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HIGH FREQUENCY E LECTRONICS

CONSIDERATIONS IN REMOTE POWER SENSING APPLICATIONS

IN THIS ISSUE:

Tom Perkins on Attending the IMS Show

Guest Editorial: Test Solutions Evolving to Meet 5G Requirements

IMS 2015 Product Preview

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

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•	ZHL-16W-43+	1800-4000	45	13	16	1595
	ZHL-20W-13+	20-1000	50	13	20	1395
	ZHL-20W-13SW+	20-1000	50	13	20	1445
	LZY-22+	0.1-200	43	16	32	1495
	ZHL-30W-262+	2300-2550	50	20	32	1995
•	ZHL-30W-252+	700-2500	50	25	40	2995
	LZY-2+	500-1000	47	32	38	2195
	LZY-1+	20-512	42	40	50	1995
	ZHL-50W-52+	50-500	50	40	63	1395
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	ZHL-100W-GAN+	20-500	42	79	100	2395
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	ZHL-100W-352+	3000-3500	50	100	100	3595
	ZHL-100W-43+	3500-4000	50	100	100	3595
	LZY-5+	0.4-5	52.5	100	100	1995

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ZVA-213X+	0.8-21	26±2	24	33	3.0	945.00		

* Heat sink must be provided to limit base plate temperature. To order with heat sink, remove "X" from model number and add 50 to price.





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APRIL2015 Vol. 14 No. 4



22

Feature Article

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Considerations in Remote Power Sensing Applications

By Orwill Hawkins

Many applications can be satisfied using small portable USB power sensors.

Feature Article

32



Maximizing Your Symposium Experience

By Tom Perkins

General advice for newcomers and veterans alike on making the most of your conference experience.

16 Featured Products



Including Broadwave Technologies, Teledyne Microwave Solutions, Herotek, Pole/Zero, SAGE Millimeter, Linear Technology, SV Microwave, Aviel Electronics, and more.

40

Product Highlights



Featuring NI, Cobham Inmet, Master Bond, OML, Anritsu, Southwest Microwave, dBm, Coilcraft, and more.

6 Editorial

8 Meetings & Events

12

In The News



Highlighting LRASM, Cobham AvComm, TE Connectivity, CST, Molex, Versatile Power, Microphase.

12 In the News

40 Product Highlights

Guest Editorial

60



Anritsu's Donn Mulder on "Test Solutions Evolving to Meet 5G Requirements."

16 Featured Products

64 Advertiser Index

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Associate Publisher/Managing Editor Tim Burkhard tim@highfrequencyelectronics.com Tel: 707-544-9977

Senior Technical Editor Tom Perkins tom@highfrequencyelectronics.com Tel: 603-472-8261

<u>Vice President, Sales</u> Gary Rhodes grhodes@highfrequencyelectronics.com Tel: 631-274-9530

> Editorial Advisors: Ali Abedi, Ph.D. Candice Brittain Paul Carr, Ph.D. Alen Fezjuli Roland Gilbert, Ph.D. Sherry Hess Thomas Lambalot John Morelli Karen Panetta, Ph.D. Jeffrey Pawlan, Ph.D.

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Editorial

The Last Man to Walk on the Moon

Tom Perkins Senior Technical Editor



I recently watched an interview with Eugene Cernan, who turned 81 last month. He was the last person to touch the surface of the moon back in December 1972. He is apparently making a documentary about his incredible experience.

I don't remember that event nearly as well as the first landing on the moon in July, 1969—Neil Armstrong and Buzz Aldrin. By 1972, with six crewed landings, this activity was almost routine. However, actually only 12 different

men landed on the moon, and none more than once. Notwithstanding all the benefits we derive from satellites, space stations, and deep space probes, it seems odd that young people today are depending on their grandparents to recount how we went to the moon. When I was a youngster I thought that landing on the moon would be impossible, and used to wonder how my grandparents dealt with oil lamps, candles, horses and outhouses. In 1972 one never would have contemplated that Apollo 17 would be the last manned moon landing.

Online research will fetch a considerable number of entertaining articles suggesting that the moon landings were a hoax. (Quite a conspiracy among 12 very highly respected military men, if the landings never happened). Also, there are a growing number of claims that extraterrestrial UFOs or space aliens were encountered on some of the missions. Well, a few things that were challenging then would be different for a future moon landing effort.

Apparently the whole idea of transmitting TV signals back to earth was questioned over four decades ago due to the extra weight of the equipment. As best I can tell, and remember, the link was established in what we generally call S-band, a portion of the spectrum between 2 and 4 GHz. The International Space Station (ISS) happens to use VHF, UHF and S-Band. The frequencies used for future moon exploration could likely be either in X-band or perhaps Ka-band. Considerably improved device technology e.g. GaAs, and smaller cameras and antennas would make for (hopefully) captivating coverage. Imagine watching the folks exploring the moon in high definition and maybe 3-D. Would such activity stimulate STEM, as in the past, or would it be just ho-hum?

Another Merger

The \$40B merger of Freescale and NXP holds the potential to contribute to revolutionary changes in our industry. At recent symposia such as the IMS, I have been particularly intrigued by NXP's ability to demonstrate unique new applications for microwave technology, employing all sorts of unique solid-state devices. Just a few of the applications are radar and communications systems building blocks, microwave heating, microcontroller and automotive products. The marriage with Freescale will likely enable lots of new inventions and innovations as these companies have very complementary technology.

IMS Phoenix

Speaking of IEEE IMS, the symposium in Phoenix (May 17 - 22) approaches rapidly. Also included is RFIC at the beginning and ARFTG at the end. If you haven't already made reservations, do it now. This year's event is loaded with well-planned activities including a kick-off reception, many excellent papers, workshops, short courses, panel sessions, several student and STEM activities. MicroApps, exhibits, interactive forums, awards, and social activities. One of the new activities, titled "RF Boot Camp," is intended mainly for newcomers to our field. This is a great idea, both from an academic perspective and also because this may help to enable interaction with industry veterans—something we traditionally have not done as effectively as possible. *High Frequency* Electronics will be in booth 329. Please come by and say hello. More on this in our May issue.

New HLM

I was pleased to recently learn that my friend Richard A. Sparks is the newest MTT-S Honorary Life Member. Over a span of 54 years, there have only been 13 given this honor. Due to Dick's long involvement with IEEE MTT, he likely knew all of the others. If you see Dick in Phoenix, thank him for his service.

"The Value of Sales Reps"

I received quite a few kind words of thanks about my February Editorial on the enduring value of sales representatives. It was even suggested that perhaps a panel session could be held on this topic at a future IMS or similar event. We will give this serious consideration. If you would be interested in being a panel member, or assisting in some other way, please let me know. My email address is listed in the masthead on page 6, and I would also welcome the opportunity to speak with interested parties in person when we all congregate in Phoenix next month.





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Meetings and Events

CONFERENCES & MEETINGS

2015 IEEE Wireless and Microwave Technology Conference (WAMICON 2015)

13-15 April 2015 Cocoa Beach, Florida, USA http://www.wamicon.org/ Paper Submission Deadline: 5 January 2015

2015 IEEE MTT-S International Conference on Microwaves for Intelligent Mobility (ICMIM 2015)

27-29 April 2015 Heidelberg, Germany http://www.icmim-ieee.org Paper Submission Deadline: 20 December 2014

2015 IEEE MTT-S International Wireless Power Transfer (WPTC 2015)

13-15 May 2015 Boulder, Colorado, USA http://www.wptc2015.org/ Paper Submission Deadline: 16 January 2015

2015 IEEE International Microwave Symposium (IMS2015)

17-22 May 2015 Phoenix, Arizona, USA http://ims2015.org/ Paper Submission Deadline: 8 December 2014

2015 IEEE Radio Frequency Circuits Symposium (RFIC

2015)

17-19 May 2015 Phoenix, Arizona, USA http://rfic-ieee.org/ Paper Submission Deadline: 12 January 2015

85rd ARFTG Microwave Measurement Symposium

22 May 2015 Phoenix, AZ, USA http://www.arftg.org/

2015 IEEE MTT-S International Conference on Numerical Electromagnetic Modeling and Optimization for RF, Microwave and Terahertz Applications (NEMO 2015)

11-14 August 2015 Ottawa, Canada http://nemo-ieee.org Paper Submission Deadline: 16 February 2015

2015 40th International Conference on Infrared, Millimeter, and Terahertz waves (IRMMW-THz)

23 – 28 August 2015 Hong Kong www.irmmw-thz2015.org

2015 IEEE International Symposium on Radio-Frequency Integration Technology (RFIT)

26 – 28 August 2015 Sendai, Japan www.ieee-jp.org/japancouncil/chapter/MTT-17/rfit2015/

2015 IEEE MTT-S 2015 International Microwave Workshop Series on RF and Wireless Technologies for Biomedical and Healthcare Applications (IMWS-BIO)

21 – 23 September 2015 Taiwan www.ieee-jp.org/japancouncil/chapter/MTT-17/rfit2015/

2015 IEEE International Conference on Ubiquitous Wireless Broadband (ICUWB)

4 – 7 October 2015 Montreal www.icuwb2015.org

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Ericsson, Alcatel-Lucent, Nokia Lead \$5B Small Cell Site Services Market

Network capacity and coverage problems demand small cells as a solution, pushing operators to scramble for suitable small cell sites. It gets worse as this growing demand for sites aggravates backhaul and power challenges; however, capable small cells vendors are up to the challenge with small cell site services, managing site CAPEX that will reach over US\$5 billion by 2019. Leading edge operators do not want this headache, and will outsource small cell operations and establish RAN sharing agreements. Operators' focus on competitive advantages of their core services opens the door for outsourced solutions and beneficial arrangements with the site owners.

