate losses, with radiation efficiencies of 90%+ possible. It's when they're integrated into something and placed near other objects that performance becomes more uncertain.

To achieve efficient and optimal wireless performance on difficult platforms, the antenna should be one of the first things considered in a design, and not treated as an afterthought. With an understanding of the propagation channel requirements and an antenna that supports these requirements, superior performance reliability and quality can be achieved.

Challenges with Wireless Systems and the Human Body

The human body is often seen as one of the most difficult platforms for the deployment of wireless systems, due to the variability of the properties across different positions on the body, and across the different morphologies of the human population. Conductive platforms make wireless communication difficult when the device is mounted close to the structure. Just like metal, the human body appears electrically conductive to electromagnetic waves, and appears more conductive as frequency is increased.

Much can be learned from devices designed to operate near the human body, as it's a lossy and dynamic platform that obstructs and drastically limits wireless coverage in the microwave frequency range from 300 MHz *(Fig. 1)*. Improvements in the physical-layer performance are advantageous for more robust and reliable connectivity, longer communication ranges, lower transmit powers, or simply more confidence in design before product deployment.

A combined antennas and propagation approach is explored here to improve the physical-layer performance of wireless body-centric networks. The techniques and understanding from the experimental measurements can be used to solve wireless connectivity problems on broader platforms such as close to metal for other communication applications.

The All-Important Antenna

The physical layer of the wireless system, namely the antenna, is the part of the system that interacts with the environment it's placed in. Placing the antenna close to different materials will impact the performance of the antenna. In particular, it can change the impedance of the antenna and its radiation characteristics.

Antennas that are sensitive to being placed next to conductive materials, such as printed antennas, or chip antennas with bespoke PCB keep-out areas, often exhibit the greatest performance variation. Nonetheless, the wireless performance of the system then depends greatly on the host platform.

For some applications, where the platform is known and the materials are well defined, the antenna can be optimized specifically for that platform. However,

In wearable products today, many systems use printed PCB antennas or opt for small chip antennas, with size being the primary selection factor, rather than wireless performance.

for applications such as the distribution of wireless sensors, where they're expected to consistently perform wherever they may be deployed, needs a different approach to achieve optimal and reliable communication links.

The human body presents a unique challenge for wireless technology, with its variable complexities. That means the wireless performance for devices in close proximity to tissue are difficult to characterize and ensure robust and reliable operation on every person, in every application use case.

In wearable products today, many systems use printed PCB antennas or opt for small chip antennas, with size being the primary selection factor, rather than wireless performance. These antennas usually come with strict guidance on the PCB layout and shaped keep-out areas to ensure the antenna radiates. In most cases, it's not the antenna supporting the radiation but the surrounding ground-plane edge and the antenna feed line.

If the designer deviates from the spec sheet keep-out area guidance, the performance suffers significantly. Often, selection aligns with what the SoC development kit used, so it must be "OK." Yes, it is, for something sitting on a desk that needs to communicate a few meters, but not the right approach for product deployment. The question remains: "How would it perform on every person or any platform?"

Standard Antenna Selection: What to Consider

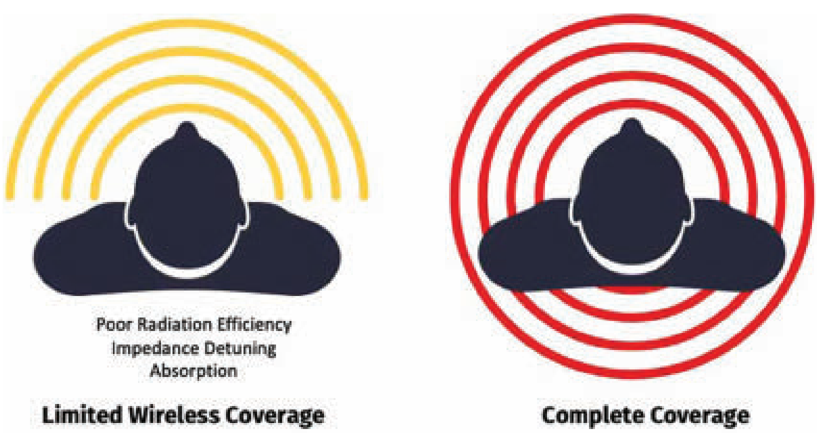
A number of metrics are important when considering an antenna's performance. However, for difficult or unknown platforms, the top three are input impedance stability, total radiation efficiency, and the correct radiation pattern to meet the propagation needs of the application.

To evaluate end-to-end communication link performance, Received Signal Strength Indicator (RSSI) or forward path gain (|S21|) are important metrics to quantify the propagation mode effectiveness. The wireless performance is only as good as its weakest link.

