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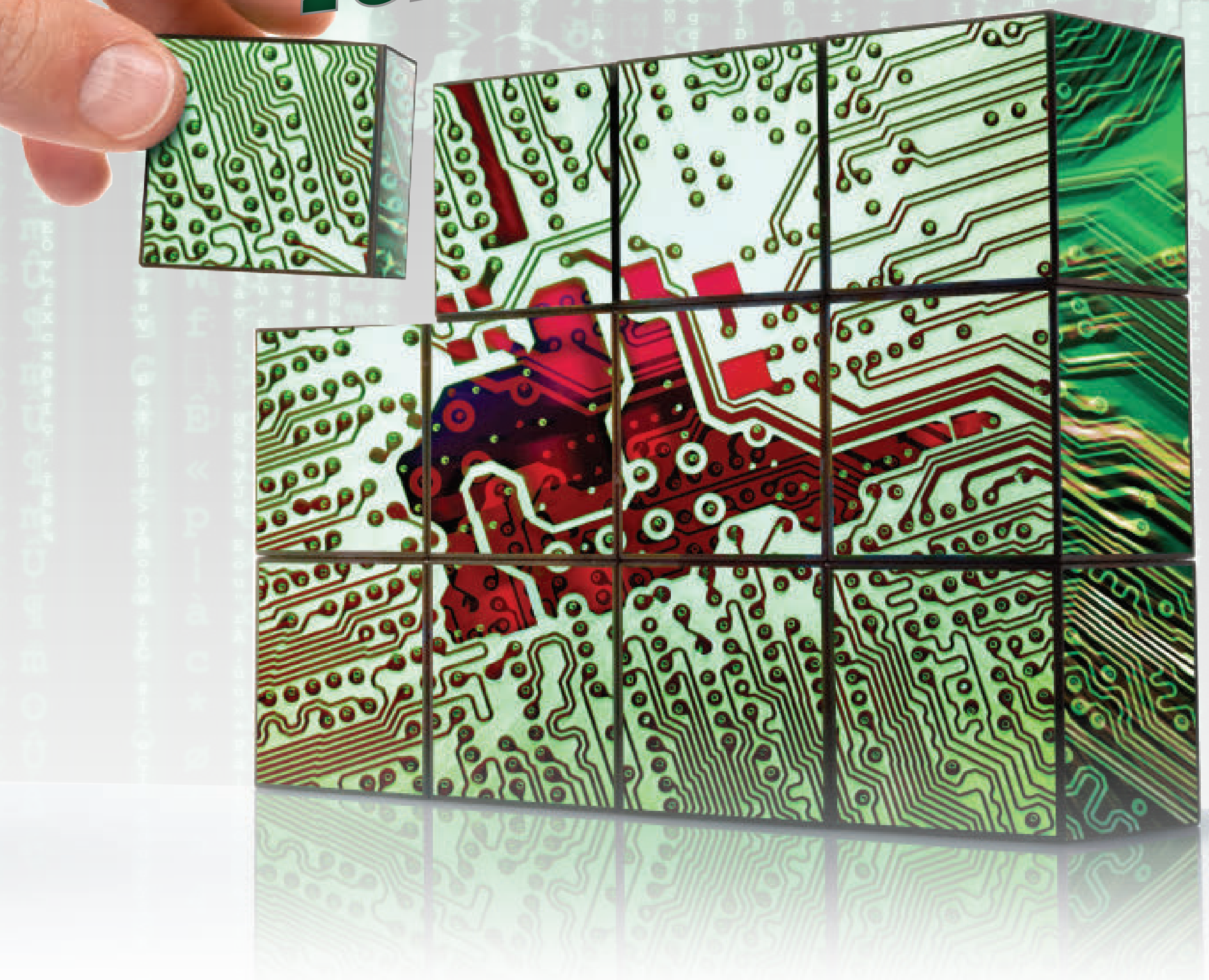

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FEATURES

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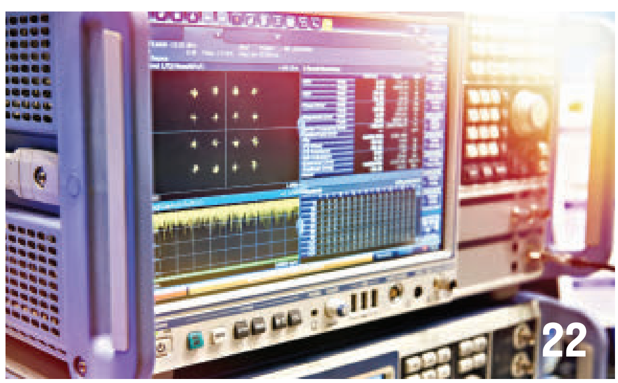

DAVID MALINIAK, Executive Editor

Some **CES 2024** Highlights

The good: Automotive test insights, RFICs, and voice vibration sensors. The bad: Narrowly missing a chance encounter with a legend.

AS ALWAYS, THERE was something for everyone at 2024's Consumer Electronics Show (CES) in Las Vegas. The sprawling extravaganza had its usual array of eye-popping technologies. Flying cars? Check. Transparent flat-panel TVs? Check. The world's fastest shoes? Check (I ought to investigate those for next year's CES). Not to mention the overlay of some form of artificial intelligence (AI) in some fashion onto just about everything under the sun.

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Truth be told, I didn't come across any of those above-mentioned innovations, but that's because I was busy seeking out impressive displays of technology and product launches in our beloved wireless space. Along the way, I had some highly informative meetings with industry experts. Here are a few of the highlights of my 2024 CES:

- Rohde & Schwarz: A meeting with high-level execs at R&S can't help but be interesting and enlightening. I spent some time with Juergen Meyer, VP of R&S's automotive market segment and COO Chris Eriksen to talk about technology trends in the automotive arena. Connectivity, once just for mobile calls from the car, is broadening out into streaming media and vehicle-to-everything (V2X) applications. In coming years, look for non-terrestrial networks (NTNs), 5G reduced capability (RedCap) chipsets, and 4D imaging radar to emerge in automotive settings. In addition, expect 130-GHz ADAS radar to solve today's interference issues and eventually displace LiDAR in vehicular applications. I had a look at the company's new production-test capabilities for electric/hybrid-vehicle batteries.
- Knowles: Known for its micro-acoustic microphones and speakers, Knowles came to CES armed with its latest innovation—the V2S200D digital voice vibration sensor. The minuscule device is a veritable Swiss Army knife of call-quality and voice-detection capabilities. Knowles's Nikolay Skovorodnikov, senior manager of applications engineering for MEMS microphones, ushered me into the company's suite for several demos of the V2S2000D's utility in automotive, medical, and smart-home applications.
- Skyworks: CES was all about front-end modules, network infrastructure, automotive, and audio products for this leader in all manner of RF-related components and RFICs. Stefan Fulga, Senior Director of Product Marketing, IoT Verticals, gave me the rundown on the company's SKY66122-11 front-end module (FEM) for high-power ISM, Wi-SUN, and other IoT uses from 863 to 928 MHz. Application Staff Engineer Namdu Ku showed off the SKY5A2105 5.9-GHz FEM for C-V2X LTE and 5G NR applications. Meanwhile, John Motter, manager of engineering services for AI solutions, demoed the SKY76305 cognitive wireless SoC, which Panasonic tapped for its latest wearable immersive gaming speaker system.

All told, CES 2024 was an overwhelming experience as always. I took some lessons from last year's edition (my first CES in a long career of covering technology) and did a better job of scheduling meetings to avoid cross-venue sprints. I also built in a few extra minutes here and there to wander around and have fun gaping at things like autonomous vehicles.

The only disappointment at CES was arriving for a meeting with the folks from TDK Corp. and learning I'd just missed the great Stevie Wonder! Apparently, Stevie visits CES from his home in Los Angeles to get caught up on the latest gadgets. He'd been a spokesman for TDK back in its heyday as a maker of cassette tapes. Oh well, I'll have to get to TDK a little earlier next year. ■

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Video ► Midrange VNA Delivers Fast, Accurate EVM Measurements

Keysight Technologies' E5081A ENA-X is presented as the first midrange vector network analyzer (VNA) that produces fast, accurate error-vector-magnitude (EVM) measurements, promising to accelerate the characterization of 5G component designs by up to 50%.
www.mwrf.com/21280361

Video ► End-Launch Connectors Target 5G and IoT

In this video, an engineer from Cinch Connectivity Solutions describes several families of end-launch connectors from Trompeter, Johnson, Semflex, and Midwest Microwave.
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A Collection of Eye-Opening Advances from CES 2024

Showcasing the latest innovations in AI, advanced embedded systems, and mobility, CES, the leading international tech platform, welcomed more than 4,000 exhibiting companies from across the globe to share their innovations, solutions, and partnerships.
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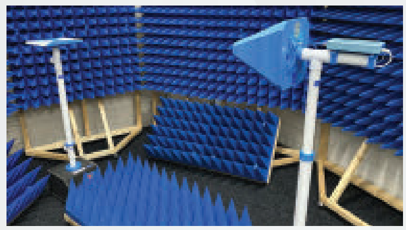

An Investigation into Wireless Signal Propagation

This article employs measurements to describe the impact of environmental factors on wireless signal propagation and strives to offer insights into the requirements for an optimal implementation of wireless networks.
www.mwrf.com/21278688

CES 2024 Showcases the Latest in Sensor Technology

The Consumer Electronics Show (2024) has once again unveiled myriad groundbreaking innovations, with the latest sensor technologies taking center stage.
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Laser and Glass Cell Create **Non-Metallic, Atom-Based Microwave Antenna**

A non-contact, non-metallic gigahertz antenna uses an enclosed vapor cell of excited rubidium atoms with laser beams for sensing their state.

CONTRARY TO CONVENTIONAL THINKING, a microwave receiving antenna needn't be metal or even implement a conductor material. Using a rubidium vapor cell with a corner-cube prism reflector to form a passive RF transducer, a team at the respected University of Otago (New Zealand) was able to detect microwave signals at a modest distance from the active components.

Their compact transducer has no electrical components and is optically linked to an active base station by a pair of free-space laser beams that establish an electromagnetically induced transparency scenario.

