4 Building Blocks for LoRa Networks **p17**

Bluetooth vs. UWB for High-Speed Data **p20**

How Distributors See the Supply Chain **p22**

Microwaves & RF®

YOUR TRUSTED ENGINEERING RESOURCE FOR OVER 50 YEARS

DECEMBER 2021 mwrf.com

IC Integration = Better Wideband Systems

p12

$10.00

THE SOURCE OF PURITY AND STABILITY

Rubidium™

Unmatched signal purity and frequency stability with on-site frequency and power calibration

Anritsu's new Rubidium™ low-noise RF/microwave signal generator redefines signal purity and stability.

Signal purity and frequency stability are essential distinguishing characteristics of a high-frequency microwave signal generator. The Rubidium MG362x1A signal generator product line is built to deliver outstanding signal purity and frequency stability across a broad frequency range from 9 kHz to 43.5 GHz, even at high output power levels.

Along with AM, FM and PM modulation, Rubidium also features comprehensive pulse generation capabilities for radar signal simulation. Coupled with built-in, easy-to-use, on location frequency and power calibration, the Rubidium MG362x1A offers exceptional overall utility and long-term value for a broad range of measurement applications.

Be a Leader - Discover how you can get better measurement confidence with Anritsu. View our complete line of test and measurement solutions at:
www.anritsu.com/test-measurement

KEY FEATURES

- Low phase noise and spurious performance unmatched in today's market
- Atomic clock frequency stability with optional internal Rubidium frequency reference
- High output power with low spurious eliminates need for external power amplification
- Low cost of ownership with on-site frequency and power calibration capabilities

FOLLOW THE LEADER
PURITY
ANRITSU

Anritsu
Advancing beyond

www.anritsu.com

IN THIS ISSUE

FEATURES

12 **Improving Wideband Multichannel Systems with IC Integration (Part 1)**
This article presents experimental results utilizing a 16-channel transmit and 16-channel receive subarray in which all transmit and receive channels are calibrated using hardened DSP blocks within the digitizer IC.

17 **The 4 Building Blocks for LoRa Networks**
This article introduces the four main elements of LoRa network architecture and discusses some of the most common challenges faced by designers while developing LoRa end-nodes. How can regulatory certified LoRa modules help overcome such challenges?

22 **Viewing the Semiconductor Supply Chain Through the Distributor's Eyes**
This interview addresses how the supply/demand imbalance has impacted companies and best practices to deal with the cyclical nature of the semiconductor supply chain—including avoiding the risk of counterfeit chips.

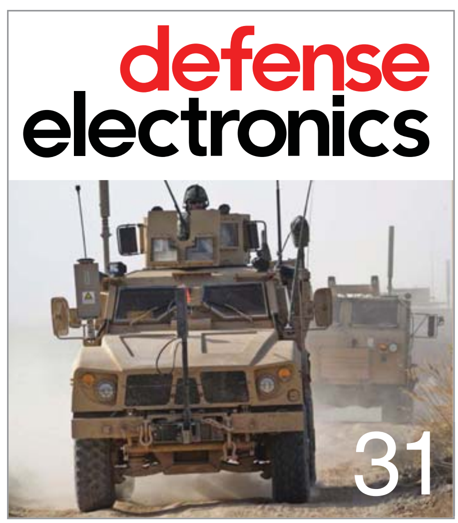
24 **Pain Points for RF Product Design**
Many unique RF challenges emerge in the development of products, from implementing active wireless technologies to passive RFID tagging. To help address them, it's crucial to engage your RF engineers early in the design and product requirements stage.

26 **Top Products of 2021**
A selection of 2021's most popular new-product stories that appeared on *mwrf.com*.

32 **Making Connections in Ruggedized UAVs**
Specifying RF connectors, cables, and cable assemblies for military UAVs, especially as they increase their use of mmWave frequencies, requires an intelligent balance of many factors to keep every system connected under all conditions.

17

26



NEWS & COLUMNS

2 **EDITORIAL**
Things Are Looking Up for Broadband Satellite

6 **ON *MWRF.com***

8 **NEWS**

38 **NEW PRODUCTS**

40 **ADVERTISERS INDEX**

COVER PHOTO CREDITS:
68083077 © Alunablue | Dreamstime.com

follow us @MicrowavesRF

become a fan at facebook.com/microwavesRF

Editorial

DAVID MALINIAK | Editor
dmaliniak@endeavorb2b.com

Things Are Looking Up for **Broadband Satellite**

Here in the wealthy western (a.k.a. "first") world, we take our ubiquitous connectivity for granted. Cellular and Wi-Fi coverage blanket our homes and offices. Internet, email, texting, and voice calling is accessible anywhere we go.

Thus, it can be mind-boggling to learn that, according to a recent study by research/competitive-intelligence firm Fact.MR, nearly four in ten people globally do not have access to the internet. Large portions of the unconnected live in rural areas, where harsh geographic realities can make the establishment of broadband infrastructure very difficult and extremely costly.

This is where broadband satellite communications come into the picture—and in a big way. Fact.MR's study determined that the satellite internet market is expected to exceed $6 billion by 2031. With high-tech entrepreneurs becoming enmeshed in a privatized space race, these players will spearhead a drive to bring advanced and highly efficient satellite broadband to market.

The enormous gap in internet penetration exists between various countries and economic sectors. Lack of an established customer base in these rural areas of the world compounds the problem. Developing nations and small island nations also suffer with this dearth of connectivity.

By the way, some of the rural areas without reliable high-speed internet access are in the United States of America. An article from earlier this year on *AppleInsider.com* reveals that broadband penetration and speed falls far short of what the Federal Communications Commission (FCC) would have us believe. In large swaths of the U.S., less than 15% of people use the internet at download speeds of at least 25 Mb/s, which is how the FCC defines high-speed internet.

The beauty of satellite internet is that it doesn't require the laying of large cables to deliver data. It will make broadband far more accessible to the unconnected, or slowly connected, masses. To that end, the setup cost for a satellite internet service is comparatively less and comes with a longer lifecycle.

Positioning of satellites in lower orbit is mitigating the problem of latency. For instance, satellites that are in orbit at around 600 km from the Earth's surface have lower latency as compared to those in higher orbits. Starlink broadband services claim to provide latency as low as 20 ms. On the other hand, visibility of satellites with the naked eye due to their placement in lower orbit is a point of concern, with prominent companies working on the same.

Some of the key points from Fact.MR's study:

- Satellite internet revenue will soar 2.2X from 2021 to 2031, reaching nearly $6 billion by 2031.
- Global market revenue is expected to total $3.5 billion in 2021.
- Demand for satellite internet will likely grow due to its utilization in the deployment of 5G and IoT technology.
- Residential satellites are likely to increase their share to reach nearly 55% by 2031 as compared to 2020.

Launching a satellite internet service for a wide spectrum of users, such as for residential use, all-level enterprises, federal governments, and so on, should fetch more revenue. For instance, comparing Telesat with Starlink, the former's business model aims at delivering services to only government clients and B2B customers, whereas the latter seeks to provide services to everyone across the globe.

Starlink has started its beta-version testing and the service will be for commercial purposes. Similarly, the company is in talks with the U.S. Department of Defense for the adoption of its services. mw

Fast Pulse Test Systems from Avtech

Avtech offers over 500 standard models of high-speed pulsers, drivers, and amplifiers ideal for both R&D and automated factory-floor testing. Some of our standard models include:

AVR-E3-B: 500 ps rise time, 100 Volt pulser

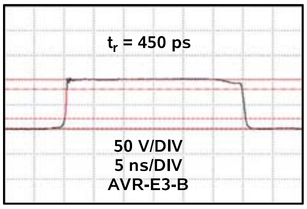
AVRQ-5-B: Optocoupler CMTI tests, >120 kV/us

AVOZ-D6-B: 1000V / 200A, 1-10 us pulser

AV-1010-B: General purpose 100V, 1 MHz pulser

AVO-9A-B: 200 ps t_r, 200 mA laser diode driver

AV-156F-B: 10 Amp current pulser for airbag initiator tests



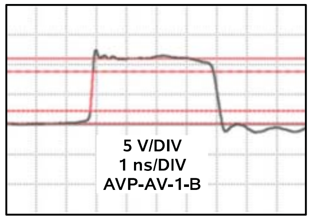
AVTECH

Nanosecond Electronics
Since 1975

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

AVTECH ELECTROSYSTEMS LTD.
US & Canada 888-670-8729, Worldwide +1-613-686-6675
info@avtechpulse.com

High Output - Low Risetime Pulsers from Avtech



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

AVTECH

Nanosecond Electronics
Since 1975

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

AVTECH ELECTROSYSTEMS LTD.
US & Canada 888-670-8729, Worldwide +1-613-686-6675
info@avtechpulse.com

Pulsed Laser Diode Drivers from Avtech

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.

Model AVO-9A-B

AVTECH

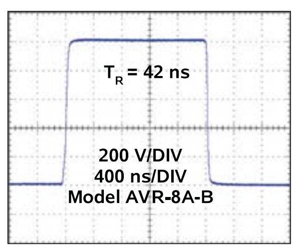
Nanosecond Electronics
Since 1975

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

AVTECH ELECTROSYSTEMS LTD.
US & Canada 888-670-8729, Worldwide +1-613-686-6675
info@avtechpulse.com

100 to 1000 Volt Lab Pulsers

Avtech offers a full line of 100, 200, 500, 700 and 1000 Volt user-friendly pulsers capable of driving impedances of 50 Ω and higher. The **AVR Series** is suitable for semiconductor and laser diode characterization, time-of-flight applications, attenuator testing, and other applications requiring 10, 20, or 50 ns rise times, pulse widths from 100 ns to 100 us, and PRFs up to 100 kHz. GPIB, RS-232, and Ethernet ports are standard.



See additional test results at:
http://www.avtechpulse.com/medium

AVTECH

Nanosecond Electronics
Since 1975

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

AVTECH ELECTROSYSTEMS LTD.
US & Canada 888-670-8729, Worldwide +1-613-686-6675
info@avtechpulse.com

Microwaves&RF **DECEMBER 2021**

EDITORIAL

SENIOR CONTENT DIRECTOR: **BILL WONG** bwong@endeavorb2b.com

EDITOR: **DAVID MALINIAK** dmaliniak@endeavorb2b.com

MANAGING EDITOR: **ROGER ENGELKE** rengelke@endeavorb2b.com

SENIOR STAFF WRITER: **JAMES MORRA** jmorra@endeavorb2b.com

TECHNICAL EDITOR: **JACK BROWNE** jack.browne@citadeleng.com

ART DEPARTMENT

GROUP DESIGN DIRECTOR: **ANTHONY VITOLO** tvitolo@endeavorb2b.com

ART DIRECTOR: **JOCELYN HARTZOG** jhartzog@endeavorb2b.com

PRODUCTION

GROUP PRODUCTION MANAGER: **GREG ARAUJO** garaujo@endeavorb2b.com

PRODUCTION MANAGER: **DEANNA O'BYRNE** dobyrne@endeavorb2b.com

AUDIENCE MARKETING

USER MARKETING MANAGER: **DEBBIE BRADY** dmbrady@endeavorb2b.com

FREE SUBSCRIPTION / STATUS OF SUBSCRIPTION / ADDRESS CHANGE/ MISSING BACK ISSUES:

OMEDA **T** | 847.513.6022 **TOLL FREE** | 866.505.7173 **FAX** | 847.291.4816 microwaves&rf@omeda.com

SALES & MARKETING

REGIONAL SALES REPRESENTATIVES:

AZ, NM, TX: **GREGORY MONTGOMERY** gmontgomery@endeavorb2b.com

AK, NORTHERN CA, NV, OR, WA, WESTERN CANADA: **STUART BOWEN** sbowen@endeavorb2b.com

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

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

INTERNATIONAL SALES:

GERMANY, AUSTRIA, SWITZERLAND: **CHRISTIAN HOELSCHER** christian.hoelscher@highcliffemedia.com

BELGIUM, NETHERLANDS, LUXEMBURG, UNITED KINGDOM, SCANDINAVIA, FRANCE, SPAIN, PORTUGAL: **LARA PHELPS** lara.phelps@highcliffemedia.com

ITALY: **DIEGO CASIRAGHI** diego@casiraghi-adv.com

PAN-ASIA: **HELEN LAI** helen@twoway-com.com

PAN-ASIA: **CHARLES LIU** liu@twoway-com.com

REPRINTS: reprints@endeavorb2b.com

LIST RENTALS/ SMARTREACH CLIENT SERVICES MANAGER: **MARY RALICKI** mralicki@endeavorb2b.com

DIGITAL

SENIOR DIGITAL INNOVATION & STRATEGY DIRECTOR: **RYAN MALEC** rmalec@endeavorb2b.com

DESIGN & ENGINEERING GROUP

EVP, DESIGN & ENGINEERING GROUP: **TRACY SMITH** tsmith@endeavorb2b.com

GROUP CONTENT DIRECTOR: **MICHELLE KOPIER** mkopier@endeavorb2b.com

VICE PRESIDENT OF MARKETING SOLUTIONS: **JACQUIE NIEMIEC** jniemiec@endeavorb2b.com

ENDEAVOR BUSINESS MEDIA, LLC

331 54th Ave N., Nashville, TN 37209 USA | www.endeavorbusinessmedia.com

CEO: **CHRIS FERRELL**

CRO/CMO: **JUNE GRIFFIN**

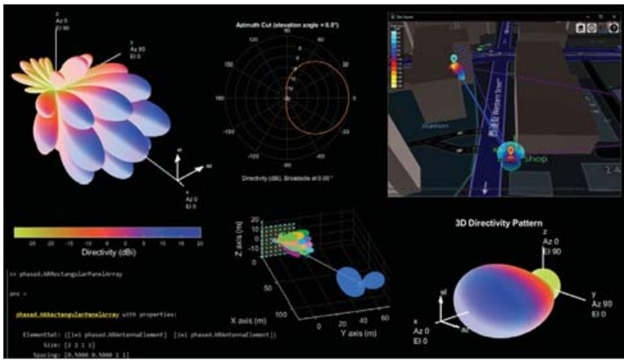
CFO: **WILLIAM NURTHEN**

COO: **PATRICK RAINS**

CHIEF ADMINISTRATIVE AND LEGAL OFFICER: **TRACY KANE**

EXECUTIVE VICE PRESIDENT, DESIGN & ENGINEERING: **TRACY SMITH**

Electronic Design | Machine Design | Microwaves & RF | Hydraulics & Pneumatics | Source ESB | Source Today | Evaluation Engineering



MODELING 5G ANTENNA ELEMENTS AND ARRAYS

The Algorithms to Antennas series has covered a range of specific topics that relate to antenna-array design for 5G systems in a number of past blogs. Here we connect these topics to published specifications related to antenna-array configurations.

www.mwrf.com/21181571

500TH RING LASER GYRO SHIPPED TO U. S. NAVY

The 500th WSN-7 ring laser gyroscope inertial navigation system (INS) was recently shipped by Northrop Grumman Corp. to the U.S. Navy.

www.mwrf.com/21181532

IS GaN REPLACING SILICON AS THE MAINSTREAM COMPUTING POWER SOLUTION?

