



Microwave Journal

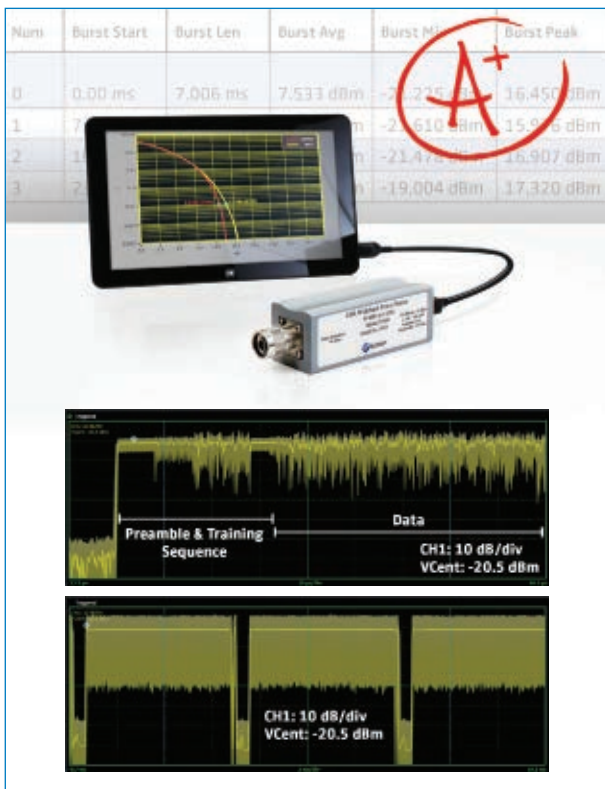
.com



Don't Settle for Average.



Demand Peak Performance.



The 55 Series USB Peak Power Sensor *Real-Time Power Measurements for Complex Communications Signals*

Others claim to have fast average measurements, but only the 55 Series measures continuous and burst average power faster than anyone in the industry. It adds wide-band peak and crest factor measurements, allowing you to see all aspects of your device's performance. This USB Sensor delivers results 100 times faster than conventional meters and with its *Real-Time Power Processing™* technology captures all glitches with 100ps resolution.

- 195 MHz Video Bandwidth
- 3 ns risetime
- 100,000 measurements/sec
- 100 MHz Sample Rate
- Multi-channel synchronized measurements

For more information visit us at www.boonton.com or call +1 973-386-9696.

BETTER COMMUNICATION SOLUTIONS



Public Safety



Satcom, mmWave
& Military



Aeronautical/Space
Transportation



AMER, EMEA,
& D.A.S

MECA 5G Products & Equipment

MECA Electronics designs and manufactures an extensive line of RF/Microwave Equipment and Components with industry leading performance including D.A.S. Equipment, Low PIM Products, supports 5G & Millimeter-Wave, Power Dividers & Combiners, Directional & Hybrid Couplers, Fixed & Variable Attenuators, RF Terminations, Circulators/Isolators, DC Blocks & Bias Tees, Adapters & Jumpers. Models available in industry common connector styles: N, SMA, 2.92mm, TNC, BNC, 7/16, 4.1/9.5 & 4.3/10.0 DIN as well as

QMA, Reverse Polarity SMA, TNC and various mounting solutions. Since 1961 MECA Electronics (Microwave Equipment & Components of America) has served the RF/Microwave industry with equipment and passive components covering Hz to 40 GHz. MECA is a privately held ISO9001:2008 Certified, global designer and manufacturer for the communications industry with products manufactured in the United States of America. We stock products so that you do not need to.



Low PIM Couplers



Low PIM Attenuators



Low PIM Terminations



Power Divider/Combiner



**Products in STOCK
when you need it!**



Low PIM & D.A.S. Equipment



Circulators/Isolators



RFPartsOnDemand.com

Online



Attenuators/Terminations



e-MECA.com
Since 1961

MECA Electronics, Inc.

Microwave Equipment & Components of America

The Professional's Choice for RF/Microwave Passive Components

459 E. Main St., Denville, NJ 07834

Tel: 973-625-0661 • Fax: 973-625-9277 • Sales@e-MECA.com







POWER SPLITTERS/ COMBINERS

from **2 kHz to 26.5 GHz** as low as **94¢** ea. (qty. 1000)

NEW!

**THE WIDEST BANDWIDTH IN THE INDUSTRY
IN A SINGLE MODEL!**

EP2K1+ 2 to 26.5 GHz

EP2W1+ 0.5 to 9.5 GHz

EP2C+ 1.8 to 12.5 GHz

The industry's largest selection includes THOUSANDS of models from 2 kHz to 26.5 GHz, with up to 300 W power handling, in coaxial, flat-pack, surface mount and rack mount housings for 50 and 75Ω systems.

From 2-way through 48-way designs, with 0°, 90°, or 180° phase configurations, Mini-Circuits' power splitter/combiners offer a vast selection of features and capabilities to meet your needs from high power and low insertion loss to ultra-tiny LTCC units and much more.

Need to find the right models fast? Visit minicircuits.com and use Yoni2®!

It's our patented search engine that searches actual test data for the models that meet your specific requirements! You'll find test data, S-parameters, PCB layouts, pricing, real-time availability, and everything you need to make a smart decision fast!

All Mini-Circuits' catalog models are available off the shelf for immediate shipment, so check out our website today for delivery as soon as tomorrow!



RoHS Compliant

Product availability is listed on our website.

 **Mini-Circuits®**

www.minicircuits.com P.O. Box 350166, Brooklyn, NY 11235-0003 (718) 934-4500 sales@minicircuits.com

See us at EuMW Stand 56

448 rev R

Solid State GaN Power Amplifiers

State of the art technology

Features:

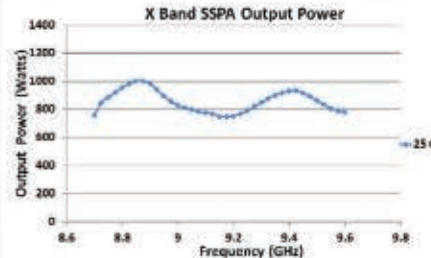
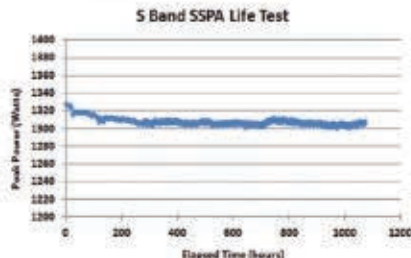
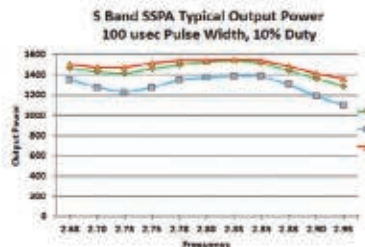
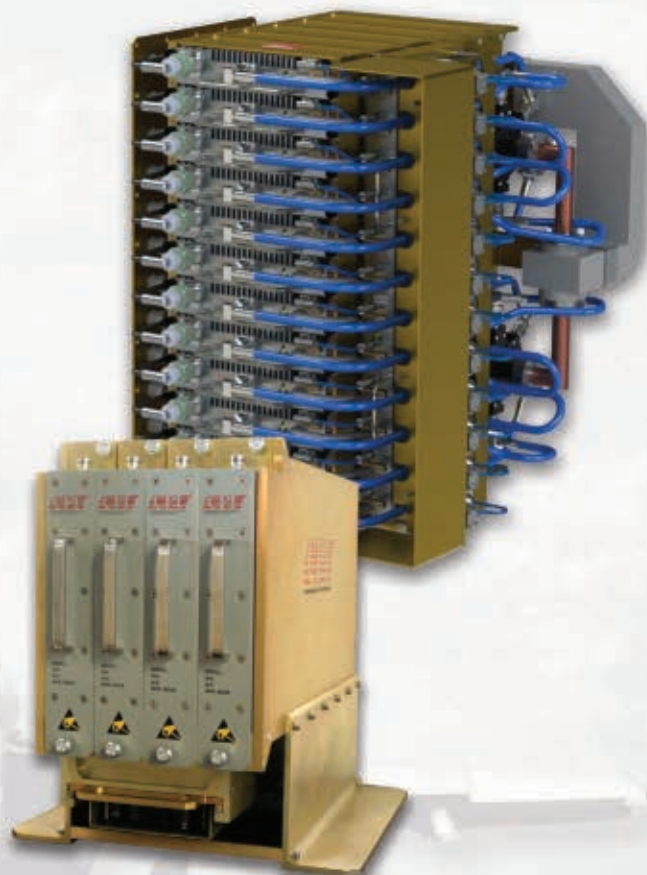
- High efficiency pulsed modules (10% duty)
- BIT and controls via EIA-422
- Compact light weight
- 9.0 - 9.2 GHz X-Band: 1 kW modules
- 5.2 - 5.9 GHz C-Band: 1.1 kW modules
- 2.7 - 2.9 GHz S-Band: 1.3 kW modules
- 1.2 - 1.4 GHz L-Band: 700 W modules
- Power combine modules up to 25 kW

Benefits:

- High reliability
- Field replaceable modules

*Our GaN Amplifiers provide high gain,
high efficiency and excellent stability,
with excellent AM/PM and
phase-noise performance.*

*Contact us about your
GaN SSPA requirements.*

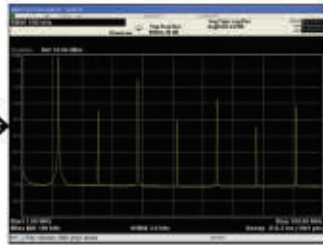


• Solid State Power Amplifiers • Integrated Microwave Assemblies • Receiver Protectors
• Control Components • Transmitters • Amplifiers • Modulators • Magnetrons • Crossed Field Amplifiers
• Ring Loop Traveling Wave Tubes • Power Couplers

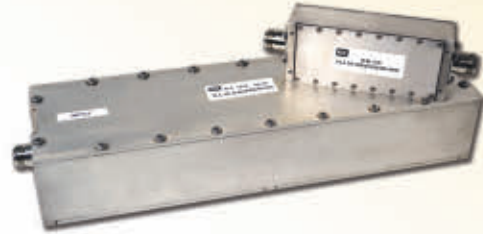
SUPERIOR HIGH-POWER LOWPASS FILTERS



+60 dBm
Amplifier



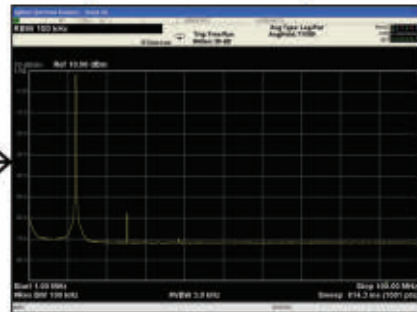
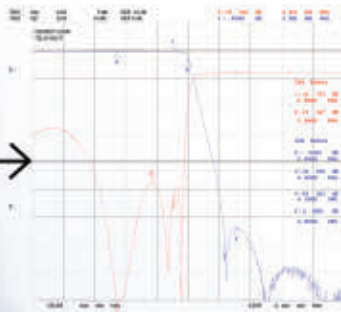
+60 dBm at Fundamental
Multiple Spurious Responses



WHICH WOULD BE
BETTER
FOR YOUR CUSTOMER?

+59 dBm at Fundamental
No Spurious Responses

+60 dBm
Amplifier



K&L HAS THE ANSWERS.



EDI 2016
Electronic Design
Innovation Conference
Workshops & Exhibition

Please join us at booth #720 on September 20-22, 2016



ENABLING COMMUNICATIONS AND SIGNAL CONTROL

www.klmicrowave.com • www.klfilterwizard.com • 410-749-2424 • sales@klmicrowave.com

See us at EuMW Stand 175

Relax

We've got you covered



Your supplier of high performance, precise equipment for AWGN



Ph. (973) 386-1119 • Fax (973) 386-1131 • info@noisewave.com • www.noisewave.com

GHz

powerfilm™



*Microwave Global
Models™ Available*

Meet the magic number for two-watt temperature-variable attenuators

Push the limits of frequency without sacrificing performance. Powerfilm surface-mount attenuators from Inmet, part of API Technologies Corp., vary with temperature and are the perfect balance of price, power, and dependability. They offer the flattest broadband performance of their kind and allow you to create automatic- and passive-link margin compensation on a wider variety of transmit and receive chain circuit applications.

Save money and space by throwing out your complicated gain-control circuitry and required bias and control voltages. Visit our website for complete details and request a sample today.

- **-0.005 dB/dB/°C shift models available from stock**
- **New higher shift models feature -0.009 dB/dB/°C**
- **DC to 12 GHz operation**
- **Superior RF attenuation vs. temperature**
- **Excellent return loss vs. frequency**
- **Design kits available**

api 
technologies corp.
▶ INMET

734-426-5553 | 888-244-6638 | inmet.apitech.com

See us at EuMW Stand 39

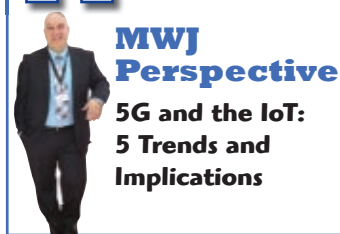
Inmet is now part of API Technologies Corp.



38

MVP
2nd Gen
Vector Signal
Transceiver

44



MWJ
Perspective
5G and the IoT:
5 Trends and
Implications

Technical Features

116 LDS Molded Interconnect Devices Fit for mmWave

Aline Friedrich and Bernd Geck, Leibniz Universität Hannover; Malte Fengler, LPKF Laser & Electronics AG

130 Design of Waveguide Windows for mmWave Components

Yong Fang, Baoqing Zeng, Xiaoyun Zhao and Jun Dong, University of Electronic Science and Technology of China; Hai Zhang, Nanchang Institute of Technology

Application Note

140 Achieving Metrology-Level Accuracy When Making THz Measurements

Andrej Rumiantsev, Toe Naing Swe, MPI Corp. and Andreas Henkel, Rohde & Schwarz

Cover Feature

22 The 5G mmWave Radio Revolution

Amitava Ghosh, Nokia Bell Labs

MVP: Most Valuable Product

38 Second-Generation VST is Smarter for Today's RF Test Challenges

National Instruments

MWJ Perspective

44 5G and the IoT: 5 Trends and Implications

Dudy Cohen, Ceragon Networks

Special Report

100 Microwaves in Europe: Leaving Unanswered Questions

Richard Mumford, Microwave Journal

EuMW 2016 Show Coverage

72 Welcome to European Microwave Week 2016

Andrew Gibson, General Chairman of EuMW 2016; Ivar Bazzi, President, Horizon House Publications

78 Attending European Microwave Week 2016

Richard Mumford, Microwave Journal

94 The 2016 EuMW Defence, Security and Space Forum

Richard Mumford, Microwave Journal

172 EuMW 2016 Exhibitor List

174 EuMW Product Showcase



AUGMENTED REALITY: HOW IT WORKS

STEP 1

Download the free Layar app from the iTunes (iOS) or Google Play (Android) store.

STEP 2

Launch the app to view enhanced content on any page with the **layar** logo.

STEP 3

Frame the entire page in the screen and tap to experience enhancements (tap screen again for full screen view).

Look for the Layar logo on participating pages. AR pages may expire after 30 days.

59 YEARS OF PUBLISHING EXCELLENCE

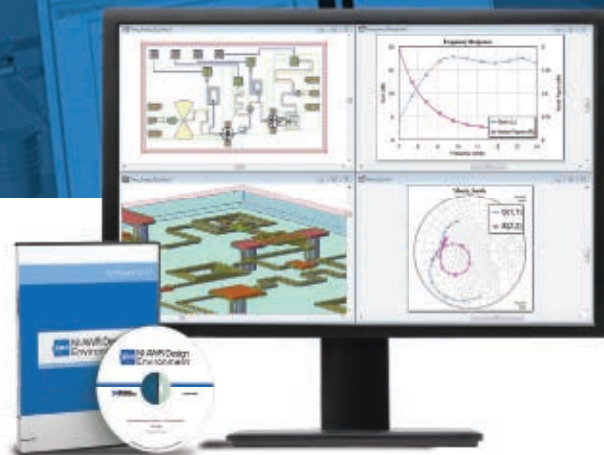
ONE PLATFORM, ZERO BARRIERS

SIMPLY SMARTER

NI AWR DESIGN ENVIRONMENT

NI AWR Design Environment™ is one platform—integrating system, circuit, and electromagnetic analysis—for the design of today's advanced wireless products from base stations to cellphones to satellite communications. Its intuitive use model, proven simulation technologies, and open architecture supporting third-party solutions translates to zero barriers for your design success. Simply smarter design.

**Visit Booth #4 at EuMW 2016 to see
recent advances in NI AWR software
or learn more at ni.com/awr**



Microwave Office | Visual System Simulator™ | Analog Office | AXIEM | Analyst™



Product Features

154 Power Analyzer Reaches 70 GHz with >100 dB Dynamic Range

Anritsu

158 Affordable, mmWave VNA Solutions

Farran Technology, Copper Mountain Technologies

162 10 mm Diameter Circulators and Isolators for Wireless Infrastructure

Skyworks Solutions, Inc.

Tech Briefs

166 USB/Ethernet-Controlled Miniature Switch Modules

Teladyne Relays

168 Tunable, Wideband, Ka-Band Source with High Output Power

Space Labs Inc.

Departments

17	Mark Your Calendar	170	Web & Video Update
18	Coming Events	182	Book End
51	Defense News	184	Advertising Index
55	International Report	184	Sales Reps
59	Commercial Market	186	Fabs and Labs
62	Around the Circuit		

Microwave Journal (USPS 396-250) (ISSN 0192-6225) is published monthly by Horizon House Publications Inc., 685 Canton St., Norwood, MA 02062. Periodicals postage paid at Norwood, MA 02062 and additional mailing offices.

Photocopy Rights: Permission to photocopy for internal or personal use, or the internal or personal use of specific clients, is granted by *Microwave Journal* for users through Copyright Clearance Center provided that the base fee of \$5.00 per copy of the article, plus \$1.00 per page, is paid directly to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923 USA (978) 750-8400. For government and/or educational classroom use, the Copyright Clearance Center should be contacted. The rate for this use is 0.03 cents per page. Please specify ISSN 0192-6225 *Microwave Journal* International. *Microwave Journal* can also be purchased on 35 mm film from University Microfilms, Periodic Entry Department, 300 N. Zeeb Rd., Ann Arbor, MI 48106 (313) 761-4700. Reprints: For requests of 100 or more reprints, contact Barbara Walsh at (781) 769-9750.

POSTMASTER: Send address corrections to *Microwave Journal*, PO Box 1143, Skokie, IL 60076 or e-mail mwj@halldata.com. Subscription information: (847) 763-4943. This journal is issued without charge upon written request to qualified persons working in the RF & microwave industry. Other subscriptions are: domestic, \$120.00 per year, two-year subscriptions, \$185.00; foreign, \$200.00 per year, two-year subscriptions, \$370.00; back issues (if available) and single copies, \$10.00 domestic and \$20.00 foreign. Claims for missing issues must be filed within 90 days of date of issue for complimentary replacement.