The Rydberg State

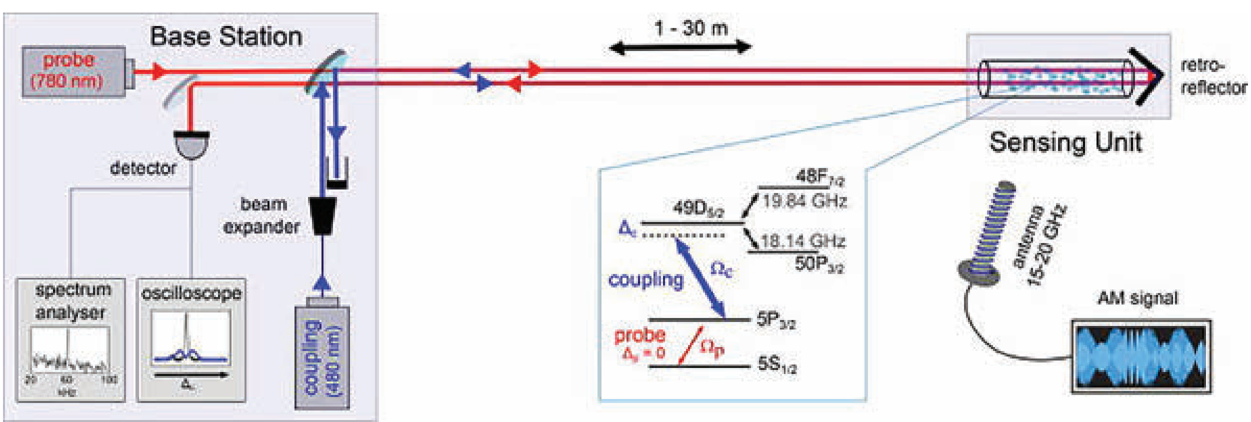
The underlying physics principle they used begins with atoms in a Rydberg state, where one of the electrons in an atom or molecule has been excited to an orbit with a higher principal quantum number (Reference 1). Among the interesting properties of these states are extreme sensitivity to external influences such as fields and collisions, extreme reactivity, and very large probabilities for interacting with microwave radiation.

Although the Rydberg state itself has been known since the early days of quantum physics, these sensitivity characteristics were demonstrated in 2012 by a team led by Jonathan Sedlacek using Rydberg-excited rubidium-87 atoms in a glass vapor cell as a sensitive detector for microwave fields (Reference 2).

Previous systems for RF measurements and applications were confined to an optical table in a laboratory due to the need to counter-align the two (or more) laser beams within the atomic vapor cell. Other attempts utilized optical fibers bonded to the glass cell to overcome this constraint and separate the laser generation and detection from the RF probe—again, the vapor cell—but that approach also had weaknesses in alignment and losses.

Laser Beams and a Retroreflector

The Otago team replaced the fiber used by previous researchers to access the vapor cell with two free-space laser beams and a corner-cube prism reflector (also called a retroreflector), which reflected the probe beam back to a photodetector *(Fig. 1)*.



1. Schematic of the experimental setup. For clarity, the laser driver electronics and the setup for frequency stabilizing the lasers aren't included in the drawing of the base station. The inset shows the relevant atomic transitions in 87Rb, including the Rabi frequencies and detunings of the coupling and probe fields, respectively. Images courtesy University of Otago

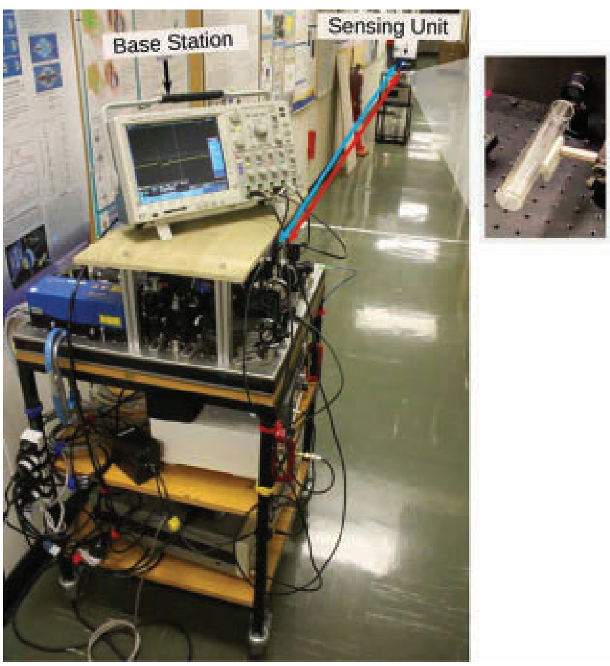
Their portable atomic-RF probe was able to sense fields at over 30 meters.

The base station contains all of the required elements to prepare two light fields for a two-photon Rydberg system: a coupling and probe laser, their drive electronics, and a setup for the frequency stabilization of the two lasers.

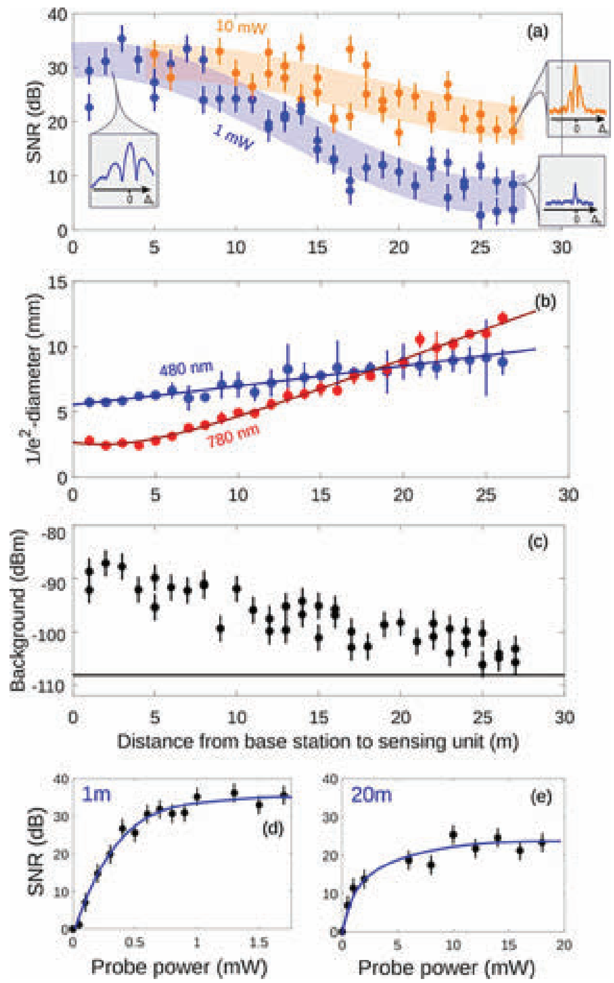
When coupled to a Rydberg state via the optical two-photon transition, the rubidium atoms became sensitive to RF radiation. This happened for RF frequencies that couple the Rydberg level resonantly to other nearby Rydberg levels. For sufficiently large fields, the atoms are receptive to a broad range of RF signals. The lasers detected the changes in energy states in the rubidium atoms.

In their demonstration, a home-built helical antenna broadcast an amplitude-modulated microwave signal with carrier frequencies between 16 and 20 GHz. Their field test (actually, done in their hallway) showed the performance of the fully portable setup *(Fig. 2)*.

They transmitted a 12-dBm/19.84-GHz RF carrier with amplitude modulation at 60 kHz near the sensing unit and extracted the signature of the modulation from the probe beam using a spectrum analyzer *(Fig. 3)*.



2. Free-space-coupled setup outside the laboratory: The base station and the sensing unit are mounted on two movable trolleys and were placed at separations of up to 30 meters (pictured here at 12 meters). The optical board used for the base station is one-meter square. The photo on the right shows the sensing unit: a rubidium vapor cell and a retroreflector.



3. (a) Peak signal-to-noise (SNR) vs. distance from the base station to the sensing unit for two probe coupling powers and an RF carrier power of 12 dBm at 19.84 GHz. The probe power values refer to the power at the base station. The inset shows the signals detected with a spectrum analyzer in the zero-span mode at 60 kHz while scanning the coupling laser frequency. The semi-transparent lines are a guide to the eye. (b) Beam diameters of the probe and coupling beam as a function of distance to the base station. The black lines are fits for the propagation of a Gaussian beam. (c) Reflected signal power measured at the base station for different distances of the sensing unit and for a resonant probe laser field of 1 mW. The horizontal line shows the noise background if the probe laser is turned off. (d) and (e) show the maximum SNR as a function of probe power for the sensing unit positioned at 1 and 20 meters from the base station (the blue lines are a guide to the eye).

Takeaways After Testing

The researchers conclude that the most important characteristic of their portable probe is it contains no electronic circuitry and doesn't require any metal parts. This reduces scattering of the RF field of interest, which can limit the accuracy of measurements, such as in an anechoic chamber setting.

In comparison to a fiber-coupled approach, their portable probe isn't bound to any optical fibers and can more easily be transported. However, this comes at the cost of needing some alignment adjustments each time it's moved.

The work is detailed in their relatively brief but highly readable piece "Distant RF field sensing with a passive Rydberg-atomic transducer," published in *Applied Physics Letters*. There's also a link to Supplementary Material that provides a characterization of the sensing performance of their sensing unit in a parameter space spanned by RF and optical coupling frequencies. ■

More articles on antennas can be found in the TechXchange: Antenna Design.

REFERENCES

1. Texas Tech University, "What's a Rydberg state, anyway?"
2. ***Nature Physics***, "Microwave electrometry with Rydberg atoms in a vapour cell using bright atomic resonances," September 2012.

Purdue Summit Seeks Resilient Supply Chain

Purdue University's first eXcellence in Manufacturing and Operations Purdue Engineering Initiative (XMO PEI) summit sought to explore development of industry infrastructure.

Purdue University

IN HOPES OF BUILDING a sustainable supply chain, Purdue University's inaugural summit on excellence in manufacturing and operations in Washington, D.C. drew more than 250 industry leaders live and online on November 7, 2023.