The unique deployment challenges facing small cells in the enterprise and public markets force multi-operator agreements, reduced equipment size, collocated cells, and minimal aesthetic impact. Increasing demand and overcrowded sites become a problem. Six small cells on a street corner or light post will not fly. "Operators see small cells networks as a competitive advantage, but mass market and hotspot rollout versus limited site selection changes the equation into site sharing services," comments **Ahmed Ali**, Research Analyst at ABI Research. "We will see the small cell needle move as these arrangements take hold."

The exact makeup of the small cell site services business model depends on the solution provider goals and the market. Leading players include equipment vendors; **Ericsson, Alcatel-Lucent, Huawei**, and **Nokia**, as well as site and fiber owners like **Virgin Media, Zayo, and CloudBerry**.

—ABI Research abiresearch.com

LTE-Advanced Coverage to Cross 1B Mark by 2018

TE-Advanced networks have been actively deployed around the world. At the end of 2014, LTE-Advanced covered its first **100 million people worldwide**, just 4 years since the network's inception. **ABI Research predicts that the coverage will reach 1 billion in 4 more years.**

At the end of 2014, there were 49 commercially available LTE-Advanced networks around the world. Western European operators lead the commercialization with 20 operators, followed by 13 in Asia-Pacific; however, North America still commands the largest population coverage at 7.8%. "All four major operators of the United States have either commercially deployed (AT&T and Sprint) or have been actively deploying (Verizon and T-Mobile) their LTE-Advanced networks," comments **Lian Jye Su**, Research Associate of Core Forecasting. Globally, a number of major auctions are expected to take place in several major markets in 2015. The Telecom Regulatory Authority of India has just recently confirmed a LTE spectrum auction on the 25th of February. In France, the government has recently approved the reassignment of the 700 MHz band for telecom services. At this moment, the FCC of the United States is currently conducting an auction for AWS-3 spectrum. "As heavy subscribers' data traffic growth has exploded, ABI Research anticipates fierce competition for more spectrum, as well as an active migration to VoLTE and higher data modulation schemes such as LTE and LTE-Advanced, which has higher spectral efficiency," adds **Jake Saunders** of ABI Research.

-ABI Research abiresearch.com

Wearable Electronics Bring New Opportunities for Sensors

The wearable devices space is viewed as the next goldmine of opportunity for **sensor manufacturers** as profits shrink in the smartphone and tablet segments. Further, the sensor landscape for wearable devices will gain a new dimension through the entry of software and hardware giants such as Google, Apple, Samsung, and Intel.

"Rising average life expectancy and increasing awareness on health and fitness monitoring have fuelled the adoption of wearable devices," said Frost & Sullivan Measurement and Instrumentation Senior Industry Analyst Sankara Narayanan. "In addition to clinical healthcare, medical, fitness & wellness applications the wearables market is witnessing a series of new product launches, such as heads-up displays, smart watches, smart fabrics, wrist bands, and glasses that are used across various consumer, industrial and other verticals. As the need to collect various physiological data and quantified self-movement surges, wearables will incorporate more complex electronics and sensors."

Since the wearable electronics ecosystem is complex, a combination of both hardware and software knowledge is required for companies to make it big in the industry. Many firms do not have the skill to design products from scratch. Further, the need to integrate a large number of sensors inside a wearable device poses serious problems in terms of battery life and time to market.

Sensor platforms, rather than sensor components, will play a critical role in wearable device innovation and shortening time to market. Sensor platform companies, with **expertise in sensors, low-power processing, and wireless connectivity**, can design solutions with the desired number of sensors while ensuring robust battery life and reduced power consumption.

—Frost & Sullivan frost.com

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In the News



Robots can learn to recognize objects and patterns fairly well, but to interpret and be able to act on visual input is much more difficult. Researchers at the University of Maryland, funded by DARPA's Mathematics of Sensing, Exploitation and Execution (MSEE) program, recently developed a system that enabled robots to process visual data from a series of "how to" cooking videos on YouTube. Based on what was shown on a video, robots were able to recognize, grab and manipulate the correct kitchen utensil or object and perform the demonstrated task with high accuracy—without additional human input or programming.

"The MSEE program initially focused on sensing, which involves perception and understanding of what's happening in a visual scene, not simply recognizing and identifying objects," said **Reza Ghanadan**, program manager in DARPA's Defense Sciences Offices. "We've now taken the next step to execution, where a robot processes visual cues through a manipulation action-grammar module and translates them into actions."

Another significant advance to come out of the research is the robots' ability to accumulate and share knowledge with others. Current sensor systems typically view the world anew in each moment, without the ability to apply prior knowledge.

"This system allows robots to continuously build on previous learning—such as types of objects and grasps associated with them—which could have a huge impact on teaching and training," Ghanadan said. "Instead of the long and expensive process of programming code to teach robots to do tasks, this research opens the potential for robots to learn much faster, at much lower cost and, to the extent they are authorized to do so, share that knowledge with other robots. This learning-based approach is a significant step towards developing technologies that could have benefits in areas such as military repair and logistics."

* * *



Initiated in 2009 in collaboration with the U.S. Navy and U.S. Air Force, DARPA's **Long Range Anti-Ship Missile (LRASM) program** has been investing in advanced technologies to provide a leap ahead in U.S. surface warfare capability. **The LRASM program aims to reduce dependence on intelligence, surveillance and reconnaissance platforms**, network links and GPS navigation in electronic warfare environments while providing innovative terminal survivability approaches and precision lethality in the face of advanced countermeasures. After LRASM prototypes completed two successful flight tests in 2013, LRASM transitioned from a DARPA technology demonstration program to a formal U.S. Navy program of record in February 2014, with fielding set for 2018.

On February 4, the Navy, Air Force and DARPA completed another successful flight test, marking a significant step in maturing key technologies for the future operational weapon system. The joint-service team, known as the LRASM Deployment Office (LDO), conducted the test to evaluate LRASM's low-altitude performance and obstacle avoidance as part of the program's accelerated development effort.

"We are very pleased with how LRASM performed today and we are looking forward to continuing integration efforts on the Air Force B-1, followed by our Navy F/A-18, over the next few years," said **Capt. Jaime Engdahl**, the LDO's Navy program manager. "We have a clear mission, to **deliver game-changing capability to our warfighters in theater as quickly as possible.**"

* * *

Cobham AvComm, formerly Aeroflex AvComm business unit, has announced an agreement with **Tait Communications** to provide automated test capabilities for Tait **P25 series radios on the Cobham 3920B Digital Radio Test Set**. Initial test capabilities will be focused on the Tait TP9100 and TM9100 series radios. The program will be later expanded to provide automated testing of Tait TP9400 and TM9400 series radios.

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With a proven track record for speed and accuracy, this application uses the precision instrumentation with the 3920B to quickly perform automated tests to specifications defined by the manufacturer. Testing can now be performed in much less time, minimizing service and support costs for end users and dealers.

* * *

TE Connectivity expanded its distributor relationship with Wesco Aircraft Holdings, Inc. Wesco Aircraft's previous agreement included the aerospace, defense and marine (AD&M) high performance relay products and DEUTSCH products. Now, it has been expanded to include the AD&M mil/aero connectors and Raychem harness protection products (engineered polymer solutions, EPS). "The TE Aerospace, Defense and Marine Business unit is pleased to expand our relationship with Wesco Aircraft; we value our relationship with Wesco and are excited to expand our portfolio with them," said Frank Breslin, Vice President of Sales, TE Connectivity, Global Aerospace, Defense & Marine. "Wesco Aircraft's extensive market presence with commercial and military aerospace customers will help strengthen TE's ability to engage the growing opportunities and demands of customers in these important market segments."

