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JULY 2022 mwrf.com

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Editorial

DAVID MALINIAK | Editor
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A Post-Mortem on IMS 2022 in Denver

Image from the Women in Microwaves event at IMS 2022.

The International Microwave Symposium featured an industry in ascendance that was eager to get back out into the world and show off its innovation and creativity.

I WAS EXCITED ABOUT last month's International Microwave Symposium (IMS) in Denver for several reasons. For one, what with COVID-19 still lurking about and the general damper it's put on travel, I haven't been out and about as much as I'd like. For another, with last year's IMS in Atlanta having been a bit of a drag, I wanted to see whether the industry would rally this time around. And I was anxious to see familiar faces, make new acquaintances, and get a first-hand look at some new and innovative products and technologies.

Happily, the show was successful on all counts. It was a very well attended and busy show, complete with congested aisles and booths and packed technical sessions. I make a habit of asking folks I meet with if they feel the show is going well, and no one had any complaints about booth traffic. We were blessed with beautiful weather all week, making any outdoor excursions refreshing.

Most importantly, my desire to see hot new stuff was fulfilled in spades. The industry backed up its enthusiasm for coming together with a boatload of interesting and creative offerings. Here are a few encapsulations of the highlights:

- Anritsu's Rubidium MG362x1A RF/microwave signal generator spans a frequency range of 9 kHz to 43.5 GHz with very high phase-noise performance. That's largely due to the instrument's internal rubidium frequency-reference option.
- Guerrilla RF showed off its GRF5526/36 ¼-W linear power amplifiers, which deliver 23 dBm even as they support ACLR performance of more than –45 dBc, IMD3 levels within –20 dBm, EVM levels within 1.5%, and power-added efficiencies of around 14%, all without digital predistortion.
- Wireless Telecom Group performed demos of test and measurement solutions from several of its operating groups. For example, Holzworth Instrumentation featured broadband, low phase-noise signal generation and real-time phase-noise analysis with a multichannel platform. Noisecom demoed how important additive white Gaussian noise can be in testing system performance under real-world conditions while using Boonton's RF power sensors to gather accurate data.
- Texas Instruments provided demos of numerous new devices, including the TRF1208, a single-ended-to-differential amplifier that spans 10 MHz to 11 GHz with 3-dB bandwidth; the AFE7950, a 4T6R RF-sampling multichannel transceiver IC with operation to 12 GHz; and the LMX2820, a 22.6-GHz wideband RF synthesizer with a high-performance PLL that offers very low in-band noise and jitter.

I'm already looking forward to next year's IMS in San Diego, but in the meantime, have a look at our full IMS 2022 coverage online. mw

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P1T-DC40G-65-T-292FF-1NS


P2T-100M56G-100-T


P3T-500M40G-60-T-55-292FF


P4T-100M53G-100-T-RD


P5T-500M40G-60-T-55-292FF-5G40G

PMI Model No.	Frequency Range (GHz)	Insertion Loss (dB Typ)	Isolation (dB Typ)	Switching Speed (Typ)	Power Supply	Configuration Size (Inches) Connectors
P1T-DC40G-65-T-292FF-1NS	DC - 40	5.5	65	5 ns	+15 V @ 15 mA -15 V @ 40 mA	SPST, Absorptive 1.2" x 1.3" x 0.5" 2.92mm (F)
P2T-100M56G-100-T	0.1 - 56	5	100	50 ns	+5 V @ 100 mA -5 V @ 100 mA	SP2T, Absorptive 1.0" x 0.75" x 0.4" 2.4mm (F)
P3T-500M40G-60-T-55-292FF	0.5 - 40	6	60	50 ns	+5 V @ 35 mA -5 V @ 15 mA	SP3T, Absorptive 1.0" x 1.0" x 0.5" 2.92mm (F)
P4T-100M53G-100-T-RD	0.1 - 53	6	100	50 ns	+5 V @ 200 mA -5 V @ 200 mA	SP4T, Absorptive 1.25" x 1.25" x 0.4" 2.4mm (F)
P5T-500M40G-60-T-55-292FF-5G40G	0.5 - 40	8	60	40 ns	+5 V @ 55 mA -5 V @ 45 mA	SP5T, Absorptive 1.25" x 1.25" x 0.4" 2.92mm (F)
P6T-2G18G-60-T-512-SFF-LV	2 - 18	4	60	50 ns	+5 V @ 121 mA -12 V @ 33 mA	SP6T, Absorptive 1.5" x 2.0" x 0.4" SMA (F)
P7T-0R8G18G-60-T-SFF-SMC	0.8 - 18	4.3	60	75 ns	+5 V @ 300 mA -5 V @ 100 mA	SP7T, Absorptive 1.5" x 1.5" x 0.7" SMA (F)
P8T-100M54G-90-T-RD	0.1 - 54	9	90	50 ns	+5 V @ 400 mA -5 V @ 300 mA	SP8T, Absorptive 1.6" x 1.68" x 0.4" 2.4mm (F)
P9T-500M40G-60-R-55-292FF-OPT1222	0.5 - 40	6.5	60	100 ns	+5 V @ 450 mA -5 V @ 75 mA	SP9T, Reflective 4.5" x 1.5" x 0.4" 2.92mm (F)
P12T-0R5G18G-60-T-SFF	0.5 - 18	5	60	100 ns	+5 V @ 300 mA -5 V @ 100 mA	SP12T, Absorptive 6.0" x 2.0" x 0.4" SMA (F)
P16T-100M52G-100-T-DEC	0.1 - 52	18	100	100 ns	+5 V @ 1100 mA -12 V @ 720 mA	SP16T, Absorptive 8.0" x 3.0" x 0.77" 2.4mm (F)
P20T-7G18G-80-T-515-SFF-SP	7 - 18	7.5	65	250 ns	+5 V @ 500 mA -15 V @ 200 mA	SP20T, Absorptive 4.0" x 4.0" x 0.63" SMA (F)
P32T-0R5G18G-60-T-SFF	0.5 - 18	9.5	60	100 ns	+5 V @ 1450 mA -5 V @ 200 mA	SP32T, Absorptive 8.0" x 3.5" x 1.0" SMA (F)


P6T-2G18G-60-T-512-SFF-LV


P7T-0R8G18G-60-T-SFF-SMC


P8T-100M54G-90-T-RD


P9T-500M40G-60-R-55-292FF-OPT1222


P12T-0R5G18G-60-T-SFF


P16T-100M52G-100-T-DEC


P20T-7G18G-80-T-515-SFF-SP

P32T-0R5G18G-60-T-SFF

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OCTAVE BAND LOW NOISE AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
CA01-2110	0.5-1.0	28	1.0 MAX, 0.7 TYP	+10 MIN	+20 dBm	2.0:1
CA12-2110	1.0-2.0	30	1.0 MAX, 0.7 TYP	+10 MIN	+20 dBm	2.0:1
CA24-2111	2.0-4.0	29	1.1 MAX, 0.95 TYP	+10 MIN	+20 dBm	2.0:1
CA48-2111	4.0-8.0	29	1.3 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA812-3111	8.0-12.0	27	1.6 MAX, 1.4 TYP	+10 MIN	+20 dBm	2.0:1
CA1218-4111	12.0-18.0	25	1.9 MAX, 1.7 TYP	+10 MIN	+20 dBm	2.0:1
CA1826-2110	18.0-26.5	32	3.0 MAX, 2.5 TYP	+10 MIN	+20 dBm	2.0:1

NARROW BAND LOW NOISE AND MEDIUM POWER AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
CA01-2111	0.4 - 0.5	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA01-2113	0.8 - 1.0	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3117	1.2 - 1.6	25	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3111	2.2 - 2.4	30	0.6 MAX, 0.45 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3116	2.7 - 2.9	29	0.7 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA34-2110	3.7 - 4.2	28	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA56-3110	5.4 - 5.9	40	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA78-4110	7.25 - 7.75	32	1.2 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA910-3110	9.0 - 10.6	25	1.4 MAX, 1.2 TYP	+10 MIN	+20 dBm	2.0:1
CA1315-3110	13.75 - 15.4	25	1.6 MAX, 1.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3114	1.35 - 1.85	30	4.0 MAX, 3.0 TYP	+33 MIN	+41 dBm	2.0:1
CA34-6116	3.1 - 3.5	40	4.5 MAX, 3.5 TYP	+35 MIN	+43 dBm	2.0:1
CA56-5114	5.9 - 6.4	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6115	8.0 - 12.0	30	4.5 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6116	8.0 - 12.0	30	5.0 MAX, 4.0 TYP	+33 MIN	+41 dBm	2.0:1
CA1213-7110	12.2 - 13.25	28	6.0 MAX, 5.5 TYP	+33 MIN	+42 dBm	2.0:1
CA1415-7110	14.0 - 15.0	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA1722-4110	17.0 - 22.0	25	3.5 MAX, 2.8 TYP	+21 MIN	+31 dBm	2.0:1

ULTRA-BROADBAND & MULTI-OCTAVE BAND AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
CA0102-3111	0.1-2.0	28	1.6 Max, 1.2 TYP	+10 MIN	+20 dBm	2.0:1
CA0106-3111	0.1-6.0	28	1.9 Max, 1.5 TYP	+10 MIN	+20 dBm	2.0:1
CA0108-3110	0.1-8.0	26	2.2 Max, 1.8 TYP	+10 MIN	+20 dBm	2.0:1
CA0108-4112	0.1-8.0	32	3.0 MAX, 1.8 TYP	+22 MIN	+32 dBm	2.0:1
CA02-3112	0.5-2.0	36	4.5 MAX, 2.5 TYP	+30 MIN	+40 dBm	2.0:1
CA26-3110	2.0-6.0	26	2.0 MAX, 1.5 TYP	+10 MIN	+20 dBm	2.0:1
CA26-4114	2.0-6.0	22	5.0 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA618-4112	6.0-18.0	25	5.0 MAX, 3.5 TYP	+23 MIN	+33 dBm	2.0:1
CA618-6114	6.0-18.0	35	5.0 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA218-4116	2.0-18.0	30	3.5 MAX, 2.8 TYP	+10 MIN	+20 dBm	2.0:1
CA218-4110	2.0-18.0	30	5.0 MAX, 3.5 TYP	+20 MIN	+30 dBm	2.0:1
CA218-4112	2.0-18.0	29	5.0 MAX, 3.5 TYP	+24 MIN	+34 dBm	2.0:1

LIMITING AMPLIFIERS

Model No.	Freq (GHz)	Input Dynamic Range	Output Power Range Psat	Power Flatness dB	VSWR
CLA24-4001	2.0 - 4.0	-28 to +10 dBm	+7 to +11 dBm	+/- 1.5 MAX	2.0:1
CLA26-8001	2.0 - 6.0	-50 to +20 dBm	+14 to +18 dBm	+/- 1.5 MAX	2.0:1
CLA712-5001	7.0 - 12.4	-21 to +10 dBm	+14 to +19 dBm	+/- 1.5 MAX	2.0:1
CLA618-1201	6.0 - 18.0	-50 to +20 dBm	+14 to +19 dBm	+/- 1.5 MAX	2.0:1

AMPLIFIERS WITH INTEGRATED GAIN ATTENUATION

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	Gain Attenuation Range	VSWR
CA001-2511A	0.025-0.150	21	5.0 MAX, 3.5 TYP	+12 MIN	30 dB MIN	2.0:1
CA05-3110A	0.5-5.5	23	2.5 MAX, 1.5 TYP	+18 MIN	20 dB MIN	2.0:1
CA56-3110A	5.85-6.425	28	2.5 MAX, 1.5 TYP	+16 MIN	22 dB MIN	1.8:1
CA612-4110A	6.0-12.0	24	2.5 MAX, 1.5 TYP	+12 MIN	15 dB MIN	1.9:1
CA1315-4110A	13.75-15.4	25	2.2 MAX, 1.6 TYP	+16 MIN	20 dB MIN	1.8:1
CA1518-4110A	15.0-18.0	30	3.0 MAX, 2.0 TYP	+18 MIN	20 dB MIN	1.85:1

LOW FREQUENCY AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure dB	Power-out @ P1-dB	3rd Order ICP	VSWR
CA001-2110	0.01-0.10	18	4.0 MAX, 2.2 TYP	+10 MIN	+20 dBm	2.0:1
CA001-2211	0.04-0.15	24	3.5 MAX, 2.2 TYP	+13 MIN	+23 dBm	2.0:1
CA001-2215	0.04-0.15	23	4.0 MAX, 2.2 TYP	+23 MIN	+33 dBm	2.0:1
CA001-3113	0.01-1.0	28	4.0 MAX, 2.8 TYP	+17 MIN	+27 dBm	2.0:1
CA002-3114	0.01-2.0	27	4.0 MAX, 2.8 TYP	+20 MIN	+30 dBm	2.0:1
CA003-3116	0.01-3.0	18	4.0 MAX, 2.8 TYP	+25 MIN	+35 dBm	2.0:1
CA004-3112	0.01-4.0	32	4.0 MAX, 2.8 TYP	+15 MIN	+25 dBm	2.0:1

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News

MERCURY LAUNCHES Industry-First Safe, SOSA-Aligned Mission Computer

The open standards-based, DAL-certifiable system delivers up to 40X more performance than current-generation computers while saving space and power.