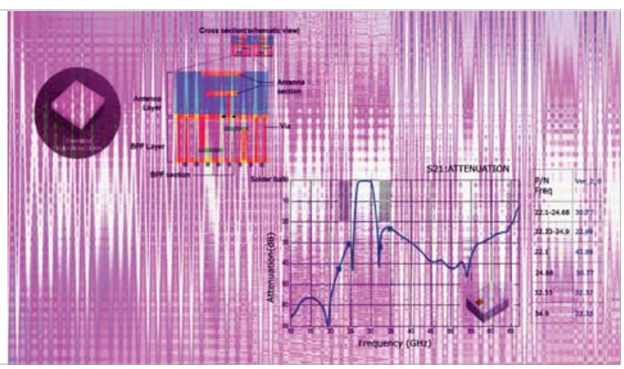
The emergence of gallium nitride (GaN) is changing the way designers think about their power electronics designs. In this video, we talked to Dan Kinzer at Navitas to get a handle on the situation.

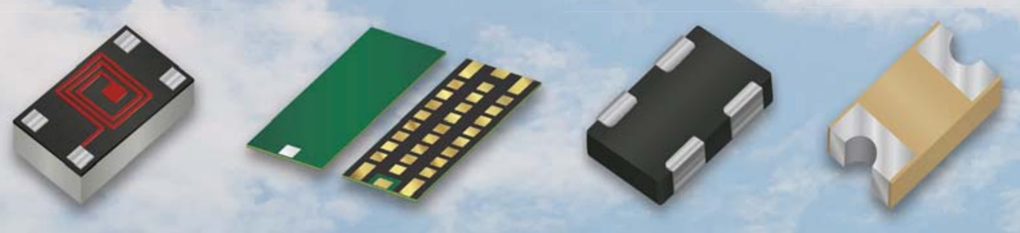
www.mwrf.com/21181808

MITIGATE INTERFERENCE USING mmWAVE ARRAYS WITH INTEGRATED FILTERING

Interference from adjacent mmWave bands can be problematic for 5G NR implementations, but a 2x2 antenna array with integrated bandpass RF filters can help.

www.mwrf.com/21178292





News

5G mmWave Beamformer ICs

Boost Transmitter Output Power Capability

Renesas' third-generation beamformer ICs enable high-efficiency, low-cost phased-array radios with extended signal range for 5G wireless and fixed wireless access.

The Overview

Renesas has debuted two new dual-polarization, mmWave beamformer ICs devices optimized for 2x2 antenna architecture for 5G and broadband wireless applications. The company claims best-in-class performance in the n257, n258, and 261 bands.

The highly integrated F5288 and F5268 transmitter/receiver (8T8R) chipsets sit on a small 5.1- × 5.1-mm BGA package and deliver the industry's highest Tx output power capability in silicon—more than 15.5 dBm of linear output power[1] per channel.

Who Needs It and Why?

At mmWave 5G frequencies, adequate signal range is among the top challenges facing the industry for both urban and suburban mobile and fixed wireless networks. Beamformer ICs with increased power output are aimed squarely at this issue, enabling design of cost-effective radios with extended signal reach in wireless-infrastructure applications. These include wide-area, small-cell, and macro base stations, as well as consumer premises equipment (CPE), fixed wireless-access points, and various other applications.

The new F5288 and F5268 ICs feature Renesas' Dynamic Array Power (DAP) technology, which enables high-efficiency operation at linear output power levels programmable from 10 dBm up to 16 dBm. This makes the third-generation ICs applicable to mobile and fixed wireless applications with a wide range of output power requirements. It also allows users to reduce design times by repurposing their antenna-array designs across different applications.

Under the Hood

Renesas' third-generation mmWave beamformer ICs address all of the beamforming capabilities required by 5G systems while achieving the highest linear RF output power in any silicon technology with high efficiency.

PASTERNACK®
an INFINITE brand

Low PIM Rated Sub 6 Ghz 5G Antennas

In-building distributed networks and outdoor wireless networks call for robust antennas that offer wide bandwidth coverage, low PIM ratings as well as MIMO and SISO technology support.

To address these requirements, Pasternack launched a new series of low PIM rated indoor wall mount and ceiling antennas as well as a series of outdoor rated omni-directional antennas. Pasternack is ready to support 5G innovation, testing, and deployments, through an expansive product offering, product support, and a commitment to same-day shipping.

Place your order by 6 PM CT, and have your antennas or any other components shipped today.

pasternack.com
+1 (866) 727-8376
+1 (949) 261-1920

In-Stock and Shipped Same-Day

The ICs' dual-polarization, 8-channel architecture provides a highly symmetric and very low-loss antenna routing network to improve overall antenna efficiency and reduce board costs. The exposed die package allows for more efficient thermal management at the board with improved heat dissipation through the back of the IC. In addition, Renesas designed the package pin map to simplify board design and reduce design risks. Lower complexity PCB design with minimum layer counts results in reduced board costs and faster time to market.

The F5288 and F5268 ICs also feature several Renesas technologies to enhance array-level performance. Dynamic Array Power technology permits a graceful scaling of output power with high efficiency. ArraySense technology with comprehensive on-chip sensor network allows users to monitor IC performance in array operation and apply critical corrections real-time. RapidBeam advanced digital control technology enables simultaneous synchronous and asynchronous control of several beamformer ICs to achieve extremely fast beamsteering operations.

Additional features include:

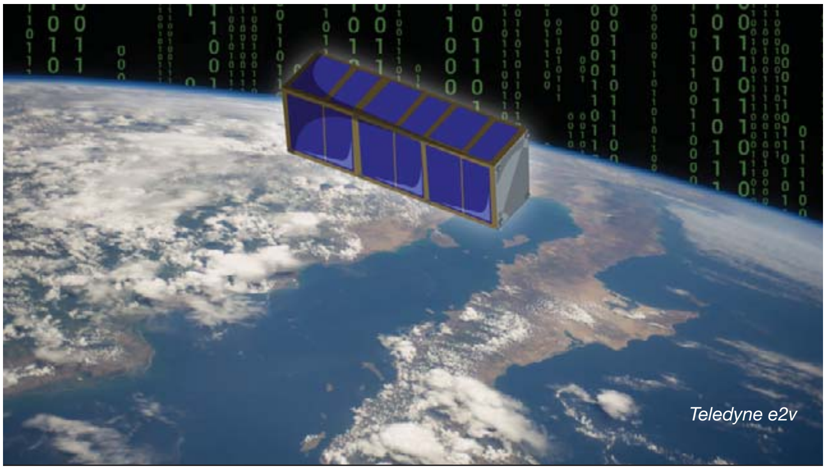
- 26.5 to 29.5 GHz (F5288) and 24.25 to 27.5 GHz (F5268) operation.
- Advanced temperature compensation techniques to minimize RF performance degradation with varying temperatures.
- State-of-the-art phase and gain control including 360-degree phase-control range with true 6-bit resolution and up to 31.5-dB gain control with 0.5-dB steps.
- Improved Rx linearity modes to provide additional flexibility for the receiver lineup.
- Rx noise figures as low as ~4.5 dB at room temperature and under 5.5 dB at temperatures up to 95°C.

The F5288 and F5268 beamformer ICs and evaluation systems are available now. mw

REFERENCES

1. Linear output power level defined at EVM.

Image-Analysis System Fits Compact CubeSats



Teledyne e2v

A compact imaging system with advanced AI provides the processing capabilities for wide-area scanning from space even within the limited confines of CubeSats.

CUBESATS MAY BE SMALL as satellites go, but now they can house a high-performance image-analysis system for detailed observation of Earth from orbit. The system was developed by the Centre Spatial Universitaire de Grenoble (CSUG) working with Teledyne e2v and unveiled at the recent Space Tech Expo 2021. It's designed to operate within the confines of 6U CubeSats measuring just 10 × 20 × 30 cm *(see figure)*. The heart of the system is a quad-core, 1.8-GHz, Qormino QLS1046-Space microprocessor module from Teledyne e2v with 64-b Arm Cortex A72 microprocessor cores accompanied by 4-GB DDR4 memory. Imaging data is captured with a 16-Mpixel Emerald CMOS image sensor, also from Teledyne e2v.

The two organizations have worked as partners for more than four years, with Teledyne e2v agreeing to full sponsorship of the QlevEr Sat project in March 2020. The imaging system, planned for launch in early 2022, is designed to acquire large-area images with the aid of artificial intelligence (AI), using an AI algorithm developed by the Multidisciplinary Institute in Artificial Intelligence (MIAI).

The system provides capabilities suitable for many applications, such as identifying areas of deforestation, damage from natural or man-made disasters, glacial and oceanic analysis, and monitoring of volcanic activity in addition to defense-related tasks. Qormino modules undergo intense screening and testing to ensure that they can effectively weather the hostile operating conditions of space. Modules can handle total-ionizing-dose (TID) levels higher than 100 krad and feature single-event-latchup (SEL) resilience of 60 MeV-cm^2/mg over a wide operating temperature range of -55 to +125°C.

Tania McNamara, Project Manager at CSUG, explained, "Integrating AI capabilities directly into CubeSats will dramatically reduce the amount of bandwidth needed for data transmission, which is clearly beneficial given the rising number of satellites now in orbit."

She added, "We envisage the system being utilized to address numerous use cases where changes on the Earth's surface need to be surveyed."

Thomas Porchez, Application Engineer at Teledyne e2v, offered, "By combining our next-generation processing, memory, and optoelectronic devices with the cutting-edge AI technology developed, QlevEr Sat overcomes these challenges. It enables image capture and subsequent processing to be carried out in even the smallest of satellite designs. Consequently, we see a lot of opportunities emerging for it." ■

Lockheed Martin Looks to Keysight for Military 5G Test Gear

FIFTH-GENERATION (5G) WIRELESS communications networks are making use of mmWave bandwidth once considered the exclusive domain of military electronic applications. Military users also are thinking the reverse might make sense and that 5G wireless communications networks provide the features and performance that support mission-critical communications for aerospace and defense applications. To make it possible, Lockheed Martin and Keysight Technologies are collaborating on a 5G.MIL testbed that will be put to use by Lockheed Martin engineers to enable the use of 5G technology for multiple applications.

The 5G.MIL testbed combines the capabilities of the model E7515B UXM 5G Wireless Test Platform from Keysight Technologies *(see figure)* along with the company's PROPSIM channel emulator for protocol signal testing and RF performance characterization and the UeSIM radio-access-network (RAN) network traffic emulator. The 5G military testbed is a flexible, modular measurement solution for evaluating the interoperability of defense electronic systems on commercial 5G infrastructure and the security and performance of commercial equipment on tactical communications networks.

Dan Rice, vice-president for 5G.MIL Programs at Lockheed Martin said, "Lockheed Martin is leveraging expertise in the commercial sector to scale, adapt, and integrate 5G technology rapidly and affordably across mission-critical operations across land, sea, air, space, and cyber domains. Keysight's end-to-end 5G test platforms, widely used commercially, provide an opportunity to develop customized solutions that meet the stringent requirements of the defense industry."

The wide bandwidth of 5G networks at microwave and mmWave frequencies compared to earlier wireless generations provides capacity for the multitude of commercial and military machines that employ 5G networks, such as Internet of Things (IoT) and unmanned aerial vehicles (UAVs), along with its human users.

Vince Nguyen, general manager for Aerospace Defense Government Solutions at Keysight Technologies explains the need to evaluate multiple technologies, "Deployment of future-proof, seamless and secure communication links serving operations across ground, sea, and air depends on the successful integration of 5G, satellite, UAV, artificial intelligence, and cloud technologies."

He added. "Leveraging Keysight's portfolio of flexible, scalable, and fully automated test, measurement, verification, and optimization tools, Lockheed Martin has implemented the most advanced testbed for 5G and hybrid networks that we have seen in the aerospace and defense industry."

The two companies will work through a strategic collaboration memorandum of understanding to add measurement capabilities as 5G continues to advance and evolve. ■

Keysight Technologies

MIKE JONES | Principal Electrical Design Engineer, Analog Devices Inc.
TRAVIS COLLINS | Software Support Engineer, Analog Devices Inc.
CHAS FRICK | Applications Engineer, Analog Devices Inc.

Improving Wideband Multichannel Systems with IC Integration (Part 1)

This article, the first in a three-part series, presents experimental results utilizing a 16-channel transmit and 16-channel receive subarray in which all transmit and receive channels are calibrated using hardened DSP blocks within the digitizer IC.

Over the past several decades, channel counts and bandwidths in wireless systems have steadily increased. The driving factors for these modern telecommunication, radar, and instrumentation systems are their data rates and overall system-performance requirements. However, these requirements also have increased power envelopes and system complexities, making power density and component-level features more important.

To help address some of these limitations, the semiconductor industry has integrated more channels on the same silicon footprint, thereby reducing watt-per-channel requirements. In addition, semiconductor companies are integrating more complex features into digital front ends that ease the off-chip hardware design. These sorts of integrations have historically been achieved in an application-specific integrated circuit (ASIC) or field-programmable gate array (FPGA) fabric. Features can range from generic components like filters, downconverters, or numerically controlled oscillators (NCOs), to more complex application-specific operations.

Signal conditioning and calibration problems only become more compounded when developing high-channel-count systems. Such architectures may require unique filters or other digital-signal-processing (DSP) blocks per channel, thereby making the shift to hardened DSP more important for power savings.

This article, the first in a three-part series, presents experimental results utilizing a 16-channel transmit and 16-channel receive subarray in which all transmit and receive channels are calibrated using hardened DSP blocks within the digitizer integrated circuit (IC). The resulting multichannel system improves size, weight, and power (SWaP) performance when compared to other architectures. When comparing the resource utilization of an FPGA for the system, it becomes clear that the hardened DSP blocks solve significant challenges for designers of multichannel platforms.