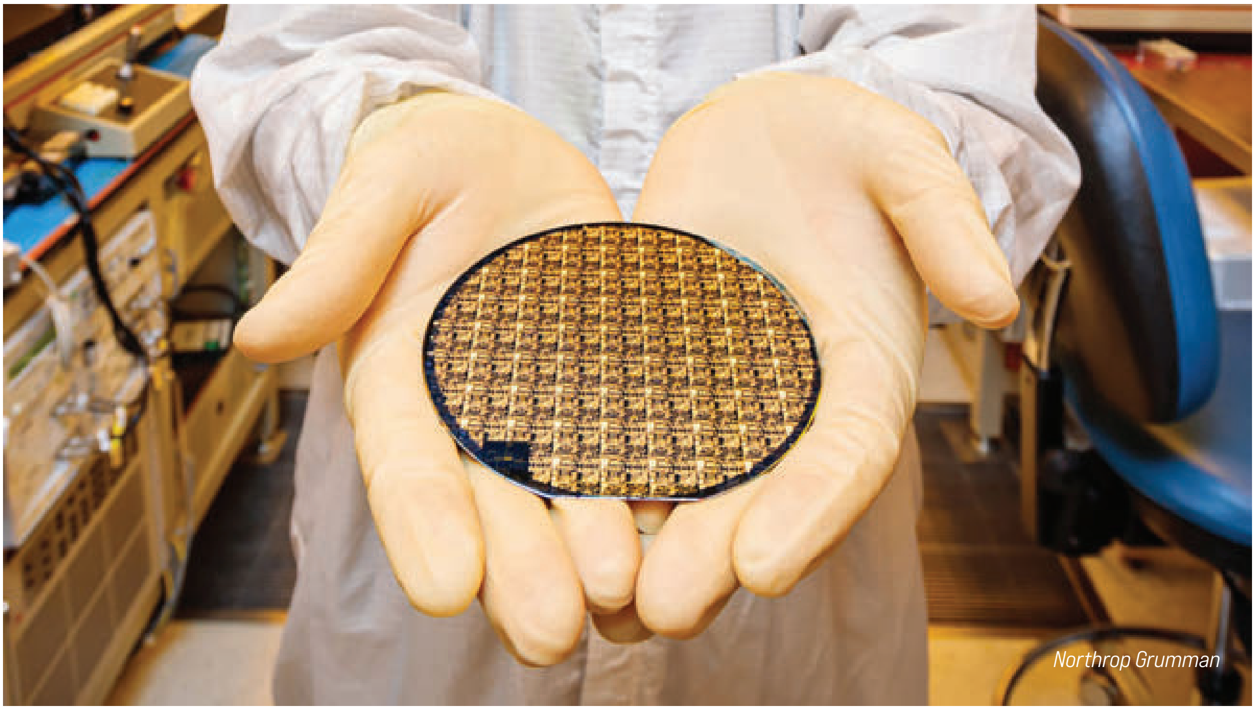
The summit, which was hosted by the school's eXcellence in Manufacturing and Operations Purdue Engineering Initiative (XMO PEI), attracted representatives to explore the development of industry infrastructure with digital, physical, and sustainable manufacturing and operations (M&O).

Mung Chiang, President of Purdue University, explained, "Reshoring, retooling, and retraining for advanced manufacturing in the U.S. has become essential and urgent, and there's no better place to accomplish the mission than the Midwest, especially here along the Hard-Tech Corridor," referring to the school's West Lafayette, Ind. campus.

> *"The XMO Summit brings expertise in the digital, physical, and sustainable innovation of manufacturing across new materials, processes, and applications."*

He added, "The XMO Summit brings expertise in the digital, physical, and sustainable innovation of manufacturing across new materials, processes, and applications."

The summit focused on key aspects of resilience for manufacturing: reshoring, retooling, and retraining in M&O. The supply chain is a vital component of many critical industries, including agriculture, aerospace and defense, microelectronics and semiconductors, and logistics and transportation. Attendees to the summit, both in person and online, represented 29 U.S. states. ■



Foundry Forms ICs for Space

Northrop Grumman's Space Park foundry processes 4-in. high-density semiconductor wafers with III-V technology followed by extensive in-house testing.

NORTHROP GRUMMAN IS considered a designer and developer of major electronic systems for aerospace and defense applications. But supporting those major systems is a surprising semiconductor foundry capability, namely the firm's Space Park foundry in Redondo Beach, Calif.

The foundry produces large quantities of reliable integrated circuits (ICs) for critical applications such as space and electronic-warfare (EW) systems working with III-V compound semiconductor materials like gallium arsenide (GaAs). The devices are fabricated and tested to withstand the most challenging operating environments, including the radiation and temperature extremes of satellite-communications (satcom) systems.

The foundry focuses on developing what it refers to as "golden" chips or semiconductor devices that will operate within the harsh conditions of outer space for more than a decade, featuring operating frequencies extending well into the mmWave range (30 to 300 GHz).

With recent supply-chain concerns over maintaining available semiconductors for space and other military and aerospace applications, the Space Park foundry is focused on producing large-capacity 4-in. wafers *(see image above)*. It can also perform in-house, accelerated life testing, including thermal and electrical stress testing, thermal cycling, and hermeticity checks, to ensure that the semiconductors provide high performance levels over extended operating lifetimes.

In support of ongoing trends in military systems for reduced size, weight, and power (SWaP), the foundry creates ICs and wafers with increased density, with chiplets only 5 µm apart, and applies wafer-level packaging technology to hermetically seal semiconductor devices at the chip-scale level. These devices with increased density enable greater electronic functionality at smaller sizes and weights in support of longer-lasting satellites. ■

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Performing eCall Testing in an EMC Test Environment

Applus Laboratories and Rohde & Schwarz demonstrated a solution that performs different eCall testing scenarios and capabilities in compliance with the UN ECE R10 standard.

R&S/Applus Laboratories

WHEN IT COMES TO automotive systems, reliability and safety are paramount, especially in systems designed for emergency response. Mandatory on all new vehicles, eCall is a system used across the EU that automatically makes an emergency call if the vehicle is involved in a serious accident.

When activated, eCall connects the driver and/or passengers to the nearest emergency response center. It also sends a set of data about the vehicle location, the time of the accident, the VIN, and direction of travel.

In a planned update to the UN ECE R10 standard, additional eCall testing immunity scenarios have been developed to enhance the safety of drivers, passengers, and other road users. Compliance with UN ECE R10 is crucial and everything must be tested to ensure the systems don't interfere with other electronic components in the vehicle and aren't affected by external electromagnetic interference.

To address this demand for compliance certification, Applus Laboratories and Rohde & Schwarz demonstrated the integration of eCall testing in an electromagnetic-compatibility (EMC) test environment. They performed different eCall testing scenarios and capabilities in compliance with the UN ECE R10 standard, which regulates automobile-related EMC. The demonstration uses the R&S CMW500 cellular network emulator with R&S CMW-KA09x eCall test software simulation and a Public Safety Answering Point (PSAP).

The R&S CMW-KA09x eCall test software supports 2G-, 3G-, 4G- and 5G-based emergency call systems, and can be used to test eCall with Long-Term Evolution (LTE) and 5G NR (Next Generation eCall or NG eCall) in line with the EU eCall, NG eCall, UN-R144, and other national standards.

During the demo, an immunity test was conducted in a radio anechoic chamber at Applus+ in Spain. Radio interference was introduced, and the test confirmed the feasibility and ease of establishing an emergency call between the automobile and simulated PSAP server with the R&S CMW500 eCall test solution.

In the test, the minimum set of data was successfully transmitted from the test vehicle to the R&S CMW500 without any data loss, voice communication was established, and the vehicle's received GNSS position was accurately transmitted. Attendees to the demonstration included the United Nations Informal Working Group on Electromagnetic Compatibility (IWG EMC) and community representatives from various countries, as well as vehicle manufacturers from the International Organization of Motor Vehicle Manufacturers (OICA).

Monopulse Comparators Offer Ultra-Broadband Beamforming from 0.5 to 40 GHz

The Overview

KRYTAR recently launched a new family of monopulse comparators that implement beamforming in multiple microwave bands from 0.5 to 40 GHz. These devices are beamforming networks comprised of hybrid couplers that feed phased arrays of antenna elements, controlling the direction of a beam, or beams, of radio transmission.

Who Needs It & Why?

Monopulse comparators, such as those offered by KRYTAR, are highly suited for antenna array beamforming, high-speed radar searching and tracking, multipath simulation and performance evaluation, and many other applications. With coverage from the L-band through the Ka-bands, KRYTAR's devices perform angular beamforming and deliver excellent functionality paired with ease of use.

Under the Hood

For monopulse comparators to be effective in beamforming, there are some key properties to look for in the devices' specifications. These include bandwidth, phase and amplitude imbalance, high isolation, low insertion loss, and VSWR. A look at the datasheet for one example of KRYTAR's offerings, the RFM100400, shows the following:

- Bandwidth: 10 to 40 GHz
- Phase imbalance: ±26° maximum
- Amplitude imbalance: ±2.0 dB maximum
- Isolation: >17 dB minimum
- Insertion loss: <12.3 dB minimum
- VSWR: 2.2 dB maximum
- Power rating: 20 W

The new family of 10 monopulse comparators is comprised of the company's high-performance 180° hybrid couplers. The comparators come in a compact package with coaxial connectors.

Automotive Wi-Fi/Bluetooth Module Clears Path to New Use Cases

225073707 © Chernetskaya | Dreamstime.com

The Overview

u-blox has launched its JODY-W6 module, a concurrent dual-band Wi-Fi 6E device with Bluetooth 5.3, including LE Audio, in a compact package measuring 13.8 × 19.8 × 2.5 mm. The new module targets automotive applications in infotainment and navigation, advanced telematics, and OEM telematics.

Who Needs It & Why?

Wi-Fi 6 and 6E technologies are seeing significant and promising growth in the automotive industry. Wi-Fi 6 focuses on efficiency, with reduced data congestion, improved network capacity, and lower overall power consumption. Meanwhile, Wi-Fi 6E focuses on spectrum, enabling more concurrent users, reduced congestion, and enhanced security.

The device offers support for Apple CarPlay, AndroidAuto, personalized entertainment, data offloading, and smart/roof-integrated antennas. It's expected to help overcome congestion and fulfill scalability requirements in vehicle designs.

