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What's in a Name? Clarifying Misused RF/ Microwave Terminology

IN THIS ISSUE:

IMS

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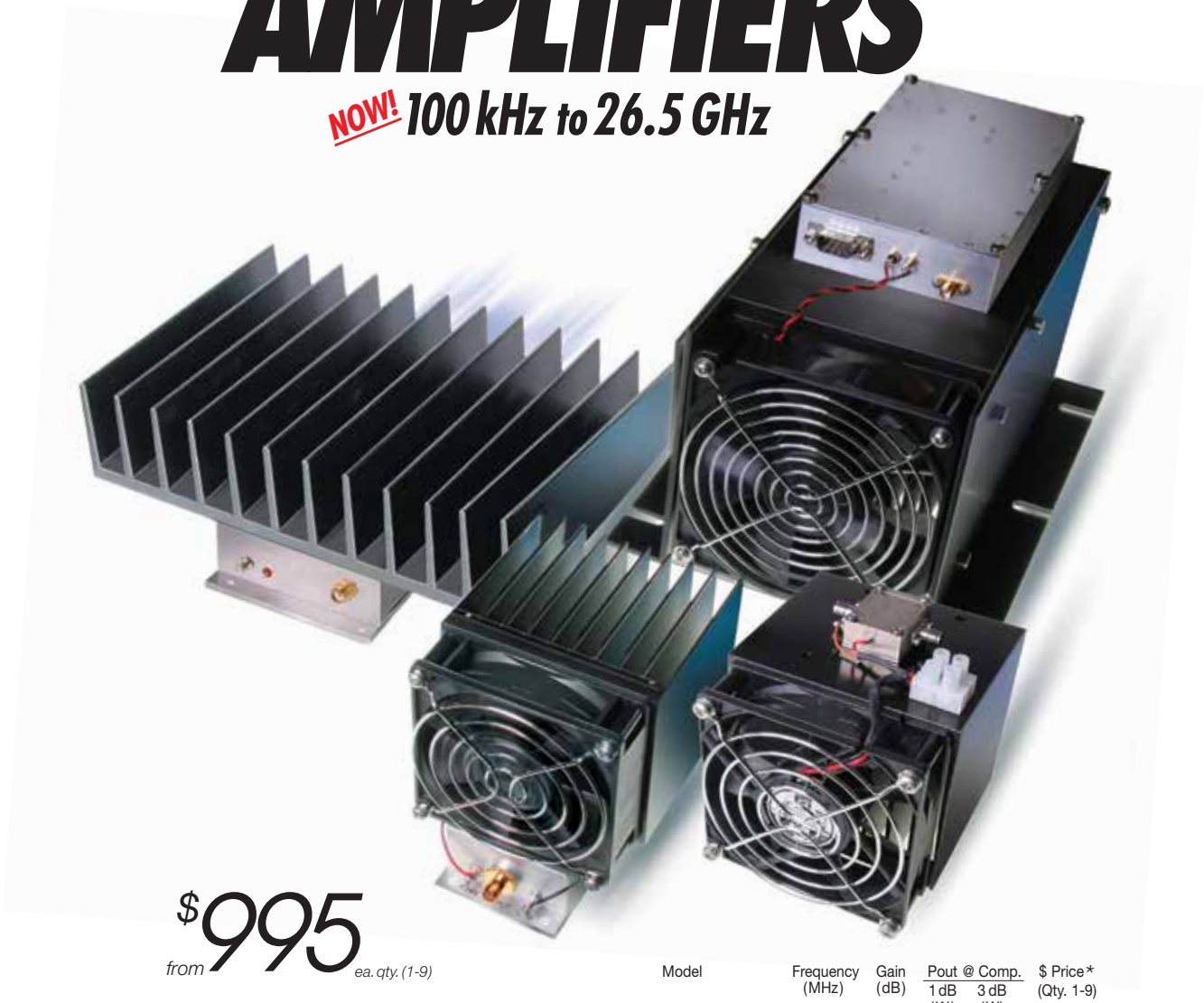

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	ZHL-4W-422+	500-4200	25	3	4	1160
	ZHL-5W-422+	500-4200	25	3	5	1670
	ZHL-5W-2G+	800-2000	45	5	5	995
	ZHL-10W-2G+	800-2000	43	10	12	1295
•	ZHL-16W-43+	1800-4000	45	12	16	1595
•	ZHL-20W-13+	20-1000	50	13	20	1395
•	ZHL-20W-13SW+	20-1000	50	13	20	1445
	LZY-22+	0.1-200	43	16	30	1495
	ZHL-30W-262+	2300-2550	50	20	32	1995
	ZHL-30W-252+	700-2500	50	25	40	2995
	LZY-2+	500-1000	47	32	38	2195
	LZY-1+	20-512	42	50	50	1995
•	ZHL-50W-52+	50-500	50	63	63	1395
•	ZHL-100W-52+	50-500	50	63	79	1995
•	ZHL-100W-GAN+	20-500	42	79	100	2395
	ZHL-100W-13+	800-1000	50	79	100	2195
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	ZHL-100W-43+	3500-4000	50	100	100	3595

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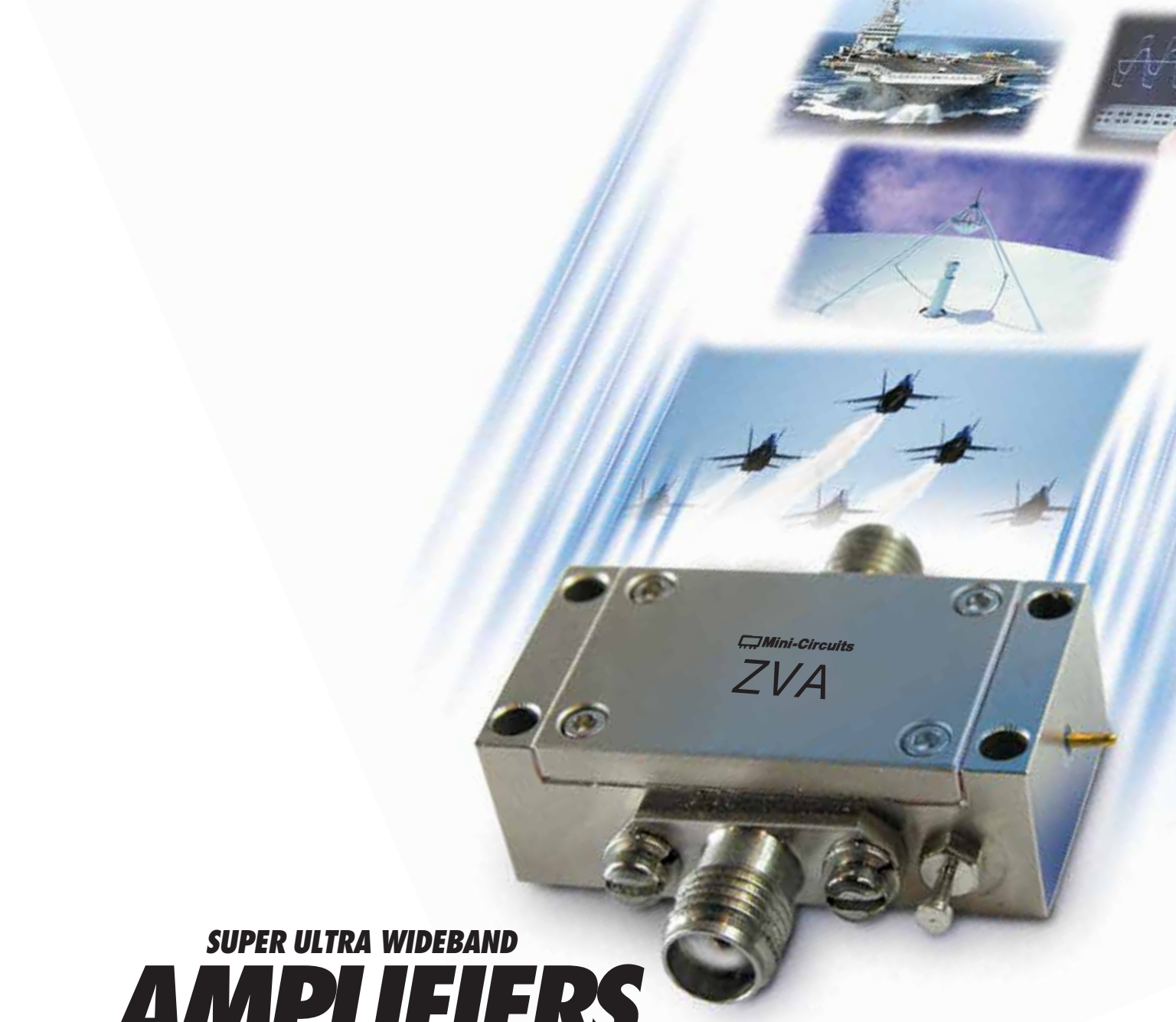

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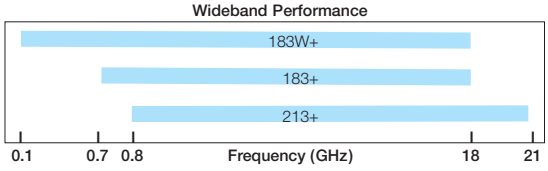

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Editorial

A Look Back: IMS in 1975

Tom Perkins
Senior Technical Editor

The first IEEE IMS I attended was in May 1975. The three-day symposium that year happened to be held in the same general area as this 2016 event, specifically, Palo Alto in Silicon Valley. That area is also called the Santa Clara Valley, which embraces the southern half of the San Francisco Peninsula and also lower portions of the area commonly known as the East Bay. It includes parts of three counties, Santa Clara, San Mateo, and Alameda. San Jose is generally thought of as the "capital" of Silicon Valley.

Silicon, Not Silicone

The word silicon, sometimes referred to incorrectly as the polymer, *silicone,* by non-technical types, refers to the material from column IVA on the periodic chart. Before the emergence of III-V FET devices in our microwave world, doped silicon ruled the day. Silicon Valley referred to the massive numbers of silicon chip developers and manufacturers that dominated the previously agricultural region. Over the ensuing several decades Silicon Valley became a reference to practically all high technology businesses in the region. The term has now become a synecdoche for the high technology sector of the U.S. economy—much like referring to the Department of Defense as the Pentagon.

As I hail from New England, arguably the older bastion of microwave roots due to the MIT Radiation Laboratory (Rad Lab) and the Radio Research Laboratory (RRL) at Harvard and others, it was quite revealing to contemplate the rapid, post-WWII growth in California. They say at one time, if you didn't like your job in microwaves in the Silicon Valley, you could literally walk across the street and apply for another one. Such was the case in the 1970s, but not so much today. Many of those buildings have since been taken over by software and website enterprise companies in the 21st century.

Polyester and Sideburns

Those were the days of polyester suits, sideburns, and planes with three engines. IMS attendees, mostly male, wore a tie and jacket to practically every activity. During my extended stay in Palo Alto I had an opportunity to visit HP and Watkins-Johnson, which, like Varian Associates and Stanford University, were heavily involved in development of new techniques and products. I still have the 1975 IEEE MTT-S International Microwave Symposium Digest. It was all contained in one volume of 375 pages. The theme was *Microwaves in Service to Man.*

There were 21 people on the Steering Committee. The IEEE MTT-S Honorary Life Members were Alfred C. Beck, Donald D. King, William W.

Mumford, Theodore S. Saad, and Kiyo Tomiyasu. There were two named previously, and only four since. Of these from the 1975 timeframe the last, Dr. Tomiyasu, passed on 9 December 2015 at age 96. There will be a memorial honoring him as well as another for Seymour Cohn at this year's symposium.

By 1975 the symposium had expanded to three parallel sessions. Approximately 115 papers were presented. Accompanying presentation graphics were either slides or framed "foils" which took a long time to prepare, often required a presentation assistant, and could not be easily corrected. A few of the members of the Technical Program Committee are still around and attend the symposium. Examples include Jesse Taub, Barry Perlman, and Larry Whicker. Many of the first generation "giants" of our industry are on that list, and I was fortunate to get to know some of them. One of the highlights in 1975 was meeting Phillip H. Smith, inventor of the Circular Transmission Line Chart dubbed the "Smith Chart." I mention circular, because there also was a less popular rectangular chart developed by Harold A. Wheeler, who was presented the Microwave Career Award at the same event. Attendance in '75 was probably under 500, with a high representation from U.S. academia and defense contractors.

Rickey's and Dinah's Shack

The talks were held in a small hotel/conference center called Rickey's Hyatt House, and nearby was Dinah's Shack, a much-loved local eatery. I believe that '75 was the first major participation by exhibitors. The exhibits were held in a large circus tent-like venue as there was no room inside the conference facility. In spite of the very comfortable Bay Area weather, I recall that in the tent it was very warm, partly due to test equipment.

Now about every 10 years the event is held in downtown San Francisco using major hotels and the Moscone Center, the largest convention and exhibition complex in San Francisco. As you attend this year's symposium, dubbed *Gateway to the Wireless Future,* contemplate the rich heritage of the area in our wireless world with roots going back to the mid 1800's with Sweeney and Baugh's "wired" telegraph. Please stop by and say hello to the *HFE* staff at our Booth 1211, just inside and a bit to your left as you enter the Exhibit Hall.

HFE

Meetings and Events

Conferences & Meetings

2016 IEEE MTT-S International Conference on Microwaves for Intelligent Mobility (ICMIM)
19 - 20 May 2016
San Diego, CA
Abstract Submission Deadline: 18 Dec 2015
Full Paper Submission Deadline: 26 Feb 2016
Final submission Deadline: 26 Feb 2016

2016 IEEE/MTT-S International Microwave Symposium - MTT 2016
22 - 27 May 2016
San Francisco, CA

2016 IEEE MTT-S Radio Frequency Circuits Symposium (RFIC 2016)
22-24 May 2016
San Francisco, California, USA
http://rfic-ieee.org/

87th ARFTG Microwave Measurement Symposium Topic
27 May 2016
San Francisco, California, USA
http://www.arftg.org/

EDI CON 2016
20 – 22 September 2016
Boston, Mass.
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IEEE MTT-S Latin America Microwave Conference (LAMC)
12 – 14 December 2016
Puerto Vallarta, Mexico
lamc-ieee.org

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MLOS-Series. Units cover 600 MHz to 40 GHz in bands. Standard 1.75" or 2" cylinder packages are provided. Millimeter wave units are available in wide band configurations covering 18 to 26.5 GHz, 18 to 40 GHz and 26.5 to 40 GHz. Commercial and extended temperature units are available throughout the product line.

MLPB/MLMY-Series. Permanent Magnet based PCB mount and Mini designs are available covering the 2 to 20 GHz frequency range. Output power levels up to +16dBm are provided along with low phase noise between -124 dBc/Hz to -130 dBc/Hz depending on frequency. Commercial and extended temperature units are available throughout the product line.

MLSMO-Series. Permanent magnet based surface mount units are available covering the 2 to 16 GHz frequency range. A test fixture is available for evaluation and test. Units provide very low phase noise of -128 dBc/Hz at 10 GHz. Low prime power inputs of +8 Vdc and -5 Vdc are utilized and no heater power is required.

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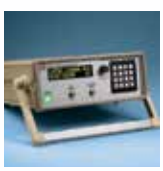

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Market Reports

DoD's Focus on Increased Training Bolsters Military Technology and Drives Growth Opportunity

The Department of Defense (DoD) training and simulation budget is expected to increase throughout the fiscal years defense plan (FYDP) to compensate for the previous years' training shortfalls. Notably, significant spending reductions in live training is not expected for several years as the DoD is still evaluating the optimal balance of live, virtual and constructive (LVC) training or mixed reality training.

New analysis from Frost & Sullivan finds training and simulation funding through 2020 is forecast to experience a 1.7 percent compound annual growth rate (CAGR). This translates to a flat market after adjusting for inflation.

While there will be an increase in the funding for research, development, test, and evaluation (RDT&E), mainly driven by the Air Force's next-generation T-X trainer program, there is likely to be a substantial drop in the funding for training and simulation procurement. This will be due to the winding down of training system deliveries for new start programs such as the P-8, KC-46 and littoral combat ship (LCS).

Spending cuts for both foreign and domestic operations as well as uncertain future DoD funding levels are hampering the military's ability to invest in and plan for current and future training. Furthermore, tighter global defense spending may hinder the Foreign Military Sales program, a significant source of sales for U.S. defense companies.

"While spending is an issue, the global crises in Eastern Europe and the Middle East will still require a large number of assets and combat-ready troops," said Frost & Sullivan Aerospace & Defense Senior Industry Analyst **Michael Blades**. "Technology, robust mixed reality exercise and portable equipment will be required to ensure quality and timely training."

The continuing demand for mixed reality training is the main driver for investment and innovation in the military training and simulation market. This creates a distinct opportunity for vendors of virtual reality (VR) and augmented reality (AR) devices.

Interestingly, the eager adoption of VR and AR in the consumer market will translate to increased familiarity and use of these technologies in the defense market. Game-based learning is quickly gaining traction and could prove to be a very popular training method.

VR systems, which currently dominate the training landscape, will experience increased usage in virtual environments. However, as AR systems evolve, they will become the technology of choice.

—Frost & Sullivan
frost.com

Sub-6 GHz Backhaul Becomes Operators' Favorite by 2020

The evolution toward 4.5G and 5G will be imminently accompanied by substantial network densification and massive deployments of small cells. The trend will completely transform the backhaul market and create tremendous opportunities for wireless backhaul links. ABI Research, the leader in transformative technology innovation market intelligence, forecasts that the market will deploy more than one million Sub-6 GHz licensed backhaul links by 2020.

As the fastest growing market segment, **Sub-6 GHz will challenge microwave and millimeter waves for the largest market share of 35% in 2020.** The combined wireless backhaul equipment revenues from Sub-6 GHz links and millimeter waves make up nearly 57% of the total backhaul revenue in 2020.