DSP Blocks

Real-world signals, whether used for synthesis or reception, require some amount of analysis or processing to collectively achieve the performance required for any application. A common method to compensate for signal-chain amplitude droop or flatness is to leverage compensation filters. *Figure 1* shows an example of a gain and flatness compensation filter designed and used to correct imperfections across a given frequency band, thereby creating a more ideal response for downstream applications.

For multichannel systems, this processing must allow for independent control on a per-channel basis to isolate each channel's performance with respect to another. Therefore, separate DSP blocks are utilized in this system to achieve channel phase and amplitude alignment while also attaining gain flattening within the passband of interest. Because each channel and system are unique, the DSP must be tuned specifically for that configuration, environment, and hardware lot.

Digital Up/Downconverter Blocks

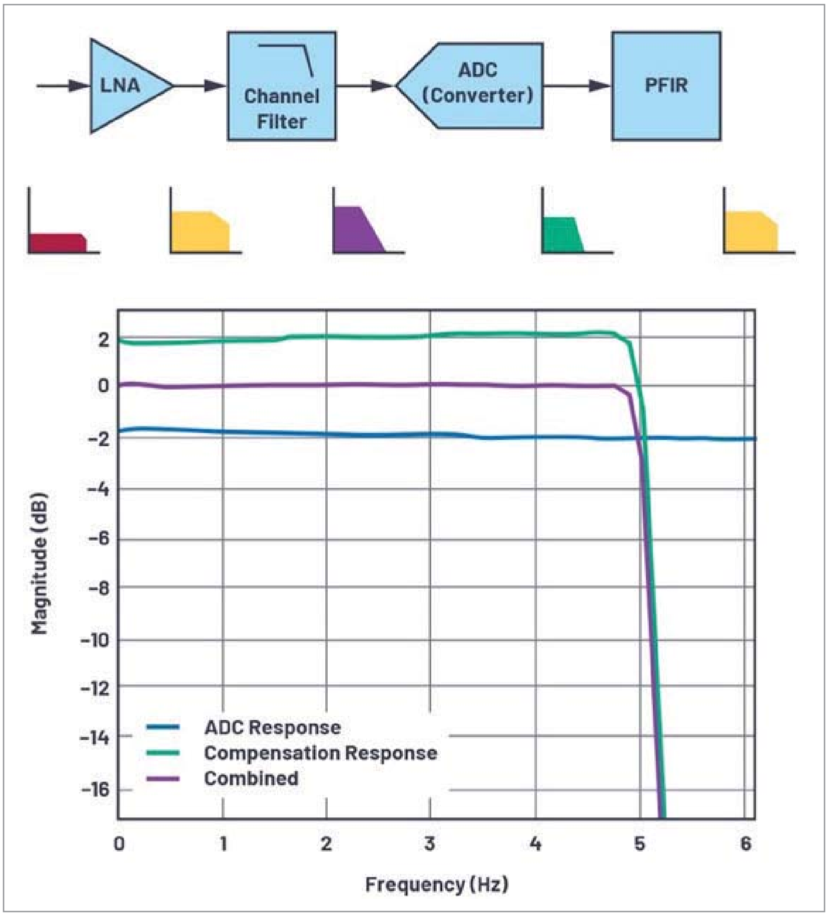
The results of this article hinge on heavy use of digital-upconverter (DUC) DSP blocks and digital-downconverter (DDC) DSP blocks colocated within monolithic DACs and ADCs. *Figure 2* shows an example of a DUC and DDC block diagram revealing the details of these often-used data paths.

DUC and DDC blocks can serve many useful purposes:

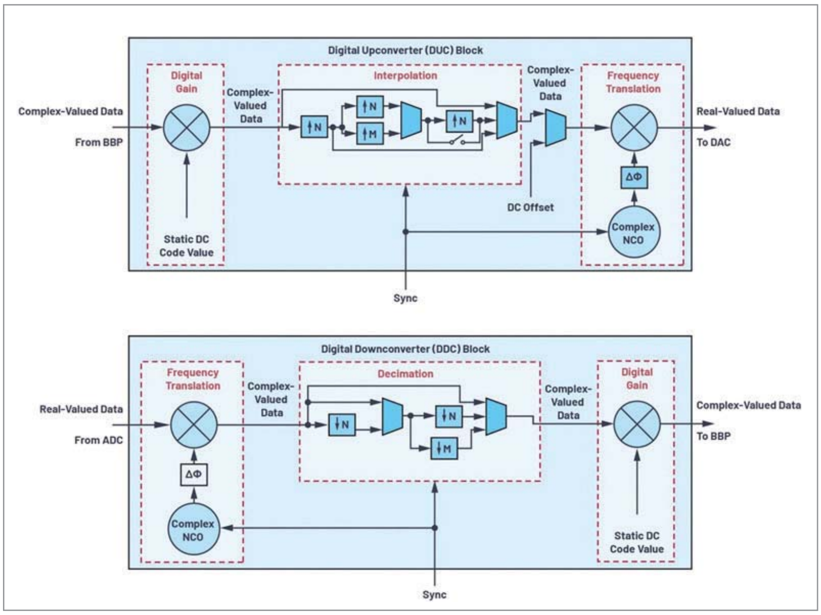
- Interpolate (DUC) and decimate (DDC) the converter sample rate as compared to the digital interface's data rate.
- Translate the frequency of the to-be-synthesized DAC data (DUC) and the digitized ADC data (DDC).
- Channelize the digital data transmitting on the interface to the baseband processor (BBP).
- Enable digital gain for each channel to generate code values closer to the system's full-scale value.
- Enable injection of simple digital tones to ease system bring-up without the need for digital data links.
- Align the phases of each channel with respect to a common reference.

It's often desired that the digital data rate offloaded to or from a converter be different than that of the converter's sample rate. This can reduce system power consumption and improve overall system flexibility. Therefore, designers often implement digital upconverter and downconverter blocks.

DUC blocks allow the transmit waveform data from a BBP to be transmitted at a lower rate than the DAC's sample rate, and thereby make it possible for interpolated waveform data to be synthesized by the DAC at this higher rate, as shown within the interpolation sub-block at the top of *Figure 2*. Similarly, DDC blocks allow the receive input to be digitized at a higher-speed ADC sample rate prior to being decimated and then sent to the BBP at a lower data rate, as shown within the decimation sub-block at the bottom of *Figure 2*.



1. An ADC's amplitude flatness response across frequency can be improved with digital filtering.



2. DUC and DDC blocks provide many useful DSP features now within converter ICs.

PLUG 'N PLAY

Leave the amplifier design to us and focus on your end system

MODULAR

Easy to scale to higher power levels

CONTROL

High-resolution frequency and power control at your fingertips

Amplifiers Available Now

2.4 TO 2.5 GHZ | 300W

ZHL-2425-250X+

- Suitable for CW and pulsed signals
- High gain, 40 dB
- High efficiency, 60%
- Built-in monitoring and protection for temperature, current, forward and reflected power
- User-friendly I2C control interface

27 MHZ | 1.7 KW

ZHL-0027-1K7X+

- Suitable for CW and pulsed signals
- 26 dB gain
- High efficiency, 80%
- Built-in monitoring for temperature and current
- Built-in emergency switch-off

2.4 TO 2.5 GHZ | +25 DBM

Signal Generator & Controller ISC-2425-25+

- High-resolution control range of key RF parameters
- Freely programmable with comprehensive command language
- Embedded functionalities for end-user applications
- Standalone or multi-channel operation (coherent or incoherent modes)
- Easy integration with control protocols such as RS422 & RS485

2.4 TO 2.5 GHZ | 300W

ZHL-2425-250X+

- 1 input to 4 19W output channels
- Suitable for CW and pulsed signals
- 16 dB gain at P3dB
- High efficiency, 55%
- Integrated harmonic suppression
- Temperature compensated gate bias

Preliminary Specifications:

Product specifications and features are subject to change without warning.

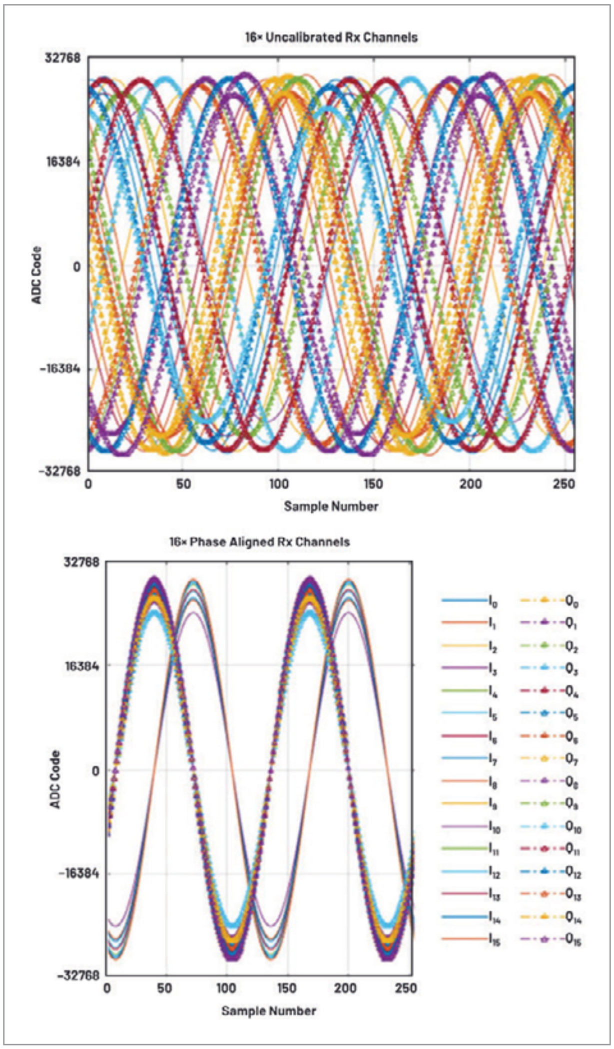
Mini-Circuits®

Furthermore, frequency translation is often desired within the digital domain to synthesize or analyze higher-frequency analog signals when compared with those signals sent over the digital interface to or from the BBP. Many systems utilize complex-valued NCOs within DUCs and DDCs to achieve this frequency translation *(Fig. 2, again)*.

NCOs can be regarded as digital signal generators. They may serve as a local-oscillator (LO)-equivalent signal that, when sent into a digital mixer also contained within the DUC/DDCs, can increase the transmit waveform's frequency sent into the DAC (as in the DUC case) or decrease the receive waveform's frequency sent out of the ADC (as in the DDC case).

When digital frequency translation occurs, the output of these digital mixers inside a DDC often becomes a complex-valued signal. In this case, both in-phase (I) and quadrature-phase (Q) signals can propagate along a single digital channel ultimately attached to a sole ADC sampling real-valued data. Similarly, the input complex-valued signal to the digital mixer of the DUC's digital gain block becomes real-valued at its output prior to being issued to a sole DAC synthesizing a real-valued signal.

Furthermore, DUCs and DDCs enable users to achieve multiple digital channels within the converter's instantaneous bandwidth. Thus, more data streams are capable of being synthesized and/or analyzed by the BBP than the number of converters in the subarray itself. The result is a system that can provide improved signal synthesis or analysis for cases involving two narrow channels separated far apart.



3. Experimental results showing the simultaneous I/Q capture of 16 receive channels that are phase aligned (but not amplitude aligned) strictly using the complex NCO phase offsets provided in DDC blocks located on the digitizer IC.

Digital-Gain and Phase-Offset Blocks

As can be observed in *Figure 2*, digital gain blocks also are frequently present in DUCs and DDCs. The digital gain is enabled by providing a static digital code value to the input of another digital mixer in the sub-block. By using this feature, the user can achieve code values closer to the full-scale value provided by the number of bits utilized for the digital interface.

Similarly, dc offset continuous-wave (CW) tones can be injected instead of baseband data by simply providing a continuous static code value into one port of the digital mixer. This allows the user to easily synthesize transmit CW tones via the DAC into the analog domain without the need to establish JESD204B or JESD204C data links with the BBP.

Phase-offset blocks are often implemented at the output of the NCOs *(Fig. 2, again)*. These phase offsets can be employed to correct channel-to-channel phase anomalies with respect to a common baseline reference present in the system. Because each DUC and DDC contains its own NCO, this makes it possible to achieve phase alignment for each channel in the system simply by offsetting the phase of the NCO by a determined amount for a given NCO frequency. The result, when used in conjunction with available multichip synchronization algorithms, is a deterministic phase relationship between all channels that can be corrected with these NCO phase offsets.[1]

Figure 3 shows the experimental results of 16 simultaneous receive I/Q data captures before and after achieving phase alignment strictly by setting the required NCO phase offset values for each receive data path. Note that these digital corrections also correct the RF and microwave impairments located in the front-end networks for each channel.

In the next part of this article series, we'll cover programmable finite-impulse-response (FIR) filters and how to achieve channel amplitude alignment and gain flattening. mw

REFERENCE

1. Michael Jones, Michael Hennerich, and Peter Delos. *"Power-Up Phase Determinism Using Multichip Synchronization Features in Integrated Wideband DACs and ADCs."* Analog Devices Inc., January 2021.

RAMYA KOTA | Product Line Manager, Wireless Solutions Group, Microchip Technology

The 4 Building Blocks for **LoRa Networks**

This article introduces the four main elements of LoRa network architecture and discusses some of the most common challenges faced by designers while developing LoRa end-nodes. How can regulatory certified LoRa modules help overcome such challenges?

Courtesy of Phuttaphat Tipsana | Dreamstime.com

Long-range (LoRa) technology is extending the reach of the Internet of Things (IoT) by combining long-range wireless connectivity with low-power performance. From smart cities to smart agriculture to supply-chain tracking, LoRa is an ideal choice to create flexible IoT networks that can operate in both urban and rural environments. But how easy is it really to develop a new LoRa solution or migrate to one?

Understanding a new wireless technology and choosing the right solution for your application can be exhausting. Wireless radio-frequency (RF) design usually requires in-depth RF expertise and adds significant development time for designers.

LoRaWAN Network Architecture

LoRa is a wireless modulation technique or physical layer that allows low-power end-devices to communicate over long range. LoRaWAN—a wireless networking protocol that acts as a media-access-control (MAC) layer—is implemented on top of the LoRa physical layer. The LoRaWAN specification details the communication protocol and network architecture and is meant to provide secure communication of end-devices and interoperability within the network.

