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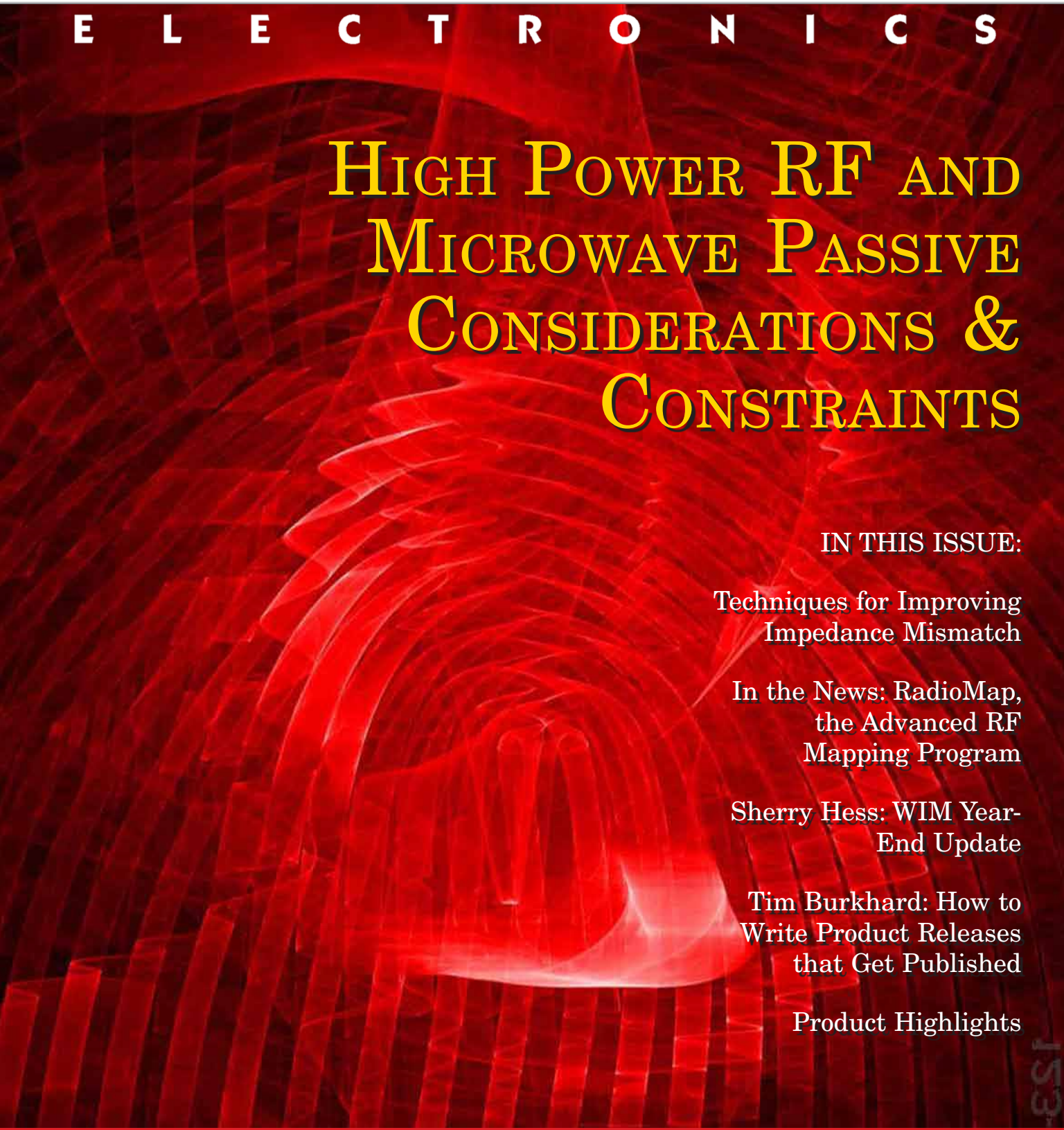
DECEMBER2015

HIGH FREQUENCY ELECTRONICS



High Power RF and Microwave Passive Considerations & Constraints

IN THIS ISSUE:

Ideas for today's engineers: Analog · Digital · RF · Microwave · mm-wave · Lightwave

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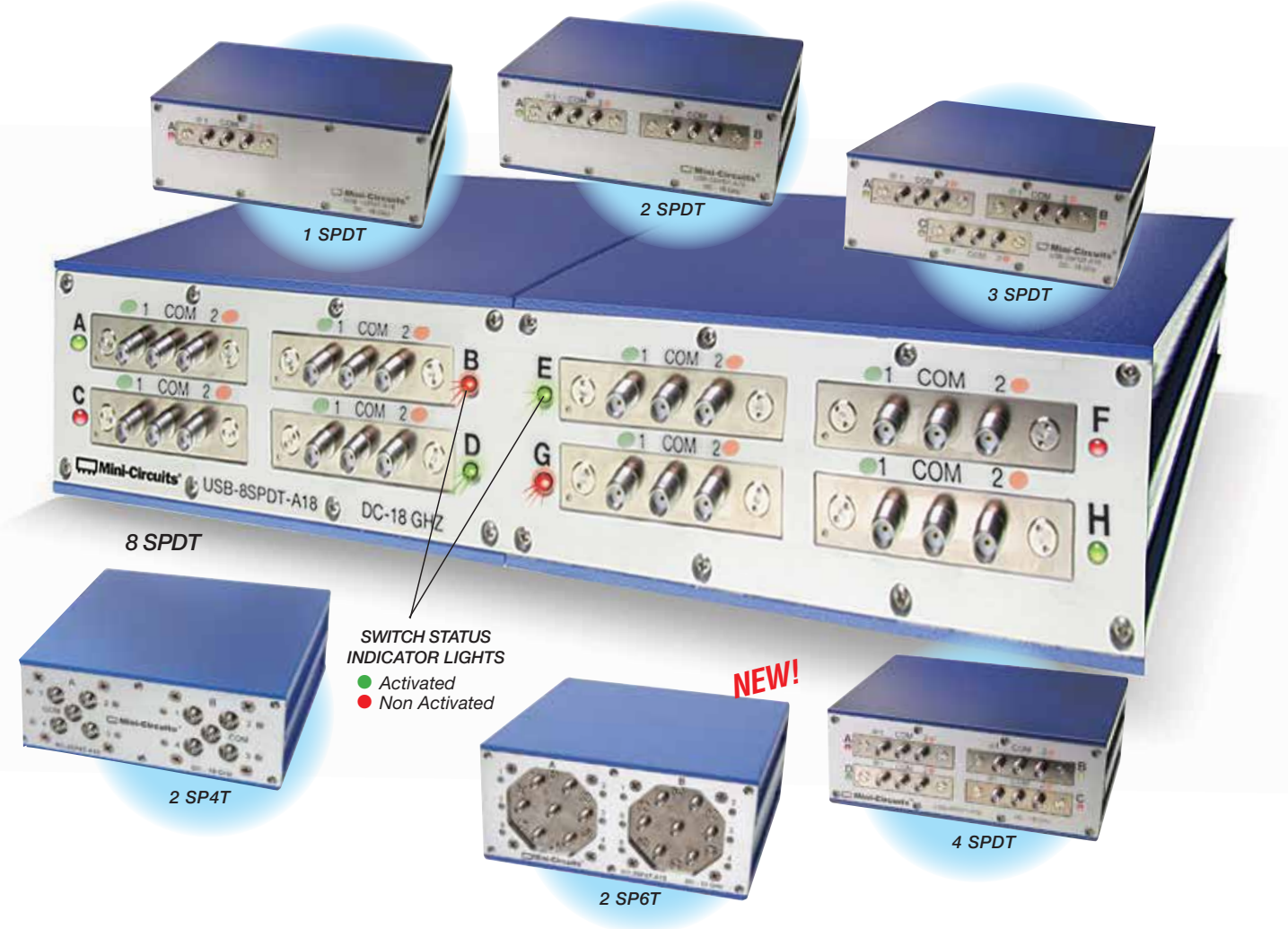

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	PWR-8FS	CW	1 to 8000	USB	969.00
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Editorial

How to Prepare Product Releases that Get Published—and Help Sales

Tim Burkhard
Associate Publisher & Managing Editor

At *HFE's* editorial desk we receive at least 300 email messages per day. While many of these are junk mail, a good portion consists of product announcements from companies in our industry. And we eagerly welcome them, as this information is critical to our engineering readership to assist them in making their buying decisions.

Here's how to increase the odds of your product announcement being published—not just with *HFE*, but almost any type of media.

Simplicity

While introductory statements regarding the fact that a given company, for example, "has been the industry leader for over three decades with no competition from anybody, ever, in world history," may be satisfying to the submitting company's top management, they are a non-value-added proposition for the engineering-oriented reader. Better to just keep it simple. Identify the product, supply the key specs, name the markets targeted, and tack on contact info including a website. An effective product release requires no more than 60 words.

Keep in mind that editors are only human and receives piles of such info daily. If you make their jobs easier by sticking to "just the facts," you decrease the workload required to put a given release into usable shape. That in turn increases the likelihood that your announcement is published.

Frequency

Like advertising and other forms of promotion, PR depends on frequency to be effective. Make it a goal to send out at least one product announcement per month to all appropriate outlets. If you are targeting a specific issue or month to conform to an editorial theme, be sure to check editorial calendars and get accurate contact info for the editor in charge of new-product coverage. After the fact, avoid harassing an editor for not running your material, as that increases the likelihood that he/she will skip over your releases in the future. The better strategy is to ask an editor what he/she is looking for, and then adapt to those requirements going forward.

Make the E-Mail Subject Line Your Headline

Many submitters write excellent release announcements and then neglect to capitalize on exploiting the email subject line to their advantage. The fol-

lowing is an example of an email subject line that a microwave editor is very likely to open: "XYZ Co. Introduces DC – 18 GHz SMA Adapters." That's it. Short and sweet. Then embed or attach your text (MS Word) and photo (300 dpi JPG) to the email and it's off to the races.

Everything Old is New Again

Contrary to popular belief, a product announcement *need not* be about a product only recently released to market. At least for us at *HFE,* the opposite is true. It's fine to send a product that may be months or years old, because the audience needs to be constantly reminded of your offerings. Don't expect something you announced three years ago to be fresh on the market's collective mind. And, new engineers are entering the market all the time, so this is your opportunity to get their attention. Your widget may not be brand new—but it's new to them.

Take Clear Product Photos

While this would seem self-evident, in many cases it is not. With proper lighting you can take a perfectly acceptable product photo with even the simplest of cameras. Upload to a computer and save your image as a JPG. If your saved image is measured in megabytes rather than kilobytes, then compress it prior to sending. Large image files clog the system and sometimes do not reach their intended destination at all.

It's About Sales

As we enter Presidential primary season, stories abound about candidates of various political stripes criss-crossing early primary States, including Iowa and New Hampshire. They stop in towns and cities both small and large, often multiple times, in advance of the primary vote. This is done for a reason: to get in front of the customer—in this case, the voter—as often as possible. Assuming you have a value-added proposition, then the more you are in front of the customer, the greater your odds of making a sale.

Your PR and promotional efforts need to mirror this behavior. The more your products are in front of the customer, the greater your odds of closing a sale. And increasing sales is the end game of all PR and promotional efforts.

About the Author

HFE Associate Publisher and Managing Editor Tim Burkhard has three decades of management experience in public relations, advertising, publishing, and trade shows in the tech field. He can be reached at tim@highfrequencyelectronics.com.

Meetings and Events

Conferences & Meetings

2015 IEEE MTT-S International Microwave and RF Conference (IMaRC 2015)
10 - 12 December 2015
Hyderabad, India
http://www.imarc-ieee.org
Paper Submission Deadline: 7 August 2015

DesignCon 2016
19 - 21 January 2016
Santa Clara, Calif.
http://www.designcon.com/santaclara/

2016 IEEE MTT-S Radio Wireless Week (RWW 2016)
24 - 27 January 2016
Austin, Texas
http://www.radiowirelessweek.org/
Paper Submission Deadline: 27 July 2015

2016 IEEE MTT-S International Wireless Symposium (IWS)
14 - 16 March 2016
Shanghai, China
Full Paper Submission Deadline: 16 Oct 2015
Final Submission Deadline: 16 Jan 2016

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/

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http://www.analog.com/en/training-tutorials-seminars/resources/index.html

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http://www.awrcorp.com/news/trainings

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MLMB/MLMY-Series. Electromagnetic PCB mount and Mini designs are available covering 700 MHz to 12 GHz frequency range. Phase noise of -130 dBc/Hz is provided with output power levels to +16 dBm. Commercial and extended temperature units are available throughout the product line.

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.

MLX-Series. Electromagnetic units that cover 6 to 22 GHz. Extremely low noise versions providing phase noise performance between -125 dBc/Hz to -130 dBc/Hz @ 100 kHz offset. Power output levels of +14 and +15 dBm are standard. Package sizes of 1" cube, 1.25" cube and 1.75" cylinder gives the user flexibility in mechanical design. Commercial and extended temperature range units are available. All standard driver interfaces are available from analog, 12 bit TTL and 16 Bit serial.

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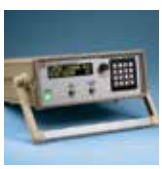

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Market Reports

Demand Increasing for Advanced Signal Generators

The increasing sophistication of consumer electronics, rising acceptance of 4G, and the constant introduction of innovative products all contribute to the growth of the signal generator market. **Signal generators have evolved from mere continuous wave devices to advanced modulation devices with superior software control, modulation capabilities and user interfaces.** These improvements, along with the use of new software techniques that enhance the linearity, bandwidth and signal creation capabilities, are stoking the market for signal generators.

New analysis from Frost & Sullivan finds that the market earned revenues of $742.0 million in 2014 and estimates this to reach $1127.5 million in 2020. The study covers the segments of radio frequency (RF) tests, microwave tests, arbitrary waveform generators (AWG) and peripheral component interconnect (PCI) eXtensions for instrumentation (PXI).

Earlier, users found it challenging to synchronize multiple instruments for multichannel applications because of the closed architectural designs. This is now a thing of the past as these integrated systems share internal local oscillators.

"This will enable the synchronization of multiple instruments and in turn, ease the tasks of test engineers." said Frost & Sullivan Measurement & Instrumentation Industry Analyst **Prathima Bommakanti**. "This is important as more applications are requiring multiple simultaneous signals."

Another important technological issue in the microwave signal generators market is the **management of phase noise.** Phase noise increases with carrier frequency multiplication during the generation of higher frequencies. **The use of yttrium iron garnet (YIG)-based microwave oscillators, rather than voltage controlled oscillators (VCOs), is expected to help achieve the desired level of phase noise performance.**

In spite of their improved functionalities, signal generators' prices have remained stable. Since alternative integrated test solutions and have become attractive options, one way to improve the revenue generation potential of the equipment is to offer modular options.

"Developments in semiconductors, including processors, field-programmable gate array and data converters, have resulted in cutting-edge modular solutions," observed Bommakanti. "With the communication industry introducing new standards constantly, there is a need for scalable/flexible solutions, which in turn is driving the need for PXI-based instruments, including signal generators."

