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OCTOBER 2015

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IN THIS ISSUE:

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

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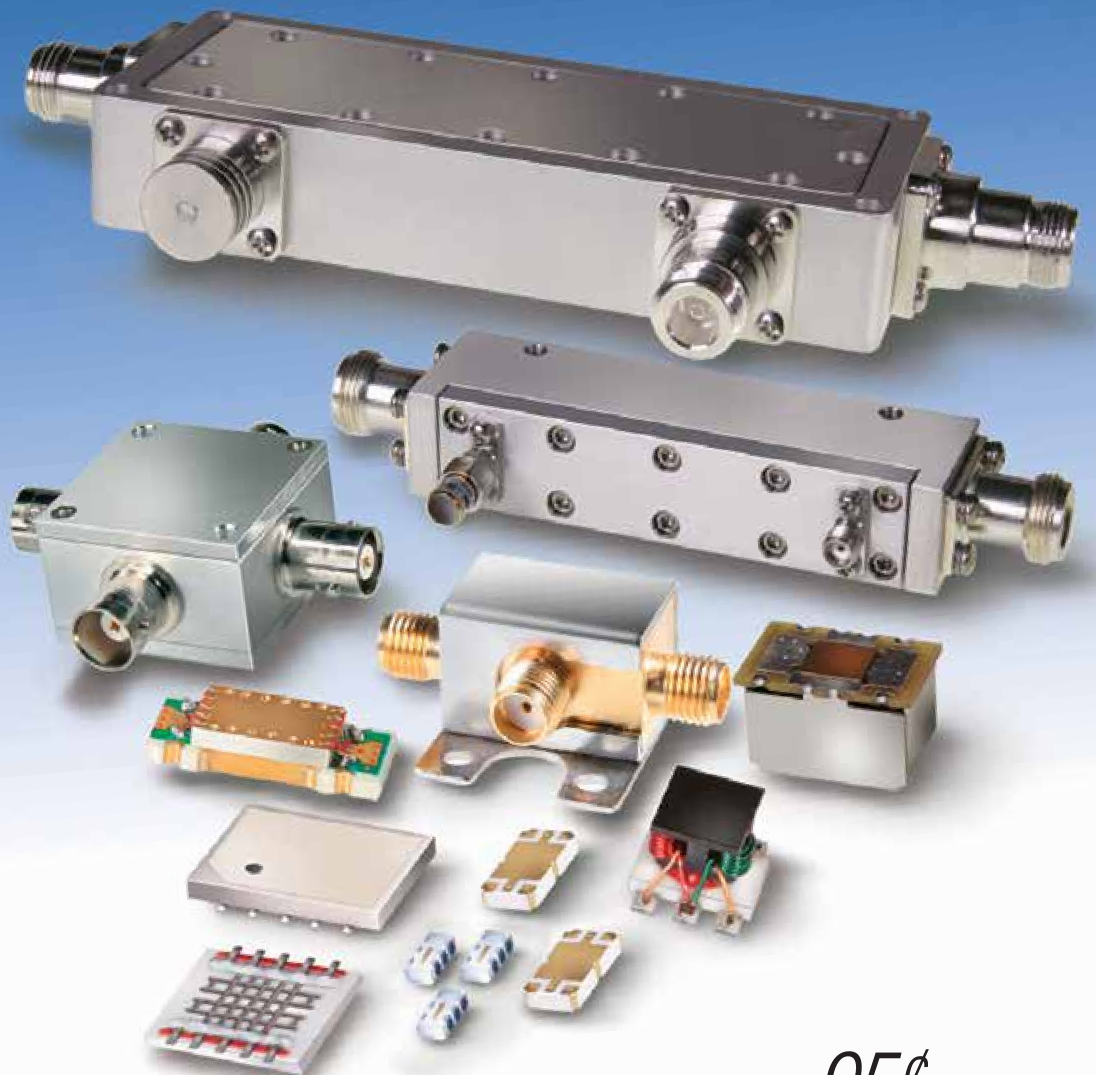

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HIGH FREQUENCY ELECTRONICS

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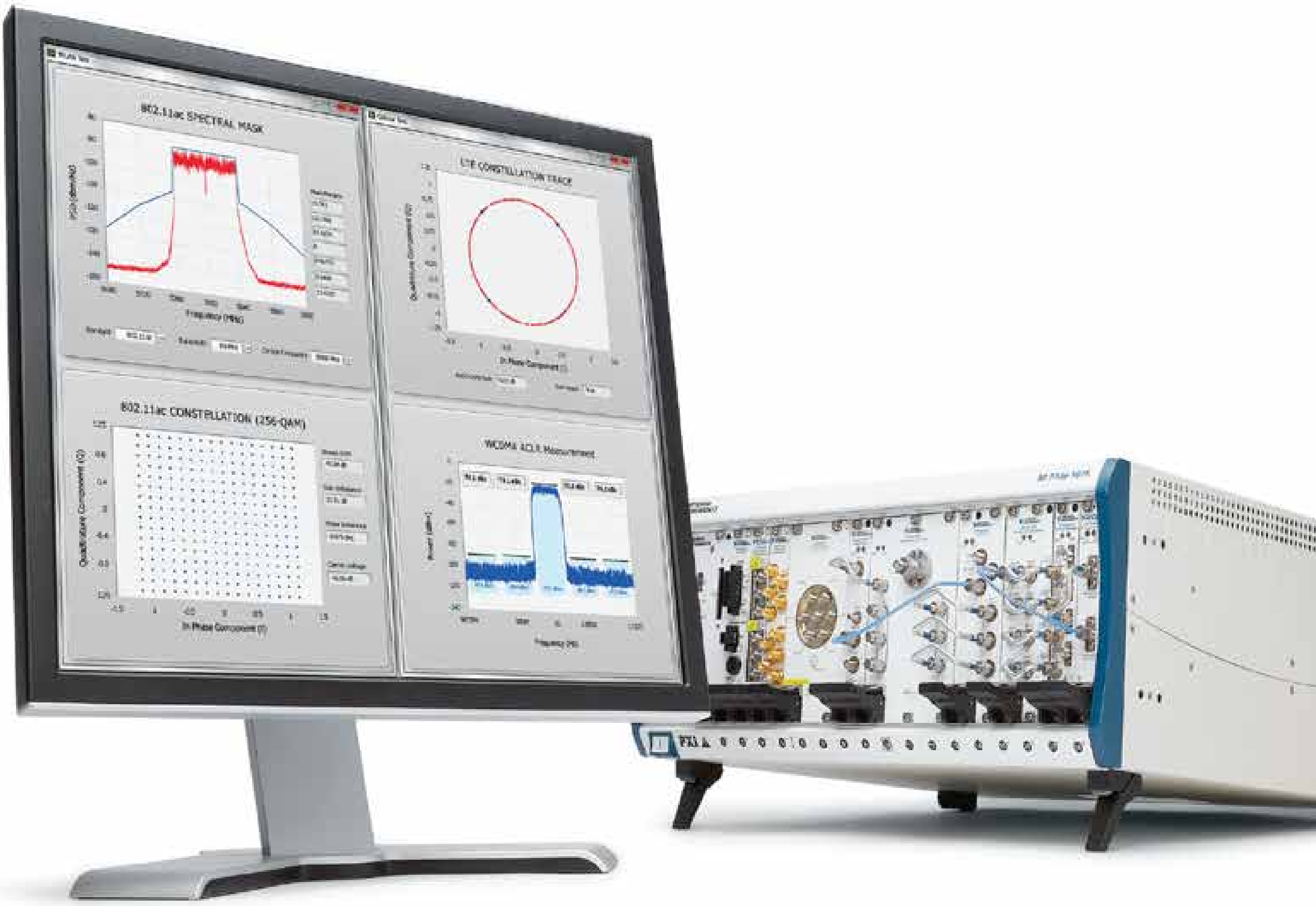

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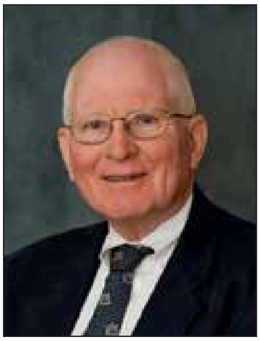
Editorial

The Wayland "Haunting"

Tom Perkins
Sr. Technical Editor



With Halloween just weeks away, the following is an interesting story related to me recently. No, it's not about long delayed echoes (LDE), also called ghost echoes, although that is an interesting and mysterious topic in itself. That phenomena seems to occur on HF frequencies moreso than on VHF, UHF or microwave frequencies.

Since we are on the subject, there are at least five explanations for the HF behavior: 1) Ducting in the magnetosphere and ionospheric reflection, 2) Multiple trips around planet earth, 3) Mode conversion involving coupling to mechanical waves in the ionosphere, 4) Reflection from distant plasma clouds, and 5) Non-linearity in addition to mode conversion. Some delayed signals have been reported up to 20 minutes, which, if strictly propagated in a vacuum, would be about 223 million miles, or represent about 9,000 trips around the world.

We are also not going to discuss Navy personnel warming themselves in front of a horn antenna during WWII. That, too, was spooky at the time, as were many other phenomena in the days of mysterious and misunderstood microwaves.

Raytheon

Now the story. The son of a good friend worked at the Raytheon Equipment Division in Wayland, Mass., over 25 years ago. We'll call him Dr. K. Although not an engineer, he was tied closely to large radar projects and we discussed one of them at some length. The large facility, strictly limited to research and design by apparent town mandate and zoning, was located on land previously dedicated to farming in a picturesque suburb of Boston, close to the town center. To the north and northwest were vast wetlands and swampy land somewhat intersected by the winding Sudbury River. A visit to the area reveals the rich heritage of Colonial America with many well-kept homes, barns, historical markers and occasional ancient taverns, restaurants, hostelries, and grist mills.

Over a period of approximately 40 years, the facility served as a testbed for many radar system prototypes. A casual sightseer passing through would have no idea, as most of the equipment was well hidden from the main roads. Dr. K was working on a very high power UHF search radar that had a mechanically steered azimuth antenna. Because of the effective radiated power (ERP), and possibly other criteria, it was permitted to radiate only over a very narrow "window" as it made its 360-degree sweep. This would generally be out over the unpopulated wetlands, which extended for several kilometers.

One day Dr. K was asked by his manager to pay a visit to a nice colonial farmhouse neighboring the facility. Once there, an elderly lady invited him in, perhaps served tea and said that for some time her house had been haunted. She believed it was due to some sort of "Raytheon demons." She lived alone and was terrified at times from eerie sounds, seemingly out of nowhere. After hearing the lady's descriptive story of low-frequency "wooing" noises, Dr. K called the plant and asked operators to turn on the radar.

Tracking the Source

There was initially nothing heard or felt but suddenly an eerie, audible sound emanated for a many milliseconds, repeating periodically several times a minute. Dr. K carefully searched for the source of the sound. He eventually traced it to an electronic organ, apparently plugged in, but powered off. The edge of the radiated beam was strong enough at the home to stimulate parts of the organ through diode rectification or otherwise cause some sort of conduction in whatever devices it had, probably transistors. One could speculate several possibilities. If the radar was sometimes operated after dark, this would have added to the spooky intrusion. The corrective action was to move or narrow the radiated beam. The "haunting" thus ceased.

To the casual observer, the defense contractor facility would appear to be "misplaced." But the availability of an outdoor radar range in such proximity to Boston and nearby manufacturing facilities was a big benefit during the Cold War. The tax benefits to the town were likely equally lucrative. The Raytheon Wayland facility, built circa 1955, no longer exists, since replaced by upscale shops and residential housing facilities.

With EMI/EMC increasingly a big issue, particularly since many devices are interconnected wirelessly, this actually makes a good story for today's engineers and technicians. It also crudely exhibits the possibilities for wireless power transfer, directed energy, and energy harvesting. So, this Halloween—don't be afraid, investigate thoroughly, and may your pumpkin have a smiley face!

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Meetings and Events

Conferences & Meetings

2015 IEEE International Conference on Ubiquitous Wireless Broadband (ICUWB)
4 – 7 October 2015
Montreal
www.icuwb2015.org

2015 IEEE 24th Electrical Performance of Electronic Packaging and Systems (EPEPS 2015)
25 - 28 October 2015
San Jose, California
http://epeps.ece.illinois.edu
Paper Submission Deadline: 26 June 2015

2015 IEEE International Conference on Microwaves, Communications, Antennas and Electronic Systems (COMCAS)
2 - 4 November 2015
Tel Aviv, Israel
http://www.comcas.org
Paper Submission Deadline: 30 May 2015

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

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

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

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

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Market Reports

Demand from Aerospace and Defense Boosts Prospects for T&M Vendors

The aerospace and defense (A&D) industry policy of getting things right on the first attempt has created a greater need for testing and measurement/inspection. With a number of complex systems in place, the emphasis is particularly on electronic test and dimensional metrology solutions.

New analysis from Frost & Sullivan finds that the market earned revenues of $3.18 billion in 2014 and estimates this to reach $3.87 billion in 2019 at a compound annual growth rate of four percent.

“Modularity is a key trend in any technologically-evolving industry and A&D is no exception,” said Frost & Sullivan Measurement & Instrumentation Industry Analyst Prathima Bommakanti. “It is a major aspect of aircraft design – components are in the form of separate modules, which are then integrated in the total engine system. Modular components are preferred as they offer scalability and flexibility. This, however, will reduce the cost of tests.”

With strict defense budgets, A&D participants are also less likely to invest in new capital equipment. Along with economic uncertainty and pricing pressure, these factors can negatively affect the growth of the global test, measurement and instrumentation market. Small players will be hit hard as global customers stay conservative and opt for bigger, well-established test equipment vendors.

“Further, widespread use and decreasing prices of electronics mean that end users continually demand attractively-priced software and hardware despite the enhanced performance of products,” noted Bommakanti. “Customers also want more extensive services and support from test and measurement equipment manufacturers.”

Focus on massive upgrades to existing systems and select new installations to improve high throughput connectivity will, nevertheless, create opportunities for testing, instrumentation and measurement equipment vendors that offer products with competitive price-performance attributes. Ease-of-use and minimum set-up time will be highly valued. By ensuring such solutions, which cater to evolving end-user technologies, vendors can considerably improve their market position.

—Frost & Sullivan
frost.com

China Driving RF Power Amp Sales for Wireless Infrastructure

The year 2014 was a banner year for wireless infrastructure hardware, especially RF power amplifiers; and prospects look good for growth through 2020, according to ABI Research. The Asia-Pacific region, including Japan, continues to account for the majority of RF power amplifiers sold into the mobile wireless infrastructure segment. According to Research Director Lance Wilson, “For the foreseeable future the Asia-Pacific region, particularly China, will remain the most important region and focus for RF power amplifiers for wireless infrastructure.”

LTE and TD-LTE have become increasingly important factors in this business and will continue to drive growth for the future. “Up until 2014, LTE had not significantly impacted RF power amplifier sales to the degree some would have wished,” says Wilson, “but that has changed now and as 2014 demonstrated, LTE is going to drive RF power sales in the wireless infrastructure space from 2015 onward.” The continuing overall need for wireless data remains an important driver for the overall market for RF power amplifiers for wireless infrastructure.

RF Power Amplifier Equipment for Cellular and Wireless Infrastructure examines how RF power amplifiers are evolving to the changing topologies of modern base stations, remote radio heads, and active antennas. Quantitative forecasts are presented through 2020.

—ABI Research
abiresearch.com

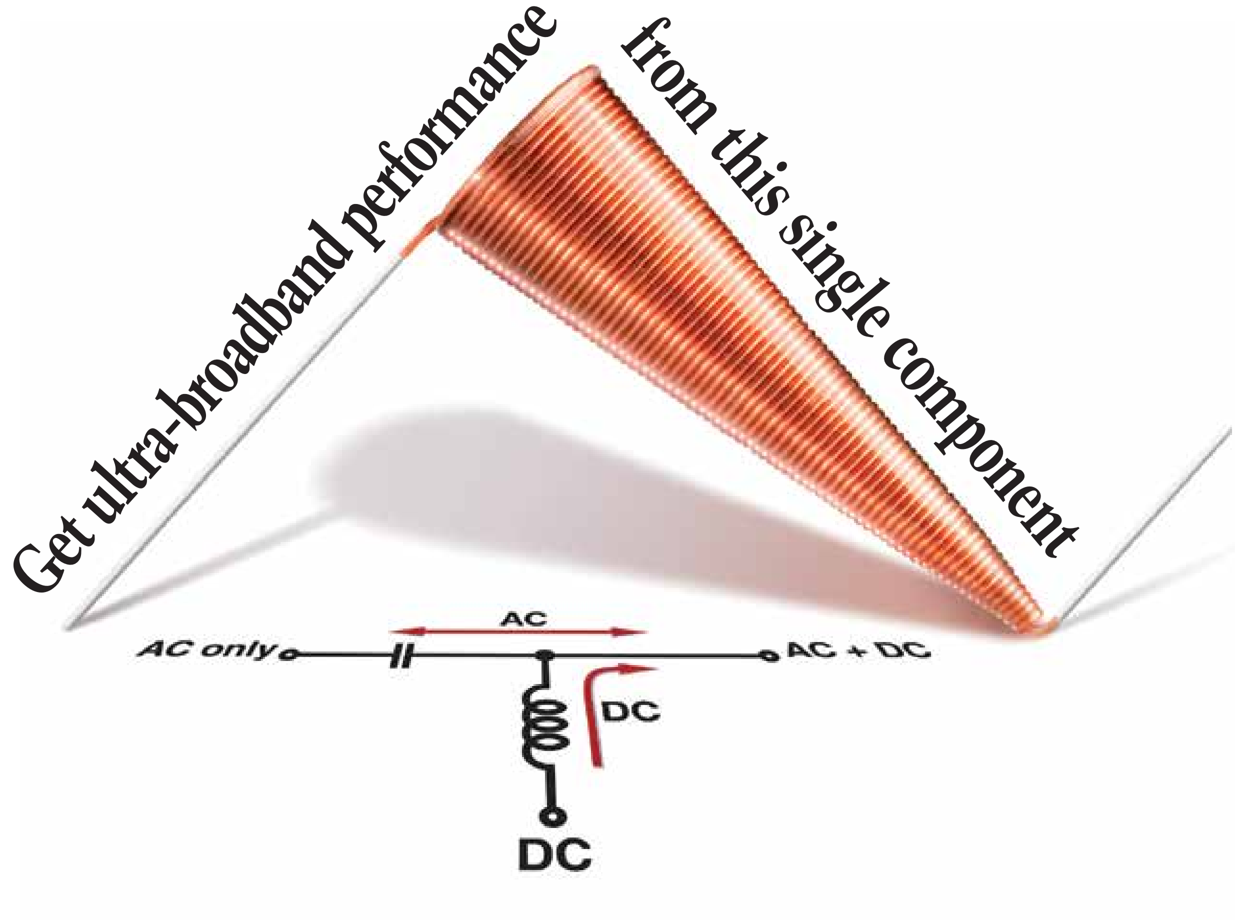
Gartner: Internet of Things Will Change Cybersecurity Forever

Over 20 percent of enterprises will have digital security services devoted to protecting business initiatives using devices and services in the Internet of Things (IoT) by year end 2017, according to Gartner, Inc. Gartner defines digital security as the risk-driven expansion and extension of current security risk practices **that protect digital assets of all forms in the digital business and ensures that relationships among those assets can be trusted.**

“The IoT now penetrates to the edge of the physical world and brings an important new ‘physical’ element to security concerns. This is especially true as billions of things begin transporting data,” said Ganesh Ramamoorthy, research vice president at Gartner. “The IoT redefines security by expanding the scope of responsibility into new platforms, services and directions. Moving forward, enterprises should consider reshaping IT or cybersecurity strategies to incorporate known digital business goals and seek participation in digital business strategy and planning.”