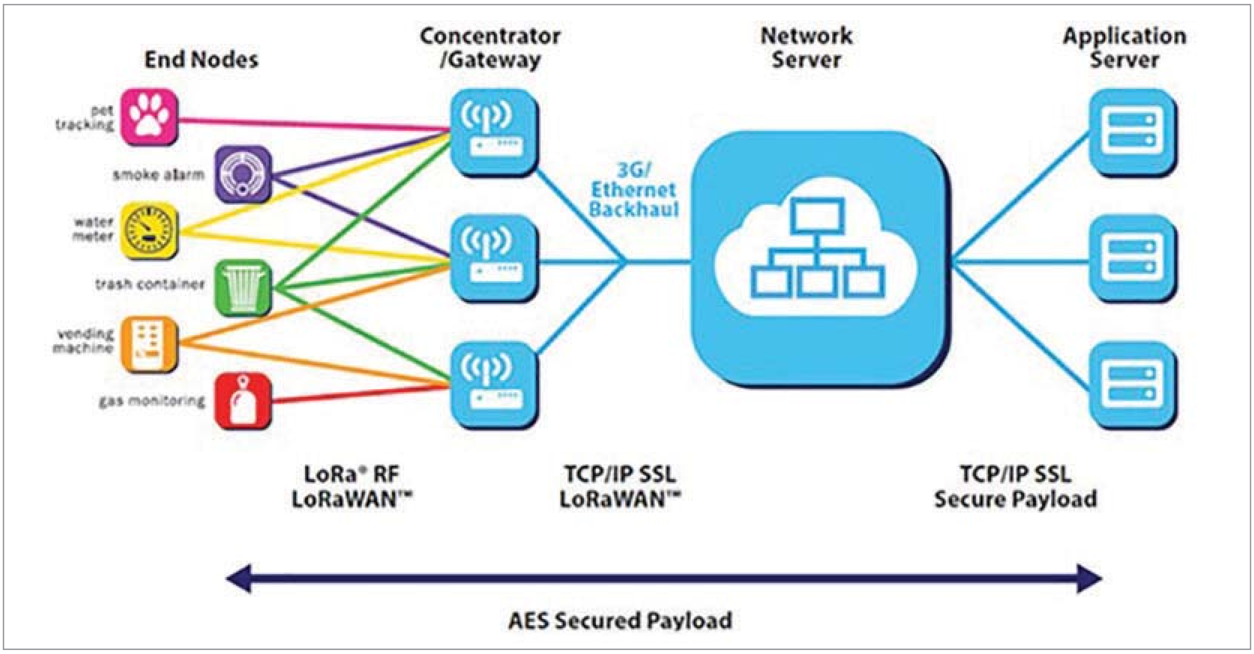
The LoRa network has four elements *(Fig. 1 on page 18)*:

1. *End-nodes* are elements of the LoRa ecosystem that gather sensor data and transmit/receive the data. They're generally remotely connected and are battery-powered.
2. The *gateway* is a transparent bridge between the end-nodes and network server. Typically, end-nodes use LoRaWAN to connect to the gateway, while the gateway uses high-bandwidth networks such as Wi-Fi, Ethernet, or cellular to connect to the networks.
3. A *network server* connects to multiple gateways. It gathers data from the gateways and filters out duplicate messages, decides which gateway should respond to end-node messages, and adapts data rates to extend battery life of end-nodes.
4. The *application server* collects data from end-nodes and controls the actions of the end-node devices.

Let's take a closer look at LoRa end-nodes and the challenges in designing them.

Common Challenges in Designing LoRa End-Nodes

End-nodes are simple objects, such as sensors and actuators. Typically, they comprise the "things" within the Internet of Things (IoT). In the LoRaWAN ecosystem, an end-node communicates



1. These are the four main elements of the LoRa network. (Source: LoRa Alliance)

to the network server through one or many gateways.

LoRa end-nodes are typically low-cost battery-powered applications that need to be power-efficient. Depending on the development time, target costs, power consumption, and RF expertise available, several options are available to build LoRa end-nodes. Before researching those options, let's look at some of the most common challenges that designers face when building thse end-nodes. They include:

RF Design

As with any wireless design, significant RF design expertise is needed when creating LoRa end-nodes. When using LoRa systems-on-chip/systems-in-package (SoCs/SiPs), the end-node device developer is responsible for the entire RF design, including schematics, bill of materials (BOM), PCB layout, antenna tuning, and other RF hardware.

Even with the best documentation and application design guides, RF design isn't always easy. It not only requires in-depth RF expertise, but also adds up significant development time for designers. Furthermore, debugging RF designs most often requires special equipment, adding further to the development costs.

To overcome the RF design challenges, some suppliers offer SoCs/SiPs that are supported by excellent documentation, regulatory certified reference designs, and detailed chip-down design packages. However, for the shortest development time and reduced risk, an RF optimized, tested, and certified LoRa module is almost always the best choice. These modules can provide a complete solution as a single component reducing design risk and development times.

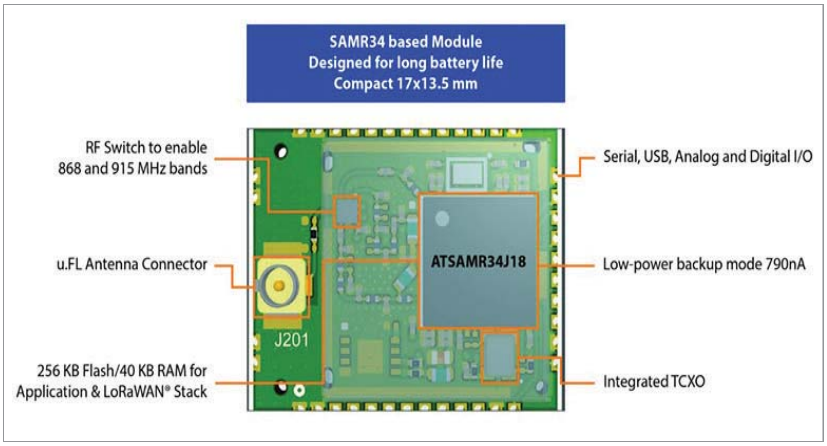
Regulatory Compliance and Certifications

LoRa/sub-GHz radios typically operate in the ISM license-free band. The frequencies vary depending on the region, making it challenging for hardware and software designers. Diligent care must be taken to design a fully compliant solution while keeping the BOM costs minimal. Also, RF regulatory requirements are constantly changing. Thus, keeping up with the regulatory changes, re-testing the devices, and re-certifying for compliance can cost several thousands of dollars—as well as engineering time—for end-node developer companies, money and time that could otherwise be spent on new projects.

Using a certified LoRa module solves this issue easily; the module manufacturer takes care of keeping up with the regulatory requirements and re-certifying modules to the latest specifications. All of these costs and time spent on regulatory compliance can be completely avoided by choosing a regulatory certified LoRa module.

Multi-Region Operation

LoRa devices support several frequencies, depending on the region. Often end-node manufacturers release their end-products in one major region first. Once the demand ramps up, companies investigate expanding the same design in other regions. Having a single SKU that supports multiple regions allows for seamless migration and expansion of the end-product into different countries and regions. A regulatory certified LoRa module that works for multiple frequency bands is ideal for this type of product expansion.



2. Shown is the block diagram for the WLR089U0 LoRa module.

3. The WLR089U0 LoRa module is based on Microchip Technology's SAM R34/35 family of ICs.

Robust Software

Generally, LoRa modules integrate the whole LoRaWAN stack inside the module. The end-node developer only needs to implement the initialization and communication to the module. With LoRa SoCs/SiPs and with standalone LoRa modules, the stack must either be provided by the manufacturer, or the developer must develop its own stack if no stack is provided.

To minimize software development, it's recommended to choose LoRa modules/ICs that are supported by the manufacturer's LoRaWAN stack. Proven LoRaWAN stacks from manufacturers ensure interoperability of end-nodes with major LoRaWAN networks and gateways, enabling end-nodes to work across different networks with reduced risk.

Migration Path from Modules to SoCs

Many companies start their prototypes and initial production runs with certified modules to reduce risk and get their products faster into market. Once their product starts to ramp up, companies may decide to move to LoRa SoCs/ICs for increased flexibility or lower BOM costs. The migration isn't always easy, so it's very important to consider standalone modules that allow for simple software migration between the modules and ICs. Also, it's essential to choose suppliers that sell both modules and SoCs; therefore, the development platform, software migration, and support structure remain the same.

Regulatory Certified LoRa Modules Simplify LoRa End-Node Designs

LoRa modules consist of all required radio components along with LoRaWAN stack and RF circuitry, thus helping accelerate development of LoRaWAN end-devices. Since the RF development and certification are implemented by the module manufacturer, any changes in certification specifications or component replacements are completely handled by the manufacturer, saving tons of development time as well as re-certification costs for end-device manufacturers.

Standalone LoRa modules with highly integrated LoRa ICs provide enough memory to run the application code along with the LoRaWAN stack. This eliminates the need for an external microcontroller, saving board space and system costs. *Figures 2* and *3* show a simple example of such a standalone module.

Standalone LoRa modules with highly integrated LoRa ICs provide enough memory to run the application code along with the LoRaWAN stack.

The WLR089U0 module based on the SAM R34/35 family of ICs from Microchip Technology is a compact module with 256 kB of flash and 40 kB of RAM, suiting it for space-constrained applications. Also, the module includes an integrated RF switch, enabling multi-band operation and allowing the same module to be used across multiple geographies, facilitating market expansion for end-products. In addition, the WLR089U0 is supported by Microchip's LoRaWAN stack and proprietary peer-to-peer software, which helps ease the software development for end-users developing LoRa applications.

Because the modules are based on the SAM R34/35 ICs, the migration path from modules to ICs and vice versa also is much simpler. Choosing such a module helps overcome all of the common design challenges while developing LoRa end-nodes, easing the entire design process.

Conclusion

Developing LoRa end-nodes can be complex and time-consuming. Highly integrated, certified LoRa modules provide an easy and proven approach to overcome the complex challenges involved in designing these end-nodes. Reliable software, larger memory, integrated RF switches, and regulatory certifications are some of the key features to look for in LoRa modules. Choosing a highly certified LoRa module not only helps simplify the design process, but also enables end-node developers to successfully differentiate their products and release them to market faster. mw

DR. FREDERIC NABKI | Cofounder and CTO, SPARK Microsystems

What's the Difference Between Bluetooth and UWB for High-Speed Data and Multimedia?

For nearly 20 years, Bluetooth has dominated as the short-range technology for wirelessly connected devices. But UWB's latency and power-efficiency advantages position it as a compelling alternative with faster, freer dataflow and low power consumption.

Bluetooth and ultra-wideband (UWB) short-range wireless technologies both rose to prominence at the turn of the century, and their development paths have been driven by the unrelenting need to reduce power consumption and extend battery life for an endless proliferation of wirelessly connected devices.

Bluetooth Low Energy (BLE) was ratified in 2006 to address the early power-consumption deficiencies of Bluetooth. More recently, Bluetooth 5.2 added features to reduce consumption for targeted applications like audio. However, these modifications are strictly incremental. Fundamentally, reductions in power consumption are physically limited by the Bluetooth architecture—a carrier-based transceiver will always require a significant amount of power to start, stabilize, and maintain its RF oscillator.

The *figure* shows the two significant power penalties inherent to all narrowband radio architectures, including Bluetooth.

First, crystal oscillator overhead *(lower left)* cripples low data-rate performance. Bluetooth uses a ~20-MHz crystal oscillator, which requires a few milliwatts to power. When efficiently optimized, UWB radios can operate with impulses that don't require a high-frequency crystal oscillator and can be designed to operate with a low timing power-consumption overhead. Much depends on the UWB optimization technique, though, so this is an area that should draw scrutiny.

Many of today's UWB technology implementations must in fact use *higher*-frequency crystal oscillators than what's required for BLE. Meanwhile, advanced UWB implementations can utilize crystal oscillators down to 32-kHz timing.

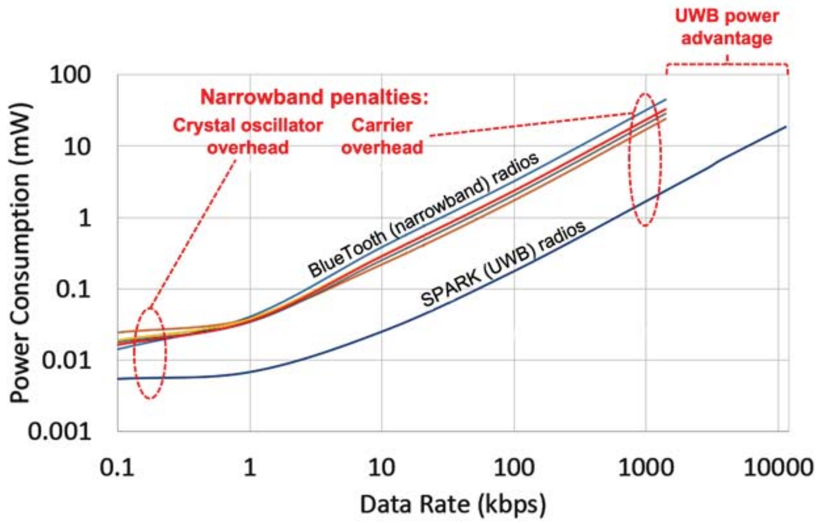
Second, the modulated carrier overhead *(upper middle in the chart)* penalizes high data-rate performance. Transmitting a large amount of data over a narrow bandwidth channel such as that used in Bluetooth radios requires lots of time and power.

Large amounts of data can be transmitted with UWB far more quickly because it's spread across a wide bandwidth, keeping the transmitter on for a much shorter duration and significantly reducing power consumption. This means for the same amount of consumed power, UWB can transmit much more data *(far upper right)*.

This owes to the time-frequency duality, well encapsulated by the Fourier transform. In simple terms, this duality states that if you have an infinitely long periodic time signal, it will have an infinitely small bandwidth. On the other hand, if you have an infinitely short impulse signal, it will have an infinitely large bandwidth. In other words, you can trade time for bandwidth.