—Frost & Sullivan
frost.com

Emerging 802.11ah Low-Power Wi-Fi Standard Facing Difficult Path in IoT

The emerging low power IEEE 802.11ah Wi-Fi standard will face a number of challenges as it seeks to address the limitations of existing 802.11 technologies for large-scale wireless sensor networking, Internet of Things (IoT) and machine-to-machine (M2M) applications in terms of both energy consumption and coverage. In ABI Research's latest report, Market Opportunities for Low Power Wi-Fi and 802.11ah, it finds **that annual IC shipments are set to reach just 11 million units by 2020, four years after the appearance of the first chipsets expected in 2016.**

Operating in the sub-1 GHz (S1G) license-exempt bands, 802.11ah offers a much greater range over 2.4 GHz and 5 GHz technologies, while several further enhancements have also been made to the PHY and MAC layers, such as power-saving mechanisms to support several years of battery life, support for up to 8,191 devices per access point, and an extended range mode offering 150 kbps of throughput at a distance of 1 km. These enhancements make it attractive to IoT markets such as the smart home, healthcare and fitness devices, and automation and control.

The standard will find itself competing in the increasingly crowded and fragmented IoT connectivity space, while the move to the S1G spectrum brings new challenges such as incompatibility with existing infrastructure. **Whereas other Wi-Fi standards, such as 802.11ac, are backwards-compatible with existing 802.11a/b/g/n routers, 802.11ah enabled products will require a separate gateway or new access point with an 802.11ah radio. This puts it in direct competition with other technologies such as ZigBee and Thread.**

"The success or failure of 802.11ah will greatly depend on how long device designers and manufacturers are willing to hold back on developing products using alternative technologies and wait for the standard to develop. There are already strong and well-established low-power, low-cost wireless connectivity technologies available on the market, many of which are operating on the globally available unlicensed ISM bands. Tri-band devices supporting Sub-1GHz, 2.4GHz and 5GH will need to come quickly to the market if it is to have any chance of success," says **Andrew Zignani**, Research Analyst at ABI Research.

Recent delays in the standards development process will also need to be quickly resolved in order to ensure that the technology, which is already relatively late to the party, has every chance of success.

—ABI Research
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In the News

DARPA has awarded a contract for the third and final phase of its **Advanced RF Mapping program, known as RadioMap, which seeks to provide real-time awareness of radio spectrum use across frequency, geography and time**. Akin to smartphone maps that show color-coded current traffic **conditions**, RadioMap is developing technology that visually overlays spectrum information on a map enabling rapid frequency deconfliction and maximizing use of available spectrum for communications and intelligence, surveillance and reconnaissance (ISR) systems.

Lockheed Martin Corp. in Manassas, Virginia, was recently awarded an $11.8 million Phase 3 contract to further develop technology from Phases 1 and 2 into a full system suitable for transition to the military services.

Today's interconnected wireless world has led to congested airwaves, making Radio Frequency (RF) management a hot topic. For military members around the globe, efficiently managing the congested RF spectrum is critical to ensure effective communications and intelligence gathering.

"RadioMap adds value to existing radios, jammers and other RF electronic equipment used by our military forces in the field," said **John Chapin**, DARPA program manager. "This program doesn't require purchasing new spectrum-sensing devices. Rather, **it uses existing radios and jammers that do double-duty. In the 'down' time when they aren't performing their primary function, the devices sense the spectrum around them and, through RadioMap technology, provide an accurate picture of what frequencies are currently in use and where."**

RadioMap seeks to make spectrum management more efficient by giving operators the tools to see real and potential frequency interference and usage. For example, a forward-deployed unit might reserve a particular frequency for a communications link at a specific time, but due to the dynamic nature of the situation, the frequency ends up not being needed. RadioMap's real-time visualization of actual spectrum use helps spectrum managers detect the unused frequency and enhance mission effectiveness by quickly reusing it for other needs.

RadioMap can also support small units—such as squads or platoons, which rarely carry equipment for monitoring radio emissions—by identifying nearby RF Spectrum emitters that may indicate tactical threats or opportunities.

"The Marine Corps is an ideal transition partner for RadioMap," Chapin said. "They have in place the doctrine, organizational structure, and information systems framework that can effectively integrate RadioMap software. After successful tests at Quantico Marine Base in Phase 2 of RadioMap, I look forward to further collaboration and to transitioning the technology to Marine Corps use at the end of Phase 3."

The base period of RadioMap Phase 3 is scheduled to continue through summer of 2016. If the Marine Corps test of the system in summer 2016 is successful, the program could transition to the Marine Corps after further operational testing in early 2017.

* * *

SmartFlow Compliance Solutions announced products designed to help companies combat intellectual property (IP) theft and establish effective in-house compliance programs. Once deployed, **SmartFlow detection, identification and analysis software intuitively compiles data and provides insight to clients on how non-compliance and piracy are affecting their business, customers, and income.** Armed with actionable information, businesses can easily enforce compliance and recover lost revenue.

As companies continue to expand globally into emerging economies, information security and software piracy are becoming major business obstacles. According to a recent study by the Business Software Alliance (BSA), an estimated 43 percent of software installed today is not properly licensed, which equates to more than **$63 billion in lost revenue**.

"Software piracy is becoming a rampant global epidemic with significant impacts on businesses and the economy," said **Ted Miracco**, CEO of SmartFlow. "We've developed a turnkey solution that allows businesses to start seeing ROI immediately. Armed with SmartFlow, our clients take charge by tracking down pirated versions of their software and compiling the data to take necessary action against IP theft. We streamline the compliance enforcement process, so it's simple and effective for companies to recover this valuable source of revenue, while protecting their paying customers from unfair competition."

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In the News

The SmartFlow product suite includes SmartFlow Software Development Kit (SmartFlow SDK), which monitors applications to ensure they are being used in compliance with licensing terms, and SmartFlow Professional or SmartFlow Enterprise programs, which provide everything a company needs to establish an in-house compliance program.

SmartFlow technology is licensed on a subscription basis, starting at $5,000 USD. For detailed pricing or more information, contact info@smartflowcompliance.com.

* * *

Comtech Telecommunications announced that its Santa Clara, California-based subsidiary, **Comtech Xicom** Technology, has received production contract for more than $3.2 million from a U.S. military integrator to supply high-power traveling wave tube amplifiers (TWTAs). This is the first installment of a multi-year program for tactical military transportable satellite terminals.

"Comtech is a key supplier on this highly advanced multiband satellite system," said **Dr. Stanton Sloane,** President and Chief Executive Officer of Comtech Telecommunications Corp. "This order demonstrates our customer's continued confidence in our military satcom solutions. We are committed partners on this program."

Comtech Xicom also announced a $1.7M contract from a major U.S. system integrator to supply 500-Watt Ka-Band Traveling Wave Tube Amplifiers (TWTAs) for HTS gateways. These high-power amplifiers will be used to expand existing European infrastructure and add gateway facilities in Africa.

* * *

AVX Corp. launched its new corporate website. The new site delivers a virtual corporate presence that accurately reflects the cutting-edge technology and seamless integration that its products enable in applications including: automotive, medical, renewable energy, optical communications, telecommunications, consumer electronics, and lighting. The new site anticipates user needs, providing several different intuitive paths to the same information from various entry points — including product pages, industry applications, and catalogs — in addition to a dynamic new search engine and much more detailed top, side, and bottom navigation bars. It also offers an interactive and illustrated application-to-component search feature, a new video library for both passive and interconnect products, and more direct links to engineering design tools, like its Part Builder.

* * *

ETL Systems, manufacturer of Radio Frequency (RF) distribution equipment for satellite communications, has provided online global enterprise satellite monitoring service **SatSignature** with carrier monitoring switches.

SatSignature combines state-of-the art software and hardware to allow users access to real-time satellite spectrums, enabling them to get live feeds of any satellite at any time over the web. It will be utilising ETL's 32x1 IF/L-band LS series monitoring switch to continuously monitor satellite RF feeds located in various parts of the world for verification, qualification, and carrier monitoring purposes.

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Featured Products

Module

L-3 Electron Devices announced the M1292-02 Ka-Band Millimeter Wave MPM. The module is available for immediate insertion on advanced Ka-Band communications systems requiring linear output power and high efficiency in an ultra-compact, fully airborne-qualified (up to 50,000 feet) package that enables users to physically mount the MPM extremely close to their transmitting aperture, thus minimizing RF losses. The MPM is also reconfigurable for 100 Watts of saturated power operation.

L-3 Electron Devices
L-3com.com/edd

Filter

Mini-Circuits' X-Series reflectionless filters employs a novel filter topology which absorbs and terminates stop band signals internally rather than reflecting them back to the source. This capability enables unique applications for filter circuits beyond those suited to traditional approaches. Reflectionless filters eliminate stop band reflections, allowing them to be paired with sensitive devices and used in applications that otherwise require circuits such as isolation amplifiers or attenuators.

Mini-Circuits
minicircuits.com

Power Analyzer

Keysight Technologies announced an extension to the IntegraVision

family of power analyzers, the first in the industry to combine high-accuracy power measurements and touch-driven oscilloscope visualization in a single instrument. The Keysight IntegraVision PA2203A 4-channel power analyzer gives R&D engineers working on three-phase power devices an intuitive tool that delivers the dynamic views they need to see, measure and prove design performance.

Keysight Technologies
keysight.com

Frequency Multiplier

Model SFA-106SF-S1 is an active X6 frequency multiplier with an input frequency of 15.00 to 16.33 GHz and an input power of +5 dBm. Output frequency is 90 to 98 GHz, and typical output power is +18 dBm. The multiplier also has a typical harmonic suppression of -20 dBc. DC power requirement is +8 VDC/750 mA. The input port configuration is a female SMA connector and the output port configuration is WR-10 waveguide with a UG-387/U-M flange.

SAGE Millimeter
sagemillimeter.com

Tester

Wireless technologies such as LTE, Bluetooth® and WLAN make it possible to connect devices with the Internet or with each other anywhere and everywhere. Manufacturers who integrate wireless modules into devices must ensure the correct functioning of the target platform and the applications. Rohde & Schwarz has specifically designed its economical R&S CMW290 functional radio communication tester to meet the requirements of integrators with mostly cost-sensitive applications.

Rohde & Schwarz
rohde-schwarz.com

Connector

TE Connectivity launched its DEUTSCH AFD Series connectors that feature bayonet coupling and rear release contacts in a miniature circular connector system with sealing. These connectors are specifically designed to withstand harsh environments and are frequently used in aerospace applications and military ground vehicles, and are MIL-DTL-26482 Series II-qualified.

TE Connectivity
te.com

MLCC

Design engineers looking for capacitors to have a more defined change of capacitance with applied with voltage can now specify the VC1 range from Knowles Capacitors brand, Syfer Technology. This residual capacitance range of X7R MLCCs are designed to not drop more than 50% of their cap value from the 1Vrms 1kHz value, all the

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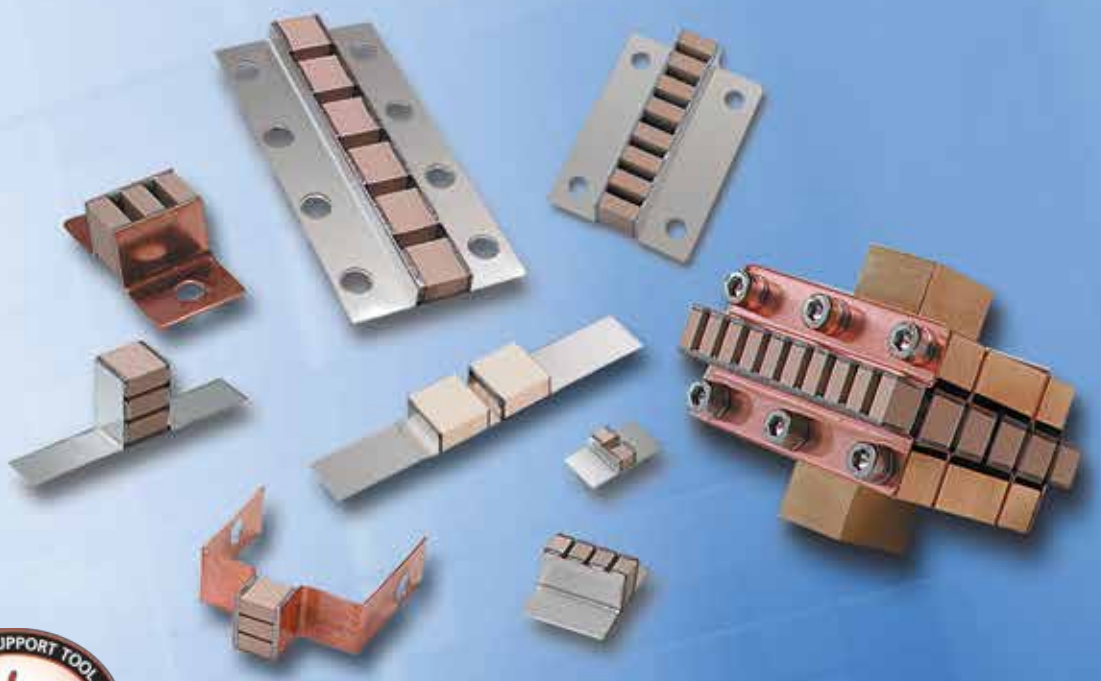

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Phase Shifters

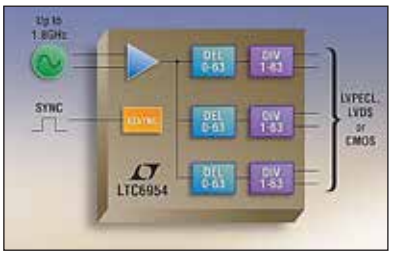
Pasternack introduced a series of 8-bit digital phase shifters which are programmable over a full 360° srange and can produce a discrete set of phase states of up to 255 total steps with 1.4° increments with a high level of accuracy and minimal phase shift error. These components cover broadband microwave and millimeter wave frequencies and are ideal for aerospace and defense radar and EW applications which involve phased-array antennas, phase discriminators, beam forming networks and RF communication systems.

Pasternack
pasternack.com

Calibration Kits

OML's millimeter wave calibration kits contain the waveguide components that accurately calibrate vector network analyzer for precision S-parameter measurements. The calibration techniques supported include: TRL, SSoLT and SSoLs. Waveguide calibration kits are available in the millimeter and sub-millimeter wave frequencies between 50 and 500 GHz.

OML
omlinc.com



Clock Distribution Chip

The LTC6954 is a family of ultralow jitter 1.8GHz clock distribution chips with three independent outputs, each with its own divider and phase delay. With less than 20fsRMS additive jitter over the 12kHz to 20MHz bandwidth, it minimizes the amount of introduced noise while dividing and distributing its input clock. This enables it to deliver the low jitter clocks necessary to achieve optimum signal-to-noise ratios (SNR) when driving high resolution data converters.