* * *

Computer Simulation Technology (CST) announced educational seats for CST EMC STUDIO, a simulation tool for electromagnetic compatibility (EMC) analysis, at the 2015 **IEEE Symposium on Electromagnetic** Compatibility and Signal Integrity.

EMC is an important consideration in a wide range of applications, and an increasing number of universities have set up courses and research groups for its study. CST develops electromagnetic simulation solutions that are widely used in academia, research and industry, and has long supported universities through discounted licenses and co-operation programs.

* * *

Molex announced the expansion of its fiber optic technology platform following the recent acquisition of Oplink Communications. A wholly-owned subsidiary of Koch Industries, Molex will now manage Oplink, a leading provider of optical communication components, intelligent modules and subsystems for a wide variety of customer applications.

* * *

Versatile Power announced the addition of **Instrument Engineers**, San Diego, Calif., to its list of authorized distributors of the company's new family of BENCH Programmable Power Supplies. The Versatile Power BENCH series are compact, programmable, DC power supplies and are nearly half the cost compared to the industry's leading producer of power supplies.

"As a premier North American technical distributor of electronic test and measurement equipment and accessories, Instrument Engineers has a solid history of assisting customers in the selection of high quality equipment and this distribution arrangement offers additional opportunities for market exposure of our new family of BENCH Programmable Power Supplies," said Jerry Price, CEO of Versatile Power.

* * *

Microphase Corp., provider of telecom, military and aerospace products, has joined AmpliTech to support more product development using AmpliTech's state-of-the-art SATCOM LNAs and subsystems and combining them with Microphase's RF integrated assemblies including high-frequency converters, switches transmitters and filters.





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Featured Products



Modem

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Teledyne Microwave Solutions teledyne.com



Dual Amp

RFMW announced support for the TAT7472A1F from TriQuint (Qorvo). The TAT7472A1F is the next generation replacement for the popular AH22 that has served CATV designs for many years. With a bandwidth of 50 to 1218MHz, it increases the frequency coverage to support newer designs.

RFMW rfmw.com



Cable Assemblies

Pasternack released a line of 75 ohm test cables with operation up to 3 GHz. These rugged cable assemblies are specially designed to withstand the rigors of test lab use and applications in 75 ohm communications systems. Technicians commonly rely on these cables in technologies such as cable TV, MoCA 2.0 and MoCA 1.1, and DOCSIS.

Pasternack pasternack.com



Termination

Model series 552-308-050 is a 50 watt of RF power (avg.) rated conduction cooled termination that has been deployed in commercial and military applications. This 50 Ohm device has an operating frequency range of DC - 4 GHz and features maximum VSWR of 1.35:1. The RF connector is N male. Additional heat sinking is required for safe operation of this device at 50 Watts.

BroadWave Technologies broadwavetech.com



Attenuator

Model SKA-6039033030-1212-A1 is a full E band high dynamic range electrical attenuator with a dynamic attenuation range of 25 dB typical in the frequency range of 60 GHz to 90 GHz. The typical insertion loss of 2.5 dB and 30 dB isolation are exhibited in the common E Band frequency range of 71 to 86 GHz. The control voltage range is 0 to -5.0 Vdc.

SAGE Millimeter sagemillimeter.com

Attenuator

PMI Model PVVAN-2040-60-MP is an analog controlled 60dB PIN diode attenuator operating over the



frequency range of 2.0 to 4.0 GHz. This model switches in 115ns typical with an insertion loss of less than 2 dB.

Planar Monolithic Industries pmi-rf.com



Switch

Mini-Circuits' MSP6TA-12+ is a 50Ω , DC to 12 GHz, 24 Volt SP6T switch featuring: low insertion loss, 0.2 dB typ.; high isolation, 90 dB typ.; ultra-reliable; break-before-make configuration; absorptive fail-safe switch; protected by US Patents 5,272,458; 6,414,577; 6,650,210; 7,633,361 and 7,843,289. Applications: ATE; reliable "sleeptime" switching; redundancy switching for microwave radio.

Mini-Circuits minicircuits.com



Amplifier

This multi-octave, ultra-wideband amplifier has excellent gain flatness and low power consumption. Model AF00120243A operates from 0.01 -20 GHz. It has 24 dB gain with max gain variation of +/- 1.5 dB, noise figure of 3 dB, P1 dB output of +8 dBm, and current draw of 90 mA at +5 V bias. It comes in a hermetical-

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Herotek herotek.com



Filter

Pole/Zero's NANO-ERFTM tunable bandpass filters cover the entire military tactical radio band of 30 to 520 MHz while fitting in a lowprofile package. It combines SMT capability with +6 dBm in-band and +20 dBm out-of-band RF power handling, +16 dBm IIP3, low IL (5 dB typical in a 6% filter), 27 µs typical tune time and remarkable selectivity (20 dBc @ fc \pm 15% for 6% BW) for a compact device.

Pole/Zero polezero.com



Transformers

Coilcraft's new CST2010 Series of current sense transformers detect switching current up to 40 amps over a frequency range of 50 to 500 kHz while also isolating circuits electrically, resulting in up to 10X lower power dissipation than current sense resistors. This makes them ideal for switched-mode power supply applications, including feedback control, overload detection, and load drop/shut down detection.

Coilcraft

coilcraft.com

Controller

Linear Technology announced new high reliability and military temperature grade versions of its



LTC4412, a robust "ideal diode" PowerPathTM controller. It permits low-loss ORing of multiple input DC power sources. Its 20mV forward voltage is at least 10 times lower than that of a Schottky diode. It increases efficiency by an order of magnitude, due to much lower power loss and less selfheating.

Linear Technology linear.com



Capacitor

Knowles Capacitors will be launching an increased range to its 'UX' Ultra-High K Dielectric at the MTT-S show, booth 129. 'UX' material has the highest dielectric constant of any of DLI's wide variety of materials and allows for higher capacitance values in existing case sizes, or smaller sized components – all achieved without sacrificing performance.

Knowles Capacitors knowlescapacitors.com



Attenuator

Mini-Circuits' RCDAT-6000-110 is a general purpose programmable RF attenuator supporting frequencies from 1 to 6000 MHz with attenuation from 0 to 110 dB in 0.25 dB steps. Its unique

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design maintains linear attenuation change per dB, even at the highest attenuation settings. The attenuator is controlled via USB or Ethernet-TCP/IP connections and supports both HTTP and Telnet network protocols.

Mini-Circuits minicircuits.com



Power Amp

Model SBP-3335033020-2222-S1 is a full Q band high power amplifier with a small signal gain of 30 dB and a P-1 dB of +20 dBm minimum in the frequency range of 33 GHz to 50 GHz. The DC power requirement is +6.0 to +12.0 Vdc/650 mA. The input and output port are right angle configuration as shown with both WR-22 waveguides and UG383/U flanges.

SAGE Millimeter sagemillimeter.com



Adapter

Aviel Electronics designed a BNC bulkhead adapter incorporating a glass bead that hermetically seals the connector to withstand a 100 PSI leak test. The adapter, Aviel model # Z-1142 may be used in IP67 or IP68 applications in the mated and unmated condition. All interface dimensions are designed to IAW MIL-C-39012 specifications and overall dimensions to UG-492D/U specification.

Aviel Electronics avielelectronics.com



Board Connectors

SV Microwave's Compression Mount High Speed Eval Board Connectors feature solderless contact for quick and easy assembly. Features: DC to 50 GHz; New, smaller footprint; SMA, 2.92mm and 2.4mm options available; Stripline and CPW/Microstrip available.

SV Microwave svmicrowave.com

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Power Sensors

Considerations in Remote Power Sensing Applications

By Orwill Hawkins

Modern communication systems, military applications, satellite testing and other applications have increased the need for remote and autonomous testing. Because accurate power measurements are best made with the sensor as close as possible to the RF measurement point, sensor-

Many applications can be satisfied using small portable USB power sensors. to-user connectivity is very important. Many power measurement applications can be satisfied using small portable USB power sensors. Longer distances require the use of USB extenders, Ethernet, or Autonomous functionality. Power sensor manufacturers have responded with new products that are well suited to these applications.

Meters vs. Sensors

As new advanced power sensors with remote capability are introduced, it has become important to understand the differences between power meters, power sensor and the various sensor technologies that are available. Modern power sensor systems employ a variety of interfaces allowing users to place sensors in inaccessible locations. Further, some sensors such as the LB5918A, can operate autonomously. In remote, unattended, and autonomous applications, understanding your power sensor's temperature stability, zero and calibration functionality can be of great significance. Other power sensor systems such as measurement technology and path selection requirements can be extremely important as well. We will review how these important factors come into play when power sensors are used in remote applications.