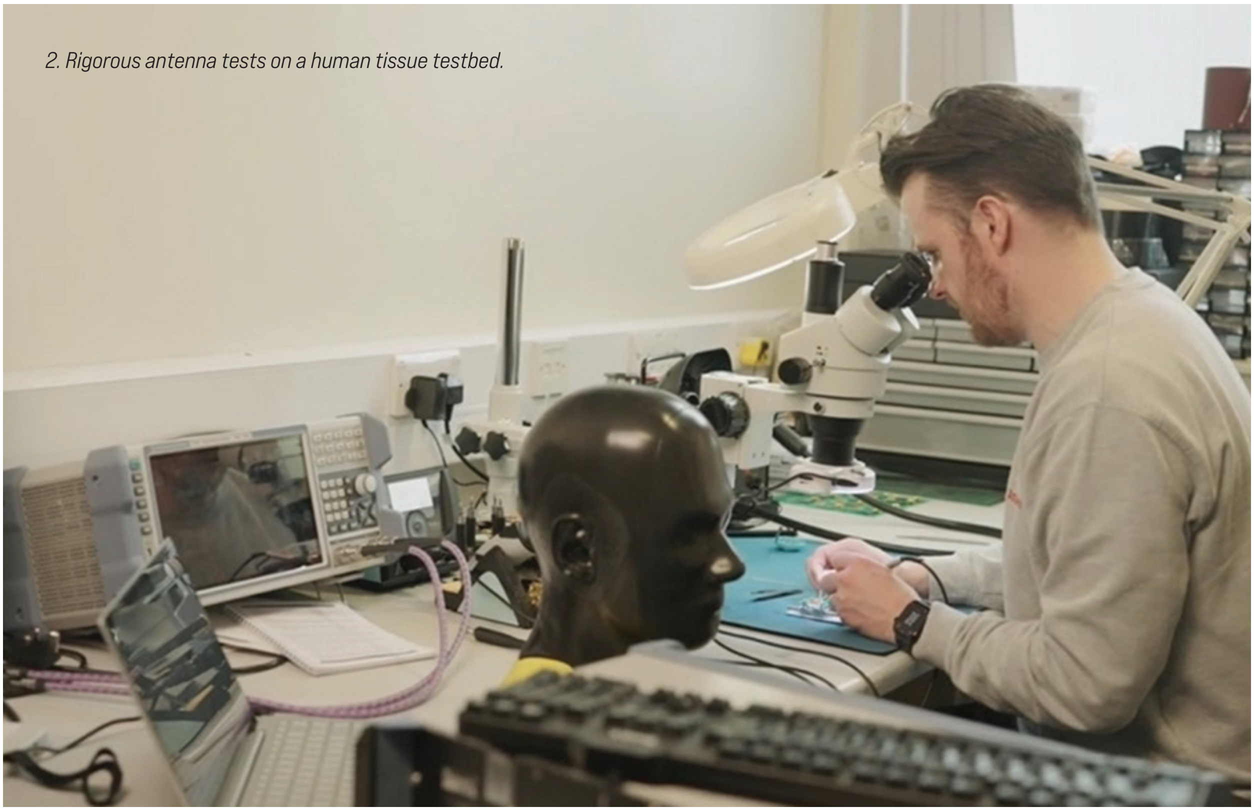
It's advisable to test for worst-case body-blocking scenarios with non-line-of-sight (NLoS) propagation and no significant nearby objects for the electromagnetic waves to reflect and diffract off (low multipath environments). In this type of environment, the received signal strength will be weakest, and performance is marginal at distance.

A communication system that performs effectively in NLoS anechoic environments doesn't depend on the proximity of nearby objects for multipath communication. Thus, it has more reliable performance as the platform moves through or is deployed in different environments.

Therefore, to get the best quality of performance from a wearable wireless device, it must strive to exhibit the fol-



1. Wireless coverage concept on difficult platforms. Images courtesy AntennaWare



2. Rigorous antenna tests on a human tissue testbed.

lowing characteristics on different people and at different antenna-body spacing distances on the same person/platform:

- Stable return loss |S11| or resonant frequency
- Minimal power absorption into the tissue
- Predictable or repeatable radiation efficiency reduction
- Overcome body shadowing (limited wireless coverage)

And, finally, it must be tested and validated for worst-case scenarios, i.e., when the wireless received signal is weakest and the communication link becomes marginal or drops out *(Fig. 2)*.

NLoS Performance Enhancement

When all of the above is understood, and the right antennas are used, gains of 10 to 20 dB in worst-case NLoS are achievable versus conventional printed antennas and chip antenna approaches. The performance enhancement and gains can be validated in the forward path gain, measured between the transmitting and receiving wearable antennas.

AntennaWare developed an antenna technology called BodyWave that's designed specifically for proximity to difficult platforms, with results shown in *Figure 3*. The results reveal what good looks like. And with combined antenna characteristic performance gains, achieving up to 20 dB, it overcomes body-blocking in NLoS conditions.

In *Figure 3d*, the path gain of the antennas |S21| was measured from ear to ear for the BodyWave antenna and compared to chip and printed monopole UWB antennas. Even for a short link around the head, the path loss could be as great at 95 dB when using printed and chip antennas as the antenna under test.

Don't Treat Antennas as an Afterthought

An antenna that's agnostic to the platform holds the key to unlocking the wireless performance and differentiating product performance. To mitigate the effects of near-field coupling from the antenna to the tissue, and the absorption of energy into the tissue, the antenna must be decoupled from the platform.

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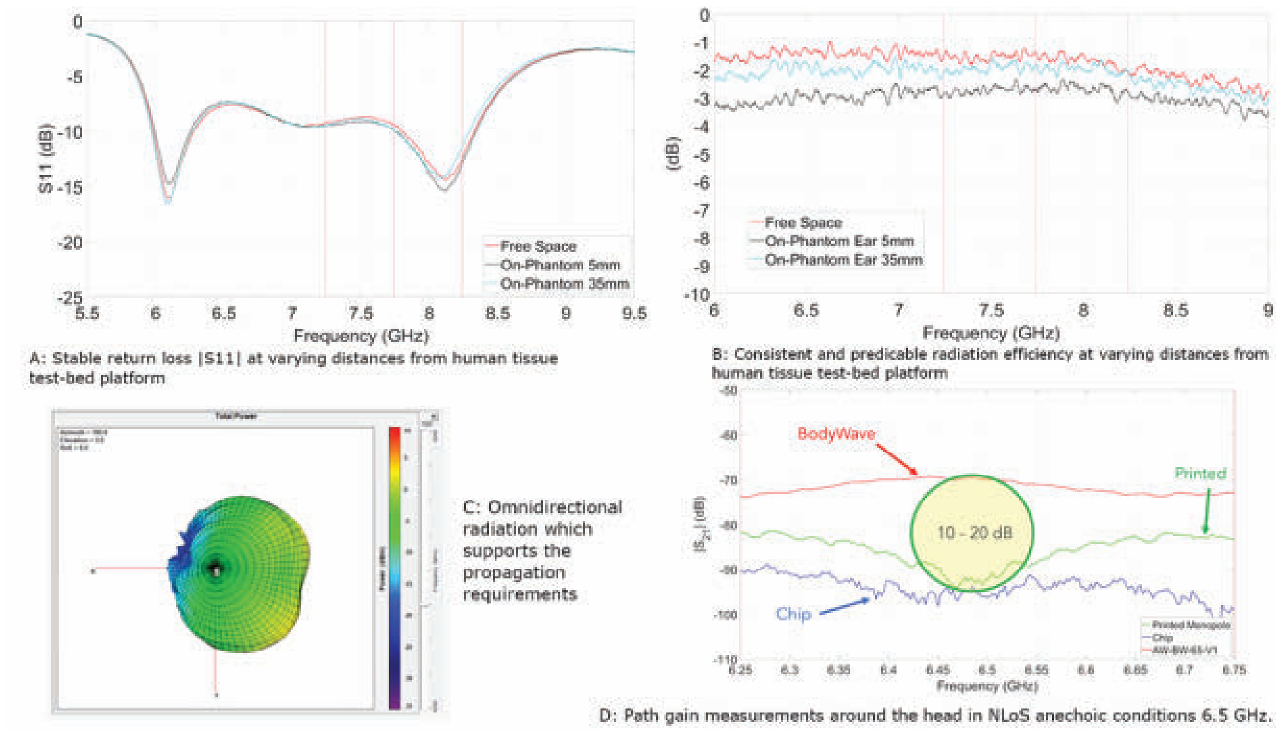

3. Shown are the antenna performance characteristics of AntennaWare's BodyWave on an industry-standard Speag PopEye human tissue phantom testbed.