©2016 by Horizon House Publications Inc.
Posted under Canadian international publications mail agreement #PM40612608

STAFF

PUBLISHER: CARL SHEFFRES

EDITOR: PATRICK HINDLE

TECHNICAL EDITOR: GARY LERUDE

MANAGING EDITOR: JENNIFER DiMARCO

ASSOCIATE TECHNICAL EDITOR: CLIFF DRUBIN

MULTIMEDIA STAFF EDITOR: LESLIE NIKOU

MULTIMEDIA STAFF EDITOR: BARBARA WALSH

CONTRIBUTING EDITOR: JANINE LOVE

CONSULTING EDITOR: HARLAN HOWE, JR.

CONSULTING EDITOR: FRANK BASHORE

CONSULTING EDITOR: DAVID VYE

CONSULTING EDITOR: RAYMOND PENGELLY

ELECTRONIC MARKETING MANAGER:

CHRIS STANFA

DIGITAL CONTENT PRODUCTION SPECIALIST:

LAUREN TULLY

AUDIENCE DEVELOPMENT MANAGER:

CAROL SPACH

TRAFFIC MANAGER: EDWARD KIESSLING

DIRECTOR OF PRODUCTION & DISTRIBUTION:

ROBERT BASS

ART DIRECTOR: JANICE LEVENSON

GRAPHIC DESIGNER: SACHIKO STIGLITZ

EUROPE

INTERNATIONAL EDITOR: RICHARD MUMFORD

OFFICE MANAGER: NINA PLESU

CORPORATE STAFF

CEO: WILLIAM M. BAZZY

PRESIDENT: IVAR BAZZY

VICE PRESIDENT: JARED BAZZY

EDITORIAL REVIEW BOARD

Dr. I.J. Bahl	Dr. J.M. Osepchuk
F.M. Bashore	R. Pengelly
Dr. C.R. Boyd	Dr. Ajay K. Poddar
M. Goldfarb	Dr. J. Rautio
J.L. Heaton	Dr. U. Rohde
Dr. G. Heiter	Dr. P. Staecker
H. Howe, Jr.	F. Sullivan
Dr. T. Itoh	D. Swanson
Dr. J. Lasker	Dr. R.J. Trew
Dr. S. Maas	G.D. Vendelin
Dr. G.L. Matthaei	D. Vye
Dr. D.N. McQuiddy	Prof. K. Wu

EXECUTIVE EDITORIAL OFFICE

685 Canton Street, Norwood, MA 02062

Tel: (781) 769-9750

FAX: (781) 769-5037

e-mail: mwj@mwjournal.com

EUROPEAN EDITORIAL OFFICE

16 Sussex Street, London SW1V 4RW, England

Tel: Editorial: +44 207 596 8730 Sales: +44 207 596 8740

FAX: +44 207 596 8749

SUBSCRIPTION SERVICES

Send subscription inquiries and address changes to:

Tel: (847) 291-5216

e-mail: mwj@halldata.com



www.mwjournal.com

Printed in the USA



High performance VNAs for any application

In the Lab | On the Manufacturing Floor | In the Field

With a wide variety of Vector Network Analyzers (VNAs) to suit your application and budget, Anritsu has the perfect solution to your VNA needs.

From RF to THz and value to high performance, Anritsu allows you to select the right VNA for you. Designers can choose the VectorStar® family for premium measurement performance while manufacturers can utilize the ShockLine™ family for speed and cost-effectiveness.

Our extensive range of VNAs now includes the NEW 2 or 4-port ShockLine performance line (with NEW E-band option) and the world's first 40 GHz USB VNA.

No matter what your application, Anritsu has your VNA needs covered. Learn More Today.

Download our Understanding VNA Guide: www.GoAnritsu.com/MWJ9

1-800-ANRITSU
www.anritsu.com

© 2016 Anritsu Company

Anritsu
envision : ensure

See us at EuMW Stand 8

eLEARNING free webinars

How to Design Phased Arrays for 5G, Radar and Satellite

Presented by: Keysight Technologies

9/1

Specifying Flexible Building Blocks for Automated Production Test Systems

Sponsored by: Mini-Circuits

9/7

The Promise and Perils of mmWave

Sponsored by: National Instruments

9/8

SiGe and RF SOI for Sub-6 GHz LNA Applications

Sponsored by: GLOBALFOUNDRIES

9/13

Vector Network Analyzers as a Tool for Signal Integrity in High Speed Digital Systems

Sponsored by: Anritsu

9/15

On the Road to 5G, Advances in Enabling Technology: A Materials Perspective

Sponsored by: Rogers

9/28

Web Survey

Which Briton said, "The only laws of matter are those which our minds must fabricate, and the only laws of mind are fabricated for it by matter"?

Look for our multiple choice survey online at mwjournal.com/polls

July Survey

What is the biggest shift underway in the RF industry?

GaN adoption by commercial markets (39%)

AESAs adoption by commercial markets (8%)

5G research and trials (29%)

IoT implementation (16%)

NewSpace and small satellites (8%)



Don Bradfield, general manager of **Southwest Microwave**, discusses the company's history, what differentiates their connectors in a crowded field and how they continue to push connector performance into millimeter wave.



WHITE PAPERS



Testing of Wireless Designs to Ensure Compliance



Product Development Flow for 5G/LTE Envelope Tracking Power Amplifiers



Benefits of Time-Domain Electromagnetic Simulation for Automotive Radar



Catch Frequency Matters, the industry update from **Microwave Journal**, www.microwavejournal.com/FrequencyMatters

NEW

Introducing our new Common Mode Choke Finder



There's nothing common about it!

Search and compare hundreds of common mode choke options in four easy steps.

Step 1: Search parts by Impedance, Attenuation or Inductance at your operating frequency.

Step 2: View results in a sortable table with complete performance specifications and select parts for further analysis.

Step 3: Make direct comparisons of up to six components on single impedance and attenuation graphs.

Step 4: Request free samples of the most interesting parts for evaluation and testing.



It's that Simple!

Try it at coilcraft.com/CMCfinder.



Visit us @
Stand 159



WWW.COILCRAFT.COM



No min. order. Next day delivery.



photo courtesy of the
U.S. Military & NASA



ULTRA-REL[®] 10 MHz to 7GHz **CERAMIC MMIC AMPLIFIERS**

Low NF from 0.5 dB High IP3 up to +42 dBm Low DC current 65 mA **\$4.95** from ea. (qty 20)

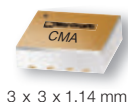
When failure is not an option. Our CMA family of ceramic MMIC amplifiers is expanding to meet your needs for more critical applications. Designed into a nitrogen-filled, hermetic LTCC package just 0.045" high, these rugged models have been qualified to meet MIL standards for a whole battery of harsh environmental conditions:

Qualified for: (see website for complete list and details)

Gross and Fine Leak	HTOL (1700 hours @ +105°C)
Mechanical Shock	Steam Aging
Vibration	Solder Heat Resistance
Acceleration	Autoclave
PIND	And More!

Robust performance across wide bandwidths makes them ideal for instrumentation, or anywhere long-term reliability adds bottom-line value. Go to minicircuits.com for all the details today, and have them in your hands as soon as tomorrow!

Electrical Specifications (-55 to +105°C)



3 x 3 x 1.14 mm

Model	Freq. (GHz)	Gain (dB)	P _{OUT} (dBm)	IP3 (dBm)	NF (dB)	DC (V)	Price \$ea. (qty 20)
New CMA-81+	DC-6	10	19.5	38	7.5	5	6.45
New CMA-82+	DC-7	15	20	42	6.8	5	6.45
New CMA-84+	DC-7	24	21	38	5.5	5	6.45
CMA-62+	0.01-6	15	19	33	5	5	4.95
CMA-63+	0.01-6	20	18	32	4	5	4.95
CMA-545+	0.05-6	15	20	37	1	3	4.95
CMA-5043+	0.05-4	18	20	33	0.8	5	4.95
CMA-545G1+	0.4-2.2	32	23	36	0.9	5	5.45
CMA-162LN+	0.7-1.6	23	19	30	0.5	4	4.95
CMA-252LN+	1.5-2.5	17	18	30	1	4	4.95

RoHS compliant



OCTOBER

3-7

MARK YOUR CALENDAR



**EUROPEAN
MICROWAVE WEEK**
LONDON, UK
3-7 OCTOBER 2016
www.eumweek.com

European Microwave Week 2016 is a FIVE day event, including THREE cutting edge conferences and ONE exciting trade and technology exhibition featuring leading players from across the globe. EuMW 2016 provides access to the very latest products, research and initiatives in the microwave sector. It also offers the opportunity for face-to-face interaction with those driving the future of microwave technology.

www.eumweek.com

5 The 2016 EuMW Defence, Security and Space Forum at European Microwave Week



This year, the emphasis will be on complex urban environments, encompassing the challenges and opportunities for indoor/enclosed and urban communications and sensing technologies. Topics will include: smart city initiatives; 3D tracking technologies in complex and indoor environments,

sensing complex targets in dense target environments, congested spectrum and network issues, integrated mmWave sensing and universal RFID technologies. www.eumweek.com

5-7

**COMSOL
CONFERENCE
2016 BOSTON**

Boston, Mass.
[www.comsol.com/
conference](http://www.comsol.com/conference)

11

Millimeter Wave PA
Sponsored by:
**NATIONAL
INSTRUMENTS**

11

WEBINAR Real-Time Recordings
and Post-Processing
of Wide-Bandwidth
EW Signals
Sponsored by:



12

WEBINAR VCO Fundamentals
Sponsored by:
Mini-Circuits

13

WEBINAR RF Energy Alliance
Sponsored by:
**ROGERS
CORPORATION**

18-21

Phased Array 2016
Waltham, Mass.

This symposium will present
the most recent advances in
phased array technology.

www.array2016.org

19

WEBINAR Sponsored by:
IDT

23-26



Austin, Texas

Coverage includes all
aspects of the technology
from materials issues, device
fabrication and modeling
through IC design and testing,
high volume manufacturing
and system applications.

www.csics.org

26

WEBINAR MMIC
Sponsored by:
**NATIONAL
INSTRUMENTS**

30-11/4

AMTA 2016
October 30 - November 4


Austin, Texas
www.amta2016.org

FOR DETAILS, VISIT MWJOURNAL.COM/EVENTS

10 MHz to 67 GHz Components




Directional Couplers




Power Dividers



Antenna Beamformers



90°/180° Hybrids



QPSK Modulators

ET Industries
Electromagnetic Technologies Industries, Inc.
50 Intervale Rd., Boonton, NJ 07005 U.S.A.
Tel: 973-394-1710 • Fax: 973-394-1710
sales@etiworld.com • www.ETIworld.com

Coming Events

CALL FOR PAPERS

88th ARFTG Conference

October 7, 2016

EDI CON China

October 11, 2016

ICMIM 2017

November 4, 2016

IMS2017

December 5, 2016

WAMICON 2017

January 4, 2017

RFIC 2017

January 9, 2017

mwjournal.com



OCTOBER

EuMW 2016

October 3–7, 2016 • London, UK

www.eumweek.com

The 2016 Defence, Security and Space Forum at EuMW

October 5, 2016 • London, UK

www.eumweek.com

COMSOL Conference 2016

October 5–7, 2016 • Boston, Mass.

www.comsol.com/conference

ICUWB 2016

October 16–19, 2016 • Nanjing, China

<http://icuwb2016.njupt.edu.cn>

Phased Array 2016

October 18–21, 2016 • Waltham, Mass.

www.array2016.org

IME/China 2016

October 19–21, 2016 • Shanghai, China

www.imwexpo.com/siteengine.php?do=en/index

IEEE CSICS 2016

October 23–26, 2016 • Austin, Texas

www.csics.org

AMTA 2016

October 30–November 4, 2016 • Austin, Texas

www.amta2016.org



NOVEMBER

MILCOM 2016

November 1–3, 2016 • Baltimore, Md.

www.milcom.org

ITC/USA

November 7–10, 2016 • Glendale, Ariz.

www.telemetry.org

NIDays London

November 29, 2016 • London, UK

uk.ni.com/nidays



DECEMBER

IEEE International Electron Devices Meeting

December 3–7, 2016 • San Francisco, Calif.

www.ieee-iedm.org

APMC 2016 and IMaRC 2016

December 5–9, 2016 • New Delhi, India

www.apmc2016.org, www.imarc-ieee.org

88th ARFTG Microwave Measurement Conference

December 6–9, 2016 • Austin, Texas

www.arftg.org

IEEE MTT-S Latin America Microwave Conference (LAMC 2016)

December 12–14, 2016 • Puerto Vallarta, Mexico

www.lamc-ieee.org



JANUARY

RWW2017

January 15–18, 2017 • Phoenix, Ariz.

www.radiowirelessweek.org

DesignCon 2017

January 31–February 2, 2017 • Santa Clara, Calif.

www.designcon.com



FEBRUARY

Mobile World Congress 2017

February 27–March 2, 2017 • Barcelona, Spain

www.mobileworldcongress.com



MARCH

Satellite 2017

March 6–9, 2017 • Washington, DC

www.satshow.com

ICMIM 2017

March 19–21, 2017 • Nagoya, Aichi, Japan

<http://icmim-ieee.org>



APRIL

IEEE Wireless and Microwave Technology Conference (WAMICON)

April 24–25, 2017 • Cocoa Beach, Fla.

www.wamicon.org

EDI CON China 2017

April 25–27, 2017 • Shanghai, China

www.ediconchina.com

VITA 67

Multicoaxial RF backplane connection system



HUBER+SUHNER VITA 67 is the first true high-density and high-performance 65 GHz coaxial interconnect system on the market. The design incorporates the solderless Minibend bend-to-the end technology which permits bending the cable immediately behind the connector at the tightest bending radii (0.06"/1.5mm). The snap-in captivation method guarantees quick, easy and precise installations without tooling or loose parts. VITA 67 is designed for side-by-side implementation with VITA 46 and VITA 66 hardware. The Vita67 cable assembly portfolio offers various .086" and smaller cable types.

Features and benefits:

- Solderless bend-to-the-end technology ensures durability
- Simplest connector installation saves time
- Frequency range up to 65 GHz delivers excellent performance
- Extreme phase stability vs. temperature and bending increases system accuracy

Learn more at richardsonrfpd.com/Vita67



An Arrow Company

Your Global Source for RF, Wireless, Energy & Power Technologies

www.richardsonrfpd.com | 800.737.6937 | 630.262.6800

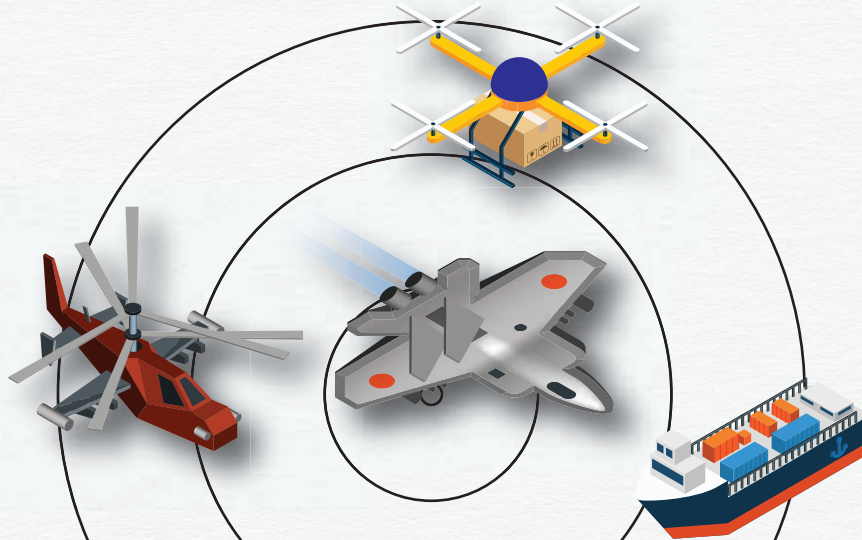


World's first Si AESA Core IC
for **5G** hybrid beam forming

Anokiwave
mmW Solutions. Enabling a new world



Quad Core Si AESA ICs
for Planar **SATCOM** Arrays



Highly Integrated Si AESA Core ICs for **RADAR**

Anokiwave's silicon mmW core IC solutions enable next generation 5G, RADAR, and SATCOM applications. Our proprietary chip architectures, feature-rich solutions, and complementary III/V products deliver unprecedented system performance. We provide disruptive value by solving the toughest problems with creative system architectures and optimal selection of semiconductor technologies.

Visit us at booth #208 EDI-CON USA 2016

mmW Si
Core ICs

AESA
ASICs

mmW
Front End ICs

www.anokiwave.com

The 5G mmWave Radio Revolution

Amitava Ghosh
Nokia Bell Labs, Arlington Heights, Ill.

The future of mobile communication will be very different from what we see today, with wireless data traffic projected to increase 10,000 fold within the next 20 years, due to increased usage of smartphones, tablets, new wireless devices and the Internet of Things (IoT). To meet this ever-increasing demand in capacity and to support 5G requirements of greater than 10 Gbps peak and edge rates greater than 100 Mbps for extreme mobile broadband (eMBB) applications, one has to use new spectrum beyond sub-6 GHz frequencies. Due to the availability of large bandwidths at mmWave frequencies, the 5G requirements for eMBB can be met using a simple air interface and high dimension phased arrays. mmWave systems also face inherent challenges, such as high penetration loss, higher sensitivity to blockage and diminished diffraction, which the system must overcome. There are multiple ongoing research and channel measurement activities around the world on 5G mmWave systems, including METIS2020,¹ COST2100/COST,² ETSI mmWave SIG,³ MiWEBA,⁴ mmMagic⁵ and NYU WIRELESS.^{6, 7, 8} In this article, we examine the practical use of mmWave spectrum for 5G and ultra-dense network deployments.

Radio spectrum is a scarce resource and is the lifeblood of the cellular industry. 5G will exacerbate the situation, promising a wider range of use cases and related applications, including 8K video streaming, augmented reality (AR), different ways of data sharing and various forms of machine type applications (vehicular safety, different sensors and real-time control) requiring ultra-low latency. Demand for wireless data traffic will probably grow 10,000 fold within the next 20 years, and without suitable new spectrum it will be difficult to

make all the promised new use cases and applications happen. The cellular industry is exploring several ways to address these challenges; one promising path is the utilization of under-used mmWave frequency spectrum for future 5G networks, coupled with the densification of networks. By their nature, those high frequencies provide much more bandwidth than the spectrum below 6 GHz that is currently being used for mobile communication, and mmWave is more amenable to small cell deployments. Bands having a worldwide primary or co-pri-

COAXIAL DIRECTIONAL COUPLERS

RLC has the exact solution you're looking for.

Our complete line of Directional Couplers covers cellular, octave and broadband frequencies.

Designs include micro-strip, stripline and airline for high power applications.

- Frequencies from 10 MHz to 40 GHz
- Power ratings up to 500 watts average
- Custom design & packaging
- Low loss, high directivity
- Single or dual directional
- Low coupling variation
- Surface mount
- Directional detectors
- Very low passive intermodulation designs
- Standard connector types
- Waveguide

For more detailed information on Directional Couplers and Directional Detectors, visit our web site.



RLC ELECTRONICS, INC.

83 Radio Circle, Mount Kisco, New York 10549 • Tel: 914.241.1334 • Fax: 914.241.1753
E-mail: sales@rlcelectronics.com • www.rlcelectronics.com

ISO 9001:2000 CERTIFIED

RLC is your complete microwave component source...