Under the Hood

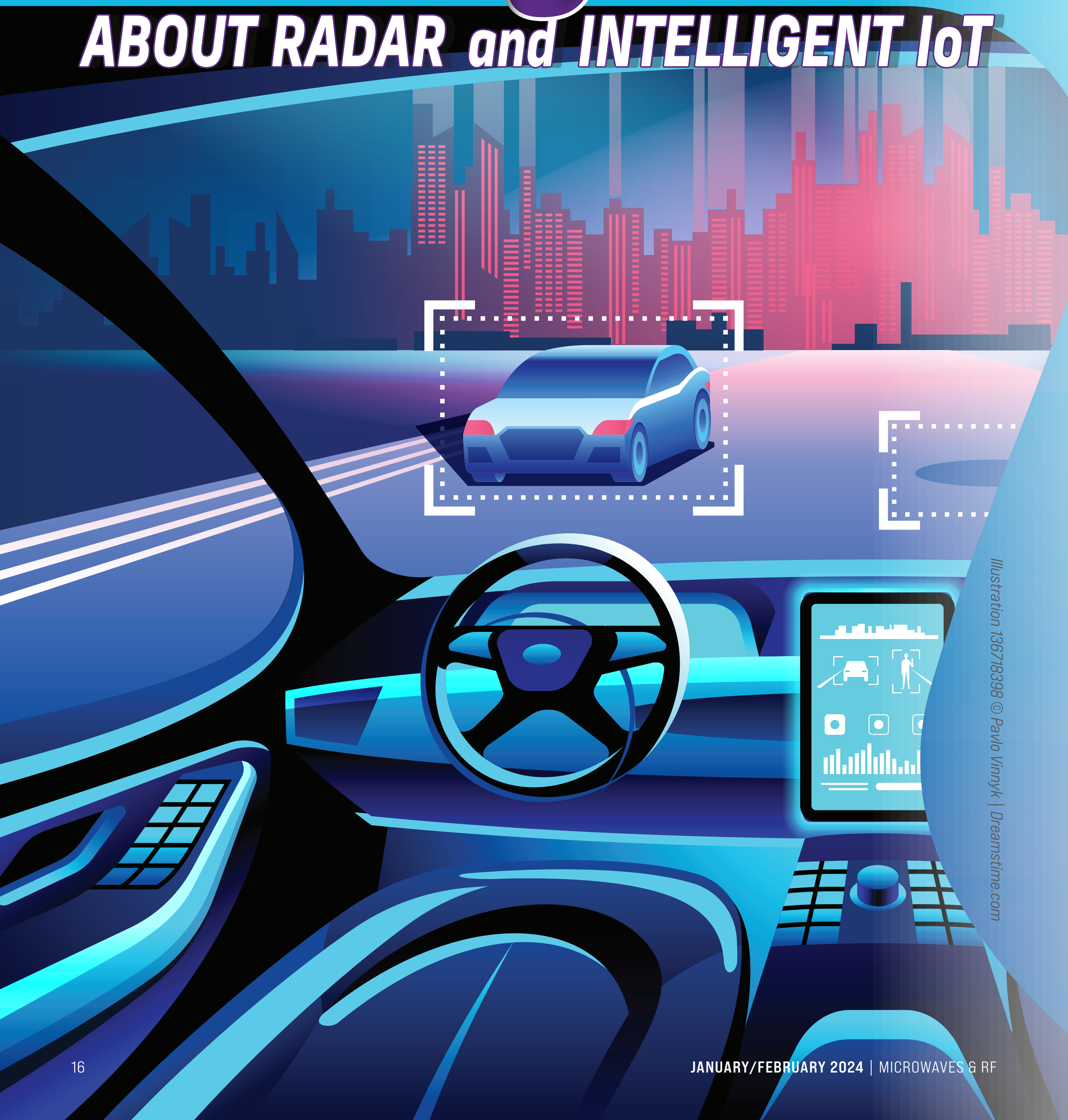
u-blox's JODY-W6 not only provides tri-band Wi-Fi 6E functionality, but it also features dual-mode Bluetooth 5.3 with LE Audio. The globally certified device can withstand harsh automotive operating temperatures from −40°C to 105°C.

Equipped with an embedded NXP Semiconductors AW693 chipset, the module comes with either two or three antennas. It can also integrate an LTE filter. An EVK and an M.2 card will be available for the JODY-W6 series. Furthermore, its compatibility with previous JODY modules ensures seamless scalability. Other features of the AW693 chipset include MU-MIMO, OFDMA, and target wake time (TWT).

Samples of the JODY-W6 module are currently available, with volume production scheduled for Q1 2025.

11 Myths

ABOUT RADAR and INTELLIGENT IoT



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Radar isn't just for aircraft and self-driving cars. This article debunks some of the myths surrounding radar and reveals how radar is one of the essential sensors needed to enable intelligent IoT applications.

***By Kim Y. Lee,** Sr. Director, System Applications Engineering, Sensor Systems & IoT, Infineon Technologies Americas Corp.*

RADAR ISN'T JUST for aircraft and self-driving cars. This article debunks some of the myths surrounding radar and reveals how radar is one of the essential sensors needed to enable intelligent IoT applications.

As intelligent IoT devices become smarter, they make our lives better, more efficient, safer, and more secure in a vast array of applications. Market demand for smart devices will continue to grow as the number of possible applications expands. In fact, according to Statista market research, the global IoT market will reach almost $1.6 trillion by 2025.

A key element in enabling smarter IoT devices is the sensors that enable devices to gather data from their surrounding environment. With the ability to "see," "hear," "smell," "perceive," and other novel perceptive capabilities, smart IoT applications can better understand and more proactively interact with their environment.

In particular, sensors enable IoT devices to learn more about the people who use them, as well as determine what they need and when they need it. With this information, smart IoT can transform a wide range of applications, including smart homes, security, industrial, medical, automotive, consumer, and more.

While many different types of sensors are available to use in smart devices, radar is one of the most powerful given the capabilities it makes possible. This article will address some of the myths that have arisen around radar and show how radar is one of the critical types of sensors for enabling intelligent IoT applications.

1. Radar is only for long-range applications like airplanes and self-driving cars.

Radar can be used in a great variety of ways. The most common application is to detect the presence and movement of objects. However, since radar was invented for air defense in 1935, advances in technology have allowed radar to be used in a wide range of IoT applications, from large-scale security monitoring in parking lots down to tracking small movements, such as monitoring a person's heart rate.

2. Radar only detects distance/range to an object.

As an active radio-frequency (RF) technology, radar-based systems send out pulses and track their echoes to gather information. While these data provide the distance/range to an object, they can be used to determine much more about the object, including its size, speed, direction, and, with a little help from AI, its behavior. With the right setup, IoT that leverages radar can even track multiple objects simultaneously.

3. Infrared is the best motion-detection sensor.

While passive-infrared (PIR) sensing is the traditional sensor of choice for detecting motion, it has several limitations compared to radar-based sensing. Because of factors such as environmental infrared radiation and interference from other sources that operate on the same frequency, PIR sensing is limited in range and lacks directional information. PIR sensors also require a direct line of sight to detect motion.

Radar addresses all of those limitations while offering greater resolution and accuracy, enabling many new applications.

4. Radar can only detect big movements.

Based on the application, radar sensors can detect extremely small micro-movements, even those as small as a person breathing while standing still. This high level of resolution and accuracy enables a great variety of advanced capabilities and applications (see Myth #11).

5. Radar can only detect presence.

Because they require a significant movement to trigger, PIR sensors are limited in their ability to detect presence. This also impacts their ability to detect absence, or the lack of an object being present. Thus, issues arise in terms of people remaining still "disappearing" to the PIR sensor.

For example, a PIR sensor would only see a person sleeping when they rolled over. Radar, with its extraordinary resolution and accuracy that can detect actions as subtle as breathing, is able to detect people who aren't even moving for long periods of time. Therefore, a radar sensor will know when there's no person present to detect (i.e., absence). Absence detection is an important capability for use cases such as elder monitoring or turning off lights when a room is empty.

6. Radar requires a bulky sensor that the user can see.

Radar may bring images of large dishes to mind. However, modern radar chipsets have a small footprint, enabling them to be integrated into even IoT systems of relatively small size.

In addition, one of the key features of a radar sensor is that its high-frequency RF signal can pass through most materials, including plastic, glass, and wood. Thus, the sensor can be concealed behind the product enclosure or casing. Conversely, a PIR-based device must have the sensor exposed and pointing in the direction over which it has coverage, potentially making the people being monitored feel uncomfortable.

With a radar sensor, OEMs have flexibility in how they design what their product looks like. Furthermore, because the sensor is hidden, radar-based designs are inherently non-intrusive, meaning people don't even notice them.

7. Radar needs specific environmental conditions to operate.

Traditional PIR sensors require an environment that minimizes interference. Conditions such as too much sunlight can cause PIR sensors to falsely trigger. Radar is inherently robust under different environmental and climate conditions. It provides consistently reliable performance even with varying temperature or lighting.

8. Radar operates in only one frequency.

Radar sensors operate across different frequencies. The primary frequencies are 24 GHz and 60 GHz. Generally, 24-GHz radar, which is within the regulated ISM band and has a narrow bandwidth of 250 MHz, is used extensively outdoors since it offers high detection range and is extremely robust to environmental conditions, including humidity.

Applications requiring higher bandwidth and close proximity sensing will leverage 60-GHz radar, with its 7-GHz unregulated bandwidth. It can detect motion and complex micro-movements/gestures with greater granularity and accuracy than 24 GHz.

9. Radar consumes too much power for battery-operated devices.

Radar sensors are designed to consume little power, resulting in more efficient devices for greater sustainability and longer operating life for battery-powered applications. As a result, OEMs can use radar in a wide range of IoT applications that need considerable autonomy and energy efficiency.

10. Radar is too complex to implement in small devices.

Radar is at the forefront of low-cost and low-power technology without compromising performance or accuracy. Continuing innovation from companies such as Infineon has led to product lines like the XENSIV family of sensors, which include an array of precise radar sensors

Development resources accelerate time-to-market and deliver significant energy savings compared to other technologies. Radar is such an efficient technology within a small footprint that it's already being integrated into head-mounted displays (HMD) for applications such as augmented reality (AR) and virtual reality (VR) where size, weight, and power efficiency are all critical.

11. Radar can't be used in advanced applications.

Radar is an incredible flexible technology that's already being used in many diverse applications:

- *Human detection:* Because it can track size, radar is able to differentiate between a burglar prowling close to a house and the neighbor's cat. This reduces false triggers typical of PIR sensors.
- *Presence/absence detection:* In addition to detecting presence, radar can detect when no one is present. No more waving your hands to get the conference room lights to turn back on if you haven't moved for a while.
- *Tracking and localization:* Radar can identify where a person is located within a room. This could be used for high-end sound systems to adjust the speakers to always locate the "sweet spot" wherever the listener is currently located.
- *Automatic door control:* Rather than opening a store door whenever a person walks by, radar enables automatic doors to open only when a person is continuously approaching with the intent to pass through the door.
- *Advance elder care:* Radar sensors in beds and chairs can track if a person has gotten up and not returned within a few minutes, thus triggering an alarm.
- *Fall detection:* Radar sensors mounted to the ceiling could detect whether a person has fallen and can't get up. This system is superior to active emergency call systems because it's passive; i.e., the person needn't even be conscious to allow the system to trigger an alarm to call for help.
- *Vital signs monitoring:* Radar is accurate enough to track breathing patterns and heart rate. Possible applications include monitoring an elder or baby to track irregular heartbeat patterns and increase safety.
- *HVAC and lighting efficiency:* Heating, cooling, and lighting can be turned on or off accordingly based on whether a person is detected in the room. Advanced systems could direct heating or cooling toward where the person is currently located to improve performance and sustainability.

Radar is a powerful enabler of pervasive and user-friendly IoT applications. With its high resolution and accuracy, radar supports "intuitive sensing" where users can have simple, effortless, and natural interactions with smart devices. Due to its power efficiency and the flexibility it brings to product design, radar will be an essential component of next-generation, non-obtrusive applications that make our lives easier, safer, efficient, and sustainable. ■

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Empowering SOMs for IoT Devices with **Matter Connectivity**

For Matter to realize its full potential, robust hardware solutions are needed, which is where systems-on-modules play a pivotal role.