PCB printed antennas and ceramic chip antennas are not the right approach. They were never designed to be placed close to a difficult platform, thus radiating inefficiently, and are subject to varying impedance caused by near-field coupling.

Launching the electromagnetic waves to support on-body propagation, in addition to isolating the antenna from the tissue by placing it above the PCB ground plane, has led to significant performance gains of up to 20 dB. To achieve optimal performance from the wireless link on difficult platforms, and maximize available link budget, it's recommended to start with the antenna radiation characteristics and selection, rather than treating antennas as an afterthought.

The step-change improvement in link budget performance by overcoming body blocking could more than double the communication distance, significantly reducing the power and battery size. Or it could simply provide a more robust and reliable quality connectivity, which is core to wearable audio, sport, and healthcare applications. ■

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The Microwaves & RF Industry Converges at IMS 2024

Learn about the latest in components, MMICs/RFICs, PCB tech, CAD software, and RF test at the industry's main event in Washington, D.C.

By Jack Browne, *Technical Editor*

REPRESENTING AN INDUSTRY that's grown steadily with the world's adoption of radio waves prior to World War II, the annual IEEE MTT-S International Microwave Symposium (IMS) offers the opportunity to catch up with friends and competitors. The exhibition floor is crowded with small and large RF/microwave companies and visitors hoping to learn more about their products and services.

For specifiers, the 2024 IMS Exhibition (June 18-20, 2024, Walter E. Washington Convention Center, Washington, DC) affords the chance to explore products that may make a difference in the latest communications, electronic-warfare (EW), radar, and other high-frequency systems. It's a popular portion of the IEEE MTT-S International Microwave Symposium, which runs from June 16-21, 2024 and includes a host of practical educational events such as the Automatic RF Techniques Group (ARFTG) meeting to broaden RF/microwave measurement expertise.

The 2024 IMS Exhibition promises to simulate an RF/microwave "department store" of products and services, from the smallest semiconductor integrated circuits (ICs) and surface-mount-technology (SMT) components to complete systems and test-and-measurement equipment.

Walking the floor in hopes of finding a solution for a set of specifications for a design in progress takes time, especially with the many attention-grabbing booth displays promoting new levels of performance over extended frequency ranges. More companies than ever offer products into the millimeter-wave (mmWave) frequency range to meet the growing needs of applications such as 5G wireless communications networks and advanced driver-assistance system (ADAS) equipment.

Personnel at company booths on the IMS exhibition floor are typically knowledgeable and courteous, often presenting "live" demonstrations of new products under simulated working conditions. On the test-and-measurement side, booths at the IMS exhibition often contain new hardware and software for visitors to operate and evaluate with a connected device under test (DUT). Researchers can collect stacks of datasheets and application notes to assist with a future project.

With over 500 exhibitors, not all will be included in this short preview of the 2024 IMS Exhibition. But some exhibitors with recent product introductions are featured here, organized by product categories to aid specifiers in search of a particular product or service. As specifiers usually learn, walking a show floor with such a variety of products, many of them developed for introduction at the event, could easily take a day or two. But when the search leads to a meaningful relationship with a future supplier, it can be time well spent.

For specifiers, the 2024 IMS Exhibition (June 18-20, 2024, Walter E. Washington Convention Center, Washington, DC) affords the chance to explore products that may make a difference in the latest communications, electronic-warfare (EW), radar, and other high-frequency systems.

Components: MMICs, Filters, Passives, and Transmission Lines

Visitors in search of high-frequency active and passive components will find a sampling of one of the industry's most comprehensive lineups at booth 1639 for Mini-Circuits. With a long history of reliable discrete and monolithic-microwave-integrated-circuit (MMIC) active and passive components, the company has built a sizable inventory of low-temperature-cofired-ceramic (LTCC) filters and switches, including surface-mount bandpass filters in packages as small as 0603 size.

1. The SSG-44G-RC is a modular signal generator with low phase noise from 0.1 to 44.0 GHz. Mini-Circuits

Though best known as a component supplier, Mini-Circuits also offers practical test equipment such as the SSG-44G-RC signal generator *(Fig. 1)*. Capable of pulsed and continuous-wave (CW) output signals from 0.1 to 44.0 GHz, the source features a dynamic range of −40 to +17 dBm. Controllable with a PC and free software via USB or Ethernet ports, it produces CW signals and pulses as narrow as 0.5 µs available at a 2.92-mm female connector. Typical phase noise is −102 dBc/Hz offset 10 kHz from a 10-GHz carrier.

Component specifiers will find an exhibit hall full of coaxial and SMT components at the 2024 IMS exhibition. They range from building-block components such as resistors, capacitors, and inductors from Kyocera AVX at booth 420 to a low-loss Butler matrix from Krytar at booth 1412 supporting beamforming and direction-finding (DF) systems from 0.5 to 40.0 GHz.

At booth 507, Herotek will show a variety of wideband amplifiers spanning 10 MHz to 20 GHz in drop-in packages. Among them is the AF0012073A low-noise amplifier (LNA) with 3-dB noise figure and 17-dB gain flat to ±1.0 dB from 10 MHz to 20 GHz. At booth 1931, Narda-Miteq will highlight components and integrated assemblies into the mmWave frequency range in support of 5G and radar systems.