Switches, Filters, Power Dividers, Terminations, Attenuators, DC Blocks, Bias Tees & Detectors.



mary allocation to mobile service have the most potential for spectrum designation. In the United States, the FCC recently published rules which opened up 10.85 GHz of spectrum for flexible use wireless broadband. The rules create 3.85 GHz of licensed flexible use spectrum in the 28 to 40 GHz bands and an unlicensed band from 64 to 71 GHz⁹ (see **Figure 1**). The FCC also released a Further Notice of Proposed Rule Making (FNPRM) on the following new bands: 24 to 25, 32, 42, 48, 51, 70 and 80 GHz.⁹

While mmWave frequencies start around 30 GHz and go through 300

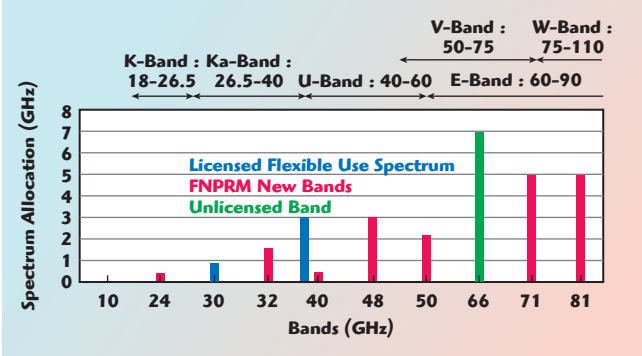
GHz, 5G deployments are expected only up to around 100 GHz. For “low band” mmWave systems with up to a 40 GHz carrier frequency, larger bandwidths can be achieved by aggregating multiple carriers. For example, 10 × 100 MHz carriers can be aggregated to achieve a bandwidth of 1 GHz. Bandwidths from 500 MHz to 2 GHz are envisioned to be realized at mmWave frequencies above 40 GHz without the use of carrier aggregation. The narrow beams operated at these high frequencies impose challenges a mmWave system must overcome; user devices need to be acquired and

tracked all of the time, using a narrow beam antenna, while mitigating shadowing with base station diversity and rapid rerouting around obstacles when it occurs.

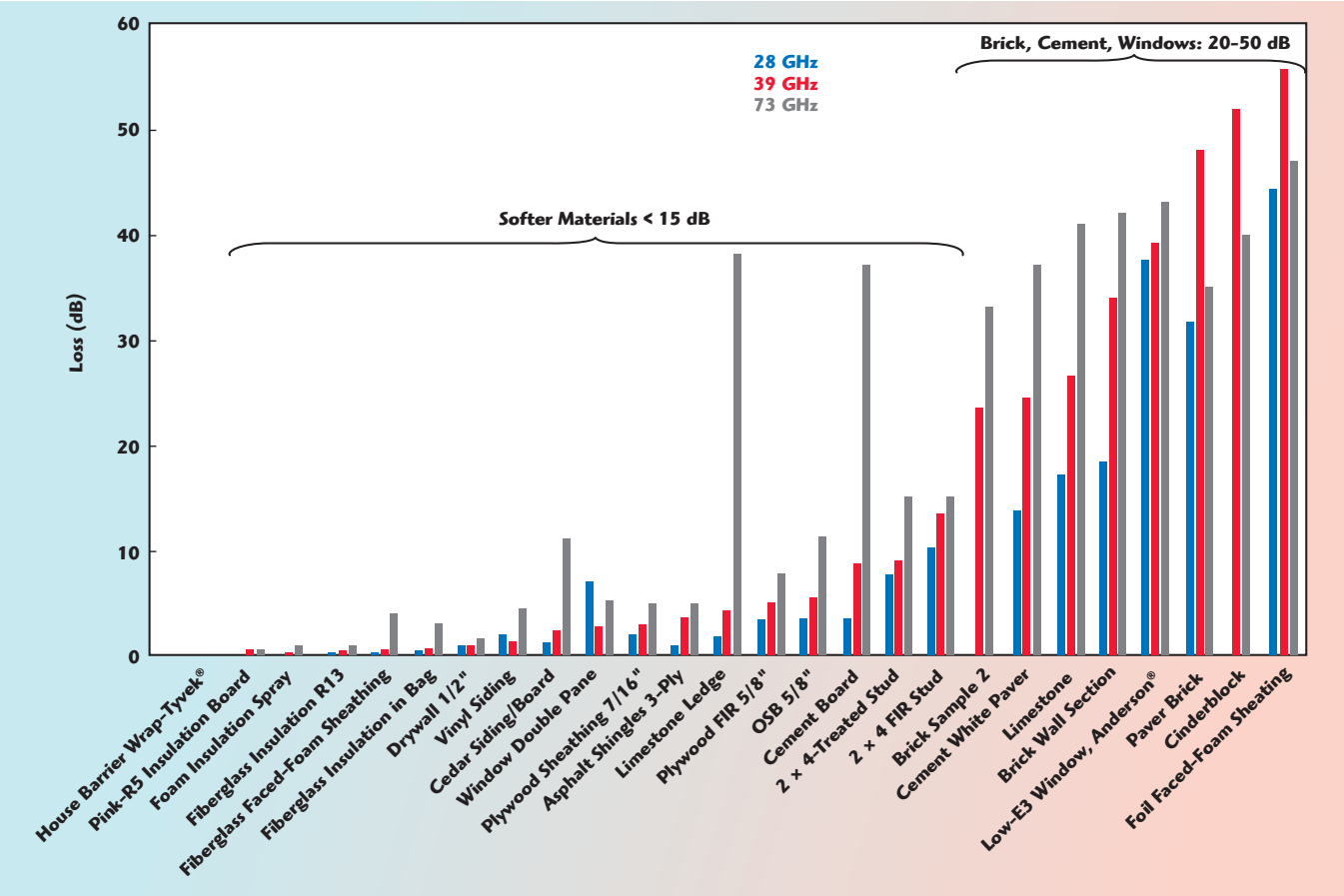
5G mmWave systems are currently targeted to be deployed in the following environments:

- Urban micro (UMi), comprising street canyons and open squares with cell radii less than 100 m and access points (AP) mounted below rooftops
- Suburban micro (SMi), with residential houses in a suburban setting with cell radii around 200 m and APs mounted at 6 to 8 m
- Indoor hotspots (InH), comprising indoor offices and cubicles and indoor shopping malls which are 3 to 5 stories high and APs at 2 to 3 m.

The first step in designing a 5G system at mmWave is to understand the channel characteristics of the above deployment scenarios. Multiple companies, European research consortiums¹⁻⁵ and academia⁶ have conducted measurements campaigns for 5G channel modeling, along with ray tracing measurements. The findings of this extensive effort were published at GLOBECOM 2015.¹⁰ The measurements indicate that smaller wavelengths introduce increased sensitivity in the propagation models due to the scale of the environment and show frequency dependent path loss and certain large scale parameters. Dif-



▲ Fig. 1 Proposed 5G mmWave spectrum.



▲ Fig. 2 Penetration loss vs. frequency.



Make the Connection

Find the simple way through complex EM systems with CST STUDIO SUITE



Components don't exist in electromagnetic isolation. They influence their neighbors' performance. They are affected by the enclosure or structure around them. They are susceptible to outside influences. With System Assembly and Modeling, CST STUDIO SUITE helps optimize component and system performance.

Involved in antenna development? You can read about how CST technology is used to simulate antenna performance at www.cst.com/antenna.

If you're more interested in filters, couplers, planar and multilayer structures, we've a wide variety of worked application examples live on our website at www.cst.com/apps.

Get the big picture of what's really going on. Ensure your product and components perform in the toughest of environments.

**Choose CST STUDIO SUITE –
Complete Technology for 3D EM.**



See us at EuMW Stand 5

CST – COMPUTER SIMULATION TECHNOLOGY | www.cst.com | info@cst.com

TABLE 1	
MODULATION FOR mmWAVE BANDS	
3 to 40 GHz	> 40 GHz
CP-OFDMA	Null CP SC

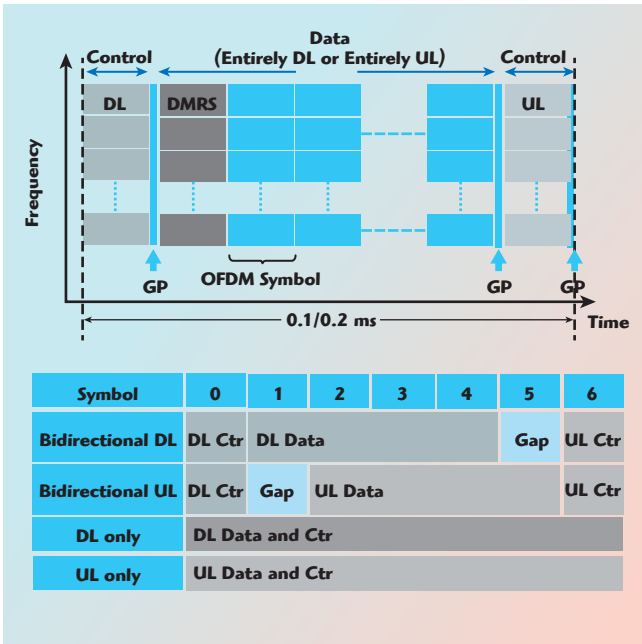
fraction, the bending of rays around building corners and roofs, decreases with frequency and is no longer a dominant effect in outdoor channels above approximately 10 GHz. Atmospheric and rain losses are frequency dependent but are small: less than approximately 2 dB for worst-case rain for cell radii less than 100 m, even at 100 GHz. One of the important considerations in channel modeling is penetration loss, which is highly dependent on materials and tends to increase with frequency (see **Figure 2**). The shadow fading and angular spread parameters are larger and the boundary between line-of-sight and non-line-of-sight depends on the local environment as well as antenna height. The small-scale characteristics of the channel, such as delay and angular spread, and the multipath richness of the channel are somewhat similar over frequency, which is encouraging for extending the existing 3GPP models to wider frequency ranges. The standardization of 5G channel models in 3GPP is complete¹¹ and was primarily based on the GLOBECOM white paper.

5G mmWAVE AIR INTERFACE

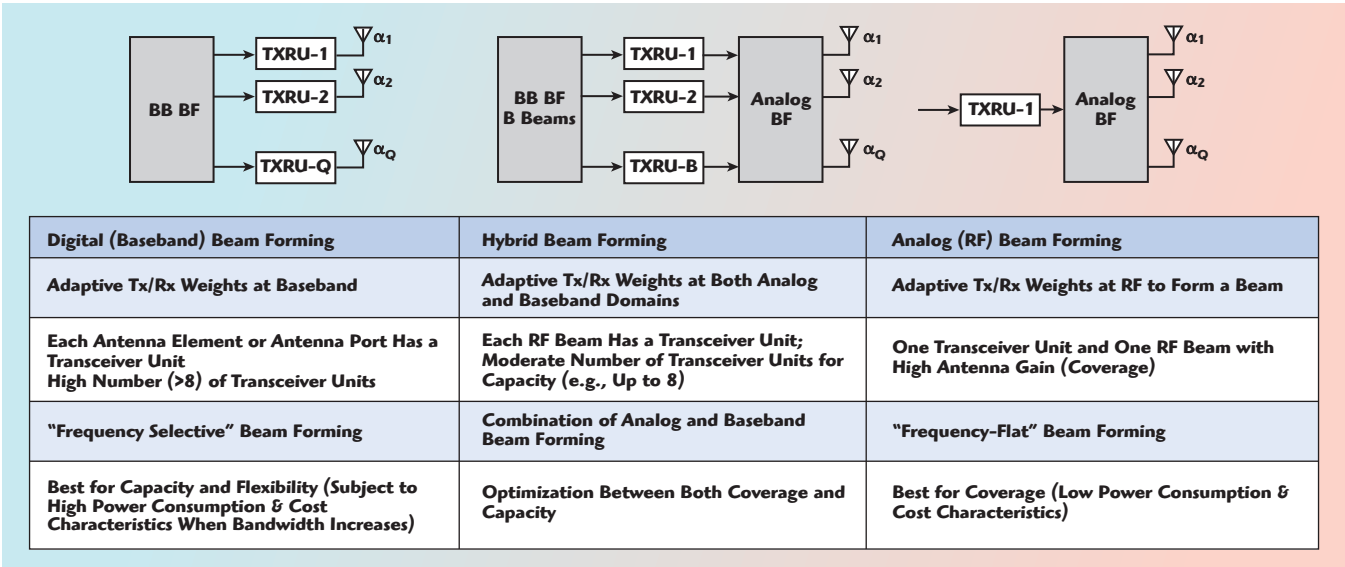
Time division duplex (TDD) is the preferred duplexing method in mmWave cells because it eliminates the

TABLE 2			
NUMEROLOGY FOR 5G mmWAVE SYSTEM			
Spectrum Band	3 to 40 GHz	20 to 100 GHz	
Maximum Carrier Bandwidth (MHz)	200	400	1600
Waveform	OFDM	OFDM	NCP-SC
Clock Rate (Mchip/s)	245.76	491.52	1966.08
Sub-Carrier Spacing (kHz)	120	240	960
Ts (μs)	8.335	4.17	1.04
Maximum (I)FFT Size	2048	2048	2048
# Symbols per Subframe	14	28	120
Sub-Frame Length (μs)	125	125	125
CP (μs)	0.6	0.3	—
CP Overhead	6.7%	6.7%	—

need for paired spectrum and is more flexible handling the elastic demand of uplink and downlink traffic. To maximize mobile broadband capacity, the 5G waveforms should be based on cyclic prefix orthogonal frequency division multiplexing (CP-OFDMA) and its variants, like in LTE (4G). 5G mmWave systems will use the same waveforms for both uplink and downlink. For bands above 40 GHz, a single carrier (SC) based waveform is preferred, to



▲ Fig. 3 Low latency frame structure for 5G mmWave.



▲ Fig. 4 Baseband, RF and hybrid architecture properties for massive MIMO.

YOUR COMPLETE MILLIMETER WAVE **SOLUTION**

new

Low-Cost
VNA Extender



MANY ITEMS IN STOCK

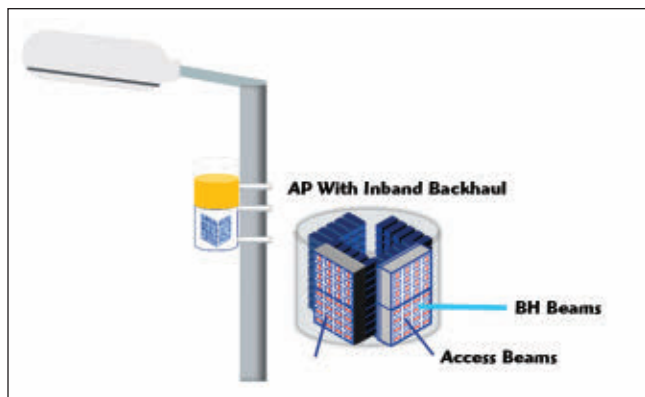


MADE IN USA

www.sagemillimeter.com | 3043 Kashiwa Street, Torrance, CA 90505
T: 424-757-0168 | F: 424-757-0188 | sales@sagemillimeter.com



SAGE
Millimeter, Inc.



▲ Fig. 5 Access point with inband backhaul.

maximize power amplifier efficiency and allow efficient beam forming, minimizing switching overhead.¹² The promising SC waveforms are null CP SC (NCP-SC) or its frequency domain counterpart called zero-tail OFDM (ZT-OFDM),¹³ where the regular CPs are replaced with null CPs and has nearly constant envelope properties. NCP-SC modulation is inherently efficient, like LTE's reverse link,¹³ which uses DFT-spread OFDM (DFT-S-OFDM). The choice of modulation schemes at various mmWave frequency bands is illustrated in *Table 1*.

Another important requirement of the 5G mmWave system is to achieve a 10× reduction in the latency of the air interface, compared to 4G. The primary mechanism

for meeting this 1 ms latency is the frame structure of the 5G TDD system (see **Figure 3**). Transmissions are organized into radio frames with 10 ms duration. A radio frame consists of an integer multiple of sub-frames with a predefined number of OFDMA symbols, which depends on the numerology adopted for 5G systems. Three sub-frame types are supported: downlink (DL) only, uplink (UL) only and bidirectional sub-frame. The sub-frame length, in OFDMA symbols, is common for all sub-frame types for a given sub-carrier spacing value. Each sub-frame contains demodulation reference signals (DMRS) for demodulating DL or UL data, DL and UL control and separate reference signals for demodulating broadcast control signals. Both the data and control signals are user-specific beam formed, along with the respective user-specific DMRS. In addition, a dynamic TDD operation can be supported where each sub-frame could be UL, DL or backhaul and can be configured differently from AP to AP. The choice of numerology for 5G mmWave system is guided by channel characteristics and the beam forming methodology at these bands. Smaller cell sizes at higher frequencies and narrow beamwidths imply lower delay spreads and allow shortening the cyclic prefix. Further, short symbol duration with larger subcarrier spacing maximizes beam switching opportunities and enables efficient TDMA control. Finally, the base clock rate of 2^N of the base sampling rate used in LTE facilitates multi-mode implementation with LTE and simplifies implementation. **Table 2** provides some exam-

IT DOES EXIST...



HA7062C PHASE NOISE ANALYZER

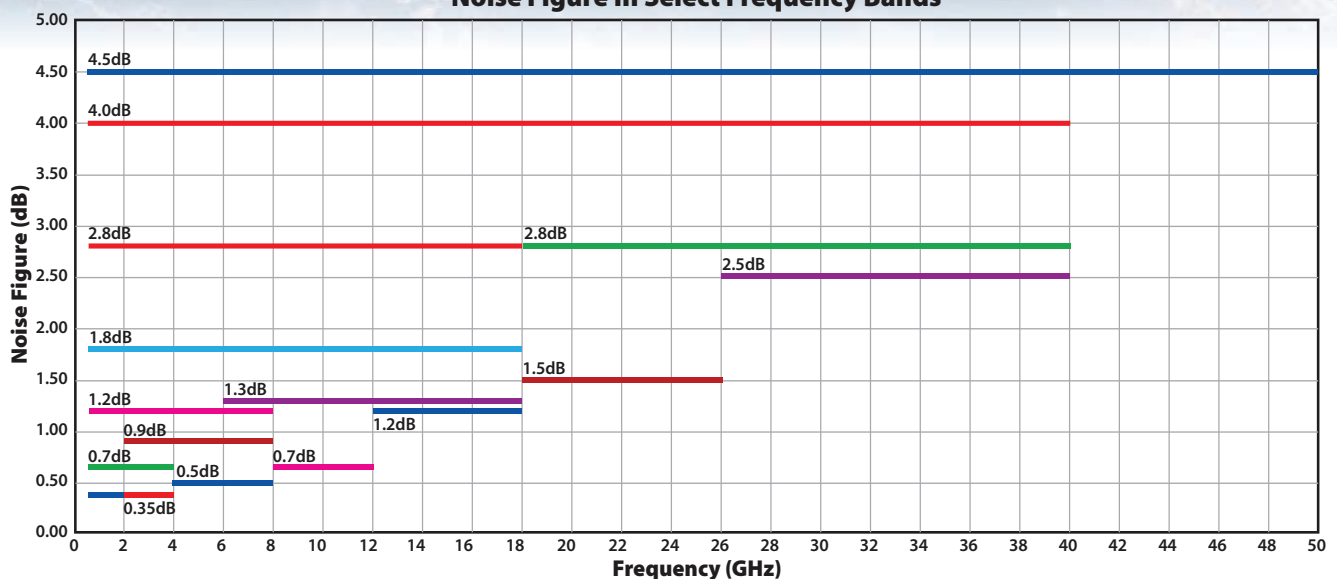
- >> FAST: Real Time Data Analysis
- >> 10MHz - >20GHz DUT Input Range
- >> 0.1Hz - 40MHz Measurement Offsets
- >> ANSI z540 NIST Traceable Data
- >> 3 YEAR PRODUCT WARRANTY

ACCURATE PHASE NOISE MEASUREMENTS ARE NO LONGER A MYSTERY

Has Amplifier Performance or Delivery Stalled Your Program?