Linear Technology
linear.com

Multiplier

Model SFA-126SF-S1 is an active X6 frequency multiplier with input frequency of 12 to 15 GHz and an input power of +0 dBm. Output frequency is 72 to 90 GHz, and the nominal output power is +9 dBm. The multiplier also has a typical harmonic suppression of -20 dBc. DC power requirement is +8 VDC/450 mA. Input port configuration is a female SMA connector and output port configuration is a WR-12 waveguide with a UG-387/U flange. Other port configurations are available under different model numbers.

SAGE Millimeter
sagemillimeter.com

isola

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	RF/MICROWAVE MATERIALS				
	IS680	I-Tera® MT RF	I-Tera® MT	TerraGreen®	Astra® MT
Tg	200°C	200°C	200°C	200°C	200°C
Td	360°C	360°C	360°C	390°C	360°C
Dk @ 10 GHz	2.80 - 3.45	3.38, 3.45 & 3.56	3.45*	3.45*	3.00
Df @ 10 GHz	0.0028 - 0.0036	0.0028, 0.0031 & 0.0034	0.0031*	0.0030*	0.0017
CTE Z-axis (50 to 260°C)	2.90%	2.80%	2.80%	2.90%	2.90%
T-260 & T-288	>60	>60	>60	>60	>60
Halogen free	No	No	No	Yes	No
VLP-2 (2 micron Rz copper)	Available	Available	Available	Standard	Standard
Stable Dk & Df over the temperature range	-55°C to +125°C	-55°C to +125°C	-55°C to +125°C	-55°C to +125°C	-40°C to +140°C
Optimized global constructions for Pb-free assembly	Yes	Yes	Yes	Yes	Yes
Compatible with other Isola products for hybrid designs	For use in double-sided applications	Yes	Yes	Yes	Yes
Low PIM < -155 dBc	Yes	Yes	Yes	Yes	Yes

* Dk & Df are dependent on resin content NOTE: Dk/Df is at one resin %. Please refer to the Isola website for a complete list of Dk/Df values. The data, while believed to be accurate & based on analytical methods considered to be reliable, is for information purposes only. Any sales of these products will be governed by the terms & conditions of the agreement under which they are sold.

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http://www.isola-group.com/conversion-service

FREE! Impedance and Power-Handling Calculator

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- This software tool provides a design or an equivalent dielectric constant to facilitate modeling for PCB designers to predict impedance and other design attributes. The software computes changes in the effective dielectric constant due to dispersion at higher frequencies. The software then computes the total insertion loss—a measure of power lost through heat for power handling calculations, including the dielectric loss, conductor loss, and the loss due to the surface roughness. The main factors affecting the typical power-handling capability of a material are its thermal conductivity, the maximum operating temperature, and the total insertion loss.

https://isodesign.isola-group.com/phi-calculator

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Mini-Circuits' ZHL-2-8+ is a medium-power connectorized amplifier providing 34 dB gain and +30 dBm P3dB across the 10 to 1000 MHz frequency range. Excellent gain flatness across its entire frequency range (±0.8 dB) makes it ideal for systems where consistent performance across frequency is required. It operates on a 24V DC supply and comes housed in compact aluminum alloy case (4.75 x 2.00 x 2.12") with SMA connectors and an optional heat sink for efficient cooling.

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High Power RF And Microwave Passive Considerations and Constraints

By Mark Blackwood

Specialized components and techniques are used to meet extreme application requirements.

RF and Microwave passive components bear a burden of many design constraints and performance metrics. Depending upon the power requirements of the application, the demands on the material and design performance can significantly increase. For example, in high power telecommunications and military radar/jamming applications, high performance levels are desired alongside extremely high power levels. Many materials and technologies cannot withstand the power levels these applications demand, so specialized components, materials, and techniques must be used to meet these extreme application requirements.

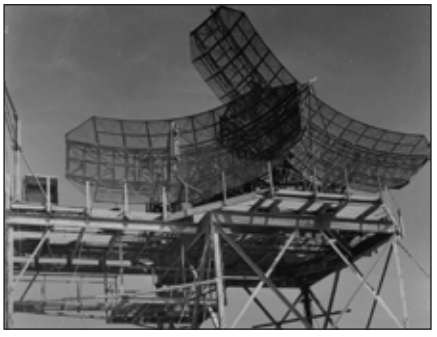

Figure 1 • For either weather or military radar, high power amplifiers often generate hundreds to thousands of watts of RF energy to the radar antennas or antenna arrays. Source: http://www.erh.noaa.gov/iln/research/ThunderstormProject/TSP.php.

High levels of RF and Microwave power are invisible, challenging to detect, and capable of producing incredible amounts of heat in a small area. Often, over power stress is only detected after a component failure, or complete system failure. Such a scenario is commonly encountered in the telecommunications and aerospace/defense applications, as the use and exposure of high power levels are necessary to meet these applications performance demands.

RF and Microwave power levels high enough to damage the components in the signal path can be a product of poor design, material aging/fatigue, or even strategic electronic attack. Any critical system that may encounter high power RF and Microwave energy must be carefully designed and bolstered by components specified for the maximum potential power levels. Other concerns, such as RF leakage, passive intermodulation distortion, and harmonic distortion are exacerbated at high power levels where greater consideration must be placed on the quality of components.

Any interconnect or component with insertion loss has the potential to absorb enough RF and Microwave energy to risk damage. This is why all RF and Microwave components have a maximum power rating. Often, as there are several different operating modes for RF energy, the power ratings will be specified for either continuous wave (CW) or pulsed power. Additionally, as the various materials that make up RF components may change behavior at different power, temperature, voltage, current, and ages, these parameters are also often specified. As always, some manufacturers are more generous with their components' specified capabilities, so testing of a particular component under actual operating conditions is recommended to avoid in-field failures. Which is of particular concern with RF and Microwave components, as cascade failures are common.

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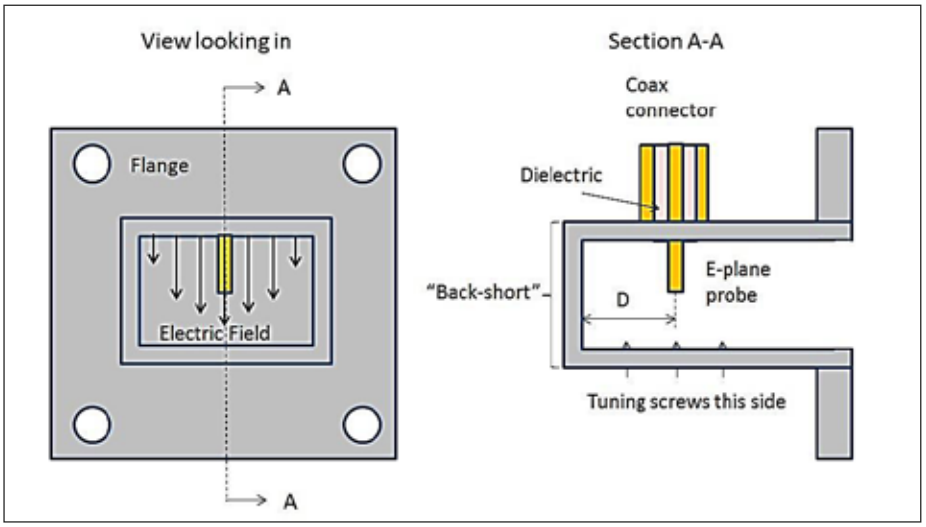

Figure 2 • Waveguides can be tapped with either a magnetic loop or electric field probe to convert the TE or TM waveguide mode to a TEM coaxial transmission mode. Source: http://www.microwaves101.com/encyclopedias/waveguide-to-coax-transitions.

Coax or Waveguide Interconnect?

Depending upon the frequencies, power levels, and physical requirements, either coaxial or waveguide interconnects are used for high power RF and Microwave applications. Both technologies vary in size as a function of frequency and require higher-precision materials and manufacture to handle higher power levels. Generally, as a product of the way the RF energy is carried through a waveguide with an air dielectric, waveguides tend to be able to handle higher power levels than comparable coaxial technologies. On the other hand, waveguides are usually a more expensive, custom installed, and a narrower-band solution than coaxial technologies.

This being said, for applications that require lower cost, higher flexibility installation, greater signal routing density, and medium power levels, coaxial technologies may be the preferred choice. Additionally, there are a greater selection of components that use coaxial interconnect over waveguide interconnect

Figure 3 • After an attenuator the coaxial connector type may be able to be reduced in size and cost as the signal power levels after attenuation may be low enough to avoid damaging a smaller coaxial connector. Source: http://www.pasternack.com/50db-fixed-sma-male-7-16-female-25-watts-attenuator-pe7355-50-p.aspx

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due to reduced cost and size. Though broadband and generally a more straightforward installation, where high performance, ruggedness, and reliability are concerned, waveguide technologies tend to exceed coaxial. Often, these interconnect technologies are used in tandem, with the highest power and fidelity signals routed through waveguide interconnect, when possible.

An important feature to note with coaxial technologies is that their power and voltage related dielectric breakdown is much lower than waveguide interconnect at similar frequencies. This may be acceptable if weight and cost are high concerns. Though, issues with material outgassing and material performance changes at high temperatures and pressures may reduce coaxial technologies viability in aerospace applications.

Adapters and Terminations

As every adapter and termination can introduce unwanted insertion loss and reflections, carefully choosing the right component can prevent unwanted signal degradation and potential damage to sensitive electronics. Adapters and terminations come in many forms, generally coaxial or waveguide for high power applications. Additionally, adapters can be more complex as the sizes and types of either end of an adapter may be different. Moreover, the adapter itself may introduce turns or bends.

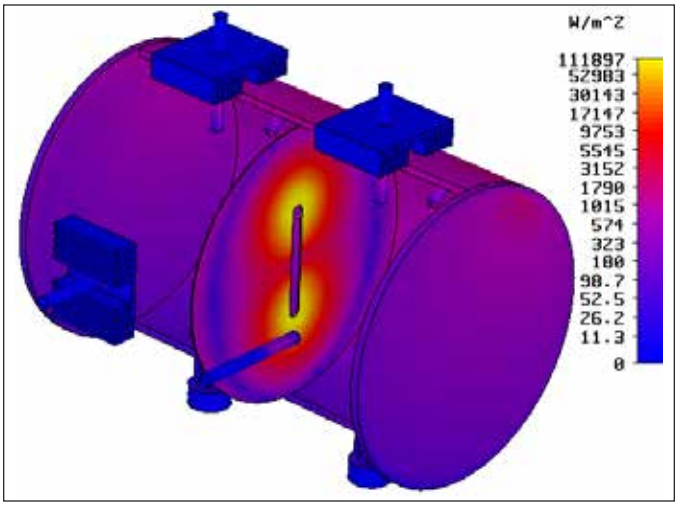

Figure 4 • Modern simulators now include EM and thermal simulations to predict the thermal behavior and stresses seen within a filter, or other passive component device. Source: https://www.cst.com/Applications/Article/Thermal-Analysis-Of-A-Two-Cavity-Dual-Mode-Bandpass-Filter.

The power and frequency range of an adapter must be scrutinized, especially if the adapters are waveguide to coaxial transitions. Waveguides naturally only enable a bandpass like range of frequencies to be carried with high signal fidelity, where coaxial technologies only have a cutoff frequency. However, the different coaxial connector types also have varying power and frequency capacities. If an adapter is a transition between two different coaxial connector types, the frequency, power handling, PIM, insertion loss, and other parameters will be affected.

Terminations bear the brunt of dissipating potentially extreme amounts of RF energy within the device. Generally, terminations for high power applications will have a heatsinking metal body and possibly forced air thermal management. The impedance match and voltage-standing-wave-ratio (VSWR) of a termination are absolutely critical, as unpredicted reflections could lead to overpower and overvoltage conditions in the upstream electronics. This could be hazardous in the case of shunting a high power amplifier (HPA) to a termination that doesn't meet adequate VSWR specs, as it could permanently damage the HPA.

Attenuators

Attenuators, like terminators, are designed to dissipate RF energy within the body of the device without producing any unwanted signal distortion or reflections. There are fixed and variable attenuators. For most extremely high power applications, fixed attenuators are more common. Like terminators, they can be either waveguide or coaxial. Additionally, an attenuator can also be an adapter to dif-

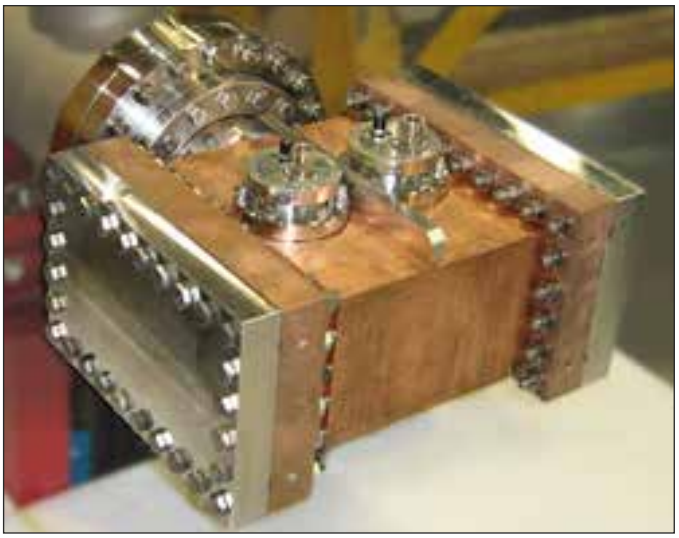

Figure 5 • Waveguide directional couplers may have coaxial outputs, as the power level of the coupled signal is low enough to be carried in a lower weight and cost coaxial transmission line. Source: http://www.megaind.com/customApplications.html.

ferent sized coaxial connector size, though this is rarely done with waveguide connectors.

Depending upon the amount of power the attenuator is designed to dissipate, metallic radiators will commonly surround the body and even forced cooling may be an option. The higher the frequency, power handling, and attenuation will dictate the amount of RF energy is converted into heat. When installing an attenuator it is critical to ensure that the attenuator gets adequate ventilation and isn't mounted in close proximity to other heat dissipating electronics.

Filters

As filters can act as either frequency selective attenuators or reflectors for out-of-band signals, considering the types of upstream electronics and the signals entering a filter are necessary. Absorptive filters will absorb the RF energy from out-of-band signals and convert that into heat. Where, reflective filters will redirect the RF energy back to the source. This type of filter may risk damaging sensitive upstream electronics due to overpower or overvoltage. Depending upon the filter technology and construction, the power handling capability of a filter is often highly frequency dependent.

As with most RF and Microwave components, higher frequency components have a lower power threshold than their low power cousins. The relative sizes and materials of a filter will have significant impact on the power and frequency limits. The passband of a filter naturally attenuates the signal slightly, so the passband characteristics are just as important as the out of band filter characteristics in terms of RF energy absorption or reflection.

Directional Couplers and Power Dividers/Combiners

Directional couplers have many of the same concerns and constraints as adapters, with the added complexity of having built in terminations or forward/reverse coupled signal paths. Moreover, a directional coupler's coupled signal paths are hundreds, thousands, or tens of thousands of times less power than the RF energy passing through the main propagation line. As the power levels are dramatically lower on the coupled lines, even for high powered waveguide couplers, the coupled lines are often coaxial connectors. This is obviously not the case for hybrid couplers, or 3dB 90° hybrid couplers, which evenly split the power of a signal in two equal RF signal paths.