Among its assortment of surface-acoustic-wave (SAW) filters and power amplifiers (PAs), at booth 1125, Qorvo US will display GaN-on-SiC technology with its model QPM1002 MMIC front-end module (FEM). For X-band radar systems from 8.5 to 10.5 GHz, it combines a low-noise amplifier (LNA), PA, and transmit/receiver (T/R) switch in a 5.0- × 5.0-mm, surface-mount QFN package *(Fig. 2)*. It handles input signals as high as +33 dBm (2 W) without a limiter.

2. Qorvo's QPM1002 front-end module (FEM) targets X-band radar systems from 8.5 to 10.5 GHz. Qorvo

RF/microwave specifiers will find a diversified display of component solutions on an exhibition floor that includes trusted suppliers such as RLC Electronics at booth 1013 with mechanical switches and filters and Flann Microwave Ltd. at booth 1152 with passive waveguide components like adapters, power combiners/dividers, and transmission lines to 1.1 THz. Others include Communications & Power Industries at booth 1512 with amplifiers and traveling-wave tubes (TWTs) for high-power radars, and Micro Lambda Wireless next door at booth 1513 with electronically tunable YIG filters and oscillators.

RFICs, SIPs, SoCs, and Power Devices

Semiconductor-driven devices will be on display in many forms, from chip and packaged power transistors to system-in-package (SiP) and system-on-chip (SoC) devices. At booth 1239, Analog Devices will present some of its thermally efficient gallium-nitride (GaN) PA ICs as well as more highly integrated examples of its semiconductors like its new model ADSY1100 RF/microwave transceiver that operates to 20 GHz.

Housed in a compact package that meets Sensor Open Systems Architecture (SOSA) requirements, the transceiver includes Ethernet and Optical Ethernet computer interfaces to 100 Gb/s. It incorporates several high-performance field-programmable gate arrays (FPGAs). ADI's AD9084 SoC transceiver packs four receivers and four transmitters in a 24- × 26-mm, 899-ball, ball-grid-array (BGA) package.

At booth 445, Texas Instruments also offers a wide range of highly integrated semiconductor devices, including GaN power stages like the recently introduced LMG2100R044 and LMG3100R017 100-V devices. Designers seeking mmWave radar sensors for guidance in automotive and robotic systems can turn to the firm's AWRL1432 and IWRL1432 single-chip 76- to 81-GHz radars that integrate multiple receive and transmit channels in miniature packages. Suitable for short-range applications, the devices have built-in power management, self-test, and calibration functionality.

With its acquisition of Wolfspeed late in 2023, MACOM (booth 921) added to its assortment of semiconductor products with GaN and GaN-on-silicon-carbide (GaN-on-SiC) RF power devices, both types capable of delivering high-power outputs from small packages. As an example, the CGHV59350 GaN-on-SiC PA for 5.2- to 5.9-GHz C-band radar can be supplied in a ceramic-metal flange or pill package. It provides 10.7-dB power gain and 60% typical power-added efficiency (PAE) over that range while delivering 470-W typical pulsed output power.

At higher frequencies, the MAAP-001379 distributed PA employs gallium-arsenide (GaAs) pseudomorphic high-electron-mobility-transistor (pHEMT) technology for 22-dB linear gain and +30-dBm (1 W) saturated output power from 20 to 55 GHz. Additional high-power-density semiconductor devices can be found at Polyfet RF Devices' booth 1815 with its silicon LDMOS and GaN FET devices.

PCBs, Laminates, and Packaging

Several of the IMS technical presentations explore the use of additive manufacturing and three-dimensional (3D) printing techniques to produce shape-sensitive circuits and components such as phased-array antennas. However, most specifiers at the exhibition will still need more traditional printed-circuit-board (PCB) materials.

They will find such options from the Advanced Electronics Solutions (AES) group of Rogers Corp. at booth 739. The company's RO3010 and RO4003C laminates are widely used in RF/microwave circuits through mmWave frequencies. Ceramic-filled polytetrafluoroethylene (PTFE) RO3010 laminates are usable to 77 GHz with a dielectric constant (Dk) of 10.2 and low dissipation factor (Df) of 0.0022 at 10 GHz. For circuit designers preferring to start with a lower Dk, RO4003C laminates have a Dk of 3.38 with Df of 0.0027 at 10 GHz.

With even lower Df values, TerraGreen 400G and TerraGreen 400G2 laminates from Isola Group at booth 1821 are halogen-free materials that support analog PCBs into the mmWave frequency range and digital circuits at speeds to 100 Gb/s and more. The glass-filled circuit materials can be processed with FR-4 methods and standard PCB fabrication equipment.

TerraGreen 400G, with a typical Dk of 3.15 at 10 GHz, has a typical Df of 0.0017. It features a high-temperature composition, with glass transition temperature (Tg) of typically +200°C and decomposition temperature (Td) of typically +380°C. TerraGreen 400G2, the company's latest circuit material for 5G systems, high-end computing, and advanced wireless communications, has a typical Dk of 3.10 at 10 GHz with Df of typically 0.0015. Both circuit materials support PCBs with data rates past 100 Gb/s.

When faced with designing and producing large, multilayer circuits based on flexible and rigid circuit materials, Amphenol Printed Circuits at booth 1004 provides the capabilities and experience to handle designs with as many as 70 circuit layers.

At booth 1015, Northrop Grumman will be showing its novel hypersonic materials. Handling speeds greater than

1 mile/s, these materials must withstand temperatures exceeding +2000°F for hypersonic missiles as well as counter-hypersonic systems. Although showing materials, Northrop Grumman is well-known as a systems house and represents one of many systems suppliers at the 2024 IMS exhibition, including Mercury Systems at booth 1332, Teledyne Technologies at booth 1021, and The Boeing Co. at booth 2051.

CAD Software: FEA, SI, and EMI Analysis

RF/microwave engineers in need of computer-aided-design (CAD) software can compare a variety of programs at the 2024 IMS exhibition from many developers, including Ansys in booth 621, Cadence Design Systems in booth 1321, COMSOL in booth 446, MathWorks in booth 2139, and Sonnet Software in booth 606. For example, among its many finite-element-analysis (FEA) software tools, Ansys will show SiWave software for signal-integrity (SI) analysis, power-integrity analysis, and EMI analysis of IC packages and PCBs.

COMSOL MultiPhysics software can adapt to different forms of computer analysis with add-on modules that support functions such as mechanical and thermal analysis. MathWorks will demonstrate several of its math-based tools, such as MATLAB and Simulink. And Sonnet's EM-based simulators are well-established for modeling high-frequency analog and high-speed digital PCBs.