In an IoT world, information is the “fuel” that is used to change the physical state of environments through devices that are not general-purpose computers but, instead, devices and services that are designed for specific purposes. As such, the IoT is at a conspicuous inflection point for IT security, and the chief information security officer (CISO) will be on the front lines of its emerging and complex governance and management.

—Gartner
gartner.com



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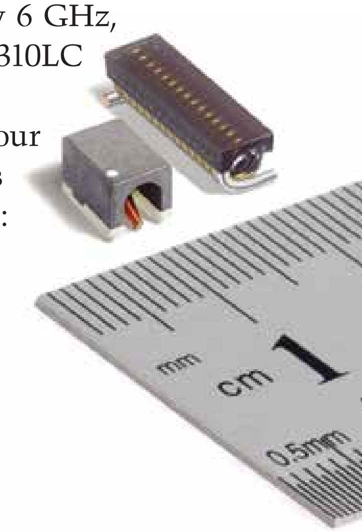

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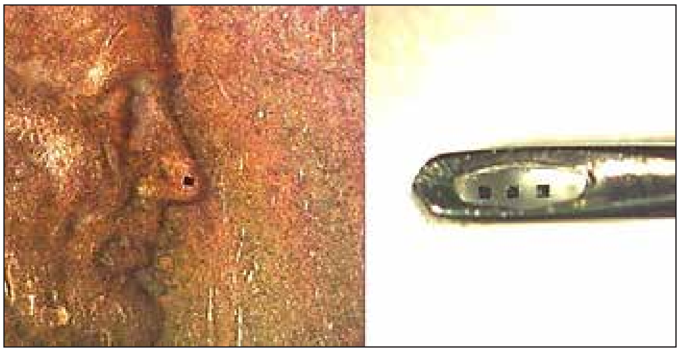

See that black speck on the Lincoln's penny-minted nostril? And on the right, notice another three of those specks comfortably framed by the eye of a needle? Those semiconductor chiplets, or "dielets" as DARPA Program Manager Kerry Bernstein calls them, could become Lilliputian **electronic tamper-watching sentinels affixed to virtually every chip built into commercial and military systems.**

Their future job? To safeguard against an expanding arena of 21st century crime that could threaten the trustworthiness of just about anything with a chip in it—from smart credit cards to engine- controlling automotive computers to F-16 fighter-jet radar systems. **Counterfeit, cloned, and otherwise doctored electronic chips already are circulating in markets and the problem is only likely to grow in the coming years.** Shown here are dummy dielets that DARPA-supported researchers have produced to help them learn how to dice, sort, pick, place and otherwise handle such teensy components, which would affix to individual chips with a footprint the size of a dust speck.

If fully developed as envisioned in DARPA's Supply Chain Hardware Integrity of Electronics Defense (SHIELD) program, each of these dielets will host up to 100,000 transistors and have features and functions remarkable for their scale, among them two-way radio communication, on-board encryption, an energy harvesting function that casts away the need for a battery, and passive sensors for tamper-detection—all the while consuming less than 50 microwatts and costing the equivalent of the portion of a penny occupied by Lincoln's head, that is, a fraction of a cent. "We are on track to build the world's smallest highly integrated computer chip," says Kerry. "If we succeed, then an untrained operator at any place along the supply chain will be able to interrogate the authenticity of any component used by the Defense Department or in the commercial sector, and get high-confidence results back immediately, on site, securely and essentially for free."

* * *

For decades, U.S. military air operations have relied on increasingly capable multi-function manned aircraft to execute critical combat and non-combat missions. Adversaries' abilities to detect and engage those aircraft from longer ranges have improved over time as well, however, driving up the costs for vehicle design, operation and replacement. **An ability to send large numbers of small unmanned air systems (UAS) with coordinated, distributed capabilities could provide U.S. forces with improved operational flexibility at much lower cost than is possible with today's expensive, all-in-one platforms—especially if those unmanned systems could be retrieved for reuse while airborne.** So far, however, the technology to project volleys of low-cost, reusable systems over great distances and retrieve them in mid-air has remained out of reach.

To help make that technology a reality, DARPA has launched the Gremlins program. Named for the imaginary, mischievous imps that became the good luck charms of many British pilots during World War II, the program seeks to show the feasibility of conducting safe, reliable operations involving multiple air-launched, air-recoverable unmanned systems. The program also aims to prove that such systems, or "gremlins," could provide significant cost advantages over expendable systems, spreading out payload and airframe costs over multiple uses instead of just one.

"Our goal is to conduct a compelling proof-of-concept flight demonstration that could employ intelligence, surveillance and reconnaissance (ISR) and other modular, non-kinetic payloads in a robust, responsive and affordable manner," said Dan Patt, DARPA program manager.

The Gremlins program seeks to expand upon DARPA's Request for Information (RFI) last year, which invited novel concepts for distributed airborne capabilities. It also aims to leverage DARPA's prior success in developing automated aerial refueling capabilities, as well the Agency's current efforts to create advanced UAS capture systems for ships.


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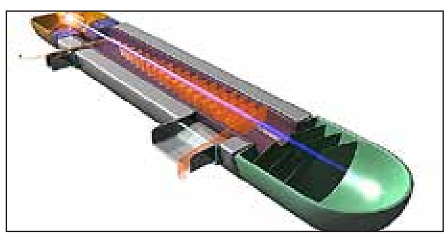
In the News

The program envisions launching groups of gremlins from large aircraft such as bombers or transport aircraft, as well as from fighters and other small, fixed-wing platforms while those planes are out of range of adversary defenses. When the gremlins complete their mission, a C-130 transport aircraft would retrieve them in the air and carry them home, where ground crews would prepare them for their next use within 24 hours.

DARPA plans to focus primarily on the technical challenges associated with safe, reliable aerial launch and recovery of multiple unmanned air vehicles. Additionally, the program will address new operational capabilities and air operations architectures as well as the potential cost advantages.

* * *



Millimeter wave vacuum tubes, including ones like the travelling wave tube (TWT) depicted here, amplify signals by exchanging kinetic energy in the electron beam (shown as a blue line) with electromagnetic energy (shown as a wave) in the signal. This figure represents a cutaway view of a TWT with all of the critical components: electron gun, magnetic circuit, electron collector, and the windows that keep the vacuum inside the tube while letting the signals flow in and out.

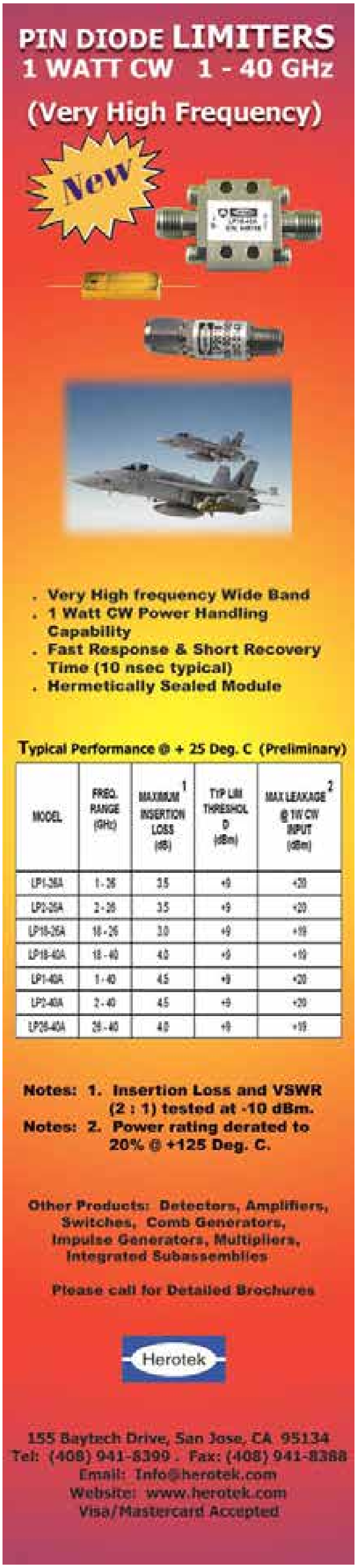
Solid-state electronics began to overtake vacuum tubes in radios, computers and other electronic and radio frequency gadgetry more than 60 years ago. Now we live in a Silicon Age. Even so, vacuum electronic devices, whose origins date to the 19th century, touch our lives every day.

Those microwaves that heat the food in your microwave oven come from a magnetron, the vacuum tube that made radar possible in the first half of the 20th century. **Traveling wave tubes (TWTs), not solid-state amplifiers, generate the strong electromagnetic signals in communication satellites because of their exceptional on-orbit reliability and high power efficiency. And it's the unique ability of vacuum tube electronic devices to generate high-frequency signals at chip-melting operating powers that makes possible modern aviation radar systems for navigation and collision avoidance.** What's more, there are more than 200,000 vacuum electronic devices (VEDs) now in service in the Department of Defense, powering critical communications and radar systems that cover the land, sea, air, and space. With its new Innovative Vacuum Electronic Science and Technology (INVEST) program, DARPA aims to develop the science and technology base for new generations of more capable VEDs.

* * *

JitterLabs

JitterLabs (jitterlabs.com), Milpitas, Calif., announced the launch of an **independent test lab to characterize frequency sources,** and a software-as-a-service application for vendors of clock and timing devices to manage their test data. JitterLabs provides an independent test lab to characterize clock (and clock-like data) signals between 10 MHz and 7+ GHz, such as **output by timing devices, VCOs, PLLs, PHYs,** ASICs, FPGAs, and test equipment. Available measurements include phase noise, jitter, Allan deviation, VCO modulation bandwidth, power supply noise rejection, PLL jitter transfer, and more.



MODEL	FREQ. RANGE (GHz)	MAXIMUM INSERTION LOSS (dB) [1]	TYP LIM THRESHOLD (dBm)	MAX LEAKAGE @ 1W CW INPUT (dBm) [2]
LP1-26A	1 - 26	3.5	+9	+20
LP2-26A	2 - 26	3.5	+9	+20
LP18-26A	18 - 26	3.0	+9	+19
LP18-40A	18 - 40	4.0	+9	+19
LP1-40A	1 - 40	4.5	+9	+20
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CST announced a series of webinars from this month through December, covering trending topics in the world of electrical engineering. They will show how electromagnetic simulation can be used to design, analyze and optimize cutting-edge devices. Topics include graphene, implantable electronics and electrical car motor control, with applications across the spectrum from low-frequency, through microwaves and RF, to optical.

CST
cst.com

Power Amps

Pasternack announced an expanded offering of gallium nitride (GaN) coaxial power amplifiers. These rugged, connectorized designs have the advantage of high output load impedance that offers easier impedance matching over wider bandwidths using lower loss components. Applications include commercial and military radar, jamming systems, medical imaging, communications and electronic warfare.

Pasternack
pasternack.com

IC

Anokiwave announced the first in a family of X-band Silicon Radar Quad Core IC solutions for commercial radar and 5G communications markets. The AWS-0103 supports 4 radiating elements with dual beam Rx, single beam Tx, and includes

6-bit phase and 6-bit gain control. It provides high input linearity in Rx mode and is intended to be used with a GaAs or GaN front end.

Anokiwave
anokiwave.com

Transistors

Infineon introduced a new family of Gallium Nitride (GaN) on Silicon Carbide (SiC) RF power transistors which enable cellular amplifier designers to build smaller, more powerful and more flexible transmitters. Key Features: 70 W to 170 W (P3dB); 1800 MHz to 2700 MHz; high efficiency; broadband capability.

Infineon
infineon.com

Harmonic Mixer

Model SFH-10SFSF-A1 is a W-Band balanced harmonic mixer especially designed for Keysight's spectrum analyzer series. It employs high performance GaAs Schottky flip chip diodes, balanced configuration to produce superior RF performance. The required LO frequency range is 3.0 to 6.1 GHz and power is +16 dBm, which translates the harmonic number 18 and resultants IF frequency range is DC to 1.3 GHz.

SAGE Millimeter
sagemillimeter.com

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Mini-Circuits
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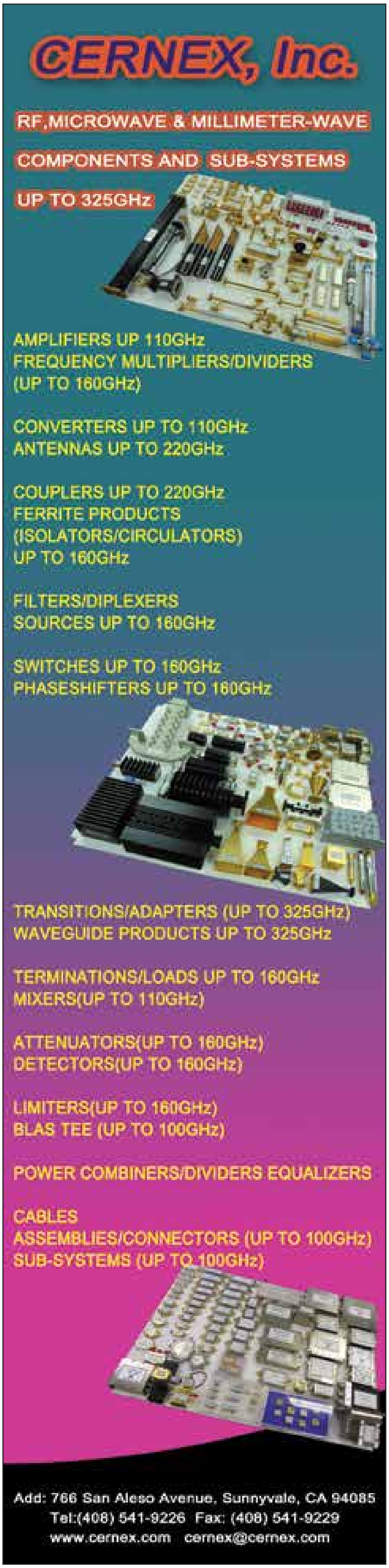

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AtlanTecRF
atlantecrf.com

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BroadWave Technologies
broadwavetechnologies.com

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RF Bay
rfbayinc.com

Instrument Amplifier

The TVA-82-213A+ benchtop instrument amplifier provides extremely wideband performance with 25 dB gain and ±3.0 dB gain flatness across the entire 0.8 to 21 GHz frequency range, ideal for wideband test instrumentation and lab use. It achieves +24 dBm output power at 1 dB compression, +30 dBm OIP3, 3 dB noise figure, 70 dB reverse isolation, and good input/output matching across its entire operating frequency range (1.35 input VSWR, 1.4 output VSWR).

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

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used in automatic test systems to turn on and off the source remotely.

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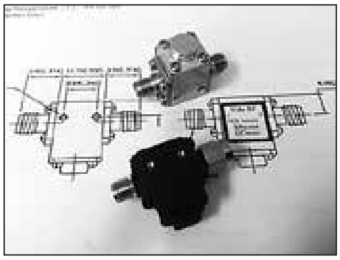
Couplers

Richardson RFPD announced availability and full design support for a selection of broadband surface mount directional couplers from Innovative Power Products. These unique couplers offer low insertion loss, high directivity, low VSWR and high power capability in a small, surface mount package. They are available in narrow- and ultra-broad-bandwidths, making them ideal for power amplifiers, antenna feeds, or anywhere a small sample of the RF signal is required.

Richardson RFPD
richardsonrfpd.com



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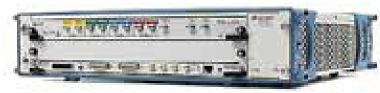
VidaRF
vidarf.com



Waveform Generator

Keysight Technologies added a 92-GSa/s, 32-GHz modular instrument to its portfolio of arbitrary waveform generators. The new high-speed, wide-bandwidth M8196A arbitrary waveform generator allows engineers to generate digital, multi-level (e.g., PAM-4, PAM-8, DMT) signal scenarios at 8 bits vertical resolution and test their electrical and optical links with complex modulated signals up to 64 GBaud.

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88-108	500	0.5	1.5	20	0.2	1.2	PH90-88-108-R5N
	1000	0.5	1.5	20	0.25	1.15	PH90-88-108-1KN
100-500	500	0.8	3	18	0.3	1.3	PH90-100-500-R5N
	1000	0.8	2	20	0.3	1.25	PH90-100-500-1KN
200-400	500	0.5	2	23	0.2	1.2	PH90-200-400-R5N
	1000	0.5	2	20	0.2	1.2	PH90-200-400-1KN
250-1000	250	0.6	2	20	0.4	1.2	PH90-250-1000-R25S
	500	0.6	2	20	0.4	1.2	PH90-250-1000-R5N
400-1000	500	0.6	2	20	0.25	1.25	PH90-400-1000-R5N
	1000	0.6	2	15	0.2	1.2	PH90-400-1000-1KN
800-1600	250	0.4	2	23	0.25	1.2	PH90-800-1600-R25S
	500	0.5	2	20	0.2	1.25	PH90-800-1600-R5N
800-2500	250	0.6	4	20	0.4	1.25	PH90-800-2500-R25S
800-4000	200	0.5	4	18	0.3	1.25	PH90-800-4000-R2S
1000-2000	250	0.5	3	20	0.25	1.2	PH90-1000-2000-R25S
	500	0.5	3	20	0.25	1.22	PH90-1000-2000-R5N
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ZHL-10W-2G+	800-2000	43	10	12	1295
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LZY-22+	0.1-200	43	16	30	1495
ZHL-30W-262+	2300-2550	50	20	32	1995
ZHL-30W-252+	700-2500	50	25	40	2995
LZY-2+	500-1000	47	32	38	2195
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• ZHL-100W-52+	50-500	50	63	79	1995
• ZHL-100W-GAN+	20-500	42	79	100	2395
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Evaluating and Demonstrating Odd Mode Amplifier Stability

By John E. Penn

Explaining odd mode stability and demonstrating it using common CAD tools.

Introduction:

Most Radio Frequency (RF) and microwave engineers know about amplifier stability but may not understand odd mode stability. Computer Aided Design (CAD) tools have the standard stability measures including the single stability parameter mu[1], but these represent "even" mode stability. Often this is sufficient for most amplifier designs unless one is doing a balanced amplifier, or power amplifier, that is, anything that has more than one device in parallel. The purpose of this article is to explain odd mode stability and demonstrate it using the common RF CAD tools, Keysight's Advanced Design System (ADS) and National Instruments/Applied Wave Research's (NI/AWR) Microwave Office (MWO). Also, measured results are shown from an amplifier designed to demonstrate even and odd mode stability.