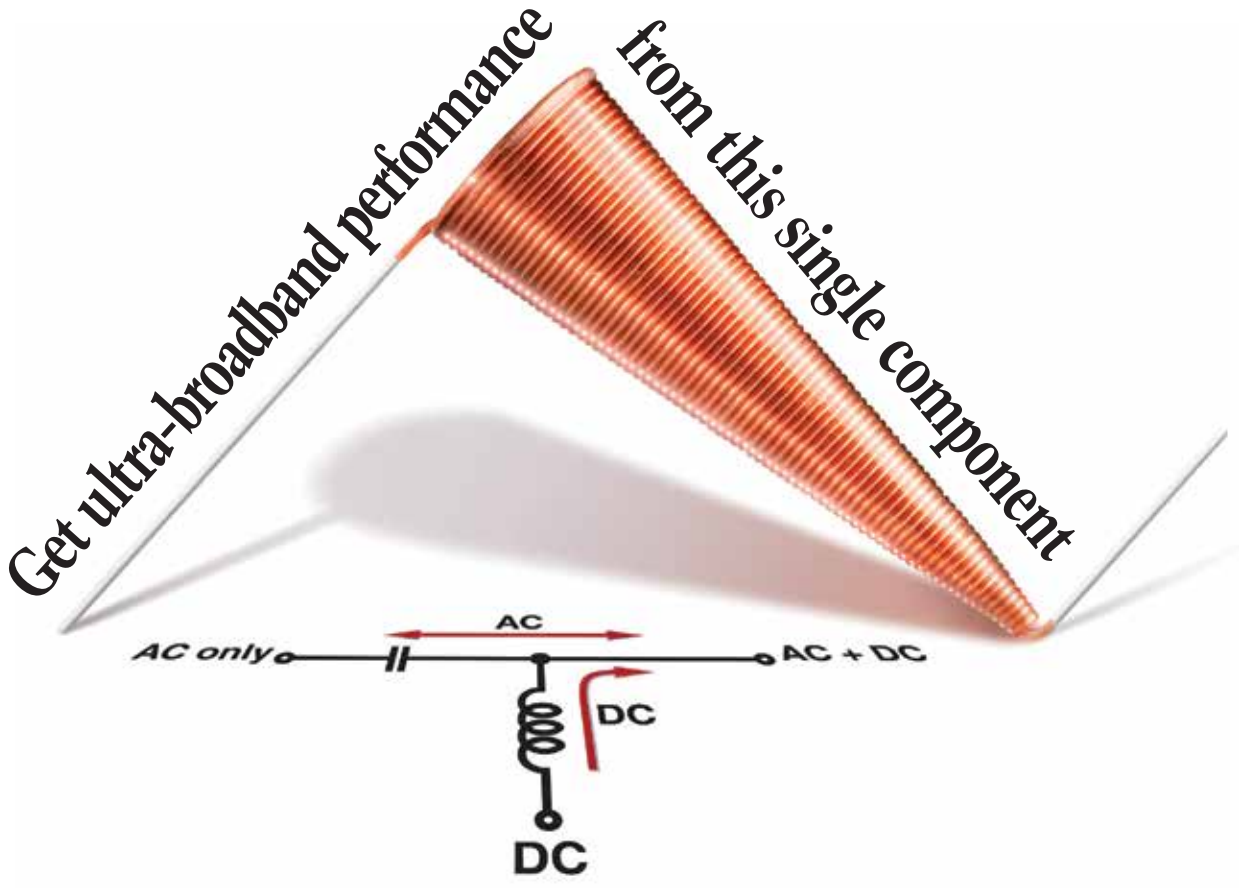
"Ultimately, operators' network densification plans continue to grow in order to support demands for higher capacity in metro locations and extend coverage in to the rural and remote areas," says **Ahmed Ali**, Research Analyst at ABI Research. "This accelerated growth will mandate higher capacity links, lower equipment cost, and easier network installation. The development will, in turn, drive further investments in the wireless backhaul market."

Over the course of 2016, outdoor small cell rollouts will gain momentum. As Wi-Fi and distributed antenna systems (DAS) continue to advance and compete with small cells for the enterprise and in-building connectivity, their impact on the outdoor deployments is imminent.

"MNOs are also exploiting distributed network structures like Cloud-RAN (C-RAN) to cope with the explosive data traffic," concludes Ali. "Such evolution in the access network technologies and structures dictates the availability of diverse, flexible and interoperable backhaul solutions."

ABI Research suggests suppliers consider offering professional services, including high-resolution 3D mapping for backhaul link placement. They should also support multiple backhaul technologies and partner with Tangible Asset Monetization Companies (TAMCos), like advertising agencies, cable providers, and tower companies, to offer rights of way, and attach permits for small cell sites. Service providers, on the other hand, should look into leveraging network sharing schemes, unlicensed spectrum, and virtualization technologies in order to lower the cost of expanding backhaul and increase the overall ROI.

—ABI Research
abiresearch.com



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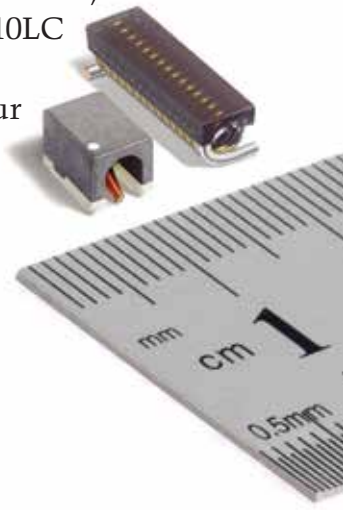

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In the News

Gremlins Takes Flight to Provide Air-Recoverable Unmanned Air Systems

DARPA has awarded Phase 1 contracts for its **Gremlins program, which seeks to develop innovative technologies and systems enabling aircraft to launch volleys of low-cost, reusable unmanned air systems (UASs) and safely and reliably retrieve them in mid-air.**

Such systems, or "gremlins," would be deployed with a mixture of mission payloads capable of generating a variety of effects in a distributed and coordinated manner, providing U.S. forces with improved operational flexibility at a lower cost than is possible with conventional, monolithic platforms. The Phase 1 contracts have been awarded to four teams whose proposals cover a spectrum of technical approaches to this challenging mission. The teams are led by:

- Composite Engineering, Inc. (Roseville, Calif.)
- Dynetics, Inc. (Huntsville, Ala.)
- General Atomics Aeronautical Systems, Inc. (San Diego, Calif.)
- Lockheed Martin Corporation (Dallas, Tex.)

"We've assembled a motivated group of researchers and developers that we believe could make significant progress toward Gremlins' vision of delivering distributed airborne capabilities in a robust, responsive and affordable manner," said **Dan Patt,** DARPA program manager. "These teams are exploring different, innovative approaches toward achieving this goal and are rolling up their sleeves for the hard work ahead."

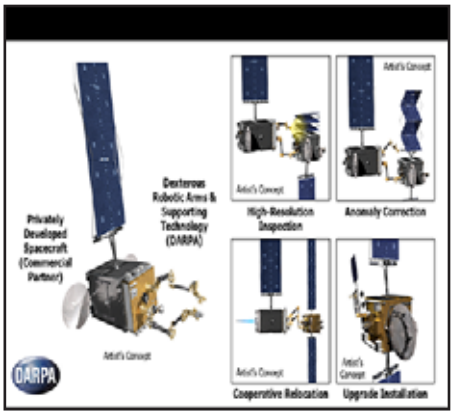
Phase 1 of the Gremlins program is designed to pave the way for a proof-of-concept flight demonstration that would validate an air recovery concept of multiple gremlins. The program plans to explore numerous technical areas, including:

- Launch and recovery techniques, equipment and aircraft integration concepts
- Low-cost, limited-life airframe designs that leverage existing technology and require only modest modifications to current aircraft
- High-fidelity analysis, precision digital flight control, relative navigation and station keeping

Named for the imaginary, mischievous imps that became the good luck charms of many British pilots during World War II, the program envisions launching groups of UASs from existing large aircraft such as bombers or transport aircraft—as well as from fighters and other small, fixed-wing platforms—while those planes are out of range of adversary defenses. When the gremlins complete their mission, a C-130 transport aircraft would retrieve them in the air and carry them home, where ground crews would prepare them for their next use within 24 hours.

The gremlins' expected lifetime of about 20 uses could provide significant cost advantages over expendable systems by reducing payload and airframe costs and by having lower mission and maintenance costs than conventional platforms, which are designed to operate for decades.

* * *



Program Aims to Facilitate Robotic Servicing of Geosynchronous Satellites

Hundreds of military, government and commercial satellites reside today in geosynchronous Earth orbit (GEO) some 22,000 miles (36,000 kilometers) above the Earth—a perch ideal for providing communications, meteorology and national security services, but one so remote as to preclude inspection and diagnosis of malfunctioning components, much less upgrades or repairs.

Even fully functional satellites sometimes find their working lives cut short simply because they carry obsolete payloads—a frustrating situation for owners of assets worth hundreds of millions of dollars. With no prospects for assistance once in orbit, satellites destined for GEO today are loaded with backup systems and as much fuel as can be accommodated, adding to their complexity, weight and cost. But what if help was just a service call away?

DARPA's new Robotic Servicing of Geosynchronous Satellites (RSGS) program intends to answer that question by developing technologies that would enable cooperative inspection and servicing in GEO and demonstrating those technologies on orbit within the next five years. **Under the RSGS vision, a DARPA-developed modu-**

In the News

lar toolkit, including hardware and software, would be joined to a privately developed spacecraft to create a commercially owned and operated robotic servicing vehicle (RSV) that could make house calls in space. DARPA would contribute the robotics technology, expertise, and a Government-provided launch. The commercial partner would contribute the satellite to carry the robotic payload, integration of the payload onto it, and the mission operations center and staff. If successful, the joint effort could radically lower the risk and cost of operating in GEO.

"The ability to safely and cooperatively service satellites in GEO would vastly expand public and private opportunities in space. It could enable entirely new spacecraft designs and operations, including on-orbit assembly and maintenance, which could dramatically lower construction and deployment costs while extending satellite utility, resilience and reliability," said RSGS program manager **Gordon Roesler**.

* * *

Molex announced it has received the **2015 Best Quality Partner (Gold Award) from Huawei Technologies** Co., Ltd., a leading global information and communications technology (ICT) solutions provider based in Shenzen, China. Molex won the Gold Award based on the strength of its product quality performance and quality management process and was the only Huawei cable and connector supplier to receive the award.

* * *

Quantenna Communications, Inc., a leading developer of 802.11ac and 802.11n semiconductor solutions for the next generation of ultra-reliable Wi-Fi networks, has selected **Azimuth's scalable automated RF platform, Spider™,** for its wireless development and product testing, and for its system verification within its ecosystem of carriers, home networking, and consumer electronics vendors.

* * *

Exodus Advanced Communications announced that construction has been completed on its **new corporate headquarters in Las Vegas, Nev**. It will open the door for continued excellent service featuring added design capability, system integration/manufacturing and source inspection. This facility is an extension of Exodus's existing engineering capability, including state of the art Chip and Wire design and manufacturing centers. Exodus Advanced Communications, 3674 E. Sunset Road, Suite 100, Las Vegas, NV 89120 USA, 702-534-6564, exoduscomm.com.

* * *

SAGE Millimeter launched a **new website** featuring over **800 downloadable datasheets** with measured data and full specifications. SAGE Millimeter's complete product offering can now be browsed in "photo" view (pictured here) or in "sortable table" view, which allows users to sort by their most critical performance specifications. Products can be added to the RFQ Cart with a few clicks and submitted directly to the sales team for speedy pricing. Sagemillimeter.com.

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ATC's Family of 800 Series NPO Ceramic Ultra-Low ESR High RF Power MLCs

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Radio tower image courtesy of Tom Rauch, W8JI

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  Case R (0.070'' x 0.090'')
  Case C (0.250'' x 0.250'')
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- NPO Low Loss Rugged Dielectric
- Voltage Ratings up to 7200 WVDC
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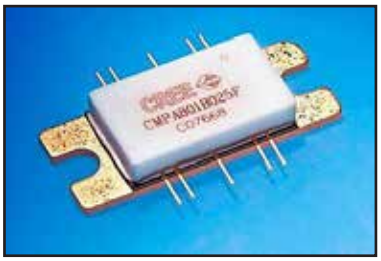
Featured Products: IMS Show



Transistor

Wolfspeed announced that its GaN-on-SiC RF power transistors have completed testing to demonstrate compliance with NASA reliability standards for satellite and space systems. Customers now have the ability to specify Wolfspeed GaN RF devices in the most critical aerospace, military, and satellite electronics systems to achieve a significantly lighter payload and longer operating life, amongst other benefits.

Wolfspeed
IMS Booth # 1621

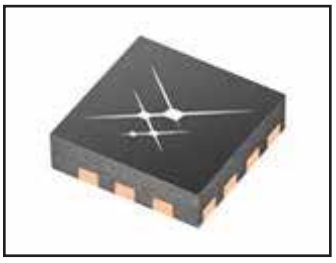
Antenna Synthesis

AntSyn™ antenna synthesis and optimization technology has been added to the NI AWR software product portfolio. AntSyn is a new cloud-based Software as a Service (SaaS) antenna design, synthesis, and optimization solution that enables designers to input their antenna engineering requirements and produce antenna designs as outputs. It addresses the growing need for rapid development of embedded miniaturized, high-performance antennas called for by the Internet of Things and other emerging wireless applications.

National Instruments
IMS Booth # 1529

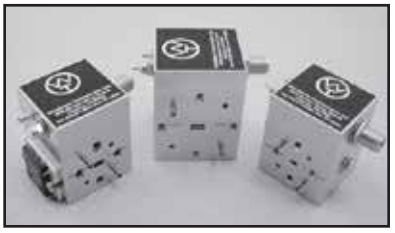
Switch

RFMW announced design and sales support for Skyworks' dual-band, internally matched, SP4T switch developed for WiFi applications in the 2.4 and 5GHz ISM bands. The Skyworks SKY13575-639LF supports access points and CPEs along with WLAN test and measurement



equipment. Frequency coverage is from 100MHz to 6GHz with a maximum insertion loss of 1.4dB. Isolation ranges from 26 to 40dB and the SKY13575-639LF can handle up to 32dBm of input power for demanding applications.

RFMW
IMS Booth # 649



Oscillators

OGV series varactor tuned Gunn oscillators combine proprietary circuit design capability and experience with either GaAs or InP Gunn diode to cover the frequency range of 18 to 110 GHz in seven waveguide bands. They are especially designed for high output power, wide varactor tuning range, mechanical tuning ability and low AM/FM noise characteristics. The DC power is applied via a low pass EMI filter, while a female SMA connector is utilized for the varactor tuning voltage.

Ducommun
IMS Booth # 1417

Switch

Model SKS-5037533030-1515-R1 is a PIN diode based, single pole, single throw switch with a TTL driver that covers 50 to 75 GHz. It offers a low insertion loss of 2.0 dB with a minimum of 25 dB isolation. It has WR-15 waveguides with UG-385/U flanges for RF input and output with an SMA(F) connector for TTL control. It can be modified for various operational frequencies under different model numbers.

SAGE Millimeter
IMS Booth # 302

Coupler

KRYTAR's directional coupler model 101065013 is a multi-purpose, stripline design that exhibits excellent coupling over the 1.0 to 65.0 GHz frequency band. Coupling (with respect to output) is 13 dB ±1.0 dB, Frequency Sensitivity of ±1.0 dB (1.0 to 30.0 GHz) and ±2.0 dB (30.0 to 65.0 GHz). Directivity specifications are >15 dB (1.0 to 20.0 GHz), >10 dB (20.0 to 30.0 GHz), and >7.2 dB (30.0 to 65.0 GHz).

KRYTAR
IMS Booth # 1429

Size #8 to SMA Adapters

SGMC Microwave's Size #8 to SMA Adapters are Precision Between-Series Adapters that feature: DC-18 GHz; VSWR: 1.15:1 Max; Blindmate Interface; Body & Contact: Heat Treated Beryllium Copper/Gold Plated; Dielectric: PTFE (Teflon); O-Rings: Fluorosilicone Rubber; Epoxy Captivated. SGMC Microwave's hallmarks are always: Quality, Performance, & Reliability.

SGMC Microwave
IMS Booth # 2330

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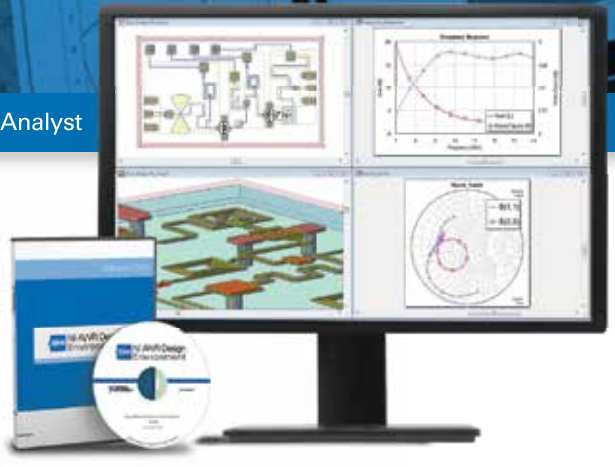

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Featured Products: IMS Show

Frequency Extension Module

Expand your existing Signal Generator capabilities to conduct measurements in WR-12 (60-90 GHz) with OML's Source Module. With high output power of +10 dBm, this module provides high performance source for DUT characterization activities. It offers options such as manual (0-25 dB) and electronic (0-20 dB, 0- 40 dB & 0-60 dB) adjustable attenuation.

OML
IMS Booth # 1333

Cable Assembly

DC-3GHz Low PIM, RG402, 7/16 Male -7/16 Female flange mount connectors. VidaRF offers CA-5000-35B-XX series a Low PIM cable assembly. The assembly operates from DC-3GHz with low PIM of (2x20w) -156dBC. Available in a wide variety of connector combinations.

VidaRF
vidarf.com

Limiters

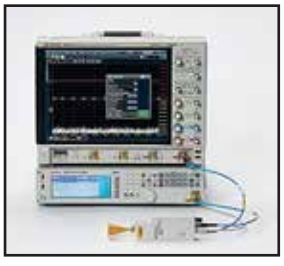
Herotek introduced six new models of Broadband Limiters to its LS Low Leakage Limiter Series. The frequency now goes down to 100MHz and up to 18GHz. They have low insertion loss and typical limiting threshold of +6 dBm with a max leakage of +14 dBm at 1 Watt CW input power. They are offered in standard B (SMA M/F), BF (SMA F/F), and L (surface mount, drop-in) packages. Custom higher power limiters and custom limiters down to 10MHz are also available.

Herotek
IMS Booth # 1225

Inductors

Coilcraft's new SLR Family of high current, shielded power inductors is offered with current ratings up to 100 Amps and inductance values from 85 to 370 nH, making it suitable for high frequency applications such as multi-phase VRM/VRD/EVRD regulators, Intel™ IMVP compatible systems, and GPUs/video graphic cards. The inductors also feature a tight DCR tolerance (±5.4% to ±10%) for lossless, inductor DCR-based current sensing.