Although best known for its test equipment, Keysight Technologies in booth 721 will also contribute to a strong CAE software showing at the exhibition. Its EM-analysis-based Pathwave ADS 2024 for RF & Microwave Circuit Design is well-suited for modeling ICs and highly integrated modules through mmWave frequencies.

RF Test & Measurement: VNAs, Signal Generators, and Scopes

In addition to powerful design software, Keysight will be leading a strong lineup of test-equipment suppliers at the 2024 IMS exhibition. Along with its audio analyzers, digital storage oscilloscopes (DSOs), signal generators, and spectrum analyzers, Keysight will invite visitors to see its PNA family of vector network analyzers (VNAs), which feature impressive 110-dB dynamic range through mmWave frequencies. The PNA N5290A two- and four-port VNAs operate from 900 Hz to 110 GHz while the PNA N5291A two- and four-port VNAs add frequency extenders for coverage from 900 Hz to 120 GHz.

In booth 704, Maury Microwave will show examples of its load-pull systems working with VNAs. And in booth 729, Marvin Test Solutions will show its digital multimeters (DMMs) and source measure units (SMUs) in PXI form.

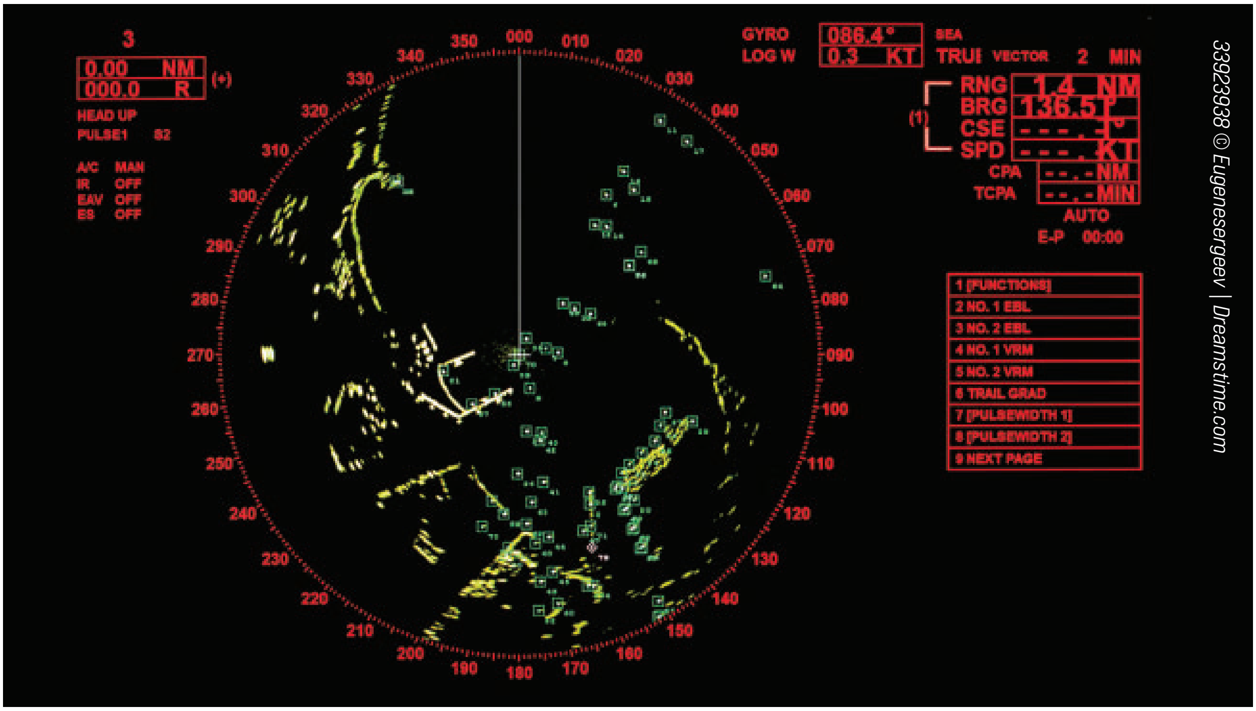
Known for portable spectrum analyzers and digital storage oscilloscopes (DSOs), Tektronix will generate test signals in booth 2205 with its AWG70000B Series arbitrary waveform generators (AWGs). Models operate to 50 Gsamples/s with better than 20-GHz bandwidths and 10-bit resolution. Programmable signals exhibit –80-dBc spurious-free dynamic range (SFDR).

For spectrum analyzer enthusiasts, Signal Hound will show its compact but powerful SM435C spectrum analyzer *(Fig. 3)* with frequency range of 100 kHz to 43.5 GHz in booth 1209.

3. The SMA435C modular spectrum analyzer is controlled by a PC and software for measurements from 100 kHz to 43.5 GHz. Signal Hound

The exhibition floor will abound with test-equipment demonstrations from many notable suppliers. They include Anritsu with Spectrum Master portable spectrum analyzers to 170 GHz at booth 1039, Boonton Electronics with RF power meters at booth 704, Copper Mountain Technologies with USB VNAs at booth 1111, Focus Microwaves displaying mmWave load-pull tuners at booth 439, GGB Industries with 110-GHz Picoprobe probe cards at booth 642, and Rohde & Schwarz presenting mmWave component testers at booth 1521.

For an industry event with over 500 exhibitors, visiting every booth in two-and-a-half days may end up as not much more than a wave of the hand at each booth. But with a specifier's approach, lists of requirements can be turned into potential solutions and future professional relationships. ■



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How Software-Defined Radio is Advancing Radar Systems

Radar systems are increasingly important in many industries. However, as they carry out complex techniques, they need transceivers that can meet their needs. Software-defined radio provides a versatile and effective solution.

***By Kaue Morcelles,** Independent Technical Writer, Per Vices*

RADAR (OR RADIO DETECTION and ranging) systems are precise and versatile RF instruments that have become indispensable for many industries, playing a significant role in shaping the modern world. From military operations to air traffic control, these systems are now the main tools for monitoring and tracking objects in motion. Naturally, development of novel radar techniques and devices requires significant resources.

However, complex techniques involving multiple channels and anti-jamming waveforms can't be easily performed using traditional RF transceivers. They lack the flexibility and programmability to address dynamic tasks and adapt to different scenarios.