Generally, a directional coupler is designed to have very low insertion loss and reflection. At high power levels, the method of coupling can introduce significant insertion loss and reflection, if it's not precision designed. Another factor to consider is the loading of the coupled lines. Though at low power levels a simple termination may be

TABLE I

DIVIDER NORMALIZED IMPEDANCE VALUES

	Power Split				
Divider	m=1	m=2	m=3	m=10	m=100
Wilkinson	$Z_1 = Z_2 = \sqrt{2}$ $R_2 = 2$	$Z_1 = 2.060$ $Z_2 = 0.612$ $R_2 = 2.121$	$Z_1 = 2.630$ (difficult to realize) $Z_2 = 0.385$ $R_2 = 2.309$	N/A	N/A
Ring	$Z_1 = Z_2 = \sqrt{2}$	$Z_1 = \sqrt{3/2}$ $Z_2 = \sqrt{3}$	$Z_1 = 2/\sqrt{3}$ $Z_2 = 2$	N/A	N/A
Two-branch	$Z_1 = 1$ $Z_2 = 1/\sqrt{2}$	$Z_1 = \sqrt{2}$ $Z_2 = \sqrt{2/3}$	$Z_1 = \sqrt{3}$ $Z_2 = \sqrt{3}/2$	N/A N/A	N/A N/A
Coupled line	$Z_{0e} = 2.414$ $Z_{0o} = 0.414$	$Z_{0e} = 1.931$ $Z_{0o} = 0.518$	$Z_{0e} = 1.732$ $Z_{0o} = 0.577$	$Z_{0e} = 1.365$ $Z_{0o} = 0.732$	$Z_{0e} = 1.060$ $Z_{0o} = 0.905$

Figure 6 • There are a variety of power divider technologies, each with their own impedance and performance characteristics. Source: http://www.microwavejournal.com/articles/3042-the-basics-of-print-reciprocal-dividers-combiners.

Figure 7 • Moisture ingress can cause device failure by changing the electrical characteristics and increasing the power dissipating in a connection, such as a rotary connector. Source: http://www.microwaves101.com/mortuary/993-microwave-mortuary-2011.

adequate. But, at higher power levels any mismatch or reflections could lead to significant power fed pack into the main signal path. Also, the terminations of a directional coupler may need to have higher power handling than their low power counterparts, depending upon the coupling strength.

Much like directional couplers, power dividers split the RF signal energy along multiple paths. Where, power combiners feed the RF signal energy into one main path. The concerns for insertion loss and reflections are much the same with power dividers/combiners as they are with direction couplers. The major difference is that power dividers/combiners are often at roughly equal power levels, though not phases. As a product of this, any impedance or VSWR mismatch in the connections or feed lines may induce undesired signal degradation, phase deviation, and reflections. Some power dividers/combiners have the inputs or outputs as waveguide or coaxial connections and the inputs and outputs use a different connector size or technology. The frequency and power handling capability for each connection must be accounted for in a final design to ensure acceptable response.

Passive Intermodulation Distortion in High Power Passives

PIM has significant impacts on wireless network performance, specifically with high power RF electronics. As PIM is often challenging to determine in a complete system of passive devices, if PIM is a design concern, having highly precision and low-PIM passive components may be a first step in ensuring lower PIM thresholds. Any nonlinearities in the materials or induced from the environment may lead to high levels of PIM.

Be it the presence of surface imperfections, microfractures, or dissimilar material junctions, high power levels often exacerbate the effects of the nonlinearities resulting in PIM. As high power applications are also generally associated with more extreme environments, temperature variations, vibrations, and material aging can also lead to nonlinearities causing PIM. In order to reduce the PIM response, each individual connection and component can be verified to operate with a reduced 3rd order intercept point, and thus lower distortion. The

PIM response can also be confirmed after installation with rigorous post-assembly testing.

Thermal Management Challenges and Lifetime and Material Degradation

High power levels at high frequencies tend to induce RF energy dissipation in non-ideal surfaces and materials. The dissipation of RF energy into most surfaces induces heating. RF heating may cause material changes in peak power operation or material degradation over several use cycles.

Understandably, the temperature and RF power level specifications of a device should be maintained with a reasonable within a reasonable margin. As many manufacturers are very optimistic about the performance of their products, it stands to reason to allow for as much power and heat headroom as other design constraints enable. This is especially important in critical applications that cannot afford downtime, as thermal stresses can induce thermal runaway that rapidly leads to device failure.

Other environmental factors, such as moisture ingress and shock/vibration, can also temporarily reduce the power and thermal handling capability of a component. Thorough testing of high power components in salt fog, temperature, and mechanical stress test benches is commonly employed to verify a component design for the extremes of certain applications. Many manufacturers have detailed information of the testing done with their in-stock products and are willing to share that information with component buyers.

References & Resources

http://www.odyseus.nildram.co.uk/Systems_And_Devices_Files/Component%20Reliability%20Tutorial.pdf

http://www.asc-i.com/pdf/Thermal_Management_for_Power_Electronics.pdf.

About the Author

Mark Blackwood is Pasternack's Product Manager for Passive RF Components. He has more than 20 years of engineering, program management, product marketing and product line management expertise in the RF and microwave industry. Prior to joining Pasternack he held management positions in engineering, program management, product marketing and business development with some of the industry's most recognized corporations including TriQuint Semiconductor, Texas Instruments, Anritsu and others. Mr. Blackwood holds advanced degrees in electrical engineering and physics.

Techniques for Improving Impedance Mismatch

By Mini-Circuits

Introduction

Impedance matching is a complex subject cloaked in a certain degree of mystery. Whenever a circuit fails or systemic problems are encountered, impedance matching is most often attributed as the cause. As a result, there are many situations in which it becomes necessary to match the impedance of a load to that of the source in order to maximize power transfer. There are many different techniques for impedance matching, and the best application of each will depend on the situation. This article will review the basics of impedance matching and describe some of the effective techniques commonly used to overcome impedance mismatch in a circuit.

Impedance matching is a complex subject cloaked in a certain degree of mystery.

Understanding Impedance Mismatch: Concept Review

The primary figures of interest in evaluating impedance mismatch are the voltage standing wave ratio (VSWR), return loss, and mismatch loss. These are defined below for review:

VSWR

When a transmission line is terminated with impedance, Z_L that is not equal to the characteristic impedance of the transmission line, Z_O, not all of the incident power is absorbed by the termination. Some of the power is reflected back to the source so that phase addition and subtraction of the incident waves creates a voltage standing wave pattern on the transmission line. The ratio of the maximum to minimum voltage where the successive maxima and minima are spaced by 180˚ ($\lambda/2$) is known as the voltage standing wave ratio (VSWR).

Return Loss

Return loss is a measure in dB of the ratio of power in the incident wave to that in the reflected wave. Return loss, by this definition, always has a positive value. For example if a load has a return loss of 10 dB, then 1/10 of the incident power is reflected. The higher the return loss, the less power is lost from the thru-signal.

Mismatch Loss

This is a measure of how much the transmitted power is attenuated due to signal reflection. Mismatch loss is determined by the following equation:

$$\text{Mismatch Loss} = -10 \log(1 - \rho^2)$$

Where ρ is the reflection coefficient.

For example, a filter with VSWR of 2:1 would have a reflection coefficient of 0.333, a mismatch loss of 0.51 dB, and a return loss of 9.54 dB (11% of the transmitted power is reflected back). In some systems, this is significant and indicates the need for components with low VSWR.

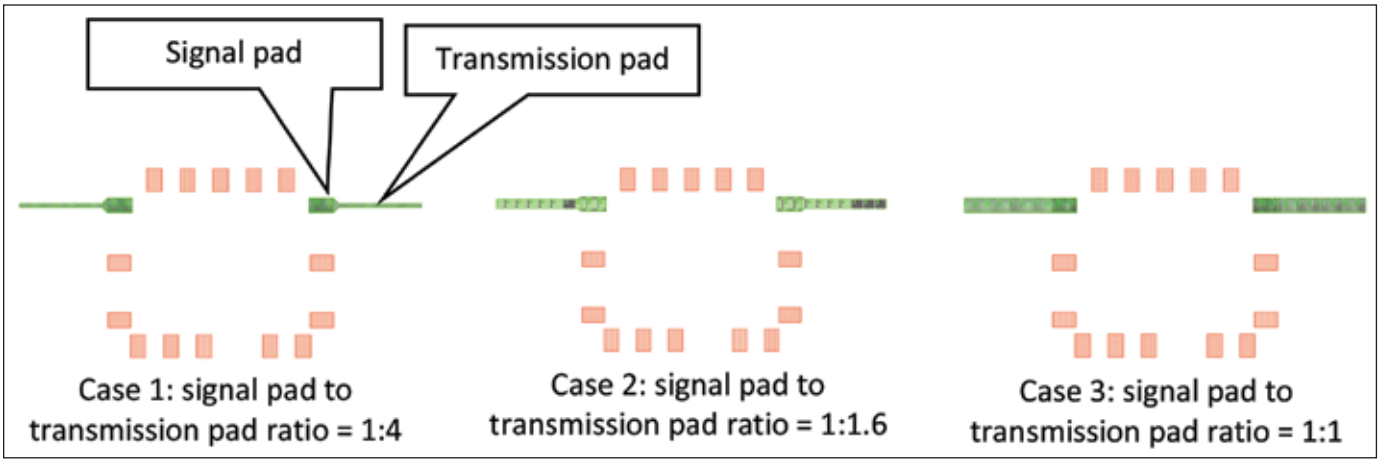

Figure 1 • Land pattern of a band pass filter with 3 different ratios of signal pad width to transmission pad width.

What Causes Mismatch?

Impedance mismatch in a circuit can be caused by a number of factors. These include discontinuities in the physical path of transmission which reduce the quality of the signal; improperly terminated lines; and sudden step discontinuities in impedance lines. Of these causes, impedance lines with sudden step discontinuities are most common because customers often use substrate materials with different trace thickness than that recommended by the component manufacturer.

Consider the suggested land pattern in figure 1 showing the footprint of a band pass filter. The green pads denote the signal pad, and the brown pads denote the ground pads.

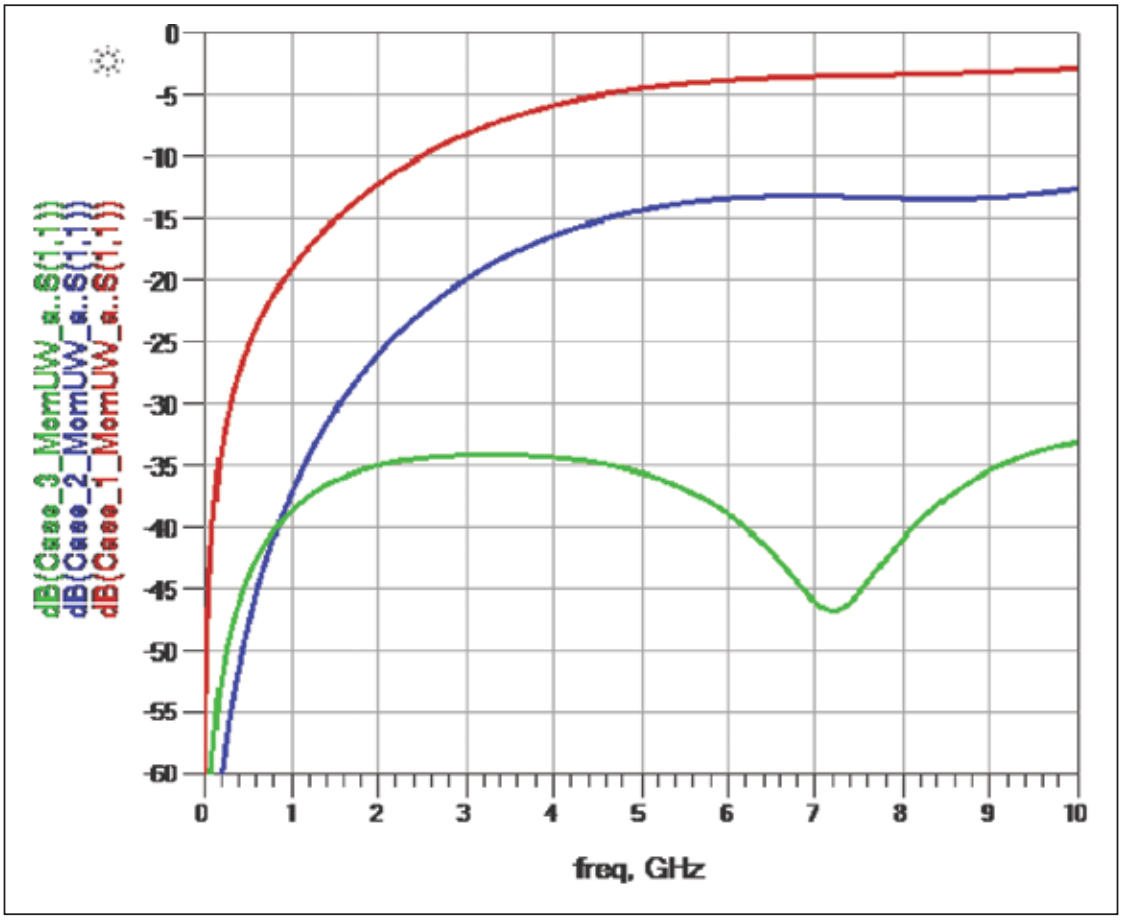

Figure 2 • Simulated return loss plots for the 3 cases shown in figure 1.

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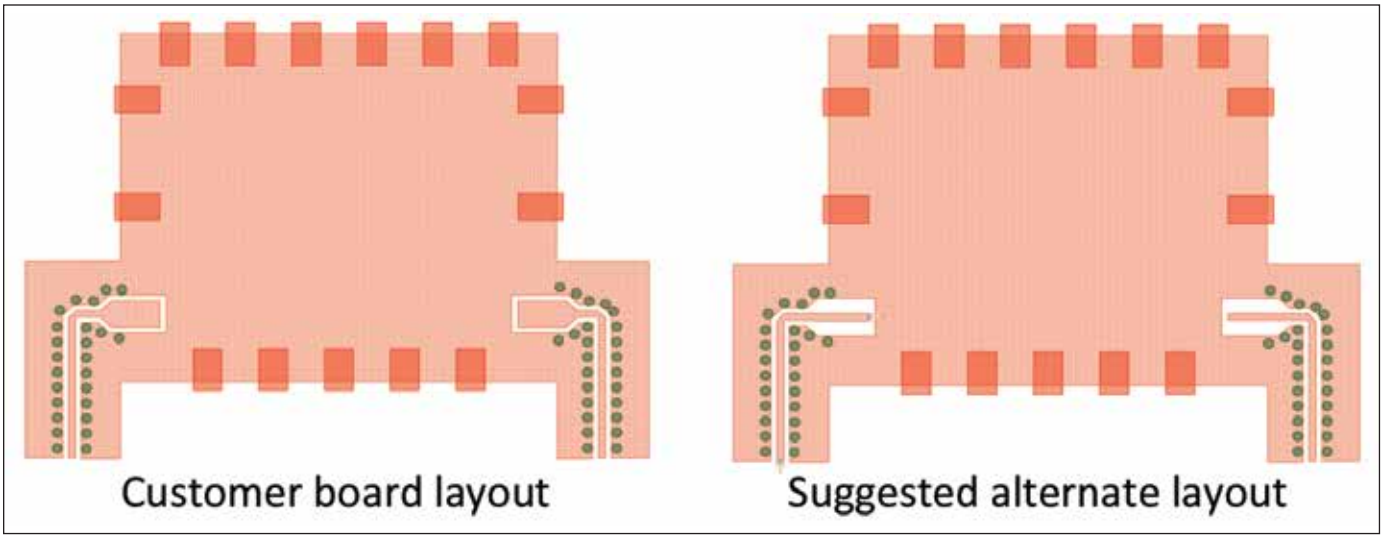

Figure 3 • Customer's board layout of CBP-1300F-1+ and suggested modification altering signal pad width.