Ultra-wideband enjoys a clear inherent advantage over narrowband given its allocation and support over a large portion of radio spectrum. A UWB signal is defined as a signal having a spectrum larger than 500 MHz. In the United States, the Federal Communications Commission (FCC) in 2002 authorized the unlicensed use of UWB in the frequency range from 3.1 to 10.6 GHz.

UWB systems use short-duration (i.e., nanosecond timescale) electromagnetic pulses for high-speed transmission and reception of data over large bandwidths. They also have a very low duty cycle, which is defined as the ratio of the time that an impulse is present to the total transmission time.



These are the two significant power penalties inherent to all narrowband radio architectures, including Bluetooth.

Bluetooth vs. UWB for Positioning

After two decades of maturation, Bluetooth today is nearly ubiquitous in the battery-powered wireless-device market, spanning smartphones/tablets, earphones/headsets, gaming peripherals, IoT sensors, and more. For wireless apps that could get by with high latency and highly compressed audio signals, Bluetooth has delivered an acceptable user experience for some wireless apps. However, it could be argued that Bluetooth has reached its point of diminishing returns.

Today, UWB is emerging as a compelling successor to Bluetooth/BLE for the next generation of low-power short-range wireless applications. Consumer electronics manufacturers like Apple, Samsung, and others sure to follow are leveraging UWB spectrum for the delivery of electromagnetic impulses for applications like positioning for object/asset tracking, as exemplified by Apple's AirTags. This is a narrow application of UWB's technology potential, but nonetheless an effective one.

In this capacity, UWB measures time of flight (ToF): an impulse is sent from one device to another, and we measure the time it took from transmit to receive. The distance between objects is determined accordingly, and this can be measured with picosecond accuracy with UWB chips. Leveraging onboard antennas, measurements are then able to be correlated to determine a signal's angle of arrival, and UWB "tagged" objects can consequently be located with accuracy down to a mere 10 cm.

Bluetooth technology comes nowhere close to matching this precision, as it utilizes received signal strength (RSS) to measure spatial distance. RSS is a very simple technique to implement and can be used by any wireless transceiver, which explains why it's so widely used. However, it's severely limited in its accuracy: The perceived distance between two immobile objects will change according to obstacles in their direct path, and BLE typically achieves positioning accuracy only to within several meters.

Positioning technology enabled with UWB—while extremely accurate—is exceedingly complex from a design perspective and therefore extremely power-hungry. As a result, UWB chips used today for object tracking are actually less power-efficient than Bluetooth chips/radios by as much as 10X. So, while UWB is well-suited for positioning, it's a power-intensive application by nature and at the end of the day, there's no device-level power benefit delivered with UWB.

UWB for High-Speed Data and Multimedia Communication

The aforementioned time-frequency duality expresses how time and bandwidth are interchangeable. If one wants to compress in time a wireless transmission, it requires more frequency bandwidth. This property can be used to increase the accuracy of positioning and ranging, but these capabilities represent a mere sliver of UWB's potential.

Another very interesting capability enabled by the time-frequency duality is that it can reduce the latency in systems. This has huge implications for untold short-range wireless applications into the future.

Impulses delivered over ultra-wide bandwidth ensure extremely low latency—these signals can be sent in microseconds with UWB, whereas Bluetooth would take milliseconds. The end result is ultra-efficient wireless data communication. What's more, UWB implementations have demonstrated at least 10X less power consumption than BLE for non-positioning applications.

Bluetooth's latency penalties will only persist for applications like gaming, audio, and IoT, which is the chief reason why wired connectivity has lingered so stubbornly for peripherals and sensors used in these applications. We welcome the free-

(Continued on page 40)

Q&A

WILLIAM G. WONG | Senior Content Director

Viewing the Semiconductor Supply Chain Through the Distributor's Eyes

This interview addresses how the supply/demand imbalance has impacted companies and best practices to deal with the cyclical nature of the semiconductor supply chain—including avoiding the risk of counterfeit chips.

Jm10 | Dreamstime.com

The pandemic dramatically increased the demand for semiconductors in a way that companies were not adequately prepared to handle. In this interview, we discuss how the supply/demand imbalance has impacted companies and best practices to deal with the cyclical nature of the semiconductor supply chain—including avoiding the risk of counterfeit chips.

I spoke with Todd Burke, President of Smith, about how the supply chain is changing.

How are different industries being affected by the supply/demand imbalance? What can businesses/consumers in those industries expect in the coming months?

The semiconductor supply and demand imbalance has had a ripple effect across industries, from automotive to gaming, PCs, mobile phones, and beyond. In the auto industry, specifically, the shortage has severely impacted manufacturing capacity. While balance will eventually be restored, manufacturers are expecting supply to be tight into 2022 or, by some estimates, 2023.

Take the electric-vehicle sector, for example. Manufacturers are doing everything they can to combat the chip shortage and keep plants running. Many manufacturers are expanding their vendor bases, getting more directly involved in sourcing, and assisting their subcontractors in the sourcing process. Some are redesigning boards using alternative chips and some, when feasible, are producing cars without certain features that key semiconductors would otherwise support.

The need is there and boils down to simple supply-and-demand economics, and the end customer will see the effects of the shortage in price and availability of electric vehicles. It takes a long time to build new factories and, depending on how the pandemic continues to impact supply chains, the road could be a bumpy one for the foreseeable future.

One thing is for certain—with the continued growth of the electric-vehicle market and technology in general, there will be an ever-growing need for more semiconductors, not fewer.

What does the semiconductor supply chain look like in terms of how chips are bought and sold?

Chips are increasingly being incorporated into products across more and more industries, with specific components often being used in hundreds of different applications. The result is that chips are bought and sold across industries and geographies under different legal, regulatory, and time pressures. This complexity within the semiconductor supply chain and its wide array of vendors can make it challenging for companies to navigate when their usual suppliers run out of stock.

Procurement teams must search the market to secure the right parts in the right quantity at the right price, and they must get them delivered on tight deadlines. Layered on top of this are additional factors to consider, including product quality and authenticity. In this current shortage situation, we're seeing a difference between customers who regularly and strategically use the open market compared to those who are entering it for the first time out of necessity.

For newcomers, the key to purchasing semiconductors on the open market is selecting a knowledgeable and trustworthy supplier. But what should you look for?

First, you should know their background. Determine how long they've been around, how well they understand the current market conditions, and how they have navigated shortages in the past. You should also investigate their financials and ensure they have the capital needed to secure parts in a shortage market. And, finally, dig into their quality program to make sure they have the resources needed to verify component authenticity and functionality.

What's the difference between brokers and distributors? Can you describe a few of the pitfalls to avoid and best practices that you recommend for companies sourcing components on the open market for the first time?

The open market distribution channel has seen quite an evolution over the last

30+ years. Small brokers with no real quality control, vendor management system, or value-added services are still out there. But a narrowing number of open-market players—independent distributors—have really distanced themselves by all measures, whether it's gross revenue, financial stability, longevity in the market, global footprint, variety of services provided, or quality-assurance capabilities.

The most important differentiator is that an independent distributor, such as Smith, has the extensive quality-control protocols and certifications in place to ensure that customers receive reliable, high-quality products.

Our best advice to companies looking to source components on the open market for the first time is to do your research. Just because a part was found on Google doesn't mean that its authenticity can be trusted. Look at what kind of certifications the supply partner has.

For example, suppliers who hold aerospace & defense or medical certifications—such as AS6081, AS9120, and ISO 13485—are more likely to have the necessary quality-assurance processes in place because they have to meet the extremely high standards of these industries where safety and reliability can be life-or-death concerns. Additionally, examine the supply partner's testing capabilities. Smith, for example, has in-house counterfeit detection testing labs that are ISO/IEC 17025-certified and provisioned with the most advanced in-house tools to verify component authenticity, so that the integrity of parts is never in question.

What are the long-term implications of the current supply/demand imbalance, and how can businesses best navigate them?

At the moment, as companies deal with the supply shortages, it may be difficult to look beyond the issues that are right in front of them—primarily, obtaining the components that they need. Therefore, it's crucial to have a relationship with a trusted partner that can help them navigate the ebbs and flows of the semiconductor supply chain. The first reason, reiterating what was said previously, is to ensure quality.

The second reason is inventory management. Under the current market conditions, companies are most concerned with increasing supply. However, there's also a longer-term concern which is the potential for inventory hangovers.

A practice of Smith's has always been inventory management as a tool to minimize disruptions to business from both lack of supply and oversupply. Many of our long-time customers are coming to Smith with plans for hubbing or inventory management on parts that they know have long lead times. They're taking a proactive stance to source them and have them on the shelf for when they're needed.

On the other end of the spectrum, Smith is also able to assist customers when they're ready to offload excess inventory. Smith has decades of experience matching buyers and sellers, which helps customers to maximize their returns while filling a need for another customer in search of that product.

How has the supply/demand imbalance increased the risk of counterfeit chips?

As a result of the chip shortage, buyers are sometimes desperate for certain parts, and nefarious parties take advantage of that with counterfeit components. Buyers can develop tunnel vision in this type of scenario, and they may miss some major red flags around the components' authenticity.

To explain further: In this context, companies have found that their regular suppliers are unable to keep up with demand. Desperate and in a hurry to obtain components, a company may turn to alternative markets; the internet, at first glance, may seem like the ideal place to find a part that has been impacted by the chip shortage.

However, without a trusted arbitrator and partner who vets suppliers, this can be dangerous and cause long-term damage to the company's reputation if the parts end up being damaged, counterfeit, or otherwise flawed. Turning to an experienced middleman is equivalent to having a filter and safety net—ensuring that what you order is what you receive.

How does Smith protect customers from counterfeit chips while helping them navigate the current supply-chain challenges and plan for the post shortage future?

At Smith, we have a comprehensive systems-based approach to quality, which brings everything together from our sourcing and traceability to our packaging and logistics. This helps us to ensure that the product is correct, authentic, and of the highest quality.

As a frontrunner in the development of industry standards for digital imaging and inspection, Smith has both experience and expertise to help customers navigate the current challenges. Additionally, we're accredited through numerous third-party certifications, and we confirm our procedures with our documented third-party auditing and certification processes. All of the systems and checks we have in place give customers peace of mind while addressing their supply needs.

Looking beyond the current shortage, Smith assists customers with inventory management in the case of surplus supply. The longer parts sit untouched on warehouse shelves, the greater the potential for loss as they grow obsolete and lose resale value. Smith's excess inventory services can recover value by turning surplus electronic components into a revenue stream.

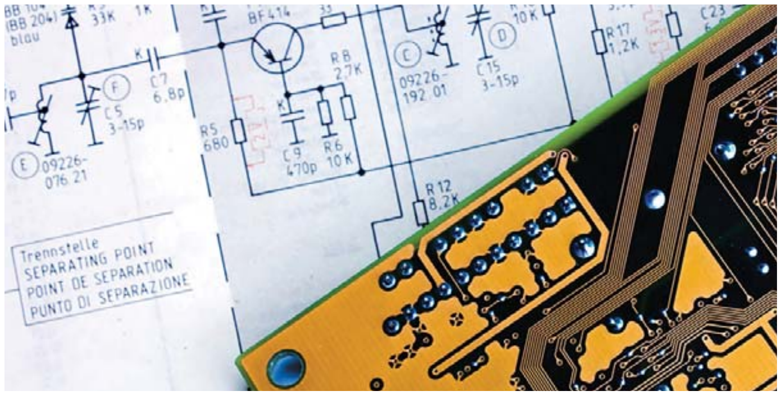
Shortages are an inherent part of the semiconductor supply chain. Arming customers with knowledge, resources, and support, we help companies strengthen their ability to navigate the market's cyclical nature successfully. mw

TODD BURKE is President, Americas, at Smith. He supports Smith's five Americas-based trading offices in developing their focus on growing relationships and supply-chain strategies with Smith's key accounts in the region, while working closely with his EMEA and APAC counterparts.

MITCH MAIMAN | President and Cofounder, Intelligent Product Solutions

Pain Points for RF Product Design

Many unique RF challenges emerge in the development of products, from implementing active wireless technologies to passive RFID tagging. To help address them, it's crucial to engage your RF engineers early in the design and product requirements stage.



Having been involved in developing products in virtually every product category from consumer to medical to commercial to DoD/aerospace, we've discovered that in every case requiring wireless technology, one comes across the seemingly black art of RF system design. Such engineering requires a high level of experience to solve tough problems involving strong fundamental expertise in physics.

The problem set in RF design spans the gamut from implementing active wireless communication technologies (transmit and receive) like satellite, cellular, Wi-Fi and Bluetooth, to passive RFID tagging used in applications such as NFC payment systems or tagging of retail items like clothing. RF system design also includes UL- and FCC-related issues, robust circuit design, and good PCB layout to minimize unintentional radiated emissions and low susceptibility to outside interference. Because of the latter, RF system design is a factor in just about anything with a wire attached to run power.

What follows are five of the unique RF challenges in the development of technology products:

1. Issues related to PCB design

Design of a PCB, especially high-density and mixed-signal boards, presents a big challenge in system design. While physically larger/lower-density boards may be able to leverage off-the-shelf or reference antenna designs, in cases when circuits are compressed, there may not be easy antenna solutions.

Antenna configuration and placement is a *major* factor in radio performance. In many handheld and mobile products, severe space constraints make it difficult to incorporate efficient antenna operation due to limitations on antenna size. This can drive the need to use small chip antennas, for example. For monopole antennas such as chip antennas and quarter-wave whip antennas, the PCB ground plane is needed to form the counterpoise half. As a result, PCB size constraints can make it challenging to optimize antenna efficiency and communication range.

In a host of products, the current crop of systems-on-a-chip with integrated radios and antennas are ideal solutions. However, these come with their own challenges especially in high-density systems. Such modules are not necessarily optimized for size compression. They also present difficulties in PCB layout when using existing reference designs.

2. Multiple radio systems

The more radios in the system, the more antennas and more intricate the antenna design. This presents challenges in board layout that affect performance and crosstalk noise-related issues that are difficult to resolve. With close placement of antennas, interference between cellular and Wi-Fi can be an issue implying the need for careful antenna placement, orientation, and filtering techniques.

3. 5G system design

Everyone is jumping on the 5G bandwagon for many of the right reasons. 5G builds upon the existing technologies and frequency bands of 4G, but also adds a new band of frequencies in the region of 25 to 40 GHz for super high-speed communication applications. However, high-frequency 5G systems present design and application challenges.

