January/February 2023 | mwrf.com

Microwaves & RF®

Unlocking the SMART HOME'S BRAIN with MATTER

CONTENTS

January/February 2023 | VOLUME 62, ISSUE 1

FEATURES

10 In 2023, Look for Cellular Providers to Continue Their 5G Transformations

11 Should Users Wait for 5G to Implement IIoT Networks?

12 Survey Affirms the Ever-Evolving Test Industry's Expansion

16 How to Cloak Radiating Elements in Multiband Antennas for Optimized Performance

22 The Past, Present, and Future of Ultra-Wideband Technology

26 Unlocking the Smart Home's Brain with Matter

28 CSA Launches Matter IoT Protocol for Simple, Secure Device Interoperability

29 Space-Based SDR: NASA'S SCaN Testbed

DEPARTMENTS

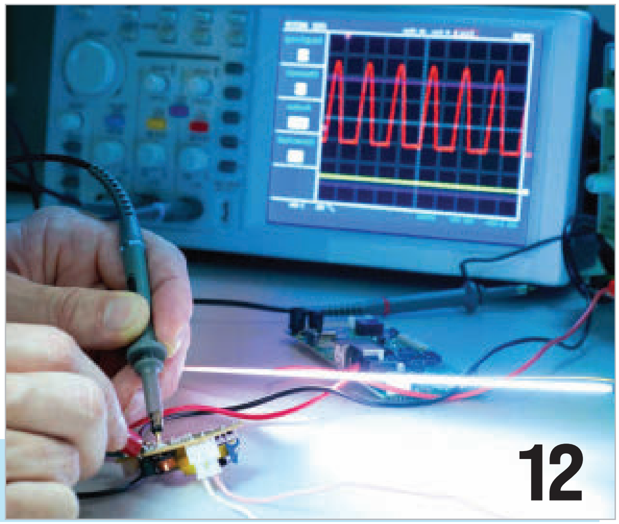
4 From the Editor

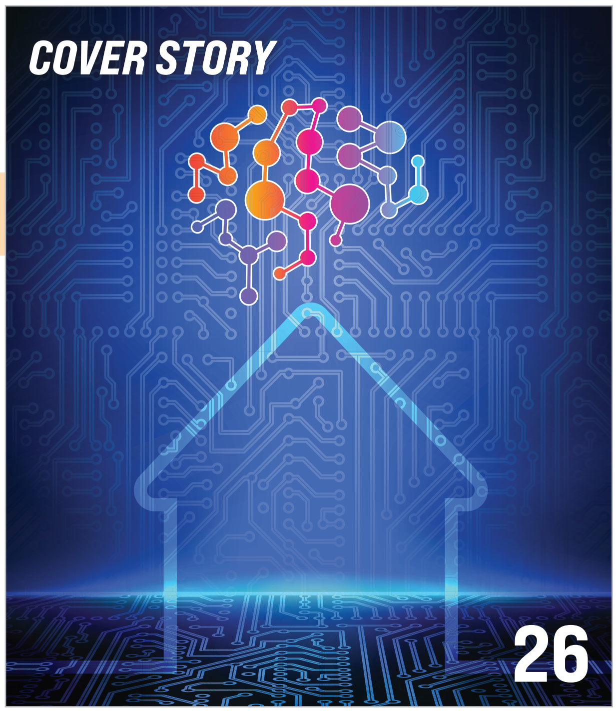
5 Ad Index

6 Featured Products

8 Watch & Connect *@mwrf.com*

33 New Products





Cover photo credit: 34035999 @ Germina | Dreamstime.com

DAVID MALINIAK, Senior Editor

Note to Self: For CES 2024, **Wear Better Shoes**

I learned a lot at CES 2023 about the future of the IoT and smart homes. I also learned something about my shoes.

Consumer Technology Association

WHEN PLANNING FOR editorial sorties to large industry events, the primary concern is, of course, one's meeting schedule. Who's looking for meetings? Who do I want to seek out? What do I want to get out of the trip?

When it comes to an event like the Consumer Electronics Show, with so much to see and so many exhibitors to visit with, planning the schedule is a more involved exercise than with some of the smaller trade shows. Despite my many years as a member of the electronics OEM trade press, CES 2023 was, believe it or not, my first. So, I wanted to be careful about organizing my time.

Another aspect of trade-show planning is how and what to pack. When I started attending such events long ago, we were a more formal society. You packed suits, ties, and dress shoes in anticipation of fine evening dining. It was just how people presented themselves.

No doubt, we're a lot more casual these days, so "business casual" is the code. While many show attendees go with T-shirts/golf shirts and jeans, I still prefer dress shirts, but I pair them with khakis and the like, and leave the ties at home. I'm not sure if I still have any ties, to be honest.

Then there's the shoes. These days, I generally rely on a pair of well-cushioned shoes that still look somewhat dressy but provide more comfort than real dress shoes. Going in, you know you'll be on your feet much of the time and doing lots of walking. Dress shoes would be asking for great pain.

Yet, I was not prepared for CES in footwear terms. I'm told that CES has contracted significantly from pre-pandemic years. But this was, by quite a bit, still one of the largest shows I've ever attended. With some 6.4 million square feet of exhibit space, the Las Vegas Convention Center is among the largest in the U.S. CES sprawls over most of it and spills over into other venues like the Venetian Expo (formerly the Sands), which is itself a large space.

By the end of the first day, my proverbial dogs were barking. Feet? Hurt. Shins? Hurt. Thighs? Hurt. Hips? Yeah, they hurt, too. Next year, I might have to rethink the ensemble and find some decent-looking, yet more sneaker-like, shoes.

Despite my discomfort, I did find what I came to CES for, in the form of smart-home innovations centered on the Connectivity Standards Alliance's Matter 1.0 protocol. Matter builds on Internet Protocol to let smart-home devices, mobile apps, and cloud services communicate seamlessly whether it's Amazon's Alexa, Apple's Siri, or Google's Assistant coordinating the action.

We've got a large compendium of CES 2023 coverage for your perusal on our site, with lots of show-floor videos, media galleries, and new product coverage. If you couldn't get to Las Vegas, it's the next best thing to sore feet. ■

David Maliniak

dmaliniak@endeavorb2b.com

EDITORIAL ADVISORY BOARD

AD INDEX

AVTECH ELECTROSYSTEMS LTD 9
CIAO WIRELESS, INC 19
COILCRAFT, INC. 2
HUBER+SUHNER, INC 15
MARKI MICROWAVE 21
POLYFET RF DEVICES 25
PULSAR MICROWAVE 7

Microwaves&RF

mwrf.com

EDITORIAL

Group Content Director: Michelle Kopier
mkopier@endeavorb2b.com

Senior Content Editor: Bill Wong
bwong@endeavorb2b.com

Senior Editor: David Maliniak
dmaliniak@endeavorb2b.com

Managing Editor: Roger Engelke
rengelke@endeavorb2b.com

Editor-at-Large: Alix Paultre
apaultre@endeavorb2b.com

Senior Staff Writer: James Morra
jmorra@endeavorb2b.com

Technical Editor: Jack Browne,
jack.browne@citadeleng.com

ART & PRODUCTION

Group Design Director: Anthony Vitolo

Art Director: Jocelyn Hartzog

Production Manager: Brenda Wiley

Ad Services Manager: Deanna O'Byrne

AUDIENCE MARKETING

User Marketing Manager: Debbie Brady
dmbrady@endeavorb2b.com

Article Reprints:
reprints@endeavorb2b.com

LIST RENTAL

Smartreach Client Services Manager:
Mary Ralicki, mralicki@endeavorb2b.com

DIGITAL & MARKETING

VP Digital Innovation Data: Ryan Malec

VP of Marketing Solutions & Data:
Jacquie Niemiec

SALES

AL, AR, SOUTHERN CA, CO, FL, GA, HI, IA, ID, IL, IN, KS, KY, LA, MI, MN, MO, MS, MT, NC, ND, NE, OH, OK, SC, SD, TN, UT, VA, WI, WV, WY, CENTRAL CANADA:
Jamie Allen, jallen@endeavorb2b.com

AZ, NM, TX: Gregory Montgomery
gmontgomery@endeavorb2b.com

CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT, EASTERN CANADA:
Elizabeth Eldridge
eeldridge@endeavorb2b.com

AK, NORTHERN CA, NV, OR, WA, WESTERN CANADA, AUSTRIA, BELGIUM, FRANCE, GERMANY, LUXEMBURG, NETHERLANDS, PORTUGAL, SCANDINAVIA, SPAIN, SWITZERLAND, UNITED KINGDOM:
Stuart Bowen, sbowen@endeavorb2b.com

ITALY: Diego Casiraghi,
diego@casiraghi-adv.com

PAN-ASIA: Helen Lai
helen@twoway-com.com

PAN-ASIA: Charles Liu
liu@twoway-com.com

ENDEAVOR BUSINESS MEDIA.

ENDEAVOR BUSINESS MEDIA, LLC
30 Burton Hills Blvd., Suite 185.,
Nashville, TN 37215 | 800-547-7377

CEO: Chris Ferrell

President: June Griffin

CFO: Mark Zadell

COO: Patrick Rains

CRO: Reggie Lawrence

Chief Administrative and Legal Officer:
Tracy Kane

EVP, Design & Engineering Group:
Tracy Smith

DESIGN & ENGINEERING GROUP
Electronic Design, Machine Design, Microwaves & RF, Power & Motion, SourceESB, Source Today, 3DX

Microwaves & RF Magazine ID Statement 2023:

Microwaves & RF, ISSN 2162-1411 online, is published 6 times a year (January/February, March/April, May/June, July/August, September/October, November/December) by Endeavor Business Media, LLC. 1233 Janesville Ave., Fort Atkinson, WI 53538.

POSTMASTER: Send address changes to Microwaves & RF, PO Box 3257, Northbrook, IL 60065-3257. **SUBSCRIPTIONS:** Publisher reserves the right to reject non-qualified subscriptions. Subscription prices: U.S. $68.75 per year; Canada/Mexico $81.25 per year; All other countries $93.75 per year. All subscriptions are payable in U.S. funds. Send subscription inquiries to Microwaves & RF, PO Box 3257, Northbrook, IL 60065-3257. Customer service can be reached toll-free at 877-382-9187 or at microwavesRF@omeda.com for magazine subscription assistance or questions.

Tough TCXOs Boost Bandwidth and Latencies in 5G, Satcom Apps

The Overview

SiTime's Elite RF Super-TCXOs enable the higher bandwidths and lower latencies critical to modern and future 5G and satellite communications deployments. They're a new class of MEMS-based, highly integrated temperature-controlled crystal oscillators built to withstand extreme environments.

Who Needs It & Why?

The ongoing densification of 5G and satellite communications means a need for greater bandwidths and lower latencies. That, in turn, means more deployments in extremely harsh environments that engender lots of thermal shock and vibration.

Historically, quartz-based miniature TCXOs have been the go-to devices as timing references in 5G and satcom radios. Such devices provided the stability over changing temperature that was necessary to clock advanced synchronized radios.

However, although they're accurate, quartz-based TCXOs are notoriously unreliable, especially in harsh environments. Moreover, they consume excessive power and board space and require additional components, such as jitter cleaners and VCXOs for generating RF-capable clocks. One Elite RF Super-TCXO replaces all of these components in 5G small cells, remote radio units, microwave backhaul, and satcom applications.

Under the Hood

Whereas older quartz-based TCXO architectures meet the frequency stability over temperature requirements of 5G systems, they're not only unreliable, but also large in size. That's due, at least in part, to the fact that they contain a quartz TCXO/OCXO, a digital-to-analog converter (DAC), and a quartz VCXO. The Elite RF Super-TCXOs include all of these components in a package that's 4X smaller and consumes 3X less power.

Quartz-based TCXOs offer a mean time between failure (MBTF) of between 250,000 and 1 million hours at best. That means you'll need to replace such devices every two to three years. Elite RF Super-TCXOs are said to be 30X more reliable.

Elite RF Super-TCXO devices offer a frequency range of 1 to 220 MHz with ±100-ppb stability over temperature and a –40 to +105°C operating temperature range. Limited customer sampling is available now; general sampling will be available in Q2 2023. Mass production is expected in Q3 2023.

Firms Team Up to Boost Power Efficiency of Wi-Fi 6/6E Front-End Modules

The Overview

The marriage of Skyworks Solutions' front-end module (FEM) technology with Broadcom's family of Wi-Fi 6/6E silicon has resulted in Skyworks' Incredible Current & Efficiency (ICE) FEMs, which are claimed to deliver substantial gains in processing speed, latency, and system-level power efficiency.

Who Needs It & Why?

Wi-Fi 6/6E is a key element in our connected world. Besides bringing more functionality to mobile devices, it drives improved connectivity for IoT, private networks, and deployments in dense public areas as well as across new products. The Wi-Fi Alliance estimates that Wi-Fi 6/6E will surpass 80% of the total Wi-Fi market by 2025. FEMs are found in numerous Wi-Fi-related products such as routers, set-top boxes, and more.

Under the Hood

Wi-Fi 6/6E devices are typically equipped with multiple radio systems-on-chips (SoCs) driving up to 16 RF streams and FEMs. To dissipate the heat generated by these high-performance Wi-Fi systems often housed in small industrial form factors, manufacturers were previously forced to compromise between performance, the cost of thermal management, size, and design aesthetic.