Often, the best way to learn RF and Microwave amplifier design is to build and test an actual circuit, not just perform a design based entirely on simulations. After all, a significant portion of a typical engineer's time is spent figuring out why something is not working as expected. Simulations can only take one so far, actual measured performance is much more useful.

Hands-On Experience

Many Universities offer engineering courses with hands-on practical experience. Johns Hopkins University's (JHU) Engineering for Professionals (EP) offers several classes that include hands-on practical experience. The author, John Penn, co-teaches one such class, RF & Microwaves II, with Dr. Willie Thompson. Students design a low noise amplifier and a medium power amplifier, then fabricate and test those circuits during one of the laboratory sessions. These designs typically are single stage amplifiers using a single layer Rogers RO4003 dielectric board, 0.06"x0.03" (0603) chip resistors, inductors, and capacitors, plus a Gallium Arsenide (GaAs) Pseudomorphic High Electron Mobility Transistor (PHEMT) in a plastic package, e.g., Avago atf54143 or atf34143.

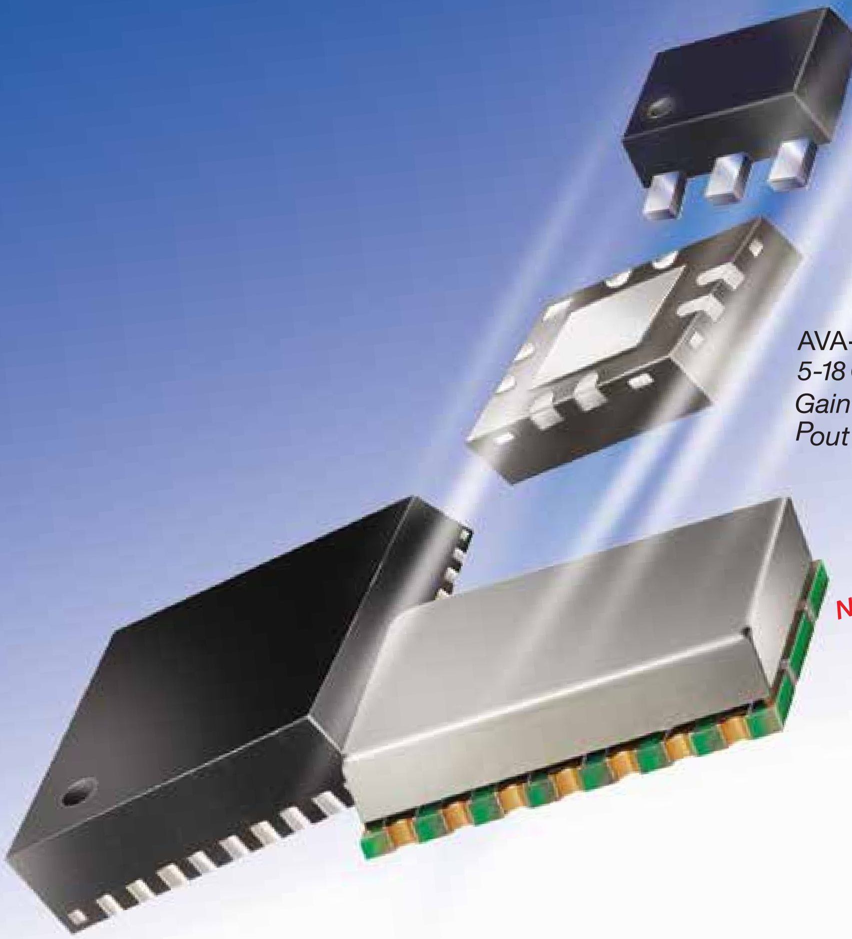
During the course, students learn the different tradeoffs of amplifier design—gain, noise figure, output power, power efficiency, bandwidth, return loss, DC bias, and stability. Sometimes those amplifier designs oscillate unintentionally. Learning how to distinguish the type of oscillation, low frequency versus high frequency, and how to quell the oscillation is an important part of the student's experience of building and testing their designs. When those amplifier designs do not work as expected, yet they are able to figure out and solve the problem—those hard earned lessons make a strong impression.

Usual Solutions

For high frequency oscillations, maybe the tradeoff of gain versus stability was too aggressive in the amplifier design which might be solved by modifying the stabilizing resistor values. Conversely, for low frequency oscillations—a few MHz, providing the appropriate capacitors on your DC bias flags is the likely solution. That 0603 100pf chip capacitor makes a nice RF short

50 MHz to 26.5 GHz

MICROWAVE MMIC AMPLIFIERS



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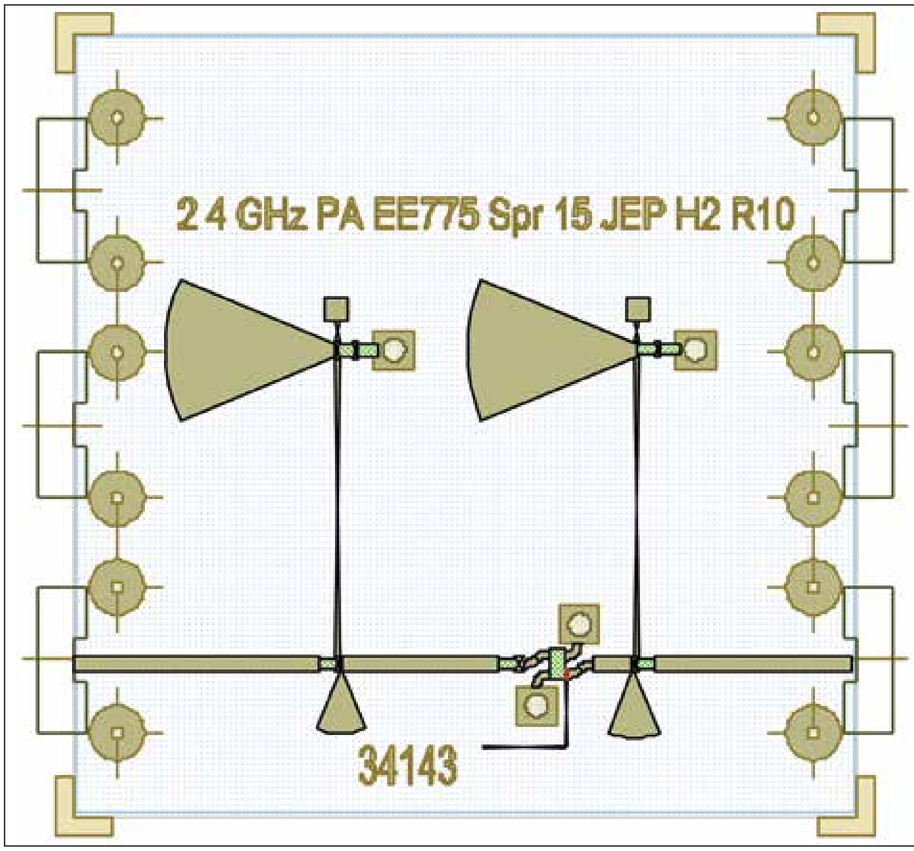

Figure 1 • Typical 2"x2" Medium Power Amplifier Design Layout (525.775).

circuit at microwave frequencies, a few GHz, but does not isolate the external power supplies from the amplifier at a few MHz! The usual solution is multiple parallel capacitors on the bias flag to provide a nice RF short circuit from a few MHz to a few GHz. Usually, a 100pf 0603 chip capacitor in parallel with an 0.08"x0.05" (0805) 1uf chip capacitor solves the low frequency oscillation problem. Figure 1 shows a typical board layout with DC bias flags for gate and drain supplies, SMA connectors for the RF input and output, a 4 pin SOT343 Avago 34143 PHEMT, chip capacitors, and a chip resistor for stability.

So, while many RF engineers understand stability, it is most often the even mode stability that they are familiar with. Another type of oscillation in amplifiers is odd mode oscillation, which does not occur in the single transistor designs. As is probably the case with most RF courses, students build and test single transistor amplifiers. Multi-stage amplifier stability and odd mode stability are not always covered in the basic RF courses. JHU students can take Professor Dale Dawson's Power MMIC Design course to learn about odd mode oscillations, which can occur when you combine parallel transistors to increase output power. That class also teaches about subtle bias dependent, or non-linear, stability, not just small signal linear stability.

As a means of analyzing and demonstrating odd mode oscillations in an actual circuit, an amplifier was designed, built, and tested to illustrate this phenomena. This amplifier has the potential to oscillate in an odd mode as well as an even mode.

Predicting stable and non-stable operation with standard CAD tools, e.g., Keysight's ADS and NI/AWR's MWO, is discussed with comparison to the actual measured results. Figure 2 shows the layout of an amplifier using two parallel Avago 54143 PHEMTs, along with a series chip resistor to stabilize the

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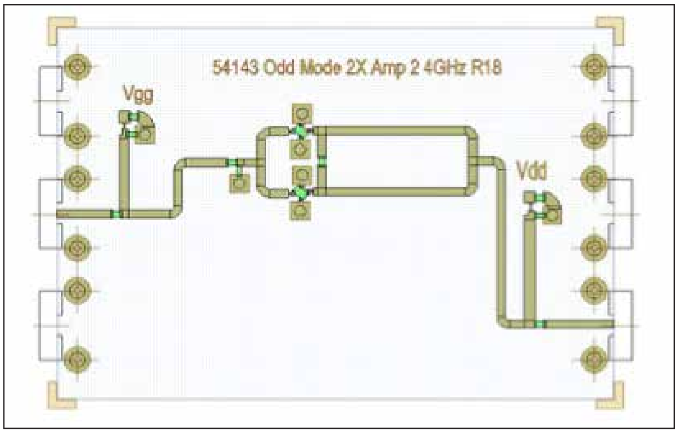

Figure 2 • 2" x 3" Odd Mode Power Amplifier Demo Design Layout (525.775).

even mode, and a shunt chip resistor on the outputs of the two transistors for stabilizing the odd mode.

Non-linear models, as well as linear s2p files, were available for the Avago 54143 PHEMT, for both Keysight's ADS and NI/AWR's MWO programs. One technique to analyze odd mode oscillations uses a transient simulator and requires non-linear models for the transistor. Another odd mode analysis technique only requires a linear simulator and linear models, or s2p files, of the transistors. Both techniques are discussed in the course notes for Professor Dawson's Power MMIC Class[2], and the students do a homework exercise to illustrate the first transient technique. Both approaches will be explained.

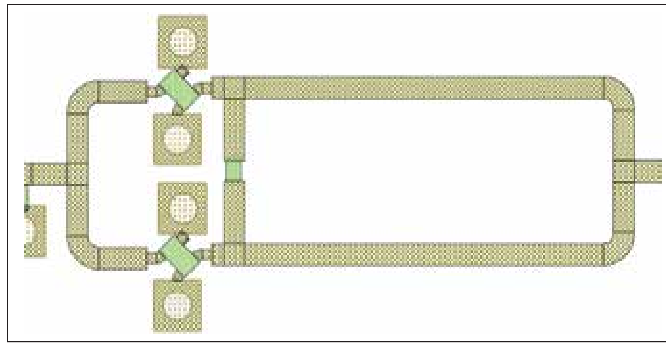

Figure 3 • Odd Mode Power Amplifier Two-Way Combiner Layout.

Odd Mode Oscillation

What is an odd mode oscillation? While the standard even mode stability approach analyzes the stability of the amplifier over any possible passive impedance applied to the RF input and output, an odd mode oscillation would occur if applying a short circuit applied at the microstrip "tee" intersection where the two gates, or two drains, of the PHEMTs in figure 2 causes an instability. The series and/or shunt resistors to the left of the tee that splits the input to the two PHEMTs affects even mode stability but will not affect odd mode stability. Conversely, the shunt resistor connected to the drains of the two PHEMTs has no effect on the "normal" even mode operation of the amplifier but can completely determine whether there will be an odd mode oscillation in the design.

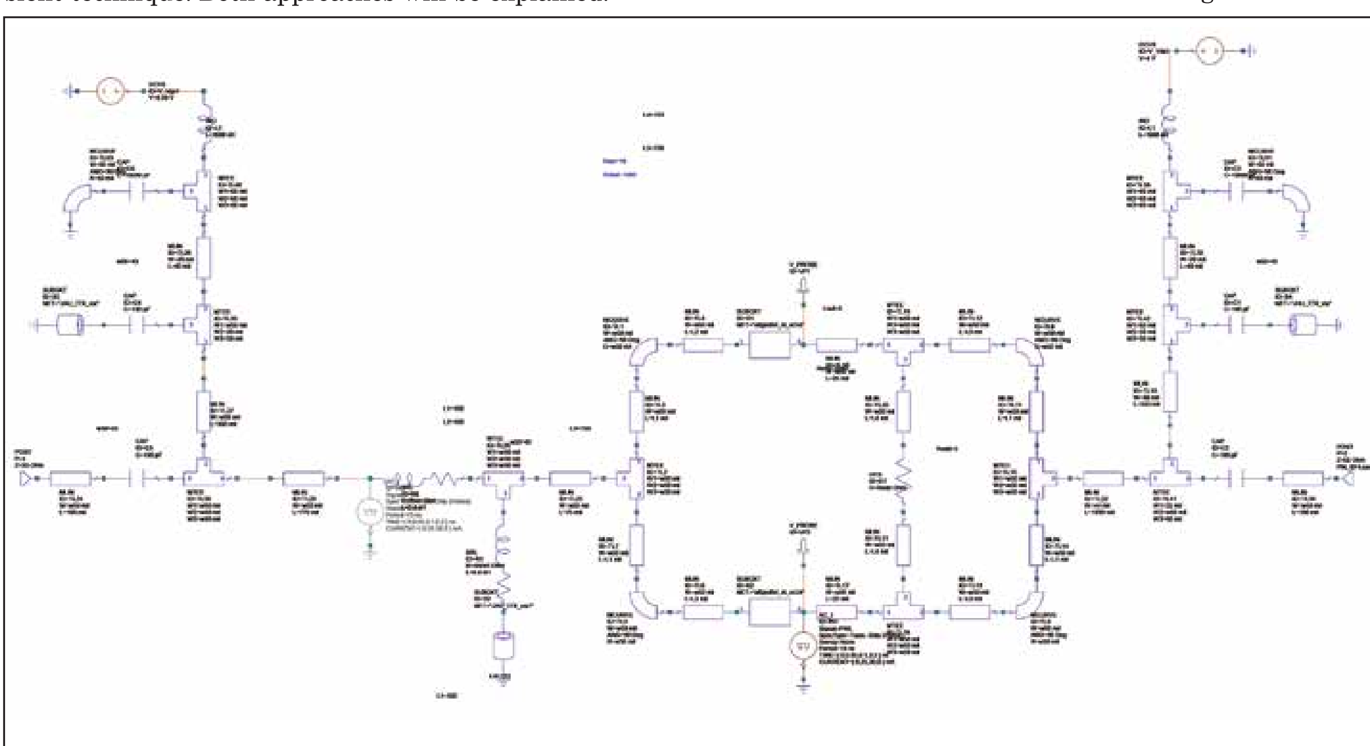

Figure 4. MWO Schematic of Odd Mode Power Amplifier.

It would be possible to prevent odd mode oscillations by making the upper branch and lower branch of the combined amplifier sections unconditionally stable by using series and/or shunt resistors on the gate of each PHEMT "before" the two branches are connected. If each branch were unconditionally stable, then the amplifier would be stable, even with that "virtual" short circuit of the odd mode. This demonstration amplifier was intentionally designed such that changing the shunt resistor at the drains of the PHEMT would cause a known odd mode oscillation, or could damp out the odd mode oscillation.

Transient Odd Mode Analysis

One method to look at odd mode stability is to do a transient analysis to determine if an oscillation will build—bad, or damp out—good. This requires both a transient simulator and a good non-linear model. For the demonstration circuit I used the Avago 54143 PHEMT since there was a non-linear model for both ADS and MWO, as well as s2p files at various DC biases. Figure 3 shows the arrangement of the two parallel devices with a shunt resistor at the drains for damping an odd mode stability. If there is an odd mode stability problem, the transient simulation should show a problem if there is no resistor between the two PHEMT outputs.

Figure 4 shows the full schematic of the amplifier for demonstrating odd mode oscillation as entered in Microwave Office (MWO). Note the DC supplies which are required for proper operation of the non-linear model, as well as the addition of a simulation element to provide an impulse spike at one of the PHEMT outputs. If the circuit is stable, this impulse should attenuate, or damp out. Conversely, if it is unstable, the odd mode oscillation will build. Figure 5 shows the odd mode oscillation building when the odd mode stabilizing resistor is 5000Ω. Using the markers at two peaks predicts an oscillation frequency of about 1.04GHz (period=0.96ns). Note that the oscillation frequency is the odd mode oscillation frequency of each transistor, which are 180 degrees out of phase with each other. As will be shown in simulations and measurements, the difference of these two signals dominates the output which is at twice the frequency of oscillation. The transient simulator predicts that the impulse dampens out with a 100Ω odd mode stabilizing resistor (see figure 6).

Similar results are achieved with ADS using its transient simulator. Figure 7 shows the full schematic of the amplifier for demonstrating odd mode oscillation in ADS. Likewise figure 8 shows the odd mode oscillation with a 5000Ω odd mode resistor, with a frequency of oscillation around 1.1 GHz. The sum of these two out of phase odd mode oscillations appears as a 2.2 GHz (2X) oscillation frequency at the combined output as shown in figure 9. When a 100Ω odd mode resistor is used, the oscillation does not occur, as shown in figure 10. Convergence with

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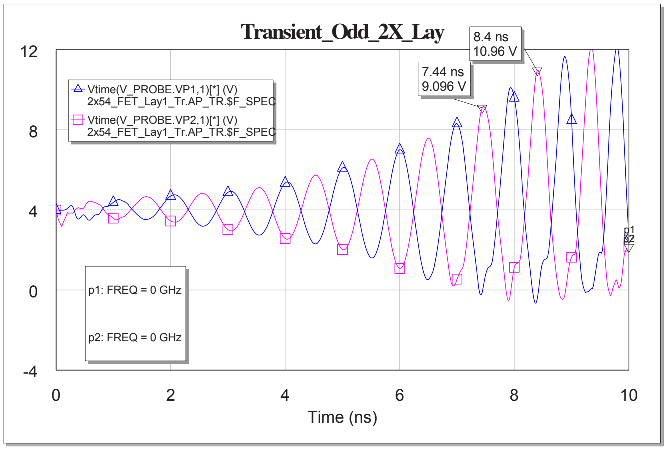

Figure 5 • Transient Simulation in MWO Schematic with a 5000Ω Odd Mode Resistor.