***By Ohad Yaniv,** Chief Executive Officer, Variscite*

IN AN AGE of constant technological evolution, the Internet of Things (IoT) stands as a testament to the power of connectedness. However, as we dive deeper into an era of smart devices, the need for a universal communication protocol becomes paramount.

Enter Matter—a unified IP-based protocol aimed at creating seamless and secure connections across smart devices, irrespective of brand. But for Matter to realize its full potential, we need robust hardware solutions. This is where systems-on-modules (SOMs) play a pivotal role.

The Promise of Matter

Before delving into the critical relationship between Matter and SOMs, it's essential to understand the significance of Matter in the IoT landscape. Matter, as proposed by the Connectivity Standards Alliance (CSA), seeks to bridge the gaps that have long plagued the smart-device ecosystem. With disparate brands and platforms often functioning in silos, users have had to juggle multiple applications and systems to achieve basic interoperability. Matter aims to resolve this issue.

Matter was born out of the pressing need to address a fragmented smart-device market. With the proliferation of IoT gadgets, from smart thermostats to wearable tech, consumers found themselves ensnared in a complex web of incompatibility. Different brands, each with their own protocols, often lacked the ability to communicate with each other efficiently. Such a lack of interoperability not only diminished the user experience, but also limited the potential applications of these devices.

CSA's proposal of Matter aims to break these barriers. At its core, Matter strives to be more than just another communication protocol. It's envisioned as a unifying fabric that interweaves devices across brands and ecosystems. By doing so, Matter targets two primary pain points:

- *Interoperability:* For so long, users have grappled with disparate apps and systems, trying to get their devices to "talk" to each other. Matter, with its open-source nature, ensures that devices built on its protocol can effortlessly communicate, irrespective of the manufacturer.
- *Consumer choice:* Brand loyalty is valuable, but it shouldn't come at the cost of technological confinement. With Matter, consumers are no longer tethered to a single brand's ecosystem. They can pick and choose devices based on their preferences and needs, without fearing compatibility issues.

Matter's robust architecture ensures that devices leveraging not only SOMs, but various microcontroller units (MCUs) and other platforms commonly used in IoT devices, operate with minimal latency and maximum efficiency. This is especially vital as the IoT landscape isn't limited to our homes. Industrial IoT, healthcare devices, and smart-city infrastructure also stand to benefit immensely from a unified, efficient protocol.

By establishing a universal language for IoT devices, Matter promises a unified, secure, and robust communication protocol. This means buyers can invest in smart devices without being confined to a single brand or ecosystem, ultimately promoting innovation and competition in the market.

SOMs: The Unsung Heroes of IoT Connectivity

While Matter provides the blueprint, it's the hardware—particularly SOMs—that brings this vision to life. SOMs, for the uninitiated, are compact modules that encapsulate a computer's key components. They offer an ideal blend of performance, flexibility, and scalability, making them instrumental for IoT applications. Benefits of using SOMs include:

- *Agility and fast time-to-market:* As the world of IoT expands, time-to-market becomes crucial. SOMs allow manufacturers to bypass the intricacies of designing and testing new systems from scratch. By utilizing pre-validated modules, device manufacturers can expedite their development processes and ensure quick deployment.
- *Scalability:* Matter's beauty lies in its ability to support myriad devices across various ecosystems. SOMs echo this sentiment by offering scalable solutions that can be tailored to a vast array of applications, be it industrial IoT or portable devices.
- *Optimized performance:* SOMs come pre-optimized to function efficiently, ensuring that Matter's promise of robust connectivity is realized. With advanced processing capabilities and integrated features, SOMs provide the necessary firepower for devices to communicate seamlessly under the Matter protocol.
- *Future-proofing:* As IoT evolves, so will its requirements. SOMs are inherently modular, allowing for easy upgrades and replacements. This ensures that devices remain compatible with future iterations of Matter and other advances in the IoT sphere.
- *Complete package:* Matter protocol is only one aspect of the SOM connectivity support. SOMs can function as a network gateway due to the support of Wi-Fi, Bluetooth, Bluetooth Low Energy, and Ethernet. In addition, SOMs support many features like graphic acceleration, display, and audio that enable infrastructure for a large variety of applications.

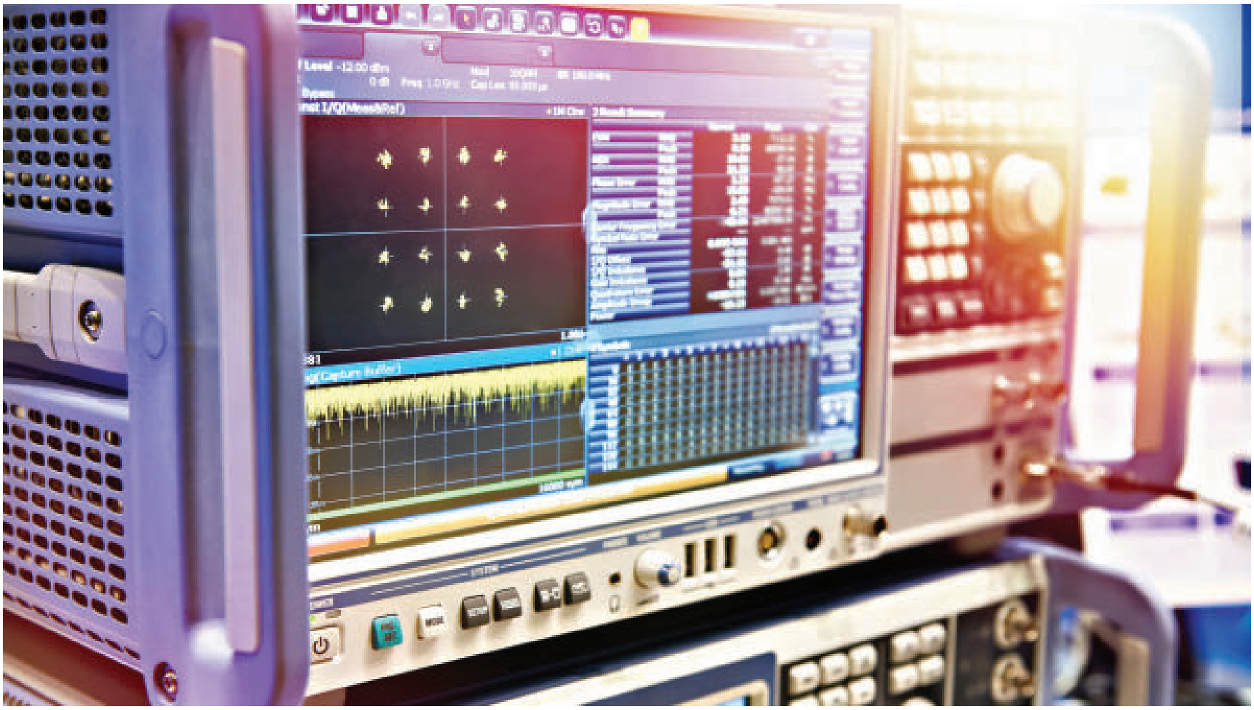
The Way Forward: A Collaborative Endeavor

Adherence to Matter and the use of SOMs signify more than just a technology convergence. It symbolizes the collaborative spirit needed to drive the next phase of IoT. The intrinsic relationship between the two underscores the importance of holistic solutions in creating a truly connected world.

Adherence to Matter and the use of SOMs signify more than just a technology convergence. It symbolizes the collaborative spirit needed to drive the next phase of IoT.

Manufacturers and developers must recognize that the success of Matter, and by extension IoT, hinges on symbiotic relationships. The protocol requires robust hardware solutions that can be easily upgraded, and SOMs need a universal platform to showcase their full potential.

The importance of Matter and the deployment of SOMs isn't just desirable, but essential. As we march toward a future dominated by smart devices, it will become imperative to invest in solutions that guarantee seamless connectivity, enhanced user experience, and unparalleled interoperability. Together, Matter and SOMs paint a promising future for IoT connectivity. ■



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The Move into mmWave Frequencies

This is Part 1 of a video series that details the issues RF/mmWave designers face as they address the millimeter-wave spectrum. Here, we focus on frequency dispersion and interfering signals in wideband receivers.

By David Maliniak,
Executive Editor

MORE OFTEN THESE days, wireless-related design projects are migrating to the rarefied reaches of the millimeter-wave (mmWave) bands, where systems deliver wider signal bandwidths. You get the advantages of higher throughput, but you also must bear new requirements for wideband linearity and frequency flatness.

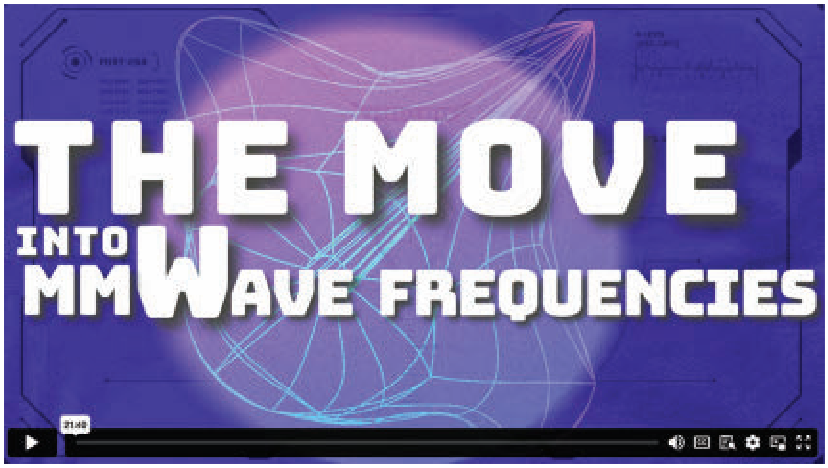
With carrier aggregation comes bandwidths of hundreds of megahertz, and with them comes phase compensation, equalization, and active linearization algorithms that must be tightly integrated with RF transceivers.

All of the above implies a new world for system architects, who must explore and coordinate the design and implementation of multiple system elements. Antenna arrays, RF transceivers, and DSP algorithms operate across multiple standards and in many scenarios that involve interfering signals.

In this first of a series of three videos exploring the arena of millimeter-wave 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.

Dealing with Frequency Dispersion

With increasing bandwidth, frequency dispersion becomes more of a problem



In this first of a series of three videos exploring the arena of millimeter-wave 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.

because either the transmitter or the receiver may not provide flat performance in terms of amplitude and phase over that bandwidth. As a result, one may see distortion of the signal constellation that looks like noise. The dispersion can come from any number of factors, such as distributed elements like transmission lines, PCBs, and antennas, as well as RF amplifiers.