Due to the high frequency, performance is impacted by reduced range—high frequencies don't penetrate the environment as well as lower frequency ranges. It's a tradeoff between range, bandwidth, and transmission rates when considering 5G implementation. For example, to ensure super-high-speed data rates at these high frequencies, a high base-station density and line-of-sight communications will be more important and will increase infrastructure costs.

4. System design and regulatory issues

The obvious domain for RF designers is in radio integration. However, such engineers also are called upon to debug problems in passing regulatory requirements. Virtually every product with a wire has run into challenges passing the radiated and conducted emissions and susceptibility requirements.

Systems in the corporate lab not impacted by noise get into the agency approval process and find noise problems that can be traced to things as simple as cable layout. RF engineers must assist in design of robust guard-band on emissions and susceptibility to ensure variances in the test setup don't result in failures. Such failures can be a killer due to additional redesign cost, additional agency lab time, and the delay in time to market.

It's crucial to engage RF engineers early in the design and product requirements stage to ensure PCB design, layout, and shielding is up to snuff. For example, making sure a design has sufficient capacitance, good power/ground plane layout, and good signal trace routing is necessary to minimize spurious emissions and contamination of the circuits from external noise sources. Oftentimes, cables are a cause of spurious emission failures, too, due to them carrying common-mode currents that need special attention, such as cable placement filtering and shielding techniques.

5. Finding the talent

Good RF engineers must have a strong background in both electrical engineering and physics. Not only is the competition for experienced talent fierce, but there's a scarcity of RF-focused engineers being turned out of engineering colleges and universities. RF engineering is sometimes viewed as a mysterious skill set somewhere between engineering and science. The pipeline for staff is small and doesn't appear to be improving any time soon. (By the way, this is good news for those considering an EE career in the domain of RF.)

Almost any company developing electronic systems, whether or not they have wireless communications, needs access to an RF expert either on the team or on standby to call in when needed (and they will be needed). Few, if any products sail through UL and FCC testing unscathed—even those designed with the benefit of a highly skilled and experienced EE or RF designer. In no engineering discipline does this phrase apply better: *You have to understand the physics of the problem.*

At IPS, we're fortunate to have a sub-team of highly experienced and technically proficient RF and antenna system designers. They're worth their weight in gold. Without such talent, one can spend inordinate amounts of time designing and testing to get a high-performing (or even minimally satisfying) result that secures regulatory approval for product sales in a developed country. mw

DAVID MALINIAK | Editor

Here's a selection of 2021's most popular new-product stories that appeared on *mwrf.com.*

This year was one of reawakening for the microwaves and RF industry. As if coming out of a long hibernation, we all tentatively ventured out in June to attend the International Microwave Symposium in Atlanta. After the long period of pandemic-related isolation and lockdowns, it was a harbinger of a better year. And indeed, 2021 has been just that, with a bumper crop of new and interesting products to prove it.

Here, we gather together the Top Products of 2021 as determined by their popularity on our website, *mwrf.com*. This is just the tip of the iceberg—the full roster can be seen in the form of Media Galleries on the website.

Signal Creation/Analysis Tool Melds EDA Simulation with Hardware Test

Rohde & Schwarz collaborated with Cadence Design Systems to develop the R&S VSESIM-VSS signal creation and analysis tool, which supports all major standards such as 5G, the latest Wi-Fi incarnations, and many more *(Fig. 1)*. The joint solution combines signal generation, design simulation, and signal analysis, building on the strengths of both companies' proven solutions. As a result, developers and design engineers benefit from an optimized tool that allows them to address design challenges earlier than before in the development process.

The R&S VSESIM-VSS signal creation and analysis tool functions as an addition to the Cadence Visual System Simulator (VSS) software, an established solution for system simulation and modeling, particularly for RF components and RF assemblies used in wireless communications and radar design. Rohde's VSESIM-VSS expands the capabilities of the VSS software by adding realistic signals to the workflow, increasing simulation accuracy and simplifying the design process.

1. Rohde & Schwarz and Cadence cooked up a signal creation and analysis tool that hastens the development process for RF components.

Space-Ready SDR Module Carries Open Reconfigurable FPGA

In its SDR-1001, a flight-ready, credit-card-sized modular software-defined-radio (SDR) module, CesiumAstro delivers four transmit and four receive channels tunable from 300 MHz

2. In a credit-card-sized module, CesiumAstro's SDR-1001 delivers four Tx and four Rx channels of SDR for LEO satellites and airborne missions.

4. Raltron's design kit contains over 60 combinations of frequencies, load capacitances, and package sizes for use with a multitude of popular ICs.

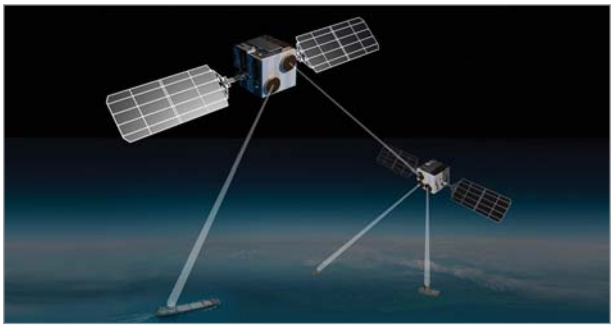
to 6 GHz for commercial, government, and defense applications *(Fig. 2)*. The module, which is tested to NASA GEVS standards, ships with a default BPSK/QPSK modem and optional FPGA Developer Toolkit, enabling custom waveform development.

Meant for low-Earth-orbit satellites and airborne missions, the SDR-1001, which weighs just 100 grams, offers custom waveform support with 70% of its FPGA resources available for custom designs. It integrates a flexible RF front end with high-performance FPGA to support a 5- to 7-year mission duration.

Phased-Array Antennas Take on Space-Payload Duties

ThinKom Solutions developed a new family of phased-array antennas for deployment on satellites and other space vehicles *(Fig. 3)*. The antennas, based on ThinKom's Variable Inclination Continuous Transverse Stub (VICTS) technology, are multi-frequency, full-duplex antennas for operation on geostationary and non-geostationary satellites using the C-, X-, Ku-, Ka-, Q-, V-, E-, and W-bands. They can provide steerable high-capacity inter-satellite links as well as space-to-Earth and Earth-to-space feeder and user links.

The ThinKom payload antennas are compact and lightweight, with a 30-cm-diameter antenna weighing less than 5 kg. They can be nested for multi-beam applications without the blockages that can occur with multiple parabolic dish arrays. They also can support digital beamforming within regional user beams.



3. ThinKom Solutions' compact, lightweight antennas serve inter-satellite, Earth-to-space, and space-to-Earth links while supporting nesting and beamforming.

Design Kit Provides Quick Access to Crystal Resonators

In a bid to facilitate design projects involving crystal resonators, Raltron now offers a Crystal Resonator Engineering Design Kit *(Fig. 4)* comprising more than 60 combinations of frequencies, load capacitances, and package sizes that are recommended for use with many of the popular ICs on the market.

The crystal resonator design kit includes frequencies from 8 to 50 MHz in ceramic package sizes from 5032 to 1210, and 32.768 kHz in 3215 to 1210 size packages. A printed card behind each sample pocket allows the user to connect to a special website providing the Raltron part number, part description, full specs, environmental data, an RFQ form, and a connection to distributors who carry the item in inventory.

K-band Passive Components Serve Space Applications

Smiths Interconnect's broad range of K-band passive components for communication payloads in GEO/MEO and LEO satellites includes coaxial and WR51 isolators, circulators, and iso-adapters; waveguide loads, and microstrip isolators *(Fig. 5)*.

The company's K-band coaxial and WR51 isolators, circulators and iso-adapters, waveguide loads, and microstrip isolators are broadband devices and, as such, require fewer part options to address the allocated frequency band. They are temperature-stable and multipaction-free.

5. Smiths Interconnects' isolators, circulators, iso-adapters, and loads are born of an extensive product line and specifically engineered to reduce cost and NRE charges for users.

6. STMicro worked closely with Xilinx to design a power source that ensures reliable operation of the XQRKU060 by providing fixed-point voltage accuracy and stability in the face of transients.

7. The Ultraview-8G comb generator offers a 10-MHz to 2-GHz picket for antenna range testing, communications, and jamming applications.

STMicro's Space-Qualified Regulators Power Xilinx's Rad-Hard FPGAs

Radiation-hardened FPGAs for satellite-communications applications need power from circuitry that's just as capable of withstanding the rigors of spaceflight. To that end, STMicroelectronics is collaborating with Xilinx to build a power solution for the latter's Kintex UltraScale XQRKU060 radiation-tolerant FPGAs, leveraging QML-V qualified voltage regulators from ST's space-products portfolio *(Fig. 6)*.

ST worked closely with Xilinx to design a power source that ensures reliable operation of the XQRKU060 by providing high fixed-point voltage accuracy as well as stability upon the occurrence of transients due to normal FPGA operation and radiation events. The solution uses ST's RHRPMPOL01 rad-hard, point-of-load, 7-A monolithic synchronous step-down regulator and RHFL6000A linear voltage regulator, all single-event-latchup (SEL)-immune and QML-V qualified. These devices meet the requirement for an input voltage up to 12 V and output voltage down to 0.8 V. Both exhibit high fixed-point accuracy with radiation performance that ensures high resistance to total ionizing dose, thereby minimizing any output-voltage drift.

Comb Generator Offers Spectral Content Programmability

Based on a custom, ultra-high-repetition-rate GaN differential pulser IC, Ultraview Corp. now offers a new class of microwave comb generator said to reach formerly unattainable output power levels with low jitter and spectral content programmability *(Fig. 7)*. The palm-sized Ultracomb-8G is powered from any USB3.0/3.1 port, through which the user can program comb amplitude, comb picket spacing, and low/high-frequency spectral weighting.

Comb picket spacing at the device's output can be software-programmed to any frequency from 10 MHz to 2 GHz in single-ended-output mode (10 to 50 MHz in differential-output mode) in 0.01-Hz steps, generated by an on-board LMX2594 synthesizer driven from an internal reference clock with 150-fs jitter, or from an external 10- to 500-MHz reference.

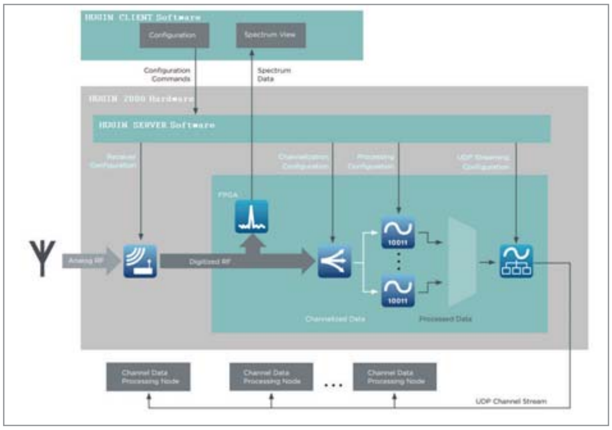
The palm-sized Ultracomb-8G is powered from any USB3.0/3.1 port, through which the user can program comb amplitude, comb picket spacing, and low/high-frequency spectral weighting.

43.5-GHz Spectrum Analyzer Handles mmWave Tasks

With its SM435B RF spectrum analyzer and monitoring receiver, Signal Hound has taken the leap into millimeter-wave spectrum analysis *(Fig. 8)*. The instrument touches a broad swath of mmWave applications from 5G to military, aerospace, and many others.

8. Signal Hound's latest spectrum analyzer and receiver combines 110-dB dynamic range, 1-THz sweep speed, and 160-MHz real-time bandwidth within a compact form factor.

The SM435B tunes from 100 kHz to 43.5 GHz, boasts 160 MHz of instantaneous bandwidth (IBW), a high dynamic range of 110 dB, and a sustained sweep speed of 1 THz/s. It also brings to the table a built-in sub-octave preselector from 20 MHz to 43.5 GHz, and ultra-low phase noise—introducing no more than 0.1% error to EVM measurements. This low level of phase noise rivals the most expensive spectrum analyzers on the market, the company claims. Its system noise figure ranges from 12 to 15 dB between 700 MHz and 15.2 GHz.



9. Novator Solutions's updated HUGIN 2000 receivers deliver improved signal quality, more flexibility/usability, and greater uptime for COMINT applications.

V/UHF Receivers Gain Signal-Quality Updates

Novator Solutions refreshed its HUGIN 2000 family of networked multichannel receivers to address communications intelligence (COMINT) and other narrowband monitoring applications even more thoroughly *(Fig. 9)*. The high-dynamic-range, networked receiver provides one or two tuners with 50-, 80-, or 200-MHz instantaneous bandwidth per input and up to 2,048 individually configurable digital downconverters (DDCs). The receivers cover a frequency range of 2 MHz to 3.6, 14, or 26.5 GHz with demodulation of AM, FM, SSB, and CW signals.

Key to the receivers' overhaul was a reworking of the core firmware, which provides up to 1,024 narrowband DDCs per receiver. In collaboration with its partner, RFEL, a Rheinmetall Defence UK company, Novator redesigned the entire internal signal path to handle 32-bit IQ-data, resulting in higher dynamic range. On top of that, the channel filters are narrower and sharper (500 Hz for CW; 3 kHz for SSB), the automatic gain control (AGC) has been updated, and the receivers' squelch now offers a hysteresis function. The upgraded signal quality improves both the channel selectivity and dynamic performance, enabling operators to detect previously hidden and weak signals.