Software-defined radios (SDRs), on the other hand, are digital-based radio transceivers with high levels of versatility, scalability, and adaptability. Thus, they're able to address the changing needs of the industry while also allowing for the implementation of extremely complex and powerful measurement schemes—e.g., beamforming and frequency hopping—that require very low-latency computation of multiple RF channels.

In this article, we'll delve into the role of SDR technology in advancing radar systems, enabling these transceivers to adapt to new challenges as well as increasing their overall precision, effectiveness, and size, weight, and power (SWaP) characteristics. Also discussed are the key features and performance benefits that SDRs introduce in the radar industry, as well as some of the challenges that must be overcome in this type of design.

In addition, we'll examine some of the most promising applications of SDR-based radars in industries ranging from aerospace and defense to transportation. The article wraps up with a look at the future of this industry and how it will continue to evolve in response to changing technological and environmental factors.

Basic Concepts of SDRs

Before diving into the implementations of SDR-based radars, we should understand the basic concepts of both devices and how the RF features of SDRs intersect with radar requirements. As the name suggests, software-defined radios are wireless transceivers that implement most of the radio functions in the software domain. They use only the essential analog hardware required to operate the RF chain and pre-process signals.

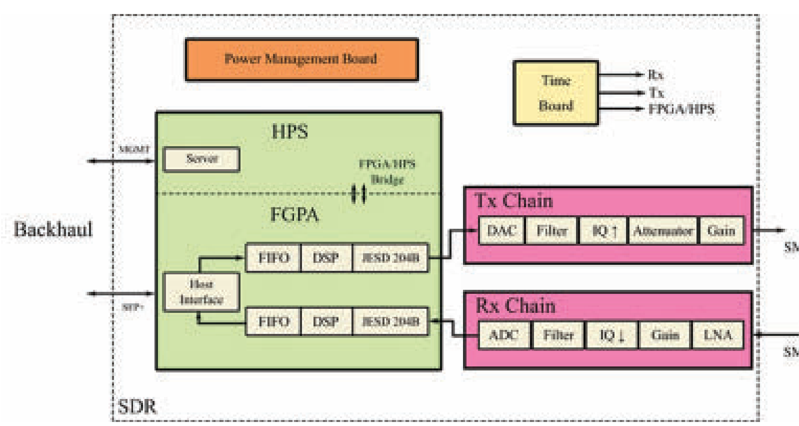
Thus, the radio's processing functions can be reprogrammed and adjusted without the need for hardware modification. Therefore, a single unit essentially can be completely repurposed for a different function without component replacement or physical knob tweaking.

A generic SDR architecture comprises two main parts: the radio front end (RFE) and the digital back end *(Fig. 1)*. The RFE includes receiver (Rx) and transmitter (Tx) functions that operate over a wide tuning range, typically from dc to 18 GHz. Instantaneous bandwidth also is very important in terms of defining the slice of spectrum that can be analyzed at once—the highest-bandwidth SDRs in the market can reach up to 3 GHz per channel.

The digital back end of SDRs contains a field-programmable gate array (FPGA) with on-board DSP for modulation/demodulation, up/downconverting, data packetization, filtering, and waveform storage to meet custom interface requirements. The FPGA-based architecture enables the SDR to be completely reconfigured and upgraded to support the latest radio protocols and DSP algorithms, which significantly extends the service life of radio equipment.

SDRs also contain multiple independent RF channels with dedicated analog-to-digital and digital-to-analog converters (ADCs/DACs). Multichannel operation combines with the parallel computing capabilities of the FPGA to enable simultaneous transmission and reception of multiple signals with very low latency while still maintaining phase coherency and stability.

Naturally, parallel operation produces a huge amount of data that needs to be sent to/from the host system. Thus, high-end SDRs provide high-speed backhauls based on qSFP+ optical links, which reliably connects the SDR management and data lines with the host system. The main advantage of SDR over conventional architectures is its flexibility and upgradability.



1. A generic SDR architecture comprises two main parts: the radio front end (RFE, in pink) and the digital back end (green). Per Vices

It allows for updates and improvements to be made via software updates rather than requiring costly hardware upgrades.

Introduction to Radars

The word "radar" is an acronym for radio detection and ranging, which covers any device capable of detecting a target and evaluating its position and velocity using RF waves. Radar technology plays a crucial role in a variety of industries, including aerospace, military, navigation, and air traffic control, so these devices must evolve and adapt to properly address the ever-changing requirements of the technological landscape.

The working principle of any radar involves sending out radio waves and measuring the time it takes for the waves to bounce back to the receiver after hitting an object. By analyzing this reflected signal, it's possible to determine the distance, size, and speed of the object. Typically, a radar transceiver consists of the receiver, transceiver, multifunctional antenna dish, and duplexer switch, which controls whether the Rx or Tx portions of the radio have access to the antenna.

Furthermore, a conventional radar system also requires a time-synchronization system, data processor, waveform generator, ADCs and DACs, a radio chain, and a radar display for user interface. However, traditional radars have limitations and drawbacks that affect their performance and flexibility.

Although radar systems share a common principle and electronic requirements, they come in different types and configurations, each with specific capabilities. One such type is the synthetic aperture radar (SAR), which employs radar movement to generate a virtual antenna aperture, delivering high-resolution imaging with a compact system. These systems are widely used for mapping, surveillance, and target recognition.

Doppler radar is another popular type, which uses the Doppler effect to measure the motion and direction of moving targets, in addition to their position. Doppler radar is widely used for weather forecasting and aviation, as it can detect the movement of particles and thus provide a more accurate prediction of weather events.

Finally, phased-array radars employ an array of antennas that electronically steer the radar beam, allowing for faster scanning, clutter/jamming suppression, and SNR optimization at the beam direction. They're typically used for air traffic control, military surveillance, and missile defense, thanks to their ability to track multiple targets simultaneously with high precision and accuracy. It's essential to comprehend the variations between these radar types to select the most appropriate technology for a particular application.

How to Integrate SDRs into Radar Systems

Traditional analog-based radar suffers from a fatal limitation in the modern world: It lacks flexibility and adaptability. In the current scenario, with smart software-based systems dominating electronic warfare (EW) and signals intelligence, it's crucial that radars keep up with the fast technological development to properly detect targets and protect themselves against EW attacks.