The combination of Skyworks' ICE FEMs and Broadcom's Wi-Fi silicon enables manufacturers of products such as Wi-Fi routers to deliver a dramatic and material reduction of up to 30% in overall power dissipation, reducing product cost and simultaneously contributing to a greener planet. It's claimed that with these devices, equipment providers can offer more sustainable products, smaller form factors, enhanced reliability, and superior performance as compared to any alternative solutions.

Skyworks Solutions

Video ► A Comparison of **Wireless Connectivity Protocols**

Texas Instruments recently introduced Matter-enabled software development kits for Wi-Fi and Thread SimpleLink wireless microcontrollers that will help streamline adoption of the Matter protocol in IoT applications. Matter is a royalty-free standard to connect compatible devices and systems with one another. Matter runs on Thread and Wi-Fi network layers and uses Bluetooth Low Energy for commissioning. **www.mwrf.com/21258843**

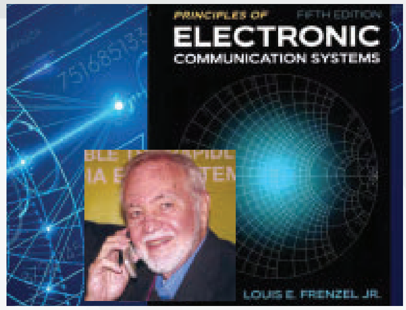
Video ► Minimizing the Signal Chain with **Direct RF Tech**

Mercury Systems' Ken Hermanny and Rodger Hosking discuss the company's deployment of Direct RF technology in its signal-processing products for defense and aerospace applications. **www.mwrf.com/21259424**

CONNECT WITH US

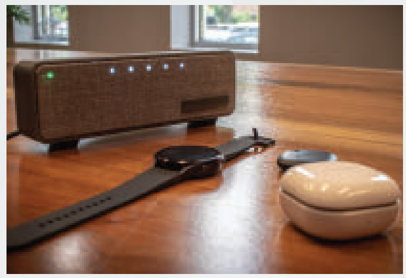
- www.facebook.com/microwavesrf
- @MicrowavesRF
- linkedin.com/groups/3848060/profile
- www.youtube.com/@engineeringtvEBM

Visit *www.mwrf.com* for more information on stories in this issue, plus exclusives on pertinent topics in the RF, Communications, and Microwaves Technology industry.



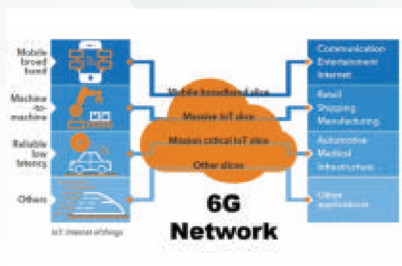
Remembering a **Communications Legend**

Lou Frenzel was an engineer, book author, and long-time contributor and editor with *Electronic Design* and *Microwaves & RF*. **www.mwrf.com/21258418**



RF Power Transmitter Ushers **Over-the-Air Wireless Charging into Homes**

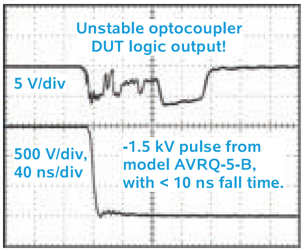
Powercast's RF power transmitter means to slash RF transmitting technology costs and make convenient, contactless power ubiquitous. **www.mwrf.com/21257162**



Using Integrated Digital Twins to Continuously Assess the 6G Testbed

This proposed testbed is intended for early and continuous assessment of relevant 6G technology elements on end-to-end user applications. **www.mwrf.com/21259199**

Transient Immunity Testers



The Avtech AVRQ series of high-voltage, high-speed pulsers is ideal for testing the common-mode transient immunity (CMTI) of next-gen optocouplers, isolated gate drivers, and other semiconductors. GPIB, RS-232, Ethernet ports are standard.

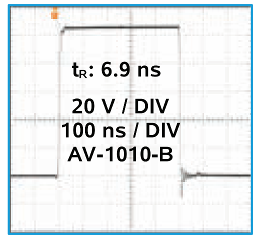
- Kilovolt amplitudes (±1 kV, ±1.5 kV, ±2 kV)
- Transition times down to < 10 ns, dV/dt rates up to 120 kV/us
- Daughterboards to handle a variety of DUT package styles

Nanosecond Electronics
Since 1975

Pricing, manuals, datasheets and test results at:
http://www.avtechpulse.com/semiconductor

30, 50 and 100 Volt Lab Pulsers

Avtech offers an extensive series of user-friendly ±30V, ±50, and ±100 Volt general-purpose lab pulsers. In many applications, these can replace the discontinued Agilent 8114A or HP214. Higher-voltage models are also available.



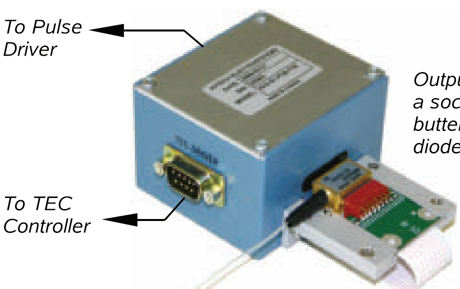
AV-1015-B:	±50V, 10 MHz, 20 ns - 10 ms, 10 ns rise
AV-1010-B:	±100V, 1 MHz, 20 ns - 10 ms, 10 ns rise
AV-1011B1-B:	±100V, 100 kHz, 100 ns - 1 ms, 2 ns rise
AV-1011B3-B:	±30V, 100 kHz, 100 ns - 10 ms, 0.5 ns rise

Includes switchable output impedance and double-pulse modes. Flexible triggering. GPIB / RS-232 / Ethernet.

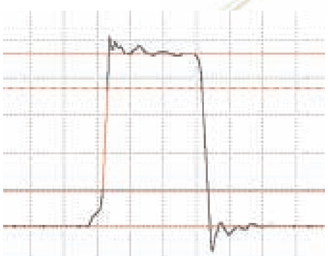
Nanosecond Electronics
Since 1975

Pricing, manuals, datasheets and test results at:
http://www.avtechpulse.com/general

Nanosecond Laser Diode Drivers With Butterfly Diode Sockets



Output module with a socket-mounted butterfly-packaged diode installed.



Model AVO-9A-B
40 mA/DIV
1 ns/DIV

Each of the 18 models in the Avtech **AVO-9 Series** of pulsed laser diode drivers includes a replaceable output module with an ultra-high-speed socket, suitable for use with sub-nanosecond pulses.

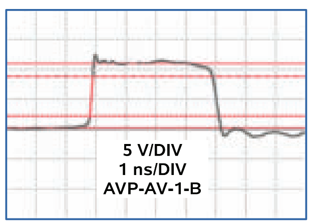
Models with maximum pulse currents of 0.2A to >10A are available, with pulse widths from 400 ps to 1 us.

GPIB, RS-232, and Ethernet control available.

Nanosecond Electronics
Since 1975

Pricing, manuals, datasheets and test results at:
http://www.avtechpulse.com/laser

High Output, Low Risetime Pulsers



Nanosecond and faster pulsers covering a wide range of amplitudes!

GPIB / RS-232 / Ethernet standard on “-B” models.

Standard and customized models available.

Ampl	t_{RISE}	Max. PRF	Model
5 V	80 ps	1 MHz	AVP-AV-1S-C
10 V	120 ps	1 MHz	AVP-AV-1-B
20 V	120 ps	1 MHz	AVP-AV-HV2-B
20 V	200 ps	10 MHz	AVMR-2D-B
40 V	150 ps	1 MHz	AVP-AV-HV3-B
50 V	500 ps	1 MHz	AVR-E5-B
100 V	500 ps	100 kHz	AVR-E3-B
100 V	300 ps	20 kHz	AVI-V-HV2A-B
200 V	1 ns	50 kHz	AVIR-1-B
200 V	2 ns	20 kHz	AVIR-4D-B
400 V	2.5 ns	2 kHz	AVL-5-B-TR

Nanosecond Electronics
Since 1975

Pricing, manuals, datasheets and test results at:
http://www.avtechpulse.com/laser

In 2023, Look for Cellular Providers to Continue Their 5G Transformations

Densification, automation, scaling up of private networks, and a push for monetization are among the trends Spirent sees for 5G in the coming year.

Photo 206953469 / 5g © Melpomenem | Dreamstime.com

By Steve Douglas, *Head of Market Strategy, Spirent*

THE TELECOMMUNICATIONS INDUSTRY has been talking about 5G for so long, it can be easy to forget that we're still in early days of the technology. After the COVID disruptions that began in 2020, rollouts proceeded at a brisk pace in 2022, and millions of subscribers gained access to 5G services. This year, communication service providers (CSPs) in every market will take the next step. Based on our work helping mobile operators test new technologies and validate their networks, here are the biggest 5G trends we're anticipating for 2023.

Operators Look to Densification, Core Evolution

5G has already brought more change to telecom networks than any previous cellular generation, and CSPs are still undergoing transformation. In 2023, most mobile operators will continue focusing on expanding 5G mid-band macro coverage. Some, however, will embark on the next big step in 5G rollouts: densification. We should see early production deployments using small cells and massive MIMO arrays this year.

2023 also will see CSPs push ahead with 5G Standalone (SA) core migration—albeit slowly. The biggest challenge remains the complexity of operating and securing multi-vendor, cloud-native 5G SA environments. Operators will need to weigh migration tradeoffs, too, as they work to guarantee performance and optimally align early deployments with their spectrum portfolios.

Open RAN Moves (Gradually) Forward

Many CSPs conducted testing and trials of Open Radio Access Network (RAN) architectures last year, and these efforts will continue in 2023. However, while CSPs are eager for the benefits of multi-vendor, plug-and-play RAN environments, actual solutions still aren't mature enough for large-scale adoption.

CSPs and their partners continue to demonstrate the technical feasibility of multi-vendor RAN interoperability in testbeds. The operational models needed to support Open RAN in large-scale networks, however, remain well behind those used for traditional vendors. Instead of jumping into fully open networks, many CSPs will take an intermediate step this year, adopting virtualized RAN solutions from traditional vendors while continuing to test Open RAN in small trial deployments.

More Operations Get Automated

Open RAN isn't the only operational challenge affecting CSPs. They also continue to struggle with the complexity that comes with new architectures and technologies in 5G, cloud, edge, and other areas. Facing pressure to lower costs and become more agile, more CSPs will focus on automating across the network lifecycle in 2023.

This push will affect everything from implementing DevOps processes, to building multi-vendor collaboration environments, to more closely integrating labs and testbeds to streamline product development and speed time-to-market. Many operators also will push to transform service assurance and move more of the network to zero-touch, "self-driving" operations.

Testing and requests for proposals (RFPs) in all of these areas grew throughout 2022, and that trend continues in the coming year, especially around assurance and Operational Support System (OSS) functions. As CSPs face pressure to match hyperscalers that have already automated much of their operations, we also anticipate more industry-wide discussions around removing the structural barriers—chiefly, lack of consistency and standardization—slowing service provider automation.

Operators Turn to Monetization

By end of 2022, CSPs had built out 5G networks enough to provide decent coverage for most users. However, new 5G subscriptions have typically just displaced 4G/LTE, leaving average revenue per user (ARPU) largely flat for most operators. This year, especially in more mature markets, CSPs will shift their focus toward aggressively pursuing new revenues.

Look for major pushes in areas like gaming, Voice over New Radio (VoNR), and Fixed Wireless Access (FWA) as a broadband alternative, especially for connecting rural and remote communities. Some CSPs will launch early enterprise edge offerings like advanced video analytics using Ultra High

(Continued on page 34)

Should Users Wait for **5G to Implement IIoT Networks?**

The emergence of 5G cellular networks promises a lot, but it's still some time away from complete global deployment. While 5G tech offers some exclusive features and benefits, much is already available via existing 4G networks.

By Stephen Mooney, *Product Sales Manager, Advantech IIoT Europe Wireless Systems*

ONE OF THE hottest topics these days is the introduction and rollout of 5G technology and the benefits it will bring to the industrial Internet of Things (IIoT).

The potential benefits of 5G are widely reported:

- Higher data throughput
- Better penetration
- Low latencies enabling real-time operations
- Higher mobile-device densities
- Flexible public/private network space that enable performance-based service-level agreements (SLAs)
- Low-power transceiver designs for long-term battery-powered devices

What's less widely discussed, and therefore less widely understood by those considering adoption of 5G, is that these benefits aren't all available concurrently. Indeed, some are effectively mutually exclusive. This means that while 5G offers many more ways to optimize the characteristics of the communications network to match the requirements of specific application deployments, it's by no means a panacea for all mobile communication issues.

So, although 5G will undoubtedly be a very significant technology for the future of the IIoT, there are many cases in which existing 4G/LTE-based technology readily meets the application's needs. Then, there's the huge additional benefit brought by 4G/LTE being widely and cost-effectively available today.

What is 5G?

The latest generation of mobile cellular telephony has a number of differences from its predecessors. Most of the detail changes exist buried deep in the core of the network infrastructure. These pave the way for more flexible radio-access protocols, leading to higher mobile device densities, more flexible private-network creation, and more efficient and reliable routing of traffic through the core.