Coilcraft
IMS Booth # 1826



Test Platform

Keysight announced an E-band Signal Analysis Reference Solution to provide low-cost millimeter wave analysis capability for applications in the 60-90 GHz range. The reference solution is based around the 10-bit ADC Infiniium S-Series oscilloscope to provide 2.5 GHz of high-fidelity, millimeter wave frequency analysis bandwidth. It provides a powerful test

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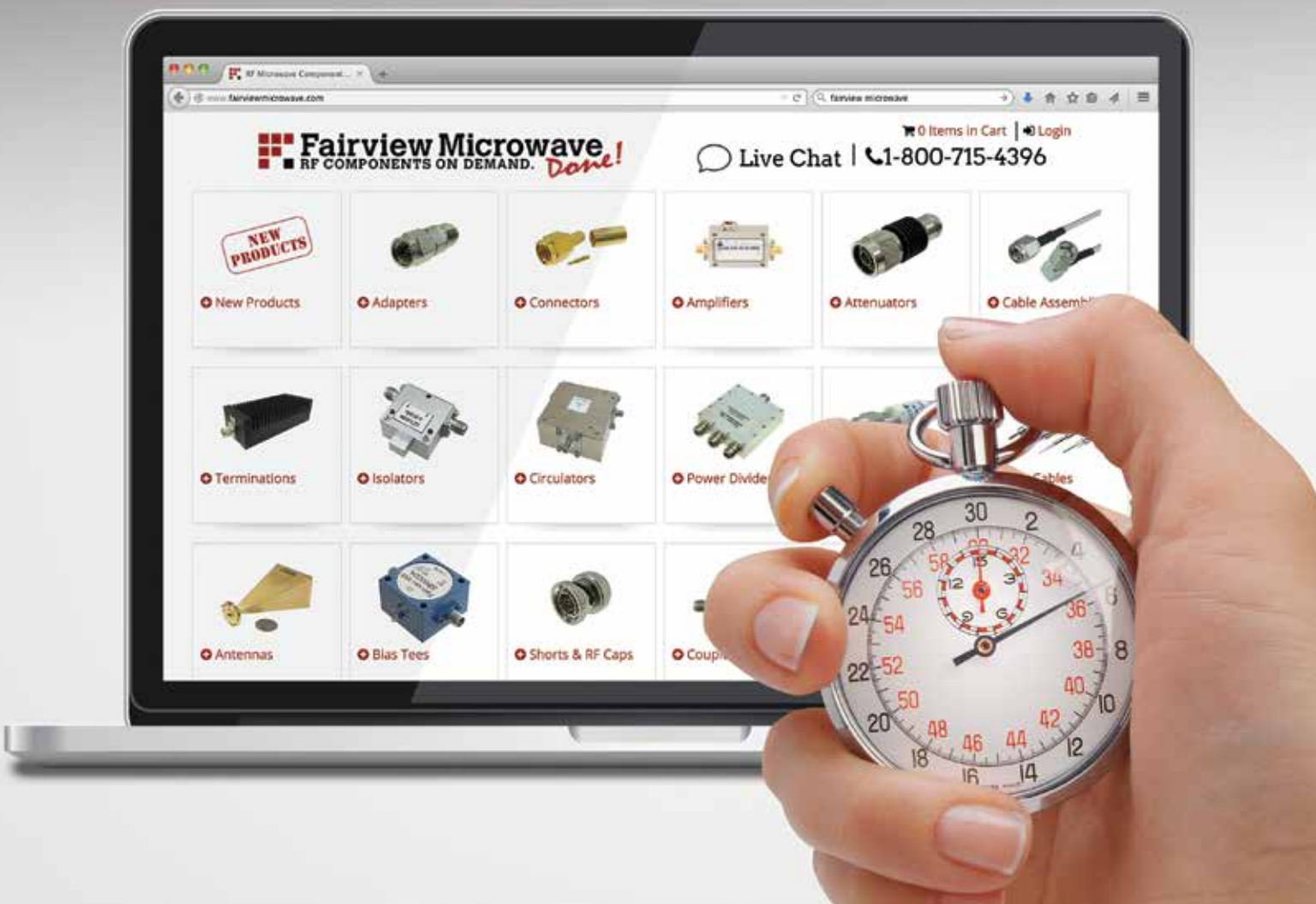

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Keysight Technologies
IMS Booth # 1239

Signal Generator

The SG6800HF microwave signal generator brings a new level of performance. Lowered phase noise, a small frequency step size, more

stable reference oscillator, complete active harmonic filtering, and output level power control past 13GHz make it our most powerful signal generator yet. Both stand-alone interface and USB remote operation past 22GHz make the SG68000HF an incredible value for any RF application.

DS Instruments
dsinstruments.com

Adapter

Models SWC-15VF-E1 and SWC-15VM-E1 are end launch V-Band waveguide to coax adapters that cover the frequency range of 50 to 70 GHz. They are designed and manufactured for instrumentation grade quality, but offered at a commercial grade price. The adapters allow for an efficient transition between the rectangular waveguide and 1.85 mm (V) coax connector. The right angle (90°) versions are offered under model numbers SWC-15VF-R1 and SWC-15VM-R1.

SAGE Millimeter
IMS Booth # 302

Power Divider

MECA expands its extensive power divider line to include multi-octave 3-way Wilkinson power divider optimized for excellent performance covering; 8.0-18.0 (P3S-12.000) with specifications; Isolation 20dB, VSWR's 1.4:1, 07 dB Insertion Loss and Amplitude balance of 0.4dB. Made in the USA – 36 month warranty. e-MECA.com.

MECA Electronics
IMS Booth # 818

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What's in a Name? Clarifying Misused RF/Microwave Terminology

By Tom Perkins, HFE Senior Technical Editor

Clarifying some commonly misused terminology in the RF/Microwave industry.

With IMS2016 upon us and the author teaching springtime classes, it might be educational, controversial, and somewhat humorous to clarify some misunderstandings encountered in the RF/microwave business. Some of these questions have been asked repeatedly over the years, while others are quite isolated. This article attempts to address terminology and physical entities that sometimes are ignored, misinterpreted, or have skewed meaning. Some items may be topics the reader has been reticent to ask about.

Balun Has No "m"

The term balun is sometimes mispronounced "balum." This is possibly because its meaning is not well understood. A balun is a type of transformer used to convert a balanced transmission line (two signals working with each other with no ground) to an unbalanced line (working against ground or pseudo-ground). An example would be to attach a 300 ohm impedance twin lead to a 75 ohm coaxial cable. One would employ a 4:1 balun. The device can also work in the opposite direction. At low frequencies, they are made primarily of wire windings. At microwave frequencies, baluns are realized with sections of transmission lines. Besides trying to make the term correct, Googling "balum" yields some strange definitions, including "round rugs."

Diplexer vs. Duplexer

In a Diplexer signals are offset in frequency by a small percentage. An example is 0.5 to 1% of the operating frequency. A common antenna is connected to a matched power splitter followed by high Q, bandpass filters, one or more on the transmit frequency and the other(s) on the receive frequency. The cross-over point typically requires about 80 dB of rejection. The desired signals must be in the bandpass of their respective filters. Diplexers are primarily used in communications.

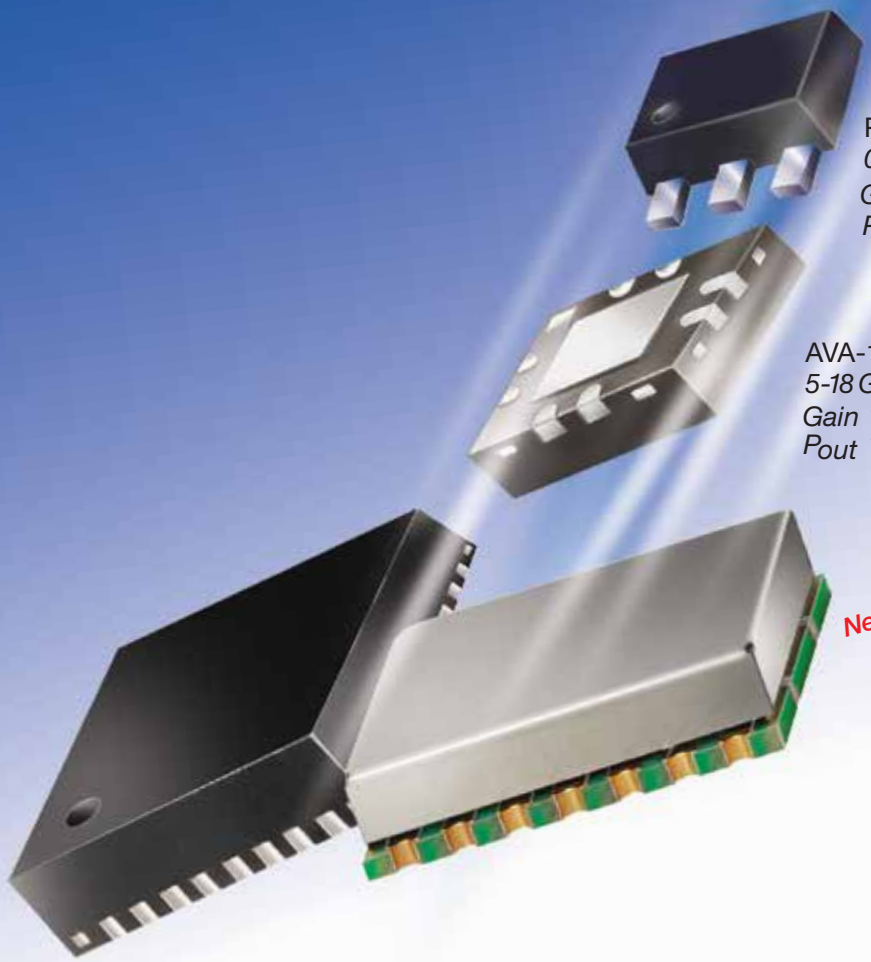
A Duplexer is a three-port network that allows a transmitter and receiver in a radar or communications system to use the same antenna. The duplexer can be a circulator in low power applications, or a gas-discharge T/R tube for megawatt radars. (A T/R tube breaks down and conducts in presence of high power). Ham radio operators and even the ARRL Handbook describe the device that allows the high power transmitter and sensitive receiver in a repeater to use the same antenna in lieu of separate antennas separated by at least 100 feet as a duplexer. This is probably better described as a diplexer.

50 vs. 75 Ohms

Many are curious about the origin of the 50 ohm and 75 ohm characteristic impedance lines. The arithmetic mean between 30 ohms (best peak power handling) Figure 1, and 77 ohms (lowest loss) is 53.5 ohms, the geometric mean is 48 ohms. Thus the choice of 50 ohms is a compromise between power handling capability and signal loss per unit length, for air dielectric. Also,

50 MHz to 26.5 GHz

MICROWAVE MMIC AMPLIFIERS



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The AVA-183A+ delivers 14 dB Gain with excellent gain flatness (±1.0 dB) from 5 to 18 GHz, 38 dB isolation, and 19 dBm power handling. It is unconditionally stable and an ideal LO driver amplifier. Internal DC blocks, bias tee, and microwave coupling capacitor simplify external circuits, minimizing your design time.

The PHA-1+ + uses E-PHEMT technology to offer ultra-high dynamic range, low noise, and excellent IP3 performance, making it ideal for LTE and TD-SCDMA. Good input and output return loss across almost 7 octaves extend its use to CATV, wireless LANs, and base station infrastructure.

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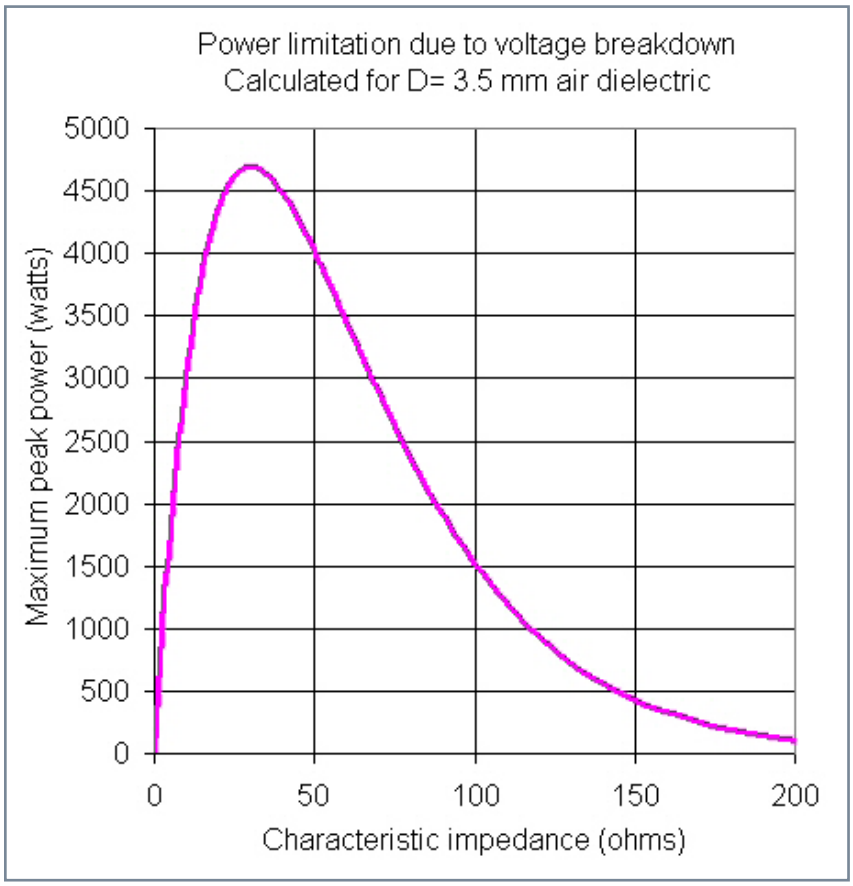

Figure 1 • Peak Power Handling vs. Characteristic Impedance. (Courtesy Microwaves101, IEEE).

only a few dielectric materials are suitable for making coax with 30 ohm impedance. 50 ohm cables, along with associated connectors, was set early in the development of microwave techniques. It is sort of like choosing 60 Hz as a standard for alternating current frequency (in the United States).

75 ohms is generally used for video cables and digital applications. For square wave signals, minimal capacitance is highly desirable. Ideal impedance to meet this criteria would be 93 ohms, so 75 is closer than 50.

Ku and Ka Band

As use of higher frequencies becomes affordable and necessary because of available bandwidth, many systems are now in the Ku, K, and Ka bands. See Figure 2. Apparently many folks are unaware that u stands for *under* and a stands for *above.* If you would rather refer to these with the newer Electronic Warfare band designations it would essentially be just J and K bands. The lower frequency J band (10 to 20 GHz) does dip into about half of X band which precedes Ku, however. This K band goes from 20 to 40 GHz. Confused?

Microwave Oven Cavity

If a metal object should never be placed in a microwave oven, how can the walls and door be metal—and why? A conventional microwave oven consists of a magnetron and its power supply producing microwaves in the industrial, scientific, medical (ISM) band centered at 2450 MHz. Operation at that frequency, which is not optimum for heating many items, equates to a wavelength

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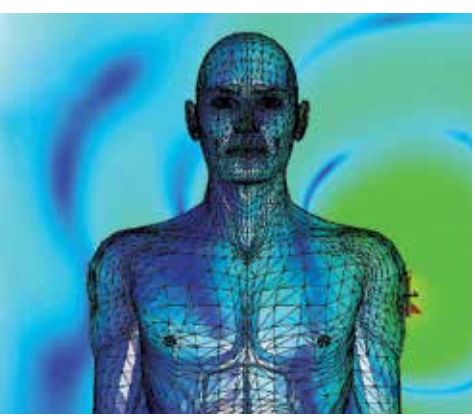

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Band Designation	Frequency Range (GHz)	Wavelength in Free Space (centimeters)
L	1 to 2	30 to 15
S	2 to 4	15 to 7.5
C	4 to 8	7.5 to 3.8
X	8 to 12	3.8 to 2.5
Ku	12 to 18	2.5 to 1.7
K	18 to 26	1.7 to 1.1
Ka	26 to 40	1.1 to 0.75
V	40 to 75	0.75 to 0.40
W	75 to 110	0.40 to 0.27

Figure 2 • Traditional Microwave Band Designations.

of 12.2 centimeters. Usually a short waveguide directs the energy to a six sided "cavity" where the food or liquid is placed for heating. That cavity is most often stainless steel or occasionally ceramic enamel. It is, in effect a Faraday Cage. The point is that it is a cavity that is reasonably resonant at S band, equivalent to a high Q parallel inductor and capacitor in parallel at low frequencies. The door has an embedded mesh and gasket designed to shield the operator from potentially harmful microwave energy. If the cavity contains a rotating plate whose purpose is to help in distributing the energy evenly, it is non-conductive glass. Thus there are no sharp or protruding metal objects within the enclosure.

If there is no way to move the object to be heated, or to "stir" the "load" or waves generated, there would be hot spots every one-half wavelength (about 6 cm), causing very uneven heating. Demonstrations have been conducted with cheese or similar homogeneous food (maybe pasta?) used to illustrate standing waves using a microwave oven. The introduction of metal objects into this near field environment can cause dangerous arcing and actually start a fire, with even semi-flammable material present. It also could cause a very disruptive VSWR to the magnetron and may destroy it.

Return Loss Minus Sign

Dr. Ed Niehenke is the IEEE MTT-S Ombuds Officer. In the May 2016 issue of *IEEE Microwave* magazine he states that in many books and articles, insertion loss and/or return loss are labeled as a negative number on the figures, where they are positive values. He goes on to state that one MTT-S member pointed out to the Standards and Technology Electronic Components Industry Association that their definition of *return loss* in their standards is incorrect and adds that a minus sign needs to be included in the equation. Edward goes on to say that this change has been tentatively approved and once finalized, will be included in the *Microwaves101* website (which IEEE MTT-S now oversees). I asked Ed for clarification and an example and he sent me to the Wikipedia definition of Return Loss. This did not fully satisfy me and I will attempt to have more dialog shortly.

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Clarifying Terminology

		IIIA	IVA	VA	VIA	VIIA	VIIIA
							2 He 4.003
		5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.183
IB	IIB	13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.064	17 Cl 35.453	18 Ar 39.948
29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.909	36 Kr 83.80
47 Ag 107.870	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.904	54 Xe 131.30
79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po (210)	85 At (210)	86 Rn (222)

Figure 3. Note: Silicon and Germanium Semiconductor Materials in the IVA Columns.

Also several IIIA-VA Materials that can be used to Make Compound Microwave Semiconductors. III-V Direct Band Gap Examples are: GaAs, GaN, and InP Groups III and V are also Referred to as 13 and 15 in the Modern Group Periodic Table.

I believe that for passive devices, in particular, return loss should always be expressed without a minus sign. We don't always catch this in articles submitted to *HFE*. This subject remains controversial because some test procedures and even detailed specifications do refer to greater than, or less than a negative return loss value. For further contemplation, I refer the reader to: http://www.microwaves101.com/encyclopedias/loss-or-gain.

Silicon not Silicone

Silicon, which is a group IV chemical element occurring naturally, is the most commonly used semiconductor material as it forms the basis for transistors and integrated circuit (IC) chips. Silicon is the 14th element on the periodic table (See Figure 3) and is called a metalloid, having properties of both metals and nonmetals. Next to oxygen, it's the second most abundant element. Silicon is used in indirect band gap material.

Silicone is a synthetic polymer consisting primarily of silicon, oxygen, carbon and hydrogen. It is mostly produced in the form of a liquid, or flexible plastic having high resistance to moderate heat and low toxicity. It is used in a number of medical, cooking, sealing, lubricating, and personal care items. The confusion may come where silicone is also used as electrical insulation and with electronics, and sometimes used to make enclosures to shield sensitive devices from electrical discharges and static shock. So there can be silicon within silicone, but these are in no way interchangeable.

What's in a Name?

This subject could go for many pages. Just be aware that like many electrical terms, some directly describe the entity (e.g. IMPATT Diode, PIN Diode, FET, Rat-Race, SAW, BAW, Log-Periodic Antenna), while others are named after people (e.g. *Schottky, Wilkinson* Power Divider, *Lange* Coupler, *Gunn* Diode, *Yagi* Antenna).