Mercury Systems

The Overview

Mercury Systems has debuted its Avionics Modular Mission Platform (AMMP), the industry's first and only SOSA-aligned, DAL-certifiable, 3U OpenVPX mission computer. Featuring the latest Intel Core i7 safety-certifiable processors, AMMP delivers up to 40X more performance than current-generation avionics computers while drawing 50% less power. It's well-suited to a wide range of platforms including rotary- and fixed-wing aircraft, ground stations, and unmanned aerial vehicles.

Who Needs It & Why?

By leveraging AI and autonomous capabilities, Mercury's modular and scalable mission computer improves decision accuracy and response times for pilots, making the pilots and their aircraft safer and more capable. In many cases, safety-certified flight mission computers are built with custom or proprietary architectures that make them difficult and expensive to maintain and upgrade. Mercury's AMMP aligns with the U.S. Department of Defense's need for open mission systems that support its modular open-systems approach (MOSA) mandate.

Under the Hood

Mercury's AMMP is purpose-built to support advanced and real-time safety-critical applications such as mission management, sensor fusion/processing, surveillance, 5G communications, and artificial intelligence. The computer comes integrated with Mercury's BuiltSAFE commercial-off-the-shelf (COTS) multicore single-board computers, avionics I/O, video processing, and software. Those features help deliver flawless performance while simplifying integration and the certification process, saving customers time and cost.

The system, built with open architectures and the latest safety-certifiable commercial technology, includes:

- SOSA-aligned architecture for faster integration and sustainment at a lower cost.
- Multiple Intel Core i7 Gen 11 processors with integrated GPUs for increased performance.
- A range of avionics I/O including ARINC-429 to capture and distribute HD video.
- Fully configurable, independent 3U boards to run multiple, mixed-safety workloads.
- Rugged, compact, and low-power design to reduce risk and save aircraft resources.
- Green Hills, Lynx, and Linux board support packages to achieve FAA CAST-32A objectives.

Mercury also can integrate a display, mapping system, cockpit management system, and sensors with AMMP to maximize interoperability, optimize display performance, and save customer integration time. mw

PURDUE PREPARES for Growing Demands in Microelectronics

SEMICONDUCTORS AND MICROELECTRONIC devices are being incorporated into many major application areas, from automobiles to telecommunications networks. One concern with growing demand is too many users and not enough workers.

Fortunately, Purdue University and its College of Engineering have extensive experience working with government organizations and other universities and offer educational programs designed to prepare students for careers in microelectronics and semiconductors, from design and simulation to fabrication and test. Some of the course content has been summarized in a recent roundup available from the university, "Semiconductors and Microelectronics."

Purdue has been selected by the National Institute of Science and Technology (NIST) to define future needs for semiconductors and their packaging. The roundup lists the many other universities that team with Purdue to provide the comprehensive postgraduate education in microelectronics and semiconductors expected to be needed for the next generation of electronics engineers. ■

RF GaN-ON-Si Prototypes Hit Performance Milestones

STMICROELECTRONICS AND MACOM HAVE TEAMED to produce RF GaN-on-Si device prototypes demonstrating performance that puts them on par with today's LDMOS and GaN-on-SiC technologies. The two organizations will continue their work to bring these devices to market.

RF GaN-on-Si technology offers high potential for 5G and 6G infrastructure. The long-term incumbent RF power technology, laterally diffused metal-oxide semiconductor (LDMOS), dominated early-generation RF power amplifiers (PAs). GaN can offer superior RF characteristics and significantly higher output power than LDMOS for these RF PAs, according to the companies Further, it can be manufactured on either silicon or silicon-carbide (SiC) wafers.

RF GaN-on-Si technology offers high potential for 5G and 6G infrastructure.

RF GaN-on-SiC often is more expensive because of the competition for SiC wafers from high-power applications and due to its non-mainstream semiconductor processing. On the other hand, the GaN-on-Si technology under development by ST and MACOM is expected to offer competitive performance paired with large economies of scale, enabled by its integration into standard semiconductor process flows.

It's claimed that prototype wafers and devices manufactured by ST have achieved cost and performance targets that would allow them to effectively compete with the incumbent LDMOS and GaN-on-SiC technologies on the market. These prototypes are now moving to the next big milestones—qualification and industrialization, targets that ST expects to hit in 2022.

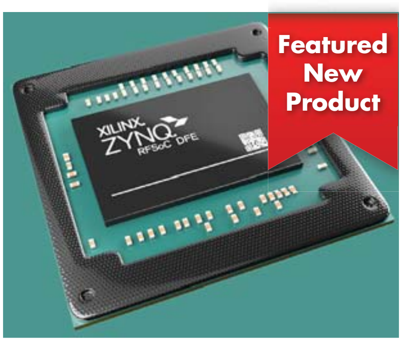
With this progress, ST and MACOM have begun discussions to further expand their efforts to accelerate delivery of advanced RF GaN-on-Si products to the market. It's hoped that these developments can offer supply-chain relief to high-volume applications for RF power semiconductors in the wireless-infrastructure market. ■

STMicroelectronics

DAVID MALINIAK | Editor

AMD's 4G/5G Open RAN RUs
Fuel Meta Connectivity's Evenstar Program

The efficient, adaptable radio units are intended to expand global mobile network infrastructure and accelerate Open RAN adoption for metaverse-ready networks.



The Overview

AMD announced that its Xilinx Zynq UltraScale+ RFSoC has enabled the development of multiple Evenstar radio units (RUs) to expand 4G/5G global mobile network infrastructure. The Evenstar program, led by Meta Connectivity, is a collaborative initiative between operators and technology partners to build adaptable, efficient, and metaverse-ready radio-access-network (RAN) reference designs for 4G and 5G networks in the Open RAN ecosystem.

Who Needs It & Why?

The Evenstar RU launch comes as a bandwidth explosion is overwhelming wireless networks. With the demand for internet connectivity continuing to grow rapidly, the infrastructure that supports it needs to keep pace and improve. According to the Ericsson Mobility Report, year-on-year data growth on wireless networks is at 46%.

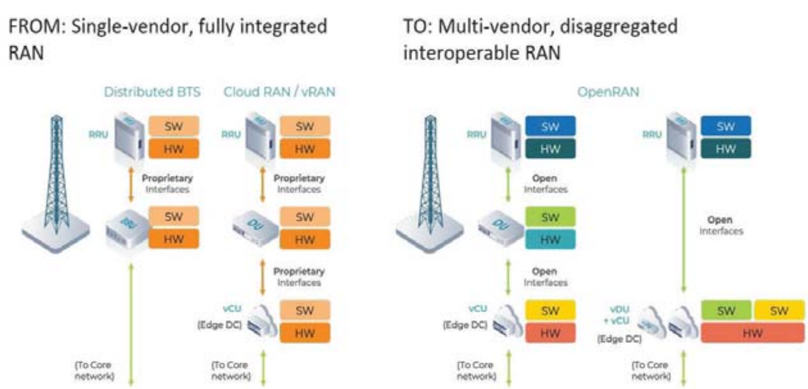
Moreover, interest in Open RAN infrastructure is slowly but surely growing. According to the Dell'Oro Group, Open RAN revenues will account for about 15% of the overall 2G-5G RAN market by 2026. AMD's Evenstar RUs come at an opportune moment when burgeoning bandwidth requirements are being met with the interoperability of Open RAN as an option for network providers looking to build out their infrastructure.

The *figure* below shows how Open RAN is critical to making metaverse-ready networks a reality. At left is the structure of today's single-vendor, fully integrated RANs, which are rife with proprietary interfaces. Open RAN architectures require open interfaces as seen at right in the *figure*. The goal of a multi-vendor, disaggregated RAN accomplishes a few things. For one, it brings compute power closer to users and allows data to be broken out locally. Over-the-air bandwidth is optimized. Further, it opens more opportunities for innovation in connectivity and can improve network economics.

Under the Hood

Evenstar RUs with the Xilinx Zynq RFSoC architecture provide the flexibility to meet a wide range of requirements, including 4G/5G, mmWave, and sub-6 GHz using the same foundational hardware. The ability to leverage the platform and address diverse radio configurations and emerging standards enables radio vendors to react quickly to new market opportunities.

5G radios require solutions that not only meet bandwidth, power, and cost efficiencies for widespread deployment, but must also scale for evolving 5G standards such as Open RAN as well as new and disruptive 5G business models. Evenstar RUs powered by Xilinx Zynq RFSoC technology are said to offer operators greater choice and flexibility when building mobile networks. mw



Open RAN is an essential factor in enabling metaverse-ready networks. At left is today's single-vendor architecture while at right is a multi-vendor, disaggregated, and interoperable Open RAN structure. *Credit: AMD*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STMicro Teams with AWS, Microsoft on IoT Development

STMicroelectronics joins forces with AWS for secure IoT links to its cloud and with Microsoft on quicker development of highly secure IoT devices.

IN SEPARATE COLLABORATIVE efforts with Amazon Web Services (AWS) and Microsoft, STMicroelectronics is extending its reach into the IoT realm. On the AWS front, STMicro now offers a reference implementation that makes for easier and secure connection of IoT devices to the AWS cloud. Meanwhile, in a joint effort with Microsoft, STMicro has endeavored to strengthen the security of emerging IoT applications.

The AWS Collaboration

The work that STMicro has done with AWS combines ST's STM32U5 ultra-low-power microcontrollers (MCUs), the FreeRTOS open-source real-time operating system, and Arm's Trusted Firmware for embedded systems (TF-M). The reference implementation is realized on ST's B-U585I-IOT02A Discovery Kit for IoT nodes with STM32U5 MCUs, which contains rich features including USB, Wi-Fi, and Bluetooth Low Energy (BLE) connectivity, as well as multiple sensors.

The STSAFE-A110 secure element support is being added and comes pre-loaded with IoT object credentials. It helps secure and simplify attachment between the connected objects and the AWS cloud.

FreeRTOS comprises a kernel optimized for resource-constrained embedded systems and software libraries for connecting various types of IoT endpoints to the AWS cloud or other edge devices. AWS's long-term support (LTS) is maintained on FreeRTOS releases for two years, which provides developers with a stable platform for deploying and maintaining their IoT devices.