In general, if the RF trace matches the width of the signal pad exactly, then signal reflection is minimized. The simulated return loss response for the three cases drawn in figure 1 is shown in figure 2.

Case 1 has a signal pad to transmission pad width ratio of 1:4 and return loss of 5 to 10 dB; case 2 has a ratio of 1:1.6 and return loss from 10 to 15 dB; and case 3 has a ratio of 1:1 and a return loss of >30 dB across the swept frequency range. This demonstrates that the impedance mismatch is inversely proportional to the ratio of signal pad width to transmission pad width. Mismatch is minimized when the signal pad and transmission pad are the same width.

Techniques to Improve Impedance Matching

There are multiple techniques that can be applied to improve matching in a circuit. One such technique is to insert a matched attenuator in front of a mismatched load impedance. The mismatch observed at the input of the attenuator is improved by an amount equal to twice the value of the attenuator. For example, consider a 3 dB attenuator. The signal at the input of the attenuator will

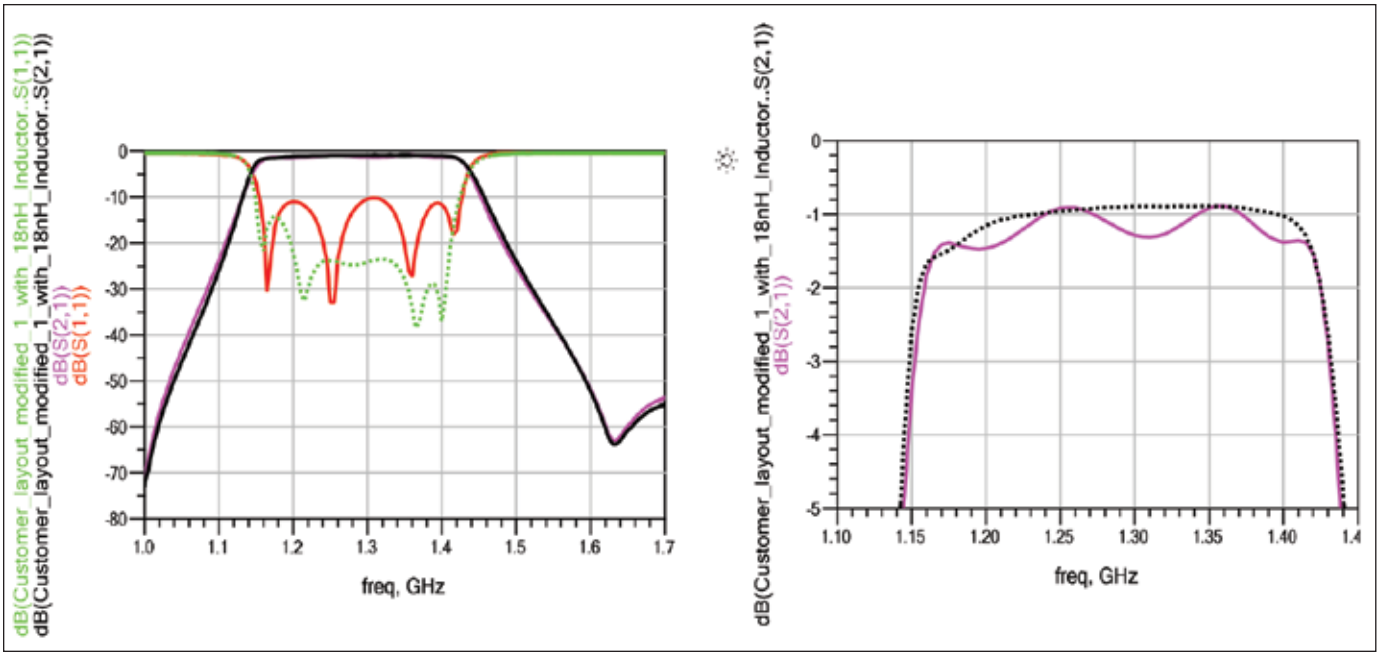

Figure 4 • Return loss plots of CBP-1300F-1+ in customer's board layout versus suggested alternate layout with modified signal pad width.

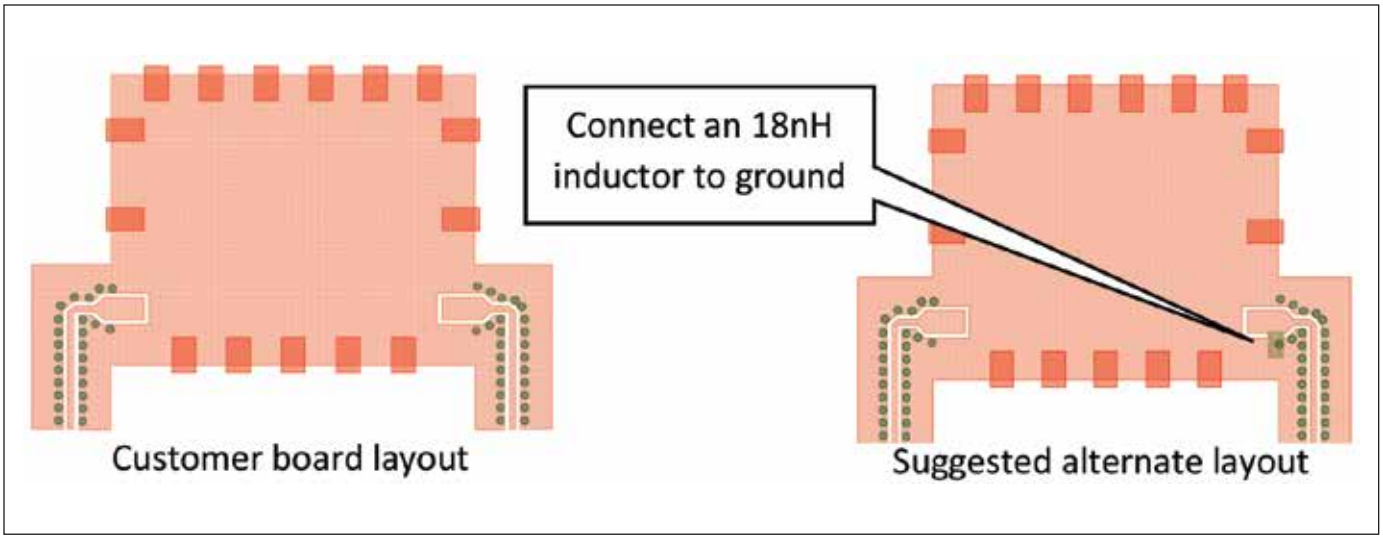

Figure 5 • Customer's board layout of CBP-1300F-1+ and suggested modification connecting 18nH inductor at output.

experience a 3 dB reduction in power by the time it reaches the load. That signal will be 100% reflected by the load and experience another 3 dB reduction in power before returning to the input for a total reduction of 6 dB. Hence the return loss improves by 6 dB, thereby improving the match. The disadvantage of this technique is that the amplitude of the thru-signal is also reduced by 3 dB, which must be compensated for in adjacent networks.

An LC network can also be used as a matching network. This is basically an L-network, which is a simple inductor-capacitor (LC) circuit that can be used to match a wide range of impedances in RF circuits. There are four basic versions of the L-network with two low pass versions and two high pass versions. The low pass versions are probably the most widely used because they attenuate harmonics, noise, and other undesired signals, which is usually necessary in RF system designs. While the L-network is very versatile, it may not fit every situation. There are limits to the range of impedances it can match. In some instances, the calculated values of inductance or capacitance may be too large or small to be practical for a given frequency range. This problem can sometimes be overcome by switching from a low pass L-network to a high pass L-network or vice versa.

Another popular technique is using impedance matching transformers. These transform the load impedance as a square of the voltage-transformation ratio. The ratio of the voltage transformation depends on the number of turns on the input winding (primary), divided by the number of turns on the output winding (secondary). For radio frequency use, transformers are sometimes made from configurations of transmission line, sometimes bifilar or coaxial cable, wound around ferrite cores. This style of transformer provides extremely wide bandwidth, but only a limited number of ratios (such as 1:9, 1:4 or 1:2) can be achieved with this technique. At the same time, the ferrite increases the inductance dramatically while also lowering its Q-factor. The cores of such transformers generally enhance performance at the lower end of the frequency range.

Real World Application

Mini-Circuits CBP-1300F-1+ is a ceramic resonator band pass filter with a pass band from 1200 to 1400 MHz. A particular customer had used this model on a PCB such that the ratio of signal pad width to transmission pad width was 1:4. The customer sought recommendations to improve the matching of the circuit, and Mini-Circuits offered two suggested options.

Option 1: Modify the signal pad to match the width of the transmission pad

As we've shown, modifying the width of the signal pad to match the width of the transmission pad will minimize mismatch between the component and the substrate. The customer board layout and the suggested modification are shown in figure 3.

The modified layout was tested in comparison to the customer's board layout by sweeping return loss measurements from 1000 to 1700 MHz. Results from the test are shown in figure 4.

Testing revealed that altering the signal pad width significantly improved matching. The solid red trace in figure 4 shows the return loss performance of the customer's board layout of about 10 dB. The dotted green trace shows the return loss performance after the signal pad width was modified. Return loss in this case improved to about 20 dB and pass band ripple has been significantly reduced as well.

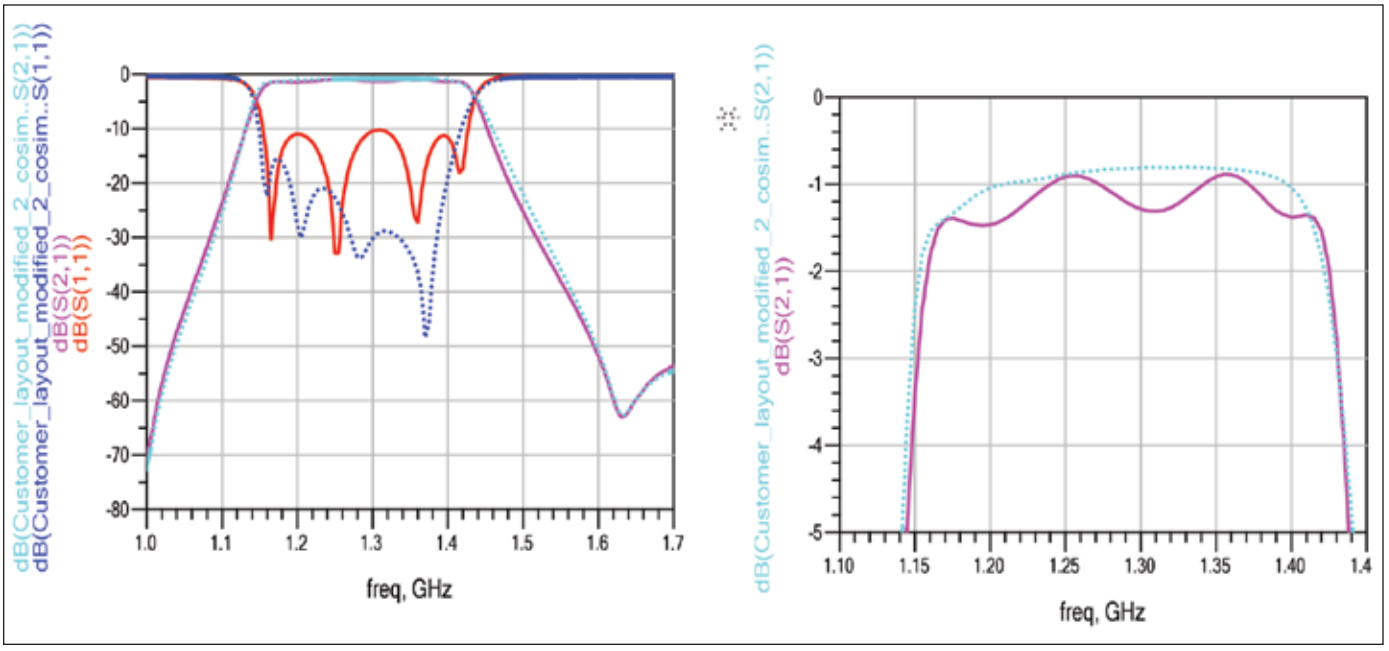

Figure 6 • Return loss plots of CBP-1300F-1+ in customer's board layout versus suggested alternate layout with 18nH inductor at output.

Option 2: Connect an Inductor to Ground at the Output

Another method to improve matching in the circuit is to connect an 18nH inductor to ground at the output of the filter as shown in figure 5. This creates an LC matching network where the shunt capacitor effect is reduced by resonating with the 18nH inductor.

Again, testing was performed comparing the return loss of the customer's board layout to that of the alternate layout across the 1000 to 1700 MHz range. Results are shown in figure 6.

Connecting an 18nH inductor to ground has again improved matching in the circuit. The solid red trace represents the return loss performance in the customer board which has return loss of about 10 dB and the dotted blue trace shows the performance after connecting a 18nH inductor to ground at the outout. Return loss in the latter case was improved to 20 dB and passband ripple has been reduced.

Conclusion

Impedance matching is a problem that arises in many circuits, and techniques to improve mismatch are often necessary. The solutions discussed above can help provide good impedance matching when a customer's circuit board has different pad layouts than those of the component being used. The most appropriate technique will depend on the particular circuit and cause of the mismatch.

References:

1. David M. Pozar, *Microwave Engineering* (Hoboken, NJ: John T. Wiley and Sons, Inc., 2012)
2. Kirt Blattenberger, "VSWR Reduction by Matched Attenuator" *RF Café,* last modified September 16, 2015. http://www.rfcafe.com/references/electrical/vswr-reduction.htm
3. Lou Frenzel, "Back to Basics: Impedance Matching (Part 2)," *Electronic Design,* last modified September 21, 2015. http://electronicdesign.com/communications/back-basics-impedance-matching-part-2

Software Used:

Agilent ADS®

Signal Source Analyzer Series Extends Measurement Capability to 26 GHz

Berkeley Nucleonics has enhanced the 7000 series of fully automated signal source analyzers and extended the measurement capability to 26 GHz. In addition to measuring absolute phase noise on a large variety of CW sources with offsets from 0.01 Hz to 50 MHz, the 7000 series performs residual and absolute phase noise characterization of CW and pulsed signals, transient analysis and VCO characterization. High speed measurement modes are optimized for automated testing, making the 7000 series a very versatile signal source analyzer for both R&D and production testing.