At the cell towers, beamforming technology improves signal quality for any individual user session, and new frequency bands have become available beyond those used in previous generations of cellular equipment. These additional, much-higher-frequency bands enable faster transmission and therefore higher data throughputs coupled to higher device densities. It should be noted, though, that the highest frequency bands are only for applications over relatively short distances.

Advantech

5G Better for Some

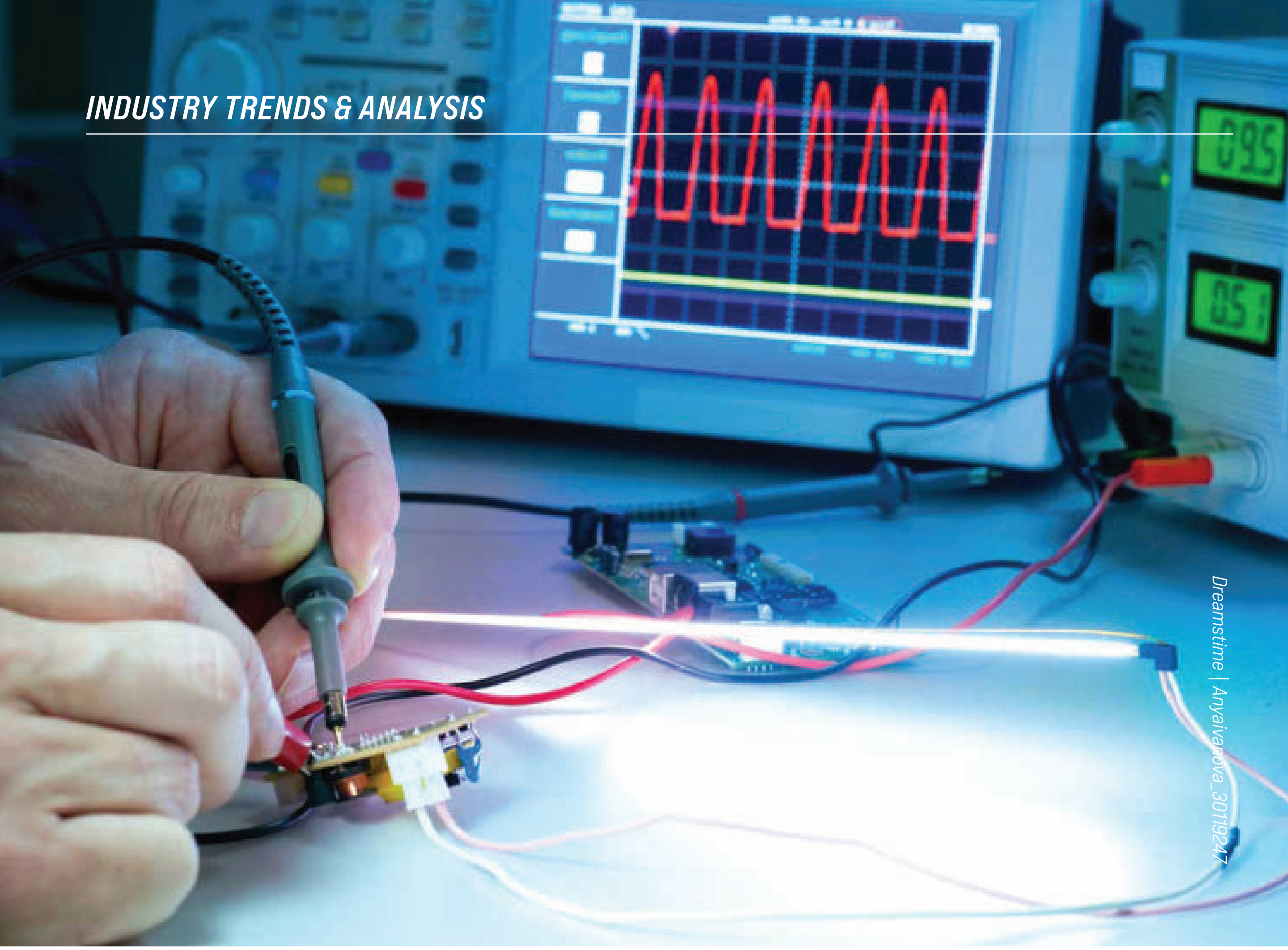
This means that rollout of 5G networks across Europe will bring with it the possibility to address applications that were previously not practical. For example, at the high end of the radio spectrum, the high-bandwidth, low-latency expansion will provide opportunities to expand real-time video-monitoring applications beyond the current physical limitations imposed by the need for fixed wire or Wi-Fi connection.

Yet, in the middle ground, a huge number of use cases need near real-time reporting of a medium volume of data, and here the benefits are less clear. The ability to support more subscribing devices within a particular cell is of value in extremely densely populated urban environments, and the beamforming capability should mean service levels in sparsely populated rural locations are better. However, both of those situations tend to be outliers from the majority of IIoT applications.

Better implicit security exists within the access mechanisms to a 5G network, plus there's much more flexibility to create and maintain private-access groups to the network Still, other than convenience and perhaps some cost benefit, these achieve little that can't already be done with LTE in many cases.

The same is true for low-speed, low-power, and high-penetration applications. 5G leverages the NB-IoT technology that's already available in many LTE deployments. For sure, the vastly improved device densities promised by 5G will enable the coexistence of many installations in non-mission-critical monitoring applications. In turn, that will provide massive volumes of low-level data upon which AI systems can operate.

(Continued on page 34)



Survey Affirms the Ever-Evolving **Test Industry's Expansion**

***By Alix Paultre,** Editor-at-Large*

The test & measurement space continues to morph while spreading its wings, as well as grow in capability and utility. Our recent survey on this industry offers a glimpse into this developing marketplace.

The role of test & measurement engineering in our modern electronic development environment is undergoing a period of expansion in terms of functionality, capabilities, and application, among others. In one sense, the T&M community is a victim of its own success, as many of the latest T&M solutions in the industry aren't always recognized as such. Design engineering tasks that used to require a bench session or a visit to a development lab can now be done in the cloud on a laptop, blurring the lines between design and development duties.

This isn't a bad thing. Today, it's imperative that T&M be integrated into every step of design, development, and manufacturing to achieve the performance and productivity demanded by the modern marketplace. A design can now go from a concept drawing on a datapad, to a file in a collaborative simulation software tool, to a six-sigma smart factory, to over-the-air updates in the field until the product runs out of warranty. Advanced T&M solutions are involved in every step.

We recently held our annual test & measurement industry survey, where several hundred editors provided us with

Our current electronic development environment is full of design challenges involving the latest technologies and ways to ensure that an application solution has the desired functionality and performance.

answers to several questions about their work. Design engineers made up 33% of the group, with an additional 17% being directly involved in R&D. Notably, 10% were instructors or teachers, giving us an insight into where we are from that perspective. Interestingly, 7% identified themselves as hobbyists/makers, a demographic growing in both size and importance. Not surprisingly, 80% of the respondents identified themselves as working regularly with T&M technologies.

Challenges in Test & Measurement

Our current electronic development environment is full of design challenges involving the latest technologies and ways to ensure that an application solution has the desired functionality and performance.

When it came to the challenges they're facing *(Fig. 1)*, our engineering audience was roughly equally split into four blocks, the largest two being those who indicated that system integration was the biggest challenge and those who felt that it was validation and compliance. Addressing developing technologies and the challenges of automated test made up the rest of the bulk of replies.

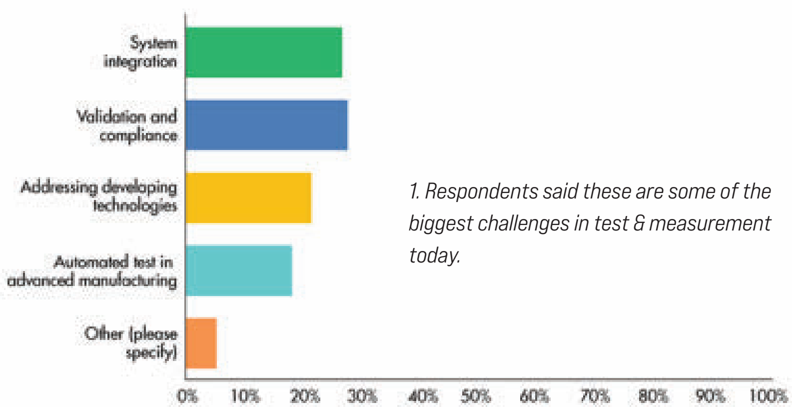
System integration and compliance and validation are closely related, as the issues of one are manifested in the other. If problems with EMI or RF noise arise in a poorly designed system, it will directly impact the product's performance when it comes to standards compliance. Of course, integrating the latest technologies in a design can help address these issues, but they typically come with learning-curve and solution maturity challenges.

For example, using wide-bandgap semiconductors can help with power-density and thermal-management issues. However, the higher operating frequencies usually involved with the advanced topologies needed to achieve the promised performance place stresses on the passives and magnetics, which if not properly addressed can lead to cascading problems throughout the circuit. Then, of course, everything must be tested during manufacture, requiring proper design of automated testing stations and processes.

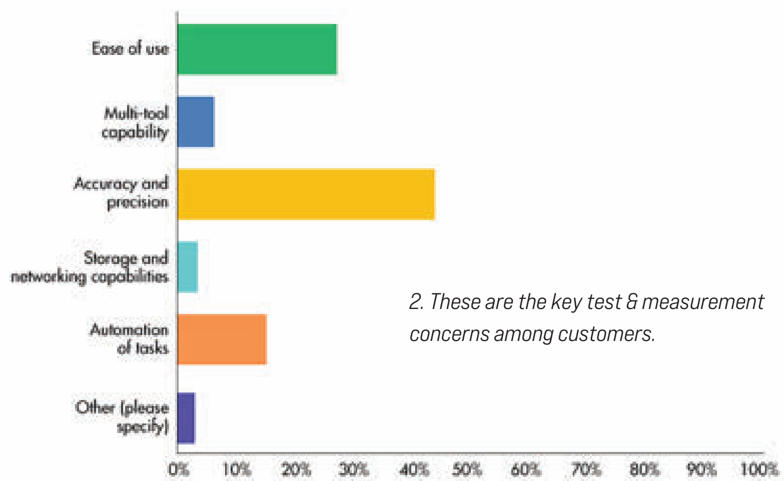
Concerning the Customer

How the T&M industry sees things and how their customers see them often differ due to perspective. When we asked about important test & measurement concerns among their customers *(Fig. 2)*, our respondents told us that accuracy and precision was number one by a wide margin, followed by ease of use and task automation, which are in their own way related. This makes a lot of sense, as it reflects on the engineer's concern about how to achieve the application performance desired by the customer.

Today's electronic solutions are noteworthy for their advanced levels of func-



1. Respondents said these are some of the biggest challenges in test & measurement today.



2. These are the key test & measurement concerns among customers.

tionality integration, compact dimensions, and wireless capability, and that can only be achieved using the latest T&M tools and methods. The hardest aspect of T&M is that those devices must use the latest technologies and implement them in a way that's even more accurate and precise than the systems they're testing. The lines on your ruler have to be closer together than the features you're trying to measure, or there's no precision.

The latest T&M solutions can perform tasks and measure things that were either impossible or extremely expensive to do only years ago. In addition, recent events have caused the remote and collaborative aspects of these tools to become more refined.

Integrating multiple subsystems and making them operate properly together, ensuring standards compliance, and establishing an optimal manufacturing process to create the desired product can now be done by a team connected only by their software and hardware development tools.

Current Trends in Test & Measurement

The future is always an uncertain place, and it is hard to predict with any great certainty what will happen in the marketplace. However, trends that are hot today will be of high interest for the foreseeable future. *Figure 3* shows the results of our question on trends in test & measurement today. Most answered that cost-effective benchtop solutions were the most important to them, followed by two items that are also related—connectivity and collaboration along with software-based design tools.

This is a direct reflection of the interest the T&M industry has in these new collaborative, electronic system-development software tools, and the force-multiplier they are to a design team. The ability of a team, locally based or far-flung, to collaborate on a circuit, board, package, or process can't be understated. This ties directly into other smart initiatives like design-for-manufacture and supply-chain management, as well as supporting team flexibility in location and accessibility.

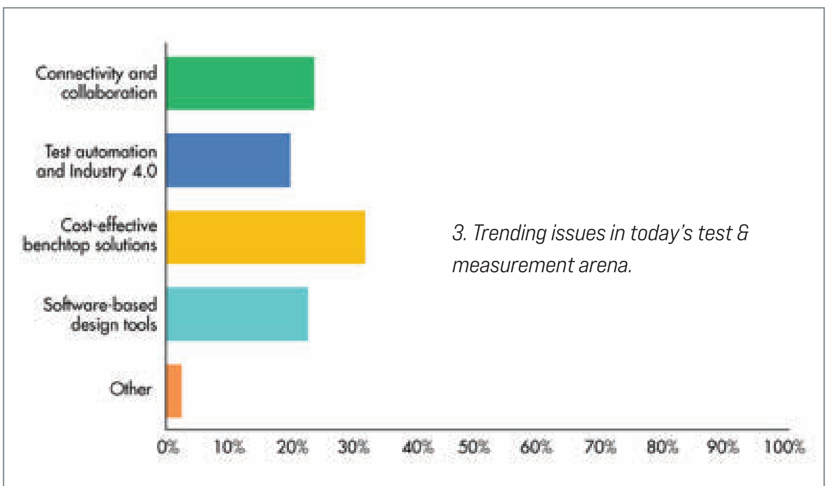
The other trend mentioned ties directly into the leaders, and that's the growth of test automation and Industry 4.0. These are all connected (no pun intended), as they leverage one another to serve the goal. The simulation software takes supply chain into consideration in parts selection, while the design team also collaborates on how the product will be made and tested. Any issues at any stage are fed back through the system to ensure proper fixes and redesigns are made.