Solid-State Data Recorder Tolerates Space Radiation

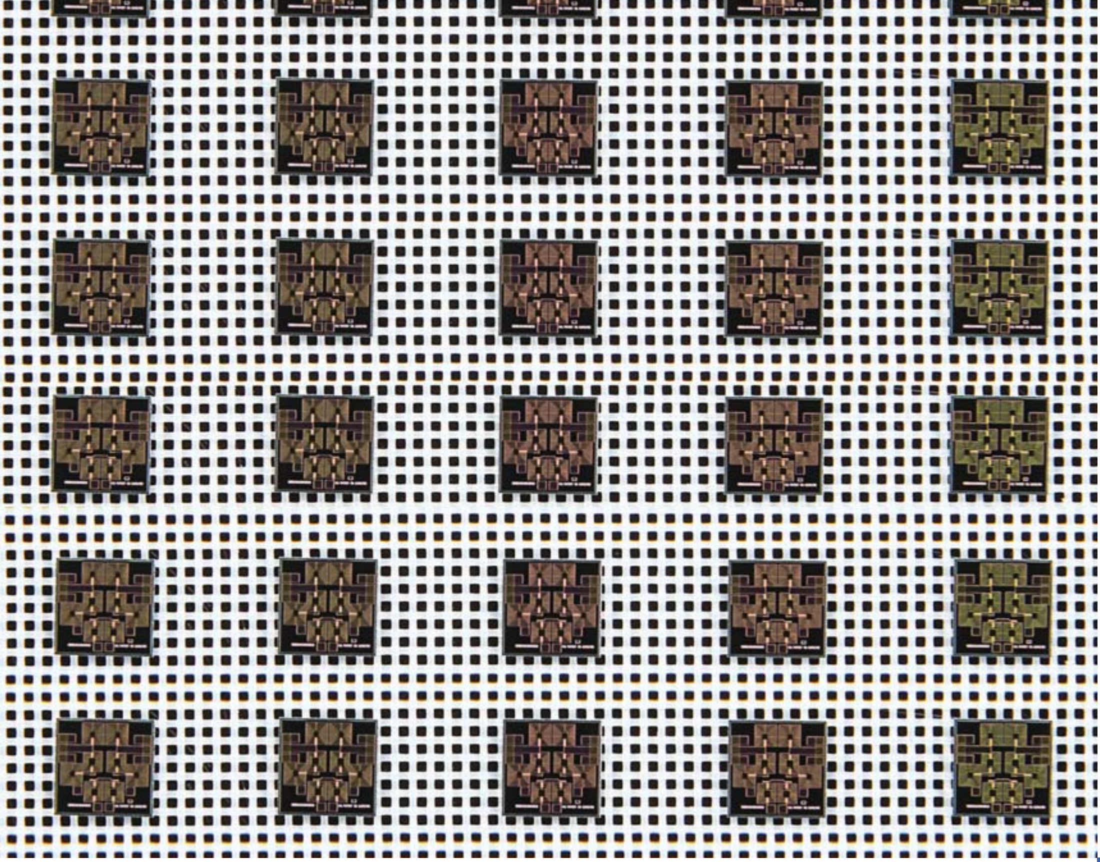
Satellites are becoming increasingly important components in a global electronic network for communications and navigation, even though the components within satellites are subject to high radiation levels that can limit reliability and operating lifetimes. Fortunately, electronic devices such as the model RH3480 solid-state data recorder (SSDR) from Mercury Systems, are being designed with radiation in mind, featuring the capabilities to withstand radiation levels found in space applications and on board low-Earth-orbit satellites *(Fig. 10)*.

Based on single-level-cell (SLC) NAND flash memory, the RH3480 SSDR provides a reliable 480 GB of storage in a compact 3U VPX-compatible form factor. Designed and built according

10. Mercury Systems' RH3480 SSDR is SWaP-optimized to provide 480 GB of industrial-grade memory in a 3U VPX-compatible enclosure weighing only 750 g.

to reduced size, weight, and power (SWaP) demands, it features highly dense data storage but weighs only 750 g in keeping with satellite communications (satcom) and navigation requirements.

In addition to high radiation tolerance, the SSDR employs advanced error-correction-code (ECC) algorithms to maintain data integrity under the harsh operating conditions of space. It functions in linear and host-addressable operating modes. The dual-port design can write data at rates to 18.4 GB/s and read data at rates to 16.0 GB/s. mw



JACK BROWNE | Technical Editor

Army Assists SiC Research at University of Arkansas

SiC semiconductor technology has interested the U.S. Army in the past for its potential in high-power energy sources for electric vehicles.

Silicon carbide (SiC) holds great interest for its potential as a base semiconductor material, especially for the U.S. Army. To fuel the progress of SiC semiconductors with high-temperature-capable, high-efficiency devices and integrated circuits (ICs), the Army Research Office (ARO) and the Army Research Laboratory (ARL) recently awarded grants totaling $5.4 million to the University of Arkansas for a new SiC semiconductor fabrication facility. This funding follows an $18 million grant from the National Science Foundation (NSF) for the operation of a national SiC fabrication facility at the University of Arkansas.

Courtesy of U.S. Army

As a compound semiconductor material, SiC supports the fabrication of discrete power devices, sensors, and ICs for use by the Army and other branches of the U.S. armed forces. The Army has previously invested in SiC semiconductor technology for high-power electronics for electric tactical vehicles *(see figure)* and would like to explore the capabilities of SiC semiconductors from dc through RF/microwave frequencies, such as for motion and radar detectors.

The individual grants included $4.5 million from the ARO for semiconductor fabrication equipment and $0.9 million from the ARL will be used for student and staff compensation, tuition, and materials to support collaborative research activities with the ARL. For both grants, Alan Mantooth, Distinguished Professor of Electrical Engineering at the University of Arkansas is the principal investigator.

The University of Arkansas is considered by the Carnegie Foundation to be among the top 3% of colleges and universities in the U.S. In addition to Mantooth, researchers at the University of Arkansas on the SiC project include Greg Salamo, Distinguished Professor of Physics, Zhong Chen, Associate Professor of Electrical Engineering, and Shannon Davis, Business and Operations Manager in the Department of Electrical Engineering. mw

DoD Fields 5G Network for First Responders

U.S. Dept. of Defense

THE DEPARTMENT OF DEFENSE'S (DoD's) Defense Innovation Unit (DIU) unveiled a year-long prototyping project in California to explore future military uses for fifth-generation (5G) cellular wireless networks. Working with private wireless networks, the DIU will use the emerging wireless networks for critical communications between first responders, including the California National Guard.

Motivated by the savagery of the state's forest fires during the year *(see figure)*, the DoD saw the need for more instantaneous voice and data communications between firefighters and National Guardsmen, and 5G networks appear to provide the infrastructure needed to reach beyond rough terrain and natural disasters. The 5G networks will provide cost-effectiveness compared to satellite-communications (satcom) networks and performance advantages compared to older two-way radios, with added geo-location capabilities.

A full mobile 5G network is not yet operational in California, but the DIU hopes to establish usable branches of the network where more needed, through carefully applied prototyping efforts. The DIU is partnering with the California Military Department to procure commercial citizens-band-radio private 5G equipment for the emergency deployments. In addition, Nokia Innovations, a business unit of Nokia America, will provide the DoD with enough portable cellular radios to blanket an area under emergency conditions. ■

DAVE MURRAY | Senior Applications Engineer, Times Microwave Systems

Making Connections in Ruggedized UAVs

Specifying RF connectors, cables, and cable assemblies for military UAVs, especially as they increase their use of mmWave frequencies, requires an intelligent balance of many factors to keep every system connected under all conditions.

Military unmanned aerial vehicles (UAVs) are growing in numbers and complexity, taking on more advanced payloads with multiple sensors. Modern battlefield UAVs do everything that human-piloted air vehicles and their avionics systems once did, including electronic warfare (EW), signal intelligence (SIGINT), and surveillance, often flying at high altitudes and high speeds. Many military UAVs are designed with modular configurations to install different subsystems for each mission to optimize results.

Whether in standard or modular formats, military UAVs rely strongly on their RF/microwave interconnections to keep all systems linked, including from the UAV to the ground through demanding operating conditions. Specifying RF connectors, cables, and cable assemblies for military UAVs, especially as they increase their use of mmWave frequencies, requires an intelligent balance of many factors to keep all systems connected under all conditions.

Military UAVs vary in size and complexity according to application and mission, with larger, fixed-wing vehicles flying at higher speeds and altitudes compared to smaller, fixed- and rotary-wing vehicles used at lower altitudes in commercial and industrial applications. One of the better-known high-altitude UAVs, the RQ-4 Global Hawk *(Fig. 1)*, has flown at altitudes of 60,000 ft. and higher.

SWaP Considerations for UAV Components

Military requirements for size, weight, and power (SWaP) offer excellent guidance for component selection in UAVs because component weight and power consumption translate to a UAV's operating range. In addition, components such as cables and connectors must fit into tight spaces and still be accessible for maintenance and measurement purposes.

UAVs contain many electronic parts and subsystems that must be interconnected, such as antennas, data recorders, radars, receivers, and transmitters. The cables and connectors provide the pathways for routing data, signals, and power throughout these subsystems. Any interruption in the pathways can be mission-critical, even fatal.

In general, space for components and payload in a UAV is limited, whether for military, commercial, or industrial use. The cables, connectors, and cable assemblies that provide interconnections within a UAV must meet tight space requirements while maintaining high performance and reliability. These interconnections have to satisfy challenging mechanical and electrical requirements within a UAV capable of enduring severe environmental conditions.

Choosing Cables and Interconnects: Where to Begin?

A practical starting point for sorting through coaxial-cable interconnects is determining if they will even fit within the airframe. Smaller cables may fit where space is limited, adding little to the total weight of the UAV, but they may lack the performance to meet the electrical requirements of its electronic systems, so mechanical and electrical needs must be balanced.

Ideally, once installed, coaxial interconnections can be readily accessed for testing and maintenance purposes. UAVs with modular sensor systems will require access to interconnections for different modules used within the airframe.

Cable selection requires a balance of the mechanical, electrical, and environmental requirements for a UAV's systems. Maximum cable diameter and weight are practical starting points when sorting through available cable solutions. The coaxial cable should exhibit low loss across a frequency range of interest, which will depend on the length and diameter of the cable.

1. The Global Hawk is a high-altitude UAV that has shown the endurance to remain in flight for 30 hours continuously. *(Courtesy of Northrop Grumman)*

The cable's insertion loss and return loss (VSWR) also will be affected by the choice of connectors and how well the cable assembly and connectors are constructed. Low loss is particularly important for cable assemblies used at higher frequencies since signal power is limited at mmWave frequencies.

In addition to cable diameter and weight, the flexibility of a coaxial cable assembly is essential when determining whether a particular assembly can fit the needs of a UAV's interconnections. Interconnect flexibility can be gauged in terms of its minimum bend radius, which is a function of a cable's construction. Minimum bend radius effectively defines the space required for the smallest change in a cable's direction.

The quality of a coaxial connector's machined components, as well as performance and reliability, are impacted by how well the connector is attached to the cable and the effectiveness of its locking mechanism in a mated pair of connectors.

Weathering High-Stress Conditions

High-frequency interconnect cable assemblies for military UAVs face severe conditions while in flight due to changing weather and stresses caused by high-speed operation. Some UAVs developed for high-altitude operation include hypersonic capabilities with speeds reaching Mach 5 and above. These speeds result in high-temperature environments for the UAV's electronic components and systems, which must operate reliably at these higher temperatures.

Because the interconnections are such critical components, cables and connectors for military-grade UAVs are designed for operating temperatures as high as +300°C and total operating temperature ranges as wide as –65 to +300°C. Even the 300°C limit is being challenged; thus, Times Microwave Systems (TMS) has been asked to develop materials for its cables and connectors to handle these new challenges.

RF/microwave interconnections in military UAVs, especially those with phased-array antennas, require high phase stability with temperature. Phase-matched cable assemblies are typically used in antenna systems where phase is used as a beam-forming and tuning parameter and in multiple-input/multiple-output (MIMO) antennas that combine the contributions of multiple antennas to send and receive high-frequency signals, often with wide modulation bandwidths.

High-altitude (typically 50,000 ft. or more above sea level) UAVs often operate in conditions that expose their components to near-vacuum environments, resulting in moisture-absorption problems when it returns to sea level. This "water in the cable" affects the interconnect amplitude and phase characteristics of the cable's conductive metals and dielectric insulators and may result in significant degradation and failure of an electronic system. As a preventative measure, coaxial cables designed for military UAVs, especially those for high-altitude operation, usually include some form of environmental seal against the effects of vacuum-like environments.

Adding Connectors

The mechanical, electrical, and environmental performance levels achieved by a UAV's coaxial cables also must include its connectors as they contribute to the SWaP levels. Connectors are typically designed for ease of installation and minimal mechanical and electrical performance degradation. For UAV applications, the high-performance levels must be maintained at high shock and vibration levels.

The quality of a coaxial connector's machined components, as well as performance and reliability, are impacted by how well the connector is attached to the cable and the effectiveness of its locking mechanism in a mated pair of connectors. Connectors can be soldered or crimped to a cable, with soldering the more labor-intensive approach but providing a robust mechanical attachment with little performance degradation over time. An effective plated finish on a coaxial connector also can contribute to reliable and consistent long-term performance.

Due to the modular architecture of some UAVs, some coaxial connectors must endure many mate-demate cycles for changing of function modules within the UAV. In such cases, a connector's mate-demate lifetime needs to be evaluated along with its mechanical, electrical, and environmental performance parameters to achieve the best fit within a particular UAV. Oftentimes, high-frequency, high-performance blind-mate connectors are used in UAVs for this purpose.

Seeking Solutions

Practical UAV interconnection solutions are typically available as cables or cable assemblies constructed according to precise lengths and designated connectors. For example, MILTECH flexible cable assemblies *(Fig. 2)* from Times Microwave Systems feature excellent shock and vibration resistance and good phase stability over a wide operating tem-

2. Times Qualified MILTECH flexible cable assemblies provide high phase stability over a wide temperature range. *(Courtesy of Times Microwave Systems)*

perature range (–65 to +200°C). They're manufactured to applicable military standards with tight cable/connector interface control to achieve the hermetic seal needed for high-altitude flight.

The cables are constructed with polytetrafluoroethylene (PTFE) dielectric, a solid silver-plated copper center conductor, and a silver-plated copper shield for protection from electromagnetic interference (EMI). Furthermore, they're factory-terminated with a variety of coaxial connectors.

To meet the tight space requirements of different UAV systems, MILTECH cables come in various sizes/weights, including 0.130-in. (3.30-mm) diameter cables with 0.650-in. minimum bend radius and 0.175-in. (4.45-mm) diameter cables with 0.875-in. minimum bend radius. The smaller-diameter cables can be terminated with 2.4- or 2.9-mm connectors for use at mmWave frequencies. The cables feature high moisture resistance and vibration resistance according to MIL-STD-202 requirements and high shock resistance per MIL-E-5272 requirements.

For tight UAV fits requiring cables bent close to the connector, TMS's INSTABEND 047 cable assemblies *(Fig. 3)* provide low-loss propagation of signals up to 62 GHz in the tightest spaces. To ensure high-quality attachment of connectors to cable, they're only available as complete assemblies.