In early power measurement technology, all user zero and calibration functions were manual; zeroing and calibration was required any time conditions such as temperature changed. After a short period of time passed, zeroing and calibration would again be required. The analog connection between the meter and sensor further complicated the process. Of course this would not work well for remote or unattended power sensing applications.

Zeroing and Calibration

Today, RF power sensors using patented measurement technology such as the LB5918A, do not require any user zeroing or calibration. Other power sensor technology contains internal zeroing and calibration systems that work well for moderate power levels where measurement interruption for zero and calibrate functions do not create any issues. Both of these sensor technologies could be well suited for remote, unattended, and autonomous applications.

Recognized primary metrology laboratories such as NIST continue to use thermal mounts and Wheatstone Bridge circuitry for extremely stable CW power calibration. Power sensor manufacturers utilize and transfer this recognized accuracy to their power sensors. Well-designed manufacturing practices, increasing component stability, and new engineering ideas have allowed much of the calibration and zeroing drudgery to be pushed from the user to the power sensor manufacturer.

Modern power sensors apply these precision standards to other types of power measurements, adding capabilities such as fast accurate average power, pulse profiling, plus peak and pulse measurements. In addition to the myriad measurement types, modern power sensors may be capable of unattended operation or at the very least, remote control capability.

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Model	Power Measuerment	Frequency MHz	Control Interface	Price\$ea. (Qty 1-4)
PWR-2.5GHS-75 (75Ω)	CW	0.1 to 2500	USB	795.00
PWR-4GHS	CW	0.009 to 4000	USB	795.00
PWR-6GHS	CW	1 to 6000	USB	695.00
PWR-8GHS	CW	1 to 8000	USB	869.00
NEW! PWR-8GHS-RC	CW	1 to 8000	USB & Ethernet	969.00
PWR-8FS	CW	1 to 8000	USB	969.00
PWR-4RMS	True RMS	50 to 4000	USB	1169.00

*Measurement speed as fast as 10 ms for model PWR-8-FS. All other models as fast as 30 ms

† Dynamic range as wide as -35 to +20 dBm for model PWR-4RMS All other models as wide as -30 to +20 dBm. Excel is a registered trademark of Microsoft Corporation in the US and other countries. Neither Min-Circuits nor Min-Circuits Power Sensors are affiliated with or endorsed by the owners of the above-referenced trademarks.



Power Sensors



Figure 1 • Sensor with Internal Zero and Cal.

No-Zero No-Cal or Internal Zero and Cal, what's the difference?

Sensors with low level measurement capability function into the sensor's noise floor. Quality power sensors have the ability to reach down in power level to a point at which the noise overwhelms the signal and requires the sensor to make continuous zero calculations. In fact, random noise peaks will be well above the average noise level and well *over* a quality power sensor's minimum calibrated power measurement level. Zeroing a sensor under these conditions can be difficult, largely because environmental conditions cause continuous movement of the zero level. In most conditions zero is a moving target.

Internal Zero and Cal Sensors. Sensors that employ internal zero and cal have an electronic switch that moves the detection circuitry from the user port to calibration circuitry which is then used to zero and calibrate the sensor. Temperature sensors and timing controls are employed to determine when the sensor needs to be zeroed and calibrated. This can occur often if environmental conditions change and can easily disrupt measurements. Normally the process requires several seconds to complete and can be an issue in automated, remote or unattended measurement systems.

Figure 1 depicts a sensor with internal zero and calibration capability. Switch A is used to disconnect the source and connect the calibration circuitry. Unfortunately, electronic switches are not perfect. The switch adds a small amount of noise, plus its insertion loss affects calibration and therefore your measurement. Further, switch isolation can be an issue; some portion of the input signal may leak through the switch potentially requiring external zeroing for low power level calibration. Therefore, manufacturers of sensors with this type of calibration technology often recommend removal of the measured input signal to improve low level calibration accuracy.

While some of the issues can be characterized and accounted for, uncertainty is added to the system. It should be further noted that the calibration reference signal is normally at a single frequency that may not me close to the user's measurement frequency. For measurements below -40dBm, careful consideration is recommended, particularly in remote and unattended applications where environmental conditions may vary.

No-Zero No-Cal sensors. Patented No-Zero sensors such as LadyBug's LB5918A, undergo factory calibration across the full operational temperature range. During use, the sensor continuously measures the temperature and employs a patented technique to ensure that the correct factory temperature calibration factor is always applied to the measurements. These sensors make highly accurate measurements without the need for user zeroing or calibration, either internal or external. The measurements are never interrupted to calibrate, and source and switch uncertainty are not a factor.

Figure 2 details measurement data taken from various sensors in the marketplace and shows the degree that temperature can cause measurements to vary. Note that as power levels drop, temperature variation can be particularly significant. Patented No-Zero No-Cal sensors such as the LadyBug sensor shown in green, compensate for wide variations in temperature to stabilize your measurements,

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Power Sensors



Figure 2 • Diode Sensor Temperature Stability.

and do not ever requiring user zeroing or calibration. These sensor features are particularly useful where operating conditions are unpredictable and accuracy is important.

Sensitivity and Measurement Paths

A basic simple power sensor is depicted in Figure 3. The system consists of input impedance matching circuitry, a detector, analog to digital converter and finally the



Figure 3 • Basic Power Sensor.



Figure 4 • Basic Two-Path Power Sensor.

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Power Sensors



Figure 5 • Improved Two Path Sensor.



Figure 6 • LadyBug Two Path Sensor.

processor with power level correction and communication engine.



AMCOM GaN HEMT MMIC Summary

Model	Frequency (GHz)	G _{ss} (dB)	P _{sdB} (dBm)	Eff _(5dB) (%)	V _d (V)	I _{dq} (A)	ECCN
AM004047SF-2H*	0.05-4.0	33	47	44	25, 90	0.5, 0.9	EAR99
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

* 100uS pulse width, 10% duty cycle. They also work in CW mode at lower bias voltage with slightly reduced output power. ! CW Operation.



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With this simple arrangement and square law detection techniques, detection range is only about 40 - 50 dB of dynamic range. This limits its value in test instrumentation and remote power sensing applications.

To increase the measurement range of power sensors, multiple detectors are utilized. Each detector circuit is referred to as a path. Two or three path sensors are common in high quality modern power sensors. Certain aspects of multiple path sensors should be carefully considered when selecting power sensors for remote or autonomous applications. A common two-path detector scheme is depicted in Figure 4.

The detected analog signal from each path is switched to a single analog-to-digital converter. With this method, the user might choose to select the path manually based on an expected signal level. The sensor will most likely have an auto-ranging feature to determine the best path automatically; however the process can be time consuming because the sensor must check both paths to make the determination. This solution is problematic if a signal is in or near the crossover region or if the signal makes level changes wherein both paths must be utilized to make a fast measurement. For example, if the high sensitivity path is selected to measure the base level of a pulse stream, path change may be required to measure pulse top amplitude. The process can be made faster by utilizing two analog to digital converters, as shown in Figure 5. This allows the processor to select the path digitally from data that is already present from both detectors.

This scheme improves the sensor, however measurements are still subject to issues involving the crossover region wherein both paths are near the end of their range

ase Adjusters

					-						
Part Number	Con- nec- tors	Fre- quency Range (GHz)	VSWR max.	Inser- tion Loss max. (dB)	Phase Shift min. (°)	No. of Turns	Phase Shift Deg/ GHz/ Turn	Time Delay min. (psec.)	Time Delay max. (psec.)	Tem- perature (°C)	Weight max. (g)
LS-0002-YYYY ¹⁾	div.	DC - 2	1.2:1	0.3	85	37		393	516		98-220 ²⁾
LS-0103-6161				0.4	540	Lucian and		1826	2328	-65 to	700
LS-0203-6161	NI	DC - 3	1.15:1	0.9	1080	cont.	1.15	3693	4694	+125	1200
LS-0012-YYYY ¹⁾	div.	DC - 12	1.3:1	0.8	520	37		406	530		114-2342)
LS-0112-XXXX ³⁾											70
LS-A112-XXXX ³⁾		DC-		-	220						47
LS-0212-1121		12.0		0.4	230	-					70
LS-A212-1121			10000				8	200		-65 to	47
LS-0118-XXXX ³⁾	SMA		1.25:1		100		L. B. Marson	238	295	+125	70
LS-A118-XXXX ³⁾				-	1	10.5		X			47
LS-0218-1121		DC-								i i	70
LS-A218-1121		12.0		0.6	350	The		1	200		47
LS-0118-5161	- 341					and a		200	250	-65/+70	107
LS-U118-5161	N				Ser.	J.		300	200	-65/+165	105
LS-0018-YYYY ¹⁾	div.	DC - 18	1.5:1	1.0	770	37	1.4	406	530	Cont of the	98-220 ²⁾
LS-0121-XXXX ³⁾		in me	1		-	-		and the second			70
LS-A121-XXXX ³			-		500	110		330	1		47
LS-0221-1121		and the second		0.8		10.5	1.4	238	1000	-65 10	70
LS-A221-1121	SMA		2			S		-	S	+125	47
LS-0321-1121			1.31:1		500	35	0.6	26.7	290.5		30
LS-0170-1121			1.26:1	0.26	127	13.5	0.36	109.2	122.8		9
LS-S008-1121		No.	1.50:1	0.4	155	10	0.6	118.6	135.1	Press !!	20
LS-P140-KFKM	2.92	DG-	1.2:1	0.6	-	1		160	200		51
LS-0140-KFKM	mm	40.0	13491	0.0	27			108	208		49
LS-P150-HFHM	2.40	DC-	1.3:1	0.0	100	14	12	172	105	-65 to	55
LS-0150-HFHM	smm	50.0	1.5:1	0.8	400		1.2	1/2	195	+65	53
LS-P165-VFVM	1.85	DC-	141	0.0	cod	11.		167	105	S. M.	55
LS-0165-VFVM	mm	63.0	1.5:1	0.8	000	M [°]		107	195		53