Noise Figure In Select Frequency Bands



ple numerology based on the above principles.

MASSIVE MIMO

Massive multiple-input-multiple-output (MIMO) is the extension of traditional MIMO technology with a few controllable antennas (typically less than eight) to antenna arrays having a large number of controllable antennas (16 or more). At mmWave, the number of antenna elements at the APs

can vary from 128 to more than 1,000. The main benefit of massive MIMO is the enhancement in both capacity and coverage. At sub-6 GHz frequencies, the system is more interference limited, and capacity-enhancing solutions with massive MIMO single user (SU) and multi user (MU) MIMO become essential. At mmWave, coverage-enhancing solutions are essential to compensate the higher path loss at these frequencies. To provide the

desired wider area coverage from a single radio and antenna, the antenna system needs to dynamically steer the beam to the user devices inside the cell coverage area.

Of the variety of means to steer antenna beams, the most attractive for this frequency band is an electronically steered array (ESA), also referred to as a phased array. Phased arrays require active phase—and often amplitude—control of the antenna elements. The small wavelength at mmWave frequencies implies that the antenna elements of a phased array will be closely spaced, and the supporting circuitry is well served by modern, highly integrated monolithic microwave integrated circuits (MMIC). The phased array is envisioned to provide a wide field of view, somewhere between 90 and 120 degrees azimuth range; elevation coverage range is expected to be smaller in many applications, although the design should not preclude a range comparable to azimuth. The size of the array will vary with the deployment scenario or application, i.e., it will depend on the desired system gain. The phased array architecture must therefore support scalable solutions in which multiple phased array MMICs and antennas can be combined to form larger or smaller arrays.

Phased arrays can be designed around various RF architectures, particularly the phase and amplitude steering and combining of the antenna element signals. Phase steering can occur at baseband, RF or a combination of baseband and RF, known as a hybrid architecture (see **Figure 4**). Having a full digital baseband unit behind each antenna provides the most flexibility but requires the most hardware, particularly analog-to-digital and digital-to-analog converters. Because the converters consume a large amount of power at the higher bandwidths of mmWave, the RF or hybrid approaches are more likely for first-generation 5G mmWave systems.

mmWave APs and integrated wireless backhaul will fit in small boxes that are easy to install on lamp posts, walls or small masts (see **Figure 5**). This concept is suitable for both the UMi and SMi environments.

To overcome high diffraction and penetration losses and blockages at

Introducing the New Gallium Nitride (GaN) Amplifier for X Band Radar



Model BMC928958-1000

1000 Watts, X-Band,
Solid State Power Amplifier Module

- ECCN-3A999 (Non-ITAR Classification)
- High Output Power Dynamic Range
- RF Input & Output Sample Detectors
- Pulse Width and Duty Factor Protection
- Thermal and Load VSWR Protection
- Optional Digital Interface for Control & Status Monitoring

COMTECH PST proudly introduces a new Gallium Nitride (GaN) amplifier for applications in the X-Band weather radar market.

The amplifier design features include options for control of phase and amplitude to allow for integration into high power systems utilizing conventional binary or phased array combining approaches for power levels of up to 100kW.

Contact us today with your requirements and specs...***we'll meet your needs and exceed your expectations.***

Comtech...simply more.



X-Band Transmitter
TWT replacement



105 Baylis Road, Melville, NY 11747 • Tel: (631) 777-8900
Fax: (631) 777-8877 • www.comtechpst.com • sales@comtechpst.com



Upgrade Your Mixer

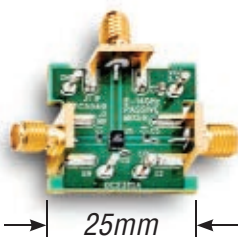
2GHz–14GHz, 0dBm LO Drive

The LTC5549 microwave mixer upgrades your transmitter and receiver performance with a +22.8dBm IIP3 at 12GHz. Its 0dBm LO drive and an on-chip frequency doubler eliminate the need for an external LO power amplifier and allow use of commonly available low frequency PLL/synthesizers, reducing power consumption and solution costs — all in a tiny 3mm x 2mm package that keeps your solution size small.

▼ Features

- +22.8dBm IIP3 at 12GHz
- 0dBm LO Drive
- Upconversion or Downconversion
- –30dBm LO Leakage
- Tiny 3mm x 2mm Package

Demo Board



▼ Info & Free Samples

www.linear.com/product/LTC5549

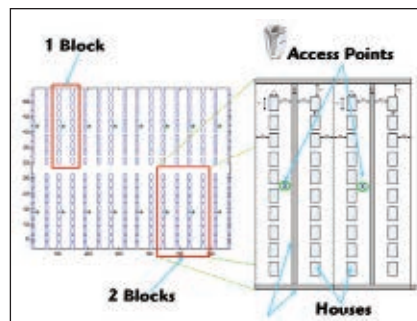
1-800-4-LINEAR

LT, LT, LTC, LTM, Linear Technology and the Linear logo are registered trademarks of Linear Technology Corporation. All other trademarks are the property of their respective owners.

mmWave frequencies, a cluster network concept is envisioned where a set of coordinated APs work together to provide ubiquitous coverage through AP diversity. In the event of blockage due to shadowing, one AP will rapidly hand off the user device (UD) to another AP in the cluster. These handoffs may be quite frequent as the UD moves through the network. Moving obstacles, hand motion and changes in orientation may all contribute to mul-

ti-ple, successive handoffs. mmWave APs can also be deployed with a sub-6 GHz overlay using LTE-Pro and/or 5G new radio (NR) to provide dual connectivity to both systems. With dual connectivity, the user can be simultaneously connected to both systems, so that the radio link connectivity is maintained even if the mmWave system is blocked.

The performance of the mmWave system is simulated in a SMi environ-



▲ Fig. 6 SMi layout with 320 houses.

ment with varying numbers of antenna elements and different values of penetration loss. The neighborhood layout in **Figure 6** shows a suburban grid with 16 blocks and 20 houses per block, totaling 320 houses. There is one AP per block and 10 active customer-premises equipment (CPE) per AP site. **Figure 7** shows the downlink user and edge throughput at 39 GHz with 800 MHz bandwidth, as the number of AP antenna elements per polarization is varied from eight to 128, and the number of antennas at the CPE is fixed to two. The figure shows that:

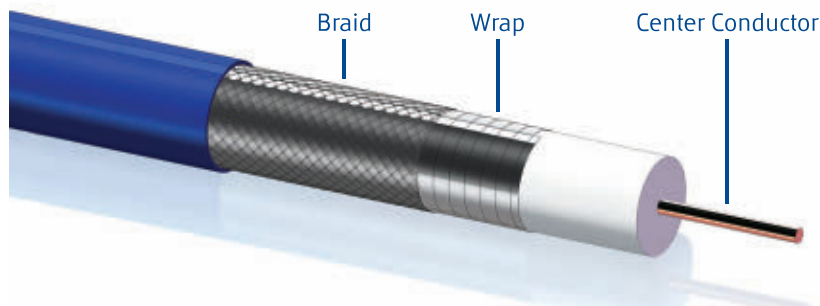
- Using outdoor CPEs, the network approaches the desired 500 Mbps UL, 500 Mbps DL mean CPE throughput
- Larger antenna arrays and sectorization at the APs improves performance significantly. Performance using indoor CPEs at 39 GHz is challenging due to the high penetration loss.

PROOF OF CONCEPT

Several proof of concept (PoC) mmWave systems were developed to prove the theoretical work and gain further knowledge about how a mmWave system behaves in the field. A first version, shown at Mobile World Congress 2015, used a steerable lens antenna and demonstrated tracking of moving users. A bidirectional system operating at 73 GHz with a 1 GHz bandwidth, it achieved a peak throughput of 2.3 Gbps using single input, single output (SISO). The design supports IP bearer data with a one-way latency of less than 1 ms. It was field tested in outdoor and indoor environments in Japan and the U.S., with peak throughput exceeding 2 Gbps and a maximum range of 160 to 200 m. At Mobile World Congress 2016, Nokia demonstrated the next version, a unidirectional 15 Gbps sys-

ULBRICH STAINLESS STEELS & SPECIAL METALS, INC.

Wire Based Solutions For High Performance Cable Manufacturers.



HELICAL WRAP WIRES

- » Thickness: 0.0005" – 0.004"
(0.0127mm – 0.1mm)
- » Width: 0.020" – 0.160"
(0.5mm – 4.064mm)
- » Aspect Ratios Up to 325:1
- » Bare Copper and Silver Plated Copper Material Available
- » Biconical and Straight Flanged Spool Packaging Available
- » In-House FFT Analysis Capabilities

BRAID WIRES

- » Thickness: 0.0015" – 0.004"
(0.0381mm – 0.1mm)
- » Width: 0.020" – 0.150"
(3.8mm)
- » Silver Plated Copper, Tin Plated Copper, Bare Copper and Copper Alloys Available
- » Mechanical Properties and High Quality Packaging are Customized to Request
- » In-Line Statistical Process Controls Ensure Low Standard Deviation Values and High CPK & PPK Values



We Deliver Precision®

(800) 243-1676
ULBRICH.COM

SMART DEVICES REQUIRE SMARTER AUTOMATED TEST SYSTEMS

The old approach to automated test isn't scaling, but you already knew that. Look at your balance sheet. To test smart devices, you need a smarter test system built on a platform of NI PXI, LabVIEW, and TestStand. More than 35,000 companies deploy NI technology to lower their cost of test—what are you waiting for?

Prepare for the future at ni.com/smarter-test



NI PXI, LabVIEW, and TestStand

See us at EuMW Stand 4

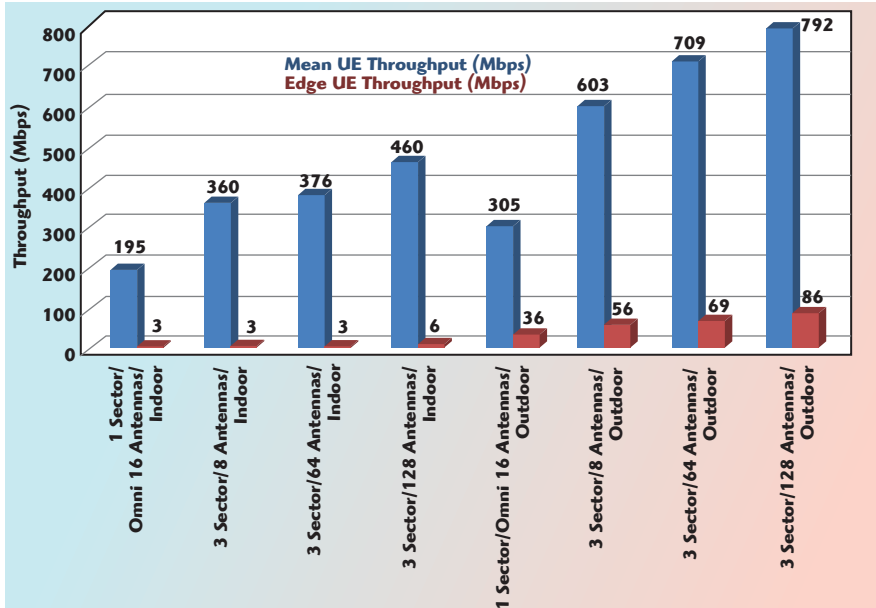
tem incorporating 2-stream MIMO in a 2 GHz bandwidth.

As a next step, the antennas were miniaturized to better match the expected phased arrays used at both the AP and UE. At the 2016 Brooklyn 5G Summit, Nokia demonstrated beam scanning using a phased array at 60

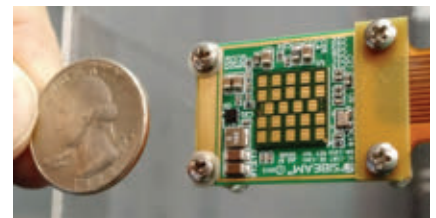
GHz with the 1 GHz bandwidth system. Because the element spacing decreases with higher frequencies (~ 2.5 mm at 60 GHz), an 8 × 8, $\lambda/2$ -spaced antenna array could easily fit into an area smaller than 20 sq mm, as shown in **Figure 8**. A fully integrated 16 element, 90 GHz phased array ASIC was

developed at Nokia Bell Labs, and the ASIC die was assembled directly on an organic PCB substrate that housed the patch antennas. The integrated array demonstrated an EIRP of 34 dBm at 90 GHz and a receiver noise figure of 7 dB per element. The system can establish multi-gigabit wireless links at distances of tens of meters. This low cost, integrated solution does not require any waveguide components or expensive materials and follows a traditional die-on-PCB assembly process.

Nokia is pushing spectral efficiency to get the most capacity out of the spectrum, demonstrating spectrum efficiencies up to 100 bps/Hz at 28 GHz. This will make wireless transmission of large data files far more economical than what is currently achievable. The prototype uses a novel physical layer



▲ Fig. 7 Full buffer DL mean user and edge throughput for various SMi environments at 39 GHz with 800 MHz bandwidth.



▲ Fig. 8 12-element phased array showing the small size of the array. Source: SiBeam Inc.

Wright Technologies Inc.

Broadband Frequency Operation

Med Power Amplifiers

ASP45-B303
25-43 GHz
+30 dBm P-1dB

ASP40-B3030
25-40 GHz
+30 dBm P-1dB

ASP40-B302
18-40 GHz
+27 dBm P-1dB

1415 5Q761
S/N 0002

25-42.5 GHz +30 dBm P-1dB
26.5-40 GHz +30 dBm P-1dB

Great Power in a Small Package

"Battle Tested & Built to Last"

Broadband Frequency Converters

Narrow Band LO Filter

Broadband filter

LO Freq. Multiplication

18-40 GHz LNA

Broadband IF Band

Low Noise

5-40 GHz
ASL40B-3011

1-80 GHz
ASL50B-3010

ASL40-30118
18-40 GHz
+12 dBm P-1dB
S/N 0001

ASL40-30116
18-40 GHz
+10 dB P-1dB
S/N 0001

5-40 GHz +5.8 dB N.F.
1-80 GHz +6.5 dB N.F.
18-40 GHz +3.2 dB N.F.
26.5-40 GHz +3.0 dB N.F.

Broadband Amplifiers

Custom Product Features

- Bit Detection
- Temperature Compensation
- Drop in Isolators
- Smaller Size
- Non Standard Frequencies
- Exclusive Hybrid Circuit Library

Noise Figure

Noise Figure

www.wrighttec.com

If your 5G idea works here...



it will work here.

Autonomous vehicles navigating through traffic. Hands free.

Soon it will be reality. A world connected as never before. Always available. Low latency. Ultra reliable. That's the promise of 5G. New spectrum. New waveforms. Millimeter-waves. More. Keysight offers the world's first 5G simulation, design and test environment able to emulate your real-world 5G wireless thesis. With deep expertise to help you navigate 5G risk and complexity. So you can go from 5G ideas to 5G reality faster.

HARDWARE + SOFTWARE + PEOPLE = 5G INSIGHTS

5G

Get the latest app notes,
white papers and tutorials
www.keysight.com/find/5G-Insight

USA: 800 829 4444 CAN: 877 894 4414

© Keysight Technologies, Inc. 2016

See us at EuMW Stand E2



Unlocking Measurement Insights

Agilent's Electronic Measurement Group is now **Keysight Technologies**.

technology, including massive MIMO, that guarantees huge system capacity and spectral efficiency. It achieved a peak transmission rate of over 50 Gbps across a short range, while supporting latency requirements as short as 250 μ s. At that speed, a 50 GB movie can be downloaded in less than eight seconds.

CONCLUSION

The use of mmWave spectrum in wireless communication is considered

revolutionary, and this article examines the state-of-art in mmWave communication for the wireless industry, covering spectrum options, channel characteristics, air interface design and massive MIMO architectures. Proof-of-concept systems have been developed and are essential to show how the challenges of a mmWave system can be overcome. The next step is commercial deployment, with first trials of specific 5G use cases in early 2017. Ideally, a simple and low cost

small cell solution, using a fully flexible baseband technology, massive MIMO and phased arrays at mmWave will be feasible by the year 2020. This solution will help achieve the promise of 5G and the many new applications and use cases it will enable. ■

ACKNOWLEDGMENT

The author would like to thank Nokia colleagues for their help in preparing this article and National Instruments for their support with the 73 GHz Proof-of-Concept system.

References

1. METIS2020, Deliverable D1.4 v3, "METIS Channel Model," July 2015. www.metis2020.com/wp-content/uploads/METIS_D1.4_v3.pdf.
2. COST, www.cost2100.org/.
3. ETSI, "New ETSI Group on Millimetre Wave Transmission Starts Work," www.etsi.org/news-events/news/866-2015-01-press-new-etsi-group-on-millimetre-wave-transmission-starts-work.
4. MiWEBA, Deliverable D5.1 "Channel Modeling and Characterization," June, 2014, www.miweba.eu/wp-content/uploads/2014/07/MiWEBA_D5.1_v1.011.pdf.
5. mmMagic, 5g-ppp.eu/mmmagic/.
6. T. S. Rappaport et al., "Wideband Millimeter-Wave Propagation Measurements and Channel Models for Future Wireless Communication System Design," *IEEE Trans. Communications*, Vol. 63, No. 9, pp. 3029–3056, September 2015.
7. T. S. Rappaport et al., "Millimeter Wave Mobile Communications for 5G Cellular: It Will Work!," in *IEEE Access*, Vol. 1, pp. 335–349, 2013.
8. G. MacCartney et al., "Indoor Office Wideband Millimeter-Wave Propagation Measurements and Channel Models at 28 GHz and 73 GHz for Ultra-Dense 5G Wireless Networks," *IEEE Access*, October 2015.
9. FCC Spectrum Frontiers (mmW) Order on 28/37/39/64-71GHz and Further Notice of Proposed Rulemaking (FNPRM): transition.fcc.gov/Daily_Releases/Daily_Business/2016/db0714/FCC-16-89A1.pdf.
10. 5G Channel Model White Paper, Globecom 2015, www.5gworkshops.com/5GCM.html.
11. 3GPP TR38.900, www.3gpp.org/ftp//Specs/archive/38_series/38.900/38900-100.zip.
12. Amitava Ghosh et al., "Millimeter-Wave Enhanced Local Area Systems: A High-Data-rate Approach for Future Wireless Networks," *IEEE Journal on Selected Areas in Communications*, Vol. 32, Issue 6, June 2014.
13. Stephen Larew, Timothy A. Thomas, Mark Cudak and Amitava Ghosh, "Air-Interface Design and Ray Tracing for 5G Millimeter Wave Communications," *Proceedings of IEEE Globecom Workshop*, 2013.