The Arm TF-M firmware simplifies protecting embedded systems, including services for secure boot, secure storage, cryptography, and attestation, forming the basis of a trusted execution environment (TEE) on the device. Designed for Arm v8-M architectures, TF-M integrates readily with TrustZone on ST's STM32U5 MCUs, which feature the Arm Cortex-M33 core.

ST's STM32U5 MCUs target demanding IoT edge applications, featuring the advanced 160-MHz Cortex-M33 core with Arm TrustZone technology and Armv8-M mainline security extension, up to 2 MB of on-chip flash, and extreme power-saving features. With hardware cryptographic accelerators, secure firmware installation and update, and enhanced resistance to physical attacks, the MCUs have achieved PSA Certified Level-3 and SESIP 3 certifications.

In addition, their extreme energy-saving design simplifies powering the application and extends battery lifetime in remote applications. Highlights include three different stop modes that maximize opportunities to operate at the lowest possible power and ST's batch-acquisition mode that captures peripheral data even while the core is powered down.

ST will release a version of the reference implementation based on STM32Cube tools and software in Q3 this year, which will further simplify IoT design, leveraging seamless integration with the rest of the STM32 ecosystem.

ST's Efforts with Microsoft

In a separate partnership, STMicro worked with Microsoft to spin out a Microsoft Azure IoT cloud reference implementation. The reference design integrates ST's ultra-low-power STM32U5 MCUs with Microsoft Azure RTOS & IoT middleware and a certified secure implementation of Arm TF-M services for embedded systems. The project has produced a TF-M-based, Azure IoT cloud reference implementation that leverages the hardened security features of the STM32U5 complemented with the hardened key store of an STSAFE-A110 secure element.

IoT device developers are faced with intense time-to-market pressures even as they must satisfy the highest-level security-industry standards. It's hoped that the STMicro/Microsoft effort will accelerate embedded development by increasing security as well as power efficiency and performance.

Microsoft Azure RTOS provides a comprehensive middleware package optimized for resource-constrained, connected applications such as IoT edge devices and endpoints. It combines the compact footprint of the ThreadX real-time operating system with services for memory management and connectivity, including NetX Duo IPv4/IPv6 and TLS secure socket support.

As it does in ST's collaboration with AWS, the Arm TF-M suite provides trusted services such as secure boot, secure storage, cryptography, and attestation. Architected for Arm Cortex-M processors, the TF-M suite integrates readily with ST's STM32U5 MCUs.

Additional security features of the STM32U5 include physical-attack resistance and Arm's TrustZone architecture that provides extra isolation for security-critical resources. The STSAFE-A110 EAL5+ certified secure element brings an authentication scheme and personaliza-

tion service that enable an automated and secured attachment of connected objects to Microsoft Azure. It safely relieves the historical burden on IoT-device makers to protect secret credentials during product manufacture.

ST will release an STM32Cube-based integration of the reference implementation in Q3 2022 that will further simplify IoT-device design, leveraging tight integration with the wider STM32 ecosystem. mw

Ubicquia, Movandi Team on mmWave 5G Streetlight Repeaters

Streetlight-mounted smart repeater installs easily, leading to drastically reduced cost of ownership of mmWave 5G small cells.

Dmitry-Mitrofanov | Dreamstime

The Overview

A strategic partnership between Ubicquia, a maker of intelligent infrastructure platforms, and Movandi, which manufactures 5G mmWave RF semiconductors, will result in mmWave smart repeaters that plug into a streetlight's photocell socket in minutes.

Who Needs It & Why?

Though mmWave 5G provides up to 100X more capacity than 5G mid-band spectrum, propagation distance is typically <250 meters and mmWaves don't turn corners or get inside buildings very well. Network operators have already spent $4.5 billion to acquire mmWave spectrum.

Now, in addition, if mmWave 5G is to deliver on its promise of pervasive gigabit-per-second throughputs in the face of booming demand, network operators must rapidly expand their infrastructure while keeping cost of ownership under control.

Such infrastructure expansion means that network operators need a readily available vehicle so that small cells can give their mmWave 5G networks enough sites to handle the capacity requirements. In urban settings as well as in less-populated areas, existing streetlights could be the answer to the looming issue of deployment economics.

Under the Hood

Ubicquia's mmWave streetlight repeater uses existing streetlights and their persistent power, 50-meter spacing, and 8- to 10-meter heights to make millions of site-ready locations available at a fraction of the time and money spent building new poles for 5G radio base stations (gNBs) and pulling fiber to them.

The repeaters install in minutes, are barely visible at street level, and are configured and managed in the cloud to turn deployments into a single trip to the pole. They meet utility power, protection, metering, weight, and wind-loading requirements.

The repeaters ensure optimal outdoor coverage and user experiences by extending the range of 5G mmWave gNBs and redirecting its signals around obstacles. They lock onto host RAN (radio access network) signals automatically to ensure repeater-to-repeater connectivity without the need for fiber connectivity to the core network. On top of that, they integrate with all major RAN/Open RAN technologies, including Ericsson, Huawei, Nokia, and Samsung, and support all global mmWave spectrum bands.

Movandi comes into the picture with its mmWave 5G RF technology and reference design platforms. Its offerings range from RF semiconductors and custom phased-array antenna modules to algorithms and software, including cloud APIs for management, control, and AI/ML data analytics.

On the fronts of speeding mmWave 5G deployment and lowering cost of ownership, Joe Madden, principal analyst at Mobile Experts, asserts that "streetlight-mounted repeaters present an incredible opportunity to dramatically speed up deployment schedules, streamline many regulatory and installation approval steps, and save money."

He adds, "In our assessment of a small city requiring 950 new 5G mmWave radio base stations [gNBs] for full coverage, we found that using 100 streetlight-mounted gNBs and 850 repeaters reduces 10-year total cost of ownership by over $13 million or 35%, and by $89 million or 80% compared to a gNB-only utility-pole configuration. Our conclusion is that streetlight deployment is absolutely the way to go." mw

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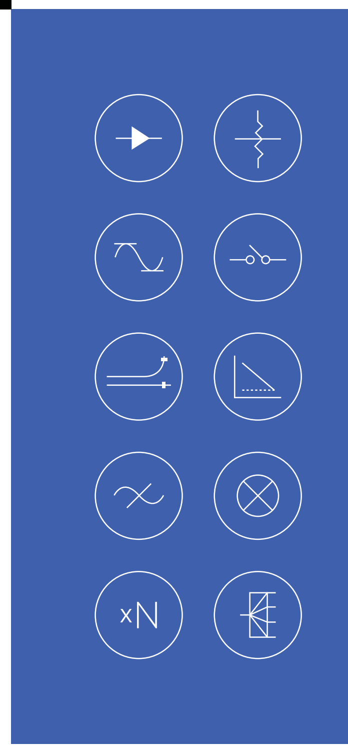

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Mini-Circuits

MICHAEL ZIEHL | Senior Manager, Product Marketing, Microchip Technology
BALJIT CHANDHOKE | Product Manager, Microchip Technology

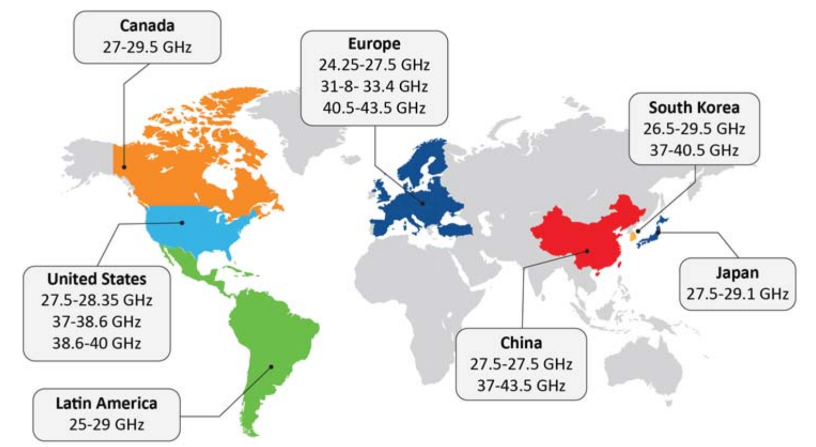
GaN-on-SiC MMIC PAs Meet 5G Network and Commercial Space System Needs

GaN-on-SiC MMIC PAs are poised to address the growing challenges posed by Ka-band satellite communications and mmWave 5G networks.

RF POWER AMPLIFIERS (PAs) are under pressure to perform as never before in a growing variety of applications. The technology is being called upon to support higher gain targets without adding cost, size, weight, or complexity. They're also expected to deliver the necessary linearity and efficiency to accommodate higher-order modulation schemes that are even more sensitive to distortion than their predecessors. Board space is at a premium, but until now the path to more compact solutions faced difficult peak-to-average power ratio (PAPR) tradeoffs.

These challenges are being solved with a new generation of gallium-nitride (GaN) monolithic microwave integrated-circuit (MMIC) PAs that are seeing greater adoption where they're needed most. With proper implementation, designers can maximize the value of these devices in applications ranging from space- and ground-based commercial and defense satellite communications to test equipment.

Expectations are particularly high for this technology's use in 5G networks, none more so than in the unused millimeter-wave (mmWave) band that carriers are embracing for the most congested portions of their subscriber base.



1. Shown are the 5G mmWave frequency bands, with the 28-GHz band being deployed first followed by the 39-GHz band.

New Era with New Needs

In the aerospace and defense sector, a rapidly evolving commercial space market is experiencing its most dramatic changes in decades. A similar set of conditions are driving the 5G mobile communications industry, where growing data congestion in densely populated urban areas poses an extremely difficult challenge.

For these and other applications, systems rely on high-performance power technology to meet the high-speed data rates required for video and broadband data. New power solutions are needed, including high-performance RF PAs that can juggle conflicting requirements to improve performance across the entire transmission path.

For example, PAs must be able to operate in their linear region where distortion products are minimal. At the same time, though, because less RF output power can be delivered in this region, more gain stages are needed to achieve the required gain, adding complexity, cost, size, and weight.

Further complicating matters, if the PA is operated beyond or even near its saturation point to maximize conversion efficiency and generate as much power as possible, digital predistortion or other techniques must be used to compensate for the inevitable AM-AM and AM-PM distortion.

AM-AM distortion is a reference to gain distortion, or the compression or peaking of the PA with input power, which often occurs due to device nonlinearities. AM-PM distortion describes the output phase variation against input power, which is typically caused by the PA's nonlinear capacitors.

Another hurdle is that the higher-order modulation schemes used in satellite communications, such as 64/128/256 quadrature amplitude modulation (QAM), are extremely sensitive to nonlinear behavior. The signal's state is difficult to determine as it "moves" around the constellation.

The inner states may not be distorted because they require less power. The outer ones, though, are a different story. Distortion occurs when the amplifier is driven into compression. Ideally, a modulation scheme for satellite transmission would have higher spectral efficiency than quadrature phase-shift keying (QPSK) but be more resistant to distortion than QAM. Amplitude phase-shift keying (APSK) is increasingly used because it has the best of both worlds and lends itself well to predistortion.

Also challenging is how to achieve the necessary PAPR, which is the ratio of the highest power the amplifier will produce to its average power. PAPR is important because the amount of data that can be sent is proportional to the average power, but the size of the amplifier needed for a given format depends on the peak power. These represent just a few of the conflicting challenges that have confounded designers prior to the arrival of GaN MMIC PAs, especially in satellite and 5G applications.