Looking Forward

The test & measurement industry and community is going through a sea change, as the tools and techniques that used to be bench- or lab-based can now be done in software, often in a collaborative fashion. Tests that need to be performed physically, especially those needed to achieve six-sigma manufacturing, can now be performed with advanced integrated networked bench tools and ATE setups.

> *The future is always an uncertain place, and it is hard to predict with any great certainty what will happen in the marketplace.*

T&M is becoming an ever-more integral part of design, with many T&M functionalities being built into development and manufacturing. As a result, our devices and solutions are more precise, accurate, efficient, and reliable than ever before. There's no precision without feedback, and the latest in test & measurement tools and solutions provide the best feedback and performance information that has ever been possible to achieve in history.



3. Trending issues in today's test & measurement arena.

How to Cloak Radiating Elements

in Multiband Antennas for Optimized Performance

The increasing complexity of mobile communications networks over the last 40 years has been astounding. This transformation has significantly changed radio-access-network antenna technology, requiring new design methodologies.

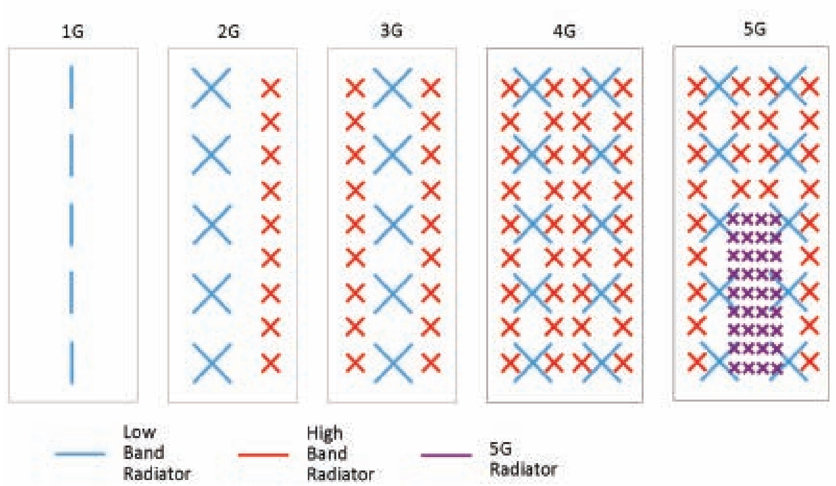
By Peter Liversidge, *Director of R&D, Alpha Wireless (Australia division)*

Over nearly 50 years, mobile radio-access-network (RAN) base transceiver station (BTS) antenna technology has advanced from single-frequency-band antennas with a single port to antennas with dozens of ports and multiple frequency bands. All of this technology is now contained within a housing roughly the same size as was used back when public mobile communications networks first started in the 1980s.

This evolution of antenna technology has been driven by the need to overcome the vagaries of radio signal propagation, where there can be multiple signal reflections from the ground and other objects in the natural and built environment, as well as direct or refracted paths that can be partially blocked. These multiple signal paths may combine or cancel out each other, producing an unreliable communications channel.

Advanced antenna design can help overcome this multipath propagation by adding more radiating elements per frequency band—in physically separated or orthogonally polarized arrays that diversify possible signal paths.

Because these elements are fed by different ports on the antenna, they are, in effect, totally isolated channels (that's the idea, anyway). If one channel is fading, then another may be less affected due to the way the various signals add and subtract over different signal paths and with orthogonal polarizations. This spatial or polarization diversity improves the quality of the received signal because there's less chance of signals fading when the different channels are combined and processed.



1. As mobile communications technology evolved from 1G to 4G and 5G, an increasing number of arrays of radiating elements within each generation of antenna has necessitated the technique of interleaving low- and high-band elements to avoid increasing antenna size. Images courtesy of Alpha Wireless

In the more advanced 4G and 5G RAN standards, these multiple ports per band also can be used to send more data to each user, enabling enhanced mobile broadband (eMBB) capabilities. Each channel is able to carry separate data streams, which can then be combined at the receiver with multiple antennas carrying the traffic within the same frequency band using a multiple-input, multiple-output (MIMO) configuration.

However, deploying a greater number of antennas increases wind load, visual pollution, and tower rental costs. Therefore, these multiple antennas should be contained within the same housing. And as the number of antennas increases in a MIMO system, so too does the RF design complexity.

Another driver of RAN antenna technology evolution is the irrepressible demand for more data. As early mobile technology (which had only voice to contend with) has progressed to 5G networks, we've added data capability, images, and now high-definition video with increasing data speed requirements.

With more frequency bands continually allocated to meet the demand for bandwidth, large chunks of spectrum are now used for mobile communications between

600 MHz and 6 GHz. The need for multiple frequency bands to be deployed has meant that radiating elements and their associated feed networks must be provided for each of these bands.

Furthermore, many government authorities and the public demand that BTS antennas don't grow bigger in size and proliferate on towers. These radiating elements from multiple frequency bands now must coexist in the same space within the antenna.

BTS Antenna Evolution

The challenge of adding new frequency bands and multiple ports to antennas, while maintaining antenna size through successive generations, has kept antenna designers very busy. *Figure 1* illustrates the evolution of the technology from 1G to 4G and 5G, showing diagrammatically the arrays of radiating elements within each antenna generation.

The diagrams show each radiating element as a short line, representing the polarization of the element. The elements are commonly arrayed vertically to increase the aperture of the antenna in the vertical direction and therefore compress the beamwidth along this axis.

For 1G technology, the antenna had only one port, in the 800/900-MHz band, and each element was just singly polarized—normally vertical linear polarization provided by a dipole or patch. For the second generation of mobile technology, a higher-frequency band was added in the 1800/1900-MHz range, and polarization diversity was included to combat multipath fading. Arrays from the two frequency bands were normally separated in the antenna to prevent them from interfering with each other—a common problem that we still need to address today.

For the advent of 3G and 4G, both low- and high-frequency bands were extended to provide greater bandwidth. More low- and high-band arrays also were added to provide more ports for the various sub-bands—for instance, the 1800-MHz band could be accommodated on separate ports from the 2100-MHz band. On top of that, more ports were required for MIMO operation.

This created the problem of having nowhere to put the extra arrays without increasing antenna size, necessitating the technique of *interleaving* low- and high-band elements. Because it involves using the same space to accommodate radiating elements from both low and high bands, the elements must be physically arranged so that they don't interfere with each other both mechanically and electrically.

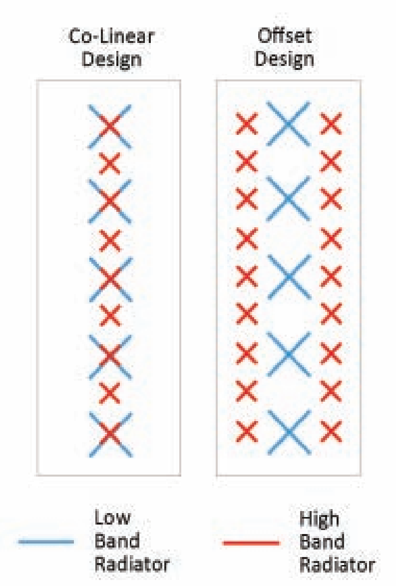
5G brought new frequency bands and more sophisticated technology. The new bands can be incorporated into the same antennas that use 3G/4G, but they're often deployed in separate antennas due to the increased complexity of the technology.

Multiband Complexity

To achieve the interleaving of radiating elements from different bands, antenna vendors have employed two separate approaches to attempt to solve the problem of mechanical and electrical interference. One approach involves arranging the radiating elements from each band in a co-linear fashion *(Fig. 2, left)*, but this requires that the higher-band elements are an integral multiple of the low-band elements—commonly two. This relationship depends on the ratio of the wavelengths for each band and doesn't always work out; these bands have been extended as the generations evolved. The result: compromises in antenna performance.

A second approach *(Fig. 2, right)* arranges the higher-band arrays alongside the low-band array(s). With this technique, the high-band arrays can be designed independently of the low-band array(s), and the spacings between the elements in the array can be individually optimized for each band.

However, regardless of how the low- and high-band elements are arranged physically, it's possible that the high-band elements can become resonant at the low band. That's difficult to combat when both the high- and low-band elements must operate over a very wide band.



2. Neither co-linear nor offset design has completely resolved the problem of mechanical and electrical interference when interleaving radiating elements from different bands.

For instance, the low-band elements are commonly required to operate from 698 to 960 MHz and the high-band elements from 1695 to 2690 MHz. It becomes a struggle to move the resonant behavior of the high-band element out of the low band while keeping the dipole operating properly at its own high band.

When the high-band dipole becomes resonant at the low band, it can significantly impact the radiation pattern of the low band, particularly the azimuth pattern (horizontal plane) when the high-band dipoles are displaced in the azimuth direction.

These extra resonator sources add to the signal radiated from the low-band dipoles and disrupt their pattern. This isn't acceptable in a mobile network where azimuth beamwidth must be well controlled and signal propagated outside an antenna's own sector needs to be minimized to avoid co-channel interference, which leads to poor quality of service (QoS).

Another problem stemming from interleaving of low- and high-band arrays is that the low-band dipoles can scatter high-band signals because they're electrically large at the high-band frequencies.

As the signals are scattered and antenna efficiency is reduced, its radiation pattern becomes disrupted.

Frequency-Transparent Cloaking

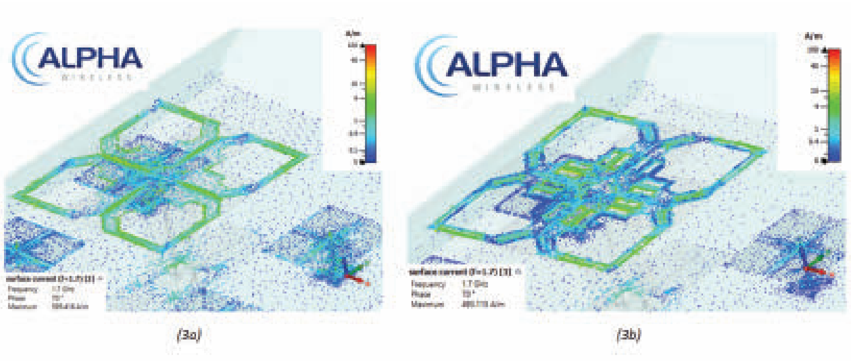
So how can antenna manufacturers tackle these common problems in an interleaved multiband antenna? One approach to designing interleaved multiband antennas is Alpha Wireless's frequency-transparent dipole technology (FTDT). When using FTDT, multiple antenna arrays for both the same and different bands can be packed into one space without compromising the performance of each array.

First, for the low-band dipoles, coupled-resonator filters were introduced onto their radiating arms, which extend over the top of the high-band elements and can cause serious scattering of the high-band signals. These filters allow for low-band current to pass unimpeded along the arms but block high-band currents from propagating. If the high-band currents are suppressed on the low-band arms, there's less scattering, and the low-band arms look more transparent to the high band. This results in less distortion to the low-band radiation patterns.

Figure 3 shows high-band current flow on the low-band dipole arms when the high-band dipoles are radiating. It shows the high-band currents when there's no filtering on the low-band dipole arms *(Fig. 3a)* and the currents after introduction of resonator filters *(Fig. 3b)*. Blue coloring indicates low signal level, with green being stronger.

It's evident from the figures that high-band current is suppressed by the filters. Also, propagation along the low-band dipole arms is blocked where the filters are located and only circulates within them.

Figure 4 shows the effect on the antenna's high-band azimuth pattern by the introduction of filtering on the low-band dipole arms. *Figure 4a* demonstrates high-band radiators without any low-band dipoles present, *Figure 4b* adds low-band dipoles without filters, and *Figure 4c* is with filtered low-band dipole arms. Pattern distortion is greatly reduced with the filters present, and the original high-band pattern is nearly recovered.



3. These images show how high-band filters on the radiating arms of low-band dipoles can suppress unwanted scattering of high-band signals on those low-band arms—a low-band dipole without high-band filters in the presence of active high-band dipoles (a), and a low-band dipole incorporating high-band filters (b). Green areas indicate long sections of high-current density excited on the low-band dipole arms, which can radiate on the high-band frequencies, whereas the blue areas have lower current density.

The resonator filters help the high-band patterns immensely, but they're awkward for the low band because they disrupt the tuning of the low-band dipoles. Thus, the low-band dipoles are harder to impedance-match and return loss will be worse, meaning more signal is undesirably reflected to the antenna's input.