These dispersion sources, says Zucchelli, are all static, meaning that they change very little, if at all, over time. Thus, they can be ferreted out using static-analysis tools or electromagnetic analysis. Other sources of frequency dispersion are found in the over-the-air (OTA) channel, which must be tested and diagnosed through OTA testing using anechoic chambers. Consider cases where either the transmitter or receiver, or both, are moving: Then, the channel effects may not be constant.

That brings us to equalization algorithms, which are embedded in the receiver to reverse the effects of frequency dispersion. However, such algorithms are unable to distinguish between static and dynamic dispersion. So, equalization algorithms, in turn, bring us to channel estimation. You can go beyond estimation by prototyping the equalization algorithm using FPGAs.

The Role of AI in Testing Equalization

In evaluating equalization algorithms, one would use pilot signals to estimate the channel. Then, the channel must be inverted to be equalized. But with the move into mmWave frequencies, systems become more complicated, incorporating more and more antennas in arrays. Multiple-in, multiple-out (MIMO) arrays are now giving way to massive MIMO (mMIMO) arrays. This makes the inversion of the channel into a massive problem, as it's a numerically complicated process.

In this context, AI can really help. It does so by providing an alternative for channel estimation, inversion, or equalization using autoencoders. Rather than treating the design and optimization of all the algorithmic elements of the receiver as separate subsystems, autoencoders can be used by applying AI to jointly optimize both transmitter and receiver as a whole system.

Autoencoders add redundancy to estimate the channel and estimate the entire transmitter and receiver information. This is achieved by using AI in an unsupervised way. Thus, AI is helping greatly to reduce the complexity of the huge numerical complexity of mMIMO systems by going beyond the equalization algorithm.

Addressing Wider Bandwidths

The move into mmWave spectrum brings much greater channel bandwidths, which makes adaptive or cognitive radios necessary to manage operation over multiple bandwidths. A technology that comes into play here is orthogonal frequency-division multiplexing (OFDM), which enables scaling up or down the boundaries of the signal. This makes signals very flexible and able to be retargeted over various frequencies (both center frequencies and bandwidth).

The first step here is to assess the system's requirements for targeting multiple frequencies. However, because transmitters and receivers don't operate in a flat fashion across frequency, some degree of algorithmic adaptability is essential to lend versatility to the system. A link-budget analysis might indicate use of highly configurable digital filters and/or analog equalization and calibration algorithms to perform digital predistortion for linearization.

All of the above must be tightly integrated. At larger bandwidths and higher mmWave frequencies, RF systems must be digitally assisted and controlled. Everything is tunable, which adds a great deal of complexity. To evaluate such designs, requires going beyond classic CW tone measurements and using metrics like error-vector magnitude (EVM) and/or adjacent channel leakage ratios (ACLR) to examine the quality of the receiver's signal constellation.

Measuring and Mitigating Interfering Signals

Interfering signals can, unfortunately, be much higher in power than the signal of interest. As a result, the signal of interest is distorted with a higher signal-to-noise ratio (SNR). That noise will be spectrally correlated—and equally uncorrelated—to the signal of interest. Interferers can be either in-band or out-of-band relative to the desired signal, which makes a difference in terms of both anticipating and mitigating interference.

The good news about mitigating interfering signals is that you can actively address them. Out-of-band interferers are much easier because they're farther away in frequency. If your band is from, say, 24 to 27 GHz, and the interfering signal is at 19 GHz or 30 GHz, it can be removed with filtering.

However, if the interferer is of much higher power than the signal of interest, it may send your receiver into saturation, potentially desensitizing the front end or ADC. Then, any digital filter you apply is, in a way, too late. It won't help recover the desired information.

Therefore, out-of-band interference can be removed with filtering, but it must be analog filters. These are often expensive, bulky, and have limited ability for tuning. In-band interferers are trickier because you can't filter them out.

However, with 5G and 6G, and the introduction of beamforming and MIMO arrays, you can steer a null in the direction of the interfering signal if the interferer and the signal of interest are coming from different directions. Also, if you're building a receiver with a very large bandwidth and your array has many antenna elements, you can steer the beams to make your receiver essentially noise limited.

So, it becomes an interesting problem because you need analog-to-digital converters (ADCs) with much wider dynamic range to ensure that you can recover the signal of interest. Those are some interesting technologies that open new doors for interference mitigation.

In terms of the effects of interfering signals on receivers, when an interferer hits the antenna, which is a passive element, the antenna lets that signal through. Usually, the first circuit after that is a low-noise amplifier (LNA), which is designed to expect a signal very close to the noise level.

The Effects of Interferers on Receivers

In terms of the effects of interfering signals on receivers, when an interferer hits the antenna, which is a passive element, the antenna lets that signal through. Usually, the first circuit after that is a low-noise amplifier (LNA), which is designed to expect a signal very close to the noise level. If the interfering signal is high in power, that LNA can go into saturation. At this point, there's nothing you can do to recover the information from the signal of interest.

That's why it's important to use filters and/or have LNAs with a high dynamic range, or to use null steering. But even with a very good LNA, you might hit saturation of the ADC.

This is where building models and using simulation tools becomes very useful in determining the limiting factor in your receiver, to find out the first thing that saturates or clips. Very often, having digital filters is too late in the signal chain because everything else happens before that.

Filtering Methods and Techniques

A good filtering strategy is to place an RF or analog filter as close as possible to the antenna. But if you want an agile receiver, these aren't great options. Beamsteering is a far more interesting technology, but that will only work in the mmWave range. You can't have a mMIMO system at sub-6-GHz frequencies because the antenna would be too large.

But the good news is that in the sub-6-GHz bands, you can use a different type of architecture that we've seen a lot in recent years. RF ADCs basically bypass the RF content and go straight into the digital domain. It requires fewer RF components and fewer components overall. This is the holy grail of software-defined radios (SDRs).

Depending on the operating frequencies and bandwidths, you may have different choices that reduce the impact of interfering signals. ■

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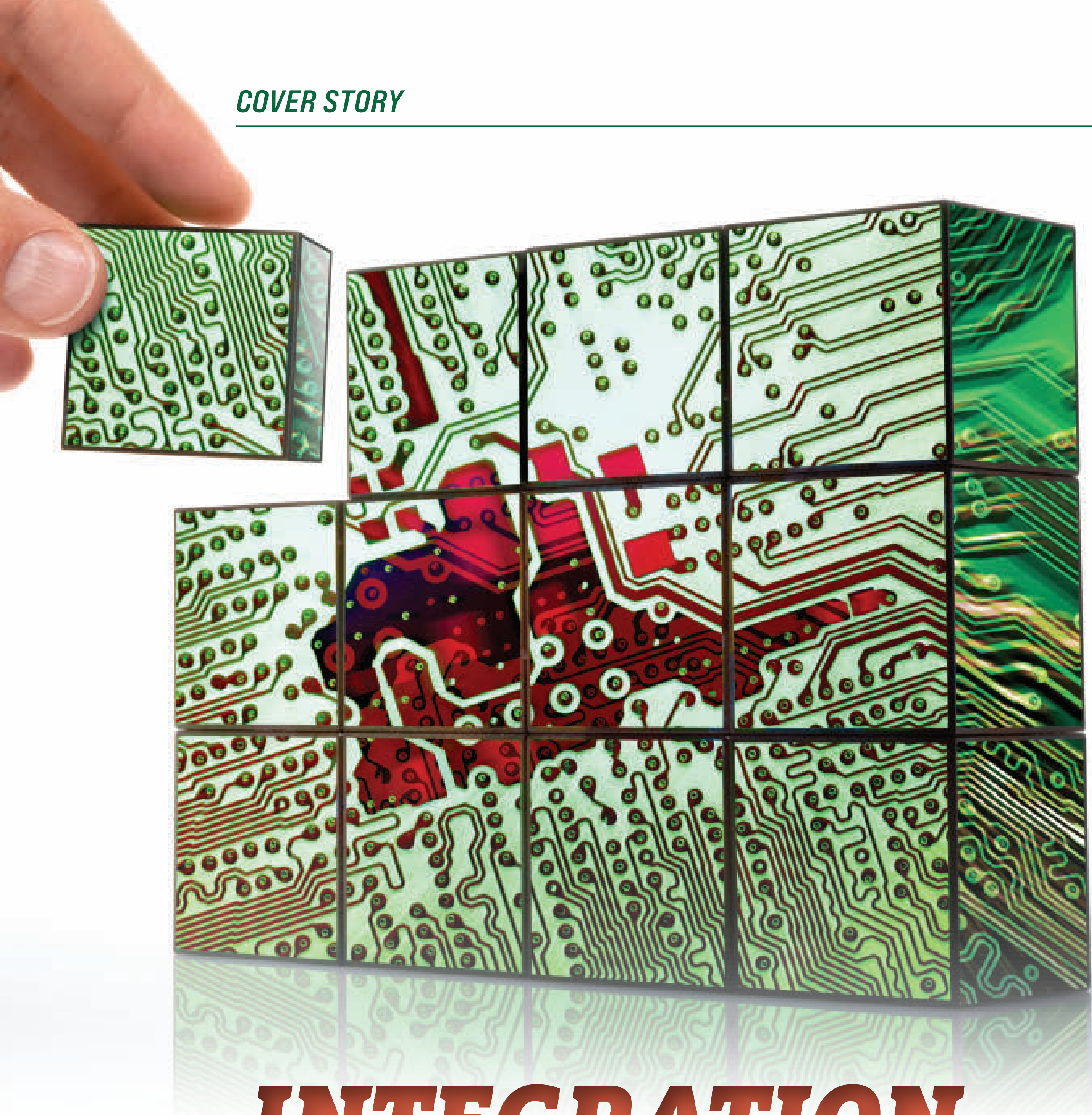

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INTEGRATION is the Watchword in Today's RF FRONT ENDS

These compact devices and modules become final additions for RF radios handling voice, data, and video over a wide range of frequencies and bandwidths.

By Jack Browne, *Technical Editor*

FRONT-END (FE) ASSEMBLIES once required an area the size of a shoebox and comprised the amplifiers, filters, mixers, and oscillators needed for RF/microwave radios. Newer RF FEs fit smaller spaces with increased functionality and performance, employing integrated circuits (ICs) and multichip modules (MCMs). They serve growing numbers of applications, ranging from automated factories and healthcare to telecommunications networks and vehicular systems.

Led by military and aerospace efforts for achieving electronic products with reduced size, weight, and power (SWaP), RF front-end modules (FEMs) and ICs are helping transfer high-frequency signals from antennas to receivers and transmitters in smaller packages to accommodate increasing numbers of users whether for casual or critical requirements.

Less semiconductor-dominated RF/microwave FE designs have employed discrete components, such as amplifiers, mixers, and local oscillators (LOs), for conversion of signal frequencies between RF/microwave spectrum and intermediate frequencies (IFs) as part of an analog radio architecture. Components were linked by coaxial connectors and cables at RF/microwave frequencies. When required for higher frequencies and/or power levels, waveguides would connect components.