Solving Ka-band Satcom Challenges

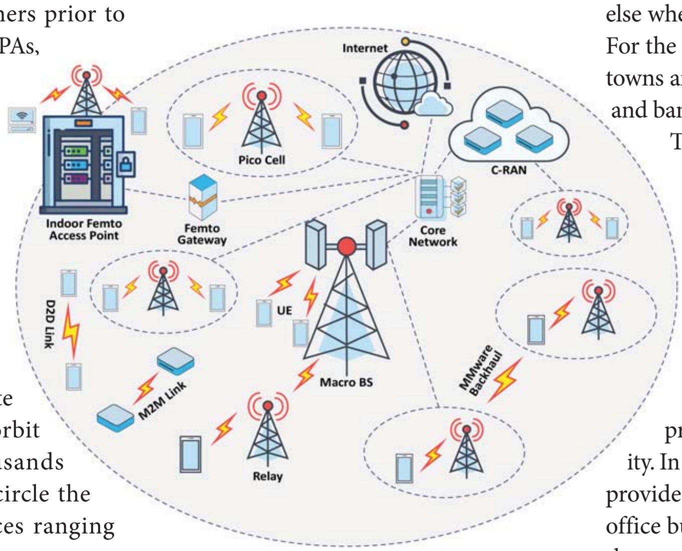
NASA created a host of new opportunities for space-launch companies and satellite operators when it enabled the private sector to populate space with low-Earth-orbit (LEO) satellites. Thousands of these satellites now circle the globe, delivering services ranging from broadband internet access to navigation, maritime surveillance, and remote sensing.

Most of these satellites operate in the Ka-band's spectrum of 27.5 to 31 GHz, which is more than 4X that of lower-frequency allocations. This frequency band is playing a major role in supporting the tsunami of traffic being generated by video and other data-intensive applications and is ideal for GaN MMIC offerings.

GaN offers significant advantages as compared to traveling-wave tubes (TWTs), which have traditionally been used as power sources at these frequencies. TWTs have lower efficiency and require extremely high operating voltages. GaN also is inherently radiation-tolerant—a valuable benefit when the satellite is in a very high geosynchronous orbit.

Much smaller than their TWT-based predecessors, GaN-based amplifiers are better suited for use with active phased-array antennas, too. They eliminate the need for complex and cumbersome power combiners.

As an alternative to gallium-arsenide (GaAs) options, GaN amplifiers deliver more RF power in a smaller footprint and operate at higher voltages. This makes them more efficient than GaAs amplifiers, although the latter are generally preferred for low-power driver stages.



2. Macro base stations are already transitioning to massive multiple-input, multiple-output (MIMO) technology operating at mmWave frequencies. In addition, both femtocells and picocells now can operate at these higher mmWave frequencies using GaN-on-SiC MMIC PAs.

Solving the 5G Network Density Problem

The RF spectrum between 24 and 100 GHz also is ideal for a portion of 5G network activities that's focused on neighborhood extension using small cells and repeaters. This mmWave frequency spectrum sees very little use as compared to lower-frequency bands struggling to accommodate the growing congestion from signal traffic, including TV, radio, and current 4G LTE networks operating between 800 and 3000 MHz. *Figure 1* shows the likely proliferation of frequency bands for 5G mmWave.

While the lower-frequency bands cover much greater distances, they offer slower data speeds. The higher-frequency bands, on the other hand, cover much smaller areas but can carry significantly more data, which is exactly what 5G carriers need in the densest parts of their networks *(Fig. 2)*.

Carriers can use the mmWave band to increase data bandwidth over smaller, densely populated areas such as stadiums, malls, and convention centers, or anywhere else where data congestion is a problem. For the rest of the coverage area in rural towns and villages, sub-6-GHz solutions and bands below 2 GHz will suffice.

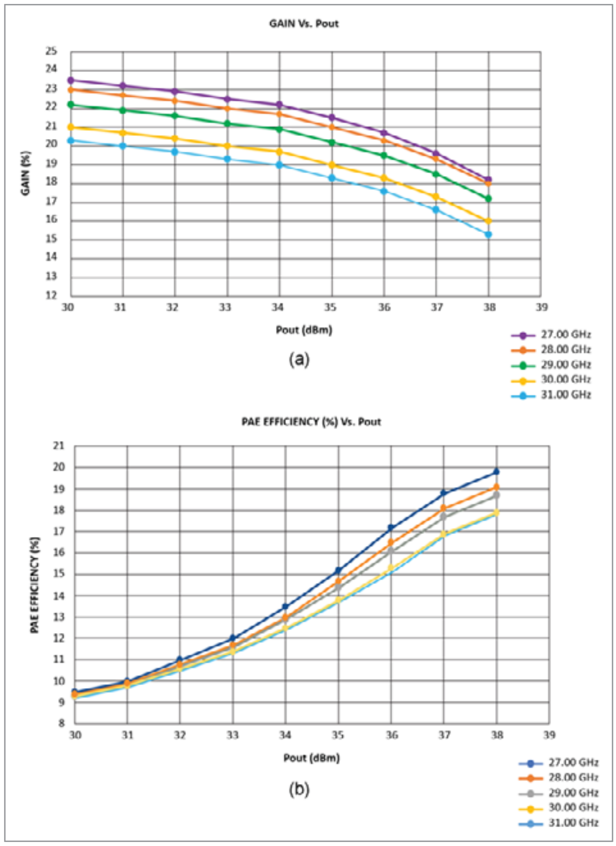
The 5G network consists of macro base stations and small cells. Macro base stations are connected to the core network using the fiber-optic links for mmWave backhaul. They can talk directly to cell phones or to the small cells that talk to the user-equipment mobile device, providing the last-mile connectivity. In addition, picocells and femtocells provide the network connectivity inside office buildings. In these environments, the connection might be weak or there might be high user density.

With output power of less than 1 W, picocells and femtocells improve coverage within a small area. High-density small cells have output power up to 10 W and provide connectivity up to 50 meters. Low-density small cells maintain output power up to 160 W and provide coverage up to 500 meters. Macro base stations have output power up to 480 W and coverage up to 2.5 km.

5G effective isotropic radiated power (EIRP) is mandated by the Federal Communication Commission (FCC) in the U.S. The base-station transmit power limit is 75 dBm/100 MHz, with maximum transportable power of 55-dBm EIRP for a base station and 43-dBm EIRP for a mobile phone. The power amplifier that provides the EIRP levels must meet linearity requirements of 17-dB adjacent-channel leakage ratio (ACLR) and an error-vector magnitude (EVM) requirement based on the modulation scheme (QAM 64 = EVM 8%, QAM 256 = EVM 3%).

GaN can extend 5G New Radio (NR) femtocell and picocell base-station deployments into the mmWave band, where they will have the needed bandwidth along with impressive data rates. Laterally diffused metal-oxide semiconductor (LDMOS) MOSFETs can't accomplish what's needed at >3.5 GHz. Nor can GaAs, which can't deliver high enough power in the mmWave band without moving to an extremely large die.

GaN offers the right combination of higher frequencies and power, wide bandwidth, and the necessary thermal properties, gain, low latency, and high switching speeds. It also delivers the higher power efficiency required by 5G NR base station towers so that they can cover both 5G and 4G/3G. But GaN still needs something else.



3. Shown are the flat linear gain up to Psat-3 dB across frequency and output power levels (a) and the linear power-added efficiency up to Psat across frequency and output power levels (b).

Benefits of GaN-on-SiC

SiC substrates are pivotal to realizing the promise of GaN technology in these applications. With triple the bandgap of silicon and 2.4X that of GaAs, GaN is better suited to high-power and high-frequency devices. The wider bandgap reduces switching and conduction losses that, in turn, translates to lower size, weight, and total solution costs when powering high-power, high-frequency RF applications.

Using SiC-based substrates takes things a step further, improving power density by enabling MMICs to offer better thermal conductivity as compared to silicon-based wafers. This also improves wafer yields through a better lattice match with GaN, and it reduces package size by 20% as compared to LDMOS technology while improving efficiencies.

Together, these advantages offer critical improvements to size, weight, power, and cost (SWaP-C) for air- and space-based systems. The result: the best combination of high-power density and yield, the smallest footprint and reduced weight, and the highest power support and best efficiency. In addition, it enables high-voltage operation and longevity of more than 1 million hours at a 255°C junction temperature.

For example, a three-stage MMIC PA using this process technology can achieve 22% power-added efficiency at 10-W saturated output power from 27.5 to 31 GHz when biased at 24 V, and 22-dB small-signal gain *(Fig. 3)*. This type of PA also supports complex modulation, such as QAM 256, and can reduce power consumption by more than 30% versus alternative GaAs MMICs. Furthermore, such PAs are able to achieve 39-dBm saturated output power from 27.5 to 31 GHz, with 22% power-added efficiency and 22-dB small-signal gain.

When evaluating GaN RF PA products, it's important to make sure that they can be used for linear applications when backed off. On top of that, they should have a balanced architecture that provides excellent broadband input and output match to 50 Ω with return loss of 15 dB across the band.

The inclusion of dc blocking capacitors at the output makes it easier to integrate the PA into the next higher assembly. Also important is the availability of compact models that enable designers to more easily model performance and expedite the design of PAs in their systems.

RF power-amplifier options will continue to grow as GaN MMIC PA suppliers extend their offerings across more frequency ranges while also offering bare die, packaged MMIC amplifier products, and complementary offerings like discrete high-electron-mobility transistor (HEMT) devices. These and other products will meet the unique needs of satellite communications networks and 5G NR base stations, including solving linearity and efficiency challenges when using higher-order modulation techniques.

System designers can move beyond GaAs, LDMOS, and TWT-based amplifiers to achieve gain improvements without making cost, size, weight, complexity, or PAPR tradeoffs. mw

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JACK BROWNE | Technical Contributor

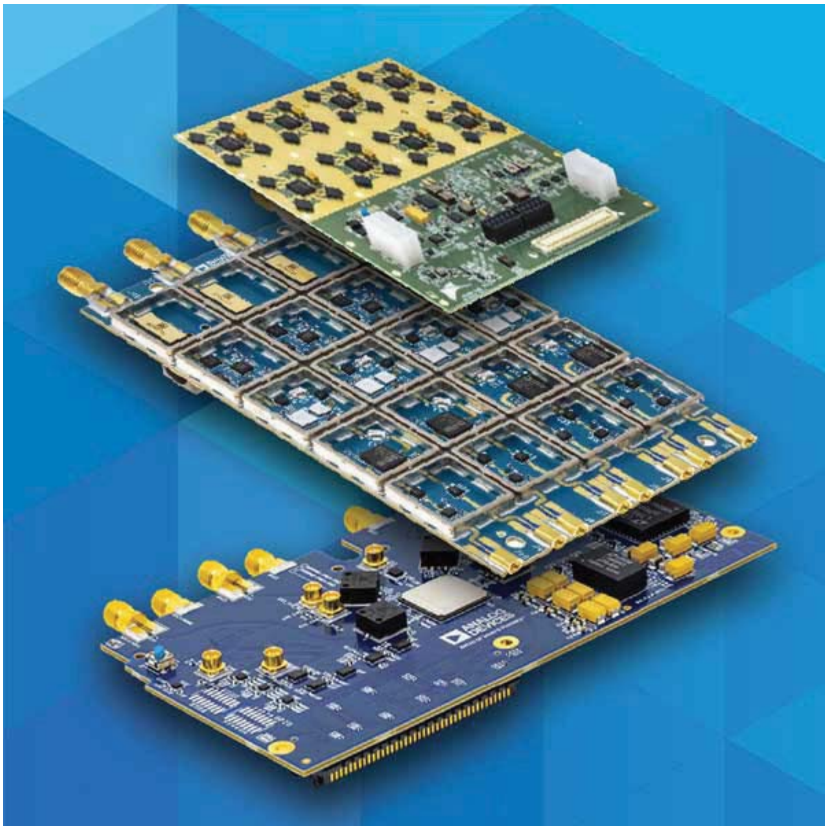
Design Kits Create Lessons for Success

By building key components into design kits and application platforms, suppliers give circuit and system designers head starts in getting the most value and performance for their applications.