Powerful Multipath/Link Emulator

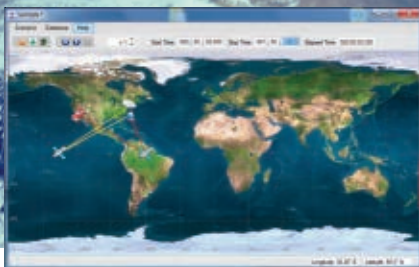
Multipath Rayleigh & Rician Fading
Unmanned Aerial Vehicle (UAV) testing
Sophisticated Satellite link emulation
Mobile Comm's on the move testing

Test solutions for

WIN-T - warfare information networks, tactical
MUOS - mobile user objective system
JTRS - Joint Tactical Radio System
IRIS - Internet routing in space

**250 MHz
bandwidth**

Software showing mobile link setup



RF Test Equipment for Wireless Communications

dBm Corp, Inc

32A Spruce Street ♦ Oakland, NJ 07436

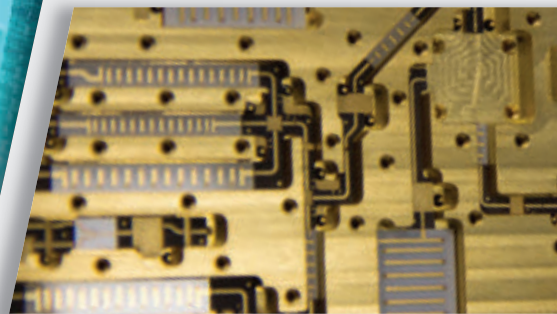
Tel (201) 677-0008 ♦ Fax (201) 677-9444

www.dbmcorp.com

Innovation *That's Open.*

INTRODUCING *OpenRFM*™

MEETING NEW GOVERNMENT INTEROPERABILITY AND AFFORDABILITY REQUIREMENTS IN RADAR, ELECTRONIC WARFARE AND SIGNALS INTELLIGENCE, REQUIRES INNOVATIVE APPROACHES IN ADVANCED RF/MICROWAVE AND DIGITAL SIGNAL PROCESSING. OPENRFM IS THE FIRST RF/MICROWAVE OPEN SYSTEM APPROACH THAT LEVERAGES BEST AVAILABLE COMMERCIAL-ITEM TECHNOLOGY TO DELIVER SOPHISTICATED, INTEROPERABLE SENSOR PROCESSING SUBSYSTEMS TO DOMINATE THE ELECTROMAGNETIC SPECTRUM. OPENRFM IS THE BETTER ALTERNATIVE FOR AFFORDABLE RF SUBSYSTEMS FOR OUR WAR FIGHTERS AND ALLIES ALIKE.



MERCURY
SYSTEMS™

INNOVATION THAT MATTERS™



Visit mrcy.com/OpenRFM and download our technical whitepaper:
Advantages and Benefits of OpenRFM™





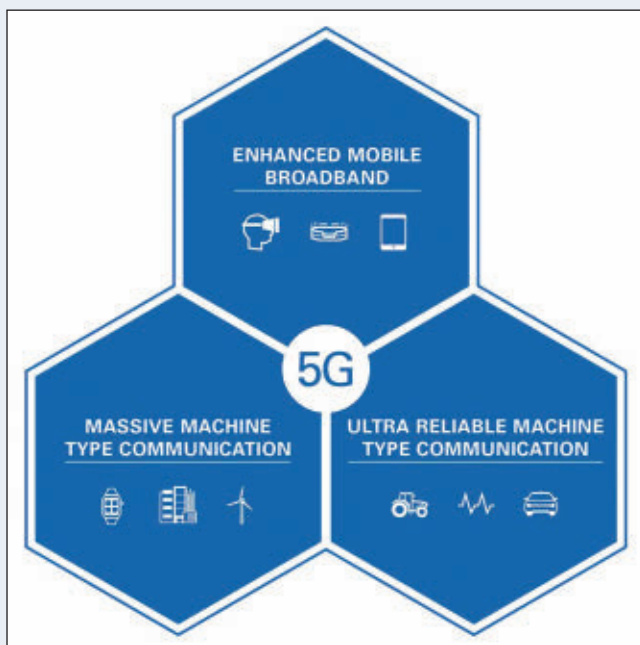
Second-Generation VST is Smarter for Today's RF Test Challenges

National Instruments
Austin, Texas

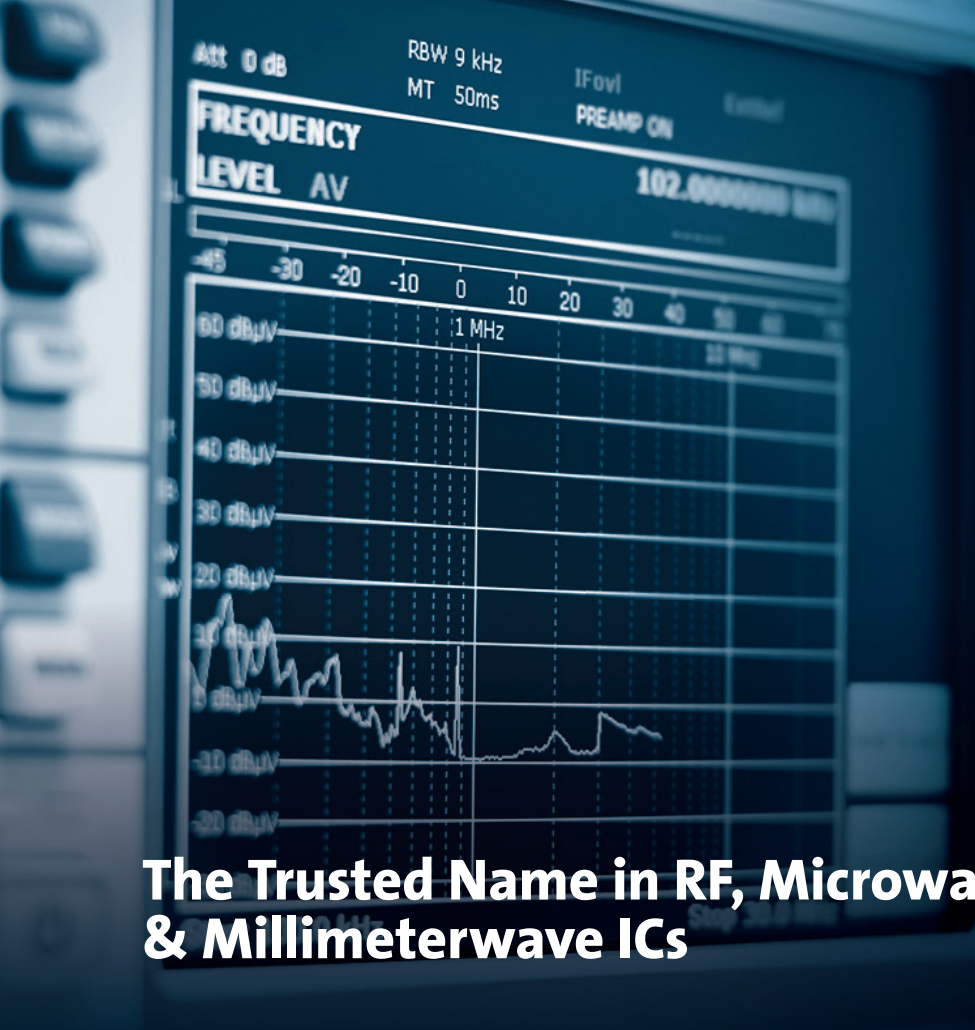
In 2012, NI announced the PXI vector signal transceiver (VST), the world's first instrument to combine an RF vector signal generator and analyzer with a user-programmable FPGA into a single PXI module. The combination of the VST's

excellent RF performance and unique software experience enabled customers to reduce test cost and accelerate productivity in a wide range of applications: from wireless test to electronic warfare (EW). Its LabVIEW-programmable FPGA enabled many test optimizations, including power amplifier (PA) test with built-in output power leveling, spectral and demodulation measurement acceleration and other real-time signal processing algorithms.

Looking to the future, the changing requirements for RF and wireless test equipment are accelerating at an ever-increasing pace. Nowhere do we see this more clearly than in the International Telecommunication Union's (ITU) defined use cases for 5G (see **Figure 1**). The first is enhanced mobile broadband (eMBB), which will drive peak data rates upwards of 10 Gbps through a combination of wider bandwidth, higher-order modulation and MIMO/beam forming technologies. The second use case, massive machine-type communication (mMTC), will connect a wide range of devices in more industrial IoT (IIoT) applications, and it will drive new mobile technologies such as LTE for machine-to-machine (M2M) communications and narrowband IoT (NB-IoT). The third use case defines ultra-reliable machine-type communication (uMTC), in which the key requirements are latency and packet error rates. Although these strong trends deal mainly with



▲ Fig. 1 Three use cases driving 5G technology vectors and standards.



Aerospace & Defense
Industrial, Scientific & Medical
Satellite Communications
Test & Measurement
Wired Broadband

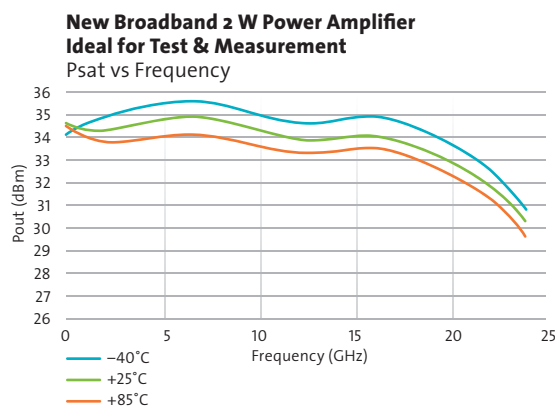
The Trusted Name in RF, Microwave & Millimeterwave ICs



MAAP-011247

MACOM delivers a leading portfolio of high-performance DC to 100 GHz MMICs

For over 60 years MACOM design and application experts have driven RF, Microwave and mmW innovation. Our engineers are delivering a new generation of wideband, high-performance MMICs for test and measurement, SATCOM, A&D, wired broadband and ISM applications.



Our 27 new MMIC products offer optimal performance, bandwidth, packaging and reliability to meet your most demanding requirements. New products include:

- Wideband Amplifiers & Mixers
- Single Bias LNAs & Gain Blocks
- Broadband VCOs
- High Power SATCOM PAs
- V-, E- & W-Band Products
- mmW Switches
- Wideband Detectors
- Broadband 75 ohm Amplifiers

MACOM™

Partners from RF to Light

Learn more and get datasheet:
www.macom.com/mmics

See us at EuMW Stand 207

Most Valuable Product

cellular technology, they also drive new connectivity standards such as 802.11ad/ax, personal area networks and near field communication (NFC). These technological developments introduce new challenges for professionals designing and testing state-of-the-art devices and components for RF and wireless systems. Higher throughput demands wideband instruments, lower cost requires faster measurements and higher reliability introduces the need for new test techniques.

To tackle these challenges, NI has introduced a second-generation VST, the PXIe-5840. With 1 GHz of instantaneous bandwidth, the second-generation VST offers five times the bandwidth of the first-generation VST. The PXIe-5840 VST offers EVM performance better than -50 dB, output power to +23 dBm and a wider frequency range, from 9 kHz to 6.5 GHz. Similar to the first-generation VST, the PXIe-5840 VST features a LabVIEW-programmable FPGA. The new instrument's

Virtex-7 FPGA offers approximately five times the number of DSP slices as the initial generation and allows customers to customize the instrument firmware in advanced test and design applications. The second-generation VST also does all of this in only two PXI slots, allowing engineers to configure PXI systems with up to eight modules per PXI system.

CELLULAR, SEMICONDUCTOR AND PROTOTYPING

Next generation wireless device and transceiver test is one application that the VST is designed to address. The latest evolution of standards like LTE-Advanced Pro and 802.11ax introduce both new carrier-aggregation requirements and higher-order MIMO configurations. The second-generation VST's smaller footprint and solution, with engineers able to configure up to eight MIMO test systems in a single 18-slot PXI chassis (see **Figure 2**). For carrier aggregation applications, the VST's wide bandwidth enables engineers to generate widely spaced LTE carriers with a single instrument. As a result, engineers can replace test setups involving multiple signal generators and multiple signal analyzers with a single instrument.

The second-generation VST's wide bandwidth is important in semiconductor test applications. Especially for PA and front-end module (FEM) testing, the bandwidth requirements for the instrument often exceed the bandwidth of the signal. For example, when testing RF power amplifiers (PA) operating in or near saturation, the VST measures the PA's output signal, computes a predistorted



Modelithics®
THE BEST OF BOTH WORLDS

Modelithics **COMPLETE** Library™ of
Scalable Models for Passives AND
Non-linear Models for Actives

For a **FREE** trial email: Trial@modelithics.com

Download the **NEW** model for IPDiA's 0201M Ultra
Broadband Surface Mount Silicon Capacitor

Advanced simulation features
accurate performance from low
frequency through 67GHz!

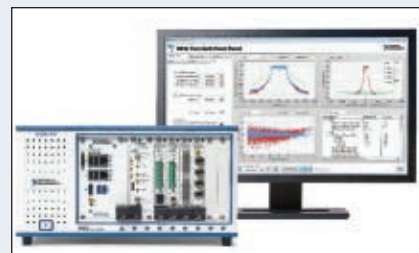
For more information and to
request a **FREE** trial, visit:
[www.Modelithics.com/
mvp/IPDiA](http://www.Modelithics.com/mvp/IPDiA)

Modelithics®
Vendor partner
Spotlight

ipdia



▲ Fig. 2 Compact 8x8 MIMO system with eight VSTs.



▲ Fig. 3 Digital predistortion setup.

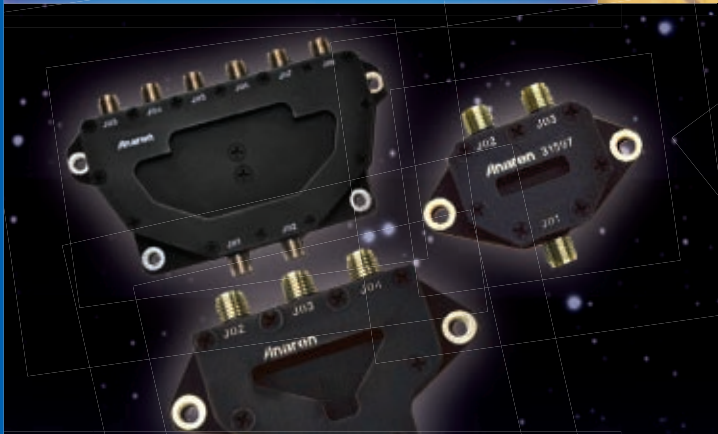


Anaren Precision Etched Ceramics (APECS) — offering thin-film tolerances & performance, at a thick-film price

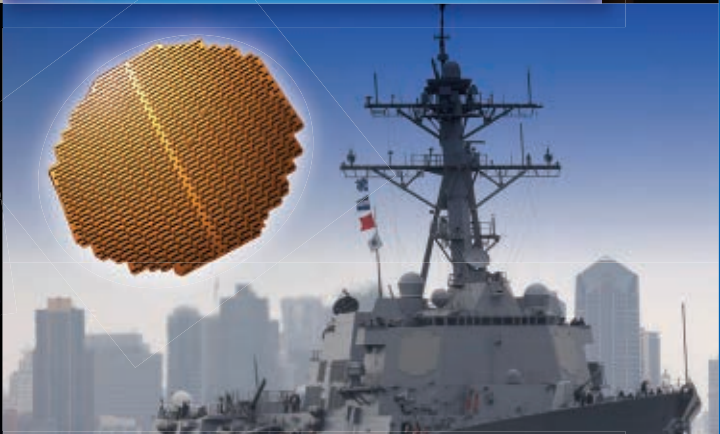


Space/Mil-grade Xinger® couplers — proven in Mars missions & ready for tough terrestrial settings, too

1 billion Xinger components sold!
First on genuine Xinger-brand components!



Space-qualified couplers & power dividers — high-rel, lightweight & low-power for today's satellite applications



RF solutions for next-gen AESAs — including manifolds, T/R modules & beam-formers for air, sea, and land platforms

Isn't it time to put Anaren innovations like these to work for you?

Fast-approaching our 50th anniversary — and this year celebrating our 1 billionth Xinger®-brand coupler sold! — today's Anaren continues to drive innovative, best-in-class RF technology for the world's most demanding space, defense, wireless, and consumer electronics customers.

- > **Our Space & Defense Group** offers a fast-growing range of passive and active solutions, including multichip modules, IMAs, and custom solutions for today's digital radars. Exciting, new PCB and ceramic substrates and multilayer packaging techniques. And a growing line-up of space-grade components and high-temperature modules.
- > **Our Wireless Group** continues to reinvent the passive components category. From new, Femto-sized and mil-grade Xinger®-brand SMTs. To subminiature baluns and couplers for consumer products. To our growing family of Anaren Integrated Radio (AIR) modules and other solutions for the wireless IoT.

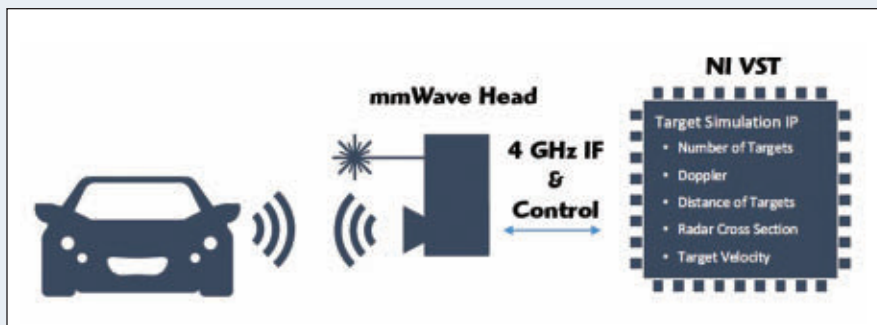
To learn more about how today's Anaren can make you more competitive tomorrow — visit www.anaren.com or email us at sales@anaren.com today!



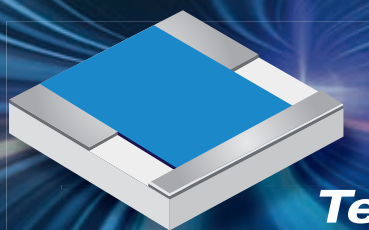
Anaren®

What'll we think of next?®

800-411-6596 > www.anaren.com



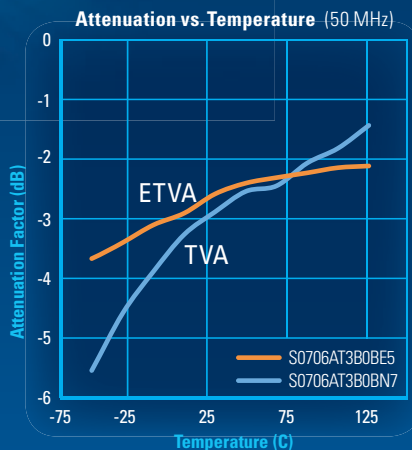
▲ Fig. 4 Radar system setup using a custom millimeter wave head.