¹⁾ div.: Connector Configuration available: SMA, male and female; N, male and female; TNC male and female
 ²⁾ Weight depends on connector configuration
 ³⁾ SMA Connector Configuration available: male/female; male/male; female/female; female/male



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80905 Munich, Germany Telephone: +49-89-3548-040 WWW.SPECTRUM-ET.COM Please see us at booth 3441 IMS Phoenix, May 19 - 21 Email: sales@spectrum-et.com and either will work. In this case user intervention and manual path selection may be desirable.

To create an effective auto-ranging path selection system, as in both analog switching and digital selection systems, hysteresis must be employed to prevent unnecessary rapid path switching due to minor level changes. It is important that all paths follow similar level-to-temperature change characteristics so that measurement stability is maintained when paths are switched. With modern digital communication signals' rapid level changes the user may need to avoid operating at certain levels or select a sensor that employs best path technology. The ideal sensor for remote and unattended applications would isolate all of these issues and deliver accurate measurements with no concerns involving path selection.

The power sensor system depicted in Figure 6 resolves the path selection issues. This two-path sensor measures both paths at once and splices them into a single measurement, using a path weighting scheme. No user path selection is ever required. Utilizing careful designs and modern components, the LB5918A sensor splices the measurement paths, ignoring the out-of-range data from each path, producing a seamless, accurate measurement that does not require user zeroing or calibration.

Depending on accuracy requirements, these modern

power sensors allow measurements to be made with little effort placed into any of these complexities. Simply make your measurements, even if the sensor is somewhere else.

Summary

Advanced electronic components including efficient, high-speed, lowpower microcontrollers with flexible interfaces, along with new engineering ideas, have allowed the creation of a new generation of RF power sensors. These sensors have fully self-contained measurement and user calibration capability. In addition to USB operation, some sensors such as the LB5918A are capable of fully autonomous measurements and do not require any connection other than power. They use their internal realtime backed-up clock to trigger highly accurate measurements; advanced, patented zero and calibration technologies complement the measurement.

Optical and cabled USB extenders, Ethernet connectivity and SPI/I2C direct control interfaces further expand capability of these new power sensors. These options allow a tremendous flexibility in making remote, unattended, and autonomous power measurements in applications such as radio astronomy, isolated military applications, and testing in dangerous locations. For example, an LB5918A sensor operating in unattended mode can monitor a transmitter with an intermittent issue, logging 1,000 measurements per second into its flash memory to be reviewed at a later time. Along with the vast array of connectivity choices, it is also important to review these zero, calibration and measurement capabilities when choosing a power sensor for remote, unattended and autonomous applications.

About the Author

Orwill Hawkins serves as Vice-President of Marketing at LadyBug Technologies, Santa Rosa, Calif. He has over three decades of management, marketing, engineering and manufacturing experience, and extensive hands-on design and manufacturing experience in the RF, analog, and digital fields. Among the many products he has designed and marketed are a self-contained RF field disturbance burglar alarm system, a sailboat speedometer, and various robotic servo systems. Additional inventions include a prototype oscilloscope, a CNC cutting system, and various other analog, digital and RF projects.



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Impedance:	50 ohm	RF leakage, min:	-100 dB to 18 GHz
Time delay:	1.2 ns/ft.	Temp range:	-65°C to +165°C
Cut off frequency:	18 GHz	Cable outer diameter:	0.31″
Capacitance:	24 pf/ft.	Velocity of propagation:	83%
Weight:	7.8 lb./100 ft.	Flame retardant rating:	UL94-V0



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Maximizing Your Symposium Experience

By Tom Perkins

There have been many articles written on the subject of attending conferences and symposia. Most of them are specific to an event that is scheduled shortly in a particular city. Although there

General advice for newcomers and veterans alike. are many conferences and symposia held worldwide throughout the year, it just happens we are in a peak season now. Many good suggestions are usually put forth with regard to specific presentations, maps, room locations, nearby things to see, and good restaurants. That's all very helpful, particularly if it's your first visit to that location. This article is more general and intended to give some newcomers some "sage" advice, and veterans a few memories and possibly, chuckles.

Getting There

Well in advance, get approval to go to the conference from your employer. If you are selfemployed, check your wallet and work backlog. Register as early as possible to take advantage of "early bird" pricing opportunities. Fees will generally be lower if you are a member of the sponsoring organization such as AOC or IEEE. Also, book a hotel early as rooms go fast, particularly if you want to be within walking distance of the convention center. If you can get into the headquarters hotel, you will generally have less hassle in getting to key events on time. In some cities, particularly where your language is not predominant, that's even a safety issue.

The expense for registration will likely be less if you are a member of the sponsoring organization. The savings may exceed the annual dues and you will reap other benefits by being a member.

If you need to go by air, make your flight reservations early. Consider the savings sometimes offered if you fly at certain times of the day or certain days of the week. The savings might even more than offset the cost of additional night at the hotel. When you arrive at the host city you will need transportation to the hotel. The cheapest way is usually a shared ride van service or hotel courtesy bus. A subway or train can be a hassle if you have much luggage. Taking a cab or renting a car are more expensive options. Unless you have other business or pleasure while there, or have to travel more than 20 or 25 miles from the airport, the rental car just becomes another expense and perhaps a challenge in itself in an unfamiliar environment with possibly different driving regulations.

Get to Registration Early

After checking in at your hotel, go complete registration (if it's open) and pick up your materials, such as badge, flash drive with proceedings/digest, and other handout materials. It's helpful to get this material as early as possible as lines are shorter and there are often more people to provide assistance. Besides you may not want to carry all the material you receive around at any one time. Use any pre-event time wisely to get familiar with the layout and location of events as well as planning where you want to be at any given time. If you have a smart phone or similar device, you can place your schedule in there as well as, in some cases, download key papers. Convenient kiosks are also sometimes available to print out technical papers. At the conference ending, before you leave for the airport, maybe a day in advance, you might want to get advance tickets at the hotel. Most hotels have this computer access capability with printers in a controlled access area for their guests.



ULTRA HIGH DIRECTIVITY DIRECTIONAL COUPLERS

Wideband, 50 - 6000 MHz Directivity up to 36 dB! ^{\$25995}

Need to make precise return loss measurements over wideband for low cost? Ultra-high directivity up to 36 dB makes our new ZHDC-series couplers ideal solutions for a variety of test applications including return loss and intermodulation measurements. We compared these couplers to a leading name network analyzer to measure the return loss of a variety of components in the field. In



a side-by-side comparison, our test setup using these couplers produced comparable results to those obtained using the network analyzer.* So why spend big bucks on expensive test equipment when a measurement setup with our high-directivity couplers is a fraction of the cost? Visit minicircuits.com for detailed specs.

- 10 and 16 dB Models
- Flat Coupling as low as ±0.3 dB
- Mainline Loss as low as 2 dB
- Return Loss Measurements up to 25 dB
- Power Handling, 1W

*Results for components with return loss rated up to 25 dB tested over frequencies from 50 to 6000 MHz.







HFE Technical Editor Tom Perkins speaks with a group of visiting students at IMS 2014 in Tampa, Fla. Courtesy Lyle Photo.