There is a third category, particularly peculiar to newer company names. Just a few examples: Triquint (describing devices from III-V columns) upon merging with RFMD became Qorvo. Cree Power and RF producing SiC and GaN devices became Wolfspeed. The microwave

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DHM124AA*	10 MHz - 12.4 GHz	1.4:1	0.5	1.0	SMA (M)	SMA (F)	*In Stock*
DZR124AA*	10 MHz - 12.4 GHz	1.25:1	0.3	0.5	SMA (M)	SMA (F)	*In Stock*
DZM124NB*	10 MHz - 12.4 GHz	1.4:1	0.5	0.5	Type N (M)	BNC (F)	*In Stock*
DZ1018*	1 GHz - 18.0 GHz	8.0:1 (Typ)	1.0 (Typ)	1.8	SMA (M)	SMA (F)	*In Stock*
DHM185AA	10 MHz - 18.5 GHz	1.5:1	0.5	1.0	SMA (M)	SMA (F)	*In Stock*
DZR185AA*	10 MHz - 18.5 GHz	1.25:1	0.5	0.5	SMA (M)	SMA (F)	*In Stock*
DZM185AB*	10 MHz - 18.5 GHz	1.5:1	0.5	0.5	SMA (M)	BNC (F)	*In Stock*
DZM185NB*	10 MHz - 18.5 GHz	1.5:1	0.5	0.5	Type N (M)	BNC (F)	*In Stock*
DZ1026	1 GHz - 26.0 GHz	8.0:1 (Typ)	1.5 (Typ)	1.6	SMA (M)	SMA (F)	*In Stock*
DHM265AAP	10 MHz - 26.5 GHz	2:01	1.0	1.0	SMA (M)	SMA (F)	*In Stock*
DZR265AA*	10 MHz - 26.5 GHz	2.0:1	1.0	0.5	SMA (M)	SMA (F)	*In Stock*
DZR400KA*	10 MHz - 40 GHz	1.8:1	1.0	0.4	K (M) (2.9mm)	SMA (F)	*In Stock*
DZR50024A*	10 MHz - 50 GHz	2.0:1	1.0	0.5	2.4mm (M)	SMA (F)	*In Stock*

Tunnel Diode Detectors: 0.1 to 40 GHz

Model Number	Frequency Range (GHz)	Min Sensitivity K (mV/µW)	Typical TSS (dBm)	Max Fatness (±dB)	Typical VSWR	Typical Output Capacitance (pF)	Delivery†
DT0105	0.1 - 0.5	1000	-51	0.75	2.0:1	200	*In Stock*
DT0520	0.5 - 2.0	800	-50	0.7	2.0:1	50	*In Stock*
DT1020P	1.0 - 2.0	1000	-51	0.5	2.0:1	20	*In Stock*
DT8016P	8.0 - 16.0	800	-50	0.7	2.5:1	10	*In Stock*
DT1018	1.0 - 18.0	700	-50	1.0	3.5:1	20	*In Stock*
DT2018*	2.0 - 18.0	700	-50	1.0	3.5:1	10	*In Stock*
DT2018K	2.0 - 18.0	600	-49	1.5	4:1	10	*In Stock*
DT6018PZ1	6.0 - 18.0	600	-49	1.0	3:1	10	*In Stock*
DT1218P	12.0 - 18.0	750	-50	0.7	2.5:1	10	*In Stock*
DT1840	18.0 - 40.0	300	-46	1.75	4.0:1	10	*In Stock*
DT2640	26.0 - 40.0	300	-46	1.5	4.0:1	10	*In Stock*

Pulse and CW Power Detectors: 1.0 to 18 GHz (Input Power Protection Built-In)

Model Number	Frequency Range (GHz)	Typ Sensitivity K (mV/mW)	Rise Time (nSec)	Max Input Power (W)	Max VSWR	Connector Input	Connector Output	Delivery†
DTM180AA	1.0 - 18.0	300	2 (Max) 1 (Typ)	1	2:1	SMA (M)	SMA (F)	*In Stock*
DTM180AB	1.0 - 18.0	300	2 (Max) 1 (Typ)	1	2:1	SMA (M)	BNC (F)	*In Stock*
DTM180NB	1.0 - 18.0	300	2 (Max) 1 (Typ)	1	2:1	Type N (M)	BNC (F)	*In Stock*

Limiters: 0.1 to 40 GHz

Model Number	Frequency Range (GHz)	Max Insertion Loss (dB)	Max VSWR	Typ Lim Threshold (dBm)	Max Leakage @ 1W CW Input (dBm)	Delivery†
LS0520	0.5 - 2.0	0.6	1.4:1	+6	+14	*In Stock*
LS2040	2.0 - 4.0	0.7	1.4:1	+6	+14	*In Stock*
LP2040	2.0 - 4.0	0.5	1.4:1	+9	+19	*In Stock*
LS4080	4.0 - 8.0	1.3	1.5:1	+6	+13	*In Stock*
LP4080	4.0 - 8.0	1.2	1.5:1	+9	+19	*In Stock*
LS01012	0.1 - 12.0	1.7	1.6:1	+6	+14	*In Stock*
LS7012	7.0 - 12.0	1.6	1.6:1	+6	+13	*In Stock*
LP7012	7.0 - 12.0	1.5	1.6:1	+9	+19	*In Stock*
LS01018	0.1 -18.0	2.2	2.0:1	+6	+14	*In Stock*
LS05018	0.5 - 18.0	2.0	2.0:1	+6	+14	*In Stock*
LP05018	0.5 - 18.0	1.8	2.0:1	+9	+20	*In Stock*
LP1018	1.0 - 18.0	1.8	2.0:1	+9	+20	*In Stock*
LP2018	2.0 - 18.0	1.8	2.0:1	+9	+20	*In Stock*
LS8018	8.0 - 18.0	2.0	2.0:1	+6	+13	*In Stock*
LP8018	8.0 - 18.0	1.8	2.0:1	+9	+19	*In Stock*
LP18-40A	18.0 - 40.0	4.0	2.0:1	+9	+19	*In Stock*
LP26-40A	26.0 - 40.0	4.0	2.0:1	+9	+19	*In Stock*

Comb Generators: 100 MHz to 18 GHz

Model Number	Input Frequency (MHz)	Input Power (W)	Max Input VSWR	Min Output Power per Picket (dBm)				Delivery†
				Up to 4 GHz	4 – 8 GHz	8 – 12.4 GHz	12.4 – 18 GHz	
GC100RC	100	0.5	2:1	-10	-20	-30	-40	*In Stock*
GC200RC	200	0.5	2:1	-5	-15	-25	-35	*In Stock*
GC250RC	250	0.5	2:1	0	-10	-20	-30	*In Stock*
GC500RC	500	0.5	2:1	+5	-5	-15	-20	*In Stock*
GC1000RC	1000	0.5	2:1	+5	0	-10	-15	*In Stock*

* Positive output version available in stock (Add P to the suffix). † Subject to prior sale.
** See Data Sheet for more details of VSWR and Flatness over narrower frequency bands.

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test equipment part of Hewlett-Packard Company (William and David) became Agilent, which became Keysight. Actually upon investigation it appears that Keysight is a portmanteau of *key* and *insight* to convey that the company "unlocks" critical or key insights. The branding or meaning of some new names may not particularly describe anything but may have a catchy sound that can easily be remembered. With the days of the Yellow Pages waning, the desire to name a company "Ajax" or "AAA" may be history. Conversely, there are a number of companies that have made extensive acquisitions or otherwise expanded their product base into things like microwave subassemblies who still identify themselves in name as, for example, a semiconductor company.

It Pays to Look it Up

Finally, if you are new to this game and have a pending interview, you might look up terms, like the following, in advance. PIN diode (not point contact probing germanium). Decibels are relative, dB absolute. TWT is not a twit. GaAs is not Gas. ERP (pronounced "burp" without the b), FPGA, massive MIMO, and many others.

When I interviewed for my first microwave job, one of the verbal questions was: "Explain viswaar." As a radio amateur (ham), I had been working with standing wave ratio (SWR) since age 14. In a my college course called Microwave Techniques I was introduced to Voltage Standing Wave Ratio (VSWR), reflection coefficient, return loss and even used a slotted line. I had fairly deep knowledge of the subject, but was completely befuddled by "viswaar" (from a brilliant Harvard man with a Maine accent). It's a miracle I was hired! There may be a lesson here. Don't assume everyone knows the jargon and abbreviations you have learned and if you don't understand something, ask for clarification.This becomes exponentially more complicated when dealing with military projects.

About the Author

Tom Perkins graduated from Monmouth University in 1966 with a BSEE. He did graduate study at Northeastern University. He has served as HFE's Senior Technical Editor since 2011 and is currently teaching a microwave course along with consulting for a leading nanotechnology company. Other pending work includes development of metalized antenna arrays for additive 3D printing.

He spent close to 45 years at various companies developing radar and EW microwave modules, PIN diode control devices, radar altimeters, expendable decoys, broadband MMIC amplifiers, flight-line microwave test sets, tactical deception equipment, microwave tag devices, space qualified hardware, GaN high power amplifiers, and unique microwave packaging including LTCC. Tom holds six patents, mostly involving microwave modules and antennas. He is a Senior Life Member of IEEE and is currently Chair of the NH Chapter MTT-S. Licensed since 1957, he holds an Amateur Extra ham radio license, AC1J.

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Small Cell Multicoupler

By Wayne Barbely

With the advent of new Wi-Fi frequencies and equipment, innovation and increased bandwidth couplers are needed to bring more services into buildings and general infrastructure. One major requirement to make cell phone operation viable is the Global Positioning System (GPS) for timing and location. GPS signals must be included as part of the RF services. This requirement adds some complexity to the system because of its vulnerability to interference from the system itself or nearby transmitters.

Increased bandwidth couplers are needed to bring more services into buildings and general infrastructure.

Combining the GPS signal with other services will require some unique hardware.

The traditional approach is multiple feed lines and or narrow band filters. Multiple feed lines are expensive to install and expensive to maintain, so the fewer the better. Performance data taken over relatively long periods and error rate history produces an obvious conclusion. It would be beneficial to have a wide RF combiner with one feed line. This would allow for simpler base station installation and maintenance.

One approach to the problem is the use of two combiners, one located at the base of the tower or equipment room, and the other at the top of the tower with a single feed line between them as shown in Figure 1. The diplexer configuration could be used in this manner where the equipment is inside a building.

Design Requirements

In order to comply with the approach proposed, the following specifications were created:

Passband loss (Port 1-Port 2) 500 MHz to 1350 MHz: 0.5db MAX .25db typical
Passband loss (Port 1-Port 2) 1700 MHz to 3000 MHz: 0.5db MAX .25db typical
Passband return loss (Port 1-Port 2) 500 MHz to 1350 MHz:14 db MIN
Passband return loss (Port 1-Port 2) 1700 MHz to 3000 MHz:14 db MIN
Stopband loss (Port 1-Port 2) 1575.42 MHz +/- 5 MHz: 70 dB Min.
Passband loss (Port 1 to Port 3) 1575.42 MHz +/-10 MHZ: 0.7 dB MAX 0.5 dB typical
Stop band loss (Port 1 to Port 3) 500MHz to 1350 MHz 70DBC min 80DBC typical
Stop band loss (Port 1 to Port 3) 1700MHz to 3000MHz 70DBC min 80DBC typical
Pass band return loss (Port 1-Port 3) Input/Output 14 DB Max. (1575.42 MHz +/-10).
DC block (Port 1 to Port 2) 40vDC > 10MEG
DC block (Port 3 to Port 1) 40vDC > 10MEG
Maximum DC Current 200 milliamperes.
RF-DC Isolation > 80 dB Frequency Dependent
Temperature Operation - 20 to 70 degrees C
Temperature Storage - 40 to 85 degrees C
PIM min: -153dbc

At the common port, broadband RF + GPS + DC will be coupled to the GPS filter Port # 3. Port # 2 is DC blocked and supports RF in two bands – GPS that is notched to -70 dBc 1575.42 +/- 10MHz. DC bias provides power to the GPS preamp.

Design is Utilized

In order to meet the above requirements, a diplexer is employed that incorporates a bandpass filter passing the GPS frequencies and a notch filter that accepts all other frequencies and rejects the GPS frequencies. Also included is a provision for supplying DC power to the remote

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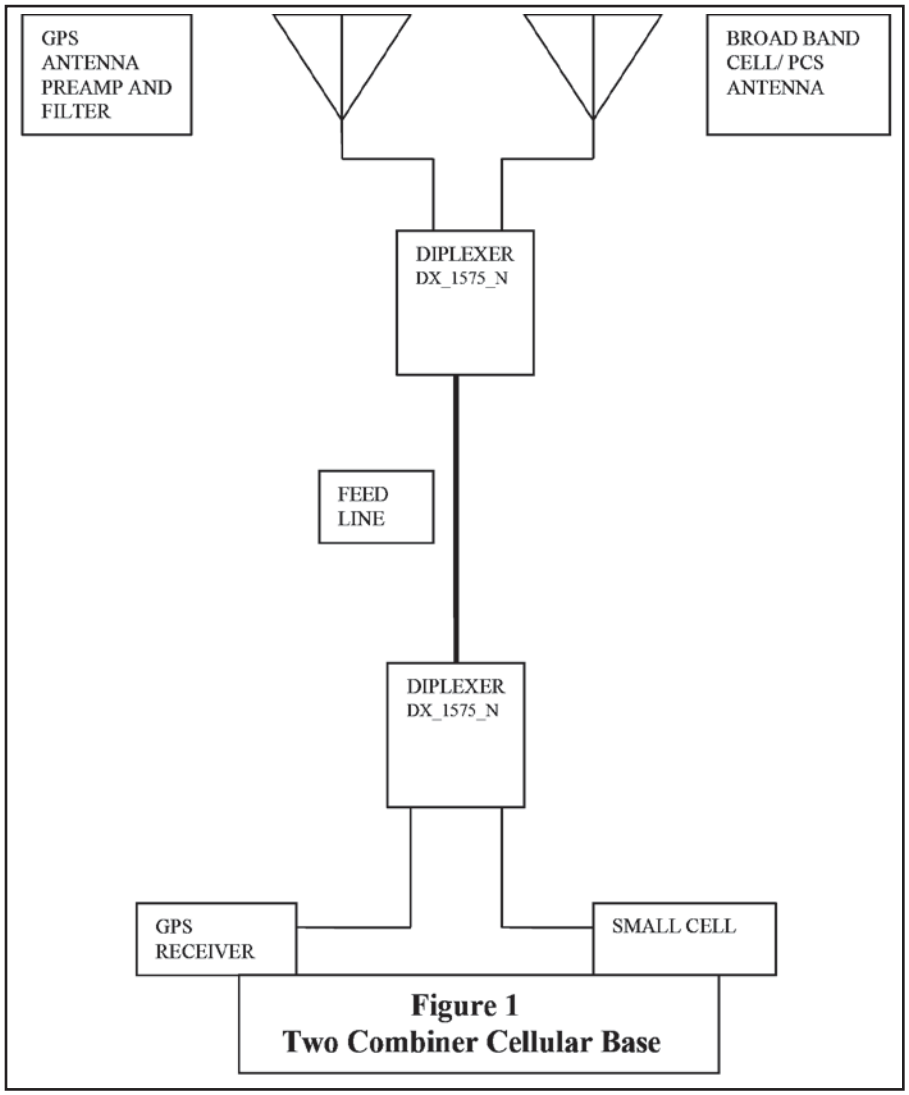

Figure 1 • Two Combiner Cellular Base.

GPS preamp, a low pass filter that isolates the DC bias from the cell, Personal Communications Service (PCS), and Wi-Fi equipment that would be connected to the broad band port (port 1).

A DC block will be used to protect the broad band port under all conditions. As shown in the block diagram (Figure 3), the DC path can only flow from the common port to the GPS port. The overall design requirement is low Passive InterModulation (PIM) (-153 DBC). PIM, by definition, is a measure of the nonlinearity of passive components. When power is applied to a system or a component, unwanted distortion products are produced that generate interfering signals which can cause dropped calls and limit the number of viable users on any given system. Every effort must be made to insure that the components in the design do not contribute minimally to Passive Intermodulation distortion. Any bimetal components will contribute to this parameter. Connectors, DC blocks, coils, capacitors, and plating can be contributors.

The multicoupler dimensions, shown in Figure 2, are 10.5 x 6 x 1 5/16 inches. The unit can be rack mounted or pole/tower mounted outdoors.

Figure 4 is a simulation of the circuit loss of the diplexer from the common port to port #2 and port #3.

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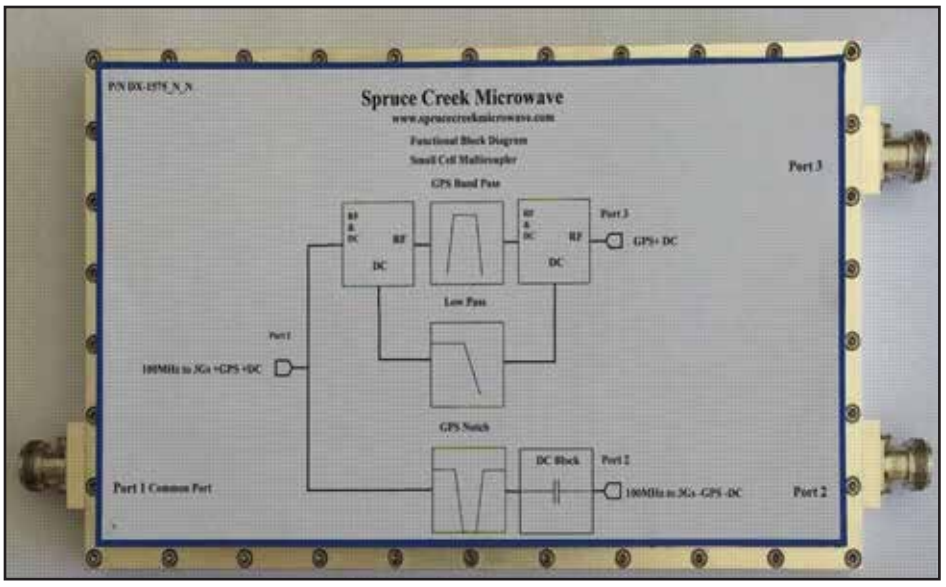

Figure 2 • Multicoupler with Block Diagram.

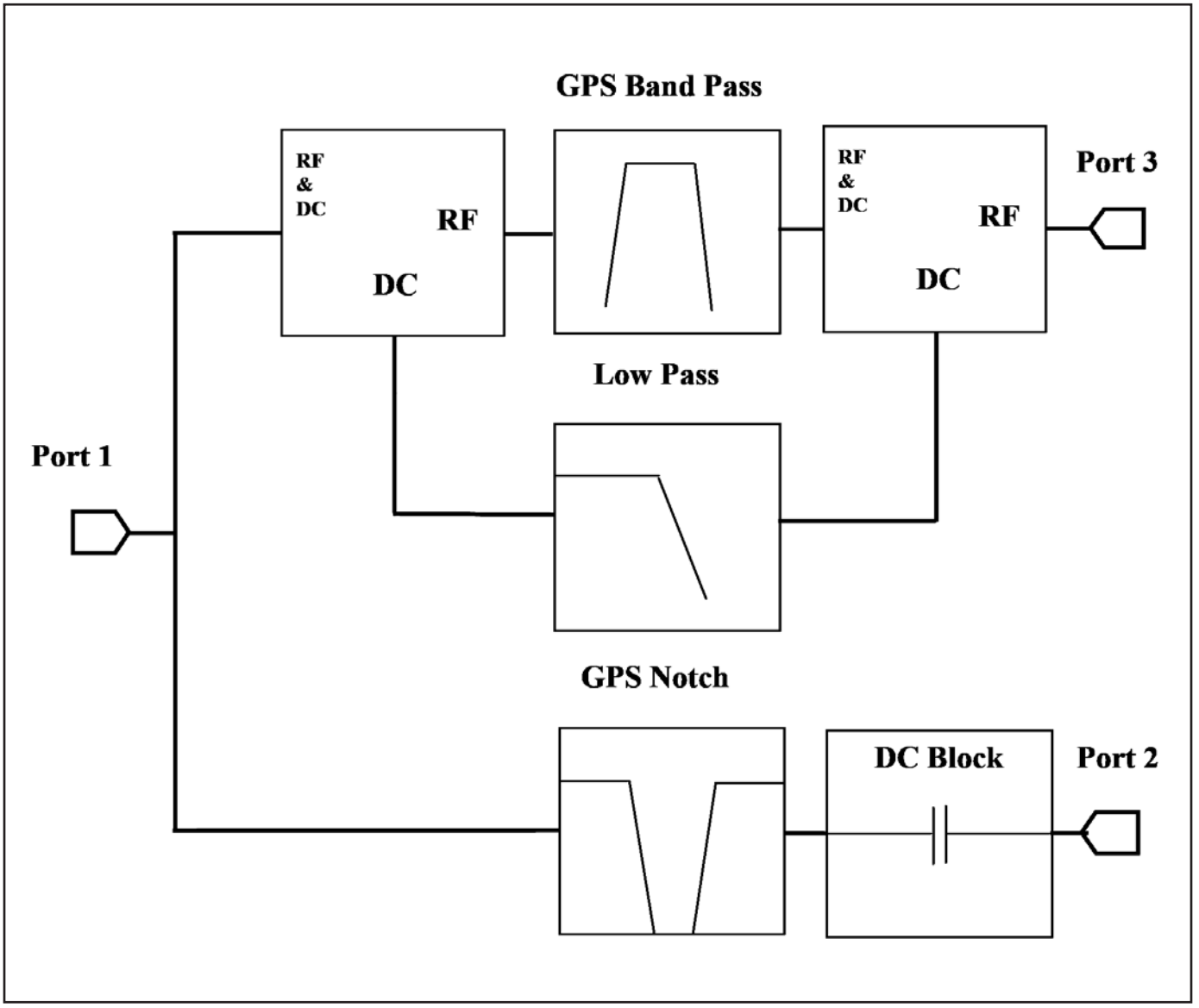

Figure 3 • Functional Block Diagram.