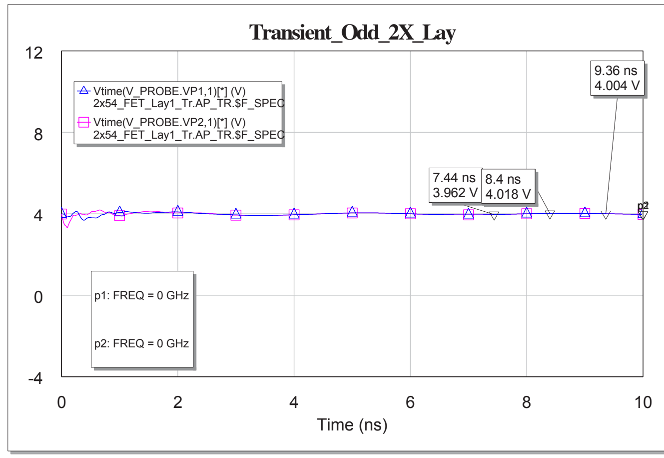

Figure 6 • Transient Simulation in MWO Schematic with a 100Ω Odd Mode Resistor.

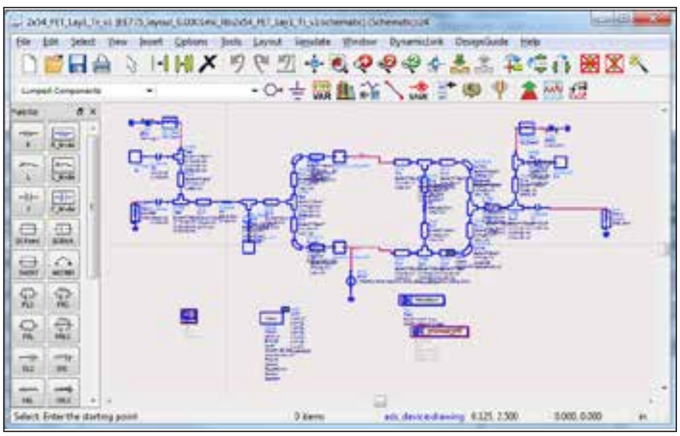

Figure 7 • ADS Schematic of Odd Mode Power Amplifier.

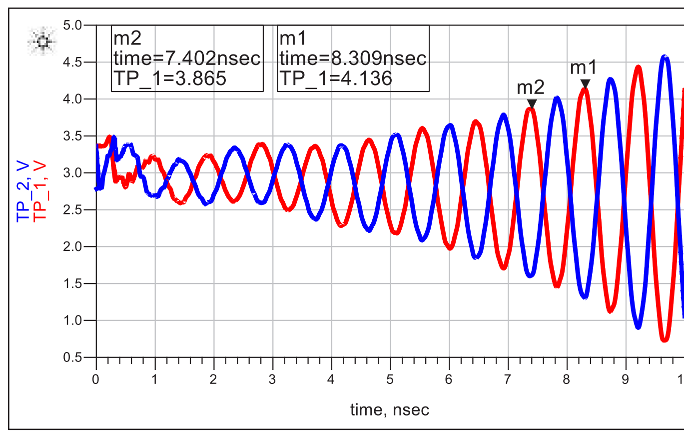

Figure 8 • Transient Simulation in ADS Schematic with a 5000Ω Odd Mode Resistor.

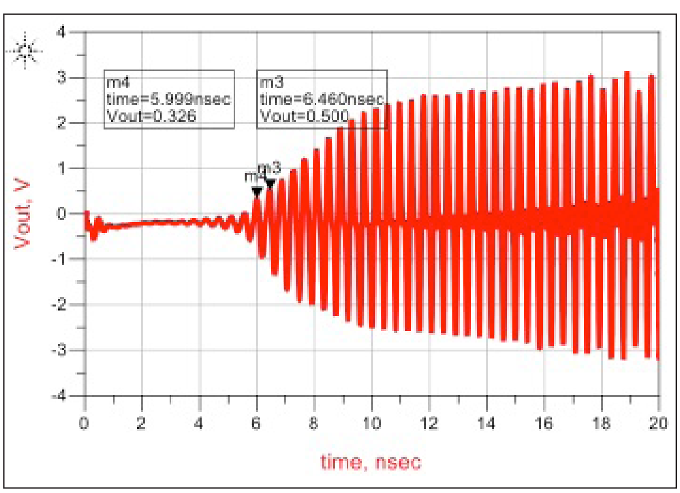

Figure 9 • 2X Frequency of Oscillation at Output (Transient Simulation in ADS).

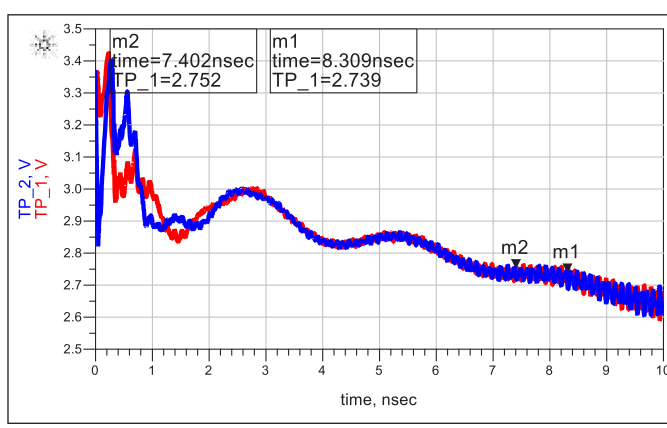

Figure 10 • Transient Simulation in ADS Schematic with a 100Ω Odd Mode Resistor.

the transient simulator and a particular non-linear model can be difficult. One may have to modify some of the simulation options in ADS or MWO to achieve a successful transient simulation.


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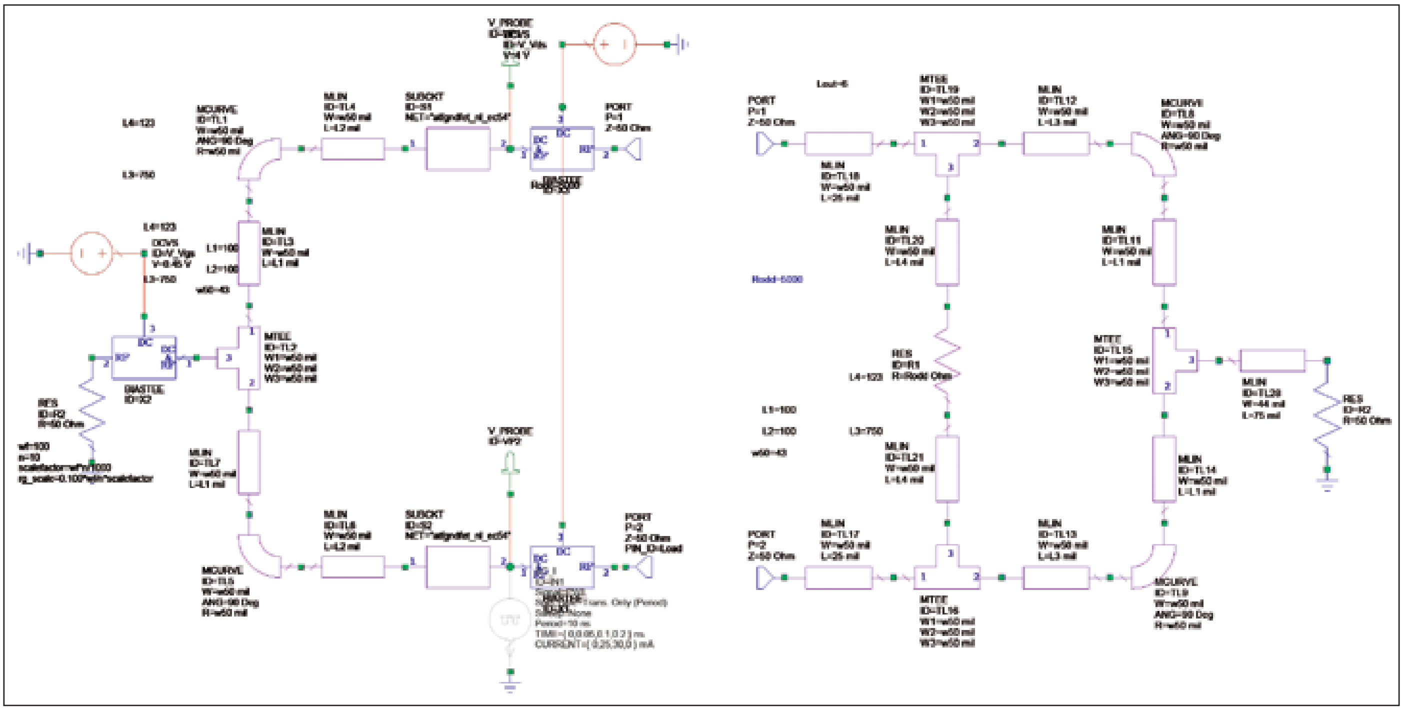

Figure 11 • MWO Schematic of Input and Output for Eigenvalue Calculation.

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AM006044SF-2H*	0.05-6.0	22	44	42	30, 60	0.4, 1.0	EAR99
AM206542TM-00!	2.0-6.5	25	42	20	28	0.96	3A001.b.2.a
AM010130TM-00!	0.05-13.0	13	33	15	28	0.24	3A001.b.2.b

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Eigenvector Odd Mode Analysis

Another method with similar results to the transient simulation only requires a linear model, or s2p files, of the devices[3]. One only needs to simulate the portion of the schematic where a virtual short circuit at the point of symmetry of the 2-way combiner would cause an odd mode oscillation. If the real portion is negative and the phase is zero, oscillation can occur. This method may miss some potential oscillations where the oscillation is dependent on subtle non-linear operation of the device, but it will yield useful results when either a non-linear model is not available, or the transient simulator is not available, or when the transient simulation fails to converge.

Figure 11 shows the MWO schematics of the parallel combiner portion of the amplifier split into an input

```
Z11i = 2x54_FET_Part1_LambdaIn:Z(1,1)
Z21i = 2x54_FET_Part1_LambdaIn:Z(2,1)
Z11o = 2x54_FET_Part1_LambdaOut:Z(1,1)
Z21o = 2x54_FET_Part1_LambdaOut:Z(2,1)

Loi = Z11i - Z21i
Loo = Z11o - Z21o

Re2X = real(Loi - Loo)
Img2X = imag(Loi + Loo)
```

Figure 12 • Equations to Calculate Odd Mode Stability using the Eigenvalues in MWO.

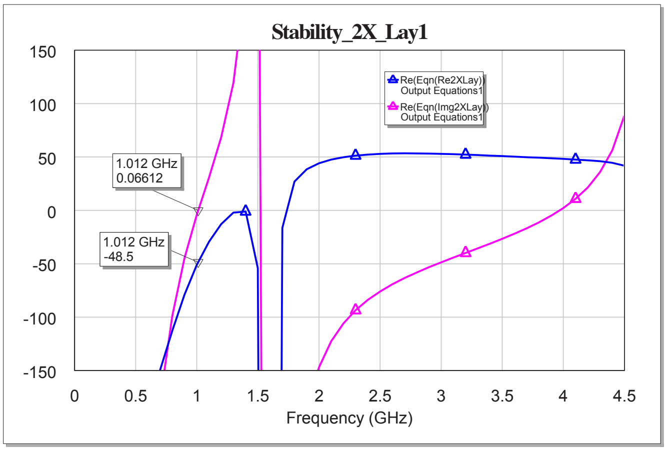

Figure 13 • MWO Plot Showing Odd Mode Oscillation with a 5000Ω Resistor.

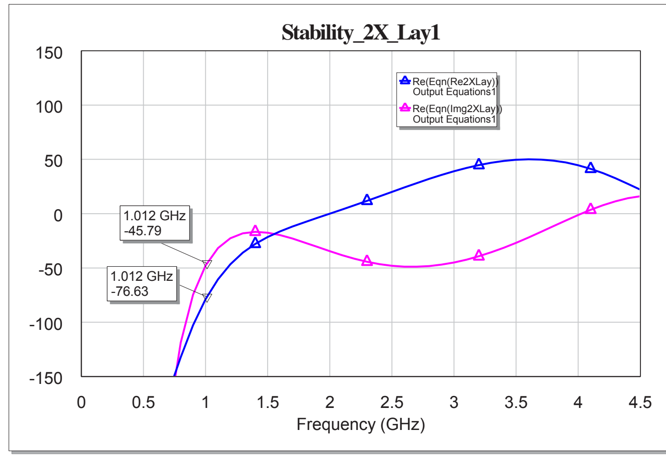

Figure 14 • MWO Plot Showing Odd Mode Stability with a 100Ω Resistor.

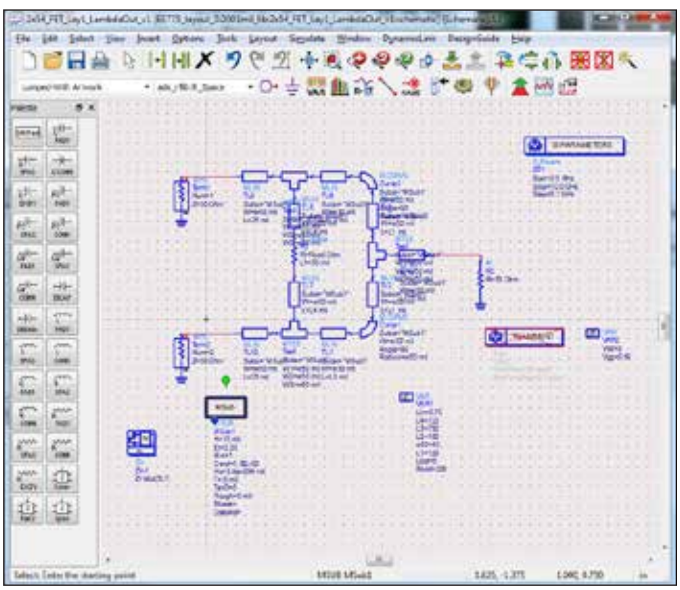

Figure 15 • ADS Schematic of Output for Eigenvalue Calculation (Z=stoz(S,1)).

(2x54_FET_Part1_LambdaIn) and an output portion (2x54_FET_Part1_LambdaOut). The equations used to calculate odd mode stability in MWO are shown in figure 12. When the phase is zero, and the real portion is negative, the odd mode oscillation condition exists. Results are similar to the transient method, predicting an odd mode oscillation around 1 GHz with a high odd mode resistor value (fig. 13), while the odd mode is stable with a 100Ω resistor (fig. 14).

For ADS, the schematics are similar in terms of splitting an input and output portion of the parallel combined amplifier to calculate eigenvalues. Figure 15 shows the schematic of the output portion with an added block to calculate Z-parameters (Z=stoz(S,1)). This conversion element to get Z-parameters was included in both the input and output amplifier halves ADS schematics. The rest of the equations as shown in fig 16 were included in the data display block within ADS. Comparable plots using ADS showing odd mode oscillation at about 1.07 GHz with a 5000Ω resistor and a stable odd mode with a 100Ω resistor are shown in figures 17 and 18, respectively.

Measured Performance of Demonstration Amplifier

The demonstration amplifier with two parallel 54143 PHEMTs was fabricated on 20 mil Rogers RO4003 material using 100pf chip capacitors for DC blocks and also for use in parallel with 1uF chip capacitors to isolate the Vgg and Vdd DC biases, plus a 20Ω chip series resistor at the input for even mode stability. Initially the odd mode resistor on the drains of the PHEMTs was not added. As expected the circuit oscillated as shown in the spectrum analyzer plot of figure 19. You can see the oscillation frequency of 1.3 GHz and its harmonics. The output of 2X the oscillation frequency at 2.6 GHz is particularly strong, as expected.

```
Eqn LambaIn = Z(1,1) - Z(2,1)
Eqn Lambda_out= _2x54_FET_Lay1_LambdaOut_v1..Z(1,1) - _2x54_FET_Lay1_LambdaOut_v1..Z(2,1
Eqn Re2X=50*real(LambaIn - Lambda_out)
Eqn Img2X=50*imag(LambaIn + Lambda_out
```

Figure 16 • Equations to Calculate Odd Mode Stability using the Eigenvalues in ADS.

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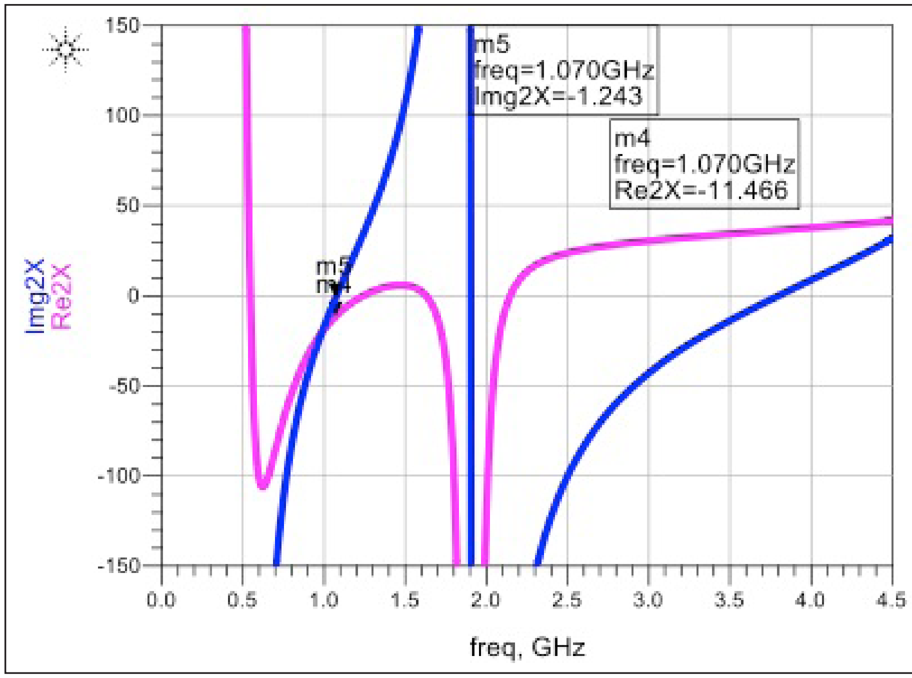

Figure 17 • ADS Plot Showing Odd Mode Oscillation with a 5000Ω Resistor.

When a 100Ω odd mode chip resistor was installed, the amplifier was stable. At that point, s-parameters were measured and compared to the linear simulations (fig. 20). Note the good agreement once the amplifier is stabilized. Typical amplifier simulations will not show an odd mode oscillation problem, but it should be noted that the transient method can predict both even and odd mode oscillations. One difference in the spectrum between even and odd mode oscillations, is that an odd mode oscillation should have a very strong signal at 2X the oscillation frequency.