Temperature Variable Attenuators

TVAs from the recognized leader in high reliability resistive components offer:

- Two case sizes:
0.150" x 0.125" x 0.018" (to 6 GHz)
0.075" x 0.065" x 0.018" (to 18 GHz)
- Three TCA values: -0.003, -0.007, and -0.009 dB/dB/°C
- Enhanced slope ETVA's with a TCA value of -0.005 dB/dB/°C
- Attenuation values from 1-10 dB
- Solderable or wire bondable terminations



When the mission is critical, choose **State of the Art.**



State of the Art, Inc.

RESISTIVE PRODUCTS

www.resistor.com *Made in the USA.*

2470 Fox Hill Road, State College, PA 16803-1797
Phone: 800-458-3401 or 814-355-8004 • Fax: 814-355-2714
E-mail: sales@resistor.com • Source code: 56235

QUALIFICATIONS ISO9001 & AS9100 • MIL-PRF-55342 • MIL-PRF-32159 • MIL-PRF-914

signal following a digital predistortion (DPD) model and then applies the new signal to the DUT. As a result, when the signal goes through the nonlinear PA, the output will have minimum spectral regrowth. Advanced DPD algorithms often require the predistorted signal to have three to five times the bandwidth of the original RF signal. The new PXIe-5840 VST can measure signals with bandwidth requirements around 500 MHz for a 100 MHz LTE-Advanced signal and 800 MHz for a 160 MHz 802.11ac/ax signal. By exploiting the power of the VST's FPGA, this whole process can run in hardware, in real time, empowering PA engineers to apply custom DPD to every DUT, even in high volume manufacturing test environments (see **Figure 3**).

NI's platform for FPGA development simplifies the process of modifying the VST's firmware on its FPGA. This empowers researchers to use the VST to process RF signals in real time, for applications ranging from EW systems to radar target emulators. In a radar target emulator, engineers can program the VST to capture a stimulus signal from a radar system under test; introduce one or more targets of various sizes; add delays, Doppler shifts and other effects to the signal in real time; and immediately generate the response back to the radar receiver (see **Figure 4**).

Designers and users of automotive radar systems, for example, understand well that the consequences of just one of their systems not performing properly can prove disastrous. They need to run long validation routines for driver assistance systems, sometimes exceeding 10,000 hours. Without reliable test emulation platforms, like the one that the second-generation VST provides, engineers would have to drive millions of km, with all kinds of obstacles and in many different scenarios, to test the possible events that would lead their vehicle's radar and networking systems to a critical failure.

Although the next wave of RF and wireless technologies is introducing significant design and test challenges, NI designed the second-generation VST to solve them. With unrivaled bandwidth, a smaller form factor and the largest and most customizable test platform, the PXIe-5840 VST empowers engineers to meet these RF test challenges.



National Instruments
Austin, Texas
www.ni.com/vst/

RF-LAMBDA
THE LEADER OF RF BROADBAND SOLUTIONS

Made in USA

BROADBAND SSPA SOLID STATE POWER AMPLIFIERS

0.1-22GHZ ULTRA BROADBAND SSPA



RFLUPA01M22GA
4W 0.1-22GHZ



RFLUPA0218GA
10W 2-18GHZ

0.01-6GHZ VHF, UHF, L, S, C BAND



RFLUPA0706GD
30W 0.7-6GHZ



RFLUPA02G06GC
100W 2-6GHZ

6-18GHZ C, X, KU BAND



RFLUPA0618GC
25W 6-18GHZ



RFLUPA08G11GA
50W 8-11GHZ



RFLUPA06G12GB
25W 6-12GHZ

18-50GHZ K, KA, V BAND



RFLUPA18G47GC
2W 18-47GHZ



RFLUPA27G34GB
15W 27-34GHZ



RFLUPA28G42GA
2W 28-42GHZ



RFLUPA32G38GB
8W 32-38GHZ

BENCHTOP RF MICROWAVE SYSTEM POWER AMPLIFIER



RAMP00G06GA - 30W 0.01-6GHZ



RAMP39G48GA - 4W 39-48GHZ



RAMP01G22GA - 8W 1-22GHZ



RAMP27G34GA - 8W 27-34GHZ

www.rflambda.com
sales@rflambda.com

1-888-976-8880
1-972-767-5998

San Diego, CA, US
Plano, TX, US
Ottawa, ONT, Canada





5G and the IoT: 5 Trends and Implications

*Dudy Cohen
Ceragon Networks, Tel Aviv, Israel*

If industry experts are correct, 5G will hit the market at the very beginning of the next decade.

Despite some uncertainties, 5G is creating buzz among mobile operators and communications service providers (CSP) that want to get in on the ground floor. And while 5G isn't slated to be finished and commercially deployed until 2020, initial trials should start in 2018. Consequently, smart operators and providers are learning all they can about 5G now to understand how they will need to evolve their backhaul strategies to create more effective and financially viable business models.

As one of the key new services in 5G networks, the Internet of Things (IoT) will influence the number of connected devices that will enter the marketplace. Additionally, the IoT will impact 5G traffic patterns as well as quality of service (QoS) requirements, all of which will also affect backhaul requirements and specifications. The aggregate data demand from the IoT will be very different from the smartphone oriented experience of 3G and 4G. Capacity demands will grow, and more base stations will have to be deployed in order to achieve the quality of service that is essential for the IoT to be successful.

Here are five key trends and characteristics of the underlying 5G networks that pose specific and well-defined challenges to the network infrastructure as IoT expands:

More Capacity per Device

One of the main goals of 5G services is to provide ultra-high capacity per end device, which means operators are going to need to add more spectrum, improve spectrum efficiency or roll out more infrastructure. With the rise in IoT devices, such as autonomous cars and manufacturing networks, the need for increased capacity will be crucial.



www.pivotone.com

Our Products send a Clear Signal!

Ask us about our latest low-PIM, high-performance products: Quadruplexers, Triplexers, Duplexer and TMAs. We help our customers send a clear signal to the telecom industry.

Vision drives the future

PIVOTONE

PIVOTONE COMMUNICATION TECHNOLOGIES, INC.

7-1 Yanyu Road, Yangqiao Industrial Park, Huashan Economic Development Zone,
Wuxi, Jiangsu, People's Republic of China Zip code: 214174
Tel: (86) 510.8374.0009 Fax: (86) 510.8374.2009
Website: www.pivotone.com E-mail: info@pivotone.com

More Devices and New Types of Devices

The exponential growth in the number of “standard” devices (for example, smartphones, tablets, computers, smart home devices and wearables) is expected to continue, and the average number of devices per person is expected to increase. In 2014, Strategy Analytics estimated that 12 billion internet-connected devices would be used worldwide by

the end of the year — an average of 1.7 devices for every person on the planet. By 2020, they forecast that number to jump to 33 billion, bringing the number of connections per person to more than 4.3 devices.

The mass introduction of the IoT and machine-to-machine services will create a large increase in the number of connected devices, adding non-human controlled devices to the mix and result-

ing, as forecast by GSMA, in an exponential increase in the total number of connected devices. With the increase of non-human controlled devices, one of the goals of 5G will be to be able to service these additional capacity requirements.

Higher Capacity and Street-Level Deployment

Multiplying the increase in capacity per device by the expected growth in the number of IoT connected devices results in a huge increase in capacity density (the required capacity per a given area). This forecast increase could multiply by 1,000 compared to the capacity density in current 4G/4.5G networks.

The clear effect of the increase is that more capacity per cell site — both at the radio access network (RAN) and at the backhaul layer — will be necessary. However, increasing a site’s capacity by 1,000× is not feasible. Since the forecast move to higher RAN frequencies will also require smaller coverage areas per cell site, the mobile grid will become much denser than it is today. This grid will incorporate the addition of macro cells as well as small cells on poles, towers, rooftops — also mass deployment at the street level, utilizing street furniture and light poles as physical infrastructure.

These issues will present several challenges to wireless transport networks. First, there will be a need for higher capacity wireless backhaul links per cell site. While current wireless backhaul links serve requirements of hundreds of Mbps, future links will be required to support ten Gbps and more. Additionally, denser wireless backhaul links will also be required, due to the condensed cell site grid. This demands better utilization of wireless backhaul spectrum, since frequency reuse will be highly limited as links get closer to each other. Finally, the mass deployment of street level sites will require high capacity non-line-of-sight (NLOS) microwave backhaul links, as well as quickly installed, low footprint, low power consumption equipment.

Mission Critical Applications Require Mission Critical Backhaul

Until recently, many of the services provided over mobile networks have been infotainment-oriented. However, new 5G service types, such as autono-

NEXT GENERATION POWER AMPLIFIERS

40-75% size reduction



Rack Mount System Features

- ▷ Frequency coverage up to 6 GHz
- ▷ Selectable Output Power Control
- ▷ Selectable Operating Modes
- ▷ Selectable Input/Output Detectors
- ▷ Upgradable to Future Modulation Standards
- ▷ LXI Optional
- ▷ Built in Web Server

Modules available from stock

SKU 1094	20 - 520 MHz	100 W	6.4x3.4x1.1"
SKU 1166	20 - 1000 MHz	200 W	7.2x7.6x1.2"
SKU 1119	500 - 2500 MHz	50 W	7.4x3.6x1.1"
SKU 1189	500 - 2500 MHz	100 W	7.4x3.6x1.1"
SKU 1164	800 - 3000 MHz	50 W	6.4x3.4x1.1"
SKU 1131	2500 - 6000 MHz	35 W	6.9x3.6x1.1"
SKU 1191	2500 - 6000 MHz	100 W	8.0x6.5x1.0"



EMPOWER

RF SYSTEMS, INC.

1(310)412-8100

www.EmpowerRF.com



AHEAD OF WHAT'S POSSIBLE™

VISIT US AT THE EuMW 2016, STAND 111

OVERCOME YOUR
TOUGHEST RF CHALLENGES
AND ACCELERATE
SPEED-TO-MARKET.

Market-leading Transceiver technologies, development kits, tools and tutorials, chip evaluation testing, deep technical and market insight: ADI's RadioVerse design environment gives you everything you need to solve the toughest RF challenges, reduce development time and bring bold ideas to life.

RadioVerse: *THE* RF DESIGN ENVIRONMENT



Radio\erse™



#ADlahead

TAKE A BOLD, NEW APPROACH TO RF DESIGN
analog.com/RADIOVERSE

mous driving, tactile Internet and many M2M applications, must be served by mission-critical networks. The risks of failure are too great.

"Five nines" availability as well as complete coverage, ultra-low latency and tight security will be standard requirements for public mobile 5G networks and wireless backhaul infrastructure—just as these are required in public safety and utility networks today.

Virtual, Cloud Based Services and Network Architecture Will Change

When 5G arrives, wireless backhaul will work to increase its position as the most flexible and cost-effective backhaul technology for mobile networks, but that status will not be achieved without serious technical advancement.

The changeover to 5G will be a good opportunity for operators to retool their network and service architecture, in or-

der to enjoy the benefits of new cloud architecture. Specifically, there will be major savings in capital expenditure and operating expenses in addition to a very quick time to market for new services and revenue streams.

Using cloud technology, it will also be much easier for network providers to address new challenges. This will be especially important as a larger number of people become more reliant on IoT devices, like connected home security systems, smart appliances, energy meters, game consoles and other applications that are enriching the lives of consumers in markets around the world.

TECHNICAL IMPLICATIONS

So, what are the technical implications of these five trends for radio frequency and microwave components?

One of the implications is that backhaul systems will have to move to higher frequencies in order to increase capacity and avoid congestion, as the current backhaul frequencies populate access services as well as backhaul. Current common wireless backhaul frequency bands include microwave frequencies, typically 6 to 42 GHz (for short haul communications) as well as millimeter waves—mostly E-Band (70 and 80 GHz).

This transition to higher frequency bands such as W-Band (100 GHz) and D-Band (140 GHz) will require intensive efforts in radio frequency integrated circuit (RFIC) design in addition to the development of new modems. New research regarding wave propagation patterns at these frequencies, as well as interference, will also be essential.

Additionally, the move to higher frequencies will necessitate full system integration, where companies will be able to leverage their ability to make in house chip-sets and bring their products to market much faster.

CONCLUSION

While 5G can offer game-changing benefits to connected users, the ultimate success of 5G hinges on wireless operators and their technology partners, who together can overcome 5G's many challenges and build mobile networks for the future. Mobile operators must understand and plan for higher capacity requirements, denser cell site grids, street-level deployments, network virtualization and mission critical applications. Driving wireless transmission to a new era is a must, in order to overcome these 5G challenges. ■

**GET THE EDGE...
WITH GT MICROWAVE**
QUALITY • DESIGN • PERFORMANCE

PHASE SHIFTERS & VECTOR MODULATORS
2-18 GHz Bandwidth
Switching Speed 500 nSec
Digital or Analog Models

SWITCHES
SP1T to SP128T
DC - 26.5 GHz
Reflective
Absorptive

ATTENUATORS
Digitally, Voltage & Current Controlled
Phase Invariant
Digital Switched Pad

MULTI-FUNCTION ASSEMBLIES
Integrate passive, active and control devices
Ultra-Broadband

GT Microwave... The Leading Edge in Performance

G.T. Microwave Inc.
2 Emery Avenue
Randolph, NJ 07869 USA
973-361-5700 Fax: 973-361-5722
www.gtmicrowave.com
e-mail: sales@gtmicrowave.com



New **0.5-8GHz** **Ultra-Wideband Low Noise Amplifiers...Matched!**

Low noise, high dynamic range, high output power, and flat gain from 0.5 to 8GHz, **all in a single model!** And it's very easy to use: all you need is a simple fixed inductor at the input and output to match impedance over the entire frequency band!ⁱ It's ideal for sensitive, high-dynamic-range receivers, instrumentation, defense systems, LTE, WiFi, S-Band and C-Band radar, SatCom and more! It operates on a single 5V supply and comes in a tiny 3x3mm MCLP package for excellent manufacturability. It's available off the shelf, so go to minicircuits.com and place your order today for delivery as soon as tomorrow!

ⁱ See datasheet for suggested application circuit.

ⁱⁱ Flatness specified over 0.5 to 7GHz.

Only **\$6⁹⁵**
(qty. 1000)

- **Matched over full frequency range!**
- Low Noise Figure, 1.3 dB
- High Gain, 21 dB
- Excellent Gain Flatness, ± 0.7 dBⁱⁱ
- High IP3, +35 dBm
- High Pout, +23.2 dBm

 **Tiny Size, 3x3 mm**



RF Amplifiers and Sub-Assemblies for Every Application

Delivery from Stock to 2 Weeks ARO from the catalog or built to your specifications!

- Competitive Pricing & Fast Delivery
- Military Reliability & Qualification
- Various Options: Temperature Compensation, Input Limiter Protection, Detectors/TTL & More
- Unconditionally Stable (100% tested)

ISO 9001:2000
and AS9100B
CERTIFIED

OCTAVE BAND LOW NOISE AMPLIFIERS

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

NARROW BAND LOW NOISE AND MEDIUM POWER AMPLIFIERS

CA01-2111	0.4-0.5	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA01-2113	0.8-1.0	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3117	1.2-1.6	25	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3111	2.2-2.4	30	0.6 MAX, 0.45 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3116	2.7-2.9	29	0.7 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA34-2110	3.7-4.2	28	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA56-3110	5.4-5.9	40	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA78-4110	7.25-7.75	32	1.2 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA910-3110	9.0-10.6	25	1.4 MAX, 1.2 TYP	+10 MIN	+20 dBm	2.0:1
CA1315-3110	13.75-15.4	25	1.6 MAX, 1.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3114	1.35-1.85	30	4.0 MAX, 3.0 TYP	+33 MIN	+41 dBm	2.0:1
CA34-6116	3.1-3.5	40	4.5 MAX, 3.5 TYP	+35 MIN	+43 dBm	2.0:1
CA56-5114	5.9-6.4	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6115	8.0-12.0	30	4.5 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6116	8.0-12.0	30	5.0 MAX, 4.0 TYP	+33 MIN	+41 dBm	2.0:1
CA1213-7110	12.2-13.25	28	6.0 MAX, 5.5 TYP	+33 MIN	+42 dBm	2.0:1
CA1415-7110	14.0-15.0	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA1722-4110	17.0-22.0	25	3.5 MAX, 2.8 TYP	+21 MIN	+31 dBm	2.0:1

ULTRA-BROADBAND & MULTI-OCTAVE BAND AMPLIFIERS

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

LIMITING AMPLIFIERS

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

AMPLIFIERS WITH INTEGRATED GAIN ATTENUATION

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

LOW FREQUENCY AMPLIFIERS

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

CIAO Wireless can easily modify any of its standard models to meet your "exact" requirements at the Catalog Pricing.

Visit our web site at www.ciaowireless.com for our complete product offering.

Ciao Wireless, Inc. 4000 Via Pescador, Camarillo, CA 93012

Tel (805) 389-3224 Fax (805) 389-3629 sales@ciaowireless.com





The F-35 is so Stealthy, it Produced Training Challenges, Pilot Says



The F-35 Lightning II is so stealthy, pilots are facing an unusual challenge. They're having difficulty participating in some types of training exercises, a squadron commander told reporters.

During a recent exercise at Mountain Home Air Force Base, Idaho, F-35 squadrons wanted to practice evading surface-to-air threats. There was just one problem: No one on the ground could track the plane.

"If they never saw us, they couldn't target us," said Lt. Col. George Watkins, the commander of the 34th Fighter Squadron at Hill Air Force Base, Utah.

The F-35s resorted to flipping on their transponders, used for FAA identification, so that simulated anti-air weapons could track the planes, Watkins said.

"We basically told them where we were at and said, 'Hey, try to shoot at us,'" he said, adding that without the transponders on, "most likely we would not have suffered a single loss from any SAM threats while we were training at Mountain Home."

"When we go to train, it's really an unfair fight for the guys who are simulating the adversaries," Watkins continued. "We've been amazed by what we can do when we go up against fourth-gen adversaries in our training environment, in the air and on the ground."

Watkins said he can take four F-35s and "be everywhere and nowhere at the same time because we can cover so much ground with our sensors, so much ground and so much airspace. And the F-15s or F-16s, or whoever is simulating an adversary or red air threat, they have no idea where we're at and they can't see us and they can't target us."

"That's a pretty awesome feeling when you're going out to train for combat," Watkins concluded, "to know that your pilots are in an unfair fight."

The pilots and crews at Hill have been putting the new fifth-generation fighter through its paces, in preparation for top Air Force brass declaring the plane operationally ready—a move expected within days.



Photo: SSgt. Staci Miller/Air Force

The Air Force's variant of the F-35 will make its first appearance at the famous Red Flag training exercise at Nellis Air Force Base, Nev., in January 2017, Watkins told Air Force Times. Marine Corps F-35Bs have already reached initial operating capability and participated in the exercise this year.