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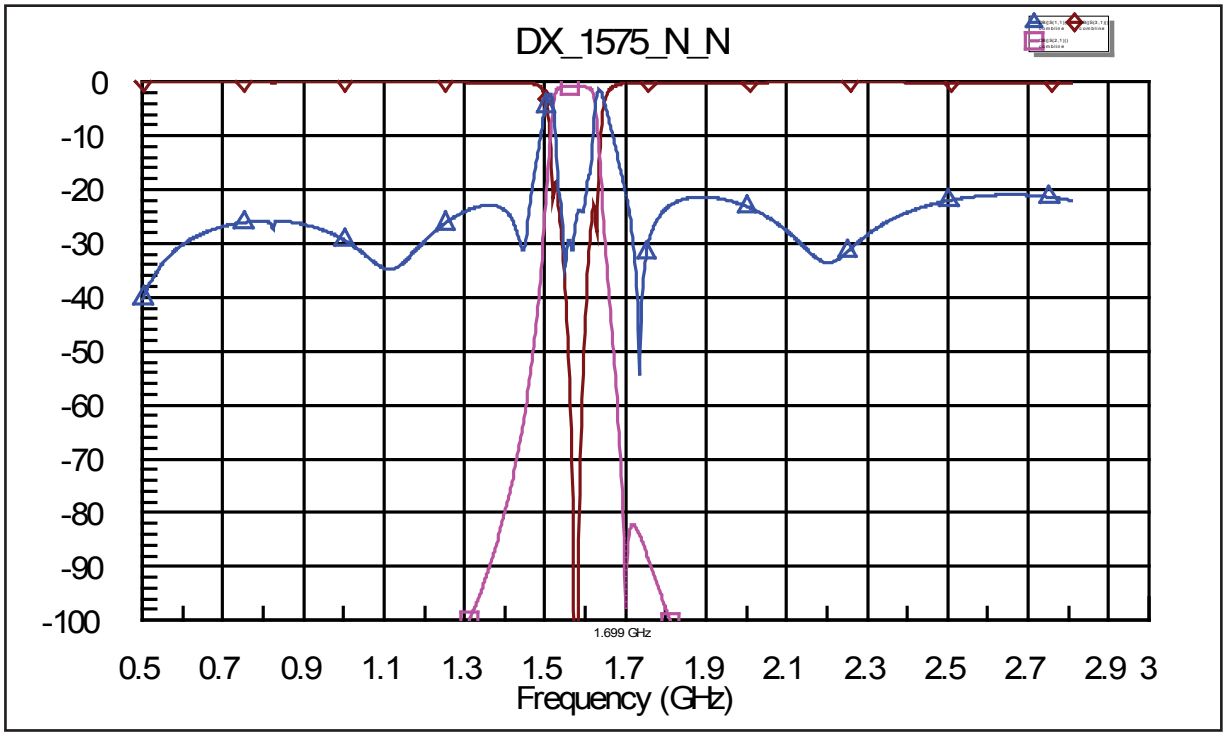

Figure 4 • Diplexer Loss Simulation.

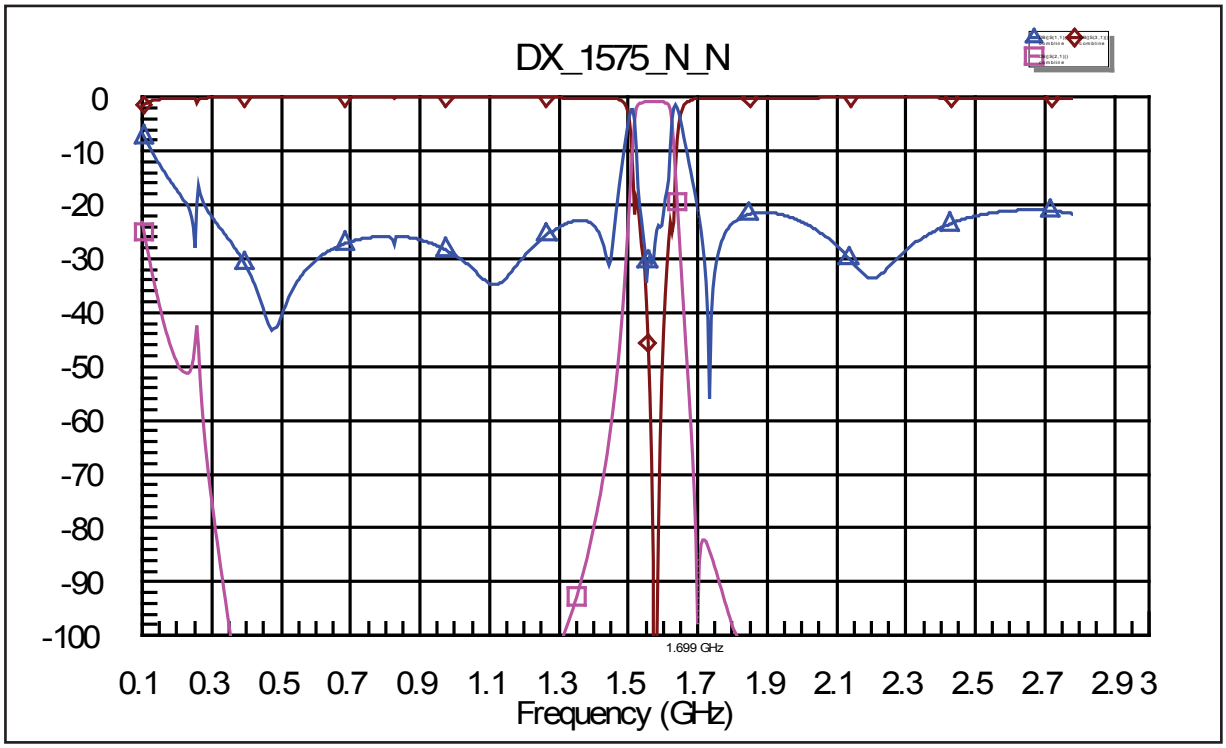

Figure 5 • Diplexer Loss Simulation (Wide Sweep).

Figure 5 is a simulated plot using the same ports as Figure 4 only with a wider sweep. Note the path provided by the low pass bias tee.

Figure 6 is a plot of a narrow sweep highlighting the pass band and stop band of the GPS band pass filter as well as the GPS notch filter.

Wideband Passive Intermodulation (PIM)

The plots indicate a wide band that opens up the possibility of passive intermod distortion. Care must be taken to insure that all materials used in the construction conform. Figure 7 is a plot of Passive Intermodulation Performance of the hardware.

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- Phase and Amplitude Tracking
- Gain / Frequency Slope
- Input Limiter Protection

Specifications:

Model Number	Frequency Range (GHz)	Gain (Min.) (dB)	Gain Variation (Min.) (±dB)	Noise Figure (Max.) (dB) *	VSWR Input/ Output (Max.)	P1dB (dBm) (Min.)	Nominal Power (+15 V, mA)
A-4D-00011800-30-10P	0.01-18	27	2.5	3.0	2.0 / 2.5	+10	200
A-2D-001010-11-13P	0.1-1	26	1.0	1.1	2.0 / 2.0	+13	90
A-2D-001020-12-13P	0.1-2	25	1.0	1.2	2.0 / 2.0	+13	90
A-2D-001040-15-13P	0.1-4	23	1.5	1.5	2.0 / 2.0	+13	90
A-3D-001060-17-13P	0.1-6	33	1.5	1.7	2.0 / 2.0	+13	135
A-3D-001080-19-13P	0.1-8	32	1.5	1.9	2.0 / 2.0	+13	150
A-3D-001100-20-13P	0.1-10	31	1.5	2.0	2.0 / 2.0	+13	150
A-3D-001120-21-13P	0.1-12	27	1.5	2.1	2.0 / 2.0	+13	150
A-4D-001180-25-10P	0.1-18	30	2.0	2.5	2.5 / 2.0	+10	150
A-4D-001200-28-10P	0.1-20	28	2.0	2.8	2.5 / 2.5	+10	150
A-4D-001220-31-10P	0.1-22	25	2.0	3.1	2.5 / 2.5	+10	150
A-5D-001265-41-08P	0.1-26.5	24	2.5	4.1	2.5 / 2.5	+8	200
A-2D-005020-12-13P	0.5-2	26	1.0	1.2	2.0 / 2.0	+13	90
A-2D-005040-14-13P	0.5-4	24	1.5	1.4	2.0 / 2.0	+13	135
A-2D-005060-16-13P	0.5-6	23	1.5	1.6	2.0 / 2.0	+13	90
A-3D-005080-18-13P	0.5-8	33	1.5	1.8	2.0 / 2.0	+13	150
A-4D-005180-24-10P	0.5-18	30	2.0	2.4	2.2 / 2.0	+10	150
A-4D-005200-27-10P	0.5-20	28	2.0	2.7	2.3 / 2.3	+10	150
A-4D-005220-30-10P	0.5-22	25	2.0	3.0	2.3 / 2.3	+10	150
A-5D-005265-40-08P	0.5-26.5	24	2.0	4.0	2.5 / 2.5	+8	200
A-3D-020120-20-13P	2-12	27	1.5	2.0	2.0 / 2.0	+13	150
A-3D-020180-23-10P	2-18	22	1.5	2.3	2.2 / 2.0	+10	150
A-4D-020180-23-10P	2-18	30	1.5	2.3	2.2 / 2.0	+10	150
A-4D-020200-26-10P	2-20	28	1.5	2.6	2.2 / 2.2	+10	150
A-4D-020220-29-10P	2-22	26	1.5	2.9	2.2 / 2.2	+10	150
A-4D-020265-39 -08P	2-26.5	19	2.0	3.9	2.5 / 2.5	+8	150
A-4D-200265-30-08P	20-26.5	24	1.0	3.0	2.0 / 2.0	+8	150
A-4D-265330-35-10P	26.5-33	23	1.5	3.5	2.0 / 2.0	+10	180
A-4D-300330-35-08P	30-33	23	1.5	3.5	2.0 / 2.0	+8	180
A-4D-340360-35-08P	34-36	23	1.5	3.5	2.0 / 2.0	+8	180
A-4D-300400-40-08P	30-40	23	1.5	4.0	2.5 / 2.5	+8	180
A-4D-180400-40-6P	18-40	20	2.5	4.0	2.5 / 2.5	+6	180
A-5D-260400-38-10P	26-40	30	2.5	3.8	2.5 / 2.5	+10	250

* Noise figure guaranteed from 200 MHz and above; all parameters are specified at +25 °C
NOTE: Other Medium and Lower cost designs available and package availabity, contact factory.

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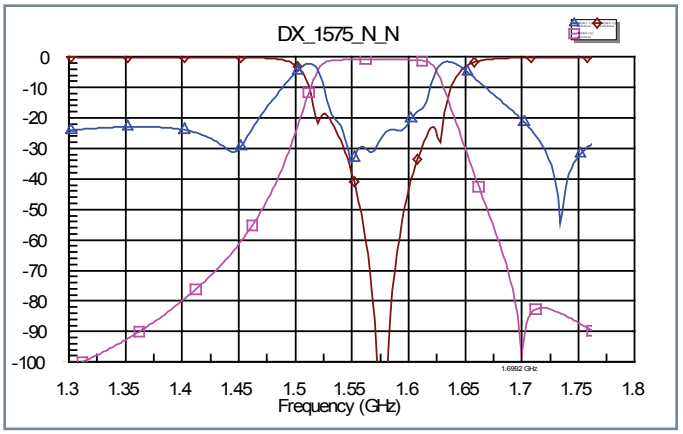


Figure 6 • Narrow Sweep Highlighting Pass Band and Stop Band.

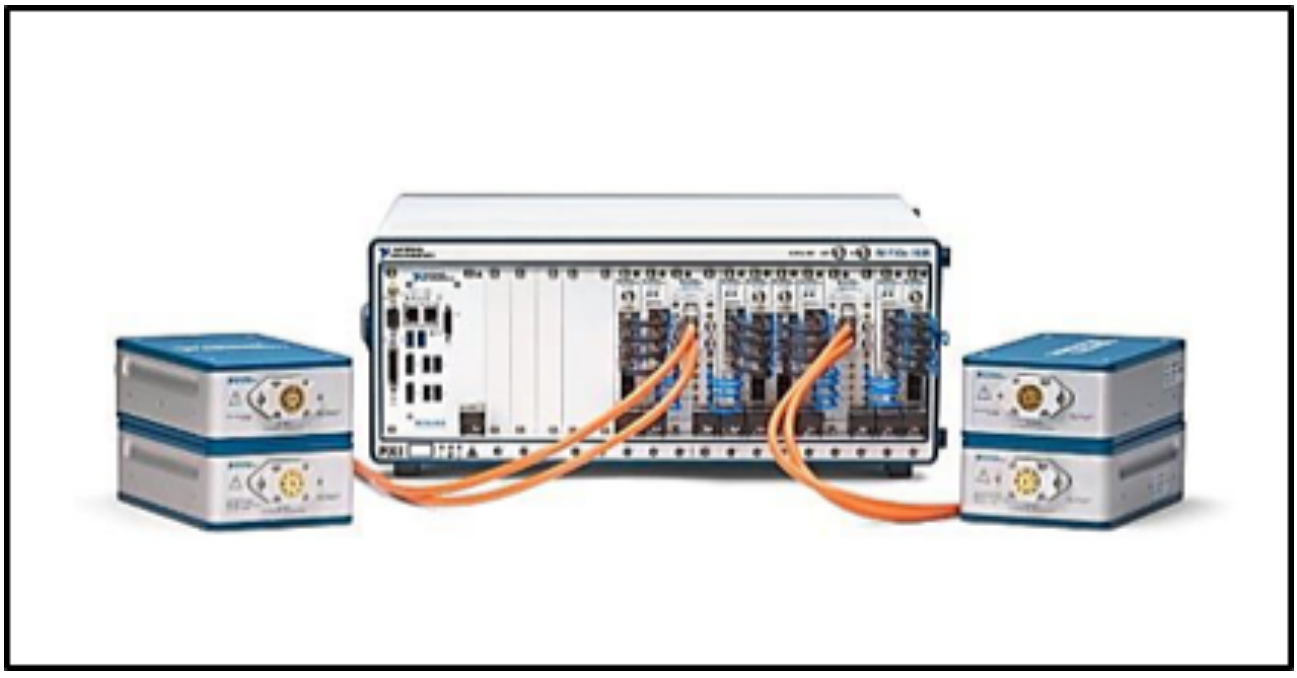
Figure 7 • Passive Intermod Performance.

Conclusions

Cellular base station microwave electronics can be significantly simplified using two combiners, one located at the base of a tower, and the other topside near the antenna with a single feed line between them. This approach saves size, weight and power (SWAP) as well as reducing prime equipment and enclosure costs.

About the Author

Wayne Barbely has 54 years of experience in the field of RF and microwave filters. He formerly owned and served as CEO of Salisbury Engineering in Delmar, Delaware. He operated the company from 1982 to 2004 and was responsible for the design and manufacturing of RF and microwave filters. Wayne started his career with NASA in 1962 and also received training from The University of Virginia. Mr. Barbely currently owns Spruce Creek Microwave in Port Orange, Florida where he manages design and sales. Wayne can be reached by email at: rwbarbely@reagan.com.



MMWave Transceiver System

> The mmWave transceiver system includes new PXI Express modules that collectively function as an mmWave access point for a user device.

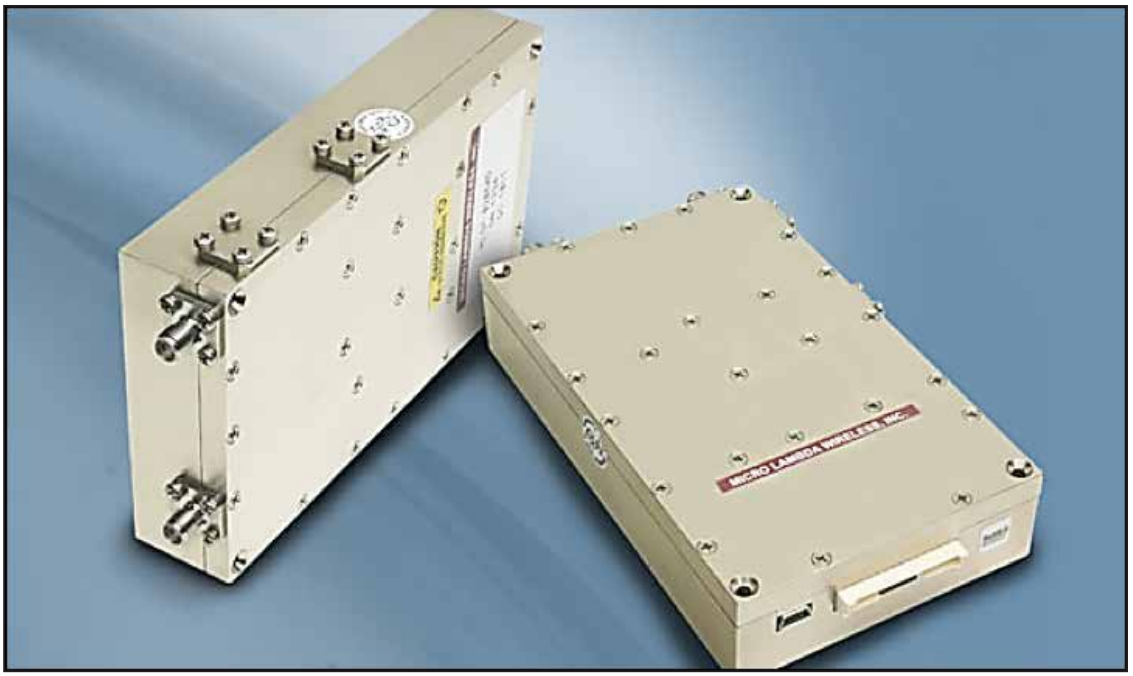
NI announced the world's first software defined radio (SDR) for the millimeter wave spectrum. The new NI mmWave Transceiver System is a full transceiver that can transmit and/or receive wide-bandwidth signals at an unprecedented 2 GHz real-time bandwidth, covering the spectrum in the E-band, 71-76 GHz. Engineers and scientists have used SDRs ubiquitously in the spectrum below 6 GHz for years. However, with companies investing in mmWave as a potential core technology for 5G, researchers now have a full-featured SDR platform to drive initiatives based on this technology.