Therefore, the design task for antenna engineers has an added dimension in that the degree of filtering, and the low-band return loss, are tradeoffs and the best compromise must be met. Significant simulation and testing must be undertaken before reaching the optimized state.

Having solved the interaction between the low-band dipole arms and high-band signals by making the low-band dipoles "frequency transparent" at the high band, antenna design engineers are still needed to solve the previously mentioned resonant behavior of the high-band dipole at the low-band frequency. These are completely independent problems requiring different solutions.

Common-Mode Resonance

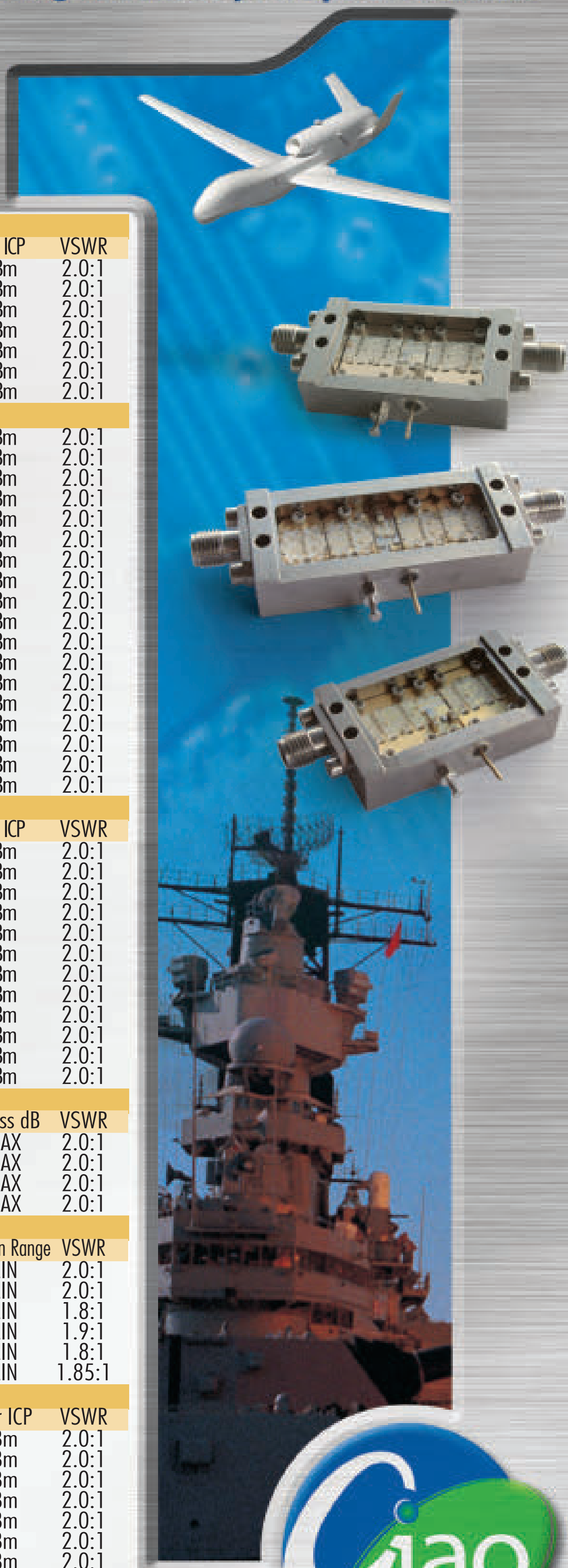
The high-band dipoles are designed to resonate at the high band, which is why they radiate and act as the transducers that convert signal propagating along a transmission line, like a coaxial cable, into electromagnetic waves.

The resonant frequency of the dipoles depends on their physical size in wavelengths. Therefore, if the dipoles are designed to be a certain size to suit the high band, one may wonder how they could resonate at a much lower frequency. To resonate at the much lower frequency band, the dipoles should be much bigger.

In normal operation, only the dipole arms radiate EM energy. Unshielded or unbalanced signal propagating along the dipole's supporting structure should be avoided, otherwise this will radiate as well in an uncontrolled and undesirable fashion.

With the before-mentioned typical frequency relationship between the commonly used bands in mobile communications—698 to 960 MHz for the low band and 1695 to 2690 MHz for the high band—an unfortunate situation arises: The *total size of the high-band dipole*, including the dipole arms and supporting structure that contains the matching balun, can become resonant at the low band much like a monopole.

This resonance is a result of the direct frequency ratio of the low and high bands and is very difficult to avoid. This occurrence is termed a "common mode" because all parts of the dipole contain



signal propagating in a common direction, from the dipole-arm tips to the ground plane where the dipole supporting structure is connected. Since the whole high-band dipole structure is conducting signal like a monopole at the low-band frequency, it will radiate and add an undesirable signal source to the antenna that disrupts the low-band radiation patterns.

Alpha Wireless's engineers devised several different means to combat the common-mode low-band resonance in the high-band dipoles, depending on the exact frequency relationship required between the low and high bands. These methods push the resonance frequency either up or down and out of the low-band frequency range.

In fact, the FTDT method uses the resonant frequency as an advantage to *improve* the low-band radiation patterns by selecting its location precisely using some aspects of the high-band dipole's signal-feeding arrangement. The technology provides a way to do this without disrupting the high-band dipole's own impedance matching, which often suffers when tackling such a common-mode problem.

The ability to improve the low-band radiation patterns is particularly important for the design of slim, multiband tri-sector antennas with a diameter of only 360 mm. It enables the common-mode frequency's position to be used to maximum effect to optimize the azimuth patterns, which are otherwise compromised due to the smaller diameter than optimum for this band.

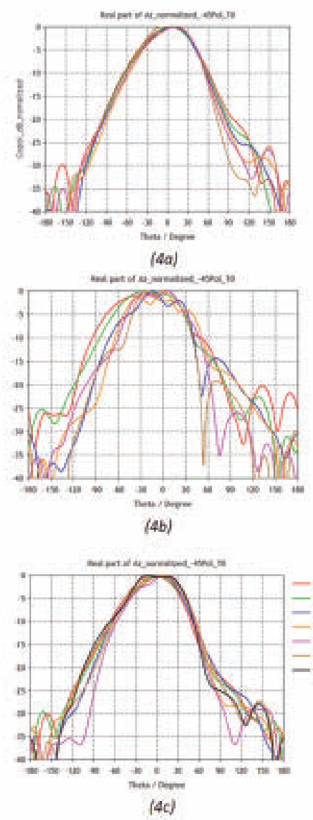
Figure 5 shows the effect on the low-band patterns of introducing these common-mode design techniques to the high-band dipoles. Evidently, the common-mode resonance can severely disrupt the low-band patterns, but the FTDT method addresses the problem *(Fig. 5c)*. In this way, we have successfully tackled the complexities encountered when interleaving radiating arrays from multiple frequency bands in one antenna: Using resonator filters on the low-band dipole arms and modifying the high-band dipole feed network shifted common-mode resonances out of the low band.

Conclusion

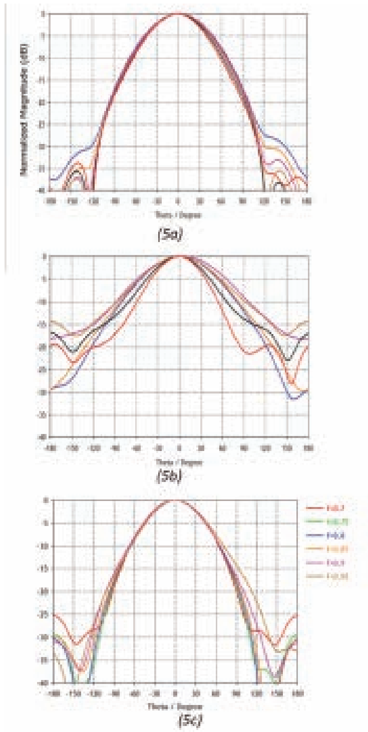
Mobile communications networks have become a ubiquitous digital infrastructure that enables our hyper-connected global society. As the subscribers' first point of contact with these networks, antenna technology plays a pivotal role in ensuring QoS.

The ever-increasing demand for bandwidth is driving a transformation in antenna technology, requiring multiple arrays of radiating elements at different frequency bands to operate together in one unobtrusive antenna design without interfering with each other. Yet, the various interactions between the radiating elements of each band can wreak havoc with radiation patterns, which has negative repercussions on network performance and customer experience.

To address this significant RF design challenge, Alpha Wireless developed frequency-transparent dipole technology. With the capability to enable exceptional radiation-pattern performance in even the smallest diameter tri-sector antennas, this design technology helps pave the way to greater mobile network speed, capacity, and performance. ■



4. Here, we see the effects on high-band radiator azimuth patterns of a multiband antenna when resonator filters are added on the low-band dipole arms. At the top is the high-band azimuth pattern in the absence of low-band dipoles (a). In the center, we see the distortion imposed by low-band dipoles on high-band patterns (b). On the bottom, the high-band patterns are nearly restored by adding resonator filters to the low-band dipole arms (c).



5. Here's how low-band radiator azimuth patterns for a multiband antenna are affected by suppressing the common-mode resonance on the high-band radiator structure. The plot on top shows the low-band azimuth pattern without any high-band dipoles present (a). The middle plot shows standard high-band dipoles present with common-mode resonance in the middle of the low band (b). The plot on the bottom illustrates the low-band patterns nearly recovered when the common-mode resonance in the high-band dipoles is moved out of the low band (c).

1. Shown is a rendering of a 5G-connected factory management network. Source: Blue Planet Studio/Stock.Adobe.com

The Past, Present, and Future of **Ultra-Wideband Technology**

UWB can (and will) provide faster data rates and enhanced security for 5G applications.

By Alex Pluemer, *Senior Technical Writer*

In a world soon to be saturated with 5G and the industrial Internet of Things (IIoT), everything from industrial sensors and inventory monitoring systems to medical wearables and smartphones will be connected to a network—and most of them already are. Parents can keep track of their kids' whereabouts, and doctors can keep receiving updates from their patients' pacemakers through apps on their respective phones. At the same time, commercial retailers can monitor and reroute deliveries through GPS tracking systems in their fleet vehicles. This connectivity and data transference strains existing signal protocols like Wi-Fi and/or Bluetooth, potentially creating lag time in uploading/downloading and possibly significant signal interference.

With these issues anticipated to only grow as the size of networks expand and the number of connected devices proliferates, developers have been investigating different ways to wirelessly connect devices/computers/vehicles to large mesh networks—and, with regulatory help, they've found one. Ultra-wideband (UWB), a signal protocol that has been restricted to public and military implementations since the early 20th century, has been repurposed for commercial use to augment Wi-Fi and Bluetooth in the quest for global connectivity.

UWB technically refers to any signal equal to or greater than 500 MHz (with a fractional bandwidth >20%). Still, UWB typically operates between approximately 3.0 and 10.5 GHz, enabling it to transfer significantly more data and making it less susceptible to signal interference than narrowband signals. UWB also is less costly and more energy-efficient than Bluetooth, and it's an appealing alternative in short-range transmission scenarios, such as within an office building or manufacturing facility. This article will examine UWB's past, present, and future and determine where it will fit into the world of 5G connectivity.

The Origins of Ultra-Wideband

The genesis of UWB can be traced back to the first radio-signal devices that utilized spark-gap transmitters to communicate wirelessly. These devices could transmit sound through short electrical impulses over short distances, eventually leading to radio-wave transmission. In its infancy, UWB sent old-fashioned telegraph signals over large distances, such as messages to ships at sea. As the technology evolved, UWB's higher frequency ranges made it an optimal method of transmitting large amounts of data, such as images or video files, over shorter distances.

UWB might have become the original wireless communication standard, but it was outlawed for commercial use in 1920, becoming a proprietary protocol for classified government and military implementations. UWB remained out of bounds for public use until 2002, when the Federal Communications Commission in the U.S. opened it back up for commercial applications.

Since then, UWB has propagated into various technologies, including radar and location/positioning systems, medical devices and wearables, and consumer electronics. Apple included UWB tech in the iPhone 11 (released in 2019), enabling far more accurate positioning and ranging capabilities than previous iterations.

Where Ultra-Wideband is Now

The ongoing transition to 5G has been an inflection point in the adoption of UWB into networking and communication technology. UWB signals are transmitted in short, quick pulses (measured in picoseconds) like the spark-gap transmitters of old or in RF carrier waves.

Data transferred in pulses is transmitted by alternately turning the signal on and off—as lighthouses used to communicate with ships off the coast by flashing signals in Morse code. It may require over a hundred pulses to transmit a single bit of data, but the high rate of speed at which the bits are transmitted (each pulse lasts fewer than 1.5 ns) enables data rates of up to 27 Mb/s.

Carrier waves also can be created by modulating the signal to simulate an RF wave. UWB is able to transmit data over multiple frequencies simultaneously and achieve much higher data rates than other wireless technologies. Implementing UWB with 5G networks can provide customers with faster upload/download speeds and greater bandwidth.

Moreover, USB is an optimal solution for real-time tracking and positioning applications, whether in consumer electronics (like the iPhone) to manage inventory or determine the location of products, or in equipment within a factory/manufacturing setting *(Fig. 1)*. UWB-enabled devices come equipped with multiple-input, multiple-output (MIMO) antennas that fit into devices as small as smartphones or watches. When two UWB-enabled devices are close enough to connect, the devices begin "ranging," or ascertaining their respective locations and distance from one another through a "time of flight" determination.