> "The instrument is simple to use and offers high accuracy and reproducibility combined with measurement speed."

The instrument is simple to use and offers high accuracy and reproducibility combined with measurement speed. It has a high dynamic range with low system noise floors, while offering an attractive cost for labs and production environments. Two models are available that are application dependent: Model 7070 covers 5 MHz to 7 GHz and Model 7300 covers 5 MHz to 26 GHz. The instruments are Ethernet, USB or GPIB controlled and "plug and play" with any standard computer. The entire instrument is enclosed in a compact, fan less, 3U, 19 inch chassis and weighs 10 kg.

Developing the product on a fully integrated, low power platform avoided fan cooling, as well as eliminated spurious signals, ground loops and power line loops. By using an external battery, this unit can be operated anywhere, without needing AC power. The instrument includes multiple accessible tuning voltages, and the dual programmable low noise power supplies each provide up to 15 V and greater than 500 mA current. The ultra-low noise close to carrier phase noise internal reference synthesizers are adequate for most applications, even when very low close-in phase noise or noise floors are measured; however, external references can be applied to maximize the use and flexibility of the instrument. A PC, laptop or tablet serves as the control unit, so no displays are incorporated in the instrument. This minimizes cost and increases reliability.

Berkeley Nucleonics
berkeleynucleonics.com

Product Highlights

Shielded Box

The new R&S TS7124 RF shielded box from Rohde & Schwarz offers the best shielding effectiveness, the largest interior dimensions and the most flexible antenna configurations in its class. It provides reliable, reproducible measurement results in a shielded test environment, especially during the production of wireless devices. Shielded RF test boxes are essential for testing the radio interfaces of wireless devices because they provide a test environment that is free from interference and other unwanted emissions. The R&S TS7124 RF shielded box is the latest addition to the Rohde & Schwarz R&S TS712x family. Unique in its class, the R&S TS7124 offers shielding in excess of 80 dB at 6 GHz.

Rohde & Schwarz
rohde-schwarz.com

Coaxial Adapter

Krytar expanded its line of microwave coaxial adapters with a new Within Series model offering application coverage over the frequency range of DC to 67.0 GHz. The Model 4030 adapter is a straight-body style constructed with 1.85-mm male gender (plug) and female gender (jack) connectors. This 50 Ohm adapter is manufactured to precise RF specifications and has a maximum VSWR of 1.25:1 (50-67 GHz). It offers superior performance ratings including low insertion loss of DC - 7 GHz: 0.040*√f GHz; 7 - 67 GHz: 0.035*√f GHz; and RF Leakage of less than -100 dB.

Krytar
krytar.com

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† Model RCDAT-3000-63W2+ specified from 50 – 3000 MHz; 120 dB models specified from 1– 4000 MHz
†† No drivers required. DLL objects for 32/64 bit Windows® environments using ActiveX® and .NET® frameworks.

Mini-Circuits®

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Product Highlights

VNA Extension Modules

OML's VNA extension modules extend from 50 to 500 GHz and enable engineers to conduct mm-wave S-parameter measurements. Compatible with most modern vector network analyzers; these modules also include options for variable attenuation, amplification in RF & LO paths and intermodulation. Contact OML for more options and solutions for your needs.

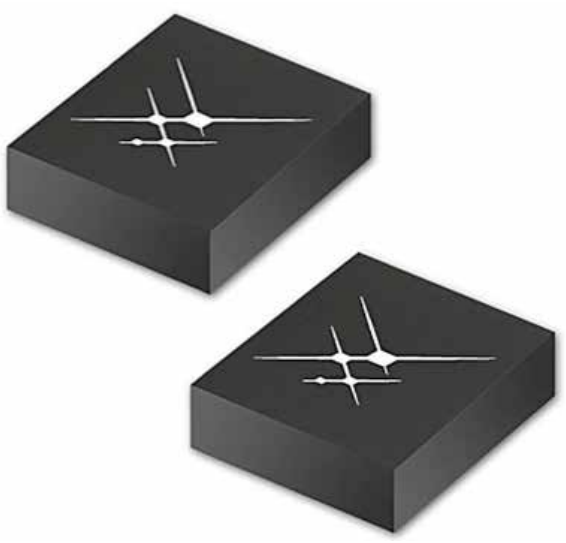
OML
omlinc.com

Peak Power Sensor

LadyBug Technologies' LB679A Peak and Pulse Sensor utilizes patented no-zero no-cal technology to deliver high accuracy statistical pulse information without zeroing the sensor before use. The USB Sensor offers frequency coverage from 50 MHz to 18 GHz. The product's broad frequency range combined with good sensitivity makes it ideal for satellite, radar, and defense applications. The LB680A is similar and adds trace based measurements. These measurements provide a visual time domain trace of the pulse power. Both sensors are provided with a complement of software that includes programmatic support for ATE builders. Triggering, Recorder Output and Optional connectors are available.

LadyBug Technologies
ladybug-tech.com

Product Highlights



FEMs

Skyworks offers two low-power Bluetooth® low energy (BLE) front-end modules (FEMs) for connected home, wearable and industrial applications. The SKY66110-11 and SKY66111-11 FEMs operate between 2.4 to 2.485 GHz, with power consumption of only 10 mA in transmit mode. They are suitable for products operating from coin cell batteries including sensors, beacons, smart watches, thermostats, smoke and carbon dioxide detectors, wireless cameras and audio headphones, hearing aids and medical pendants.

Skyworks
skyworksinc.com

Two-Part Silicone

Master Bond MasterSil 972TC-LO passes the rigorous requirements for low outgassing per ASTM E595 specifications. It is particularly well suited for use in vacuum environments as well as applications in the aerospace, electronic, opto-electronic and specialty OEM industries. This two part silicone system offers convenient handling for bonding, sealing, coating and potting.

Master Bond
masterbond.com

Product Highlights

Mixer

Model SFS-73336315-12SFKF-E1-M is an E Band sub-harmonically pumped mixer that utilizes high performance GaAs MMIC chips to offer superior RF performance. The required LO frequency and power are 35 to 38 GHz and +16 dBm, respectively. The mixer exhibits 15 dB nominal conversion loss in the RF frequency band of 70 to 76 GHz. Amplitude unbalance is within ±1 dB and phase unbalance is ±20 degrees typically. IF frequency bandwidth is from DC to 5 GHz. The mixer offers high RF to LO port isolation.

SAGE Millimeter
sagemillimeter.com

Amplifier

Richardson RFPD announced availability and design support for a GaAs MMIC low-noise, wideband amplifier from Analog Devices. The HMC753LP4E operates between 1 and 11 GHz, providing up to 16.5 dB of small signal gain, 1.5 dB noise figure, and output IP3 of +30 dBm, while requiring only 55 mA from a +5V supply. The P1dB output power of up to +18 dBm enables the LNA to function as an LO driver for balanced, I/Q or image reject mixers. Ideal for high capacity microwave radios or VSAT applications.

Richardson RFPD
richardsonrfpd.com

Product Highlights

Tech Trends Report

The NI Trend Watch 2016 annual report examines a range of topics focused on the IoT and its impact on how we manage data – from the consumerization of software to prototyping 5G to make it a reality. "As the world becomes more connected, the incredible amount of real-world data available today promises engineers and scientists great insight, but getting that insight can be a challenge," said Eric Starkloff, NI executive vice president of global sales and marketing.

National Instruments
ni.com/trend-watch

Splitter

Mini-Circuits' Z2PD-622SMP+ is a connectorized wideband 2-way 0° splitter/combiner supporting a wide variety of applications from 350 to 6200 MHz. This model is capable of handling up to 10W RF input power as a splitter and provides low insertion loss, good isolation and low phase and amplitude unbalance. It comes housed in an ultra-thin aluminum alloy case (1.98 x 4.41 x 0.43") with SMP snap-on connectors, saving space in crowded system layouts.

Mini-Circuits
minicircuits.com

Product Highlights

SMA Terminations

P1dB announced a line of SMA Terminations that operate to 6 GHz, 18 GHz and 26 GHz. The RF Loads are SMA Male, stainless steel body designs that can handle up to 2 Watts of CW power. The most common termination is the P1TR-SAM-18G2W SMA Male, 18 GHz Termination, with other connector types available on P1dB's RF Terminations webpage.

P1dB
p1db.com

SSPA

Teledyne Paradise Datacom announced a Ka-band outdoor SSPA that is based on a single 100 watt GaN module. Two and four-module models can generate power levels that exceed those of TWTAs commonly used at gateway earth stations today. With the superior reliability of solid state technology, the new SSPA finally gives operators of HTS and all other gateway earth stations the opportunity to achieve dramatic long-term CapEx savings by deploying high power SSPAs in lieu of TWTAs.

Teledyne Microwave
teledynemicrowave.com

Product Highlights

PA Modules

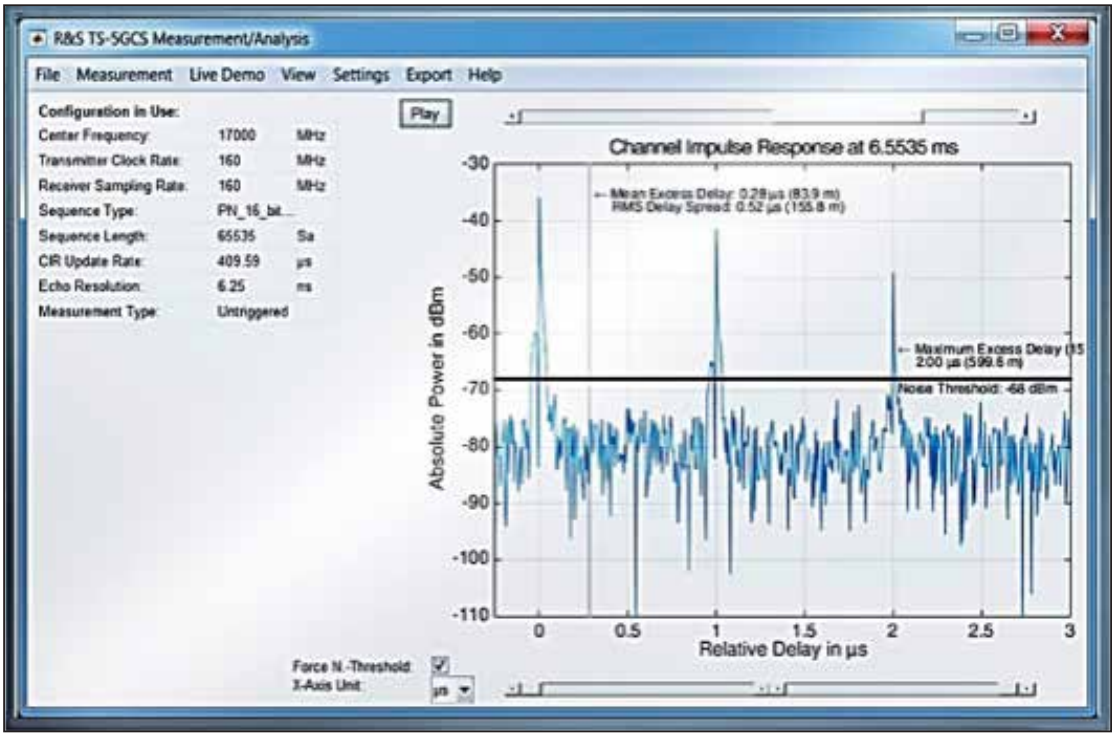
Richardson RFPD announced availability and full design support for two new Wi-Fi-integrated PA modules from Qorvo. The RFPA5522 and RFPA5542 are three-stage power amplifiers designed for 802.11a/n/ac applications. The integrated input and output 50Ù match reduces the layout area, bill of materials and manufacturability cost in the customer application. They are manufactured on an advanced InGaP heterojunction bipolar transistor (HBT) process and are capable of achieving linear powers up to +23 dBm with an EVM <1.8% while maintaining excellent power added efficiency.

Richardson RFPD
richardsonrfpd.com

W-Band Receiver

Model SSR-9630831560-10-S1 is a W-Band receiver. The receiver has a typical conversion gain of 15 dB with a typical RF input power of -60 dBm in the frequency range of 92 to 100 GHz and a IF output frequency range of DC to 4 GHz. The required LO power and frequency range are +5 dBm and 16.0 GHz . The LO and IF port are both equipped with female SMA connectors and the RF port is a WR-12 waveguide with a UG-387/U flange.

SAGE Millimeter
sagemillimeter.com



Channel-Sounding Software Enables Channel Measurement in High-Frequency Bands

Two aspects of 5G set it apart from previous generations: On the one hand, fifth generation mobile radio will open up new frequency bands for commercial wireless communications in the microwave and millimeter wave ranges. On the other hand, it will extend the wanted-signal bandwidth. The new wireless communications channels will require comprehensive analysis to ensure optimal utilization. Channel sounding is the primary method of doing this.

Using the new R&S TS-5GCS channel sounding software together with an R&S FSW signal and spectrum analyzer and an R&S SMW200A vector signal generator makes it possible to comfortably measure channels in high frequency bands. The R&S SMW200A has a frequency range of up to 40 GHz and is used as the sounding signal source. The R&S FSW operates as a receiver and can be employed with various frequencies and bandwidths. The R&S FSW85, for example, enables users to analyze sounding signals up to 85 GHz without an external mixer. Adding the R&S FSW-B2000 option extends the possible analysis bandwidth to 2 GHz. The combination of 85 GHz and 2 GHz is unique on the market.

Users need to know the exact transmission path characteristics in order to measure wideband radio signals between a transmitter and a receiver. Channel sounding makes it possible to determine the impulse response of a transmission channel or mobile radio channel. The R&S TS-5GCS PC application software delivers the channel impulse response, which provides information about the influence of an observed channel on a given radio signal. Possible influences on radio channels include signal echoes caused by reflections, shadowing from buildings and trees as well as weather induced effects. The R&S TS-5GCS software is based on MATLAB and automatically reads the R&S FSW I/Q data. It correlates the received signal with the original calibrated sequence to provide the channel impulse response. Measurement data is displayed graphically.

Rohde & Schwarz
rohde-schwarz.com

Product Highlights

Wireless Test Set

Keysight Technologies announced the successful verification of category 12 data rates with just two component carriers using the UXM's new downlink 4x4 MIMO capabilities. Using two 20 MHz component carriers, 64 QAM downlink modulation, and 4x4 downlink MIMO techniques, Keysight demonstrated 600 Mbps downlink rates using two UXM wireless test sets connected in an array.

Keysight Technologies
keysight.com

Handheld Analyzer

Bird Technologies introduced the SiteHawk SK-200-TC handheld antenna and cable analyzer that operates from 300 kHz to 200 MHz. The instrument makes it simple to detect problems in coaxial transmission lines and antenna systems and pinpoint their source using distance-to-fault measurements. The SiteHawk SK-200-TC provides all of the measurement capabilities required to evaluate the performance of a communication system's transmission path.