The mmWave transceiver system includes new PXI Express modules that collectively function as an mmWave access point for a user device. Because of the unprecedented flexibility, users can develop mmWave communication prototyping systems or perform channel measurements—necessary exercises for wireless researchers to understand the characteristics of a new spectrum—using the same system.

The mmWave baseband software delivers a complete mmWave physical layer including channel coding in LabVIEW virtual instrument (VI) source code to expedite system development while alleviating many of the system integration tasks. Researchers can also use the mmWave transceiver system baseband with the E-band mmWave heads or other third-party RF front ends to offer maximum flexibility for exploring other mmWave and microwave frequency bands.

As a key participant in NI's RF/Communications Lead User program, Nokia has been working with early versions of the mmWave transceiver system in its 5G research initiatives for over a year.

National Instruments
IMS Booth # 1529



YIG Synthesizers

> The MLSP-Series of wideband YIG synthesizers includes models with various frequency ranges through 20 GHz. This series of PXI synthesizers allows you to reduce your footprint while also providing low phase noise performance.

With standard designs covering 500 MHz to 20 GHz, Micro Lambda Wireless is the industry leader in YIG-tuned frequency synthesizers. From low cost single loop designs, to wideband configurations that outperform some test equipment, Micro Lambda is your full service designer and supplier of microwave YIG synthesizers.

The **MLSP-Series** of wideband YIG synthesizers includes models with various frequency ranges through 20 GHz. This series of PXI synthesizers allows you to reduce your footprint while also providing low phase noise performance.

The **MLSW-Series** YIG frequency synthesizers cover wideband frequencies in the 600 MHz to 16 GHz band and they are known for outperforming most microwave test and measurement equipment signal generators today.

The **MLSN-Series** is a line of narrowband synthesizers with 2 GHz and 3 GHz tuning ranges spanning a 2 to 16 GHz frequency range for SATCOM and telecom applications. They provide excellent phase noise performance for your most challenging frequency converter designs.

Finally, the **MLSL-Series** low cost frequency synthesizers offer 2 GHz and 3 GHz tuning ranges across the 2 to 12 GHz frequency band. Standard units offer 500 kHz step size with optional step sizes down to 100 kHz.

Micro Lambda Wireless
IMS Booth # 1110

100W POWER AMPLIFIERS

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IMS Booth # 1417

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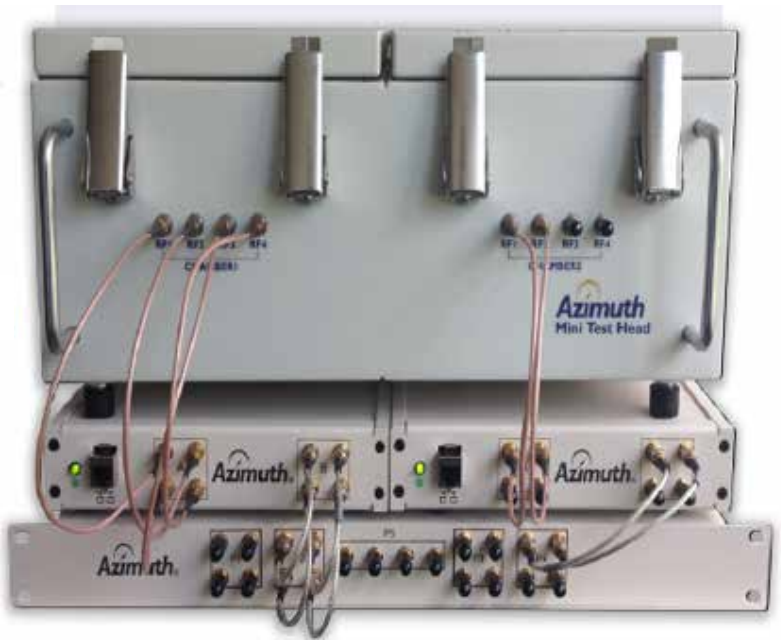


Scalable RF Platform

An Automated, Scalable RF Platform for LTE Unlicensed, Wi-Fi, and IoT. Technologies like LTE unlicensed and applications such as IoT put new requirements on testing that can't be met by existing solutions, which are geared towards link-level testing.

> "Spider™ is an automated RF Platform that is modular, scalable, and cost effective."

These challenges are addressed by Spider™. Spider™ is an automated RF Platform that is modular, scalable, and cost effective. Spider™ provides unmatched:

Accuracy, reliability, and repeatability

Modularity and scalability to a variety of technologies, applications, and use cases

End-to-end automation of the entire test-bed

Spider™ builds on Azimuth's 14+ years of technology (cellular, Wi-Fi), testing (performance, conformance), and industry (standards, forums, ecosystems) experience.

Spider™ consists of integrated hardware and software modules that provide:

Controllable bidirectional MIMO links

Wide channel bandwidth, wide frequency coverage (700MHz–6GHz)

Variety of topologies with complete RF isolation (90dB)

Connectivity with real devices in their native form

Automation of entire test-bed, including devices, APs, traffic sources, etc.

Azimuth Systems
azimuthsystems.com

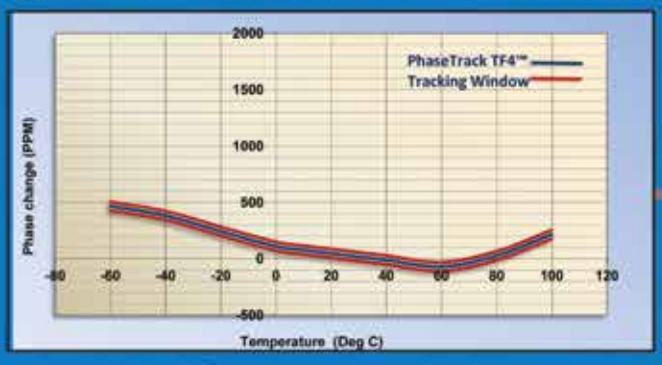
Instantly Improve the Performance of Your Phased Array Radar!

Phased Array Radar system performance has long been limited by the phase change over temperature of coaxial cables.

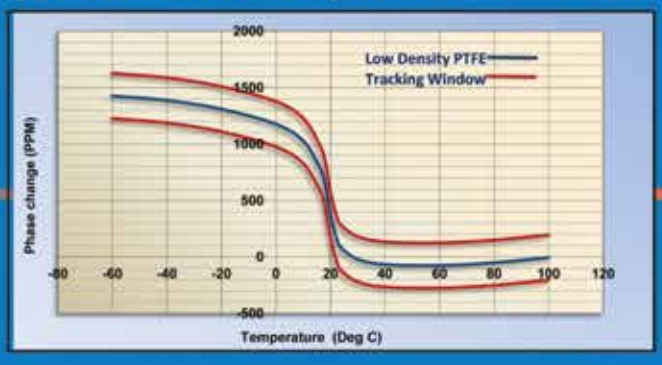
Not anymore!

TF4™ - our proprietary, ultra stable dielectric material significantly improves Phased Array Radar system performance by reducing the phase change of the interconnecting coaxial cables.

Typical PhaseTrack TF4™ Performance



Typical Low Density PTFE Performance



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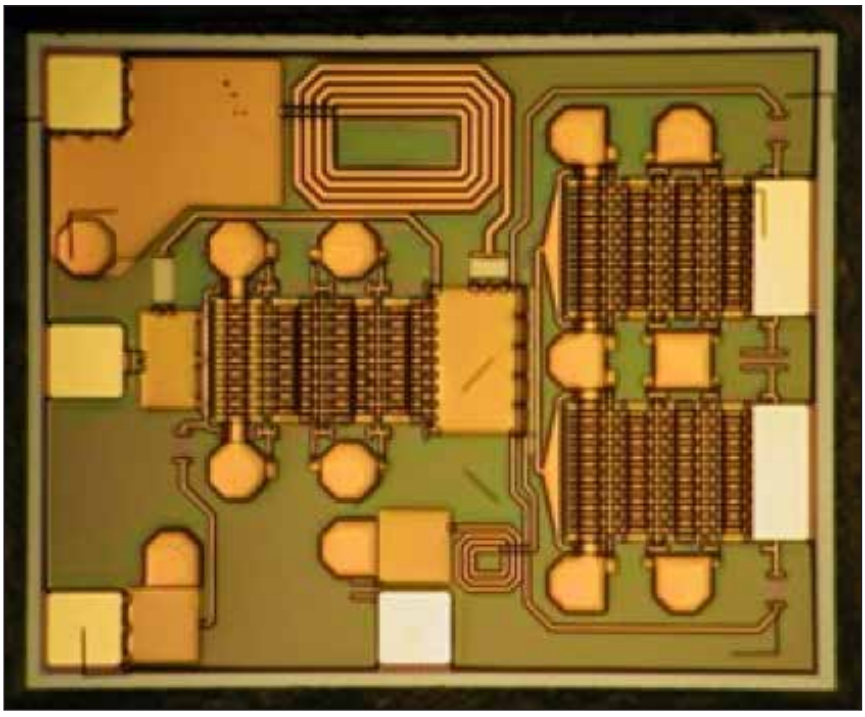

MMIC Amps, and More

AMCOM has all the expertise, manpower, space, and equipment for manufacturing state-of-the-art products. Some of our capabilities are: active device design, MMIC design, and power amplifier module design. In addition, we are experts in device/MMIC packaging, module assembly and RF/DC testing. For active devices, we either procure parts such as silicon LDMOS, or GaN HEMT, or we use a semiconductor foundry to fabricate our own proprietary device/MMIC.

One of AMCOM's specialties is custom designing MMICs and modules for our customers' specific needs. The custom products include all front-end components such as low-noise amplifiers, power amplifiers, switches, attenuators, phase shifters, and up/down converters. We make every effort to meet our customers' performance requirements including size and weight.

The company has earned a reputation as a leading edge microwave design organization that includes power FETs, MMIC power amplifiers, as well as high-power amplifier modules with RF and DC connectors that are ready to be used in microwave systems. One of our specialty products is high-power, broadband, high-efficiency power amplifiers.

AMCOM Communications
IMS Booth # 2317

Power Sensors Include Triggering

LadyBug's LB5900 and LB480A Series USB RF Power Sensors include internal and external triggering at no upcharge. Users can trigger time-gated measurements, trigger the beginning of an average power measurement or other uses. Internal level and polarity can be set to suit the particular application. The sensors also feature trigger output allowing the trigger signal to be passed to other instruments.

The multiple path sensors feature excellent dynamic range and frequency coverage. Optional features include connector types, unattended operation (Option UOP), direct connectivity through I2C or SPI and security options (Option MIL) and more.

We manufacture a broad line of high quality first tier NIST traceable USB power sensors. Our sensors are compatible with Windows XP, Win 7, Win 8; in 32 and 64 bit systems. We offer LINUX compatible sensors along with the only SPI & I2C sensor available. With our patented NoZero NoCal feature, it is not necessary to zero or calibrate before making measurements, even for low level measurements requiring high accuracy. Simply connect and measure.

The Sensors are housed in a robust metal enclosure for durability and offer a variety of connectors including N, SMA, 3.5mm and 2.92mm. We include limit free, flexible applications for use with our products at no additional cost. We cover the RF and microwave market with three sensor types.

-Our True RMS sensors make highly accurate measurements on signals with any modulation format or bandwidth.

-We offer pulse sensors that will provide statistical pulse information such as peak and pulse power, duty cycle and crest factor on pulse modulated signals as well as average CW power.

-Our Pulse Profiling sensors provide time domain trace visibility of modulation information in addition to the measurements made by our pulse sensors.

LadyBug Technologies
IMS Booth # 921

Bandpass Filters

Models SWF-65302350-15-B1, SWF-61302350-15-B1, SWF-63302350-15-B1 and SWF-58302350-15-B1 are V band, waveguide bandpass filters designed for WiGig applications. SWF-65302350-15-B1 is used to pass the frequency range of 63.8 to 65.8 GHz, while rejecting the frequencies ranging from 54.8 to 58.8 GHz and 70.8 to 74.8 GHz. SWF-61302350-15-B1 is used to pass 59.48 to 61.48 GHz, while rejecting 50.48 to 54.48 GHz and 66.48 to 69.48 GHz. SWF-63302350-15-B1 is used to pass 61.64 to 63.64 GHz, while rejecting 52.64 to 56.64 GHz and 67.64 to 71.64 GHz. SWF-58302350-15-B1 is used to pass 57.32 to 59.32 GHz, while rejecting 48.32 to 52.32 GHz and 64.32 to 68.32 GHz.

SAGE Millimeter
IMS Booth # 302

Signal Generator

The DS Instruments SG6000LQ compact Microwave Signal Generator enables users to generate a high quality RF signal easily and at low cost. The output covers 25 to 6000 MHz AND 12000 – 22000 MHz from the high-power internal Quadrupler covering the entire KU band and higher. The produced wave is fully synthesized using modern fractional N synthesis. The step size of the non-X4 RF output varies from a maximum of ~3 KHz to less than 40 Hz, depending on band of operation. The synthesized source can accept an external 10 MHz reference OR it can use its own internal 10 MHz. Output power is typically above 6 dBm and can be turned ON/OFF via USB COM commands. The crisp OLED display provides useful feedback for the user, and front control buttons provide a quick alternative to USB control. Like most of our products, the SG6000LQ easily fits in the palm of your hand, making it a truly portable and bench-space-saving device.

DS Instruments
dsinstruments.com

Fully customizable solutions for your **high-end audio** and **video applications.**

Insulated Wire provides maximum conductivity for high-frequency audio and data signal transmissions by using the highest purity precision-drawn conductors and the smoothest surface finishes, . Our proprietary lamination process for PTFE dielectric enables us to modify cable performance by using materials with various dielectric constants.

Inhouse cable design and manufacture provides:

- Industry leading **tolerance control** for all critical dimensions
- **Customizable** velocity of propagation, impedance & line size
- **Low Noise solutions** including multiple shielding layers (Foil, Helical, and Braided), and tape layers (PTFE coated Fiberglass, Kapton, and carbon filled PTFE)
- **Ruggedized designs** using our helical wire serving providing in excess of 150lbs/linear inch of crush resistance
- **Range of outer jacket materials** to provide flexibility, flame retardance, broad temperature range, resilience to aging, low smoke/zero halogen.

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At IW, we're flexible!

Digital Multimeter

> "For high-throughput applications, the isolated digitizer mode can acquire DC-coupled waveforms in all voltage and current ranges"

NI announced the NI PXIe-4081 7½-digit high-performance DMM and 1.8 MS/s isolated digitizer. The NI PXIe-4081 is the first PXI Express DMM available. It offers engineers the flexibility, resolution and isolation needed to tackle challenging applications that require smarter test systems in industries ranging from consumer electronics to aerospace and defense.

The NI PXIe-4081 is the industry's most accurate 7½-digit DMM, with an industry-leading 15 ppm accuracy for DC voltage measurements up to two years after calibration. It is capable of voltage measurements from nanovolts to one kilovolt and resistance measurements from microohms to gigaohms. A solid-state current shunt configuration offers eight DC current ranges from 1 µA to 3 A and six AC rms current ranges from 100 µA to 3 A. The DMM occupies a single 3U PXI slot and provides excellent channel density for high-channel-count systems, delivering 17 DMM channels in a single PXI chassis occupying 4U of rack space. For high-throughput applications, the isolated digitizer mode can acquire DC-coupled waveforms in all voltage and current ranges with a 1.8 MS/s maximum sample rate. By changing the digitizer sampling rate, engineers can vary the resolution of the digitizer from 10 to 23 bits for the perfect combination of speed and accuracy.

National Instruments
IMS Booth # 1529

Resistive Components

State of the Art, Inc. (SOTA) manufactures high reliability thick and thin film resistive components for the surface mount and hybrid electronic industries. Quality, reliability, and innovative design have been the guiding principles of SOTA's passive components for over a quarter of a century. As a result, we offer the industry's broadest range of high quality thin and thick film chip resistors, surface mount networks, and custom circuits. We exceed the highest standards of quality for all of our products. All of our products are manufactured in our modern facility located in central Pennsylvania.

State of the Art, Inc. is:

- the leading supplier of thick and thin film resistive components to the Biomedical, Communications, Aerospace, and Defense industries.
- the industry leader in providing customers with quality, reliability, value, prompt and courteous customer service, and the most advanced technology available.
- dedicated to achieving and maintaining an unsurpassed level of excellence in all aspects of our operations.
- committed to the ethical behavior and the fair treatment of our customers, suppliers, community, and fellow employees.
- the standard by which all other component suppliers will be judged.

State of the Art
IMS Booth # 1411

Product Focus: IMS Show

Amplifier

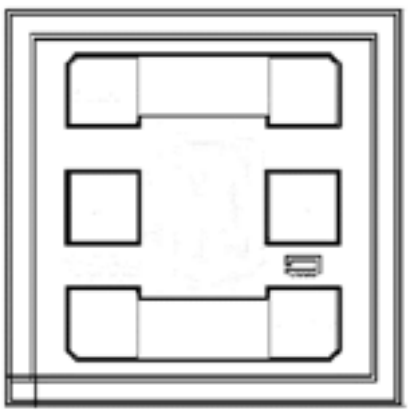
MNA-2A+ is a wideband PHEMT based MMIC amplifier with high active directivity. MNA integrates the en¬tire matching network and majority of the bias circuit inside the package, reducing the need for complicated external circuits. This approach makes it extremely straightforward to use. This design op¬erates on a single 2.8 to 5V supply, is well matched for 50Ω and comes in a tiny, low profile 3x3mm 8-lead MCLP package accommodating dense circuit board layouts.

Mini-Circuits
IMS Booth # 2029

Coupler

Model ZHDC-10-63-NS+ is a 50Ω, 10 dB Coupling, 50 to 6000 MHz Directional Coupler. Features: wideband, 50 to 6000 MHz; high directivity, 33 dB typ.; flat coupling, ±0.3 dB typ.; good VSWR, 1.20:1 typ. Applications: defense; test and measurement.

Mini-Circuits
IMS Booth # 2029



E-PHEMT Die

SAV-541-D+ is an ultra-low noise, high IP3 transistor die, manufactured using E-PHEMT* technology enabling it to work with a single positive supply voltage. It has outstanding Noise Figure, particularly below 2.5 GHz, and when combining this noise figure with high IP3 performance in a single device it makes it an ideal amplifier for demanding base station applications.

Mini-Circuits
IMS Booth # 2029

Bandpass Filter

ZVBP-11G3+ is a 50W cavity filter for X band. Frequency band of this filter is used in satellite and radar applica¬tions.