Be Courteous and on Time

When and if there are parallel technical sessions, even though scheduled and conducted in good time sync-start and finish times, I see too many folks walking in and out while a speaker is giving their (relatively) short talk. This seems to be a somewhat new phenomenon, not so common years ago. It sort of reminds me of birds seeking the leastcrowded feeder. Not finding exactly what they want, the attendee moves onto another room, sometimes encouraged by a colleague whispering something in their ear.

This is rude and distracting to the coordinators, speaker, and audience. This same advice goes for panel sessions, workshops, short courses, plenary sessions and such events. Plan ahead and once you select a presentation, stay there until it's over. Be on time also. Walking in late is distracting. At the Q&A session, if you ask a question, make sure you use a microphone, unless not available. Otherwise almost no one will hear you, including the speaker. Consequently time is wasted in repeating questions. Occasionally the Q&A session at the end will get confrontational or at least controversial. It's the job of the moderator to control this activity. Speakers often are available after the session for one-on-one discussion. If you are visiting a poster session, be discreet about joining into a conversation or presentation that is already in progress. If the author(s) are already having a discussion, you should

listen politely and ask your questions in an orderly and non-disruptive manner. If waiting seems tootedious, move on to other posters and come back. Student design competitions can be quite interesting as you will get to see real hardware being tested with some of the latest and best test equipment.

On The Exhibit Floor

First, know that there are vendor exhibits. These displays of hardware, software techniques, educational opportunities, or paper media may be a small "sideshow" in the hallway or atrium. At larger events they can be a collection of 600 or so entities in a large exhibit hall. Those companies with their simple or elaborate and comfy booths did not just fall out of the rafters on Monday or Tuesday morning. Most of these companies (some are colleges and universities) have been planning their booth for months. Setup is not particularly a pleasant experience. Tear-down goes a bit faster, but by then the participants are exhausted. The actual setup can begin several days before you see it. Often the exhibit area is not air-conditioned during set-up.

Microwave Mall

Don't ignore this great "eye candy" opportunity. At a large event it's like visiting a giant *microwave mall*.

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			Freq	(GHz)	
Specs	Description	0.1~10	10~26	26~40	40~50
Psat (dBm)	Saturated Output Power	30	28	26	24
P1dB (dBm)	1dB Compressed Power	25	24	23	22
S21 (dB)	Small Signal Gain	30	28	26	24
S11 (dB)	Input Match	-15	-15	-10	-8
S22 (dB)	Output Match	-12	-10	-8	-8
S12 (dB)	Reverse Isolation	-60	-60	-50	-50
VF (dB)	Noise Figure	9	9	11	14

VIDA Products Inc

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www.vidaproducts.com

Conferences

Sometimes I've gone to an event at just the right time to shop for parts for a new project. Although you actually cannot buy the parts at the show, you can discuss needs in great detail with factory experts and get commitments for quick follow-up. You might even get to meet with some sales representatives from your area. Sometimes you can even arrange for free samples to get a project started. The face-to-face encounter definitely helps make that possible. The best day to visit the exhibits might be the closing day of the show. By then a great deal of the activity has dwindled and is light. I never fail to see at least two or three things that stimulate new thoughts and ideas.

Don't be Afraid to Greet Others – Also Ask Questions

We are a small community. Being friendly is a big deal as it often reaps opportunities to meet people and have incredibly interesting discussions. If you are a first-time attendee, and feel out of place, remember that everyone there was once a first-timer, too. And most of the "big names" in our field actually want to meet newcomers. After all, that's the only way our profession will continue.

Take advantage of every possible opportunity. For example, in 1975 I had an opportunity to meet Phillip H. Smith of Smith Chart fame. He was a very humble man. At that time he was 70 years old. I was less than half his age. In the back of my mind I thought, I could delay this until another time, he'll be around! Well, although he lived until 1987, I never saw him again. Another time in the mid 1970s, having heard a very interesting talk by Dr. Martin V. Schneider, an IEEE Fellow, I asked him a question in the hallway between sessions about packaging microstrip circuitry in beyond waveguide cutoff channels. He said nothing, or maybe mumbled something, smiled and quickly wrote BSTJ May/June 1969 on the back of a business card. Upon looking it up the following week (not too easy in those days) I found an equation that kept me out of multiple difficulties throughout the remainder of my designing career. Having a good educational foundation in waveguide techniques, I immediately "got it." I never had to use absorber or deal with cover effects, just because of that "smile". In case you wonder, BSTJ stands for Bell System Technical Journal, published by AT&T – one of the best ongoing publications in our field for at least six decades.

Attend Social Gatherings

Attending social functions, within reasonable timeframes, may be valuable as they present an opportunity to meet people and discuss technical issues and business opportunities. You will also realize that folks engaged in our business with other companies face similar challenges. You'll get a perspective on industry trends, company mergers and acquisitions, marketing opportunities and the latest technology.

Free Food and More Sleep

I have never seen an attendee starve to death at a technical conference. There is usually more "free" and low cost food available than one could possibly consume. You don't have to spend large sums of money to survive a 3 or 4 day event. Many hotels offer complimentary breakfasts. Vendors offer evening events and special sessions and box lunches are available. The notion that you need to spend big on meals or even use up your per diem allocation (if that's the case) is overblown. With the long hours you'll be putting in, make sleep a priority. I've found that the further your room is from the elevators, the quieter.

Dress for Success (or at Least Acquiesce)

Until a couple of decades ago, almost everyone attending conferences wore a jacket and tie to symposiums. Exceptions were some vendors and possibly steering committee members, who tended to wear shirts with company or event logos. As years passed, like in business venues, dress down, business casual and such became the

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norm. Conferences in warm climates even encouraged this trend. I've seen folks in shorts and sandals lately. This seems to be an inevitable and irreversible trend. I would just say that going to extremes to draw attention to oneself might not be a good idea, depending on the event. Also some "VIP" and dinner events still demand suit and tie. Bear in mind that some folks may be your customer in the future. You might have only met them at a conference. How you appear in their memory might affect future dealings.

Spouse and Guest Events

Some conferences offer excellent opportunities for spouses or families to tag along and visit sites that they might otherwise never plan to partake of. My wife has accompanied me many times and made many longtime friends who in turn introduced me to attendees at the conference that I otherwise likely would not have become acquainted with. I think she with some of her friends are more adept than I am at collecting exhibit handout material. They can be very influential in connecting people.

After the Event, Do a Trip Report, Even if Your Employer Doesn't Ask for One

No, I don't mean an expense report, although completing that in a timely manner with accuracy is important. I'm talking about preparing an overview of what you did, who you met, what you learned, new products and trends, possible business opportunities.

Give a Synopsis of the Conference Back at the Office

Demonstrate your appreciation for and the value earned from your experience. Arrange to do a "lunch and learn" or similar event for your colleagues within a month of returning from the conference. This will go a long way towards recognition of the value of attending the conference. Highlight technology that may have added value to the future of your organization. Also talk about contacts made as they might lead to new business or good feedback on current activity. This may stimulate a desire for others to attend future conferences and reinforce what you learned. It will also improve your presentation skills and respect from your peers.

Consider Writing a Paper

Want to attend again? One way to punch your ticket is to respond to the *call for papers* and carefully follow all instructions. Make sure your work is original and has not been previously presented. Also, allow sufficient time for your company to approve your submittal and issue the appropriate releases for publication. This may include consideration of classified information, company proprietary material, information that may be patentable, and even cases where the author changes employers prior to the actual publication and verbal presentation at the event. All of these can become big and painful issues if not handled properly.

If you inadvertently get a paper into a digest, or on a CD or flash drive and there is sudden desire for paper withdrawal, a big problem can ensue. I've seen pages removed from a digest with razor blades at the last minute prior to distribution. Not fun for the organizers and even worse for the authors. With electronic media the problem even becomes more complicated. The media has to be destroyed and publications folks have to produce new material in time for handout at registration, which can be a nightmare. This could be a way not to ever go to another conference, so due diligence is the operative term. If your paper is to be given in a classified session, again make sure you have all the requirements covered, including conveying your material to/from the conference venue.

If you do successfully submit a paper and get it approved, it's best to take advantage of all opportunities including a "dry run" in front of some of your peers, prior to the presentation session to meet with your session chair or co-chairs. Many conferences provide a preparation room and sometimes a speakers' breakfast. Whatever you do, make sure you are not late to the session you are presenting. Nothing can make a session chairperson more uncomfortable than not knowing where his speakers are. Juggling schedules (sequence of talks) from those published is a big no-no because many attendees depend on that schedule being accurate. They don't like to walk in and find out they missed a paper. I've even seen speaker no-shows which is certainly awkward as once people leave a session, they generally won't return. Chances are, if you do this, you won't get a paper accepted again.