By sending a pulse from one device to another and measuring the time it takes the pulse to complete its journey, the two devices can determine their exact locations relative to one another. This is especially advantageous in indoor settings where GPS isn't always as functional, and Wi-Fi can struggle to break through solid objects and surfaces. If you're the type who's always misplacing their phone or who can never find the TV remote, UWB can pinpoint their respective locations in your home within inches.

Due to its short transmission period and small packet size, UWB also is found in applications that require lower latency and faster system response times, like gaming and training simulations. UWB's low spectral density helps prevent signal interference, too, and makes UWB signals very difficult to detect, providing more security for data transmission. The additional security UWB provides is already being incorporated into digital car keys. Companies like BMW and Tesla are reportedly developing digital car keys that implement UWB for their vehicles to reduce incidents of signal relay theft from key fobs that transmit traditional radio signals.

Where Can UWB Go from Here?

We've covered UWB's past and present—now, let's peek into its future. One of UWB's most apparent potential use cases is in applications requiring high data-transfer rates, such as real-time video streaming. Security camera and traffic camera networks can provide much higher-quality video using UWB than other wireless communication protocols and reduce latency and streaming delays (like buffering).

UWB's lower latency also makes it a good potential fit for vehicular automated-driving system cameras to avoid collisions with other moving vehicles. Automobiles with automated-driving systems can almost instantly share locations and speed/directional vectors. This kind of data-sharing between vehicles also can improve overall traffic flow and fuel efficiency by suggesting alternate routes to avoid delays.

Sharing data between vehicles and general infrastructure is another potential benefit. Ever been stuck driving around the big city on the weekend and can't find a place to park? Imagine a network of parking lots and garages that can communicate to motorists in real-time where open parking spots are available. You may never have to circle the same three-block radius looking for a parking spot again.

The enhanced safety and convenience UWB can provide doesn't just apply to transportation. Personal medical devices can utilize UWB to create a personal wireless area network around a patient that collects and shares information with a central application. A patient's heart monitor could communicate with their smartwatch or smartphone to collect medical data and provide their doctors with real-time updates on their heartbeat, blood pressure, etc. Monitoring arrhythmias and other heart-related issues in real-time can significantly impact diagnosing—and even predict—cardiac events as early as possible.

2. Realizing the benefits of mesh networks of devices, vehicles, and infrastructure in smart cities will mean large numbers of devices exchanging data almost constantly. Source: Lesley Wang/Getty Images

UWB implementations with health benefits won't necessarily be limited to serious medical conditions, either. Fitness monitors and some smartwatches have built-in health-monitoring applications that can receive and store data on a user's heart rate, body temperature, blood oxygenation levels, and more. A lifetime's worth of that kind of information, coupled with algorithms that consider a user's medical history, could have enormous predictive value in preemptively diagnosing and treating a wide range of medical ailments, including cancer.

Realizing the benefits of personal wireless area networks will require larger-area mesh networks and large numbers of mobile connected devices sending and receiving data almost constantly *(Fig. 2)*. Connected devices and vehicles will be able to reduce communication latency by sharing data directly between devices instead of through a central hub. Instead of checking for traffic information on the radio or the traffic app on your phone, your vehicle will communicate in real-time with other automobiles on the road. Commercial fleets won't have to check in with a human dispatcher to provide and receive delivery updates; their vehicles will plan their optimal routes using data collected from other vehicles in their network.

Algorithms will help find the most power-efficient and lowest latency pathways for data transmission, like how electrical current flows through a resistance network, finding the path of least resistance as the resistance increases or decreases. In a network of connected devices often in motion, optimizing data transference while reducing signal interference will be key factors. UWB can provide greater bandwidth and signal security than Wi-Fi and Bluetooth.

Conclusion

Although UWB isn't exactly new, its potential in the IIoT and the 5G-connected world is still being investigated. A world of connected devices and vehicles will require a lot of bandwidth, possibly more than existing narrowband signal protocols can handle. UWB can provide greater bandwidth and faster upload/download speeds than Wi-Fi and/or Bluetooth while coexisting alongside them—because they operate on different frequencies.

With lower signal power, UWB signals don't interfere with each other or their narrowband counterparts. UWB signals are also more challenging to detect and hack into than Wi-Fi or Bluetooth transmissions, providing enhanced data-transmission security. By implementing UWB alongside narrowband signals, a world of connected devices sending invisible streams of data to and from one another could become a reality.

Major tech conglomerates have already begun incorporating UWB technology into consumer electronic devices, and it's currently being implemented in industrial inventory monitoring and tracking applications. UWB is a significantly better option than narrowband signals in tracking and location applications—it can provide much greater specificity regarding time and location than applications using narrowband signals.

Knowing that an airplane has landed safely on the ground is one thing, but knowing exactly where it is on the tarmac relative to other aircraft and ground support vehicles could prevent serious injury or equipment damage. Receiving that kind of data in real-time could allow planes to effectively land and park themselves, much like self-driving cars. UWB has the distinction of being both the oldest and newest signal protocol on the scene, and it still has a mountain to climb to catch up to Wi-Fi and Bluetooth in the 5G realm—but, given its inherent benefits, it probably won't take long.

UNLOCKING the SMART HOME'S BRAIN with MATTER

Iurii Motov #1360235418 | iStock / Getty Images Plus

The CSA's Matter standard will enhance consumers' smart-home experiences with advanced interoperability and generate more competition in the smart-home device market. But what does this mean for developers?

By Rob Alexander, *Principal Product Manager - Matter, Silicon Labs*

ANTICIPATED IN LATE 2022, the Connectivity Standard Alliance's (CSA) Matter standard is set to positively change the way smart homes operate—with advanced interoperability between devices and more reliability overall. While consumers will enjoy a more seamless and connected smart home, with more product options than ever before, developers and manufacturers also will benefit from the streamlined processes ushered in by Matter.

Fundamentally, Matter is a home-automation connectivity standard that will allow for IoT products from different providers and manufacturers to work together. In today's pre-Matter smart home, each device requires a controller that essentially operates as the smart-home system's brain. Device manufacturers will often build "brains" into existing devices, often speakers and voice assistants like the Amazon Echo and the Google Nest, to act as the main hub for communication throughout the rest of the smart home.

For example, when a smart-home user wants a light in the house to be turned off at a certain time, the communication goes through the brain, and/or hub, of the smart home first and then to the light. For this to work properly, the devices must be able to communicate with the hub.

Prior to Matter, consumers needed to ensure that their devices work with the smart-home hub already in their home. A smart lightbulb that only works with Google Home can't perform its smart capabilities if the only hub in the house is Amazon Alexa. Thus, consumers either must purchase only the smart-home components that are compatible with the hub they already own—devices within the same "ecosystem"—or purchase multiple hubs to be able to use products in different ecosystems.

Matter will unlock the communication barriers between ecosystems. It will open up the smart-home device marketplace, giving consumers more product options without having to purchase a hub for every ecosystem, and allow for simplified smart-home device setup and standardized security.

Video ▶ www.mwrf.com/21257920

Supply Chain and Developer Advances

The introduction of Matter will give developers and device manufacturers more access to the smart-home market. Smaller, commercial home product makers will have the opportunity to connect to larger IoT ecosystems and platforms, with reduced development and production time and costs.

Consider a manufacturer selling smart doorbells that are compatible with Amazon Alexa and Google Home. Without Matter, the doorbells for the Amazon ecosystem and Google ecosystem would require different stock-keeping units (SKUs) and have different hardware and software. When the Matter standard is implemented, the doorbells would only need one SKU, greatly simplifying the supply chain.

The added effort and cost associated with providing cloud services, apps, accounts, and other infrastructure to enable multiple ecosystem connections results in lots of time, effort, and cost spent on developing smart-home products. The broad adoption of Matter will simplify the process of making devices that work with all ecosystems, and CSA boasts 214 members who are adopting Matter. This standardization will level the playing field for device makers, and the increased competition in the market will drive innovation.

Matter allows for local connectivity, without a requirement to utilize apps or cloud services. Furthermore, it's IP-based, so it can support Wi-Fi and Thread, giving developers the freedom to choose the technologies that will work best with their products.

Historically, connectivity protocols have been controlled by a single entity or are licensed, making them difficult to use with different platforms and preventing broad adoption. Matter is open-source, and has been tested, validated, and supported by major silicon suppliers in the CSA. Developers will have access to drop in code and development tools, further minimizing the barriers needed to enter the smart-home industry.

The CSA also will require Matter-developed products to meet advanced specification, certification, and testing requirements. Beyond the benefits of interoperability with Matter devices, consumers can adopt devices with the confidence that they will work as expected.

Simple Consumer Setup

Matter devices will be labeled with the Matter logo and have cryptographic ties showing their authenticity. The CSA also is introducing a device database to prevent counterfeit products.

Many existing smart-home products will be eligible to be updated once the Matter standard is officially released. When purchasing a new Matter-enabled product, users can expect the setup process to be straightforward and seamless. All Matter devices will come with a QR code to lead the user through setup, eliminating confusion and guesswork. Any Matter smart-home device of any brand can be paired with the user's smart-home app of choice—and it will work with the rest of the smart home's devices.

Security at the Core of Matter

Matter will exponentially expand the IoT, widening the attack surface and making Matter-enabled homes attractive to bad actors. Thus, robust security is critical. Each Matter device will have a certificate that binds it to the manufacturer, ensuring that the device is authentic and not impersonating another device. Once the device is set up in a smart home, it also will be bound to the ecosystem it's part of.

If an apartment complex has a shared Wi-Fi network, residents would still be able to have their own, private smart-home ecosystems on the network, without the risk of a neighbor's ecosystem interfering with their own. Devices within an ecosystem will only be able to communicate with other devices in the same ecosystem, preventing unwanted connections.

In addition, Matter security doesn't rely on the security of the communication technologies it runs on top of—like Wi-Fi and Thread. If the security of an ecosystem's Wi-Fi network is breached, the self-contained Matter security will protect the smart-home devices on the network from being hacked or compromised.

Realizing the Potential of the Smart Home

Matter will remove the limitations that the smart home has struggled with for quite some time, opening up a world of possibilities. With accelerated time-to-market on Matter-enabled products, developers will be able to focus on ways to add value to the smart home, innovating in ways that were previously too time-intensive or expensive.

After Matter's initial release, more device types will be supported by the standard, with opportunities for developing technologies to be integrated. Matter will enable consumers to enjoy the connectivity of a smart home without the bottlenecks of incompatibility, lack of interoperability, incoherent setup, and weak security. ■

CSA Launches Matter IoT Protocol for Simple, Secure Device Interoperability

The Connectivity Standards Alliance released the Matter 1.0 IoT interoperability protocol, presented as a secure and trusted infrastructure for connected things.

Tobin Richardson, President and CEO of the Connectivity Standards Alliance, presenting at the Matter launch in Amsterdam.

AT A RECENT launch event in Amsterdam, the Connectivity Standards Alliance (CSA) released the Matter 1.0 IoT interoperability protocol, with many members displaying examples of their Matter-based products and solutions. Presentations addressed a wide array of smart-home applications, including occupancy sensors, smart plugs, door locks, lighting, gateways, platform components, and Matter-based software solutions. At this point, 190 products have received certification, or are in the queue for testing and certification.

Matter is intended to address the last aspect of IoT device integration, trust, and security. Since the protocol's release, there have been thousands of downloads of the Matter specification and the Matter software development kit (SDK). In addition, eight authorized test labs are active in 16 locations across nine countries, to help developers bring Matter products to the market.

IoT Inflection Point

"This is a major inflection point for the IoT. As we become more connected and break down the walls between the digital and physical world, we need to work together to make those connections meaningful. Matter and our membership are tackling this challenge head-on," said Tobin Richardson, President and CEO of the CSA *(see figure)*. "With collaboration, inclusiveness, and a deep sense of responsibility to the market and consumers, Matter has the power to create a more connected, safe, and useful smart home."

***By Alix Paultre,** Editor-at-Large*

At the Matter launch event, member companies including Amazon, Schneider Electric, Silicon Labs, and Tuya Smart spoke about their perspectives and offerings on Matter and how they see their position in the IoT ecosystem. In addition, multiple smart-home product demonstrators were on hand for a variety of spaces, from lighting and electrical to safety and security sensors.

Beyond the current offerings, the Alliance intends to create teams to address applications like doors and gates, environmental quality, smoke and carbon-monoxide detection, and ambient motion and presence sensing.

Matter Ecosystem

The Matter 1.0 release is presented as a solid ecosystem at its release, with authorized test labs for product certification, test harnesses and tools available to the developer community, and the open-source reference design SDK is complete and downloadable. Furthermore, CSA members that already have devices deployed with plans to update them to support Matter can do so once their products are certified.

"What started as a mission to unravel the complexities of connectivity has resulted in Matter, a single, global IP-based protocol that will fundamentally change the IoT," said Richardson. "This release is the first step on a journey our community and the industry are taking to make the IoT more simple, secure, and valuable no matter who you are or where you live. With global support from companies large and small, today's Matter 1.0 release is more than a milestone for our organization and our members; it is a celebration of what is possible."