But improving semiconductor technologies have enabled smaller, more integrated radio components. RF FE components now incorporate several functions and work in several frequency bands. They enable high-frequency radios to be fashioned from a few ICs or multichip modules (MCMs).

The choice of ICs and modules determines key radio performance levels, such as receiver gain/sensitivity and transmitter output power. FEMs and ICs provide the functions and performance levels needed for practical RF/microwave/mmWave radio solutions across many markets.

Analog FE components and ICs are essential for RF/microwave radio design, with smaller devices enabling widespread use of wireless technology. FEMs and ICs typically provide the amplification, filtering, and switching needed for channel frequencies and bandwidths of interest, with smaller devices enabling the development of compact, power-efficient radio designs.

Integration of key radio functions into a single device supports a modular design approach. Therefore, other essential system functions, such as analog-to-digital converters (ADCs) and digital-to-analog converters (DACs), can be selected and optimized for best system performance.

Inspecting SWaP-Friendly ICs

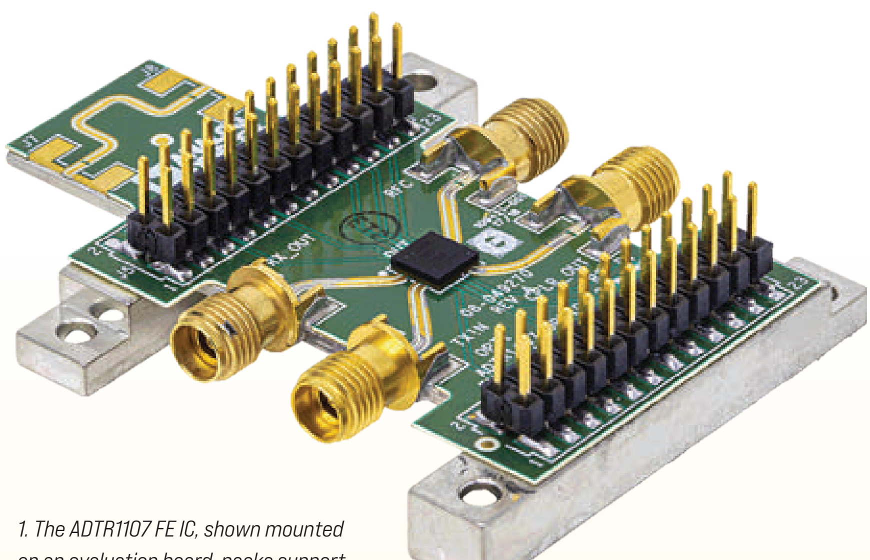
Application bandwidths vary widely, with traditional electronic-warfare (EW) systems among the widest, from 6 to 18 GHz. Through semiconductor integration, RF FEMs and ICs can shrink and simplify those systems, in keeping with the latest demands for reduced SWaP electronic equipment defense systems.

As an example, the ADTR1107 is a FE IC from Analog Devices that covers 6 to 18 GHz. The IC integrates a power amplifier (PA) for transmission; a low-noise amplifier (LNA) for reception; and a reflective single-pole, double-throw (SPDT) switch to choose signal paths.

It's housed within a 24-terminal, 5- × 5-mm land-grid-array (LGA) package. Input and output terminals are internally matched to 50 Ω to simplify installation on high-frequency printed circuit boards (PCBs). The FE IC operates on +3.3- and +5.0-V DC supplies and helps manage phased-array antennas in wideband radar systems *(Fig. 1)*.

The ADTR1107's small size doesn't compromise its performance. The PA provides +25-dBm saturated output power and +23-dBm output power at 1-dB compression (P1dB); typical small-signal gain is 21.5 dB with ±0.8-dB gain flatness across the full frequency range. The LNA delivers small-signal gain of 17.5 dB with typical gain flatness of ±0.6 dB; the typical full-band noise figure is 2.5 dB.

The integrated SPDT switch rapidly selects between the transmit and receive signal paths, with typical rise/fall time of 2 ns, turn-on/turn-off time of 10 ns or less, and 17 ns time to settle within 0.1 dB of the final selected PA or LNA output level. The miniature package incorporates a broadband directional coupler for power detection and measurements.



1. The ADTR1107 FE IC, shown mounted on an evaluation board, packs support for 6- to 18-GHz radios into a 5- × 5-mm LGA package. Analog Devices

For radio designers needing less bandwidth, the QPM1002 from Qorvo is a transmit/receive (T/R) FEM fabricated on GaN-on-SiC (gallium nitride on silicon carbide) technology for use in X-band radars from 8.5 to 10.5 GHz. The monolithic microwave integrated circuit (MMIC) FEM combines an LNA, PA, and T/R switch within a 5.0- × 5.0-mm, surface-mount QFN package *(Fig. 2)*.

2. Qorvo's QPM1002 T/R FEM serves radar applications from 8.5 to 10.5 GHz. Qorvo

The LNA contributes to receive-path gain of typically 24.5 dB with 2.2-dB noise figure and +16-dBm saturated output power. The PA adds a transmit signal path with typical small-signal gain of 33 dB, large-signal gain of 25 dB, and pulsed saturated output power of +34.5 dBm. The PA has typical power-added efficiency (PAE) of 32%. Because the FEM IC can handle antenna-port input power levels to 2 W (+33 dBm), it's able to deal with large signals without a limiter.

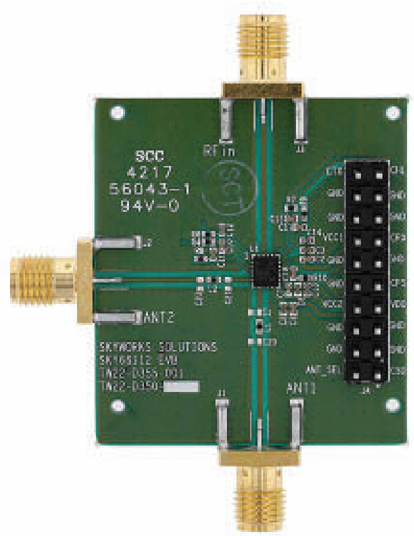
For less bandwidth in a larger package, Qorvo's QPM2637 FEM also serves X-band communications, radar, and EW applications, but from 9.0 to 10.5 GHz. The device, which combines an LNA, PA, and T/R switch using GaN-on-SiC technology, handles antenna input signals to 4 W, so there's even less need for a limiter.

The QPM2637's receive path has two output ports, each with 21-dB gain and 2.7-dB typical noise figure, while the transmit path provides 23-dB large-signal gain with as much as 4-W typical saturated output power. The T/R switch selects signal paths with typical 5-ns rise time and 35 ns or better fall time. The FEM is housed in a surface-mount package measuring 6.0 × 5.0 × 1.8 mm, complete with internal heat slug for enhanced thermal conductivity.

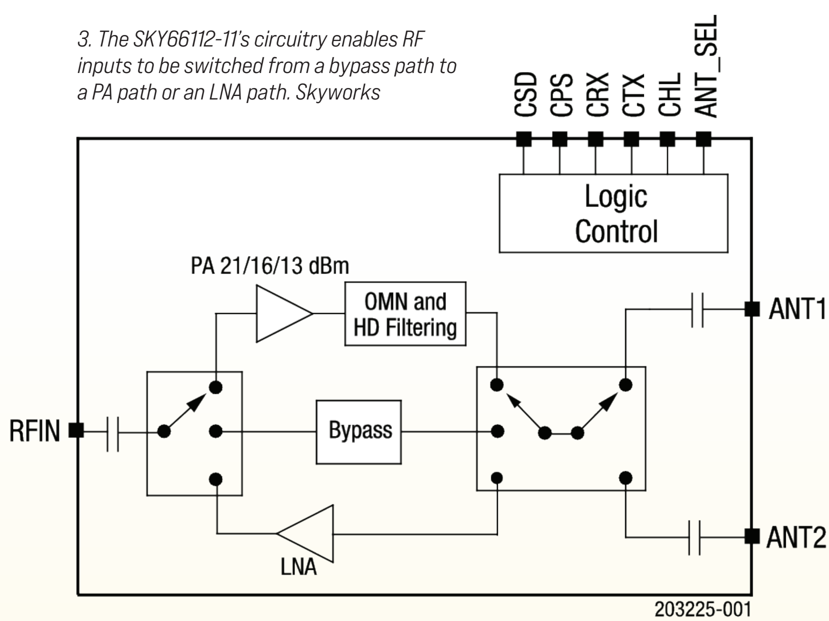
For lower-frequency wireless communications, the SKY66112-11 from Skyworks Solutions is an RF FEM designed for commercial 2.4-GHz links, such as Bluetooth, Wi-Fi, and Zigbee (2,400 to 2,483 MHz). With a control and supply voltage range of +1.8 to +3.6 V DC for flexibility in battery-powered applications, the FEM allows RF inputs to be switched from a bypass path to a PA path or an LNA path *(Fig. 3)*. Typical turn-on time for selecting a path is 800 ns.

The bypass path suffers 2-dB typical loss while the transmit path provides an antenna port with +20-dBm typical output power and 22-dB saturated gain. The receive path offers 11-dB gain with 2-dB typical noise figure. Designated an environmentally safe, halogen-free Skyworks Green product, the 2.4-GHz FEM is supplied in a 22-pin MCM package measuring 3.5 × 3.0 × 1.0 mm with an operating temperature range of –40 to +85°C *(Fig. 4)*.

Extending the 2.4-GHz starting point, Analog Devices' ADRF5545A is a dual-channel receiver FE that works from 2.4 to 4.2 GHz with time-division-duplex (TDD) modulation. Ideal for wireless infrastructure equipment and TDD-based communications systems, it integrates two signal paths, each with two LNA stages and SPDT switch.



4. The SKY66112-11 FEM serves a variety of 2.4-GHz commercial wireless applications. Skyworks Solutions



3. The SKY66112-11's circuitry enables RF inputs to be switched from a bypass path to a PA path or an LNA path. Skyworks

Featuring on-chip bias and impedance-matching circuitry, the receiver FE is supplied in a 40-lead, RoHS-compliant LFCSP housing measuring 6 × 6 mm with simple, single-supply operation. When both LNA stages are powered in high-gain mode, the gain is 32 dB at 3.6 GHz with a noise figure of 1.45 dB and typical output third-order intercept point of +32 dBm. With just one LNA stage powered in low-gain mode, the gain drops to 16 dB but with lower power consumption while maintaining the 1.45-dB typical noise figure.