Design kits and design platforms are "starting points" offered by electronic companies to help users better understand how to incorporate one or more components or devices in their own applications. The kits may be as simple as a selection of RF filters or as complex as a subsystem with multiple evaluation boards and supporting software. Users range from students pursuing an early look at the industry they hope to join, to veteran design engineers faced with adding modern technologies to their own system designs.

Design kits are widely available for essential passive components to the most complex integrated circuits (ICs). What follows is a sampling of those kits and their contents that may help designers working at circuit through system levels. It's never too late to learn!

Engineering college students typically build a strong background from reading textbooks and technical papers. They also can gain practical experience through experimentation with a pair of low-cost analog design kits offered by Analog Devices and Digilent.



1. Analog Devices' X-Band Phased Array Platform features high-speed mixed-signal ICs assembled on three PCBs and works with a fourth controller PCB for extensive phased-array beamforming experimentation.

Experience Through Experimenting

The Analog Discovery Design Kit and Analog Explorer Design Kit are single-board circuits with USB ports for connection to a PC to create a portable classroom. With a PC and Digilent's waveform software, they show how one may generate and analyze various waveforms. Students have access to downloadable teaching materials and online support; the kits come with an ac-dc converter to power each board.

For system-level architects with a bit more experience, especially those learning to apply phased-array active antenna beamforming to this modern electronic world, there are lessons to be learned from Analog Devices' much more sophisticated X-Band Phased Array Platform.

The platform leverages the company's high-performance RF analog-to-digital converters (ADCs) and digital-to-analog converters (DACs) to assemble three printed circuit boards (PCBs) into part of a learning platform that's a complete system *(Fig. 1)*. The X-band platform consists of an AD9081 FMLA-EBZ multiplexer front-end (MxFE) evaluation board, an ADAR1000EVAL TZ X/Ku-band analog beamforming prototyping board, and an ADXUDIAEBZ quad-channel X-to-C-band frequency up/down converter.

Each board holds numerous lessons and ICs. The AD9081 board, for example, is based on a highly integrated IC that packs a system's worth of components into a 15- × 15-mm, 324-ball BGA package. Individual function blocks within the IC include four DAC cores with 16-bit resolution and 12-Gsample/s maximum sample rate, and four ADC cores with 12-bit resolution and 4-Gsample/s maximum sampling rate.

The IC and its evaluation board are well-suited for signals with wide instantaneous bandwidths (up to 2,000 MHz per channel) and support single-, dual-, and quad-band operation. It provides eight transmit and eight receive lanes supporting JESD204 data standards-based operation up to 24.75 Gb/s. The board includes a clock multiplier and high-speed digital-signal-processing (DSP) capability.

The ADAR1000EVAL prototyping board is based on the ADAR1000 four-channel phased-array X/Ku-band beamforming IC. The IC uses half-duplex operation for transmit and receive modes. Input signals through the four receive channels merge at a common RF input/output (I/O) port while RF signals for transmission are split and passed through four channels.

The IC operates from 8 to 16 GHz with 360-degree phase adjustment range and 2.8-degree phase resolution. It controls signal amplitude with a 31-dB gain adjustment range and 0.5-dB gain resolution. Housed in a 7- × 7-mm LGA package, the IC integrates four power detectors and enough memory for 121 phase positions. The PCB provides power and control circuitry to take full advantage of the ADAR1000.

The X-band designer's platform works with a model ZCU102 Evaluation Board from Xilinx, which contains a field-programmable gate array (FPGA). The educational platform comes with reference software, though it also requires MATLAB system-level software from MathWorks. When linked by coaxial cables, the boards form a scalable 32-element, hybrid-beamforming phased-array radar for training, or a starting point for integration of phased-array technology into radars, 5G cellular wireless networks, electronic-warfare (EW) systems, and satellite-communications (satcom) systems.

For higher-frequency use at mmWave frequencies, Anokiwave offers Innovator's Kits that convey lessons on the company's innovative phased-array beamforming ICs. The model AWMF-0129 Active Antenna Innovator's Kit is based on one of Anokiwave's earliest ICs, the 26.5- to 29.5-GHz single-polarization, quad-core model AWMF-0108. Each Gen-1 beamforming IC supports four transmit/receive radiating elements with 5-bit phase and 5-bit gain control, using a half-duplex approach for a single antenna to receive and transmit.

The kit assembles at least 16 of the ICs into a low-profile, single-polarization, 64-element PCB antenna; its SMT layout is a lesson in power efficiency and short transmission lines at mmWave frequencies. Even with only 12-W dc power consumption, the active antenna is capable of reasonable mmWave transmit power (+50 dBmi) and gigabit-per-second wireless data rates.

2. Anokiwave's Innovator's Kits, as shown here, surround beamforming ICs with the required hardware for frequency downconversion from 26.5 to 29.5 GHz to a lower intermediate-frequency (IF) range.

The same mmWave frequency range, 26.5 to 29.5 GHz, also is available as a dual-polarized antenna design kit with downconversion to intermediate frequencies (IFs) in the AWA-0213-PAK kit *(Fig. 2)*. It's based on the company's newer, Gen 3 beamforming and IF up/downconversion ICs and provides an easy-to-apply piece when experimenting with a 5G New Radio (NR) system design at the lower mmWave frequencies (n257 and n261 bands).

For higher mmWave frequency coverage, Anokiwave offers the AWA-0219-PAK design kit with a frequency range of 37.0 to 40.0 GHz (for the n260 band) and full downconversion to a lower IF range. This dual-polarized phased-array antenna design kit also is based on the Gen 3 ICs.

Component Classrooms

Seasoned RF designers can often learn a great deal simply by substitution, by trying various parts in a circuit. For the most essential building blocks of RF circuits, long-time chip capacitor maker American Technical Ceramics, an AVX Group Co., offers a lineup of multilayer ceramic capacitor designer kits containing a set of components with different values. The kits can be specified as lead or lead-free (RoHS-compliant) versions.

Designer Kit DK0002 contains 16 Porcelain Superchip capacitors with values from 1.0 to 8.2 pF. Components from 1.0 to 3.3 pF feature consistency within ±0.10 pF, while capacitors with values 3.9 to 8.2 pF have consistency within ±0.25 pF of the rated value. Having the assortment allows experimenters to try different values on their boards and circuits to learn the results.

Skyworks Solutions offers several design kits for its Si5121x family of clock oscillators, including the Si51211-EVB evaluation kit. It includes a Model Si514 on-board programmable oscillator to generate the input clock frequency signals.

Skyworks' ClockBuilderPro software programs the clock, which contains the frequency plan for the source. The clock runs on a PC with Microsoft Windows 7 or newer operating system (OS). The software guides users through customized clock generation and provides a step-by-step process for entering reference clock parameters specific to a user's design goals. It provides feedback on optimizing performance as well, such as phase jitter and power consumption.

One of the largest suppliers of RF components, Mini-Circuits, also is one of the most diversified suppliers of design kits, offering more than 200 kits to introduce high-frequency engineers to its parts. Long associated with frequency mixers, Mini-Circuit's K1-MCA+ Frequency Mixers Designer's Kit contains five each of six triple-balanced models (30 total) and covers an overall range of RF and local-oscillator (LO) frequencies from 0.5 to 5.0 GHz. Circuit designers can experiment by dropping these tiny (0.25 × 0.30 × 0.19 in.) mixers with different RF/LO frequencies onto a PCB—they all share an intermediate-frequency (IF) range of 10 to 1500 MHz to simplify testing. Evaluation boards are available for most of the designer kits.

Mini-Circuits' Wideband Amplifiers Designer's Kit includes an assortment of compact K1-ERA+ amplifiers, with 10 each of three models (30 total) covering an overall frequency range of dc to 8 GHz (usable to 10 GHz). The small-signal, 50-Ω; amplifiers deliver as much as +13-dBm output power from drop-in, plastic packages.

On the passive side, the K1-DBTC+ Directional Couplers Designer's Kit contains five each of five surface-mount-technology (SMT) couplers (25 total) covering 5 MHz to 2 GHz with coupling values from 9 to 20 dB. The leadless couplers are built onto low-temperature-cofired-ceramic (LTCC) bases and measure just 0.150 × 0.150 × 0.150 in.

Mini-Circuits even has a kit to help evaluate its components—the model UVNA-63 microwave transceiver kit *(Fig. 3)*. With it, one may assemble different systems and subsystems, including a two-port vector network analyzer (VNA) operating from 100 MHz to 6 GHz under the control of a PC with USB connections. This kit was developed in partnership with Tel Aviv-based educational professionals Vayyar.

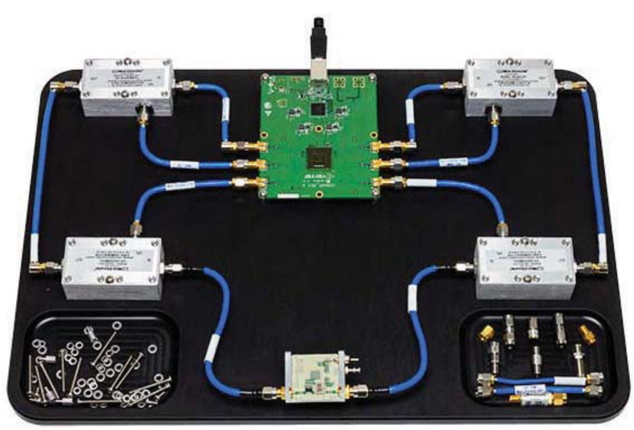
Several years ago, Mini-Circuits began teaming with Vayyar on the IMAGEVK-74 development kit for four-dimensional (4D) mmWave sensing and imaging as a function of time. The mmWave kit, which operates over radar bands from 3 to 81 GHz, is based on Vayyar's wideband mmWave transceiver IC that contains as many as 72 transceiver circuits, an integrated microcontroller, and DSP. The kit is an excellent starting point for applications in automotive, aerospace/military, medical, and security systems.

Students learning about filters at mmWave frequencies can experiment with design kits from Knowles Precision Devices. Featuring temperature-stable capacitors based on Dielectric Laboratories Inc. (DLI) technology, these kits offer an assortment of values for mmWave filters, including bandpass filters with passbands at 26 GHz and higher. The kits are available from RFMW.

Experimenters translating between RF and mmWave frequency ranges may benefit from a pair of reference design kits from X-Microwave, a Quantic Co. They leverage mmWave frequency-converter ICs from Analog Devices for upconversion to, and downconversion from, 24 to 44 GHz.

The XM-RDK-201/ADMV1013 frequency-upconversion kit *(Fig. 4)* and the XM-RDK-202/ADMV1014 frequency-downconversion kit come on PCBs with supporting components, including additional ICs from Analog Devices, and amplifiers, filters, and reference oscillators required for the frequency translation process. Both boards are programmed by the X-MWcontroller microcontroller for quick and simple operation.

Intrinsix, a CEVA Co., offers a series of Jump Start Kits for RF/mmWave semiconductor design, including kits for voltage-controlled oscillators (VCOs) and phase-locked loops (PLLs). These may be combined to perform computer modeling of phase noise and RMS jitter. Additional Jump Start Kits include phase and time delays, transmit/receive (T/R) switches,



3. A microwave transceiver kit developed by Mini-Circuits includes a first lesson on how to assemble its components into a two-port VNA with a frequency range of 100 MHz to 6 GHz.

low-noise amplifiers (LNAs), power amplifiers, and mixer/multipliers.

Semiconductor Studies

Semiconductor suppliers can speed the acceptance of their devices when they offer them as part of design kits, such as the DWM3001CDK Ultra-Wideband (UWB) Module Development Kit from Qorvo, based on the company's DW3110 UWB transceiver. The IC serves two-way ranging (TWR) and time difference of arrival (TDoA) applications at 6.5 and 8.0 GHz. The kit includes an evaluation board with a port for a planar UWB antenna and two micro-USB ports to simplify testing and system development. Batteries power the board while the user evaluates USB link integration approaches.