Matter's underlying network technologies come from Zigbee, Wi-Fi, and Thread, using Bluetooth Low Energy for device commissioning and Wi-Fi for the high-bandwidth local network and cloud communications. Thread provides an energy-efficient and highly reliable mesh network within the home.

Matter also uses security policies and processes based on distributed-ledger technology and public key infrastructure to validate device certification and provenance. This will help to ensure users are connecting authentic, certified, and up-to-date devices to their homes and networks. ■

Space-Based SDR: NASA'S SCaN TESTBED

Data obtained from SCaN Testbed experiments is paving the way for the future of space radio, with cognitive communication systems combining software-defined radios with AI/ML to improve performance and resilience of RF units.

By Brendon McHugh, *Field Application Engineer & Technical Writer, Per Vices Corp. and* ***Kaue Morcelles,*** *Independent Technical Writer, Per Vices*

DEVELOPING ELECTRONICS FOR space applications is certainly an exciting task, but it can become a real problem if the designer fails to address the critical robustness requirements of the application. It's crucial to consider not only the harsh environment of space, but also the fact that physical maintenance is very scarce and expensive. Therefore, it's not a surprise that RF devices for space communication are evolving from fixed and single-purpose hardware-based systems to flexible, robust, and reprogrammable software-defined radios (SDRs).

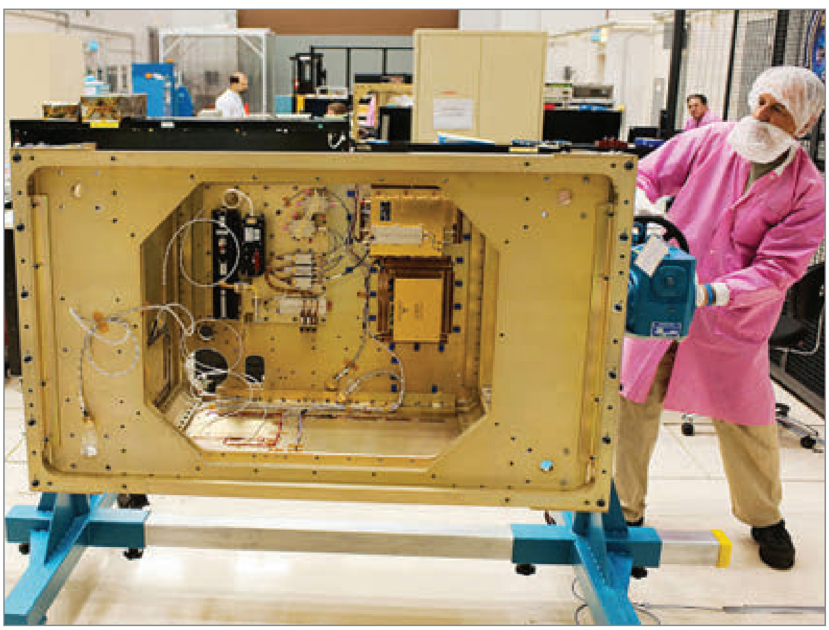
To ensure proper operation in space, SDRs must be prepared to endure harsh conditions. Thus, they must employ radiation-hardened electronics; comply with limited size, weight, and power (SWaP) requirements; and allow for remote control and programming from ground stations. To verify the feasibility of using SDRs in space, experiments ensued in the SCaN (Space Communications and Navigation) testbed *(Fig. 1)*.

In this article, we discuss the main findings obtained from the SCaN study, which include the many benefits of using SDRs and how these devices are selected for space-based applications. We focus on a set of properties that are found in high-end and custom SDRs, including radiation resistance, reduced SWaP specifications, modularity, RF performance, and the ability to be programmed and reconfigured from ground stations.

The programming and reconfigurability allows for updating and uploading waveforms while in orbit, simplifying the transition of waveforms to new platforms, changing tuning frequencies on-the-fly, reducing the overall complexity of the system by implementing multiple programmable tasks, and providing the high-data-rate (Ka-band) communications required in low-Earth-orbit (LEO) missions.

Traditional Radio Systems in Space

In general, spacecraft can be considered as two basic sections: the platform and the payload. The platform, which is



1. The SCaN testbed, implemented aboard the International Space Station (ISS), performed both software and hardware functionalities of SDRs, as well as RF applications, using NASA's Space Telecommunications Radio System (STRS) standard architecture. (Source: www1.grc.nasa.gov/space/scan/acs/scan-testbed/)

responsible for supporting the payload into space, comprises five functional subsystems:

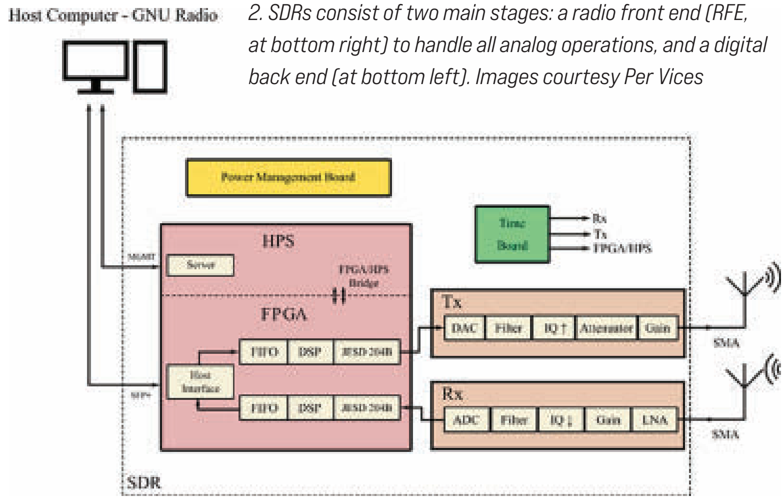
- Structural
- Telemetry, tracking, and command (TT&C)
- Electric power and distribution
- Thermal control
- Altitude and velocity control

In our discussion, we focus on the TT&C subsystem, which includes receivers, transmitters, antennas, and sensors for a variety of measurements, such as temperature, pressure, voltages, and currents. The payload is the equipment that performs the primary mission of the spacecraft. In telecommunication systems, for instance, the payload consists of antennas, transceivers, low-noise amplifiers (LNAs), mixers, local oscillators, modulators and demodulators, and power amplifiers.

Naturally, the harsh conditions of space create a difficult environment for electronics in general. First, the mechanical vibration generated by the rocket launch is tremendous, which may damage or interfere with electronics that aren't well designed. Another issue is related to plastic outgassing, which generates vapors that can deposit material on devices (especially optical windows) and consequently degrade performance.

Furthermore, heat dissipation is a major challenge, as the vacuum of space impedes dissipation of the heat generated by electronics, as heat can only travel through vacuum by radiation. Insufficient heat dissipation can significantly reduce the life expectancy and performance of electronic systems. Finally, since the space environment isn't protected by the Earth's atmosphere, the spacecraft must endure a dangerous amount of radiation, which can damage electronics and affect their performance, often leading to complete failure.

If the space environment isn't kind to electronic components in general, it's even worse for RF devices. Because any operation regarding space missions is performed remotely, wireless communications are important for any function, making robust transceivers crucial. Also, the available electromagnetic spectrum is significantly limited and therefore makes them prone to interference and channel saturation. Therefore, traditional RF systems aren't going to be enough to handle the huge amounts of data required for the future of space-based communications.



2. SDRs consist of two main stages: a radio front end (RFE, at bottom right) to handle all analog operations, and a digital back end (at bottom left). Images courtesy Per Vices

Furthermore, fixed and hardware-based systems can't account for changes in the mission conditions and priorities, as the hardware can be difficult to change. Novel solutions will require a huge level of flexibility, allowing for remote configuration and generation of waveforms, modulation schemes, bandwidths, and tuning frequencies. Thus, software-based systems are much more adequate—programs can be easily transmitted through wireless links.

In this context, SDRs can help solve most of the RF problems regarding space missions due to their high level of reconfigurability and flexibility. SDRs are composed of two main stages: a radio front end (RFE) to handle all analog operations, and a digital back end *(Fig. 2)*.

The RFE performs all of the Tx and Rx operations, including amplifiers, filters, mixers, and antenna coupling circuits. It's designed to receive and transmit signals over a wide tuning range, into the Ka-band. State-of-the-art SDRs can reach up to 3 GHz of bandwidth over multiple radio chains, providing multiple-input, multiple-output (MIMO) operation with independent analog-to-digital and digital-to-analog converter (ADC/DAC) blocks for each channel.

The digital backend, on the other hand, performs all digital-signal-processing (DSP) functions, including modulation/demodulation schemes, up/downconverting, and data packaging. It's implemented using a high-end FPGA, which can be reprogrammed and configured on-the-fly to perform complex DSP algorithms and the latest radio protocols, with minimum latency.

The digital backend can be easily integrated into host computers and networks via Ethernet links. Consequently, they're compatible with networked ground stations and RF processing software, such as GNU Radio. Finally, the modularity of SDRs also allows them to be designed for a variety of SWaP requirements, both for critical on-board missions and large ground stations.

The SCaN Testbed

The Space Communication and Navigation (SCaN) testbed was a testing platform implemented aboard the International Space Station (ISS) to perform both software and hardware functionalities of SDRs, as well as RF applications, using NASA's Space Telecommunications Radio System (STRS) standard architecture *(Fig. 3)*. It has two S-band SDRs, one of which uses GPS, and one Ka-band SDR.

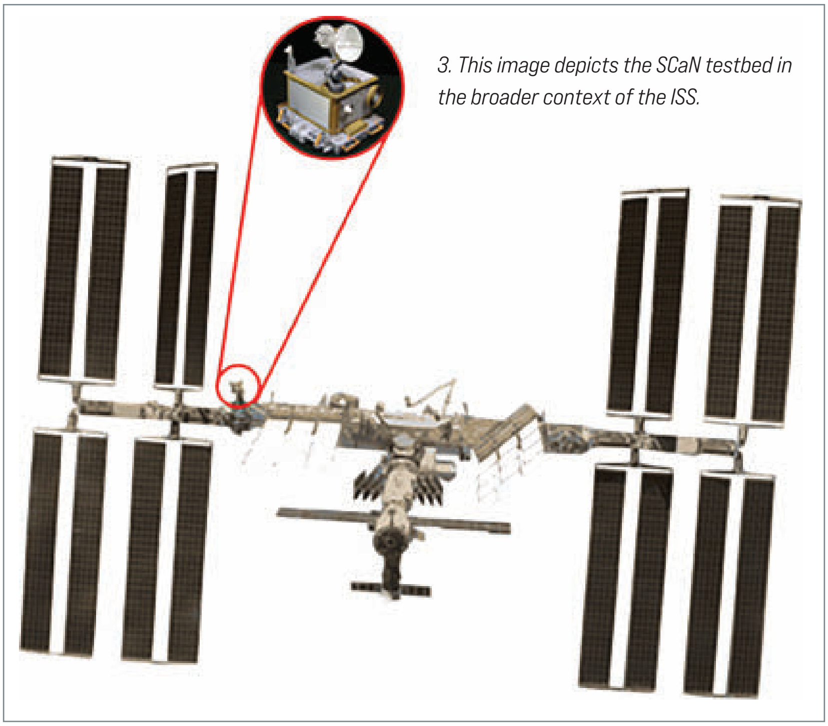
The SCaN testbed (STB) focused particularly on interfacing SDR basic functions; advanced networking technology; spectrum-efficient technology; and Position, Navigation and Time (PNT) protocols. It flew on the ISS for seven years, performing more than 4,200 hours of testing, and was decommissioned on June 3, 2019.

The STB was designed and deployed to create a readily available SDR platform to implement and test space radio systems. One of its main missions was to advance our understanding of the SDR specifications required to operate in space applications, including waveform repositories, communication protocols, design standards, and software tools. It also was responsible for conducting experiments regarding device interoperability, networking, navigation, and technological challenges faced by these SDRs.

Furthermore, the SCaN testbed helped in training and educating several waveform developers, resulting in the creation of extensive waveform repositories. Finally, the STB was used to validate the capabilities of S-band, K-band, and GPS missions before deployment.

Generally, and especially in space applications, SDRs are becoming the main building blocks of RF testbeds. This is due to the high level of flexibility introduced by these devices, which allows functions to be modified within the same device without any hardware modification. This enables work with different communication protocols, modulation schemes, and RF capabilities.

Because SDRs are able to be reprogrammed over the air, the entire testbed can be upgraded or modified in orbit and the latest RF protocols and algorithms may be implemented, while providing a means for remote failure correction. Hardware standardization is another great advantage, as general-purpose SDRs can be tailored to work with specific RF applications by simply running software on top of standard hardware, which is already stable and well validated.



3. This image depicts the SCaN testbed in the broader context of the ISS.

SDRs are compatible with open-source host software, including GNU Radio. Therefore, the testbed may be used not only by large companies, but also by students and researchers from engineering universities.

Over the years, the STB helped in the accomplishment of several research milestones in the SDR field. One of its main contributions was in the development of the STRS standard for SDRs. The STRS standard was developed by NASA to enable portability of RF software to novel SDR platforms, reducing the development time and risk.