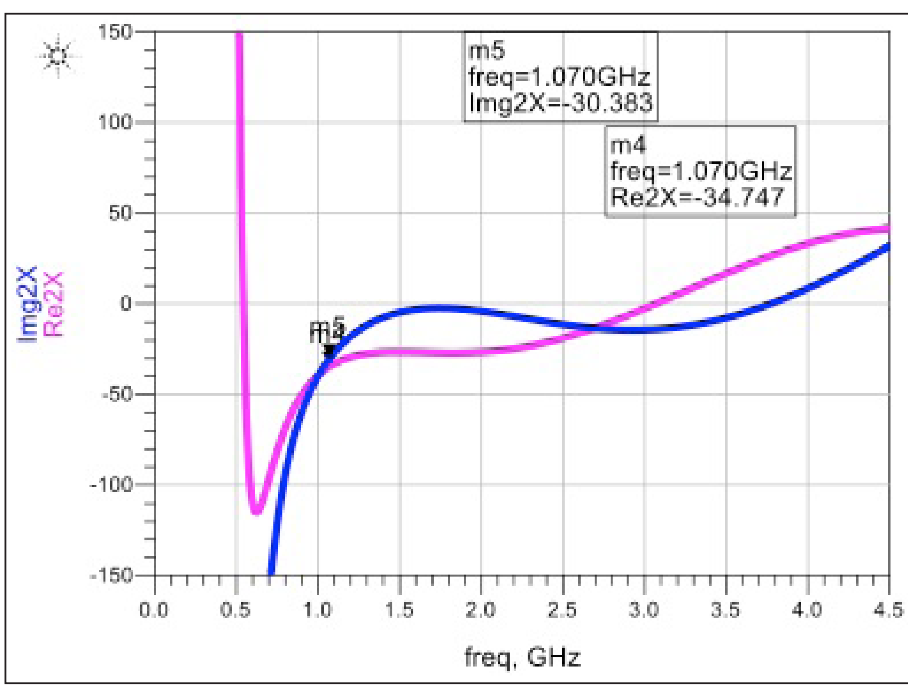

Figure 18 • ADS Plot Showing Odd Mode Stability with a 100Ω Resistor.

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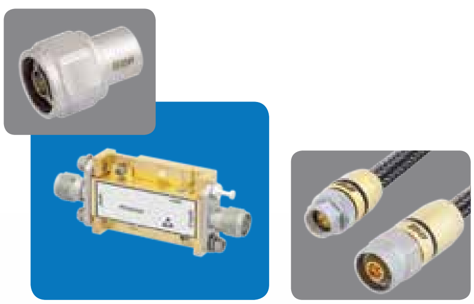

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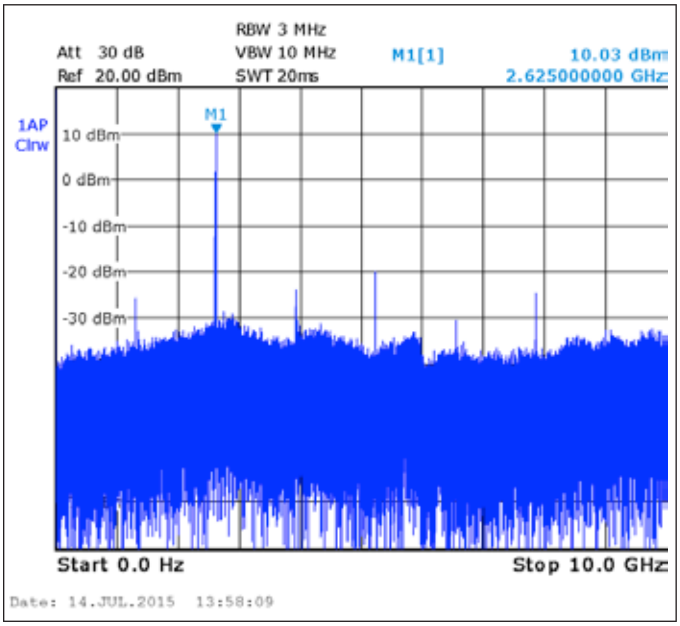

Figure 19 • Spectrum of Amplifier Showing Odd Mode Oscillation (No Resistor).

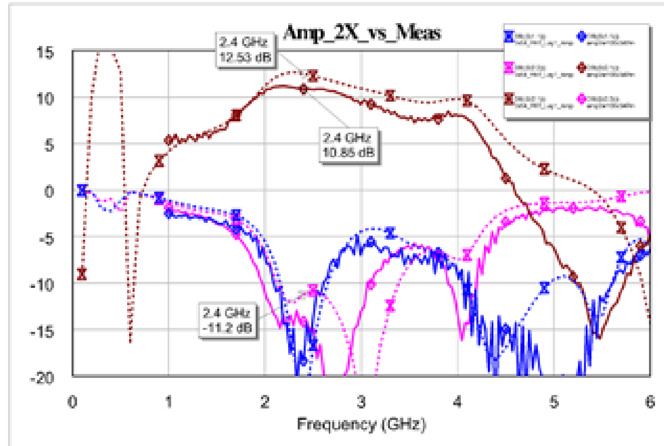

Figure 20 • Measured versus Simulations of Stable Amplifier (100Ω Shunt Resistor).

Summary

An amplifier was designed, built, and tested to illustrate odd versus even mode oscillations. Also shown were a couple of simulation techniques to predict odd mode oscillations. These techniques were illustrated using common RF CAD tools, e.g., Keysight's ADS and NI/AWR's MWO. Common stability parameters such as "mu" [1] only illustrate even mode stability, which is sufficient for single transistor amplifiers. But when one parallel combines transistor devices, odd mode oscillations can occur due to the "virtual" short circuit at the symmetry point of the combiner. Transient simulations requiring non-linear device models can be used to predict both even and odd mode oscillations. A simpler technique is to look at the eigenvalues which only requires a linear simulator and a linear model, or s2p file, of the transistor. Of course this may not catch subtle instabilities due to the non-linearities of the particular transistor. Both techniques were useful in predicting the actual odd mode oscillations of this demonstration amplifier design.

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About the Author

John E. Penn received a B.E.E. from the Georgia Institute of Technology in 1980, an M.S. (EE) from Johns Hopkins University (JHU) in 1982, and a second M.S. (CS) from JHU in 1988. Since 1989, he has been a part-time professor at Johns Hopkins University where he teaches RF & Microwaves I & II, MMIC Design, and RFIC Design. Email: profpenn@gmail.com.

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1) Marion Lee Edwards and Jeffrey H. Sinsky, A new Criterion for Linear 2-Port Stability Using a Single Geometrically Derived Parameter, IEEE Transactions on Microwave Theory and Techniques, vol. 40, No.12, pp. 2303-2311, Dec. 1992

2) Professor Dale Dawson, Power MMIC Design Course Notes, JHU 525.788

3) Ron Freitag, A Unified Analysis of MMIC Power Amplifier Stability, IEEE MTT-S Digest 1992, pg 297-300

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The Three Pain Points of the Mil/Aero Test Engineer

By Reggie Rector

Overcoming the challenges of the aerospace test engineer.

We all have our pains and struggles within our team or organization. Whether it's the junior engineer that couldn't possibly be wrong about anything—ever; the dreaded consensus-building meetings that do anything but; or a nearly impossible deadline—we all have them.

The life of the aerospace test engineer is no different. They may be supporting depot-level test systems with 30-year old technology or racing to be first to market with the latest and greatest radar technology, but inevitably they have their share of challenges to tackle.

While unloading all our pains and struggles may be therapeutically beneficial, this article will focus on overcoming the challenges of the aerospace test engineer that have the biggest impact on the organization's success and, in concert, their own career growth.

Legacy Test Program Set Support

The first, and most obvious, challenge the average test engineer faces is the need to support legacy Test Program Sets (TPSs). Commercial and military aerospace programs are extending well beyond their intended lifecycles, and support teams must carry these fleets forward into the next wave of technology lifecycles. When looking to upgrade a test system (or subsystem) for one of these programs, test engineers cannot only consider the technology insertion; they must also consider the hundreds or thousands of TPSs that have been developed for the system and the ripple-effect that technology insertion will inevitably have on the program as a whole.

The most motivating and technologically savvy approach is for the test engineer to develop a completely new test system with exciting new instruments, instrumentation test adapters (ITAs), and fixtures while rehosting as many legacy TPSs as possible. Unfortunately, these test engineers ultimately have to answer to a budget and usually end up refurbishing existing test systems to replace the obsolete pieces through planned maintenance.

Let's take the example of refurbishing an existing system by replacing an obsolete oscilloscope with the objective of minimizing TPS migration costs. Sounds simple, right? On the surface, the test engineer's job sounds relatively straightforward: find an oscilloscope that can perform as well as, if not better than, the existing scope in the system. After all, most scopes in 2015 are going to pale in comparison to the dinosaurs that were designed into the system 10, 15, or 20 years ago.

The first bump in the road is form-factor. The new instrument needs to take up the same or less space in the 19-inch rack so as not to warrant a reconfiguration of the rack layout. Because there is a significant amount of system-level documentation, changing the layout of the rack will introduce a massive amount of documentation changes (not to mention any possible signal integrity issues with changing cable lengths to the mass interconnect). This form-factor challenge is one of the many reasons that modular platforms like PXI (and formerly VXI) have dominated the Aerospace/Defense ATE market for the last 30 years. By following

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	RUDAT-6000-60	0-60 dB	±0.3 dB	0.25 dB	✓	-	✓	$625
	RCDAT-6000-60	0-60 dB	±0.3 dB	0.25 dB	✓	✓	-	$725
	RUDAT-6000-90	0-90 dB	±0.4 dB	0.25 dB	✓	-	✓	$695
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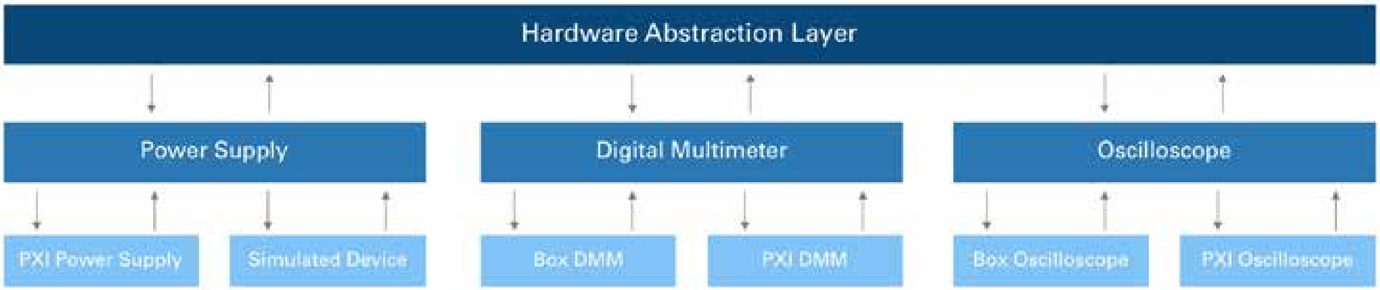

Hardware Abstraction Layers (HALs) significantly mitigate the impact of hardware obsolescence, but are difficult to justify in the absence of a long-term support strategy.

the strict guidelines of the PXI specification, a scope from vendor A will be the same size and utilize the same backplane power as vendor B, giving test engineers an easier upgrade path for their systems.

HAL Integration

The second hurdle in the road is hardware abstraction layer (HAL) integration. Any test system that is expected to last for five to 10+years will inevitably have planned maintenance and operational costs. These are significantly reduced by abstracting vendor-specific hardware and drivers into a HAL or measurement abstraction layer (MAL). The test engineer is also tasked with evaluating the driver stack of the new instruments to ensure they plug into the HAL to mitigate the risk when migrating the thousands of TPSs still to come. Many HALs utilize the IVI driver class where possible and supplement with Plug-and-Play drivers. Since this example is an oscilloscope, we'll make a blanket claim that the test engineer has it "easy" and gets a pass on software because there is an existing IVI class specified for oscilloscopes.

A third and often hidden hurdle is the answer to the question: is better really better? The specifications of this new oscilloscope are multiple generations of technology ahead of the obsolete equipment, so where's the

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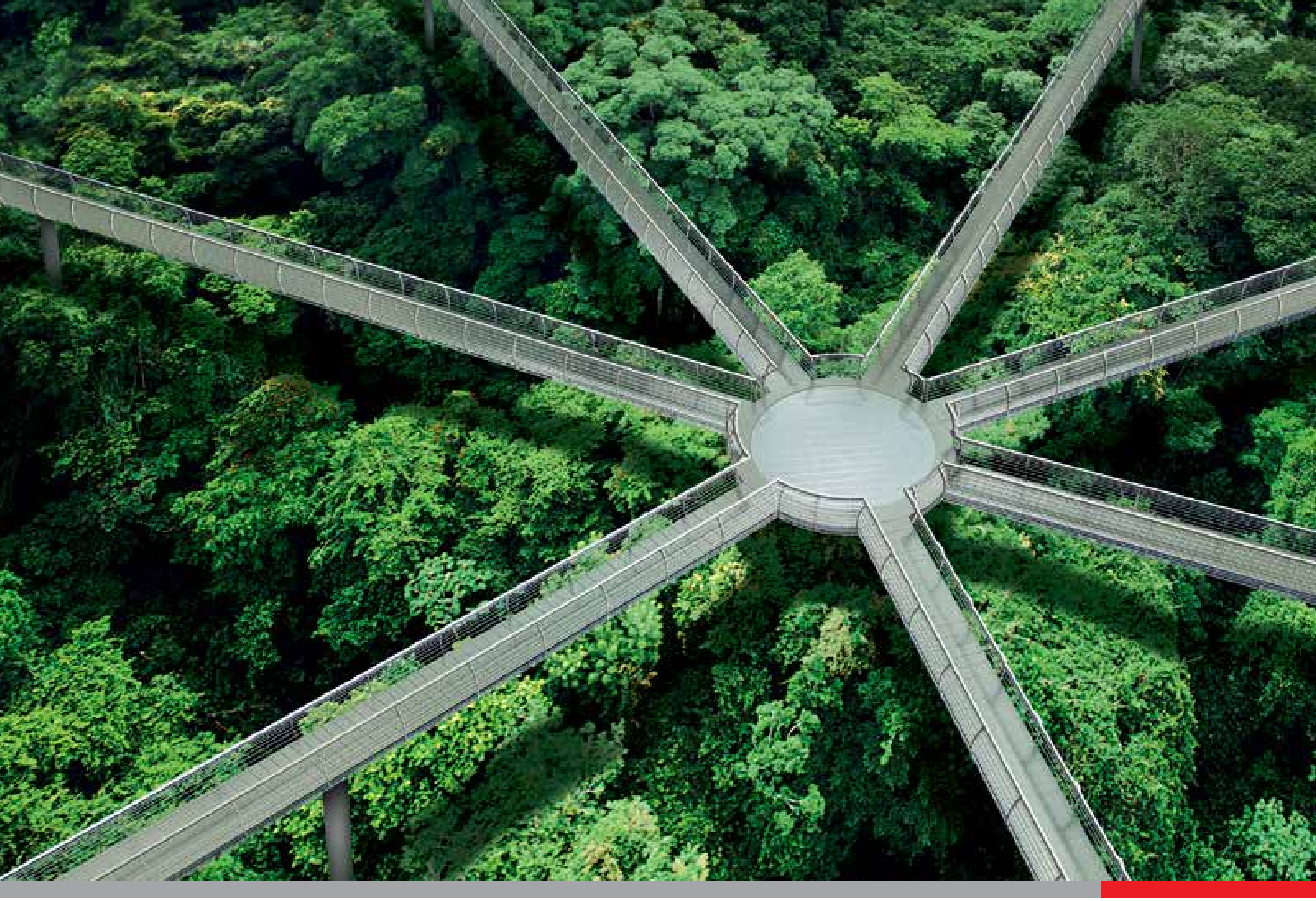

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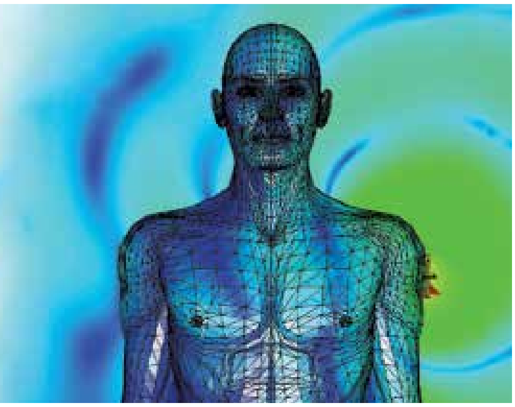

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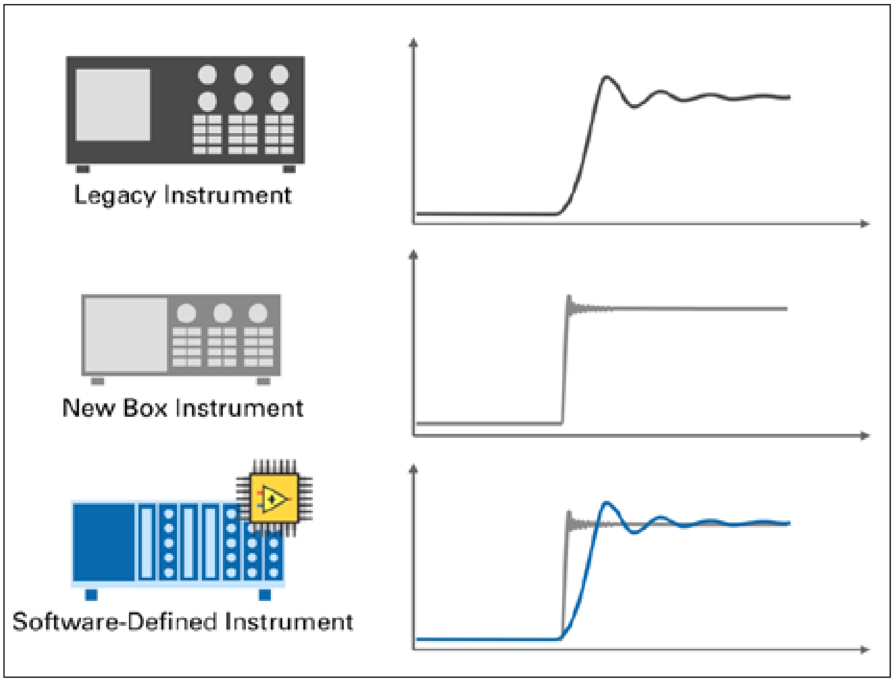


While difficult to accomplish, emulating legacy instrument capabilities greatly reduces the risk of TPS migration issues. Software-Designed, or Synthetic Instruments, offer a unique approach to test equipment emulation.

issue? The issue comes when, for example, you insert this new oscilloscope into the system and the rise time or settling time measurements change significantly because you're sampling at three, five, or 10 times the rate of the previous instrument, which results in dozens of incompatible TPSs that previously provided great system utilization. Another issue arises when legacy TPSs require trigger functionality that instrument vendors made obsolete years or decades prior. In this situation, the test engineer is challenged with looking across the entire database to identify which TPSs will be broken by inserting a new instrument that does not support the legacy trigger functionality—a database which often doesn't exist and requires weeks or months of manual effort to identify.