By integrating high-performance SDRs in the radar architecture, designers can take advantage of software-based functions that can be easily and remotely changed, tuned, updated, and upgraded via on-the-fly programming. There's no hardware modification and minimal human intervention.

Moreover, dynamic adaptations can be programmed to work automatically, including frequency-hopping techniques to prevent jamming and beamforming to avoid clutter. SDRs can provide a very stable and deterministic clock signal, too, which is crucial for synchronization and time reference, while also being capable of receiving external clocks from 10-MHz crystals to synchronize with other equipment in the architecture.

In terms of basic RF characteristics, SDRs can significantly improve the performance of radar systems, especially considering the very precise RFEs typically implemented in high-end SDRs. Firstly, multiple-input, multiple-output (MIMO) SDRs are fundamental for phased-array radars—typically implemented in beamforming/beamsteering techniques—and radars implementing multiple antennas for different ranges.

The best MIMO SDR in the market can provide up to 16 independent RF channels and a high level of frequency/phase stability, which allows for the implementation of synchronized antennas for complex radar techniques. High frequency range is mandatory for proper channel spacing and flexibility in terms of operation bands, which requires SDRs with wide tuning range and high instantaneous bandwidth.

Furthermore, the ability to rapidly change the main frequency can be extremely useful to avoid jamming as well as automatically adjust range according to the environmental conditions. Low noise figure and high sensitivity are critical to ensure that the radar system is able to detect weak signal reflections, especially in noisy or cluttered environments.

Together with a low noise floor (which defines the minimum detectable signal), high dynamic range is crucial to ensure that the receiver can work with high amplitudes without saturating. This makes it possible to detect cluttering and jamming without jeopardizing the operation.

High spurious-free dynamic range (SFDR) also is an important parameter, as it denotes the receiver's immunity to spurious signals. Finally, handling the massive amounts of data generated by a radar system requires high data throughput, especially when using MIMO techniques and parallel computing. High-end SDRs provide quad 40-Gb/s qSFP+ ports (upgradable to 100 Gb/s) to transmit data to the host system, minimizing data loss and overall latency.

More SDR Advantages

Modern radar techniques, such as beamforming and frequency hopping, require extensive DSP capabilities to work properly. Not only are SDRs able to satisfy the computation requirements, but they can perform these operations completely on-board, sending only pre-processed information to the host and alleviating the backhaul requirements.

Moreover, an FPGA-based digital back end brings a huge advantage over microprocessor- and ASIC-based solutions. First, the FPGA architecture enables parallel computing with very low latency, which is crucial for MIMO radars and systems that demand fast decision-making. For example, beamforming/beamsteering requires very fast parallel computation involving precise control over the phase and amplitude of the signal at each antenna element, adaptive signal processing, and proper phase synchronization.

Second, unlike ASICs, the FPGA can be completely reprogrammed to execute different operations, protocols, and DSP firmware. Furthermore, the digital back end provides on-board waveform digitization and storage, which is extremely useful for generation of pulsed waveforms, chirping, triggering, and phase-coherent waves, without needing to send the waveform from the host every time.

The digital back end can also automatically control the RFE characteristics, adding another layer of flexibility to the overall architecture. For instance, digitally controlled attenuators enable the implementation of adaptative algorithms to attenuate the influence of weather in the measured signal.

In addition, sensitivity time control (STC) and sensitivity gain control (SGC) are essential in radar DSP, as they allow for gain correction to be implemented to address power losses in the transmission path. Finally, frequency-measurement DSP algorithms, such as fast Fourier transforms (FFTs), are fundamental for frequency-based radar techniques—e.g., Doppler radars—where frequency shifts must be measured to detect the target's velocity and trajectory.

Beamforming

One of the most useful modern RF techniques is beamforming, which combines several signals from multiple antennas to form a single, directional beam by synchronously adjusting the phase and amplitude of the signals at each antenna. This results in greater flexibility in directing radar coverage without having to physically move the antenna, providing maximum sensitivity in a certain direction and rejecting the jamming and clutter signals from unwanted sources.

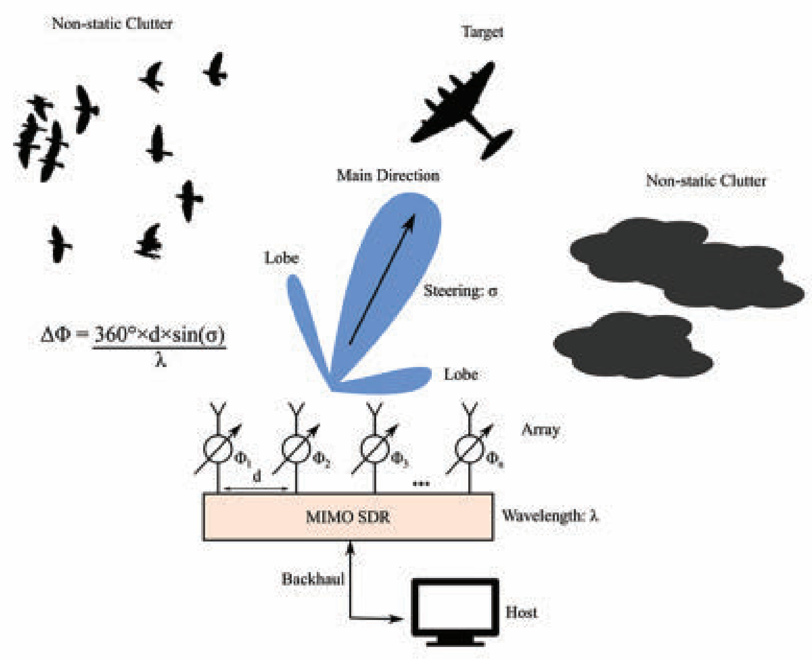
However, controlling the array's radiation pattern by adjusting the phase of each antenna isn't an easy task—it requires heavy parallel computation of MIMO channels with minimum latency. Barring that, phase coherency can't be achieved, and the radar loses control of the beam.

In an SDR system, the FPGA performs all of the necessary calculations to control the phase and amplitude of each antenna element in real-time. This allows for rapid updates to the beam direction and shape and ensures enough agility to properly follow the target.