The CSR101x Bluetooth Low Energy (LE) Starter Development Kit from Qualcomm is based on the company's CSR101x family of system-on-chip (SoC) devices for the simplified development of Bluetooth Low Energy (BLE) products. The SoCs integrate controller, host, and application circuitry within a single small package, reducing the need for external components and shortening interconnection times on product PCBs with reduced power consumption.

Among the available variations of the SoC family are smaller packages for portable and wearable applications and high-I/O-count configurations for densely configured product designs with high functionality. BLE applications include fitness devices, heart-rate monitors, and smart lighting products. The kits feature software support, too.

Texas Instruments also offers a variety of design starter kits for Bluetooth LE and other wireless protocols, including at 2.4 GHz and below 1 GHz.

NXP Semiconductors, which has developed software modeling kits with major computer-aided-engineering (CAE) simulation professionals, also maintains a wide range of kits based on development boards for its processors, power ICs, sensors, and motor-control devices.

4. The XM-RDK-201/ADMV1013 frequency-upconversion kit from X-Microwave provides components needed for upconversion of RF signals in the range of 24 to 44 GHz.

One NXP design kit features its model 88W8801 single-band SoC transceiver for high-throughput Wi-Fi applications. The SoC radio contains a medium access controller, memory, and supporting circuitry within a 48-pin QFN package; the kit serves to speed and simplify voice, video, and multimedia applications. Host interfaces include USB 2.0 and SDIO 2.0 to connect the Wi-Fi radio to the host processor.

In a unique design arrangement for engineers learning how to apply FPGAs, such as those from Xilinx, Xylon developed kits based on its applications experience and intellectual property (IP), such as its logiADAK Automotive Driver Assistance kits. They integrate Xylon's logicBRICKS library of IP with the Xilinx Zynq-7000 SoC and Zynq UltraScale+ MPSoC development platforms for advanced driver-assistance system (ADAS) applications. They help realize ADAS solutions with the Xilinx devices by interfacing with multiple sensors, processing data from the sensors, and executing required communications.

The small sampling of RF design kits presented here are available at distinct levels. Many kits also are offered by simulation software companies as collections of models based on different circuit-board materials, semiconductor devices, and even semiconductor processes. Software provides a low-cost means of trying different circuit approaches in a virtual way, experimenting with differences in such parameters as dielectric constant (Dk), transmission-line type, and conductor thicknesses.

As circuits and devices head into the mmWave range, even minute design differences can mean major differences in performance and design kits, whether based on hardware or software. And they can provide lessons worth learning. mw

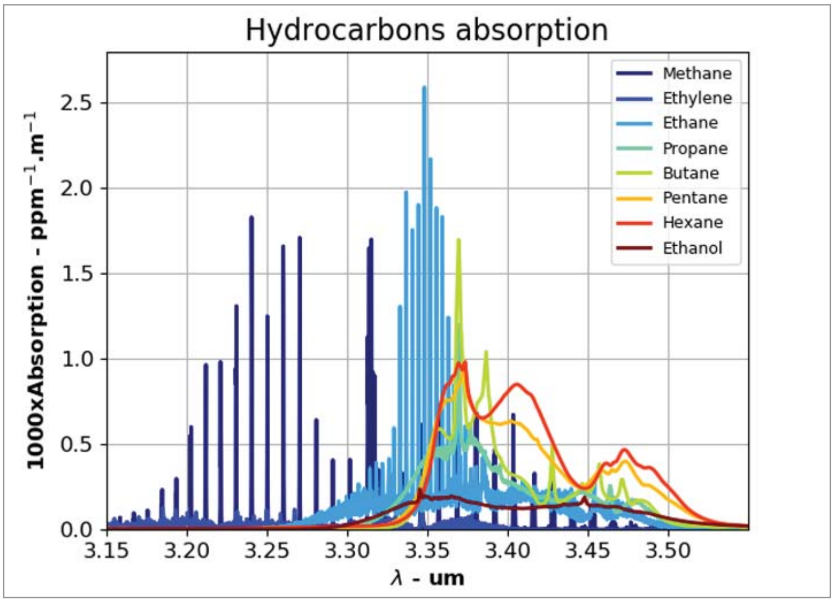
RÉMI DEMERLÉ | Director, Semtech
MAXIME VINCENT | Sales & Marketing Manager, eLichens

Low-Power, Long-Range **Sensors Detect Gas Leaks**

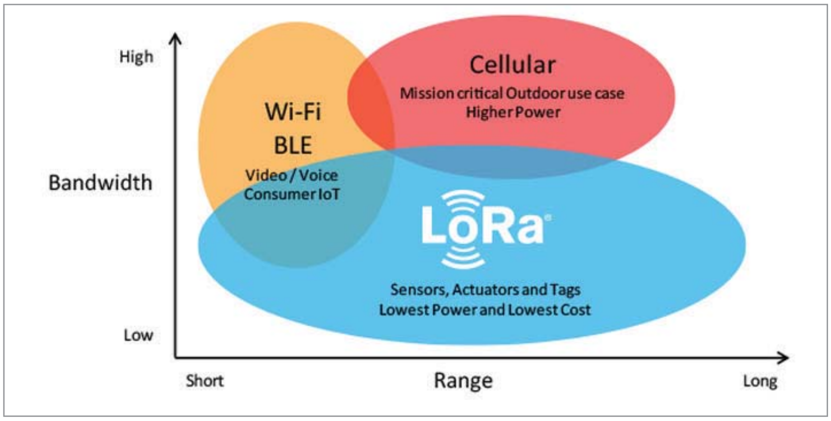
To precisely detect natural gas leaks, IoT sensors must be deployed properly. Here's an example of one sensor that helps achieve that goal.

Detecting natural gas leaks in any situation is extremely important, as the potential for catastrophic damage and loss of life is significant. This means monitoring known leaks in real-time before fixing them, including in residential networks, at the point of entry of the gas line inside homes and buildings, distribution networks, at compression stations or storage facilities, and industrial networks.

The latest wireless solutions are empowering leak detection, thanks to low-power long-distance IoT sensors that are now well-suited to detect gas leaks. These advanced devices have an extended longevity with reliable and accurate output over time due to advances in the



1. Shown are absorption rays of CH4 and other gases, illustrating how sensors designed for this bandwidth also are sensitive to many other gases.



2. Comparing the LoRA sensor range to cellular and Wi-Fi.

core technologies involved. In addition, wireless cloud-enabled open networks can provide future-proof connectivity for the foreseeable future.

One example of such an advanced solution is the eLichens avolta-CH4 gas leak detector, which can remotely identify leaks on natural gas infrastructures. Such devices are used primarily by gas utility companies, as well as gas leak survey and maintenance companies. This article will cover the configuration and system integration of the avolta-CH4 gas leak detector.

Addressing the Challenge

Sensing dangerous gases presents multiple challenges. Among them, ensuring reliability in detecting the right substance, preventing false alarms, and ensuring actual leaks are most recognized. Gas leaks are destructive, and the market is a very stringent one, where false alarms can cost a lot—and no alarm can cost even more—so reliability is paramount.

Historically, the typical leak detector is installed in the basement of a building. This is problematic as other chemicals also may be stored there, or it's where mold can grow and generate volatile hydrocarbons. Both scenarios can trigger false alarms.

In the case of the avolta-CH4 gas leak detector, the sensor embedded inside is highly selective to methane, which increases accuracy. It also can be equipped with other versions of the sensor; thus, it can detect many other gases like butane, propane, refrigerant gases, or even CO_2.

At the heart of the device is the Foxberry CH4NB sensor, designed specifically for this application. It has a no-drift output as well as an ultra-high selectivity and sensitivity to methane. This NDIR sensor has a specific proprietary optical filter, able to selectively target the CH4 wavelengths.

Since it's sensitive to a narrow range of gases, the sensor is referred to as a "CH4 Narrow Band (CH4NB)" device and is presented as the first one of its kind *(Fig. 1)*. It has been designed according to UL1484 and EN50194 standards for the highest levels of reliability.

Legacy gas sensors usually need to be recalibrated every one to two years, or the best ones on the market can barely reach five years. The avolta-CH4 gas leak detector doesn't require any recalibration over its entire lifetime of more than 10 years.

This sensor was enabled by a partnership with Semtech, which was involved from the beginning of the project, especially on the technical side. The detector was eLichens' first integration with Semtech's LoRa devices, so it relied heavily on Semtech for recommendations on things like module selection and design choices. The company now has two products utilizing LoRa in its catalog and more are in the works.

Semtech's long-range, low-power sensor technology leverages the industry expertise at eLichens to make possible the development of this battery-powered IoT product with more than 10 years of autonomy. It needs no maintenance and is easy to install, even in large-scale deployments.

Working Wirelessly

The sensor runs on the LoRaWAN standard—a low-power, wide-area network (LPWAN) protocol *(Fig. 2)*. By design, the LoRaWAN standard is able to wirelessly connect and provide information in an efficient, low-power, and sustainable manner. It's based on what's called a "chirp spread spectrum" in order to maintain low power and simultaneously increase the communication range.

Chirp spread spectrum has been used in military and space communication for decades, but LoRa is the first low-cost implementation for commercial usage. For the avolta gas sensor, LoRa proved to be an excellent fit due to its low power consumption, long communication range, and high-security characteristics. The LoRaWAN standard also allows for non-proprietary characteristics, which opens a wide range of applications.

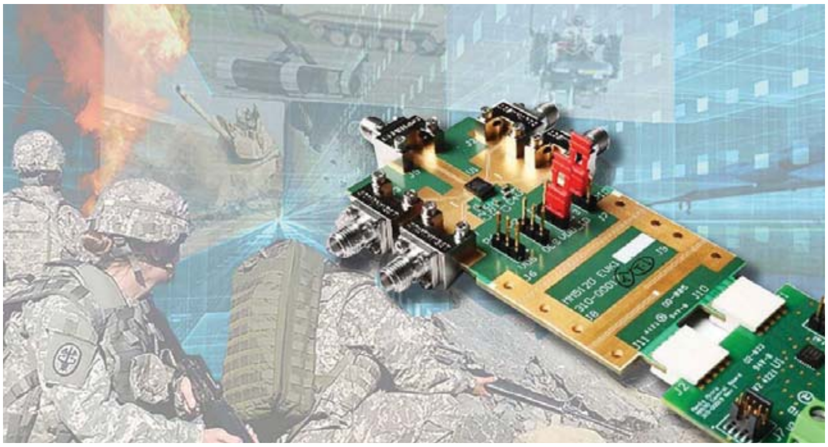
The next iteration of the avolta gas detector will have a 20-year battery lifetime version, to reach the same lifetime as smart meters. Moreover, the company is working on integrating the device into a larger ecosystem (shut-off valve, additional sensors, and more), to design a broader gas safety solution for its customers. In parallel, eLichens is working on specific versions of the detector, including an ATEX/IECEx version, to address new markets.

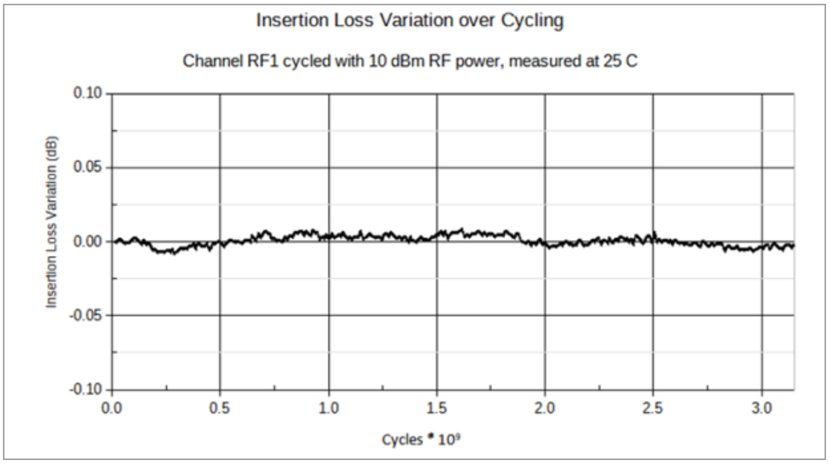
The cost of a gas incident in a residential area will always be more than the cost of installing one sensor per building. In the world of IoT, there are always economies of scale, especially when open networks like LoRaWAN are installed. Once such a network is in place, it opens the possibility to connect additional sensors, hence opening the path to more safety and more services. mw

JONATHAN LEITNER | Senior Product Marketing Engineer, Menlo Micro

RF MEMS Switches Take on Demanding Defense Applications

Tiny MEMS switches excel at defeating the toughest challenges that defense systems can throw at them—and more.