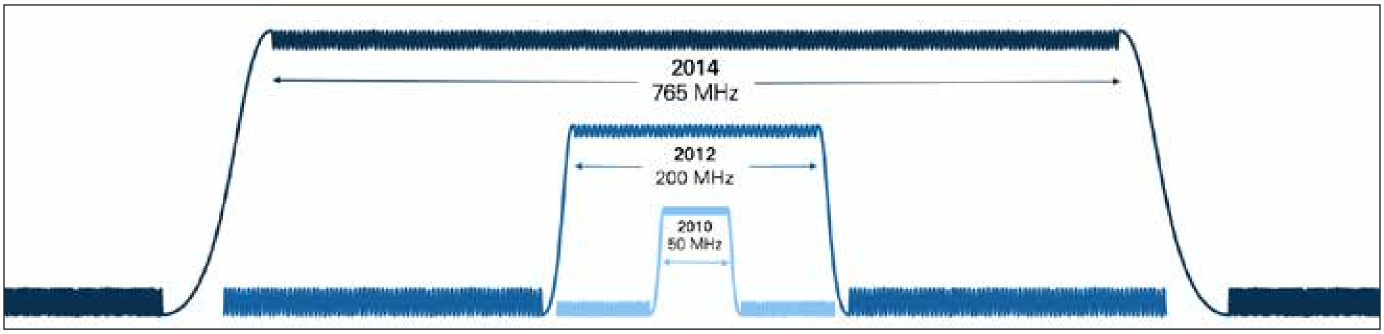
SDI Approach

In order to minimize the unknown risks of TPS rehosting, many test engineers are taking advantage of software-designed instruments (SDIs) to give more flexibility in the rehosting process. Software-designed (also known as synthetic) instruments combine core analog and digital front-end technology with powerful, user-programmable FGPAs to provide the most flexible instruments on the market. If we apply the SDI approach to the oscilloscope challenges above, the test engineer (or TPS developer) can easily implement custom trigger functionality on the FPGA of the SDI to emulate legacy trigger technology. Some go further and use digital signal processing to emulate the analog performance of the legacy instrument's analog-to-digital converter technology.

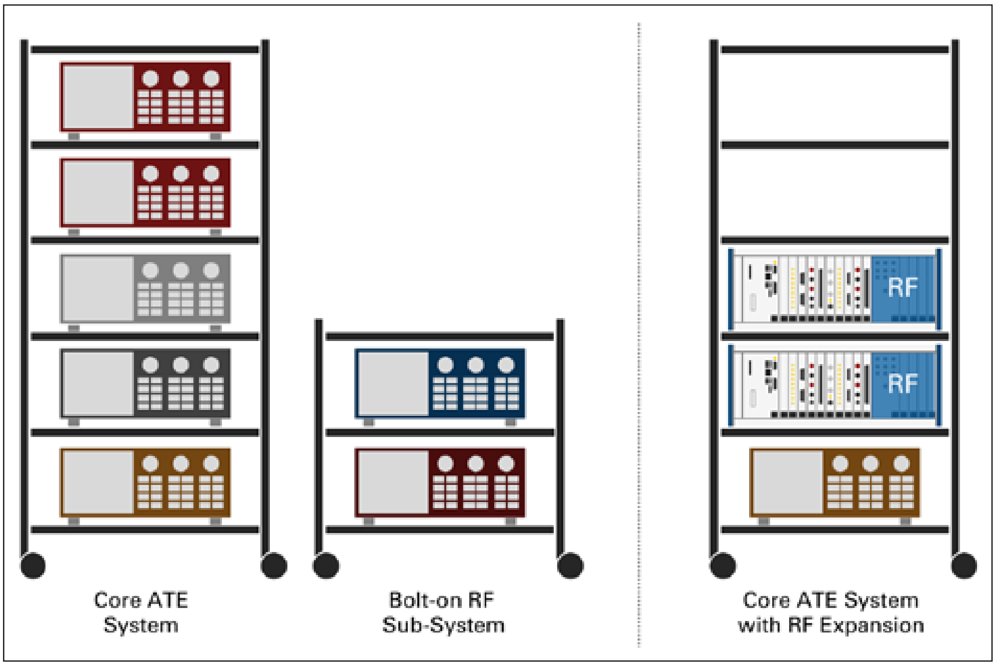
Rapid RF Evolution

On the other side of the spectrum (literally and figuratively) is the challenge of keeping pace with the rapid evolution of RF technologies engineered into radars, signal intelligence systems, communications equipment, and other line-replaceable units (LRUs). This rapid pace of innovation keeps test engineers on their toes in terms of building scalable architectures that can not only test the technologies of today, but scale to support the next "wave" of RF capabilities.

Historically, most high-mix test systems in aerospace/defense haven't included RF ATE subsystems as part of the core configuration due to the cost/benefit analysis of adding high-performance (high-price) RF



The evolution of NI vector signal analyzer bandwidth is one example of how aerospace ATE systems can scale to support the latest radar, communications, and signal intelligence systems.



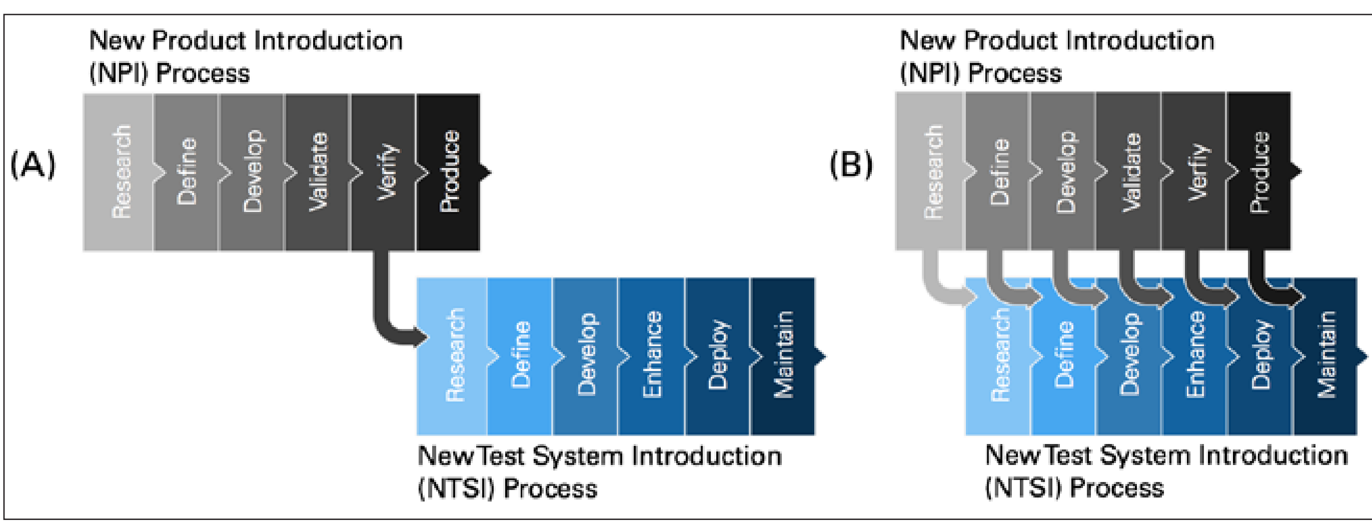
Traditional ATE systems commonly used the "bolt-on" RF sub-system strategy due to the cost of RF equipment. As RF technology becomes more prevalent in LRUs and RF test equipment costs come down, we'll see RF test equipment become integrated into the core system.

To illustrate the complexity facing the test engineer, let's use an example of a test system for a direction-finding, multi-antenna radar subsystem. In the manufacturing environment, it's reasonable to assume that each antenna will be tested serially using a high-performance signal source and a wide-band vector signal analyzer, along with some high-speed serial communication for controlling the UUT. Saying this is easy would be a massive overgeneralization, but when you compare this to the capabilities of the maintenance test system, it sounds like a walk in the park. So whose job is it to develop that complex test system for planned maintenance and field defective units? That's right—the test engineer.

test equipment to cover a small set of LRUs. The asset utilization simply couldn't justify the expense. As the number of RF-capable LRUs increases and RF instrumentation becomes more cost effective, it's becoming more common for RF equipment to be part of core high-mix test system configurations.

Emulating the Real World

When performing maintenance tests or analyzing a returned unit from the field, your test cases are far more inclusive than the "did we build it right" manufacturing test case. You will need to emulate the real-world environment with highly synchronized signal sources includ-



There are inefficient and costly flaws with the traditional approach of engaging test engineering late in the NPI process. Engaging earlier in the design cycle can lead to faster time-to-market, lower manufacturing cost, and improved yield.

ing closed-loop control between the sources and analyzers to stress the DSP engine and measure the phase-coherency of the system. To address the synchronization and data transfer challenges, test engineers need to look beyond traditional boxed instrumentation to a platform-based approach such as PXI. To emulate the real-world environment with closed-loop control, engineers need flexible RF instrumentation architecture that combines data streaming architectures, FPGA-based signal processing, and high-performance, high-instantaneous bandwidth RF front-end technology to capture and process the incoming pulses.

It's also no secret that operational costs are high when sending units back to the intermediate- (I-) or depot- (D-) Level centers for maintenance or repair. As RF test equipment becomes easier to adopt in field test, these operational costs greatly improve. Not only does the organization benefit from the decrease in operational cost, but they can get better IP leverage between the depot and field testers for in-situ troubleshooting and diagnostics.

As you can imagine, the RF challenges of scalability, synchronization, and latency create complex system-level test architectures for the test engineer and are quite different than replacing the legacy oscilloscope and mitigating TPS rehosting costs, though both technology elements are great opportunities for the test engineer to provide significant value to the organization.

Increasing Sphere-of-Influence to Reduce the Cost of Test

A third, and maybe more subtle, pain point for test engineers is justifying short-term spend to mitigate long-term operational costs. Market pressures are as high as they have ever been, so test engineers are opting for point-solutions that neither provide the scalability for evolving technology demands nor have an architecture that simplifies maintenance for future upgradeability.

Furthering this problem is the fact that this short-term spend may not actually come directly from the test engineering budget. Looking upstream, we all know how difficult it can be to get a design engineer to modify a design once it meets the design specifications, but organizations can see significant improvements to their bottom line by engaging the test engineering group early as part of a Design For Test (DFT) or Design for Manufacturability (DFM) strategy. When yields improve and asset utilization increases, these optimizations typically go directly to the gross margin of the product.

Get info at www.HFeLink.com

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Attributes

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- Voltage Ratings to 50 WVDC
- Orientation Insensitive*
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- Unit-to-Unit Performance Repeatablity

*550 Z, 550 L, and 550 S are orientation insensitive.

ATC Series	EIA Size	Capacitance	Frequency Range	Insertion Loss	Voltage Rating	Orientation Insensitive
550 Z	0201	10 nF	160 KHz to 40+ GHz	<0.4 dB typ.	10 WVDC	Yes
550 U	0301	100 nF	16 KHz to 40+ GHz	<0.4 dB typ.	6.3 WVDC	No
550 L	0402	100 nF	16 KHz to 40+ GHz	<0.5 dB typ.	16 WVDC	Yes
550 S	0603	100 nF	16 KHz to 40+ GHz	<1 dB typ.	50 WVDC	Yes

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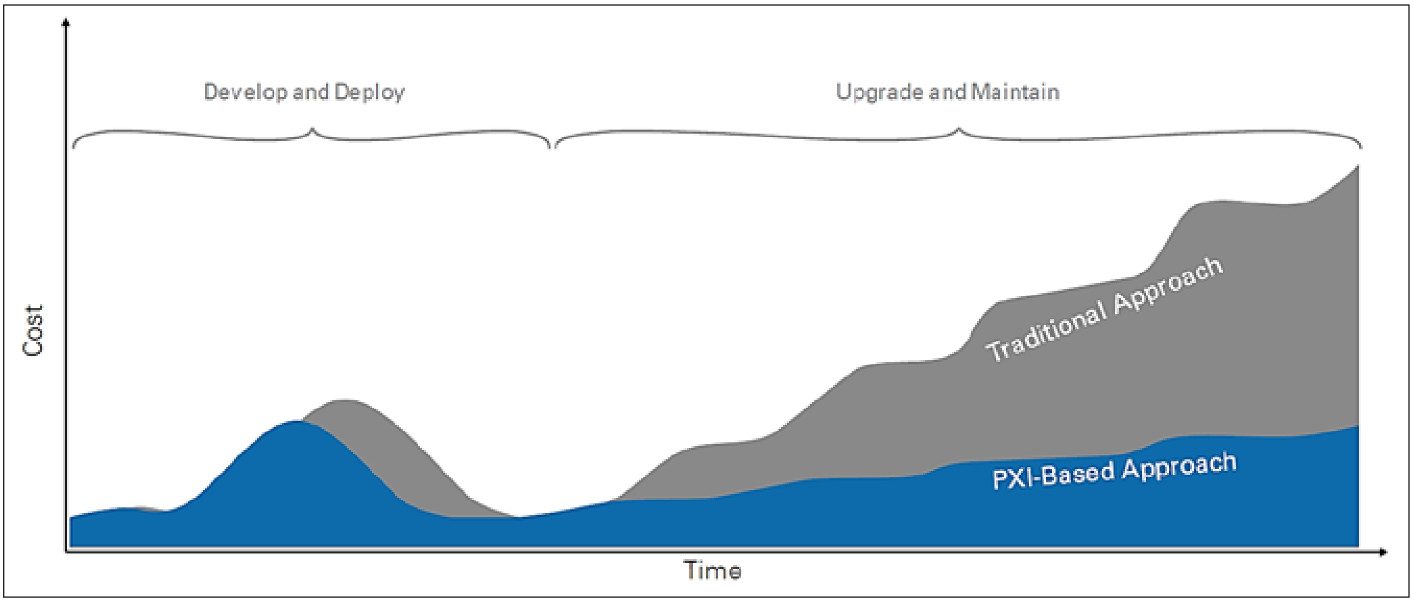

Many organizations have different business units for the develop/deploy and support/maintain costs of a test system. Test engineers can greatly impact the operational costs of supporting a system, but must expand their influence beyond their own organization to understand and implement solutions to mitigate the long-term costs of supporting an ATE system.

Beyond DFM, it's also critical that the test engineers be involved early in the new product introduction (NPI) process. By actively engaging in every stage-gate of NPI, the test engineer can be developing product-specific test code along the way and collaborating with validation engineers on automated code modules to simplify the validation and ease the transition into production. This is actually a process that NI went through in the early 2000's as we released 200+ products a year with increased complexity per generation. By bringing test engineering to the conversation early, we saw over 40% reductions in release to manufacturing (RTM) time, which directly shortened our time-to-market.

If we look downstream, the test engineering budgets and the operations budgets are often decoupled, so the test engineering organization is not inherently incentivized to architect the system in a way that minimizes long-term operational costs. This is where siloed organizations struggle and strong communicators differentiate. At the heart of these negotiations and tradeoffs is the inherent knowledge of the test engineer about the suite of UUTs supported, the stability of the test system, and the areas to optimize or improve. While it can be painful for the test engineer, expanding their sphere-of-influence to the entire design-cycle makes them a truly valuable asset to the organization.

While the challenges of obsolescence management, rapidly evolving RF requirements, and influencing DFM are by no means all-encompassing, these challenges represent tremendous opportunity for the test engineer to impact the bottom line of the organization and showcase the value the test engineering team can deliver.

About the Author:

Reggie Rector is a Senior Product Manager for PXI and ATE Systems at NI with a special focus on Aerospace ATE. His job functions include product management and lifecycle planning, inbound product definition, and market development for PXI-based ATE systems. He holds a Bachelor of Science degree in Biological Systems Engineering from the University of Nebraska-Lincoln.

Amphenol SV MICROWAVE

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Connectors

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

Resistive Components

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

Adapters

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

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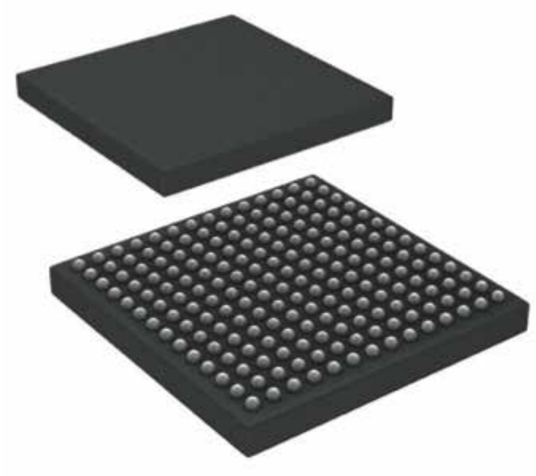
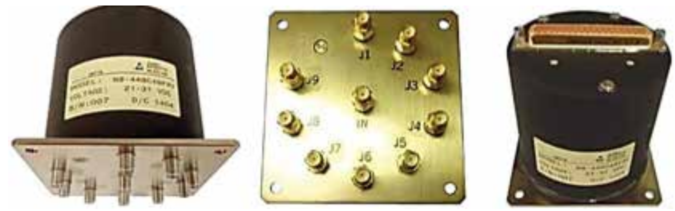
Product Highlights





ADC

Richardson RFPD, Inc. announced availability and full design support capabilities for a new dual, 14-bit, 500 MSPS analog-to-digital converter from Analog Devices. The AD9684 includes an on-chip buffer and a sample-and-hold circuit designed for low power, small size, and ease of use. The ADC is specifically designed for sampling wide bandwidth analog signals. It is optimized for wide input bandwidth, a high sampling rate, excellent linearity, and low power in a small package.

Richardson RFPD
richardsonrfpd.com

RF Coaxial Switch

Ducommun's model N9-449C49FRV is a SP9T RF coaxial switch for vacuum applications, covering 400 MHz to 8000 MHz with 10 watts CW of power handling capability. It operates from 21.0 Vdc to 31.0 Vdc at extreme temperatures of -30°C to +71°C. It is latching type with set/reset functions and equipped with telemetry circuitry. Features: Multiple output RF transmission lines; low insertion loss; high isolation. Applications: satellite testing systems.

Ducommun
ducommun.com

Microwave Substrates

CuFlon has documented performance up to 18 GHz with a 2.05dk and .00045 loss tangent. Over the years there has been considerable work with third party testing of Teflon (PTFE) in the millimeter wave frequency spectrum. One such study performed in 1959 by NASA in the E Band region reveals a dk of 2.06 and loss tangent of .00022 from 60 to 90GHz. CuFlon has proven performance in high frequency and high power applications.

Polyflon
polyflon.com

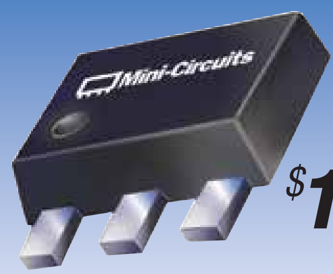
New!