From the diagram in *Figure 2*, note that the angle of steering depends on the distance between antennas and the wavelength of the signal, and the phase difference between each element of the array. The wavelength is typically defined by regulations and range, while the distance between elements is limited by physical constraints.

Thus, the steering angle is controlled by the phase difference, and that's why phase and frequency stability are so important in this application. Furthermore, the phase difference for a certain angle, as well as the timing required to achieve this difference at each waveform generator, must be calculated onboard the FPGA with minimum latency.

Modular SDRs—especially those implementing MIMO transceivers—could be implemented as "all-in-one" solutions. As a result, commercial off-the-shelf (COTS) modular SDRs could significantly reduce the overall complexity and design cost of a radar system. This is because a single SDR can implement multiple functions in the same unit, including Rx/Tx operation, telemetry, and self-calibration.



2. In a MIMO SDR system, the FPGA performs all necessary calculations to control the phase and amplitude of each antenna element in real-time, allowing for rapid updates to the beam direction and shape and ensuring enough agility to properly follow the target.

In addition, the interoperability of SDRs makes it possible to use them in older or existing legacy radar systems, enabling service-life extension programs with minimum hardware modification. Because most of the functions are implemented in the software domain, SDR-based radars are completely future-proof. That means the transceiver can be upgraded or completely repurposed with minimum intervention, requiring only the upload of a new program.

As a result, the radar can always be up-to-date with the latest protocols and techniques, enabling SDRs to significantly reduce the long-term costs of a system by reducing the need for manual maintenance, component count, system complexity, and engineering/deployment time. On top of that, using an SDR may lead to SWaP reductions, making it an attractive option for critical applications, including light aircraft radars and satellite systems.

Conclusion

Software-defined radio offers a flexible and cost-effective solution for modern radar systems. By utilizing high-performance RFEs combined with FPGA-based digital backends, these transceivers can perform a wide range of embedded DSP functions, including waveform generation, modulation/demodulation, data packaging, mixing, and pulse compression.

The RFE is able to satisfy all of the RF requirements of modern radios, including wide tuning range, MIMO operation, low noise figure, and high dynamic range. The digital back end enables the implementation of complex radar algorithms and techniques, such as beamforming and frequency hopping, in a future-proof solution.

The modular and scalable nature of SDRs also allows for interoperability with existing legacy systems, while enabling future upgrades and customizations with minimal costs. Moreover, SDRs can reduce the complexity and overall SWaP of radar devices, suiting them for applications ranging from defense and surveillance to weather monitoring and aviation.

Variable-Gain Amplifier Adjusts 20 to 54 GHz

Mini-Circuits' model ZVA-20543VG+ is a coaxial variable gain amplifier (VGA) with typical 17-dB gain adjustment range from 20 to 54 GHz. Typical gain can be set from 33 to 50 dB via analog or TTL control. With built-in power monitoring, fault tracking, and other diagnostic tools, the 50-Ω VGA operates on a single supply from +10 to +15 V DC. It is equipped with 1.85-mm female connectors and well-suited for aerospace/defense, satellite communications (satcom), and test applications.

MINI-CIRCUITS

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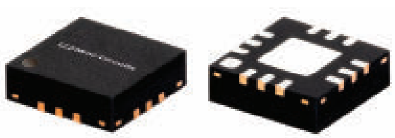


MMIC LNA Boosts 0.4 to 8.0 GHz

Mini-Circuits' model TSY-83LN+ is a surface-mount MMIC low-noise amplifier (LNA) for a wide range of applications from 0.4 to 8.0 GHz. Typical gain is 22.3 dB at 6.0 GHz and 20.6 dB at 8.0 GHz. The noise figure is typically 1.5 dB at 2.0 GHz and 2.4 dB at 8.0 GHz. The GaAs pHEMT amplifier includes a bypass mode for input signal levels as high as +29 dBm compared to maximum input levels of +22 dBm for amplified signals.

MINI-CIRCUITS

https://tinyurl.com/29xv7wav

Lightweight Permalloy Film Sheets Shield Low-Frequency Band Noise

TDK extended its Flexield family of permalloy thin-film sheets with the IPM01 series, a lightweight and 0.006-mm thin design that effectively shields low-frequency band noise. Conventional noise suppression in the kilohertz band requires thick shielding materials that can be too bulky and heavy in applications where minimizing size and weight are top priorities. Made of permalloy alloy with extremely high permeability formed into thin-film sheets, it can suppress low-frequency band noise more effectively than conventional shielding materials and metal shields while reducing weight.

TDK

https://tinyurl.com/27fxc6e2

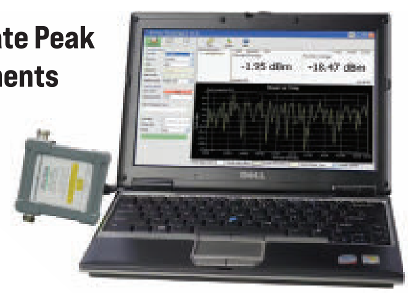
Natural Gas Detector Integrates Advanced RF Module for Cloud Connectivity

eLichens integrated the ISP4520 RF module by Insight SiP into its Avolta connected Natural Gas Detector to give it LoRa and BLE capabilities. Addressing industrial and residential environments, the combo allows for large-scale deployments with reliable connectivity in Europe and the U.S., providing a power-efficient solution. Features include ATEX certification for safe use and compliance in explosive atmospheres, with an array of power-saving features to enable multi-year coin-cell operation. The long-range capability of LoRa offers data transmission over distance, and the BLE part of the ISP4520 integrates the WLCSP nRF52832 chip from Nordic Semiconductor and the SX1262 LoRa transceiver from Semtech.

eLICHENS

https://tinyurl.com/263x484v

Inline Power Sensor Takes Accurate Peak and True-RMS Average Measurements



Anritsu's MA24103A inline power sensor can perform accurate peak and true-RMS average power measurements from 25 MHz to 1 GHz and 2-mW to 150-W power range. It addresses applications that demand accurate peak and average power measurements well below the frequency range of 1 GHz, such as public safety, avionics, and railroads, which must maintain critical communications between the control centers and the vehicles. The highly accurate inline peak power sensor communicates with a PC via USB or with an Anritsu handheld instrument equipped with the high-accuracy power meter option 19.

ANRITSU

https://tinyurl.com/288eug84