Bird Technologies
birdrf.com

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To be considered for publication, please submit text in Word along with a 300 dpi min. color JPG image of your product. *Submit to:*

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Product Highlights

Splitter/Combiner

Mini-Circuits' ZN6PD-272HP+ is a 6-way 0° high-power splitter/combiner providing up to 100W RF input power handling as a splitter and 3.0W as a combiner across the 650 to 2750 MHz frequency range. Its outstanding combination of high power handling and low loss minimize power dissipation and provide excellent signal fidelity from input to output. The splitter/combiner comes housed in a rugged aluminum alloy case measuring 8.08 x 3.25 x 2.38" and is available with your choice of SMA or N-Type connectors and optional heat sink.

Mini-Circuits
minicircuits.com

Attenuator

MECA announced a line of 50watt low-PIM Attenuators, within series and between series in; 4.1/9.5, 4.3/10.0, 7/16 DIN & Type N connectors. With PIM spec of -160 dBc typ, while handling full rated power to +85°C with no power deration over temperature. Covering 0.698 – 2.700 GHz frequency bands and weatherproof IP67 rated. Products are verified for RF performance and PIM tested to the industry standard consisting of 2 x 20 W tones at 25 degrees C in both Cell & PCS Bands.

MECA Electronics
e-MECA.com

Product Highlights

MM-Wave Synthesizers

Micro Lambda Wireless's MLSP-series of low noise frequency synthesizers cover up to 33 GHz. Standard models include MLSP-1829 covering 18 to 29 GHz and MLSP-2333 covering 23 to 33 GHz. Step sizes are programmable from 1 kHz and up using 5 wire SPI or standard USB control. Units are available with internal crystal reference, external crystal reference or both. Output power levels of +13 dBm are provided. Standard models are specified to operate over the 0 to +60 C temperature range, but extended versions covering -40 to +85 C are available on special order.

Micro Lambda Wireless
microlambdawireless.com

Capacitors

Passive Plus now offers a line of Hi-Q Capacitors available in four larger case sizes. Specifically produced for high power / high frequency requirements, these products are available in surface mount or leaded configurations that are 100% RoHS compliant and are also available in a non-magnetic termination. With over 30 years in the RF/Microwave industry, Passive Plus manufactures high quality, high power passive components using state-of-the-art manufacturing techniques.

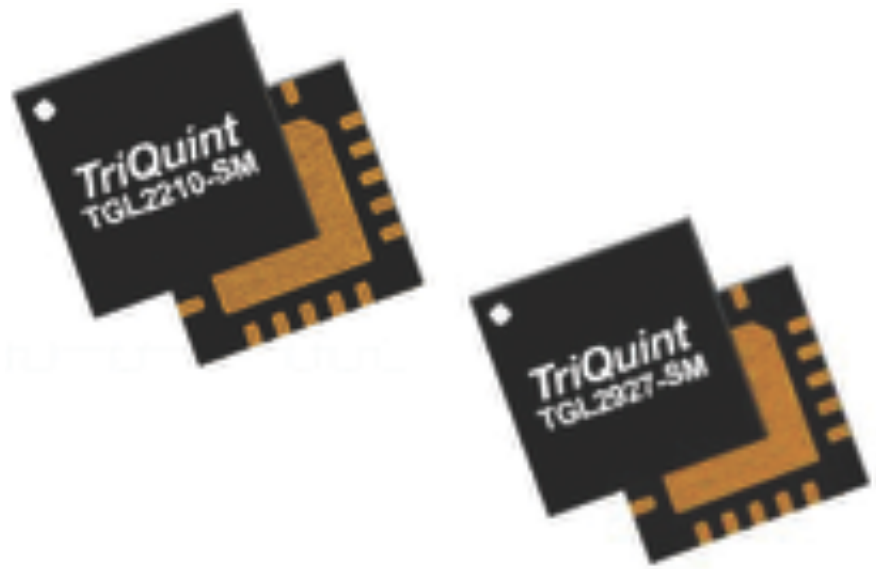
Passive Plus
passiveplus.com

Product Highlights

Integrated Test Solution

Anritsu announced an integrated test solution featuring its MP1800A BERT Signal Quality Analyzer (SQA) and innovative software by Granite River Labs (GRL) that simplifies calibration so engineers can conduct high-quality reproducible receiver and jitter tolerance tests on high-speed devices. The new solution, which also incorporates a noise signal source, variable ISI channel and real-time oscilloscope, allows highly accurate evaluations to be conducted on next-generation PCIe Gen4, 100GbE, InfiniBand and other high-speed serial interfaces for greater design confidence.

Anritsu
anritsu.com



Limiters

Richardson RFPD announced availability and full design support capabilities for two new high-power receive protection circuit limiters from Qorvo. Using Qorvo's passive GaAs VPIN technology, the new devices do not require bias and are offered in small plastic overmold packages. This simplifies system integration while maximizing performance and protection. They are ideal for commercial and military radar applications, communications systems and electronic warfare where protecting sensitive receive components from damage is critical.

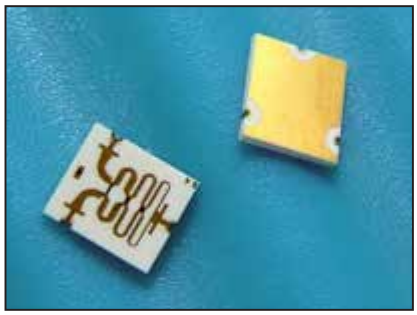
Richardson RFPD
richardsonrfpd.com

Product Highlights

Power Amp

Wolfspeed's portfolio of GaN RF devices for L-, S-, C-, and X-Band radar includes its 25W X-Band GaN MMIC power amplifier for pulsed radar and broadband CW applications, which is now available in a new, smaller form factor footprint. Designated the CMPA801B025, Wolfspeed's X-Band GaN MMIC power amplifier, rated for 25W and 8.5–11.0GHz operation, delivers high performance in a small form factor and features: 37W typical POUT, 16dB power gain, 35% typical power added efficiency (PAE), and <0.1dB power droop.

Wolfspeed
wolfspeed.com



Power Dividers

Knowles (DLI) offers surface mount and wire bondable Wilkinson power dividers offering coverage from 2 to 18 GHz. These devices offer a smaller footprint without compromising performance. Broadband performance with very little excess insertion loss and great isolation. The devices are rated for up to 5 watts of input power handling.

Knowles
knowlescapacitors.com

Product Highlights

Attenuators

Fairview Microwave introduced a line of in-stock and ready to ship high precision waveguide variable attenuators operating to 110 GHz. These continuously variable waveguide attenuators can vary the attenuation level from 0 to 30 dB over the specified band allowing the user to dial in the attenuation level needed for their application. They come in five unique models covering broad frequencies from 33 GHz to 110 GHz in five bands.

Fairview Microwave
fairviewmicrowave.com

Terminations

MECA's Low PIM Terminations now operate down to 380 MHz (-160 to -165dBc). Featuring industry leading thermally stabilized low PIM distortion performance (low thermal noise); In addition to having an overall Low PIM performance all while handling full rated power to +85°C. All of the terminations cover 0.380 – 2.700 GHz frequency bands in Type N & 4.1/9.5, 4.3/10.0 & 7/16 DIN connectors in 10, 30, 50, 100 & 250 watt models.

MECA Electronics
e-meca.com

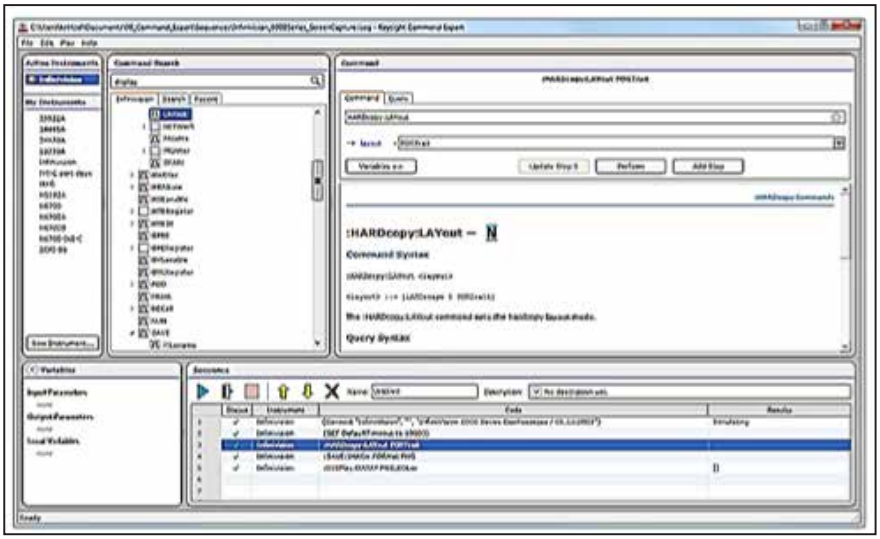
Product Showcase

Product Highlights

Mixers

Pasternack announced new millimeter-wave waveguide frequency mixers available in six down-conversion and six up-conversion models that cover full Ka, Q, U, V, E, and W bands. Designs utilize high performance GaAs Schottky Barrier Beam Lead Diodes in balanced configurations that require a +13 dBm LO drive and display low levels of conversion loss. They are a key building block component of mm-wave receivers used to downconvert very high frequency signals to usable RF frequencies for cost effective signal processing.

Pasternack
pasternack.com

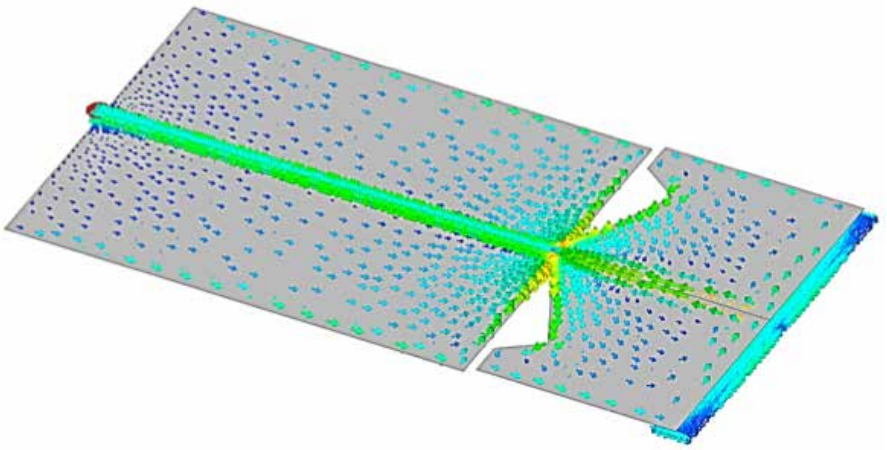


Instrument-Control Software

Keysight's Command Expert is FREE software that provides fast and easy instrument control in many PC application environments. Visit keysight.com to learn more, including: Download Command Expert 1.5 today; Learn about the new features in Command Expert 1.5; Seamless integration with Excel, VEE, SystemVue, MATLAB, Visual Studio, Python, and LabVIEW; Easy to find, use, and view full documentation for SCPI, IVI-C and IVI-COM commands; Simplifies the process of retrieving measurement data from instruments.

Keysight Technologies
keysight.com

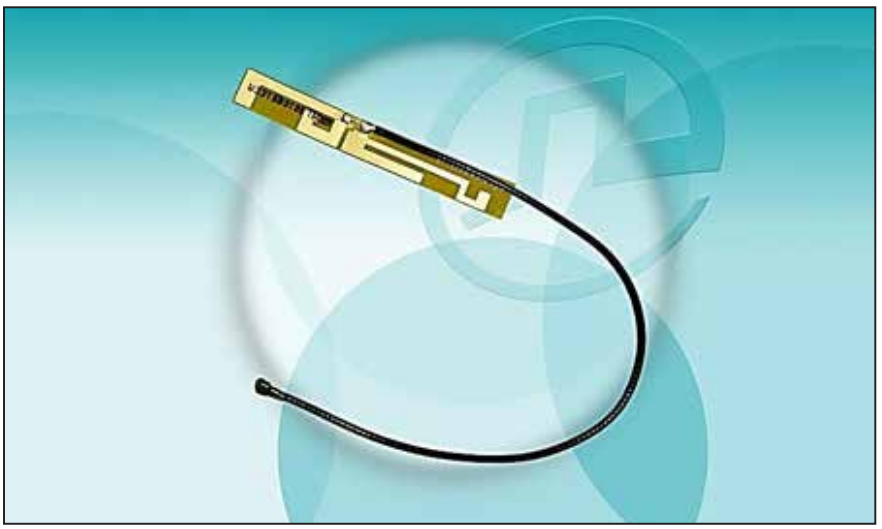
Product Highlights



Equation Solver

Antenna engineers face the challenge of optimizing antenna performance while complying with the functional and geometrical constraints of integrating multi-band antennas into compact devices. This can be simplified with CST's integral equation solver, the Characteristic Mode Analysis (CMA) tool. CMA provides physical insight into the behavior of a conducting surface. Engineers can tune an antenna to the correct resonant frequencies and work out where to place the feed to couple into a particular radiating mode.

CST
cst.com



FPC Antenna

Pulse Electronics introduced a new internal dual-band flexible printed circuit (FPC) antenna to provide connectivity and data transmission for Internet of Things applications in security, home automation, appliances, lighting, medical/telemedicine, sensors, network monitoring, data collection, wearables, automotive, in-vehicle communication, and vending. The Plume Series W3315B0100 WiFi very compact 6 x 45mm antenna has a maximum antenna gain of 2dBi on the low band and 5dBi on the upper band with over 60% efficiency across the bands.

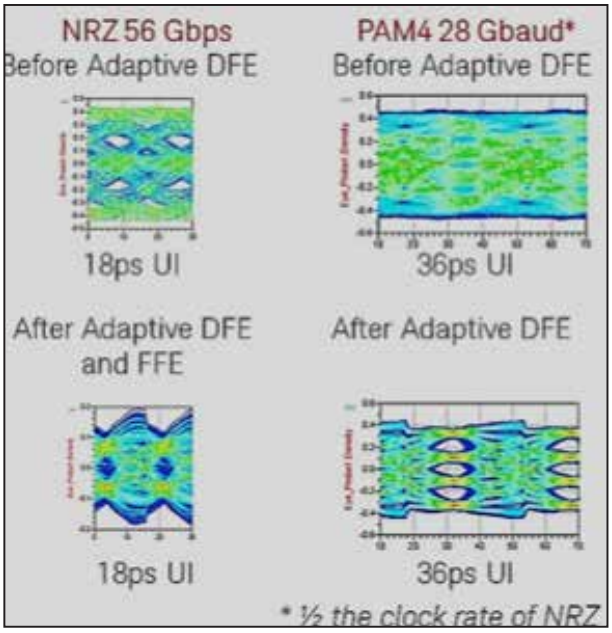
Pulse Electronics
pulseelectronics.com

Product Highlights

Linear Amp

Comtech PST has announced the release of a solid state Class "AB" linear amplifier which operates over the full 6 - 18 GHz frequency band and delivers a minimum of 50 watts. The amplifier uses the latest Gallium Nitride (GaN) technology and is packaged in a standard rack mountable enclosure measuring 19" x 22" x 5.25".