1. MEMS RF switches can deliver highly stable insertion loss for more than 3 billion on/off cycles. One example is Menlo Micro's MM5130, an SP4T switch that handles up to 25 W.

SWITCHES SELDOM RECEIVE the attention of more glamorous microelectronic devices like MPUs, GPUs, RF front ends (RFFEs), and other highly integrated technologies. However, without the ability to switch and route signals, no defense system could function.

If just a single switch among the hundreds or even thousands present in a system platform fails, the results could be catastrophic. Beyond loss of function alone, a switch failure could undermine the reliable operation of a mission-critical subsystem in a military platform designed for decades of unfailing service.

Whether operating on the ground, in the air, at sea, or in outer space, defense systems are designed to function flawlessly in extreme operating and environmental conditions. It should come as no surprise that military contractors invest considerable research and development effort in advanced components, materials, manufacturing processes, and software to ensure fail-safe operation of defense systems.

Even though traditional electromechanical relays (EMRs) are comparatively slow, large, heavy, power-hungry, and have short operating lives, EMRs remain a staple of everything from automated test systems to telecommunications equipment, and dozens if not hundreds of other applications. In extreme cases, they can consume tens of watts of power and must be replaced after just a few million switching operations.

However, mitigating the disadvantages of solid-state relays (SSRs) requires active thermal management in the form of fans, heat pipes, and large heatsinks, which are required in defense and other mission-critical applications to ensure that they will survive in extreme operating conditions. These components not only significantly increase system cost and complexity, but they also aren't well-suited to small platforms such as UAVs, which must meet critical metrics such as power consumption, size, and weight.

What's long been needed is an alternative that doesn't suffer from the traditional limitations of EMRs while also providing better overall performance at a fraction of their size, along with minimal power consumption and much longer operating lifetimes. The answer comes in the form of microelectromechanical-system (MEMS) technology.

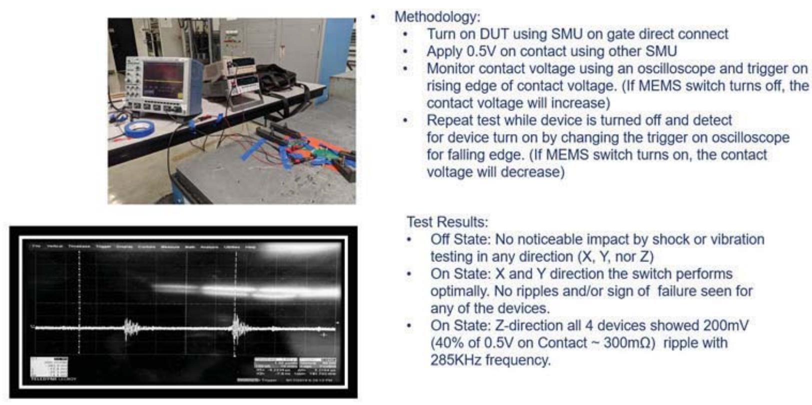
A New Approach to Switching

MEMS technology has been employed for decades in a wide variety of applications—e.g., microphones, automotive airbags, and an array of advanced sensing devices—but it's relatively new for RF switching. A history of MEMS-based switch development over the past two decades is littered with more than a dozen companies that have tried and failed to solve the vexing challenges presented by this technology.

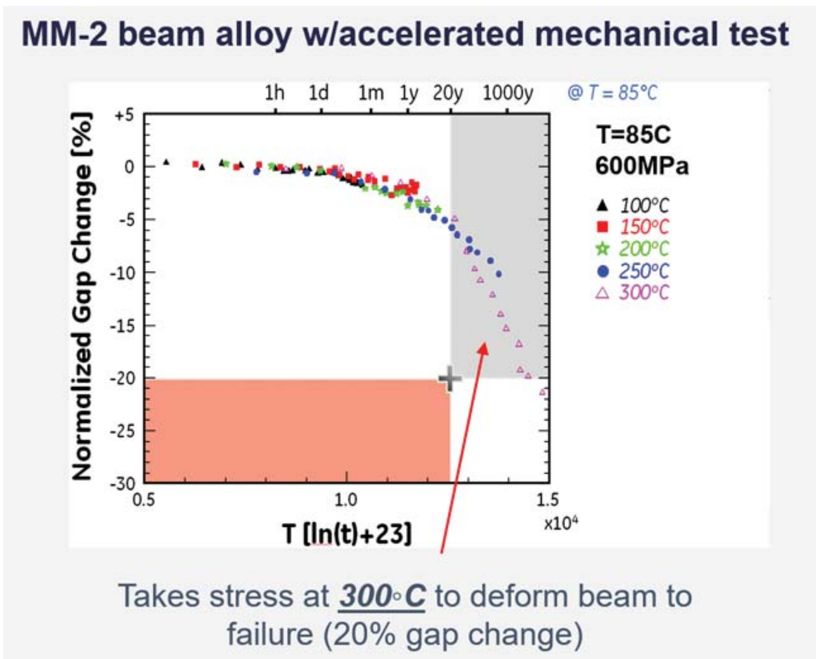
What was ultimately required was an entirely new approach to the challenge and extensive research and development of new metal alloys and other materials as well as advanced fabrication techniques. The result of these efforts comes at a time when systems are becoming smaller, more frugal with power, and packed with more features and functions previously performed by multiple discrete devices.

MEMS switches are based on breakthroughs in metal alloys that focus on minimizing metal fatigue. In fact, advances in alloys have effectively eliminated metal fatigue as a failure mechanism in the most advanced MEMS switches. The best of these devices can deliver stable performance after more than 3 billion on/off operations, a figure that soon will likely rise to more than 20 billion operations. *Figure 1* shows highly stable insertion loss for more than 3 billion on/off cycles. In addition, some advanced switch designs can provide reliable operation when undergoing acceleration higher than 100 Gs.

For example, a single MEMS switch housed in a 2.5- × 2.5- × 0.9-mm chip-scale package can replace multiple electromechanical relays, and even huge matrices of MEMS switches consume less dc power than a single EMR. A MEMS switch not only switches 1,000X faster than an EMR, but it's also at least 90% smaller, consumes tenths of milliwatts of power, and can survive more than three billion switching operations even when handling relatively high RF power levels.



2. Extreme shock and vibration testing of MEMS RF switches shows no performance degradation during and after stress verification. These measurements exceed the requirements of IEC 60601/60068 standard and MIL-STD 810G/H stresses.



3. Another test was conducted to verify switch performance during accelerated lifetime conditions for mechanical ruggedness. It took a temperature of 300°C to deform the beam to failure, which indicates decades of operating life under these conditions.

A significant contributor to this high level of performance is the fact that while all switches employ a metal beam that actuates, MEMS switch actuators are so small their mass is negligible. This, in part, means they can deliver constant performance even during extreme shock and vibration, where most EMRs subjected to the same level of extreme vibration and shock testing would fail.

The closest competitor to MEMS switches is solid-state switches, which are smaller, faster, and more reliable than EMRs, but also are comparatively inefficient power consumers. To a lesser extent than their traditional electromechanical counterparts, solid-state switches generate considerable heat, which requires large, bulky heatsinks and complex thermal management. Moreover, semiconductors are never fully "off," and the resulting leakage currents waste power.

In short, researchers throughout the world have been attempting for years to overcome the shortcomings of both traditional electromechanical and solid-state RF switches. However, the results have become a series of compromises rather than an ideal solution.

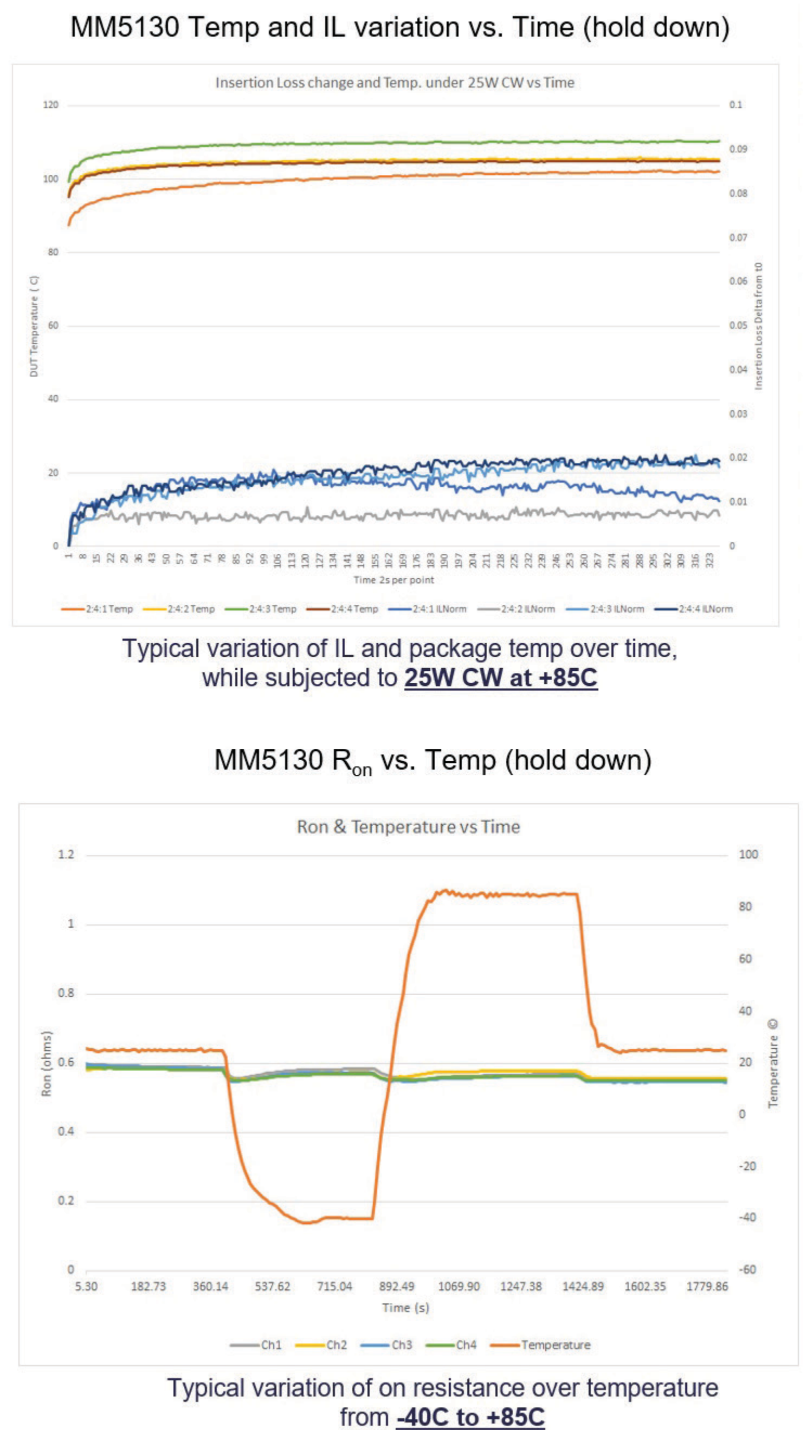
Breaking the Mold

The viability of MEMS switches in RF applications stems from research conducted by General Electric that was spun out to create Menlo Micro. The company's Ideal Switch technology led to high-performance devices that could meet the demanding challenges of extreme operating environments without sacrificing performance.