Mini-Circuits
IMS Booth # 2029

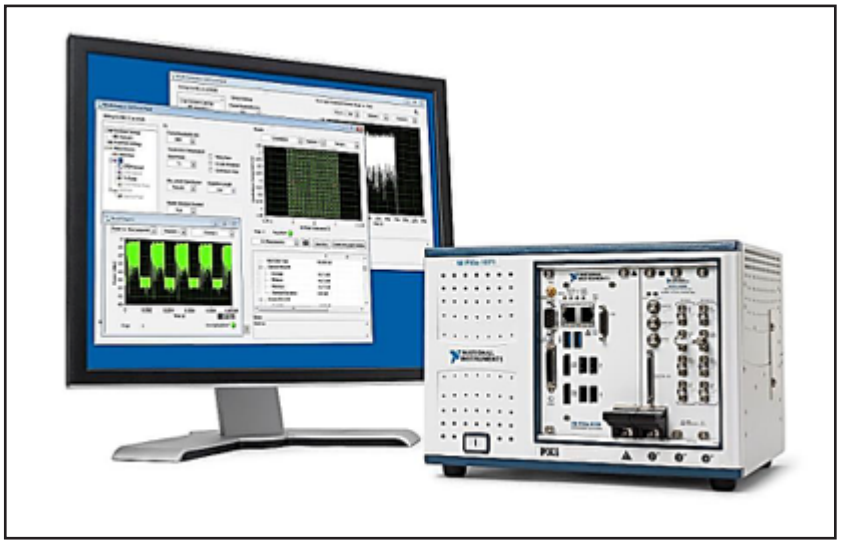
Product Showcase

Product Focus: IMS Show

SSPA Module

Exodus Advanced Communications announced the release of AMP3085, a new 8-12GHz, 100W Min/120W Typical GAN Module. Features instantaneous bandwidth from 8000-12000MHz with 100W Minimum Saturated CW Power, 4.0dB Peak to Peak flatness and 22A max consumption. Suitable for any application requiring high power and wide band coverage such as TWTA Replacement, EW, and EMI/RFI Susceptibility Testing.

Exodus Advanced Communications
IMS Booth # 2417



Measurement Suite

At IMS, NI will be featuring the industry's first measurement solution for 802.11ax or High-Efficiency Wi-Fi (HEW) devices. The new 802.11ax measurement suite supports narrower subcarrier spacing, 1024-QAM, and Orthogonal Frequency Division Multiple Access (OFDMA). The system is based on NI's PXI RF Vector Signal Transceiver (VST), which offers 200 MHz of bandwidth at frequencies of up to 6 GHz and the software is based on the latest draft of the 802.11ax specification revision.

National Instruments
IMS Booth # 1529

Attenuators, Couplers, and More

Since 1961, MECA Electronics Inc. has designed and manufactured an extensive line of RF/Microwave components with industry leading performance including Fixed Attenuators, Directional Couplers, Hybrid Couplers, Isolators/Circulators, Power Divider/Combiners, RF Loads, DC Blocks, Bias Tees and Adapters & Cables. MECA serves all areas of the RF and Microwave industries including world class network providers and supporting supply chain infrastructure, and has long been the "backbone" of high performance wired and air-interfaced networks such as in-building applications, satellite communications, radar, radio communications, telemetry applications, mobile radio, aviation & air traffic communications.

MECA Electronics
IMS Booth # 818

RF Power Transistors

Wolfspeed, A Cree Company, announced that its GaN-on-SiC RF power transistors have completed testing to demonstrate compliance with NASA reliability standards for satellite and space systems. Wolfspeed's proven GaN-on-SiC fabrication processes have demonstrated industry-leading reliability and performance, delivering more than 100 billion total hours of field operation with a best-in-class FIT rate of less than-5-per billion device hours for discrete GaN RF transistors and multi-stage GaN MMICs.

Wolfspeed partnered with KCB Solutions, a recognized leader in RF and microwave components to conduct a comprehensive testing program to demonstrate that Wolfspeed's GaN-on-SiC devices meet NASA EEE-INST-002 Level 1 reliability and performance standards, derived from the MIL-STD requirements for Class S and Class K qualifications.

"This successful testing demonstrates that Wolfspeed's GaN foundry process is capable of producing devices that meet these demanding reliability standards. Our customers now have the ability to specify our GaN RF devices in the most critical aerospace, military, and satellite electronics systems," said Jim Milligan, RF and microwave director, Wolfspeed. "Our proven GaN-on-SiC technology enables design engineers to make smaller, lighter, more efficient, and more reliable solid-state power amplifiers than are possible with conventional traveling wave tube (TWT) amplifiers or those designed with gallium arsenide (GaAs) devices. Now, aerospace designers can achieve higher performance radar and communications systems with a significantly lighter payload and longer operating life."

"As an AS9100-certified facility with an extensive history of supplying Class S and Class K devices for aerospace and satellite electronic systems, KCB Solutions implemented a comprehensive testing program in conjunction with Wolfspeed to ensure that their GaN process was capable of producing devices that meet these demanding NASA standards," said Ralph Nilsson, president, KCB Solutions. "This testing regime was derived from the established MIL-STD qualification requirements of Class S and Class K, and included evaluation for ESD, intrinsic reliability, SEM analysis, and radiation hardness."

Wolfspeed
IMS Booth # 1621

> Performance

> Power Density

Size <

Energy Costs <

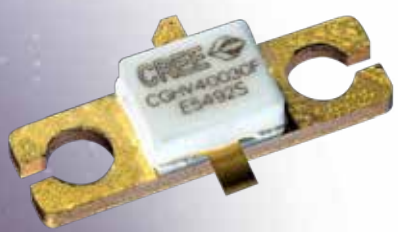
TEST THE WORLD'S HIGHEST-PERFORMING 50V WIDE BANDGAP TRANSISTOR, FREE.

Wolfspeed, a Cree company, is the leader in GaN-on-SiC wide bandgap devices for RF. Our transistors have passed 67 billion hours of end-user usage worldwide.

Put this reliability to work for you, for free. Submit your inquiry at http://go.wolfspeed.com/IMS2016HFE to receive a sample Wolfspeed 50V transistor. Models are available in two platforms, ADS and MWO. Build your next project with the most reliable and efficient high-performance RF device available.

See us at IMS. Booth #1621.

WOLFSPEED.



Wolfspeed™

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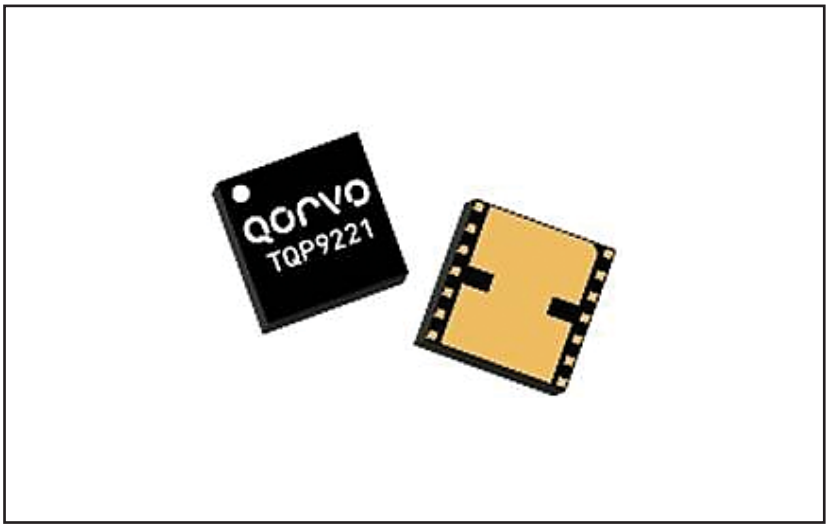

Amp

RFMW announced design and sales support for the Qorvo TQP9221, a 2.01 to 2.17GHz linear amplifier for use in enterprise femtocells, CPE and distributed antenna systems. The TQP9221 offers over 30dB of gain and is internally matched for design ease while drawing 225mA from a 4.5V supply.

RFMW services customers with products from specialized RF&MW component manufacturers who have a need to utilize a technical sales and marketing approach combined with premier customer service in the form of a time and place utility. The Company focuses its sales and marketing resources solely on applications and markets of customers who design and manufacture with RF&MW components in their end product.

RFMW
IMS Booth # 649

Epoxy

Developed for high tech bonding and sealing applications, Master Bond Supreme 11HTLP is a two part epoxy that is often selected for the aerospace, electronics and specialty OEM industries. It combines user friendly processing with a high physical strength profile.

It is formulated to have impressive toughness, which imparts high bond strength of over 3,200 psi and 20 pli, respectively in the shear and peel mode. This compound bonds well to a wide variety of substrates, including metals, glass, ceramics, composites, rubbers and plastics. Its toughness also allows it to withstand aggressive thermal cycling as well as impact and shock. Serviceable over the wide temperature range of -100°F to +400°F is outstanding.

Master Bond
masterbond.com

Microwave Components, Test Equipment

KRYTAR, founded by Thomas J. Russell in 1975, is a privately owned California corporation specializing in the manufacture of ultra broadband microwave components and test equipment for both commercial and military applications. The KRYTAR product line includes directional couplers, directional detectors, 3 dB hybrids, MLDD power dividers/combiners, detectors, terminations, coaxial adapters and a power meter. Our products cover the DC to 67.0 GHz frequency range.

The broadband design expertise at KRYTAR has created unique new designs, several of which are patented. KRYTAR has applied these designs to consistently introduce technologically advanced products with superior electrical performance and ruggedness.

Our modern facility houses a completely equipped machine shop, including CNC lathes and mills. The corporation also possesses all the electronic test equipment necessary for testing its products from DC to 67 GHz.

Included in the test equipment is a Hewlett Packard 8510B Automatic Network Analyzer with 8515A (45 MHz – 26.5 GHz) and 8517A (45 MHz – 50.0 GHz) S-Parameter Test Sets and Agilent Technologies E8361A PNA Series Network Analyzer (10 MHz – 67 GHz).

The KRYTAR Quality Assurance Program is in accordance with MIL-I-45208 including a calibration system per MIL-STD-45662.

KRYTAR
IMS Booth # 1426

RF Coax Cables and Connectors

MegaPhase designs, manufactures and markets high performance RF coaxial cables and connectors to OEMs building advanced microwave and optical electronic systems, such as test instrumentation, defense electronics, homeland defense, satellites, broadband data and communications systems. MegaPhase's core product is its industry-leading GrooveTube® technology, a unique cable design used in high reliability applications including test & measurement systems. MegaPhase has over 500 active customers in 30 countries, including the biggest names in electronic technology, as well as the US Government and its allies.

> "MegaPhase has over 500 active customers in 30 countries, including the biggest names in electronic technology"

Core Technology, Products & Applications

Test & Measurement Cables and Test Adapters: MegaPhase GrooveTube® technology provides a clear differentiation from other cable technologies, and represents the first breakthrough cable technology in over 20 years. The products provide customers with a competitive edge over ordinary cable designs by addressing three important criteria for testing electronic components and systems: phase stability, insertion loss stability and repeatable measurements for the cable's useful life. This enables MegaPhase customers to calibrate most test sets with rate of recurrence far less than competitive products, and therefore achieve the "lowest cost per measurement"™ and more reliable test results.

Interconnect Cables & Connectors - Low Loss, Low VSWR for Integrated Systems: MegaPhase also manufactures high performance coaxial cables using GrooveTube®technology for high power and phase-defined systems, including electronic warfare, telecommunications equipment and many other RF platforms on the ground, sea, air and space.

MegaPhase is headquartered in Stroudsburg, Monroe County, Pennsylvania, USA, where all aspects of design and manufacturing take place. The 20,000 square foot facility features: RF Testing on 100% of all shipped products using a state-of-the-art RF test lab including 5 microwave vector network analyzers ranging in capability from 10 MHz through 110 GHz. Semi-rigid cables are bent to the highest level of precision with a custom-designed, programmable CNC cable bending machine.

MegaPhase
IMS Booth # 2113

MegaPhase®

We're Anything But Passive When It Comes To RF Components.

Passive RF components – such as couplers, hybrids, dividers, and combiners – may not be the first thing you think about when putting together an electronic system; but they're the first and last things we think about every day.

We're always actively working on new ways to make RF components better, stronger, more durable, and more versatile. That's saying a lot, because our RF components are already the best in the industry.

Plus, nobody beats our response time. MegaPhase can even customize to your needs with lightning speed. And no RF component provider offers a better value. So don't be passive. Give us a call or visit our website.

With the right connections, anything is possible.

Come see us at IMS – San Francisco, CA, May 24-26, 2016, Booth 2113

MegaPhase®

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Product Focus: IMS Show

Connectors

SGMC Microwave's 7mm series are precision grade connectors designed for use with microwave applications requiring excellent performance up to 18 GHz. SGMC offers an extensive line of 7mm precision adapters, receptacles, and cable connectors for various semi-rigid and flexible coaxial cables. Special designs are also available upon request.

- Frequency Range: DC to 18 GHz
- Mates with Precision 7mm Connectors (Sexless/Genderless)
- Robust Coupling Mechanism
- Low VSWR and insertion loss

SGMC Microwave
IMS Booth # 2330

Hybrid Coupler

VidaRF offers a new high performance hybrid coupler Model: VHC-20180A operating frequency 2-18GHz. Type VSWR 1.20:1, Insertion Loss 0.9dB and Isolation 20dB min. Power handling Average ≤30Watt ; Peak ≤1KW with SMA connectors, operating temp -55 to 85 C. If required we could seal and paint to meet IP65 standards.

VidaRF
vidarf.com

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Synthesizers, Upconverters, and More

SignalCore, Inc. is a privately held company based in Austin, Texas. SignalCore designs and manufactures radio frequency (RF) and microwave instrumentation-grade subsystems. We serve customers worldwide in research and development laboratories, universities, and both the private and public sector industries of telecommunications, broadcasting, aerospace, defense and electronics manufacturing.

Our Mission

To provide our customers with high-performance, flexible, small form factor, and cost effective sub-systems, enabling their integration into high-end RF and microwave solutions.

SignalCore's SC5510A and SC5511A are high performance VCO-based synthesized signal sources with output frequencies ranging from 100 MHz to 20 GHz. Available in PXI Express, USB, SPI, and RS-232, these modules perform like big-box instruments at a fraction of the size and cost.

SignalCore
IMS Booth # 412

Cable Assemblies, Connectors, and More

> "SV offers a variety of millimeter wave (mmWave) coaxial cable assemblies and connectors for 5G mobile communication development and production."

SV Microwave is a world leader in the RF/Microwave industry with over 50 years of proven performance. We design and manufacture RF/Microwave coaxial connectors, cable assemblies and passive components designed for military, satellite, aerospace, commercial and telecommunications applications.

Our product lines include commercial-off-the-shelf (COTS) items and made-to-order custom, one-of-a-kind and hard-to-find products. When it comes to the design and manufacture of custom products, SV Microwave has set the standard in RF and microwave connectors, components and cable assemblies. SV Microwave is committed to helping customers meet their RF/Microwave performance goals with our highly talented engineering staff and extremely responsive sales team.

SV Microwave was acquired by Amphenol Corporation in May 2005. Amphenol Corp. is the world's second largest connector company, producing electronic and fiber optic connectors, cable, and interconnect systems for applications converging technologies of voice, video and data communications, industrial/automotive and military/aerospace.

SV offers a variety of millimeter wave (mmWave) coaxial cable assemblies and connectors for 5G mobile communication development and production. Our high frequency (26 GHz and beyond) push-on and threaded RF connectors offer industry leading signal fidelity in the 5G frequency spectrum and unique packaging designs for high density requirements including in house tape and reel. Let SV Microwave be your partner in 5G product development enabling the Internet of Things (IoT) revolution.

SV Microwave's PCB connector designs are ideal for high density applications, while allowing for axial and radial misalignment to compensate for tolerance stack up.

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SV Microwave
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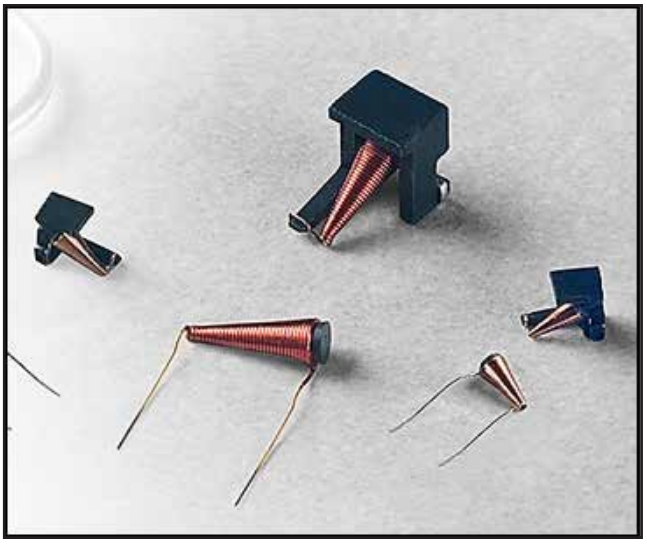
Product Highlights: IMS Show

VNA

The top-of-the-line C1220 analyzer boasts a frequency range of 100 kHz – 20 GHz, offers a typical dynamic range of 145 dB, and is designed for operation with any Windows PC or laptop. It efficiently handles advanced test applications, providing an unmatched price-performance combination for S-parameter measurement for this frequency range.

To achieve this high performance at an affordable cost, the design and production of Cobalt VNAs incorporates several innovative new proprietary manufacturing and test approaches. This technology allowed for new test grade coaxial connectors technology for internal interconnect and tighter tolerances that contribute to Cobalt's exceptional metrological accuracy. Advanced electromagnetic modeling optimizes the 20 GHz Cobalt's ultra-wideband directional coupler design, and new production methods for precision airstrip lines give the directional couplers extraordinary stability, both over temperature and very long time intervals.

Copper Mountain Technologies
IMS Booth # 423



Inductors

Gowanda's flying lead and SMT broadband inductors offer predictable frequency response and repeatable performance from 40 MHz to 40 GHz and higher. These conical inductors were specifically designed for high frequency applications where ultra-low insertion loss is a design requirement. The unique construction and proprietary design utilized in these broadband inductors helps to limit the effects caused by stray capacitance. Gowanda maintains a leadership role in custom build-to-print conical solutions to address specific customer requirements that cannot be met by off-the-shelf products.

Gowanda Electronics
IMS Booth # 2116

Corporate Focus: IMS Show

Ducommun

Founded in 1849, Ducommun is the oldest company in California. Evolving from a hardware supply store opened by Charles Ducommun in Los Angeles during the California Gold Rush, the company assisted in the birth of the aerospace industry in Southern California by providing aircraft aluminum to early aerospace pioneers like Lindbergh, Douglas and Lockheed.

Today, Ducommun is a global provider of innovative manufacturing solutions for customers in the aerospace, defense and industrial markets. We specialize in two core areas – Electronic Systems and Structural Systems – to produce complex products and components for commercial aircraft platforms, mission-critical military and space programs, and sophisticated industrial applications.

> "Ducommun is a global provider of innovative manufacturing solutions for customers in the aerospace, defense and industrial markets."

Our company is organized to leverage our full spectrum of capabilities through common, company-wide processes and value-added services like new product introduction, supply chain strategies, and program management that create value for the customer and to facilitate ease of doing business.

Electronic Solutions – Full-service manufacturing services for high mix, low volume production of complex electronics used in high cost of failure applications. Key competencies include high-reliability interconnect systems, printed circuit board assemblies, and integrated electronic, electromechanical and mechanical assemblies and systems.