3. INSTABEND 047 cable assemblies feature the tight bend radius needed to make interconnections in the space-constrained airframes of military UAVs. *(Courtesy of Times Microwave Systems)*

4. Standard PhaseTrack cables and cable assemblies incorporate a proprietary dielectric for high phase stability over temperature. A cable with a 0.108-in. diameter has a cutoff frequency of 80 GHz. *(Courtesy of Times Microwave Systems)*

An INSTABEND 047 cable assembly with an outside diameter of 0.10 in. (2.67 mm) provides a minimum bend radius of 0.3 in. (6.4 mm). Light in weight for UAVs, these cable assemblies weigh only 0.01 lb./ft. (0.02 kg/m) and are available with several different connectors depending on frequency range. They handle temperatures from –60 to +125°C, are shielded to −90 dBc, and rated for voltages to 100 V.

When phase must be tightly controlled, PhaseTrack cables and cable assemblies developed by TMS are well-suited for that parameter, coming in a variety of diameters with different connectors. A 0.108-in. diameter cable *(Fig. 4)* features a cutoff frequency of 80 GHz and a minimum bend radius of 0.550 in. The cable is constructed with proprietary TF4 dielectric and doesn't suffer the phase variations with temperature common to cables with PTFE dielectric.

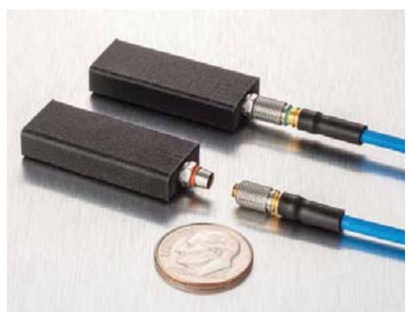
PhaseTrack cable assemblies fit ground, sea, airborne, and space platforms. They're available in many versions, including a silicon-dioxide (SiO_2) dielectric for applications with temperatures exceeding +1000°C.

Rugged Connectors

Maintaining connections under high shock and vibration levels common to a UAV while being easy to mate requires a coaxial connector with a simple but effective locking mechanism. The TLMP push-on locking connector from Times Microwave Systems *(Fig. 5)* was designed with the small form factor of the popular SMP push-on connector but with improved mechanical, electrical, and environmental performance.

The TLMP connector, which is usable to 60 GHz, has a unique mechanical design that supports high-pulsed-power, high-voltage applications. Its latching mechanism achieves improved mating retention compared to an SMP connector even in the high shock and vibration environments of military UAVs. The connector's slots are entirely covered with its mating part for improved EMI performance compared to an SMP connector. Connections must maintain high EMI and low levels of signal leakage to prevent an adversary from identifying a military drone in flight.

For UAV interconnect applications that don't require a hermetic seal or enhanced phase stability, Times Microwave Systems' LMR and TCA cables and cable assemblies can be practical options. LMR cable assemblies provide flexibility to enable tight fits while LMR LW cables feature an aluminum braid shield for effective shielding in low-weight cable assemblies usable through 8 GHz. TCA cables and connectors have long served commercial avionics systems as flexible interconnect solutions, offering a combination of light weight and durability through 5 GHz and higher. mw



5. TLMP push-on connectors are sized like SMP connectors, but offer many performance advances to serve the operating environments of military UAVs. *(Courtesy of Times Microwave Systems)*

Compact Coaxial LNA Drives 6 to 20 GHz

Mini-Circuits' model ZX60-06203ALN+ is a low-noise amplifier (LNA) with medium output power from 6 to 20 GHz. Gain is typically 17 dB through 20 GHz while noise figure is typically 2.2 dB to 12 GHz and 3.3 dB to 20 GHz. Suited for radios, radar, and EW, the RoHS-compliant LNA provides at least +14 dBm of output power at 1-dB compression. It measures 0.74 × 0.75 × 0.46 in. (18.80 × 19.10 × 11.68 mm) with female SMA connectors.

MINI-CIRCUITS, https://minicircuits.com/WebStore/dashboard.html?model=ZX60-06203ALN%2B

RF Loads Handle Communication Systems and More

Fairview Microwave released its selection of new RF loads for various applications, including test, R&D, production, and commercial and military RF communications systems. The RF loads feature a maximum power of 1 W with connector options that include 1.85 mm, 2.4 mm, 2.92 mm, 3.5 mm, SMP, and SMPM. Fairview states that its RF loads are ideal for terminating multi-coupling devices, coax cables, and test equipment across myriad applications. Additional features include male and female connector combinations and models with or without chains. These RF loads cover 18 GHz, 27 GHz, 34.5 GHz, 40 GHz, 50 GHz, and 67 GHz and provide excellent VSWR performance as low as 1.15:1.

FAIRVIEW MICROWAVE, https://www.fairviewmicrowave.com/nsearch.aspx?Category=Terminations^Waveguide+Terminations&sort=y&view_type=grid

Miniature Amp Delivers 0.25 W or More to 40 GHz

Mini-Circuits' model PMA3-83MP+ is a medium-power, monolithic surface-mount amplifier ideal for radar and communications applications from 0.4 to 8.0 GHz. It's capable of +27.8 dBm typical output power at 1-dB compression to 2 GHz and +25.3 dBm to 8.0 GHz. Noise figure is typically 3.5 dB across the full frequency range while full band gain is typically 17.3 dB. The RoHS-compliant amplifier comes in a 3- × 3-mm, 12-lead MCLP package.

MINI-CIRCUITS, https://minicircuits.com/WebStore/dashboard.html?model=PMA383MP%2B

Server-Type Module Packs an Abundance of Cores for Edge Computing

ADLINK Technology recently introduced its COM-HPC Ampere Altra, a massive 80-core COM-HPC server-type module designed for edge platforms and capable of processing the most compute-intensive workloads. The COM-HPC Ampere Altra core is an SoC (system-on-chip) outfitted with Arm's Neoverse N1 architecture, providing increased performance within a modest thermal envelope, lower TCO than x86 designs, and significantly lower power consumption. The COM-HPC Ampere Altra packs up to 80 Arm v8.2 64-bit cores running at up to 2.8 GHz, drawing only 175 W. The module features 3x PCIe Gen4 x16 lanes. It provides enough computing power for demanding workloads, including autonomous driving, stationary and mobile robotics, medical imaging and robotic surgery, test and measurement, and video broadcasting.

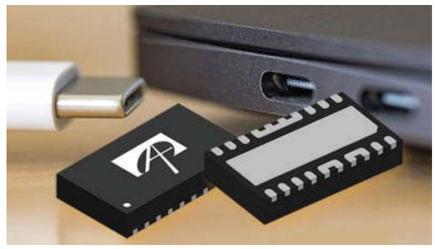
ADLINK TECHNOLOGY, www.adlinktech.com/Products/Computer_on_Modules/COM-HPC/COM-HPC_Ampere_Altra?lang=en

Dual-Directional Coupler Offers Ultra-Broadband Coverage in a Compact Package

Krytar expanded its line of dual-directional couplers with the addition of a new model delivering 10 dB of coupling over the broadband frequency range of 26.5 to 50 GHz (Ka- and Q-bands). The Model 526550010 is a multipurpose, stripline design that offers superior coupling at frequencies from 26.5 to 50 GHz. The coupler is ideal for many applications, including electronic-warfare (EW) systems and commercial wireless, including mmWave, 5G, satcom, radar, signal monitoring and measurement, antenna beamforming, and EMC testing environments. It also features increased performance ratings with a nominal coupling of 10 dB, ±1.8 dB, and frequency sensitivity of ±1.0 dB. The dual-directional coupler exhibits an insertion loss of less than 3.0 dB and a directivity greater than 10 dB; maximum VSWR (any port) is 1.80.

KRYTAR, www.krytar.com/products/couplers/dual-directional-couplers/dual-directional-coupler-526550010/

Combo Protection Switch Combines a High-Performance IC with Protection Features



Alpha & Omega Semiconductor's AOZ1380 Type-C Power Delivery-compliant 2-in-1 combo protection switch is a smart protection switch that combines both current sources and sink functions into a single small thermally enhanced 3- x 5.2-mm DFN package. The AOZ1380 high-performance IC maintains protection features and the company's state-of-the-art, high-SOA MOSFET, making it an ideal solution for notebooks, ultrabooks, Chromebooks, and docking stations with Thunderbolt/USB Type-C PD ports. Manufactured on AOS' high-SOA hot-swap platform of trench MOSFETs, it has a high SOA in soft-start conditions. An internal back-to-back discrete MOSFET provides a sinking path with a low source-to-source resistance of 20 mΩ.

ALPHA & OMEGA SEMICONDUCTOR, www.aosmd.com/res/data_sheets/AOZ1380DI-01.pdf

GPGPU Flies in Spaceflight, NEO, and LEO Applications

Aitech's S-A1760 Venus radiation-characterized space AI GPGPU is designed for space flight and small satellite constellations used in near-Earth-orbit (NEO) and low-Earth-orbit (LEO) applications. The new SSF system is based on the company's A176 Cyclone GPGPU system that's outfitted with the NVIDIA Jetson TX2i system-on-module (SoM), which features Pascal architecture with 256 CUDA cores and reaches 1 TFLOPS of processing. The S-A1760 offers a robust set of I/O interfaces, including Gigabit Ethernet, UART Serial, USB 2.0, CANbus and discretes, and DVI/HDMI output. Video capture includes an HD-SDI input with a dedicated H.264 encoder and eight RS-170A (NTSC)/PAL composite channels available simultaneously.

AITECH SYSTEMS, https://aitechsystems.com/product/s-a1760-space-gpgpu/

Popular Chassis Family Now Offered as Standalone Products

MicroMax's HalfRack Chassis Systems, including the M-Max HR 1U and M-Max Hr 3U, are now being offered as standalone products. The series consists of several chassis designed for operation in harsh environments, and several can be combined to provide redundant computer systems if needed. Features include all-aluminum chassis, configurable front panels, and passive cooling systems. They're also IP66-rated for dust and moisture, feature MIL-STD 704F/461F-compliant power supplies, can handle 40 g of shock and 2.5 g of vibration, and have an operating temperature range of –40 to +70°C.

MICROMAX, www.micromax.com/catalog/systems-and-units/chassis-and-platforms/rugged-chassis/m-max-halfrack-chassis/?utm_source=M-Max-HalfRack-Chassis&utm_medium=Mailchimp&utm_campaign=WM

(Continued from page 21)

dom of mobility that wireless affords us, but historically it's cost us quite a bit in terms of latency/delays, signal degradation, and battery drain.

Gaming

For gaming, speed is everything when it comes to outperforming one's opponents, and latency is therefore a major concern among die-hard gamers. When gamers press the mouse button, they want an instantaneous response, but Bluetooth can only deliver response speeds of 20 to 30 ms at best.

Leveraging UWB connectivity, SPARK has demonstrated sub-0.2-ms latency for UWB wireless gaming peripherals, and the company is well along the path to achieving sub-0.1 ms. This is far beyond what Bluetooth can do, and it's even faster than what many commercially available USB-wired mice is able to deliver today.

Audio

For audio, since Bluetooth is limited to a very narrow bandwidth, audio data compression must be applied to squeeze an otherwise bulky audio signal through a narrow pipe, which degrades the signal. Bluetooth codecs are inherently lossy in that lots of source audio data is stripped away. CD-quality audio is achieved with a 1,411-kb/s data rate—a Bluetooth codec renders that down to about 300 kb/s to be able to fit the audio stream within Bluetooth's limited data-rate capabilities.

UWB enables 10X more data throughput than BLE; thus, there's no need to compress the audio signal for wireless delivery to your UWB headset. This ensures that the sound stage one can hear with UWB headsets is considerably more detailed than what's possible with Bluetooth today, and exactly faithful to the audio source. These benefits extend to live music performance as well—UWB liberates performing musicians from cumbersome cables without sacrificing latency, allowing for wireless live performances.

IoT

The battery life of wireless sensors and devices is insufficient today for many IoT applications, leading to overly frequent recharge cycles, limited connectivity, and bulky batteries and/or costly maintenance. In addition, long latency makes wireless inadequate in applications requiring real-time sensing and communications.

With UWB, huge volumes of sensor data can be delivered with 60X lower latency and 40X better energy efficiency than legacy Bluetooth. This is hugely beneficial not only to IoT applications, but also to the myriad smart building, smart city, and AI-guided applications on the horizon that will require ultra-high-speed communication among sprawling networks of battery-powered wireless sensors.

Bluetooth technology is well-entrenched today and has served us reasonably well for the last two decades. However, UWB's stark latency and power-efficiency advantages position it as a compelling alternative for any wireless application requiring more data to flow faster and more freely with minimal power consumption. Everywhere Bluetooth resides today—across untold commercial and industrial applications, from our earphones to the edge—UWB can potentially reside tomorrow. mw

InfoCenter

ANRITSU COMPANY .... IFC
www.anritsu.com

AVTECH ELECTROSYSTEMS LTD 3
www.avtechpulse.com

AVX CORPORATION 7
www.kyocera-avx.com

CIAO WIRELESS, INC. 35
www.ciaowireless.com

COILCRAFT, INC. 11, 33
www.coilcraft.com

DBM CORP, INC. .... IBC
www.dbmcorp.com

HEROTEK INC 2
www.herotek.com

HUBER+SUHNER AG 37
www.hubersuhner.com

FAIRVIEW MICROWAVE .... BC
www.fairviewmicrowave.com

PASTERNACK .... FC, 8, 9
www.pasternack.com

MINI-CIRCUITS 14, 30
www.minicircuits.com

POLYFET RF DEVICES 29
www.polyfet.com

SOUTHWEST MICROWAVE INC 4
www.southwestmicrowave.com

STANFORD RESEARCH SYSTEMS 5
www.thinkSRS.com

Subscription Assistance and Information:
(ISSN 0745-2993)
Microwaves & RF is published monthly, except for a combined issue in January/February and July/August. Microwaves & RF is sent free to individuals actively engaged in high-frequency electronics engineering. In addition, paid subscriptions are available. Subscription rates for U.S. are $95 for 1 year ($120 in Canada, $150 for International). Published by Endeavor Business Media, 1233 Janesville Ave., Fort Atkinson, WI 53538. Periodicals Postage Paid at Fort Atkinson, WI and additional mailing offices. POSTMASTER: Send change of address to Microwaves & RF, PO Box 3257, Northbrook, IL 60065-3257. For paid subscription information, please contact Microwaves & RF at PO Box 3257, Northbrook, IL 60065-3257. Canadian GST #R126431964.