Existing MEMS-based switches were unreliable under harsh environmental conditions, and Menlo Micro designed its own ohmic MEMS switch from scratch, going so far as to develop an advanced proprietary fabrication process using electrodeposited alloys. The result is an electrostatically actuated beam/contact structure that combines mechanical properties near those of silicon with the conductivity of a metal.

The Ideal Switch can handle more than 20 W of RF power, with no degradation in performance at high ambient temperatures, and with operating lifetimes measured in decades. Menlo Micro's switches are fabricated using through-glass-via (TGV) packaging (using short, metallized vias), which dramatically reduces switch size, eliminating wire bonds for RF and microwave applications that also reduce package parasitics by more than 75%. This enables the Ideal Switch to operate from dc to 26 GHz, with forthcoming designs capable of pushing past 60 GHz in operating bandwidths.

Another benefit realized by Menlo Micro's approach is the ability of MEMS switches to offer high thermal performance in harsh operating environments with minimal variation in RF performance over temperatures from −40 to +150°C. The company's highest bandwidth switch, the MM5130, has operational performance data over this temperature range while achieving an insertion loss delta variation of 0.05 dB. Ideal Switch devices also have been used in extremely cold applications ranging from liquid nitrogen baths at −196°C to quantum-computing dilution fridges at temperatures below 10K.



4. Temperature cycling over a range of 0 to +100°C confirms that there's virtually no resistance change over time.

Ideal Switch technology helps solve the problem of metal fatigue that's plagued previous development efforts. The extremely low mass of these MEMS switch components also results in reliability levels far exceeding those of standard electromechanical switches, enabling superior environmental performance and resistance to shock and vibration. For example, the switch exceeds the IEC 60601/60068 standard and passes MIL-STD 810G/H stresses for vibration and shock.

Measurements Tell the Story

In its continuing development of Ideal Switch technology, Menlo Micro has performed hundreds of tests over several years to confirm its RF performance and environmental ruggedness. Three specific tests were conducted:

- IEC 60601/60068 standard: X, Y, and Z axis, 30 min.
- MIL-STD-810G random vibration: X, Y, and Z axis, 30 min.
- MIL-STD-810H random vibration: Z-axis.

Vibration testing in 6-dB increments above MIL-STD-810H were achieved, reaching the maximum level of the vibration table at 62 G_{RMS} (root-mean-square acceleration).

One of these tests determined if the switch actuators would inadvertently open and close when exposed to extreme shock and vibration. The test setup monitored the switch during stress and analyzed the resulting data for any transient open or close operations. The results *(Fig. 2)* showed that there was no performance degradation during and after stress verification. These measurements exceed the requirements of IEC 60601/60068 standard and MIL-STD 810G/H stresses.

Another test was conducted to verify Menlo Micro switch performance during accelerated lifetime conditions for mechanical ruggedness *(Fig. 3)*. A temperature of 300°C was required to deform the beam to failure, which shows that the Ideal Switch can deliver decades of operating life under these conditions.

Military aircraft and other defense platforms typically operate at both very low and very high altitudes, which creates rapid and extensive temperature cycling. To evaluate Ideal Switch devices when exposed to these conditions, they were subjected to on-resistance (hold-down) versus temperature over a range of −45 to +85°C. *Figure 4* shows temperature cycling over a range of 0 to +100°C, and the results confirm that there's virtually no resistance change over time.

Further tests of Ideal Switch technology went to the opposite extreme, with the goal of determining how the switch would perform under extraordinarily cold temperatures. The test setup was constructed to turn the switch on and off in a bath of liquid nitrogen at a temperature of −196°C (77K), and the switch performed normally without detectable performance degradation.

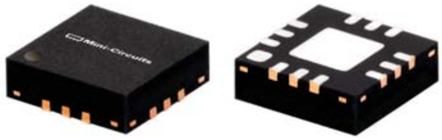
Summary

Engineers have endeavored for decades to overcome the inherent shortcomings of electromechanical relays and solid-state switches, but the results have been a series of compromises rather than a nearly ideal solution to the fundamental challenges posed by these legacy switching technologies. The history of RF MEMS switch development has also been a series of disappointments.

After investing enormous amounts of time and effort, many researchers concluded that even though MEMS technology had great promise for switching, it also posed enormous challenges. The key challenge was how to manufacture MEMS switches at scale and configure them to withstand high peak voltages and RF power levels for years or even decades without failure.

On that front, RF MEMS switches can withstand high voltages and power levels in extreme operating conditions for demanding RF applications. Such switches can be fabricated in a similar fashion to standard silicon CMOS, enabling them to be manufactured in high volumes and scaled in voltage, current, and RF power handling. mw

Low-Noise MMIC Amp Has High Gain to 30 GHz



Mini-Circuits' model PMA3-34GLN+ is a MMIC LNA covering 10 to 30 GHz. Typical gain is 25.3 dB at 10 GHz, 25.5 dB at 20 GHz, and 18.2 dB at 30 GHz. Typical noise figure is 1.9 dB at 10 GHz, 1.6 dB at 20 GHz, and 2.4 dB at 30 GHz. The 50-Ω amplifier is housed in a plastic package measuring just 3.00 × 3.00 × 0.89 mm; it operates from a single supply of 3.75 to 4.25 V dc.

MINI-CIRCUITS, https://www.minicircuits.com/WebStore/modelSearch.html?model=PMA3-34GLN&search=1

Tiny LTCC Filter Passes 22 to 31 GHz

Mini-Circuits' model BFCQ-2702+ is a low-temperature-cofired-ceramic (LTCC) bandpass filter with passband of 22 to 31 GHz. The typical passband insertion loss at a 26.1-GHz center frequency is 1.5 dB. Typical lower stopband rejection is 42 dB from 0.1 to 14 GHz and 27 dB from 14 to 17 GHz. Typical upper stopband rejection is 43 dB from 35.7 to 48.0 GHz. The filter measures 2.5 × 2.0 mm but handles 1-W input power.

MINI-CIRCUITS, https://www.minicircuits.com/WebStore/modelSearch.html?model=BFCQ-2702&search=1

Broadband Variable Attenuators Bring Panel-Mounted Convenience

RLC Electronics' broadband 8- to 22-GHz variable attenuators are intended for panel mounting into customer systems. The frequency can be extended to approximately 24 GHz, as needed. These attenuators have 20-dB minimum attenuation range, exhibit low loss (<0.5 dB), and are stable over MIL-STD-202 environments. RLC also offers similar variable attenuators that cover the 4- to 18-GHz band and will support custom frequency requirements as well.

RLC ELECTRONICS, https://rlcelectronics.com/products/attenuators/

Thin Capacitor Handles Temperatures to +125°C

Exxelia's latest HTLP (High Temperature Low Profile) CUBISIC aluminum electrolytic capacitor is said to have the highest energy density of capacitors in its class. The thin rectangular device can handle temperatures from –55 to +125°C, with a 5,000-hour lifespan. The CUBISIC HTLP also can withstand a 20-g vibration, and is low-pressure-qualified to 92,000 feet. Well-suited for integration into cockpits, actuators, and power generation in commercial and military aircraft as well as radar and laser systems, the series is available in capacitances ranging from 140 to 58,000 μF and voltages from 7.5 to 350 V.

EXXELIA, https://exxelia.com/uploads/PDF/Cubisic-htlp-v1.pdf

eSIM Test Profiles Address Network Simulators

Comprion and Rohde & Schwarz have developed R&S-specific eSIM test profiles for testing with network simulators such as the R&S CMX500. The eSIM Test Profile Service is available online via a subscription service provided by Comprion. It is fully GSMA SAS compliant and includes a repository of eSIM test profiles as well as a GSMA-standardized Remote SIM Provisioning service to deliver the test profiles to eSIM devices.

ROHDE & SCHWARZ, https://www.rohde-schwarz.com/uk/products/test-and-measurement/wireless-device-testers-and-systems_86247.html

Oscilloscope Probe Carries 10-kV Maximum Voltage Input Rating

The CT4432 oscilloscope probe from Cal Test Electronics has an improved dual-resistor design to accurately and safely step down higher voltages to an acceptable level. It offers 1000X attenuation and features a compensation range of 5 to 50 pF for a wide range of oscilloscope capacitance matching. The CT4432 High-Voltage Oscilloscope Probe enables you to safely measure voltage levels up to 10 kV. With the Cal Test Electronics name and certification by cTUVus, you can be confident this test accessory is both reliable and safe. The CT4432 is covered by a two-year warranty.

CAL TEST ELECTRONICS, https://ctemedia.s3-us-west-1.amazonaws.com/public/attachments/CT4200_series_manual.pdf

Microcontroller Integrated with Arm TrustZone Technology

Microchip Technology touts its PIC32CM LS60 as the first microcontroller to combine a secure subsystem and Arm TrustZone technology in a single package. Integrating the company's Trust Platform secure subsystem, the PIC32CM LS60 combines Arm TrustZone technology and the Common Criteria Joint Interpretation Library (JIL) "high" rated Trust Platform secure subsystem. These types of designs are supported with tools such as MPLAB Code Configurator (MCC) TrustZone Manager and the Trust Platform Design Suite to simplify the configuration of the secure subsystem.

MICROCHIP TECHNOLOGY, www.microchipDIRECT.com

Ad Index

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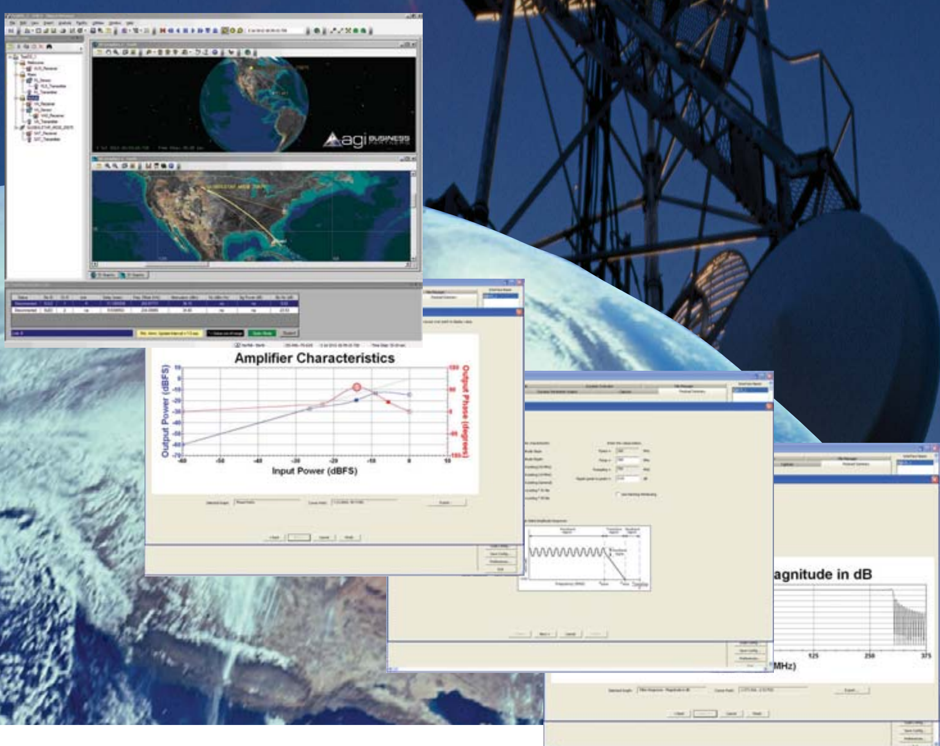

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