MMIC AMPLIFIERS

Industry-Leading…from 50 MHz to 26.5 GHz

PGA-103+

0.05 to 4 GHz



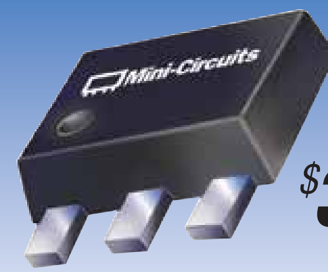
$1.49 ea. (qty.1000)

High Dynamic Range

- ✓ Low Noise, 0.9 dB
- ✓ P1dB, +22.5 dBm
- ✓ High OIP3, +45 dBm
- ✓ Gain, 11 dB
- ✓ Low Power Consumption, +5V, 97mA

GVA-91+

869 to 2170 MHz



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High Power, 1W

- ✓ P1dB up to +29 dBm
- ✓ OIP3 up to +43.4 dBm
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- ✓ Power Added Efficiency up to 47%
- ✓ Noise figure as low as 4.2 dB

TSS-53LNB+

0.5 to 5 GHz

$1.89 ea. (qty.1000)

Low Noise, Bypass Switching

- ✓ Low Noise, 1.4 dB in Thru Mode
- ✓ High Gain, 21.7 dB
- ✓ Gain Flatness, ±0.7 dB*
- ✓ Bypass Mode
  - P1dB up to +33 dBm
  - OIP3 up to +48 dBm

* 0.7 to 2.1 GHz

AVM-273HPK+

13 to 26.5 GHz

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Wideband Microwave, 0.5W

- ✓ P1dB up to +26 dBm at 26 GHz
- ✓ OIP3 up to +33 dBm
- ✓ Gain, 13 dB
- ✓ Excellent Directivity, 43 dB
- ✓ Voltage Sequencing Module Included

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Product Highlights

VNA with Extender

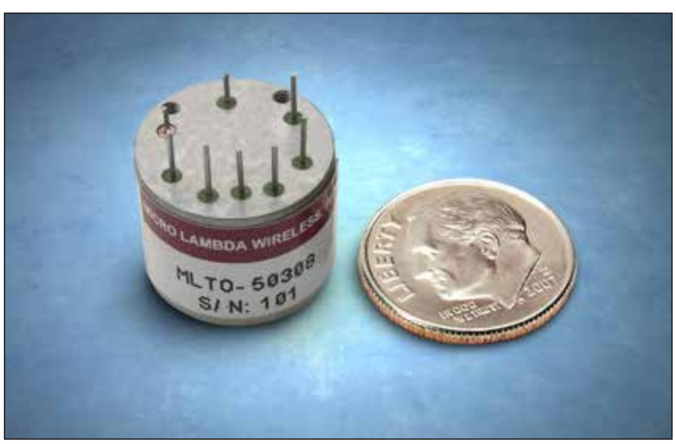
The R&S ZVA high end vector network analyzers and R&S ZVAX-TRM extension unit offer an efficient and highly flexible solution for characterizing active components. Using a combination of a high-end R&S ZVA and the R&S ZVAX-TRM, users can now measure the noise figures of amplifiers, converters and transmit/receive (T/R) modules for radar and satellite applications. The new options make it possible to carry out this measurement on amps with gain of only 10 dB and low noise figures down to the 1 dB range.

Rohde & Schwarz
rohde-schwarz.com

X-Band Downconverter

Norden Millimeter continues to expand its standard and custom product lines of frequency converters. Norden Millimeter provides frequency converters and frequency multipliers from 500 MHz to 110 GHz. Pictured are X Band Down-converters which include an Image Reject Mixer with Integrated Preamplifier. The units are phase matched over their operating temperature.

Norden Millimeter
nordengroup.com



YTOs Cover 8 to 16 MHz

Micro Lambda Wireless announced the production release of TO-8 YIG-Tuned oscillators covering the frequency range from 8 to 16 GHz. This new model is only .5" tall and perfect for next-generation products that use plug-in technology. The standard model operates over the 0 to +65 C temperature range, but military versions covering -40 to +85C are available on special order. Applications include Test Instruments, Wide Band Receivers, Telecom, Satcom and a variety of defense applications.

Micro Lambda Wireless
microlambdawireless.com

Planar Monolithics Industries, Inc.

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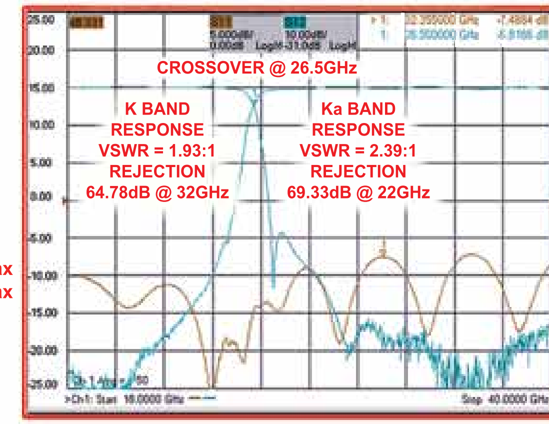
- Switch Matrices
- Switch Filter Banks
- Threshold Detectors
- USB Products

18GHz to 40GHz
DIPLEXER
PMI MODEL No: DPX-18G26R5G40G

INSERTION LOSS	2.0dB
VSWR	2.5:1
K BAND PASSBAND	18GHz Min., 25GHz Max
Ka BAND PASSBAND	28GHz Min., 40GHz Max
K BAND REJECTION	32 to 46GHz, >60dBc
Ka BAND REJECTION	DC to 22GHz, >60dBc
SIZE	0.80" X 0.60" X 0.38"

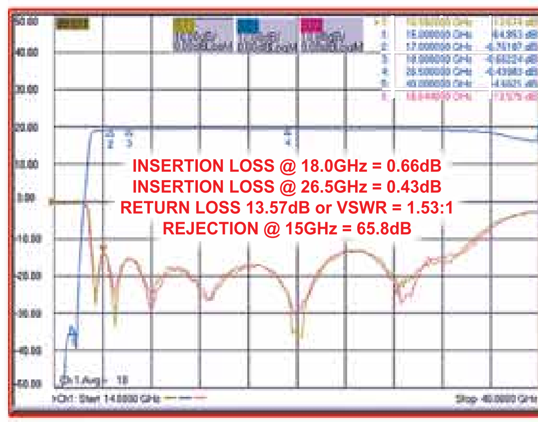
SWEPT DATA ON DPX-18G26R5G40G



18GHz to 26.5GHz
HIGH PASS FILTER
PMI MODEL No: HPF18G-DC15G

INSERTION LOSS	1.5dB
PASSBAND	18 to 26.5GHz
VSWR in PASSBAND	2.0:1
REJECTION	DC to 15GHz, >60dBc
SIZE	0.64" X 0.58" X 0.38"

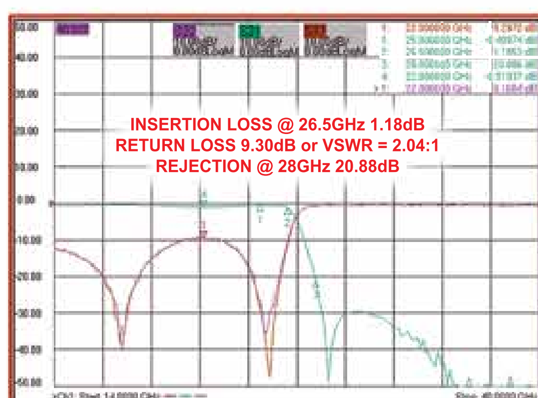
SWEPT DATA ON HPF18G-DC15G



DC to 26.5GHz
LOW PASS FILTER
PMI MODEL No: LPF26R5-28R5G40G

INSERTION LOSS	1.5dB
PASSBAND	DC to 26.5GHz
VSWR in PASSBAND	2.2:1
RIPPLE	+/-0.75dB Max
REJECTION	28.5 to 40GHz, >25dBc
SIZE	0.45" X 0.38" X 0.50"

SWEPT DATA ON LPF26R5-28R5G40G



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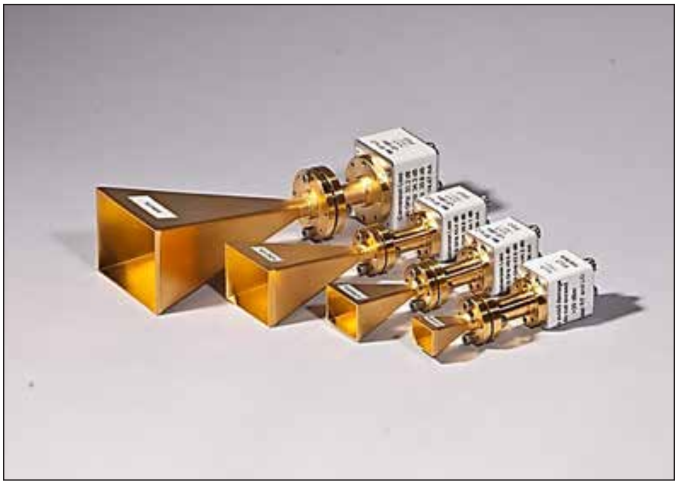
Product Highlights



Harmonic Mixers and Horns

OML offers harmonic mixers and standard gain horn antennas (+24 dBi) ranging from 18 GHz to 325 GHz. We also offer a package for testing compliance according to FCC Part 15 regulations on transmitters operating in the 10 GHz to 100 GHz spectrum. This solution is compatible with most spectrum analyzers offering optional external mixer capabilities.

OML
omlinc.com

Spectrum Monitor

Anritsu introduced its Remote Spectrum Monitor, a platform of modular and scalable products that helps operators generate a greater return on their investments and maximize network capacity to meet consumer demand. Designed without a display or keyboard, Remote Spectrum Monitor automates the method of conducting radio surveillance, interference detection, and government spectrum policy enforcement while delivering flexibilities and cost efficiencies to network management.

Anritsu
anritsu.com

Signal Source

SignalCore's high performance 20 GHz VCO-based synthesized signal source is cost effective, compact and designed for seamless integration. With frequency spanning 100 MHz to 20 GHz (1 Hz resolution), low phase noise of -118 dBc/Hz at 10kHz offset @ 10 GHz carrier, and amplitude step resolution of 0.01 dB over a -30 dBm to +7 dBm output range, this product is ideal for R&D, academic, military and commercial applications.

SignalCore
signalcore.com

Get info at www.HFeLink.com

Product Highlights

RF Amplifier

LPA-7-24 is a general purpose RF amplifier, designed for 100-7000 MHz wideband driver applications. With 24 - 27dB gain and +/-1.5dB gain flatness, LPA-7-24 is suitable for variety of RF signal applications. Measured at 1.25” x 1.25” x 0.625”, the unit can be powered with 10V to 15V DC power supply and drawing 130mA current.

RF Bay
rfbayinc.com

Epoxy System

Developed for a variety of bonding, sealing, potting and encapsulation applications, Master Bond EP3RR-80 is a one component epoxy that offers user friendly handling. It has a moderate viscosity, good flow properties and an unlimited working life at ambient temperatures. Additionally, this system can be stored at 40-50°F and does not require freezing. Unlike typical one part epoxies, EP3RR-80 will cure in 45-50 minutes at 80°C (175°F), or in 25-30 minutes at 250°F.

Master Bond
masterbond.com

LNA

Model SBL-7138632040-1212-E1 is a low noise amplifier with a typical small signal gain of 20 dB and a nominal noise figure of 4 dB in the frequency range of 71 to 86 GHz. The DC power requirement is +6 to +12 VDC/30 mA. The input and output port configurations are both WR-12 waveguides with UG387/U flanges. The mechanical configuration of the amplifier is an inline structure, which allows convenient system insertion.

SAGE Millimeter
sagemillimeter.com

Product Highlights

Couplers

VidaRF offers a wide selection of Directional Couplers, Dual Directional Couplers and Hybrid Couplers, designed to cover 0.1 GHz to 20 GHz. Average power from 50W to 1kW. Standard coupling values 3,6,10,15,20,25 and 30 dB. Standard Connector type: SMA female, other connectors available upon request. VidaRF is a North Carolina based company that is focused on being a solutions provider.

VidaRF
vidarf.com

Controller/Sequencer

Richardson RFPD announced availability and full design support for a new gallium nitride bias controller/ sequencer module from M/A-COM Technology Solutions. The MABC-001000-DP000L provides proper gate voltage and pulsed drain voltage biasing for a device under test (DUT). The bias controller module offers protection and dynamic control of all MACOM high-power transistors, including its GaN portfolio.

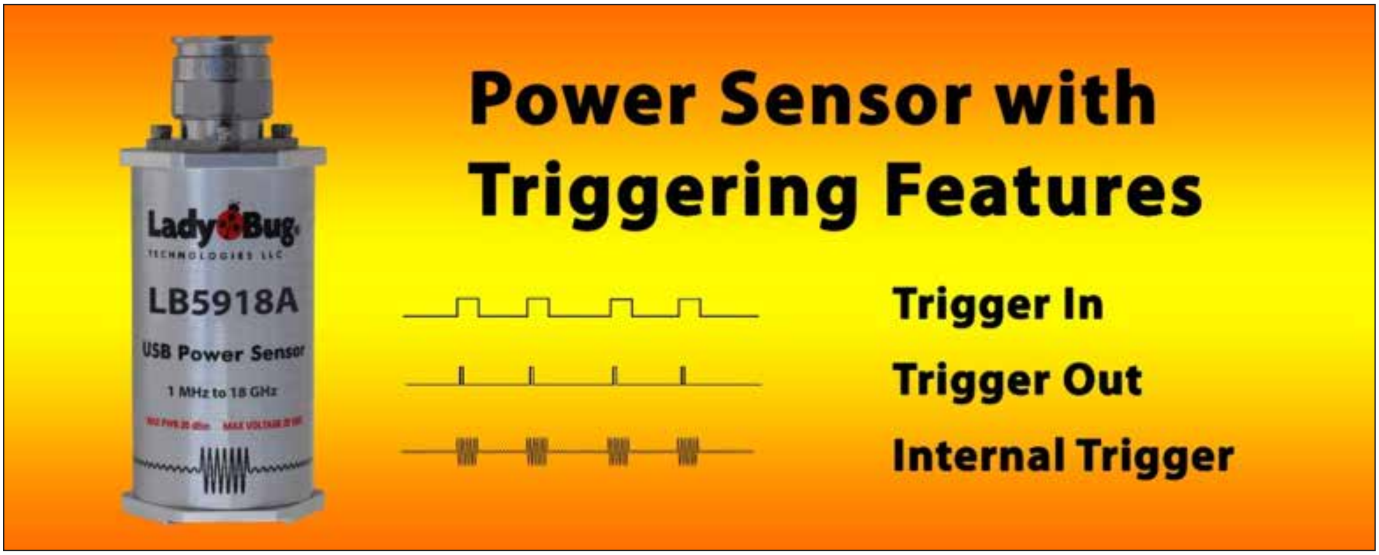
Richardson RFPD
richardsonrfpd.com

Power Dividers

P1dB introduced 2-Way and 4-Way SMA power dividers operating from 2 to 6 GHz. The new RF power dividers operate across the full frequency band and are optimized for the 2.4 and 5 GHz Wi-Fi bands with increased isolation and improved insertion loss. The SMA dividers meet the demands of production test systems for routers, cell phones, tablets and other Wi-Fi enabled products. They are in-stock and can ship immediately.

P1dB
p1db.com

Product Highlights



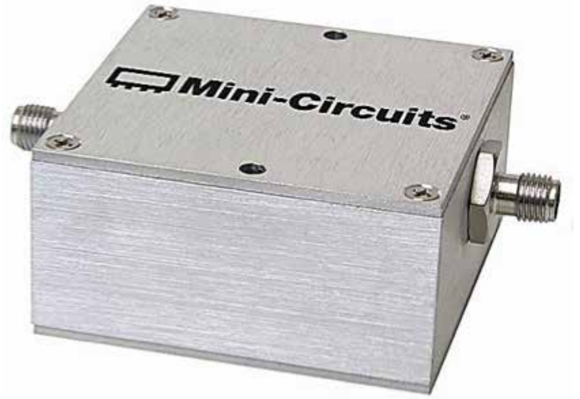
Power Sensor Includes Internal and External Triggering

LadyBug's LB5900 Series USB RF Power Sensors now include internal and external triggering at no upcharge. The state of the art high accuracy, high sensitivity True RMS Average power sensor products are ideal for making measurements on signals with wide bandwidth modulation including all modern communication formats.

The LB5900 series sensors are available with frequency coverage from 9 kHz to 40 GHz and offer excellent dynamic range. Optional features including unattended operation (Option UOP), direct connection through I2C or SPI and security options (Option MIL) are available.

The sensor features superior programmatic control using SCPI instructions through either USB HID or USBTMC protocol.

LadyBug Technologies
ladybug-tech.com



Filter

Mini-Circuits' ZLPF-120+ connectorized low pass filter provides a pass band from DC to 120 MHz, supporting applications including military communications, mobile satellite, auxiliary broadcasting, and more. It achieves 2.5 dB pass band insertion loss, and 30 dB stop band rejection. It provides fast roll off and excellent selectivity with the 3 dB cut off point at 121 MHz and 30 dB rejection at 125 MHz.

Mini-Circuits
minicircuits.com

Transceiver

Keysight announced the VXT PXIe vector transceiver, a fully calibrated instrument module that provides vector signal generation and analysis in four slots. With accelerated measurements and deep software, VXT is ideal for rapid solution creation and faster throughput in manufacturing test of wireless components and IOT devices. Test solutions for power amplifiers and front-end modules are easily created using the VXT's ready-to-run software and FPGA-accelerated measurements.

Keysight Technologies
keysight.com

Frequency Multiplier

Model SFA-713863410-12KF-S1 is an Active X4 Frequency Multiplier. It takes an input frequency of 17.75 to 21.5 GHz and a typical input power of +5 dBm and yields an output frequency of 71 to 86 GHz, and the nominal output power of +10 dBm. It also has a typical harmonic suppression of 20 dB. The DC power requirement for the multiplier is +8 VDC/240 mA. Input port configuration is a female K connector and the output port configuration is a WR-12 waveguide with a UG-387/U flange.