For higher-frequency wireless connections, the SKY-85798-11 from Skyworks Solutions integrates a 6-GHz LNA with bypass mode, a 6-GHz SPDT T/R switch, and a nonlinear PA into a FEM for Wi-Fi 7 networking systems and set-top boxes operating from 5.925 to 7.125 GHz. The RF FEM's 24-pin, 3- × 5-mm LGA package is matched at input and output ports to 50 Ω to simplify installation onto PCBs.

In addition to the FEM IC components, the miniature package includes a temperature-compensated, logarithmic power detector for closed-loop power control. The device boosts next-generation, 6-GHz Wi-Fi signals with 15-dB typical receive gain across the 1200-MHz bandwidth.

Broadcom also offers FEMs for higher-frequency Wi-Fi systems, including Wi-Fi 6 and 7. The company's FiFEM devices integrate thin-film bulk-acoustic-resonator (FBAR) filters with PAs to achieve enhanced coverage in routers, residential gateways, and access points without interference between Wi-Fi 5- and 6-GHz networks. The devices come in miniature 3- × 5-mm FEM packages.

Moving to mmWaves

As bandwidth is consumed by wireless communications, control, and other applications at RF and microwave frequencies, radios must seek reduced SWaP solutions as they reach into the millimeter-wave frequency range of 30 to 300 GHz.

Just below that range, the MAMF-011099 from MACOM Technology Solutions Inc. also integrates a PA, LNA, directional coupler, switch, and switch driver into a T/R FEM, but it targets frequencies from 24.25 to 29.50 GHz as in 5G wireless cellular communications networks. It can be used as a FEM for an antenna, antenna arrays, or connected to multichannel antenna beamformer ICs. The FEM's multiple MMIC devices fit within a lead-free, RoHS-compliant, 40-lead AQFN package measuring 6.5 × 6.5 mm.

As bandwidth is consumed by wireless communications, control, and other applications at RF and microwave frequencies, radios must seek reduced SWaP solutions as they reach into the millimeter-wave frequency range of 30 to 300 GHz.

The T/R FEM, which runs on −5- and +5-V DC supplies, requires a precise biasing sequence to avoid damage to the multiple MMICs. The LNA contributes to typical receive-path gain of 24 dB from 24.25 to 29.50 GHz and receive noise figure of 3.8 dB; typical receive path input/output return loss is 10 dB. The PA provides a typical transmit gain of 21 dB and P1dB of +27 dBm. The transmit third-order intercept (IP3) is typically +31 dBm from 24.25 to 27.50 GHz and typically +33 dBm from 27.50 to 29.50 GHz.

At higher frequencies, Qorvo's QPF4005 FEM is suited for 39-GHz, 5G phased-array base stations and network terminals. The dual-channel GaN-on-SiC device combines an LNA, PA, and T/R switch on each channel. It operates from 37.0 to 40.5 GHz with better than 15-dB gain and 4.5-dB noise figure on the receive path and +33-dBm (2 W) saturated output power with 18-dB small-signal gain on each transmit path.

Multiple MMICs are housed in a 4.5- × 6.0- × 1.8-mm, surface-mount air-cavity laminate package with internal copper heat slug for reliable thermal management over a temperature range of −40 to +95°C. The multiple-MMIC device is well-matched to 50 Ω, with typical input return loss of 12 dB and typical output return loss of 15 dB across the 3.5-GHz bandwidth.

As commercial wireless communications consume bandwidth and move higher in frequency, wireless networks such as 5G will require FEMs at higher frequencies. Some, such as the FE MMICs developed by pSemi, a Murata company, for the mmWave and near-mmWave portions of 5G cellular wireless networks, are supplied without packages, in tape-and-die form as chips.

The FEMs are well-suited for 5G base stations, 5G customer premises equipment (CPE), and point-to-point radios. They integrate LNAs, PAs, phase shifters, and switches onto a single die to serve as beamforming FEs for 5G antenna arrays with as many as 1024 elements.

As an example, the PE188100 eight-channel beamforming FE MMIC covers the n258 frequency spectrum of 5G networks, from 24.25 to 27.50 GHz. It contains two independently controllable RF signal chains, each with four channels, to control eight single-polarity antennas or four dual-polarity antennas. Also included are high-speed time-division-duplex (TDD) switches for choosing between LNA and PA signal chains.

The analog ICs do contain digital circuitry, with enough memory to retain instructions for over 500 antenna beams as well as precise 6-bit attenuation control and 8-bit phase control of the signal paths. The firm's PE188200 eight-channel beamforming FE die provides the same functionality across the 5G n257 band from 26.5 to 29.5 GHz.

Qualcomm, which has a wide range of FEMs combining amplifiers, filters, and switches into a miniature package, offers Wi-Fi FEMs for automotive and wireless infrastructure applications, including for Wi-Fi 7 connectivity. The company also offers its SnapDragon line of antenna FEMs that function across mmWave frequencies.

At higher frequencies, the firm offers the AWFM-0196, a dual-channel IF transceiver upconversion/downconversion IC for 37.0 to 48.2 GHz. Also a half-duplex FE, it includes an LO synthesizer and frequency multiplier and supports radios with dual polarization. The IF FE devices come in compact FC-CSP packages.

Automotive collision-avoidance systems have employed 77-GHz radar signals for some time and autonomous control systems in commercial, industrial, and military vehicles are expected to occupy more and higher frequencies.

Anokiwave, well known for its active antenna ICs, has also developed a dual-channel intermediate-frequency (IF) FE with frequency upconversion and downconversion for applications from 24.25 to 29.50 GHz. *(Fig. 5)*

5. Anokiwave's AWMF-0224 IC integrates an LO synthesizer to translate between 24.25 to 29.50 GHz and IFs. Anokiwave

Its AWMF-0224 half-duplex radio IC, which can be used with an external phase-locked loop (PLL) and signal source as well, integrates an LO frequency synthesizer. It combines a dual single-sideband (SSB) upconversion transmitter circuit with dual downconversion image-reject receiver circuitry. An on-chip frequency multiplier simplifies installation onto crowded PCBs.

Even higher mmWave frequencies will be at work in many other applications beyond 5G. Automotive collision-avoidance systems have employed 77-GHz radar signals for some time and autonomous control systems in commercial, industrial, and military vehicles are expected to occupy more and higher frequencies. High-frequency FE devices will be needed for vehicle-to-vehicle (V2V) communications and mmWave safety radars.

However, many more automotive electronic applications are on the way, with major semiconductor suppliers such as NXP Semiconductors exploring the use of mmWave radio technology for child-presence-detection (CPD) systems. Such electronic systems are designed to alert a user for signs of life in the back of a vehicle, e.g., a child hiding in a backseat or locked in a trunk. The short wavelengths and open spectrum of mmWave frequencies are ideal for the short-range radios used in CPD systems. ■

Source Generates 50 W from 2.4 to 2.5 GHz

Mini-Circuits' model RFS-2G42G5050X+ is a solid-state signal source for RF energy applications from 2.4 to 2.5 GHz. Over that range, it can provide as much as 50 W pulsed or CW output power with 42% typical efficiency. It can be controlled via USB or UART interface, providing 100-kHz tuning resolution and ±1-MHz typical frequency accuracy. The compact source, with current, power, and temperature detection and protection, measures just 65 × 110 × 14.5 mm and weighs 0.14 kg.

MINI CIRCUITS

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Network Cybersecurity Test Platform Facilitates Transition to 400GE

Keysight Technologies' APS-M8400 network cybersecurity test platform can validate the hyperscale distributed denial of service (DDoS) defense capabilities and carrier-grade performance of next-generation firewalls. Presented as the industry's first and highest density 8-port 400GE Quad Small Form Factor Pluggable Double Density (QSFP-DD) network security test platform, the APS-M8400 platform can generate legitimate and malicious traffic in a single test, validating the hyperscale firewall protection.

KEYSIGHT TECHNOLOGIES

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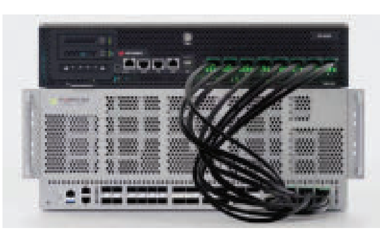

Cloud-Based Environment Accelerates Automotive AI Software Development

Renesas Electronics launched a cloud-based development environment aimed at streamlining the software design process for automotive AI engineers. AI Workbench is an integrated virtual development environment that empowers automotive AI engineers to design, simulate, and fine-tune their automotive software within the cloud. Engineers can immediately begin designing automotive software by leveraging Microsoft Azure services including Azure Compute, IaaS services, Microsoft Entra ID, and Azure Security. Instead of installing tools on a PC or obtaining an evaluation board, they can perform tasks such as performance evaluation, debugging and verification using simulation tools online.

RENESAS ELECTRONICS

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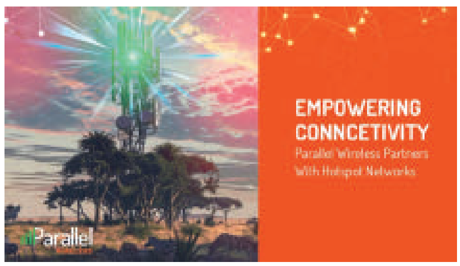

Hotspot Networks Bring First-Time Connectivity to 500 Rural Sites

Deploying 2G and 4G sites on an Open RAN foundation to enable access to remote communities in Nigeria, Parallel Wireless along with Hotspot Network, extended coverage to previously unconnected rural sites throughout Nigeria. Greatly expanding access to critical health and educational information, the collaboration aims to connect residents of rural regions to essential services that will ultimately improve their quality of life. Addressing the technology gap between urban and rural areas, Hotspot Networks is working directly with local and national governments to build 2G and 4G wireless communications infrastructure beyond the radio network.

PARALLEL WIRELESS | HOTSPOT NETWORK

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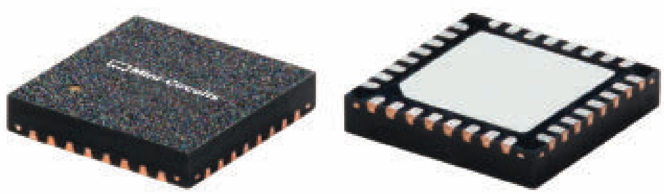

Amplifier Powers 10 MHz to 10 GHz

Mini-Circuits' model PMA5-83-2W+ is a GaAs MMIC power amplifier with +30.6 dBm or more typical output power at 1-dB compression from 10 MHz to 10 GHz. Suitable for electronic-warfare (EW), radar, and test systems, the amplifier is housed in a 5 × 5 mm, 32-lead surface-mount QFN package. With typical gain of 12.3 dB at 2 GHz and 10.3 dB at 10 GHz, the amplifier operates with typical noise figure of 4.1 dB or better from 2 to 10 GHz.

MINI CIRCUITS

http://tinyurl.com/29a84uc7