A New Generation of Electron Devices Makes Waves, Trillions Each Second

Normal radios operate in kilohertz (kHz) and megahertz (MHz) frequencies, bandwidths corresponding to electromagnetic oscillations in the thousands and millions of cycles per second ranges, respectively. Upping the ante, cell phones and radar systems operate in the billions of cycles per second range—that is, gigahertz (GHz) frequencies. But no one has managed to push radiofrequency technology into the trillions of cycles per second, or Terahertz (THz) range. With the Terahertz Electronics Program, however, DARPA has begun to make it possible. And as graphically depicted in the attached DARPA "fight" poster—fashioned after a promotion for the legendary bout in 1975 between Muhammed Ali and Joe Frazier in Manila, the Philippines—two promising and powerful approaches are dueling it out for possible dominance in this high-frequency electromagnetic frontier.

In one corner is the solid-state power amplifier (SSPA), which in 2014 was certified by Guinness World Records as the world's fastest solid-state chip, able to operate at THz speeds. This device, made of the semiconductor indium phosphide (InP), also can boost the power of a wide swath of incoming signals some thirtyfold. In the other corner is a micromachined traveling wave tube amplifier (TWTA), a miniaturized device that relies on a tiny vacuum chamber in which electrons and radio signals interact. This wee bruiser can boost the power of a narrower range of THz frequencies by a factor of about 200 and was a celebrated darling of the 2016 IEEE International Vacuum Electronics Conference.

Of course, in reality this need not be a fight. "Really, the two contenders, both of them made by Northrop Grumman, are working as a tag team to collectively smack down the technical barriers that until now have made many THz applications impossible to realize," said Dev Palmer, the DARPA program manager who has overseen the two-pronged research effort. "Together, the world-record SSPA

Two of the highest-frequency radio components ever made bode well for ushering radio technology into the super-high-speed/high-capacity terahertz bandwidth.

and highly-acclaimed TWTA open the way to a THz future featuring devices that can generate, detect, process and radiate extremely high-frequency signals, and push what is possible in areas ranging from high-resolution security imaging, collision-avoidance radar, high data rate communications, and remote detection systems for dangerous chemicals and explosives.”

Army Wants to Upgrade or Replace Patriot Missile Radar



The Army Contracting Command at Picatinny Arsenal, N.J. recently issued a request for information for the Lower Tier Air and Missile Defense Sensor (LTAMDS) project to consider upgrades or replacements to the Patriot missile radar.

The Army wants to upgrade or replace the current Patriot radar to improve its effectiveness against emerging threats and reduce maintenance costs.

The Patriot is a surface-to-air missile (SAM) that uses the Raytheon AN/MPQ-53 phased-array radar for high-to medium-altitude air defense against enemy aircraft and ballistic missiles. Army leaders want to keep Patriot in the field until at least 2040.

Army experts want new or upgraded Patriot radar systems that cost less than \$50 million per installation. Solutions must be at least as mature as component and breadboard validation in relevant environments (Technology Readiness Level 5) by late 2017.

A team from the Army Aviation and Missile Research Development and Engineering Center (AMRDEC), Georgia Tech Research Institute (GTRI), University of Alabama in Huntsville (UAH), Wyle-CAS, Dynetics and Torch Technologies will evaluate industry responses in efforts to shape requirements for future Patriot radar enhancements.

Army experts are also interested in technologies critical to a Patriot radar upgrade or replacement, including high-power amplifiers, low-noise amplifiers, limiters, low-noise oscillators, AC-DC and DC-DC power supplies, antennas, cooling systems, and prototypes.

The Army wants descriptions of proposed solutions; expected per-unit costs of radar upgrades or replacements for 80 Patriot radars over 10 years.

The Difference between ordinary and extraordinary



Maximum Power for Automotive Radar Pulse Testing

This dual band amplifier is part of the MILMEGA family of radar tuned amplifiers all using the same RF power modules.

- Continuous output power at 800 W and 400 W
- Frequency ranging from 1 to 4 GHz
- Maximum power available in 1.2 to 1.4 GHz and 2.7 to 3.1 GHz
- Harmonics below -20 dBc even at saturation
- Optimized for radar pulse testing to 600 V/m
- Output suitable for all EMC loads
- 5 year warranty!
- Upgrade from AS0104-400/200ST available, details on request

Other models in the range include AS0104R-280/150, AS0104R-280/300, AS0104R-500/300 and AS0102R-1500



**We promise only what we can deliver...
then deliver more than we promise**

AMETEK Compliance Test Solutions 52 Mayfield Ave. Edison, NJ 08837 USA
Phone +1 732 417 0501 Fax +1 732 417 0511 usasales.cts@ametek.com www.milmega.co.uk



Reactel, Incorporated

Reacting First to All Your Filter Needs.

A SHEER DESCENT INTO THE NOISE

High Performance Notch Filters

- High Q
- Bandwidths as low as 0.5%
- Frequency range up to 20 GHz
- Power levels up to 1000 W



Reactel manufactures a variety of notch filters suitable for most any application. Utilizing Discrete Component, Ceramic, Cavity, Waveguide or Microstrip technologies, we can create a unit which has extremely low pass band loss, contain up to 16 sections, and can have connectors or surface mount launch options. Contact us with your requirement and let us show you how sharp our notch filters can be.

- Submitting a request for immediate attention will never be easier.

- Full featured App contains expanded RFQ capability, catalog, data sheets and more.

- Available for iPad, iPod and Android devices via the App Store and Google Play.



8031 Cessna Avenue • Gaithersburg, Maryland 20879 • Phone: (301) 519-3660 • Fax: (301) 519-2447
For general inquiries, please email reactel@reactel.com • <http://twitter.com/reacteljim> • Go online to www.reactel.com to download your Reactel catalog today.

See us at EuMW Stand 160



@reacteljim

CALL FOR PAPERS



Electronic Design Innovation Conference

电子设计创新大会

April 25-27, 2017

**Shanghai Convention & Exhibition
Center of International Sourcing**

Do you work on RF, microwave, or high-speed digital designs and have design experience or knowledge to share? EDI CON China 2017 is now accepting abstracts. EDI CON provides practical information addressing today's RF, microwave, EMC/EMI, and high-speed digital design challenges using available materials, tools, products, and techniques. Submit your abstract today to be considered for one of EDI CON's peer-reviewed technical sessions.

Conference Topics

- RF and Microwave Design
- High-Speed Digital Design
- Measurement & Modeling
- Systems Engineering
- 5G Technologies
- EMC/EMI
- IoT Design
- Radar Communications

www.EDICONCHINA.com

Host Sponsor:



Diamond Sponsor:



Corporate Sponsor:



Organized by:



See us at EuMW Stand 240

**Submit your paper online at
www.xcdsystem.com/edicon
by October 11, 2016**



5GIC and Digital Greenwich Partner to Pioneer Smart City Technology

The University of Surrey's 5G Innovation Centre (5GIC) and Digital Greenwich, part of the Royal Borough of Greenwich, London have announced a ground-breaking partnership that will deliver the technology that will underpin future smart cities. The partnership will leverage the facilities and expertise of both parties to deliver 'Smart' resource-efficient, low-carbon, healthy and livable neighbourhoods within a city. The 5G standardised approach will provide the opportunity to scale solutions at wider city and national level.

The 5GIC is now the largest European research centre dedicated to the development of the next generation of mobile and wireless communications. Bringing together leading academic expertise and key industry partners in a shared vision, the 5GIC will help to define and develop the 5G infrastructure that will underpin the way we communicate, work and live our everyday lives in the future.

The Royal Borough of Greenwich and Digital Greenwich are working on a world-leading Smart City strategy setting out how the Council proposes to implement 'smarter' approaches to coping with future challenges related to transport, health, energy and the built environment. It will create new opportunities for businesses and local communities, securing business regeneration and growth.

Professor Rahim Tafazolli, director of 5GIC and Institute of Communication Systems, commented, "Fundamental to next generation Smart City applications is the creation of a robust communications system. Working with Digital Greenwich will enable the 5GIC to develop solutions targeted at multiple use cases in a city context. The partnership will also provide the foundation to drive standardised solutions for all of the UK to benefit from the technology."

Minister of State for Digital and Culture, Matt Hancock, said, "We want to make Britain the most digitally advanced of all nations. We are already a world leader in the development of 5G technology, so I'm delighted by the new partnership between the University of Surrey and Digital Greenwich. Collaborations like this will help make our cities better places in which to live, work and play."

SAVELEC Project to Remotely Disable Vehicles

In its endeavour to keep the public safe, one of the key challenges facing European security services is the ability to control and stop, at distance, non-cooperative vehicles posing a threat. However, this ability presents more

than a technical challenge. To comply with EU legislation, as well as adhere to ethical concerns, the technology would also have to be safe for the user, the driver (and passengers), as well as members of the public and the material infrastructure of the surrounding environment.

To address this issue the 'safe control of non cooperative vehicles through electromagnetic means' (SAVELEC) project developed a prototype device, after testing signals (magnetic pulses and microwave), which interfered with key car components, forcing it to slow down and stop. With the contribution of security forces as the ultimate end users, the researchers were able to simulate the technology's use in realistic scenarios.

Developing the technology itself first required a review and cost analysis of what was currently available on the market, as well as establishing the car components best targeted for remote interference. In lab bench testing SAVELEC evaluated signal frequency, waveform and duration—principally of electromagnetic pulses (EMP) and high power microwaves (HPM)—to determine which could best disrupt the functioning of a vehicle's electronic components.

Assessing the project's success, its coordinator, Dr. Martínez Vázquez asserted that, "An EMP/HPM car-stopping device prototype at a breadboard level was designed, fabricated and tested. Its performance was successfully demonstrated in an open field controlled track, in the presence of SAVELEC affiliated end-users."



ESSC Issues Recommendations for Horizon 2020 Work Programme on Space

The European Science Foundation's (ESF) European Space Sciences Committee (ESSC) has issued recommendations and inputs to the consultation process set up by the European Commission on the 2018-2020 Work Programme for Horizon 2020-SPACE. The committee was also asked by the European Commission to make targeted inputs to the ongoing public consultation on a Space Strategy for Europe.

Areas covered by the ESSC recommendations include the exploitation of space data, the use of 'CubeSat' miniaturised satellites and the integration of ground-based and space-based research. The committee also made recommendations on health research in space, gravitational waves research, solar system exploration, heliophysics and space weather. Space surveillance and tracking and the Copernicus and Sentinel programmes are also covered by the submissions which can be seen at www.esf.org/space.

On the European Space Strategy, the ESSC highlighted the relevance of space sciences for European citizens in the areas of security, environment, health and engineering. The

"...make Britain the most digitally advanced of all nations."

...the use of 'CubeSat' miniaturised satellites...

committee also underlined the strategic role that space sciences can play in European technology development, innovation and industrial leadership.

Professor Athena Coustenis, ESSC Chair, said, "We're pleased to make our recommendations to the European Commission as it shapes the next phase of Horizon 2020 SPACE. Additionally we have provided the inputs of European space scientists around the priorities and opportunities that we believe are important for the European Space Strategy to address."

Vodafone and Huawei Trial 4.5G Technologies

Vodafone UK and Huawei are conducting technical trials of a new mobile technology, 4.5G (TDD+) with LTE TDD, to significantly increase the capacity and efficiency of its 4G network in urban areas, as well as lay the foundations for the introduction of 5G by 2020.

New 4×4 MIMO techniques eight-way transmit and receive (8T8R), together with multi-user beamforming are being tested in Manchester, UK. By combining MIMO with beam forming, Vodafone is better able to focus cus-

tomers' mobile signals in specific directions to ensure the best user experience and minimize interference during peak times in highly populated areas.

As a result, more signal reaches more subscribers particularly at the edge of the base station coverage, in order to provide higher average speeds across the network.

Vodafone UK's chief technology officer, Jorge Fernandes, said, "We are working hard with our radio network equipment partners to ensure our network is future-proofed for the expected arrival of 5G in four to five years' time, whilst continually improving our 4G performance for customers throughout the UK."

Huawei LTE TDD President, Veni Shone, said, "This joint innovation with Vodafone has proved that 4.5G (TDD+) is a good solution to release the potential of TDD spectrum and will help Vodafone build the most advanced LTE network available. We are very proud of this collaboration, and are dedicated to providing optimal solutions to customers. The newly deployed LTE TDD network immediately serves the LTE TDD capable commercial smartphones and successfully carries significant live network traffic. This trial proves that LTE TDD with the most recent technologies can be naturally converged with LTE FDD and improve the overall experience enjoyed by all users on the network."

"...release the potential of TDD spectrum..."



Industry First Probe System Designed for THz Measurements

Meeting 1 μm accuracy requirements

Meet the THz experts at EuMW 2016
Booth 109





Ultra Small 2x2mm

2W ATTENUATORS DC-20GHz **\$1⁹⁹** ea. (qty. 1000)


Save PC board space with our new tiny 2W fixed value absorptive attenuators, available in molded plastic or high-rel hermetic nitrogen-filled ceramic packages. They are perfect building blocks, reducing effects of mismatches, harmonics, and intermodulation, improving isolation, and meeting other circuit level requirements. These units will deliver the precise attenuation you need, and are stocked in 1-dB steps from 0 to 10 dB, and 12, 15, 20 and 30 dB.

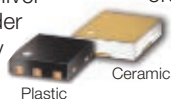
The ceramic hermetic **RCAT** family is built to deliver reliable, repeatable performance from DC-20GHz under the harshest conditions. With prices starting at only

\$4.95 ea. (qty. 20), these units are qualified to meet MIL requirements including vibration, PIND, thermal shock, gross and fine leak and more, at up to 125°C!

The molded plastic **YAT** family uses an industry proven, high thermal conductivity case and has excellent electrical performance over the frequency range of DC to 18 GHz, for prices starting at \$2.99 ea. (qty. 20).

For more details, just go to minicircuits.com – place your order today, and you can have these products in your hands as soon as tomorrow!

 RoHS compliant



FREE Simulation Models!



<http://www.modelithics.com/mvp/Mini-Circuits/>





Programmable ATTENUATORS

0 to 120 dB 0.25 dB Step* 1 to 8000 MHz† from **\$395**

FEATURES

- 0–30, 60, 63, 90, 110, and 120 dB
- USB, Ethernet & RS232 control options
- User-friendly GUI and DLLs included
- Sweeping and hopping capability
- Available from stock!

Perfect for...

- Fading simulators
- Handover system evaluation
- Automated test equipment
- And MORE!

Visit minicircuits.com for detailed model specs, application notes, and more!
Place your order today and have them on your test bench as soon as tomorrow!

* Model RCDAT-3000-63W2+ specified step size 1 dB

† Model RCDAT-3000-63W2+ specified from 50–3000 MHz; 120 dB models specified from 1–4000 MHz

†† No drivers required. DLL objects for 32/64 bit Windows® environments using ActiveX® and .NET® frameworks.





Mobile and Computing Markets Catapult WiGig into the Mainstream



The 802.11ad (WiGig) chipset market is set to reach a critical juncture in 2017 when the technology hits higher adoption levels in the mobile and computing space. ABI Research forecasts 180 million WiGig chipsets will ship to the smartphone market in 2017, with smartphone chipsets accounting for almost half of the 1.5 billion total market shipments in 2021.

“Tri-band products that incorporate 2.4 GHz, 5 GHz and 60 GHz technologies will take Wi-Fi to the next level, providing a better balance between reliability and performance than ever before,” says Andrew Zignani, industry analyst at ABI Research. “But Wi-Fi will still have one major market hurdle: it will not have an existing device ecosystem to build upon once it moves to the 60 GHz band.”

As there are currently few products on the market that utilize 802.11ad, many OEMs have yet to find a compelling enough use case to justify the additional costs and complexities in adopting the standard. But the industry is making waves, with recent collaborations from Intel and Qualcomm fueling growth and a number of others, including Broadcom, MediaTek, Nitero, Peraso and SiBeam, already providing or planning to provide WiGig chipsets to the market.

WiGig chipsets
significantly enhance
Wi-Fi throughput,
improve efficiency and
expand product use
case potential.

The first WiGig-enabled smartphones are likely to arrive later this year, albeit in limited quantities, with 802.11ad support provided alongside Qualcomm's Snapdragon 820 platform. This marks the start of a larger push from Qualcomm and other IC suppliers to

drive the technology forward. The new technology will allow OEMs to further differentiate their flagship products from the middle and lower tier devices, as well as maximize streaming performance from access points and push content between devices.

The technology will also find significant opportunities in the PC space as the push to wireless charging and cable free devices gains momentum. 802.11ad is additionally gaining traction in routers, with vendors such as TP-link relying on it to drive improvements in internet access and streaming capabilities.

“WiGig has a bright future across the mobile, PC, networking and accessory space, and beyond, with 2017 marking a critical juncture in its development and success,” concludes Zignani. “We expect to see many IC suppliers in this space taking steps to promote and scale the technology this year to prepare.”

Bluetooth 5 Will Lead to Widespread Deployments on IoT Landscape



With the new technical enhancements enabled by Bluetooth 5, in addition to the support of mesh networking, and Internet protocol, ABI Research forecasts Bluetooth-enabled device shipments will increase by an average of half a billion per year through 2021, reaching more than five billion. Bluetooth will extend beyond cable replacements and smartphones to branch out into the wider IoT landscape and result in the development of larger scale networks that no longer rely on the smartphone as a hub.

“Bluetooth is evolving from a smartphone and personal area network solution to a scalable, low-power wireless networking technology,” says Andrew Zignani, industry analyst at ABI Research. “This development will unlock growth in beacons, home automation, building automation, lighting, and other smart city applications over the next decade and beyond.”

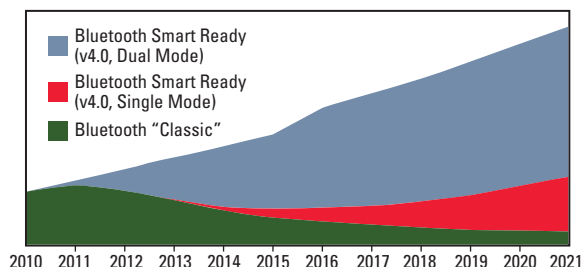
Bluetooth Smart or Smart Ready devices, combined with market growth in the connected home for speakers, remote controls, smart televisions, and game consoles, has, and will continue to, help drive the market to much greater scale in the coming years.

By 2021, smartphones will still account for 40 percent of Bluetooth product shipments, but this will represent a 12 percent drop in volume share from 2015. This significant portion of the market will continue to drive the mobile accessory market, the second largest portion of devices at this time. And as mobile and computing devices rely less on physical ports, notably headphone jacks, Bluetooth accessories will further climb in volume share, expected to capture 13% of total Bluetooth product shipments by 2021.

But it is beacons that represent one of the largest opportunities for Bluetooth-enabled devices. By 2021, it will be the third largest market for Bluetooth devices, and the fastest growing of all segments. The smart home market will also see significant growth, though it will still take some time to mature. Its major advancement will stem from home automation devices, smart lighting and smart appliances.

Bluetooth-Enabled Device Market Split by Version

World Markets, Forecast: 2000 to 2021



Source: ABI Research

CommercialMarket

“As we move forward, Bluetooth will gain market share at the expense of low data rate technologies, like Thread, ZigBee and Z-Wave, and power hungry technologies like Wi-Fi,” concludes Zignani.