SAGE Millimeter
sagemillimeter.com

Switch

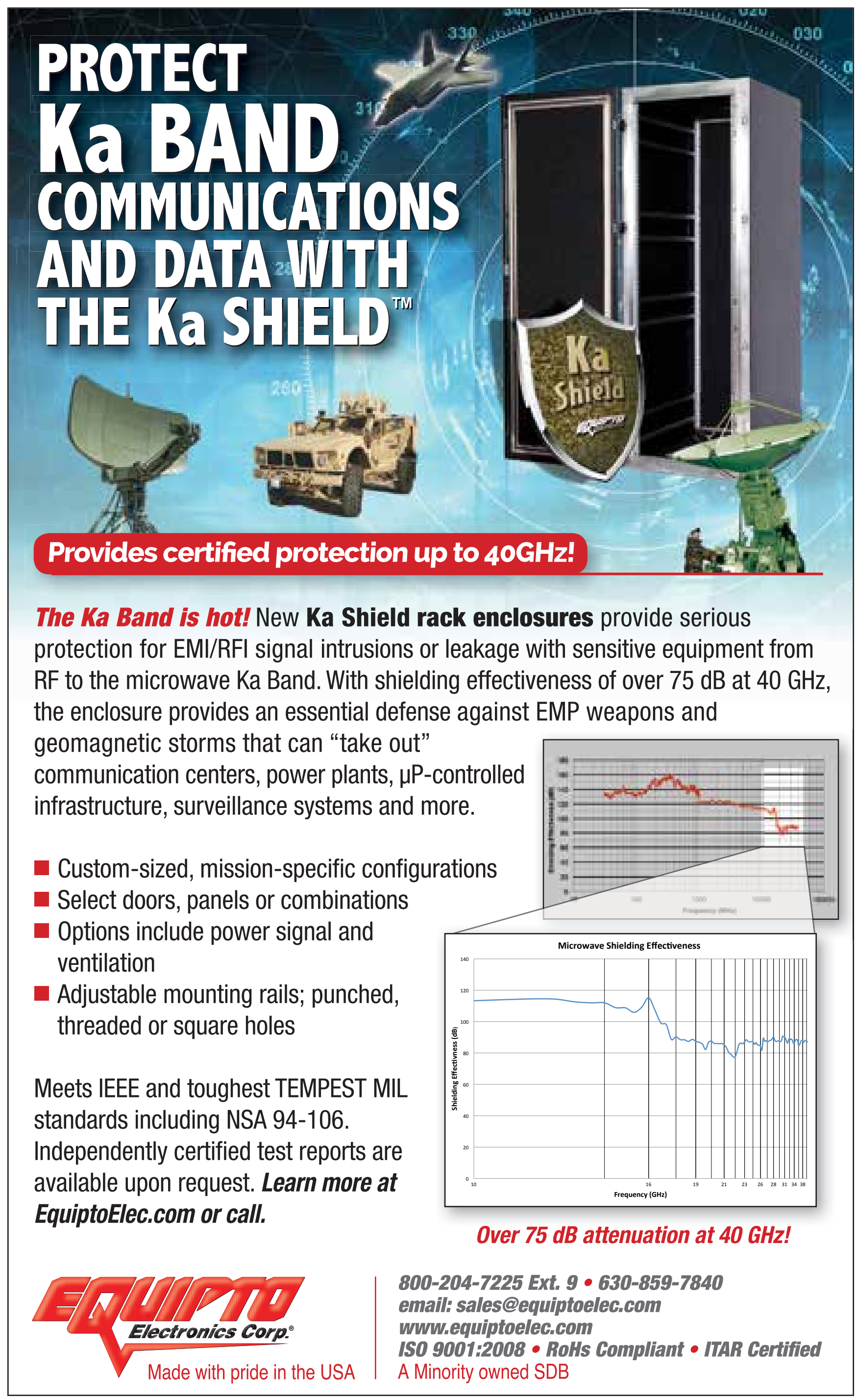
Richardson RFPD announced availability and full design support for a new dual differential, single pole double throw RF switch from Peregrine Semiconductor. The PE42920 DDSPDT RF switch is a broadband (10 kHz–6 GHz) and low loss device that enables the switching of two independent differential signals. This device consumes less power than active differential switches. It has high isolation between same-channel inputs, as well as opposite active channels.

Richardson RFPD
richardsonrfpd.com

Cables

W. L. Gore & Associates (Gore) introduced GORE® Aerospace Fiber Optic Cables to meet the civil aerospace industry's need for reliable high-speed data transmission cables in a durable, lightweight construction.

Gore
gore.com



Get info at www.HFeLink.com

Product Highlights

Transformer

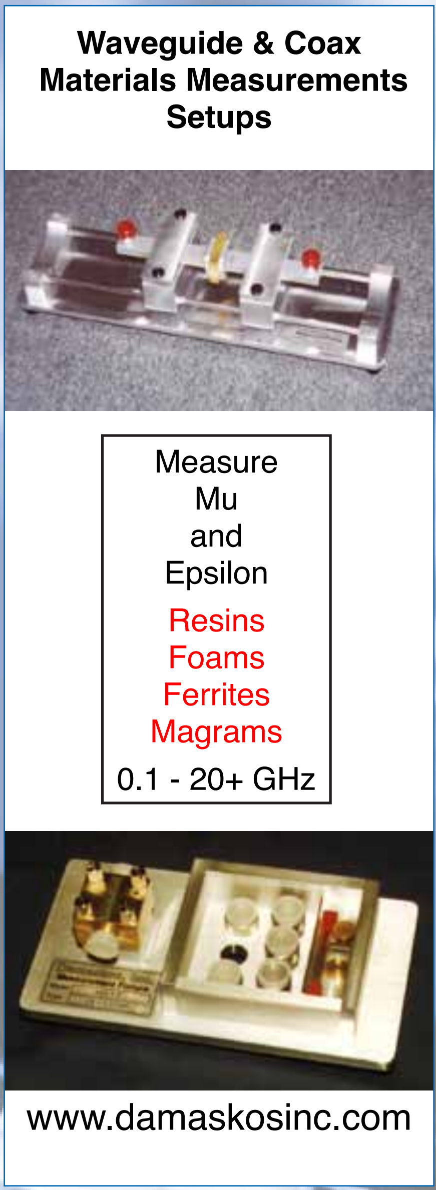
Model TXA4-512HP+ is a high power surface mount balanced transmission line transformer with a 1:4 impedance ratio, operating across the 30 to 512 MHz band. It is ideal for use in applications including PCS, cellular and more. It can handle up to 5W RF input power and 30mA DC current. It achieves 0.7 dB insertion loss, 0.3 dB amplitude unbalance and 2° phase unbalance. A center tap at the primary winding allows DC feed and DC bias without the need for an additional bias tee in the signal chain.

Mini-Circuits
minicircuits.com

Directional Coupler

This coupler features reliable Stripline construction using multi-section design and provides power sampling up to 1000 watts CW in small coaxial packages that has proven performance for power and reliability under extreme environmental conditions. Covering a 400 - 1000 MHz the coupler boasts flat coupling of 0.25 dB across the band exhibiting 0.2 dB insertion loss with 25 dB directivity. The input/output connectors are Type "SC" female and type "N" on the coupled ports.

Preferred Power Products
preferredpowerproducts.com

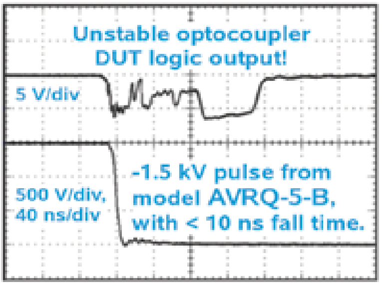


Product Showcase

Transient Immunity Testers from AVTECH

The Avtech AVRQ series of high-voltage, high-speed pulse generators is ideal for testing the common-mode transient immunity (CMTI) of next-generation optocouplers, isolated gate drivers, and other semiconductors.

- Kilovolt amplitudes (±1, ±1.5, -2 kV)
- Transition times down to 10 ns, dV/dt rates up to 120 kV/us
- Switchable daughterboards to handle a variety of DUT package styles
- GPIB, RS-232 ports standard
- Ethernet / VXI optional



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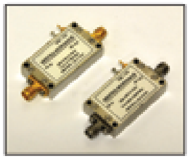

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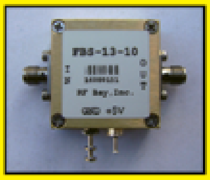
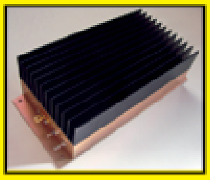
Email: sales@wenteq.com, Website: www.wenteq.com

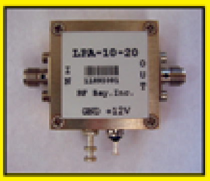
RF Bay, Inc.



10GHz Divide-by 13 Prescaler



850-950MHz 10W Power Amplifier



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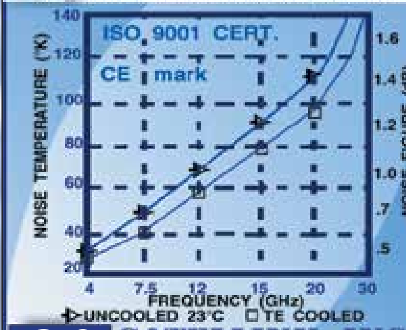

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Product Highlights

Amp Module

The Model TA1049 - 700 to 6000 MHz, 10W GaN Amplifier Module is ideal for CW, modulated or pulsed applications. The wideband DC input range of +9 to +36V allows the unit to be used with various power supplies in existing systems. Due to several state-of-the-art circuits, this unit is also highly immune from damage due to out of spec DC voltage conditions that may be applied. Its rugged construction guarantees fault-free operation in the most extreme environments.

Triad RF Systems
triadrf.com

Switch

Skyworks introduced a single-pole, double-throw (SPDT) switch that is qualified to the Automotive Electronics Council (AEC) Q100 standard. The SKYA2001 features low insertion loss (0.4 dB at 2.4 GHz) and positive voltage operation with very low DC power consumption (10 µA). It is ideal for next generation automotive systems, transportation infrastructure platforms, in addition to industrial, and aerospace and defense wireless control applications.

Skyworks
skyworksinc.com

Receptacles

SGMC Microwave introduced a new line of Precision Grade Receptacles. Type N Male and Female (4) Hole Flange Receptacles with extended pin and dielectrics (epoxy captivated). 50 Ohm, Low VSWR, Low Insertion Loss, Mode Free through 11 GHz (18 GHz version also available). Passivated 303 Stainless Steel Housings with Gold plated Center Conductors. Brass, Nickel Plated housings also available. Dielectrics: Virgin PTFE Fluorocarbon. Same-day shipping from stocking distributor C.W. Swift & Associates.

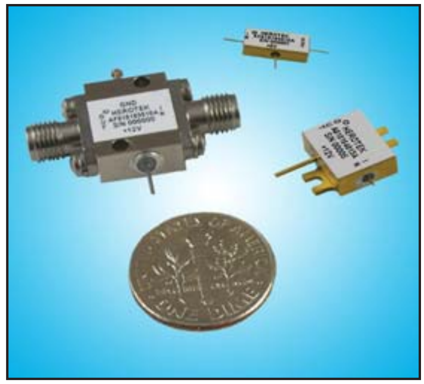
SGMC Microwave
sgmcmicrowave.com

Product Highlights

Probe Station

The LMS–2709 is a basic rugged RF (and DC) probe station for the research of advanced active and passive components. Useful for training university students in microwave and DC microprobing. Compatible with magnetic mount ball bearing microprobing positioners. Positioners compatible with DC, AC & RF microprobes. Binocular and Trinocular stereo zoom microscope with 7-30X magnification (included wide field eyepieces), LED ring Illuminator, precision x-y stage with isolated and shielded chuck, vacuum hold down and Z-lift. Vacuum pump included.

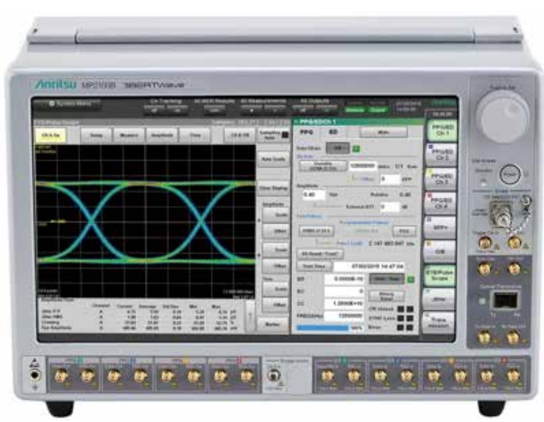
J Micro Technology
jmicrotechnology.com



LNA

Herotek's 6 - 18 GHz miniature wideband LNAs feature: Very High Optimized Gain; Low Power Consumption; Low Noise Figure; Very Flat Gain Response; Miniature Sizes for Drop-In Assembly; Hermetically Sealed Package for all Applications. Applications: Microwave Radio & VSAT; Test Instrumentation; Fiber Optics; Telecom Infrastructure; Military & Space.

Herotek
herotek.com



BERT

Anritsu's BERTWave MP2100B is a single solution that supports simultaneous BER measurements and eye pattern analyses for more efficient and accurate evaluations of high-speed optical modules and devices used in datacenter servers and network devices. By combining the measurement capability of two separate instruments, it reduces cost-of-test and significantly improves test times and measurement reliability to speed product time to market.

Anritsu
anritsu.com

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Ducommun

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- AHP-34043530-01
- Gain: 30 dB (Min)
- Gain Flatness: +/-2.0 dB (Max)
- P-1dB: 34 dBm (Typ), 33 dBm (Min)

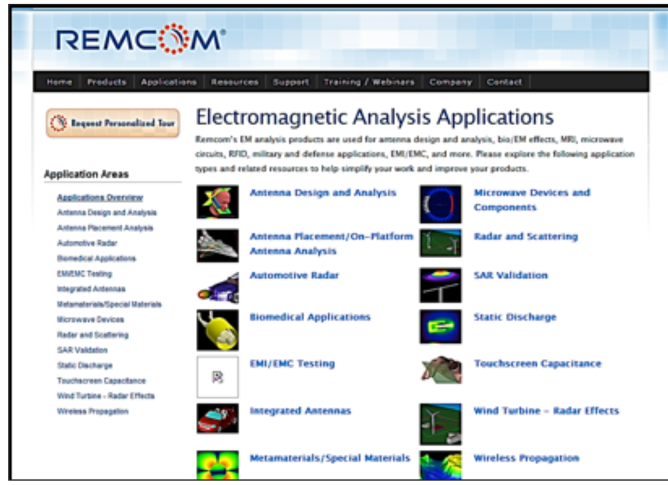
• Broadband, Low noise with high gain

26.5 to 40.0 GHz Low Noise Amplifier
- ALN-33144030-01
- Gain: 30 dB (Min)
- Gain Flatness: +/-1.0 dB across the band
- Noise Figure: 4.0 dB (Typ)

For additional information, contact our sales team at 310.513.7256 or rfsales@ducommun.com

CONTACT US

Product Highlights



Connector

Times Microwave Systems introduced a new non-solder BNC male connector for LMR-240, the EZ-240-BM-X (3190-6120) X Series NO-BRAID-TRIM Advantage™. Features: Non-solder design; Tri-metal plating (eliminates tarnishing); Chamfered cable entry hole for ease of termination; Ridged landing area on the aft end for better grip and sealing of the heat shrink boot; Improved impedance matching for low VSWR; Cable can be stripped using the standard CST-240A cable prep tool; No braid trimming required.

Times Microwave Systems
timesmicrowave.com

EM Analysis

Remcom's website features more than 85 examples showcasing a variety of EM Analysis applications, including: Antenna design and analysis; Bio/EM effects and MRI; Waveguides and microwave circuits; Radar and scattering; SAR validation; Military and defense applications; EMI/EMC; and more. Remcom engineers have written these examples and explain the steps they took to set up and run the simulations. For many examples they offer the project files as a free download.

Remcom
remcom.com

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 and is built to withstand challenging airborne environments.

TRAK Microwave
trak.com

Product Highlights

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 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.

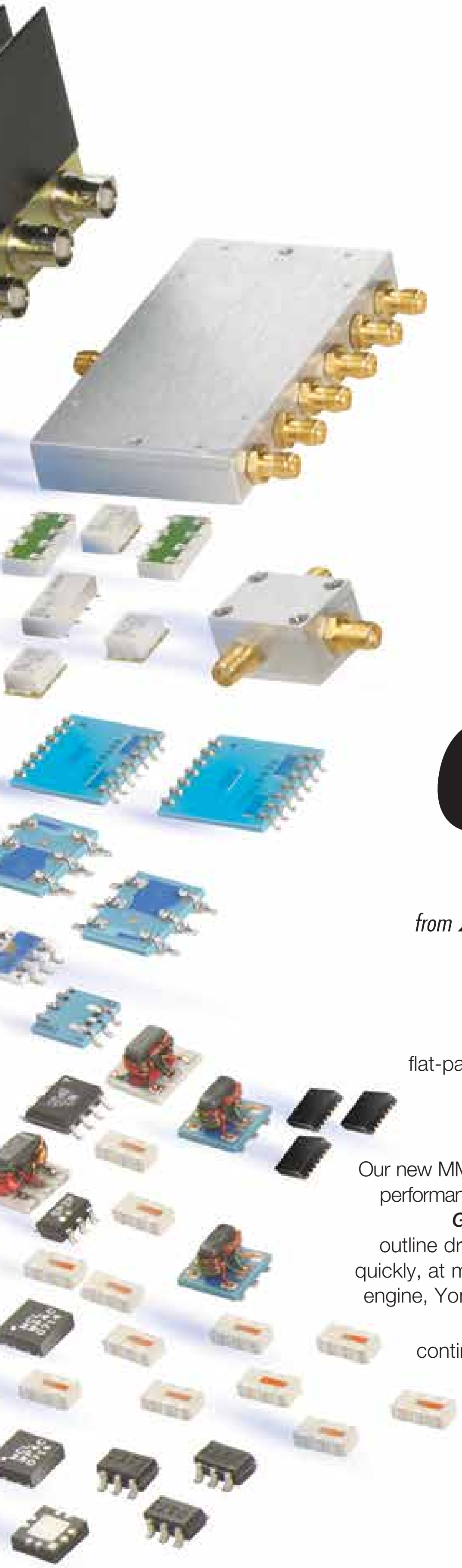
TTE Filters
tte.com

LNA

PMI Model No.PE2-28-15G18G-4R0-13-12-SFF is a 15.0 to 18.0 GHz, low noise amplifier with a typical gain of 26 dB at the 10.0 to 18.0 GHz frequency rage. This unit has a noise figure of 4.0 dB max and a typical VSWR of 1.5:1. It is supplied with removable SMA(M) connectors in PMI's standard PE2 housing.

Planar Monolithics Industries
pmi-rf.com


MCL B 744
ADP-2-10



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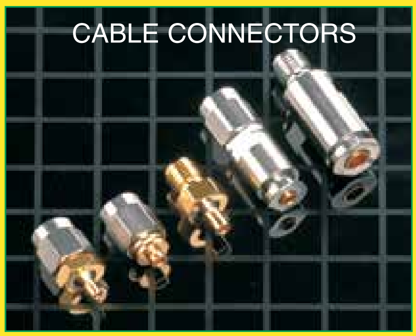

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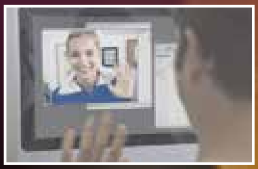
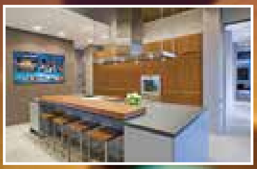

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