Volunteer

Particularly when a symposium comes to a city near you, volunteer to help the steering committee. This will be very rewarding. You will make lifelong friends in our field and get to know more engineers and other colleagues outside your immediate workplace circles. You may also find an immediate benefit in that you now have a better excuse to attend the symposium and may likely get reduced cost or even free attendance as a reward for your volunteer efforts. Your involvement will be rewarding and you'll learn a lot about teamwork.

Half a Year

Having attended approximately 35 conferences over my career, I realized that I spent about half a year of my life in this pursuit. For me this includes many activities – attending hundreds of papers, several workshops, presenting papers and poster sessions, assisting with exhibits, visiting with hundreds of vendors, serving on steering committees, editing digests, representing my IEEE MTT chapter at Chapter Chairs' meetings, and twice chairing a Ham Radio Social. It's all been highly worthwhile, and I look forward to even more in the future.

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Product Highlights

Companies on the IMS 2015 Exhibitor List as of March 30, 2015 have their booth numbers listed.



RFIC Characterization and Production Test

NI's RFIC Reference Solution is a hardware and software package for engineers characterizing PAs and Front End Modules. In addition to native support for envelope tracking, DPD, and EVM/ACP measurements, new features include extended DPD capabilities and harmonics measurements up to 26.5 GHz. NI's Semiconductor Test System now adds features such as 48-port S-parameter measurements and integrated system calibration.

National Instruments ni.com IMS Booth # 2431



Connectors

SGMC Microwave's 1.0 mm series are precision grade connectors designed for microwave applications requiring excellent performance up to 110 GHz. Optimum results are achieved with the use of a 1.0 mm outer conductor diameter and air dielectric. SGMC offers precision adapters, receptacles, and cable connectors for various semirigid and flexible coaxial cables. Special designs are available upon request.

SGMC Microwave sgmcmicrowave.com IMS Booth # 2129



Source-Leveling Power Sensor

LadyBug announced an analog output option for simpler, faster calibration. While power sensor calibration and verification can be cumbersome and time-consuming, the process can be simplified and automated by using a leveling loop, which feeds the power level back to the source's analog level control input from a LadyBug LB589A power sensor using its recorder output. This eliminates the need for manual level adjustment.

LadyBug Technologies ladybug-tech.com IMS Booth # 1931



Passive Components

Cobham Inmet (formerly Aeroflex/Inmet) is a solution minded, performance driven, and customer focused global supplier of passive RF and Microwave components for markets such as: Commercial; Military; Space; Laboratory test. Product solutions include the POWERFILM[™] line of surface mount resistive components, coaxial signal conditioning products to 65 GHz, and coaxial test cable assemblies.

Cobham Inmet aeroflex.com IMS Booth # 3436



GVA-60+

GVA-62+ GVA-63+

GVA-84+

2 New lodels!

GVA-91+ GVA-123+

DC* to 12 GHz up to 1W Output Power



GVA amplifiers now offer more options and more capabilities to support your needs. The new **GVA-123+** provides ultrawideband performance with flat gain from 0.01 to 12 GHz, and new model **GVA-91+** delivers output power up to 1W with power added efficiency up to 47%! These new MMIC amplifiers are perfect solutions for many applications from cellular to satellite and more! The GVA series now covers bands from DC to 12 GHz with

*Low frequency cut-off determined by coupling cap. For GVA-60+, GVA-62+, GVA-63+, and GVA-123+ low cut off at 10 MHz. For GVA-91+, low cut off at 869 MHz.

NOTE: GVA-62+ may be used as a replacement for RFMD SBB-4089Z GVA-63+ may be used as a replacement for RFMD SBB-5089Z See model datasheets for details various combinations of gain, P1dB, IP3, and noise figure to fit your application. Based on high-performance InGaP HBT technology, these amplifiers are unconditionally stable and designed for a single 5V supply in tiny SOT-89 packages. All models are in stock for immediate delivery! Visit minicircuits.com for detailed specs, performance data, export info, **free X-parameters**, and everything you need to choose your GVA today! *US patent 6,943,629*

FREE X-Parameters-Based Non-Linear Simulation Models for ADS



Product Highlights



LNA

The APT3-05400590-1010-LS-D4 is a low noise amplifier with super-low noise figure (<0.9 dB, 0.7 dB typical). Lower NF options are also available with custom flatness, VSWR, P1dB, and packaging. An internal limiter at the input offers protection of up to 2W CW of RF input power over the full band. The high performance is an example of AmpliTech's industry-leading low-noise design and technology.

Amplitech amplitechinc.com IMS Booth # 1126



LTE-A App Note

Keysight's app note, "Solutions for Testing Data Throughput Performance in LTE-A User Equipment" provides insight into simplified, real-world functional and RF test of LTE-A user equipment (UE) performance using a fast, flexible and future-ready one-box tester. Keysight's Power of Wireless app notes provide understanding into the evolving wireless industry and help users accelerate product development.

Keysight Technologies keysight.com IMS Booth # 739



Modulator Amp

PMI Model No. PMA-218-BAE is a modulator amplifier capable of amplitude modulation, level control and pulse modulation for an RF stimulus path that works from 0.5 to 2.0 GHz and 2.0 to 18.0 GHz. This integrated module contains switches, modulators, attenuators and amplifiers and is built using MIC/MMIC technology.

Planar Monolithics Industries pmi-rf.com IMS Booth # 1927





Formulated for die attach applications, Master Bond Supreme 3HTND-2DA is a fast curing, high performance one component epoxy system. It cures in 5 - 10 minutes at 150C and has unlimited working life at room temperature. It is available in syringes and has a shelf life of 6 months when stored at 40-50°F. It has a die shear strength of 19-21 kg-f and performed very well in 85/85 testing.

Master Bond masterbond.com

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1.0mm (W) DC to 110 GHz Connectors offer superior performance for high-frequency flange mount, thread-in, board mount and cable applications.



Size 8, 12, 16 and 20 Coax Contacts for Standard, Multi-Cavity Connectors to 110 GHz save space and reduce panel weight and size.

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Product Highlights



Adapter Catalog

A new brochure shows the updated product spectrum of hermetically sealed adapters. All adapters use fused in glass seals between center contact and outer conductor. Standard leakage is less than 10-8 cc/sec @ 1 atmosphere Helium per MIL-STD 202. Outer connector conductors are from stainless steel, center conductors are from BeCu2, both gold plated. Connector series are 1.85mm 2.4mm, 2.92mm, N and TNC.

Spectrum Elektrotechnik spectrum-et.com IMS Booth # 3441



Power Amp

Richardson RFPD announced availability and full design support for a new 4W power amplifier from M/A-COM Technology Solutions. The MAAP-011139-DIE is a four-stage, 4W power amplifier that operates from 29 to 31 GHz and provides 24 dB of linear gain (@ 30 GHz), 4W saturated output power, and 23% efficiency while biased at 6V.

Richardson RFPD richardsonrfpd.com IMS Booth # 2436

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Phoenix! IMS Booth # 2129

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Calibration Module

Anritsu's MN4765B O/E Calibration Module for its MS4640B Series VectorStar® vector network analyzers creates a cost-effective, flexible solution for measuring 40 Gb/s components and transceivers. Serving as an optical receiver, it allows engineers to use the MS4640B Series to perform highly accurate, stable optoelectronic measurements on laser modulators and photo-receivers during R&D and manufacturing.





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Anritsu anritsu.com IMS Booth # 2438



Variable Attenuator

OML's patented technology for its VxxVA25 series of variable attenuators covers the frequency range of 50 GHz to 325 GHz (WR-15 to WR-03); while providing the capability of manual adjustable attenuation from 0 dB to 25 dB minimum. The variable attenuator can be purchased separately or as an option in the Source or VNA head.

OML omlinc.com IMS Booth # 834

MIL-DTL-38999, Series 1 & 3 sealed cylindrical connectors

A full platform of environmental and hermetic class type connectors matching almost every environment in regards to number of ports, materials and plating, Availability: short deliveries.

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Product Highlights



Connectors

1.0 mm (W) DC to 110 GHz connectors offer superior performance for Flange-mount, Thread-in, Board Mount and Cable applications. Built in the USA to rigorous standards, they feature a 360° raised grounding ring and temperature rating of -55°C to 165°C. Mode-free operation through 110 GHz, well-matched impedance, excellent repeatability and the industry's lowest VSWR, insertion loss and RF leakage.

Southwest Microwave southwestmicrowave.com IMS Booth # 3022



Cable Assemblies

Superflexible, PIM rated, Plenum rated SPPTM Jumpers are the ideal DAS interconnect solution. Superior in electrical performance to other copper cable assemblies, Times Microwave SPPTM-LLPL cables are the perfect inbuilding solution for PIM-sensitive installations and system interconnects.