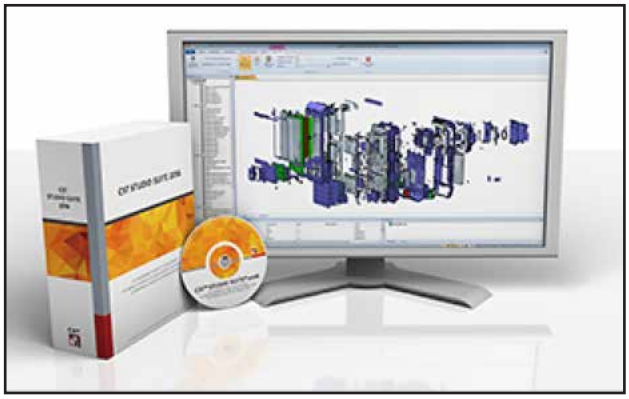
Structural Solutions – Large, complex contoured structural components and assemblies for aerospace and other applications. Our integrated processes include stretch-forming, thermal-forming, chemical milling, precision fabrication, machining, finishing processes, and integration of components into subassemblies.

The Ducommun Way

Ducommun is guided on its journey to growth by the Ducommun Way, our internal operating methodology for executing successfully, solving problems effectively and finding better ways of serving our customers through a combined focus on operational excellence, organizational development and profitable growth. The Ducommun Way is defining our path for providing the innovative solutions and services our customers require while finding new and untapped ways of growing.

Ducommun
IMS Booth # 1417

Product Focus: IMS Show



Simulation Software

CST develops and markets high performance software for the simulation of electromagnetic fields in all frequency bands.

Its success is based on the implementation of leading edge technology in a user-friendly interface.

CST's customers are market leaders in industries as diverse as Telecommunications, Defense, Automotive, Electronics, and Medical Equipment. Today CST employs 280 sales, development, and support personnel, and enjoys a leading position in the high frequency 3D EM simulation market.

CST offers a wide range of EM simulation software to address design challenges across the electromagnetic spectrum, from static and low frequency to microwave and RF, for a range of applications, including EDA & electronics, EMC & EMI and charged particle dynamics.

The centerpiece of CST's product range is CST STUDIO SUITE®. This comprises CST's complete set of 3D electromagnetic simulation tools, along with a number of related products dedicated to more specific design areas such as cable harnesses, PCBs and EM/circuit co-simulation.

As well as simulation tools, CST also offers CST BOARDCHECK™, a PCB rule-checking program that reads popular board files and examines them against signal integrity (SI) and electromagnetic compatibility (EMC) design rules, and Antenna Magus®, which significantly simplifies the antenna design process by enabling access to a large database of parameterized antennas that can be exported to CST MICROWAVE STUDIO®

CST
IMS Booth # 739

Corporate Focus

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Amphenol SV MICROWAVE

Connectors, Components & Adapters

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- Frequency Range: DC - 50 GHz
- Interfaces: IAW M39012
- Meet Requirement of M39012
- Environmental Standards per MIL-STD-202

Resistive Components

- Attenuators / Terminations
- SMA, TNC, Type N, 2.92mm, 2.4mm
- Nominal Impedence: 50 ohms
- Frequency Range: DC - 50 GHz
- Interfaces: IAW M39012
- Meet Requirement of M3933 / M39030
- Environmental Standards per MIL-STD-202

Adapters

- SMA, TNC, Type N, 2.92mm, 2.4mm, ZMA, BNC
- Nominal Impedence: 50 ohms
- Frequency Range: DC - 50 GHz
- Interfaces: IAW M39012
- Meet Requirement of M55339
- Environmental Standards per MIL-STD-202

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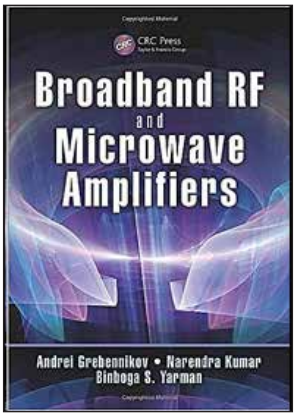
Book Reviews

Broadband RF and Microwave Amplifiers

Andrei Grebennikov, Narendra Kumar, Binboga S. Yarman

CRC Press 2016 ISBN 13: 978-1-4665-5738-3 Hardback



This 743 page book at first appears almost overwhelming. One may ask how so many pages can be dedicated to this one subject? Upon closer examination of the chapters, page by page, the reader realizes that this is a very comprehensive, up-to-date, treatment of amplifier theory and design, sprinkled with many practical examples.

The book starts with basic two-port networks and then builds on foundational knowledge, such as impedance matching, to describe and develop almost all the latest broadband amplifier techniques and technology. Standard and novel design techniques are well depicted. Of particular note is the comprehensive coverage of Doherty amplifiers in Chapter 7. About 25 years ago I experienced some scoffing at this subject matter by folks that thought this was very old technology from the 1930s that was forever relegated to the trash bin of vacuum tube memories. Well, now we find this Doherty technique in widespread solid-state application for cellular base stations. Another interesting chapter deals with the subject of low-noise broadband amplifiers which for some presents a quandary.

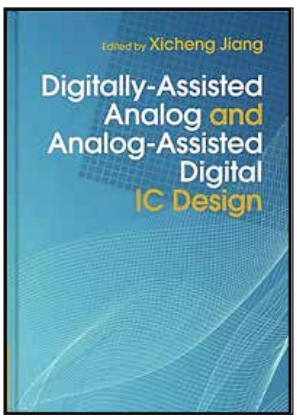
For those familiar with MATLAB®, there are significant examples of programming using real frequency techniques. Many recent innovations and inspiring techniques are described. It is a good advanced textbook and guide for the practicing amplifier designer. Systems architects could also well benefit from much of the general knowledge to be gleaned from this publication.

—Tom Perkins
Sr. Technical Editor

Digitally-Assisted Analog and Analog-Assisted Digital IC Design

Edited by Xicheng Jiang

© Cambridge University Press 2015 ISBN 978-1-107-09610-3 Hardback



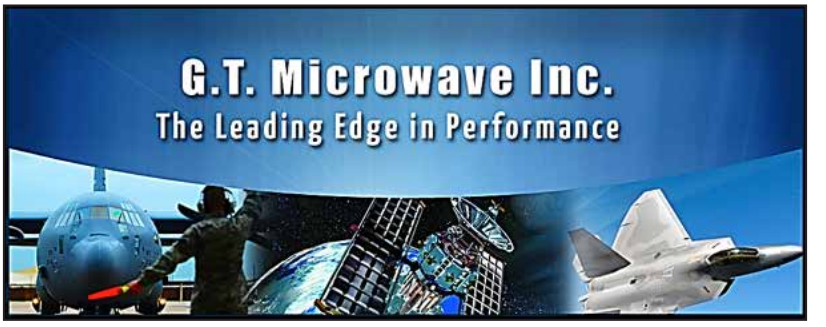
My first impression of this text was frankly: why am I looking at this? It's a strange title, and I don't really know much about the subject matter. Well, it pays to not capitulate too quickly. The early chapters speak considerably about FinFETs and a number of terms foreign to my general knowledge which admittedly is based on "ancient, traditional" RF and microwave technology.

The first chapters deal with practical innovations for improved speed, density, power conservation and cost reduction. Suddenly about half way through the book a chapter (6) appears called CMOS self-healing techniques for calibration and optimization of mm-wave transceivers. This was unexpected. We are now reading about CMOS-based Gb/s communications systems operating beyond 50 GHz as fully integrated transceivers. The methods used for robust self-healing blocks and direct-digital-frequency synthesis peaked my interest, and maybe you will respond in kind.

Like Chapter 6, Chapter 8, titled Digitally-assisted RF design techniques is of particular interest to the RF engineer. Digitally assisted correction strategies are discussed and a number of other new techniques used to deal with parameters such as noise are presented. Looks like scaled CMOS process technology has an interesting future that may go well beyond early expectations. If you carry this book around or have it on your shelf you may be a geek – a good geek. This suddenly becomes: maybe I need to know more about this stuff! It may foretell the future. Dr. Jiang is a Distinguished Engineer and Director of Electrical Design Engineering at Broadcom Corporation.

—Tom Perkins
Sr. Technical Editor

Attenuators, Modulators, Phase Shifters, and More



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The Quality Management System is regularly reviewed by senior management for adequacy, and for its ability to meet established goals. Specifically:

- Increased customer satisfaction through on-time delivery of defect-free products.
- Development of a reliable supplier base, capable of on-time, defect-free product and service delivery to the company.
- Increased employee proficiency and job satisfaction through awareness, training, and development programs.
- Maximization of company profits through elimination of quality problems and related costs.
- Consistent and ongoing regulatory compliance.
- Continuous improvement with regards to the above-stated goals.

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Precision Adapters

Southwest Microwave, Inc., a leading global supplier of high performance interconnect solutions, earlier this year added several new high-performance products to its line of precision adapters.

Additions include high-frequency within-series adapters for Southwest Microwave's 110 GHz 1.0 mm (W) connectors and 67 GHz 0.9 mm SuperMini ultra-miniature threaded coupling coaxial assemblies. Several between-series adapters have also been introduced for interface between 2.92 mm (K) and 1.85 mm (V) connectors, and between 0.9 mm SuperMini and 1.0 mm connectors.

Southwest Microwave offers a full range of commercially-priced within-series and between-series adapters with near-metrology grade performance. Produced and tested to the same criteria as adapters for calibration kits, they provide a cost-effective solution for applications that do not specify phase matching, where previously only expensive metrology-grade adapters were used.

Designed to successfully and economically address critical production and test requirements, these adapters are ideal for use as connector savers without compromising measurement accuracy, and are approved for demanding environments such as Space or other Hi-Rel applications.

"Like all of Southwest Microwave's precision adapters, these offerings are designed based on transmission line principles, which enables us to deliver the superior interconnect performance that the RF and digital design communities have come to expect from our technologies," explained Holger Stuehrmann, Southwest Microwave's Director of Sales.

"Expanding our adapters array to include broader interface options and to address higher frequencies means we can now satisfy an even wider scope of critical production and test applications at competitive prices," he added.

Southwest Microwave
IMS Booth # 2239

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IEEE MTT-S

Guest Editorial

WIM: Diversity Gone Global

Sherry Hess, VP of Marketing
AWR Goup, NI

Nearly a year ago now, the WIE (Women in Engineering) Leadership Conference was held in Silicon Valley. I have commented previously about Intel CEO Brian Krzanich's keynote and reference to its "Diversity Challenge." Little does Brian know, but his talk has had far-reaching effects within our own IMS MTT-S WIM organization. It has inspired me to take the essence of this challenge—that diversity brings different viewpoints, skills, and knowledge to the table, improving the workforce and driving better business—and use it to spearhead similar talks.

First up was IMS2015 and our WIM-sponsored panel titled, "Diversity in Microwaves: Let's Talk About the Demographics." Moderated by Dr. Kate Remley, National Institute of Standards and Technology (NIST) Metrology for Wireless Systems Project, it included participants representing our global community with the intent to share and discuss issues that women and other minorities face in their career paths around the world. This full-afternoon session spotlighted a diverse group of exceptional women and their involvement and contribution to our microwave engineering society.

COMCAS

Next stop on this world tour was COMCAS 2015 in Tel Aviv, Israel. Here I met Professor Orit Hazaan of the Department of Education in Science and Technology at Technion - Israel Institute of Technology. Prof. Hazann was the featured speaker in our WIM-sponsored session, "Diversity in High-Tech – What's Working and Why?"

In her speech, Prof. Hazaan asserted that it is in the interest of the high-tech world, rather than in the interest of any specific underrepresented group in the community, to enhance diversity in general, and gender diversity in particular. She illustrated how the creation of a culture that enhances diversity benefits the entire STEM community. The follow-on discussion, which included prominent women from Israel, the U.K. and the U.S., addressed the benefits a diverse organization offers, as well as where we are in achieving a diverse work culture in North America and Europe.

APMC

Thereafter was APMC in China in early December, where I met Professor "Cherry" Wenquan Che of the Nanjing University of Science and Technology, who led a panel discussion, "The Current Status of Women in Microwave Engineering in Universities of China." This discussion looked at diversity in engineering throughout the world and especially in China, and focused on diversity in Chinese universities. Online surveys were shared that show the outlook for engineering careers in China is bright. Some key observations were that female professors and students are becoming a more important part of the workforce, males and females have different advantages and teamwork and cooperation are the best way to achieve the highest productivity, and for women who desire to achieve balance between career development and family, more understanding and support are expected from family, colleagues, society, and government policy making.

> "teamwork and cooperation are the best way to achieve the highest productivity"

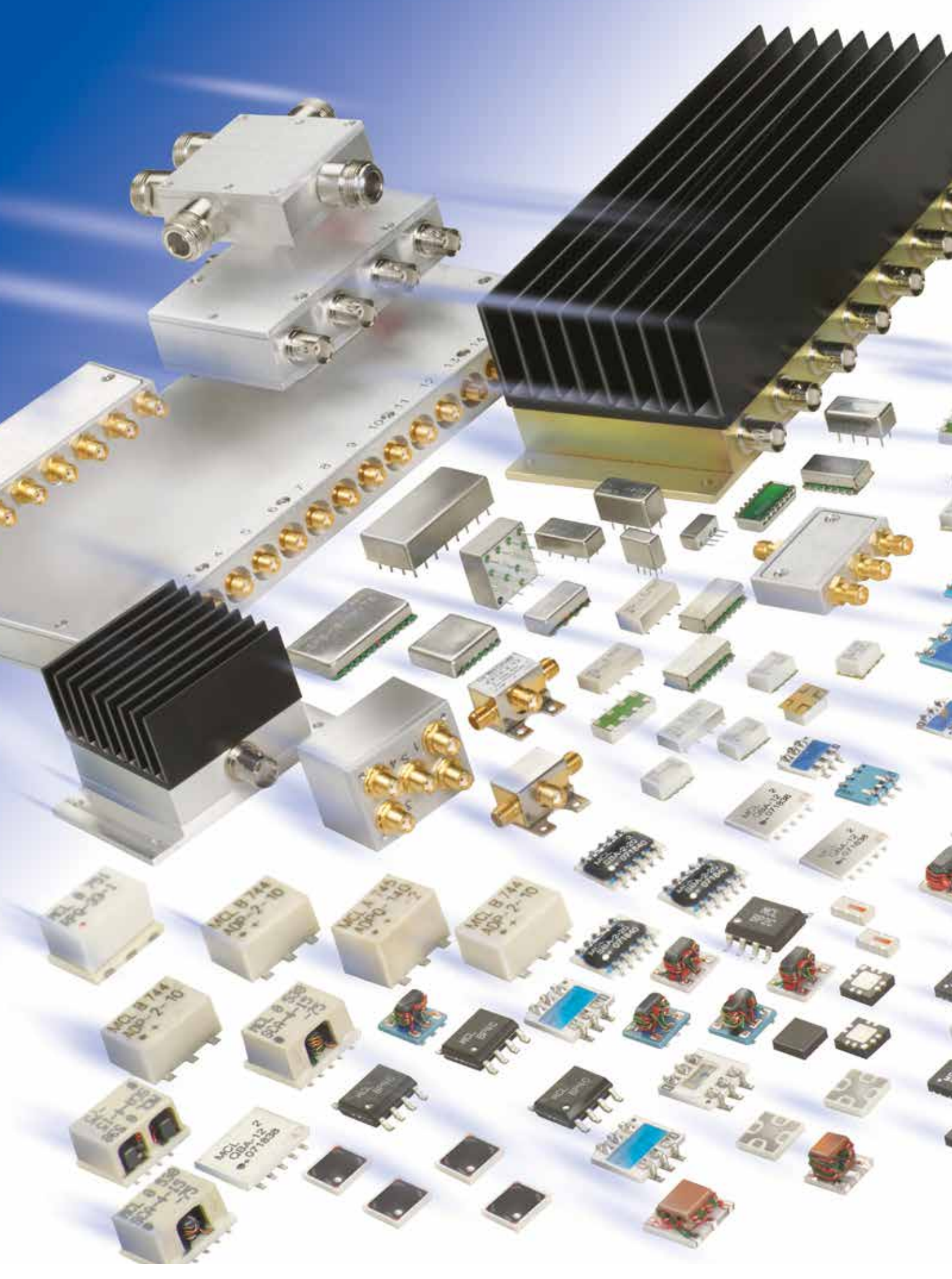
IMS 2016

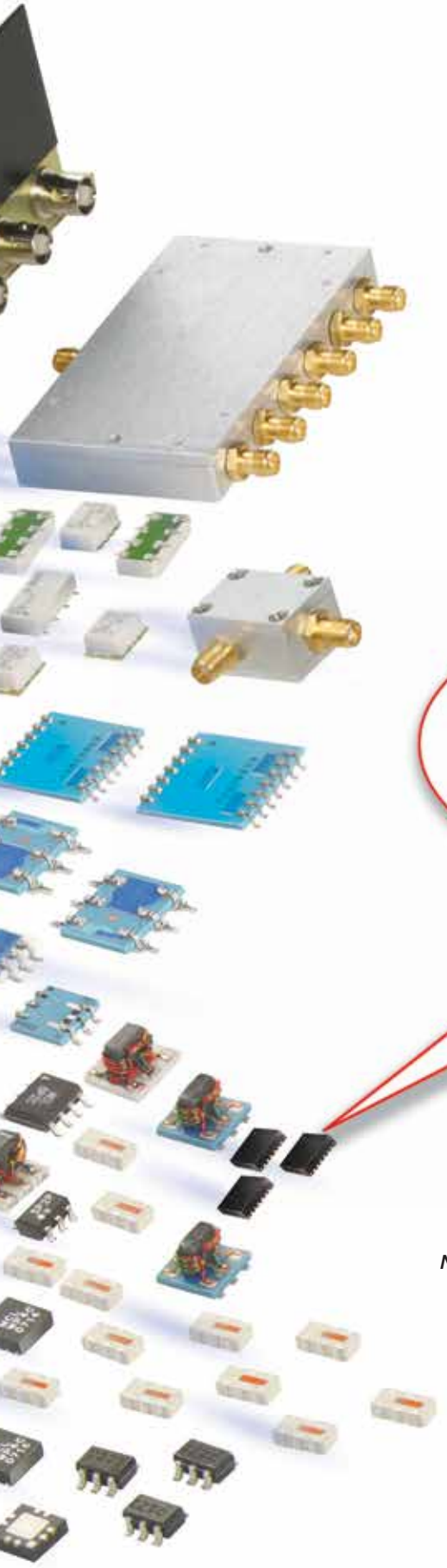
Now coming full circle, we are back to IMS again. This year the diversity challenge has evolved to take on a new angle, namely, "Leadership: How to Inspire Change." The panel will explore and discuss ideas useful to all technical professionals who are striving to grow their leadership skills. Specific topics explored include:

- How diversity helps us avoid becoming stagnant
- How to overcome career roadblocks
- The role that visibility plays in successful leadership

Visit the IMS website to learn more about this panel and other WIM-sponsored activities: www.ims2016.org/about-microwave-week/women-in-microwaves-wim

Last but by no means least, join me on LinkedIn to share your ideas for WIM: www.linkedin.com/grp/home?gid=6955695&trk=my_groups-tile-





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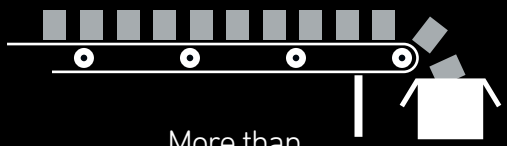

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