Comtech PST
comtechpst.com



Channel Simulator

Keysight announced a four-level pulsed amplitude modulation (PAM-4) capability for the Keysight EEsof EDA Advanced Design System (ADS) Channel Simulator. With Keysight's new ADS PAM-4 capability, system designers can now use PAM-4 IBIS-AMI models within the industry standard ADS Channel Simulator. Developed in collaboration with leading PAM-4 SerDes IC vendors, the ADS Channel Simulator provides a trusted bit-by-bit simulation engine for PAM-4.

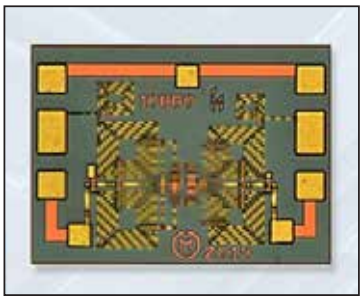
Keysight Technologies
keysight.com

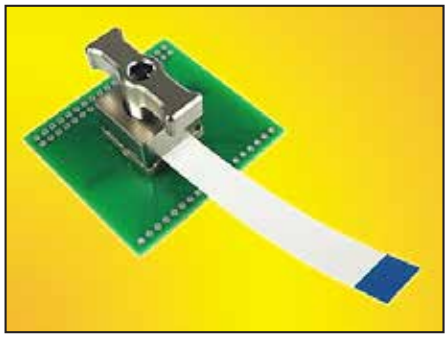
Product Highlights

Multipliers

Custom MMIC expanded its standard product portfolio with three new frequency multipliers/doublers. The multiplier family now covers output frequencies from 8 to 40 GHz, with both passive and active architectures. The active multipliers offer high output power for driving mixers directly, while their passive counterparts offer low phase noise with a lower output power.

Custom MMIC
custommmic.com





Flex Socket

Ironwood Electronics introduced a Flex socket with zero insertion force addressing high performance requirements for testing Flex devices - SBT-FLEX-7000. The contactor is a stamped spring pin with 31 gram actuation force per ball and cycle life of 125,000 insertions. The self-inductance of the contactor is 0.88 nH, insertion loss < 1 dB at 15.7 GHz and capacitance 0.097pF. The current capacity of each contactor is 4 amps at 30C temperature rise. Socket temperature range is -55C to +180C.

Ironwood Electronics
ironwoodelectronics.com

2016

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Jan: Antennas, Cables, T&M

Feb: Design Tools, Power Amps, Mil-Aero

Mar: Attenuators, Bias Tees, DC Blocks

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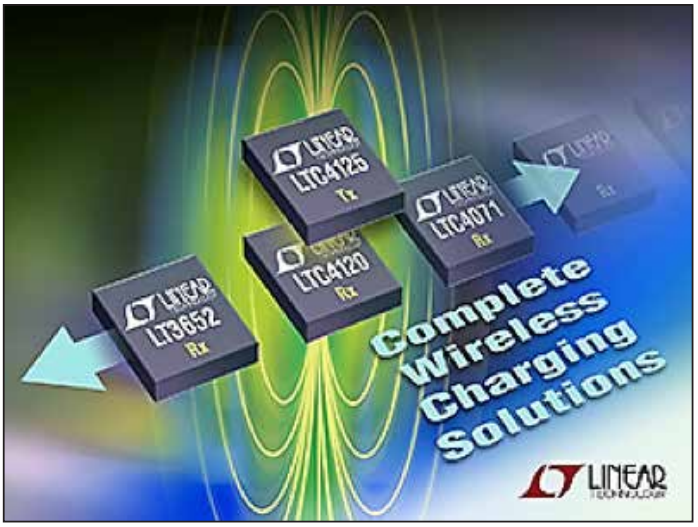
Product Highlights



Wireless Power Transmitter

Linear Technology introduced the LTC4125, a wireless power transmitter, complementing its wireless receiver ICs for the wireless charging market. The LTC4125 is a simple, high performance monolithic full bridge resonant driver, capable of delivering up to 5W of power wirelessly to a companion receiver. It functions as the transmit circuit component in a complete wireless power transfer system comprised of transmit circuitry, transmit coil, receive coil and receive circuitry.

Linear Technology
linear.com

HEMT

Cree's CGHV40050 is an unmatched, gallium nitride (GaN) high-electron-mobility transistor (HEMT). The CGHV40050, operating from a 50-volt rail, offers a general-purpose, broadband solution to a variety of RF and microwave applications. GaN HEMTs offer high-efficiency, high-gain and wide-bandwidth capabilities, making the CGHV40050 ideal for linear and compressed amplifier circuits.

Cree
cree.com

Product Highlights

Downconverter

Model MFC146 is a Dual Band Block Downconverter (BDC) and covers the Ku band segments of 10.7-11.7 GHz and 11.7-12.75 GHz with low noise figure and low phase noise, housed in a compact, rugged low-profile enclosure. It supports Ku band VSAT applications such as in-flight entertainment systems and UAV communications, and is built to withstand challenging airborne environments.

TRAK Microwave
trak.com

Bias Tees

The BTHF (high frequency), BTHC (high current) and BTS (standard) bias tee series enhance the breadth and depth of RF and microwave solutions from TTE Filters. These bias tee series are designed for use in biasing active antennas, amplifiers and laser diodes, and for DC blocking or return in broadband microwave, RF, data communication and ADC/DAC applications, including laboratory test systems.

TTE Filters
tte.com



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Guest Editorial

Women in Microwaves: Growing Our Presence

Sherry Hess, VP of Marketing, AWR Group, NI

A few months ago, I contributed an article to *HFE* on diversity in high technology that was inspired by a keynote talk that the CEO of Intel gave at the Women in Engineering 2015 (WIE) Leadership Conference I attended in Silicon Valley this past April.

Since that time, the IEEE MTT-S Women in Microwaves (WIM) committee has taken the "diversity in high tech" conversation to the International Microwave Symposium 2015 (IMS2015), where a panel discussion on this topic was moderated by Dr. Kate Remley of NIST. Following this, the dialogue continued in both the U.S. and beyond its borders. I recently returned from the IEEE International Conference on Microwaves, Communications, Antennas, and Electronic Systems (COMCAS2015) in Israel, where WIM sponsored a keynote talk by Prof. Orit Hazzan of Technion. Prof. Hazzan has published many papers on the benefits of diversity to the entire science, technology, engineering, and mathematics (STEM) community. Google her name to learn more.

APMC2015

Next up on the schedule for a diversity conversation is Asia-Pacific Microwave Conference (APMC2015) in China in December. A WIM-sponsored special panel session is being co-organized by Professor Dr. Wenquan Che of NUST, Nanjing, China and myself. The list of panelist includes:

- Prof. Wenquan Che of Nanjing University of Science and Technology
- Prof. Stella W. Pang of The City University of Hong Kong
- Prof. Qiaowei Yuan of Sendai University in Japan
- Prof. Xia Xiao of Tianjin University, China
- Prof. Xiuping Li of Beijing University of Posts and Telecommunications

While I was also hoping to take this talk to India at the IEEE International Microwave & RF Conference (iMARC2015) the same week as APMC, my travel schedules and professional commitments did not permit it. Yet the topic is still going on through post-IMS conversations initiated with Dr. Madhumita Chakravarti, DRDO at Research Centre Imarat in Hyderabad, India. The all-female panelists assembled for this session include:

- Jolly Dhar of ISRO
- Swarna Bai as Chair of WIE, IEEE Hyderabad Section
- J Manjula of DRDO
- Rajeswari of AMPL
- Madhumita Chakravarti of DRDO

Outside of my own initiatives, there are many other capable women in high tech in our society who are spawning similar discussions in the U.S. In particular, Dr. Charlotte Blair, a senior applications engineer at ANSYS and active IEEE MTT-S WIM advocate, spearheaded a similar diversity panel within IEEE Regions 1 and 2 in the USA in early November.

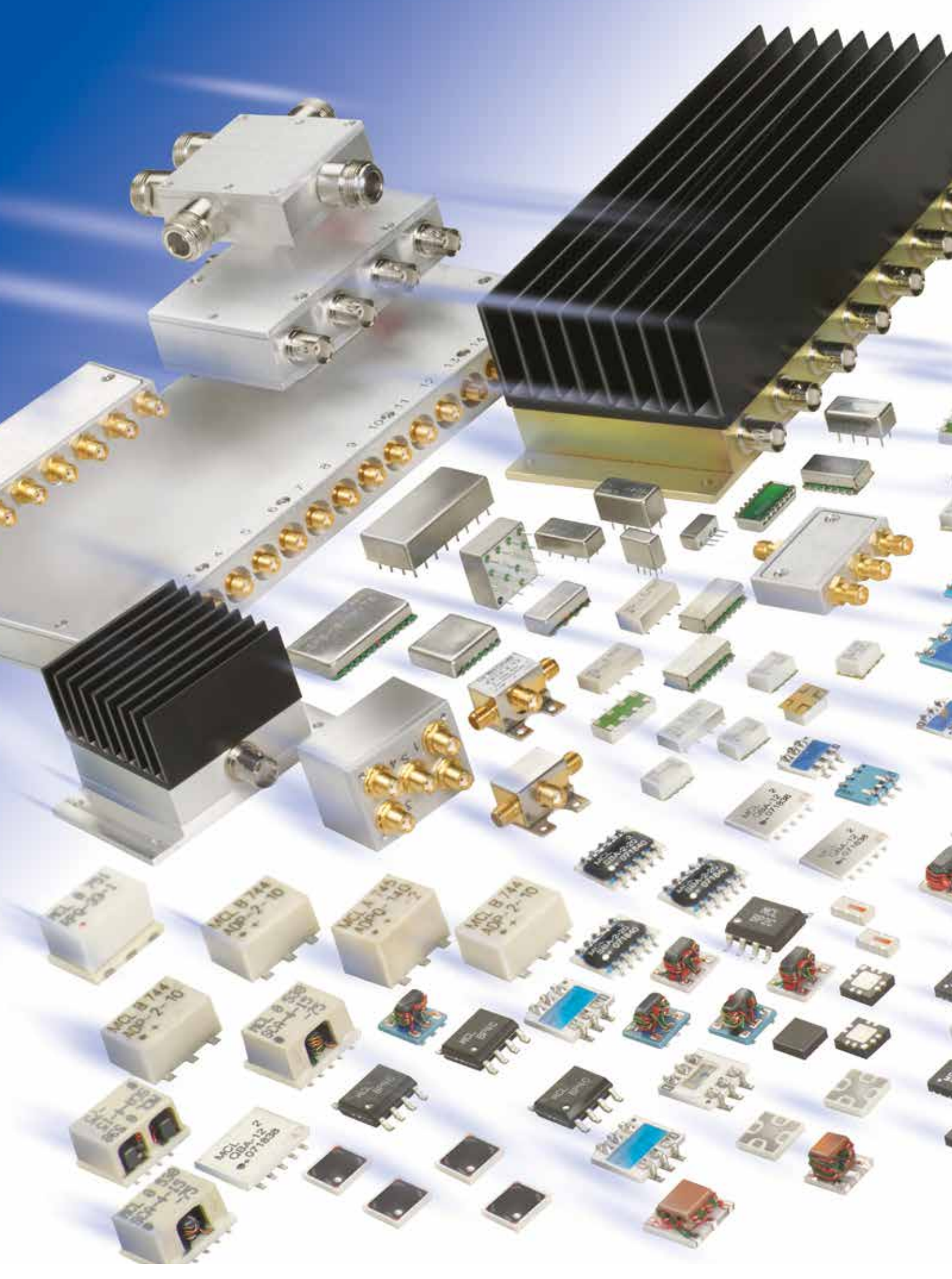
WIM Gaining Momentum

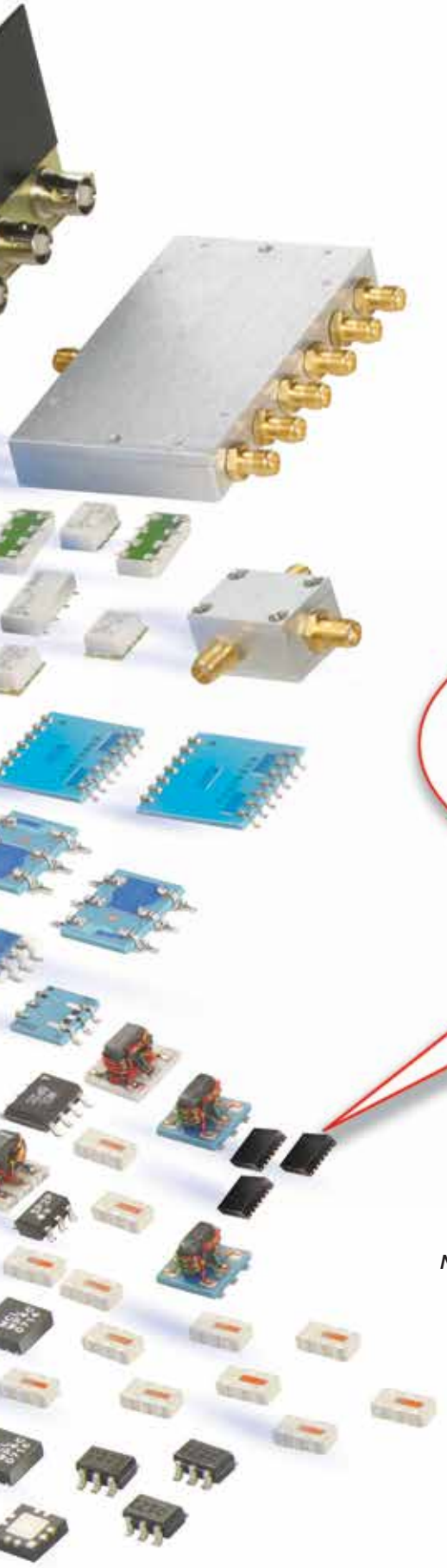
So what does this actually mean? Diversity is a hot topic in our industry? Women in microwaves can relate to it as a demographic? I don't know if I can make a judgment for all, but I do see that it signals that WIM is gaining momentum for being recognized as a demographic within MTT-S that seeks to open up a dialogue each year on a topic that is not only important to women in our society but of general interest to the community as well.

Where do we go from here? We need to continue the momentum on the common dialogue that we started on behalf of WIM within our society at IMS. Let's look at IMS2016 to see how we'll take lessons learned in Phoenix last year and apply them to San Francisco this year.

An all-female technical track is in the works for IMS2016 that will feature impressive women presenters around the theme of wireless technology. This will be followed by a panel session that will focus on career coaching/leadership/mentoring, spearheaded by Berkeley Executive Coaching Institute (berkeleyeci.com) or another successful consulting firm in the Silicon Valley area. After this, a social networking opportunity for women will take place in the evening to enable time for a more informal dialogue amongst fellow female IEEE MTT-S participants.

Like the topic of diversity that resonated with many at IMS2015, we hope our IMS2016 topic on career mentoring will also take on a discussion life of its own that lives beyond San Francisco this coming May.





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