Times Microwave Systems timesmicro.com IMS Booth # 921



Amplifier

Multi-Octave Wideband Low Noise High Gain Amplifier Model AF01-6371810B operates from 0.1 to 6 GHz. It has Noise Figure of 1.8 dBm, gain of 37 dB with max gain variation of +/- 0.8 dB, P1 dB output of +10 dBm, and current draw of 120 mA at +12V bias. It comes in a hermetically sealed package with removable connectors for drop-in assembly and is designed for military and commercial applications.

Herotek herotek.com IMS Booth # 2924



Synthesizers

The MLSP-Series of YIG-Based wideband synthesizers are ideal as the main local oscillators in receiving systems, frequency converters and test and measurement equipment. They provide 1 kHz frequency resolution over the 2 to 20 GHz frequency range. Power levels of +13 dBm are provided through out the series and full band tuning speed is 7 mSec. The units are 5" x 3" x 1" high and fit a 2 slot PXI chassis.

Micro Lambda Wireless microlambdawireless.com IMS Booth # 1622

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

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

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Product Highlights



USB-Controlled Components

Pasternack released new USB-controlled microwave and millimeter wave components including amplifiers, attenuators and PIN diode switches. They are controlled and powered by a USB 2.0 port with driverless installation, meaning no external power supply is required. The attenuators and switches require an easy-to-use downloadable software program which interfaces with any Windows computer.

Pasternack pasternack.com IMS Booth # 3214



Adapters

Cernex coaxial adapters feature: Frequency Range from DC - 110GHz; Compatible with different connector series; Air Dielectric; High Performance with All Different Series; Ruggedized Construction for Repeatability and Reliability; Economically Priced. Applications: Test equipment; Telecommunications; Satellite and Aerospace; Microwave and Millimeter-wave.

Cernex cernex.com IMS Booth # 229



Power Amps

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

AMCOM amcomusa.com IMS Booth # 626





Connectors

C.W. Swift is a distributor of RF & Microwave Components: Electronic Connectors, Adapters, Cables, Amplifiers, Mixers, Attenuators. Couplers, Terminations. Power Dividers, Variable Capacitors, EMP Protectors, DC Blocks, WG To Coax Adapters; SMA, N, TNC, BNC, MCX, MMCX, 7/16, 7mm, 3.5mm K(2.92mm), 2.4mm, SMB, SMC.

C. W. Swift & Associates cwswift.com IMS Booth # 2229

2 GHz Clock Generator

CG635...\$2995 (U.S. list)



- Square wave clocks from DC to 2.05 GHz
- Random jitter <1 ps (rms)
- 80 ps rise and fall times
- · 16-digit frequency resolution
- · CMOS, LVDS, ECL, PECL, RS-485
- Phase adjustment & time modulation



Plot shows complementary clocks and PRBS (opt. 01) outputs at 622.08 Mb/s with LVDS levels. Traces have transition times of 80 ps and jitter less than 1 ps (rms). The CG635 generates clock signals — flawlessly. The clock signals are fast, clean and accurate, and can be set to standard logic levels.

How fast? Frequency to 2.05 GHz with rise and fall times as short as 80 ps.

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Product Highlights



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Broadband Amps

Fairview Microwave released broadband RF amplifiers operating in octave bands between 0.5 and 40 GHz with noise figures ranging from 2.5 to 6 dB across the entire frequency range. These parts are commonly employed in a wide spectrum of applications including wireless communications, telecom infrastructure, radar, EW, sensors, test instrumentation, microwave backhaul and many others.

Fairview Microwave fairviewmicrowave.com

Guest Editorial

Test Solutions Evolving to Meet 5G Requirements



Donn Mulder Sr. VP and GM Anritsu Microwave Measurements Division (MMD)

We all know that faster data rates are driving commercial communication applications, such as wireless backhaul with 100-300 Mbps. We are also well aware that higher frequencies are quickly mov-

ing to other designs, including medical, security, automotive and other research areas. Assuring performance and accuracy while minimizing cost are critical in the development of new millimeter (mm-wave) applications that are helping define 5G. As mm-wave applications move into the mainstream, optimizing cost-of-test becomes extremely important to bring these higher frequency products to market on time and within budget.

These requirements at mm-wave frequencies have forced test companies to re-evaluate their solutions. In the past, the stability and quality of broadband mmwave network analysis measurements have sometimes been challenges for engineers. That was due to the required high frequency multiplexing schemes, physically large and inhomogeneous measurement structures and complex receiver chains. Traditional mm-wave measurement solutions required bulky test heads that were difficult to locate near the device-under-test (DUT).

Engineers designing at high frequencies have clamored for test systems with smaller footprints, and that eliminated the inherent disadvantages of large, complex systems at mm-wave frequencies. Measurement accuracy had to be improved. There also had to be lower costs for related accessories, such as wafer probe stations and antenna test facilities. In short, to better understand mm-wave product development, engineers needed measurement tools with performance similar to those at microwave frequencies.

New, High-Frequency Test Tools

That is why Anritsu has concentrated on developing new advanced measurement solutions that move along a parallel innovation track to the products they must test. Engineers now have the required tools that meet the test challenges associated with high-frequency designs, due in part to implementing a proven technology in a new manner.

Nonlinear Transmission Line (NLTL) technology has historically been used for pulse shaping applications and in digitizing oscilloscopes. Over the years, NLTL has proven itself to be a highly credible, robust technology. Anritsu, which filed the patent that defined the vector network analyzer (VNA) market back in 1965, continues to refine the instrument technology and has developed a new generation of instrument that addresses high-frequency requirements. The new VNA utilizes an NLTLbased architecture complemented with novel monolithic broadband directional bridges, multiplexers, and other key components.

This emerging class of VNA features a broadband, miniature front-end receiver for acquisition. Using this system layout, improved stabilities over the 70 kHz to 145 GHz frequency range have been achieved that allow for longer intervals between calibration and improved measurement accuracies. The result is a test solution that overcomes the aforementioned limitations of SRDbased sampling VNAs and meets the need for a highperformance frequency-scalable test solution.

Greater Design Confidence

Engineers now have greater confidence in their highspeed designs, thanks to the new VNA design because it offers a number of advantages, including:

• The widest broadband frequency (70 kHz - 145 GHz) that allows for measuring beyond the design frequency for enhanced curve fitting success and more accurate device characterization.

• Compact, lightweight mm-wave modules for easy, precise, and economical positioning on the wafer probe station and for ease of set-up in the bench applications. The smaller modules also eliminate the need for 1-mm cables that degrade raw directivity and contribute to the degradation of measurement stability.

• More robust designs and faster time-to-market due to a more stable test solution that reduces the frequency of calibration cycles because of improved dynamic range, lower noise floor, faster sweep time and better stability.

• Ability to more accurately characterize circuit simulation devices for first turn design success.

These new VNAs featuring the NLTL-based architectures allow engineers to gain a better understanding of mm-wave product development. They now have the mea-



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Advertiser Index

Company	Page
Advanced Switch Technology	
AMCOM	
AmpliTech	30
Avtech	
CEL	
Cernex	
Coilcraft	
Cobham Inmet	1
CST	
C. W. Swift & Associates	C2
C. W. Swift/SRI Connector Gage	
dBm	7
Delta Electronics	
Fairview Microwave	
Herotek	
IMS 2015	61
IW Microwave	
Keysight Technologies	17
KRYTAR	
Master Bond	
Micro Lambda Wireless	9
Microwave Components	
Mini-Circuits	62. 63
Molex	C3
National Instruments	5
National Instruments	
Pasternack	
Pasternack	
Pulsar Microwave	
RelComm Technologies	
RF Bay	
Richardson RFPD	C4
SAGE Millimeter	
Satellink	
Sector Microwave	
SGMC Microwave	45
Southwest Microwave	
Spectrum Elektrotechnik	
Spectrum Electrotechnik	
Stanford Research Systems	
SV Microwave	43
Times Microwave	49
VIDA Products	
Wenteq Microwave	
W. L. Gore	54

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PUBLISHER

Scott Spencer Tel: 603-472-8261 • Fax: 631-667-2871 scott@highfrequencyelectronics.com

ADVERTISING SALES – EAST

Gary Rhodes Vice President, Sales Tel: 631-274-9530 • Fax: 631-667-2871 grhodes@highfrequencyelectronics.com

ADVERTISING SALES - WEST

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(Continued from page 60)

surement tools with performance similar to those at microwave frequencies so they can conduct accurate measurements and have greater confidence when deciding on performance/cost tradeoffs. Making the most out of mm-wave prototypes can play an important role in getting to market ahead of the competition with a bestin-class product. Today's VNAs that feature a re-designed architecture have the performance to help make that happen.

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