By complying with the standard, third-party software developers can make use of extensive waveform repositories and design on top of existing open-source platforms without needing to worry about the hardware underneath. The STB was a crucial tool in the development of waveforms and reusable software components for the STRS repository, letting future missions simply reuse the software pieces already developed.

In addition, the STB was fundamental in the operation of the first Ka-band NASA mission with the Tracking and Data Relay Satellite System (TDRSS). In this case, the STB was used to implement a full-duplex space transceiver able to validate Ka-band performance of TDRS satellites and test several communication upgrades on research projects, such as the Space Network Ground Segment Sustainment (SGSS) and the User Service Subsystem Component Replacement (USS-CR).

Another demonstration of the flexibility of the STB came in 2018: The STB became the first in-orbit device to use the European Galileo E5A navigation signal, which combines GPS and Galileo signals to increase the precision in spacecraft orbit determination.

The STB was able to validate in-orbit reconfiguration of space RF systems by performing 888 reconfiguration routines, which is an incredible achievement in a field where a single maintenance routine is a high-risk endeavor.

Other applications of the STB include cognitive radio and adaptative waveforms, which are applied in signal sensing and environment awareness; spectrum- and power-efficiency techniques, which require new modulation schemes and coding; and GPS/GNSS demonstrations, involving L1/L2, l5, GPS augmentation, jammer detectors, and scintillation. The STB was extensively used in networking tests, including disruptive tolerant networking, adaptive routing, secure routing, and formation flying.

A Glimpse of the Future

The huge amount of data and insights obtained from the STB in its seven years of operation is driving important research in the space RF field. Cognitive radio is one of the frontlines in communication technology, implementing artificial-intelligence and machine-learning (AI/ML) algorithms to configure and tune the RF parameters of the channel, allowing for fast and automatic adaptation to environmental conditions.

The feasibility of implementing cognitive radio in space SDRs was demonstrated in 2018, when an AI/ML-based algorithm was used in the STB for automatic communication service scheduling, enabling the platform to request high-rate services almost in real-time. The algorithms were performed using GNU Radio, an open-source software development framework for RF applications. *Figure 4* shows the basic framework implemented in the 2018 study, as described in Shahidullah et al.[1]

Currently, cognitive radio research is being developed by NASA'S Cognitive Communications Project. The information obtained from the STB is being used to improve space radio performance and resiliency through AI/ML algorithms.

Besides the many challenges that were alleviated by the software-based nature of the SCaN testbed, SDRs can still bring many benefits to space radio systems. First, the SDR components can be radiation-hardened, which is fundamental to ensure robust operation in the harsh environment of space. Digital systems enable the use of error-correction algorithms to implement logical radiation hardening, which employs redundant techniques to provide another layer of protection to the collected data.

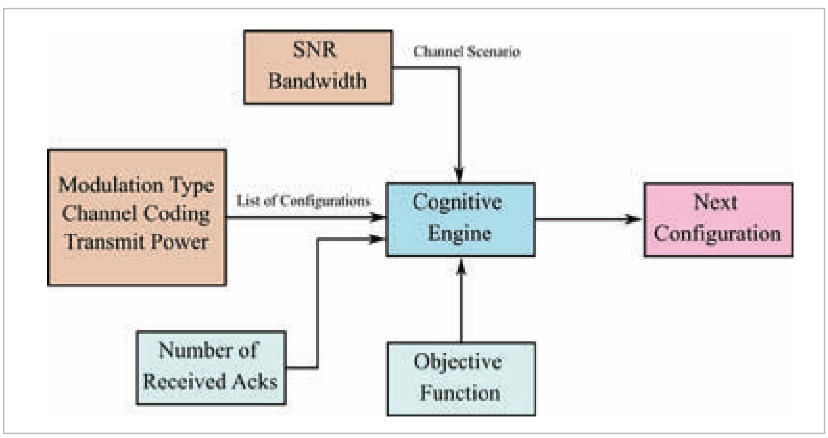
Furthermore, MIMO SDRs can perform several tasks simultaneously, which significantly reduces the total equipment count and overall complexity, relaxing the SWaP conditions. To be used in space, SDRs must be qualified via thermal, vacuum, and vibration tests.

Conclusion

The design of space electronics has never been easy, especially for RF applications. The challenges regarding maintenance, robustness, performance, and upgradability of traditional radio systems resulted in many technological limitations for the space industry, as virtually every function in a spacecraft relies on RF communications. Software-based systems, and especially SDRs, are providing a tremendous paradigm shift in RF technology, providing a whole new level of flexibility and robustness by performing most of the radio functions in the digital domain.

In this context, the SCaN testbed was essential in the development and validation of new radio algorithms and techniques, demonstrating the potential of SDR-based systems in this field. Experiments in the SCaN showed that SDR-based systems provide much more interoperability, upgradability, and adaptability when compared to traditional systems. That's because the digital back end can be completely reprogrammed remotely without any hardware replacement.

The information obtained from the STB experiments is paving the way for the future of space radio, with cognitive communication systems combining SDRs with AI/ML to improve performance and resilience of RF units. ■



4. Shown is the cognitive radio framework implemented in Asadi et al (see Reference).

REFERENCE

1. Shahidullah, A., Asadi, H., Volos, H., Ryu, B., Bose, T., Reinhart, R., & Briones, J. (2015, March). Cognitive radio experiment design for the space communications and navigation (SCaN) Testbed. In Proceedings of SDRWInnComm 2015 wireless innovation conference on wireless communications technologies and software defined radio (pp. 16-23).

COMPACT AMPLIFIER POWERS 4 TO 8 GHZ

Mini-Circuits' model ZHL-20W-83X-S+ coaxial amplifier achieves typical gain of 56 dB and typical output power at 1-dB compression of +39 dBm (8 W) from 4 to 8 GHz. It provides almost 20 W (+43 dBm) of full-band output power at saturation with a third-order intercept point of +50 dBm. Well suited for communications, radar, and test applications, the Class AB amplifier runs on a +28 V dc supply, features SMA female connectors, and is available with a fan-cooled heatsink as an option.

MINI-CIRCUITS

https://tinyurl.com/2buorbuh

INTERCONNECTS TARGET HIGH-RESOLUTION VIDEO TRANSMISSION

Pasternack broadened its line of 12G SDI interconnects engineered to maximize 4K and ultra-HD video signal transmission. Designed for high durability and reliability, the 12G SDI cables and connectors feature 10-µin minimum contact plating and BNC and 1.0/2.3 connector options, with 4X the bandwidth of HD. Available in multiple configurations, including PCB edge-mount and straight or right-angle options, the interconnects cover an operating frequency from dc to 12 GHz, and are backward-compatible with 2081-1.

PASTERNACK

https://tinyurl.com/2cjlt8sy

ENTERPRISE SOLUTION ADDRESSES CAPACITY AND SERVICE REQUIREMENTS FOR CLOUD APPLICATIONS

Edgecore Networks' EPS200 Series of high-performance, multi-gigabit enterprise solutions enables enterprises to upgrade their existing network and cabling to let the Wi-Fi infrastructure embrace higher transmission bandwidths. Based on the latest Broadcom Trident3-X3 family chipset and a COMe CPU board with an Intel Denverton CPU, they deliver high performance per watt, a power-saving thermal design, and a configurable high-speed I/O. The EPS200 Series can be used as a highly scalable, power saving, feature-rich multi-gigabit switch family for enterprise and campus access networking.

EDGECORE NETWORKS

https://tinyurl.com/2bhujjg6

ESD PROTECTION DIODES TOUT ROBUSTNESS AND PERFORMANCE

Nexperia's ESD4V0Y1BBSF and PESD4V0X2UM low-clamping ESD protection diodes combine high surge robustness with very low trigger and clamping voltages, wide passbands, and exceptional levels of immunity to surges, as shown by their IEC61000-4-5 ratings. Available in a low-inductance DSN0603-2 package, the one-line PESD4V0Y1BBSF has a trigger voltage of 6.3 V TLP and a typical device robustness and capacitance of 25 A, 8/20 µs, and 0.7 pF, respectively. The PESD4V0Y1BBSF offers a clamping voltage at 16 A, 100 ns TLP of 2.4 V, at 20 A; 8/20 µs surge is only 3.4 V.

NEXPERIA

https://tinyurl.com/27j7yylu

ASIL POSITIONING ENGINE SUPPORTS ADVANCED AUTONOMOUS VEHICLES

Point One Navigation's FusionEngine software is a complete, high-performance ASIL-rated precise location solution for automotive applications. Compatible with ST's TeseoAPP (Teseo ASIL Precise Positioning) GNSS chipset, the combined solution provides functional safety at ASIL-B, for Level 3+ ADAS systems. A trusted, tightly coupled positioning solution built on the company's proprietary self-calibrating sensor-fusion algorithms, it can be integrated into a variety of host processors. FusionEngine combines data from multiple sensors, including ST's TeseoAPP multiband GNSS receiver, for high accuracy, safety, and integrity.

POINT ONE NAVIGATION

https://tinyurl.com/28zldyoy

Cellular Providers and 5G Transformations

(Continued from page 11)

Definition (UHD) video monitoring and artificial intelligence (AI). We also should see initial forays into metaverse-related offerings combining virtual reality (VR), gaming, VoNR, and collaboration services.

Private Networks Scale Up

2023 will see a big monetization push around private cellular networks as well—though not necessarily on 5G. This follows many trials and early deployments throughout 2022, and CSPs expect to see significant enterprise adoption this year.

Many initial deployments, though, will continue using primarily 4G/LTE technology, with 5G non-standalone (NSA) networks employed only for select use cases that require additional radio capabilities, such as faster 5G speeds. Private 5G SA implementations will begin to slowly appear as market availability and operating confidence with delivery partners grows.

For early private 5G SA implementations, look to the industrial sector, where lower latencies, enhanced power efficiency, and enhanced radio features can enable new innovations in robotic automation and the industrial Internet of Things (IIoT). We expect the first production use cases for industrial 5G to begin appearing toward the end of 2023, as the first wave of 3GPP Release 16-enabled network equipment and devices hit the market.

Asia Maintains the Lead in 5G Deployments

Last year, China drove the global 5G market as CSPs rushed to expand 5G coverage everywhere across the vast Chinese nation. This year, India takes over as the world's 5G accelerator. With spectrum auctions concluded, two major Indian carriers are now racing to achieve nationwide coverage in 2023. Of particular interest to the global telecom community, leading Indian CSPs are focusing not just on consumer connectivity, but making a strong push for enterprise private networks as well.

Meanwhile in China, with the push for nationwide coverage largely achieved in 2022, 5G radio investments should slow in the coming year. Instead, China's large operators will turn their focus to enterprise use cases. Look for Chinese CSPs to begin placing more emphasis on private networks using public 5G spectrum for targeted enterprise use cases, especially in logistics and the energy and mining sectors.

Looking Ahead

5G brings enormous change to telecom networks, introducing new technologies and operating models across transport, radio networks, edge, cloud, IoT, and much more. As an industry, we're still closer to the beginning of this transformation than the end. Surveying the projects slated for 2023, however, CSPs will continue to make amazing progress bringing new capabilities and experiences to their customers. ■

5G to Implement IIoT Networks

(Continued from page 11)

Such a scenario will undoubtedly bring benefits in smart-city and infrastructure applications, as well as to OEM machine builders keen to add new services to their portfolio. It remains a fundamental truth, though, that this functionality is essentially available via LTE today.

What About Private Networks?

One element of 5G that's considered a big advantage is the ability to create private mobile networks. While it's true that the changes in the core of the network will make this easier to accomplish, many potential users fail to realize that it's perfectly possible to deploy private LTE networks today. Indeed, there are many examples where private LTE networks have been deployed within factories and other environments to create technical and commercial advantages.

So, Should You Wait?

Unless you have an application sitting in one of the categories outlined here, waiting for the relevant 5G service to become available rather than proceeding today using existing LTE networks is very difficult to justify. Time will tell if there's ultimately a cost advantage to deploying on a 5G network.

However, common sense suggests that, like any new technology, it's likely to carry a premium in the early days. This will be compounded by the need for the cellular providers to quickly recoup their costs both in acquiring the required radio-spectrum licenses, and in the capital expense associated with the rollout of the new infrastructure needed to support 5G.

Such substantial investments, and the need to maximize early revenues, suggest the initial focus of the cellular operators is likely to be biased toward high-volume, high-bandwidth applications. This means consumer-led video and broadband provision, rather than mainstream machine-to-machine (M2M) projects.

Even when 5G networks become ubiquitous, any investment made in existing LTE solutions will be preserved. The 5G specifications define the use of hybrid networks using 4G radio access networks (RANs) coupled to a 5G core, or vice versa. Indeed, many of the initial implementations have been hybrid in nature, with a focus on improvements to the core network, meaning the wireless technology used in the cell towers is still LTE.

All of this suggests that the sensible strategy for implementing a cellular architecture for an M2M deployment is not to wait. Instead, it's to analyze the application requirements and segregate those that can only work by leveraging some new feature provided by 5G.

The remainder, which is likely to be most use cases, should be implemented immediately using LTE, safe in the knowledge that the investment is protected. Those parts that need to use 5G should be piloted as soon as the required services are available, with a view to rolling out alongside the existing deployment once they're proven to be effective. ■