Sensors and Connected Peripherals Outpace Smartphones and PCs

ABI Research forecasts the installed base of active wireless connected devices will top 47 billion by 2021, more than double the current level. Smartphones, PCs and other “hub” devices historically commanded the leading share of total active connections, with accessories (including smartphone and PC peripherals, residential smart home lighting and wearable devices) and sensor nodes (like Bluetooth beacons, proximity sensors and other edge devices) rounding out the remainder. But moving forward, the latter will benefit most from continued improvements to underlying IoT infrastructure.

“A 24.1 percent CAGR through 2021 positions 2016 to be the first year that accessories and sensor nodes are in the majority, rising to more than 65 percent of total active connections by the end of the forecast period,” says Ryan Martin, senior analyst at ABI Research. “Now the critical question for companies is how to create a strategic framework that optimizes IoT solution ROI in concert with connected end-

point growth. Growth will be driven by a massive uptick in contextually-aware IoT endpoints across retail, advertising and supply chain, smart home, and industrial IoT markets.”

The recent convergence of low-power wide area, short-range wireless, and cellular networks represents a fertile battleground for the future of IoT enablement. While today about 55 percent of IoT connections can be attributed to the digital-first domain (the Internet of Digital), the emergence of low-power wide-area and short-range wireless network technologies purpose-built for the IoT puts the physical-first domain (IoT) on track to account for 65 percent of active wireless connections in the next five years.

The incipient IoT playing field includes everything from newly-minted specifications for Bluetooth 5 to the designation of Wi-Fi HaLow (802.11ah), LTE Cat M (followed by NB-IoT), and LPWAN technologies, such as those from Ingenu, LoRa, SIGFOX and Thread. Advances in mesh networking, location-aware ICs, and better utilization of unlicensed spectrum are among the key ingredients driving wireless sensor network deployments, and, in turn, the next generation of connected devices.

**Sensors and
connected peripherals
will top 65 percent
of total active
connections by 2021.**

- VNA Test Assemblies
- Low Loss Cable Assemblies
- NMD Test Port Adapters
- Calibration Kits



Up to 67GHz

Welcome to EuMW Show 2016
Stand Number 121



ARANCE ELECTRONICS
www.arance-rf.com



Tel: +86-25-58817997 Fax: +86-25-58072397
E-mail: sales@arance-rf.com; tech@arance-rf.com



Technologies

ables,



V
tors
ces



800.832.6869 | [Microwave@Teledyne.com](mailto: Microwave@Teledyne.com) | TeledyneMicrowave.com

See us at EuMW Stand 19



Around the Circuit

Barbara Walsh, Multimedia Staff Editor

MERGERS & ACQUISITIONS

Dassault Systèmes, the 3DEXPERIENCE Co., world leader in 3D design software, 3D digital mock up and product lifecycle management (PLM) solutions, announced that it has entered into a definitive agreement to acquire **CST - Computer Simulation Technology AG**, the technology leader in electromagnetic (EM) and electronics simulation, for approximately €220 million. With the acquisition of CST, based near Frankfurt, Germany, Dassault Systèmes will complement its industry solution experiences for realistic multiphysics simulation on the 3DEXPERIENCE platform with full spectrum EM simulation.

Analog Devices Inc. and **Linear Technology Corp.** announced that they have entered into a definitive agreement under which Analog Devices will acquire Linear Technology in a cash and stock transaction that values the combined enterprise at approximately \$30 billion. Upon completion of the acquisition, Analog Devices will be the premier global analog technology company with approximately \$5 billion in anticipated annual revenues. Under the terms of the agreement, Linear Technology shareholders will receive \$46.00 per share in cash and 0.2321 of a share of Analog Devices common stock for each share of Linear Technology common stock they hold at the closing of the transaction.

Infinite RF Holdings Inc., an urgent needs supplier of engineering-grade RF, microwave and millimeter wave components and cable assemblies through their Pasternack and Fairview Microwave branded lines, announced the acquisition of **L-com Inc.**, a manufacturer of wired and wireless connectivity solutions with significant custom manufacturing capabilities. Headquartered in North Andover, Mass. with global manufacturing, sales and distribution operations, L-com serves the wireless engineering community with short lead time design and product solutions. Its comprehensive offering includes wireless components, cable assemblies, antennas, specialized military/aeronautics connectivity solutions, electrical connectors and wireless sensors for IoT applications through the branded product lines L-com, HyperLink®, MilesTek®, Aiconics and Point Six Wireless.

Infineon Technologies AG and **Cree Inc.** announced that Infineon has entered into a definitive agreement to acquire the **Wolfspeed Power and RF division of Cree**. The deal also includes the related SiC wafer substrate business for power and RF power. The purchase price for this planned all-cash transaction is \$850 million (approximately €740 million). This acquisition will enable Infineon to provide the broadest offering in compound semiconductors and will further strengthen Infineon as a leading supplier

of power and RF power solutions in high-growth markets such as electro-mobility, renewables and next-generation cellular infrastructure relevant for IoT.

Gowanda Electronics, a business unit of **Gowanda Components Group (GCG)**, announced that its capabilities for the design and manufacture of inductors and other passive components are expanding in connection with its parent company's acquisition of **Butler Winding** in Butler, Pa. Terms of the deal were not disclosed but it is anticipated that the company will relocate from Butler, Pa. to GCG's facilities in Arcade, N.Y. in the near future. This is the fourth acquisition for GCG within the last five years.

Ams AG has signed an agreement to divest NFC and RFID reader IP, technologies and product lines to **STMicroelectronics** for an up-front cash consideration of \$79.3 million (approx. €71.5 million) plus a substantial deferred earn-out consideration contingent on future results of up to \$37 million. With this transaction, ST takes another step towards becoming a leading provider of sensor solutions worldwide. They will retain their sensor-related NFC/RFID tags business and relevant design capabilities to create wireless IoT sensor solutions and support upcoming sensor nodes. The transaction is part of ongoing efforts to actively manage their portfolio of technologies with a clear focus on implementing sensor solutions strategy.

COLLABORATIONS

HawkEye 360, a subsidiary of **Allied Minds** and **Lockheed Martin**, are collaborating to introduce the HawkEye 360's RF detection and mapping technology into new markets. HawkEye 360 plans to deploy a constellation of small satellites in the low-Earth orbit at less than 600 km (383 miles) from the Earth's surface, to identify, locate and analyze RF signals globally. Lockheed Martin has chosen Allied Minds to build one of the world's first privately funded global RF signal monitoring systems. Combining Lockheed Martin's expertise in satellite systems with HawkEye 360's approach to space-based radio frequency detection will enable them to develop an innovative solution to some of the big challenges being faced by their shared customer base.

Telit has announced a multi-faceted collaboration with **Tech Mahindra** on developing complete solutions for the Internet of Things (IoT). The relationship is centered on combining and integrating their leading portfolio of IoT products and services with Tech Mahindra's unmatched system integration expertise and strengths in developing end-to-end enterprise solutions. Both companies will also jointly pursue new business opportunities across many markets and industries, such as IoT horizontal and Industrial IoT around the world. Additionally, Telit has reached an

For More
Information

For up-to-date news briefs, visit mwjournal.com

STM (SPUR TAMER) WIDEBAND MIXER SERIES



Features

- | Low Spurs
- | High Isolation
- | Good Linearity
- | Small Size

Up to
**18.0
GHz**



Talk To Us About Your Custom Requirements.



Phone: (973) 881-8800 | Fax: (973) 881-8361
E-mail: sales@synergymwave.com
Web: WWW.SYNERGYMWAVE.COM
Mail: 201 McLean Boulevard, Paterson, NJ 07504

Around the Circuit

agreement to outsource related engineering development and testing activities to Tech Mahindra.

NEW STARTS

Renesas Electronics has announced that they will withdraw from the microwave devices business to strengthen and focus more on optical devices (photo-couplers, laser diodes, photo diodes). Renesas has been selling low noise amplifiers, RF switches, mixers and transistors for the wireless segment based on GaAs and SiGe for some time now. The business was profitable, however with an increase in the number of manufacturers, specially in Taiwan developing these products, they expect the profitability to decline. At this point they have no development plans for the future of microwave devices.

ACHIEVEMENTS

LPKF, the laser specialist headquartered in Garbsen, Germany, unveiled a new high-end laser system for drilling and cutting flexible circuit boards. The first system has been sold to Sagami PCI, a client from Japan. The MicroLine 5000 uses a UV laser and tops off the LPKF MicroLine series. It is extremely rapid and precise. This makes it possible to process large numbers of flexible circuit boards and simultaneously reduce the per-unit costs.

Marvin Test Solutions Inc., a provider of globally-deployed innovative test solutions for military, aerospace, and manufacturing organizations, is marking the silver anniversary of ATEasy, its evolutionary test software suite, first released in 1991 and now in its ninth generation. Since its founding almost 30 years ago, Marvin Test Solutions' singular focus has been automated functional test, with the goal to make test easy for its customers by creating innovative solutions with unrivaled long-term support. ATEasy provides test engineers with all of the necessary tools to efficiently develop, debug, document, maintain and execute test applications.

CTT Inc. a technology leader in the design and production of solid-state microwave amplifiers for use in electronic defense, industrial and commercial communications, announced the receipt of the 4-Star Supplier Excellence Award from Raytheon's Integrated Defense Systems (IDS). The 4-Star Supplier Excellence award was presented to CTT at Raytheon's Operational Excellence Supplier Conference on June 7, 2016, in Danvers, Mass. The award recognizes suppliers that consistently deliver outstanding service and partnership in exceeding customer requirements. This year there were more than 3,000 candidates, and only 159 suppliers received an Operational Excellence Supplier Award, placing CTT in the top 5 percent of eligible nominees.

Integra Technologies Inc., a designer and manufacturer of high-power RF transistors, pallets and amplifiers, announced the completion of a 1 kW GaN high efficiency amplifier, IGNP0450M1000, for aerospace radar applications, funded by NASA/JPL through SBIR Phase I and II grant awards. An additional 200 W high efficiency GaN

amplifier for shorter-term programs has also been completed through an SBIR Phase IIX grant award.

CONTRACTS

BAE Systems has received a \$245 million contract from the **UK Ministry of Defence (MOD)** to provide the gun system, known as the Maritime Indirect Fires System (MIFS), for the Type 26 Global Combat Ship. This award follows the MOD's announcement of BAE Systems as the preferred bidder last year after a competitive process. Under the contract, the company will manufacture three MIFS Integrated Gunnery Systems (IGS) and one trainer system for the UK Royal Navy. The MIFS IGS includes the 5-inch, 62-caliber Mk 45 Mod 4 Naval Gun System, along with an automated ammunition handling system, gun fire control system and qualified ammunition.

L-3 Communications announced that its Electronic Systems group was awarded a seven-year contract to provide training solutions in support of the **U.S. Air Force's Warfighter Readiness & Training Program** following a recompetition process. L-3 initially won the Warfighter Program in 1997 and will continue its prime contractor role under an initial task order valued at \$23.5 million with a maximum ceiling value of \$200 million. The Warfighter Program provides the Air Force with a wide range of research into advanced technologies to improve training effectiveness. L-3's Link Simulation & Training division in Arlington, Texas, will serve as the prime contractor on the program.

Orbital ATK, a global leader in aerospace and defense technologies, announced that the company has received a \$69 million contract that exercises a second option from the **U.S. Government** to produce artillery precision guidance kits (PGK) for the U.S. military. PGK-fuzed projectiles allow battlefield commanders to more safely employ artillery with greater accuracy and less risk of collateral damage. Orbital ATK produced 4,779 PGK fuzes under the low-rate initial production contract and has transitioned to full-rate production to support the current program needs.

Inmarsat Government has been issued modification P00001 to lift the stop-work order issued due to a bid protest filed on the initial award. Inmarsat Government remains the awardee on the single award indefinite-delivery/indefinite-quantity contract issued against solicitation HC1013-14-R-0004 announced Sept. 8, 2015. This contract supports the **U.S. Navy's Commercial Broadband Satellite Program (CBSP) Satellite Services Contract (CSSC)**. Under the contract, Inmarsat Government will support the U.S. Navy's requirement to acquire worldwide commercial telecommunication services, to include satellite capacity for mobile and fixed satellite transceivers on maritime, airborne and ground platforms, as well as CT services, backhaul connectivity, monitoring and control and operations.

Norsat International, a provider of unique and customized communication solutions for remote and challenging applications, has announced that it has received an order for \$3.8 million from **Harris Corp.** for its compact and efficient ATOM series solid-state power amplifiers (SSPA). Norsat has been working closely with Harris since 2013, in order

Don't Let Your Temperatures Rise



Let ROGERS' Thermal Management Solutions *Keep You Cool*

COOLSPAN® TECA Film • 92ML™ StaCool™ Laminates • ML Series™ Laminates & Prepregs

Heat can be damaging, especially when it is not managed. That's why Rogers Corporation invested so much time and energy into creating an array of material-based thermal management solutions to keep heat rise to a minimum in printed circuits. From automotive circuits to LED modules to power supplies, ML Series laminates and prepregs effectively conduct heat away from the source, while COOLSPAN thermally & electrically conductive adhesive (TECA) materials enhance the thermal management of new and existing designs. And for that extra cooling edge, 92ML StaCool laminates feature a thermally conductive metal bottom plate to enhance the heat dissipation.

Product	Thickness	Thermal Conductivity (Z-Axis), W/mK	Thermal Impedance, C-cm ² /W	Tg, C	CTE (Z-Axis), ppm/C		Dk, 1MHz	Df, 1MHz	Breakdown Voltage, kVAC	Flammability
					<Tg	>Tg				
92ML	8mils	2.0	0.52	160	22	175	5.2	0.013	>50	HF V-0

Don't let your temperatures rise. Use Rogers' thermal management solutions.



Advanced Connectivity Solutions

www.rogerscorp.com/acs

USA - AZ, tel. +1 480-961-1382
EUROPE - BELGIUM, tel. +32 9 235 3611

MISSION CRITICAL HIGH POWER



MIL-SPEC Compliant Solutions

SWITCHES

- ◆ 10MHz to 18GHz
- ◆ 1 watt to >10kW
- ◆ SPST to T/R to SPnT
- ◆ Built in fast driver
- ◆ Speeds to 50ns

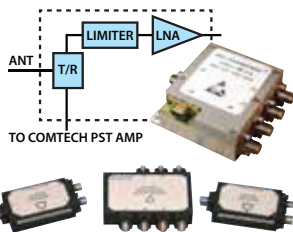


RF LIMITERS

- ◆ SMT, Coax or W/G
- ◆ Active and passive limiting
- ◆ High CW and peak power
- ◆ Low flat leakage
- ◆ Optional: BITE, indicator out

MULTI-FUNCTION MODULES

- ◆ LNA limiters
- ◆ Switch limiters
- ◆ Switch matrix
- ◆ T/R module (T/R-Limiter/LNA)



The Power of Positive Partnering



www.comtechpst.com/hill ISO 9001:2000

978.887.5754 • sales@hilleng.com

Around the Circuit

to develop and deliver custom SSPAs to meet the challenging RF performance requirements for linearity, gain flatness and phase matching that is required by the Harris system. This contract is for the second phase of the project that Norsat first announced in October 2013 and April 2014 after the successful implementation of the SSPAs.

Phoenix Nuclear Labs (PNL) announced that it has been awarded multiple contracts by the **U.S. Army** totaling \$3.6 million. Under these contracts, PNL will build an advanced neutron radiography system to detect defective munitions and demonstrate the ability to use their neutron generators to detect and identify concealed explosive threats. The company will deliver an upgraded, pilot production neutron radiography system that will be the first such system to be installed in a munitions production facility. The new system is expected to produce 10 times higher neutron yield, enabling faster performance and higher resolution.

PEOPLE



▲ Christopher C. Cambria

Mercury Systems Inc. announced that **Christopher C. Cambria** has joined the company as its senior vice president, general counsel, and secretary, reporting to Mercury's president and chief executive officer, Mark Aslett. Mr. Cambria will lead the overall direction and management of legal and regulatory matters at Mercury, including support for mergers and acquisitions and corporate finance transactions. Cambria brings more than 30 years' experience providing strategic oversight of legal and regulatory matters, managing major acquisition transactions and serving as a key advisor in rapidly growing business environments.

Skyworks Solutions Inc., an innovator of high performance analog semiconductors connecting people, places and things, announced that **Mitchell J. Haws** has joined Skyworks as vice president of investor relations. Haws will serve as the primary interface to Skyworks' existing buy-side and sell-side analysts and is chartered to expand the company's shareholder base. Most recently, Haws served as vice president of investor relations for NXP Semiconductors, which merged with Freescale Semiconductor in December 2015. Prior to NXP, he managed investor relations for Equifax Inc., Reynolds & Reynolds and Geneva Steel. Haws earned a bachelor's degree in communications from Brigham Young University and an MBA from Westminster College.



▲ Eleanor Lukens

AMETEK Inc. announced that the Board of Directors has elected **Eleanor Lukens** as vice president and general manager of the measurement and power systems division within AMETEK Aerospace & Defense. Lukens has nearly 30 years of experience with AMETEK businesses. She joined AMETEK in 1999 with the acquisition of Drexelbrook Engineering, where she held increasingly responsible positions, including director of engineering and director of op-



RF/Analog and High-reliability Solutions

| Phototransistor Hermetic Surface Mount Optocouplers: OLS249 and OLS449

For high reliability applications requiring optical isolation in radiated environments

| 100 MHz to 30 GHz Limiter Diodes for Receiver Protection: CLA46xx

For low-noise amplifier (LNA), receiver protection, commercial, aerospace and defense microwave applications

| Subminiature and Subcompact Filters for UHF to 7 GHz and Multi-user Operating Systems

Custom filters for military and homeland security, radio and satellite communications, vehicle mounted and airborne applications

| High Reliability DC to 6 GHz Hermetic GaAs IC SPST Non-reflective Switch: ISO13316

For high reliability aerospace, satellite and defense applications

| DC to 8 GHz Hermetic GaAs IC SPDT Absorptive Switch: ISO13286

For high reliability aerospace, satellite and defense applications

| 0.9–4.0 GHz 50 W High Power Silicon PIN Diode SPDT Switch: SKY12208-478LF

For military and aerospace communication system applications, JTRS, software defined radios (SDRs), VHF, UHF and land mobile radios and public safety radios

For more information, please visit our website at www.skyworksinc.com.



The company's high reliability, hermetic ceramic RFIC and optocoupler product portfolio can be found at www.isolink.com. To learn more about Skyworks' advanced technical ceramic products, please visit www.trans-techinc.com.



Multi Stage RF Frequency Converters

To meet today's demand for flexibility and scalability in RF and microwave instruments, SignalCore offers a new line of high performance and low cost frequency converters, available in various platforms to suit a wide range of applications.

Military ✓ Commercial ✓



Visit us at **EDICON USA 2016**
Booth #707

- Frequency 100 kHz to 6 GHz
- Low phase noise
- High dynamic range
- Bandwidth up to 320 MHz
- Tuning resolution 1 Hz
- USB, SPI, RS-232 & PXIe

www.signalcore.com

Do you need **Cost-effective Calibration Kits** for your measurement?

Withwave's Compact Calibration Kits offer excellent performance characteristics for fine-tuning in production environments and quality testing facilities, using 50 ohm N-type & 3.5 mm connectors up to 6 GHz and 9 GHz respectively. These Cal Kits include all needed calibration standards (Open, Short, Load, and Through) in one unit. It is the best solution available for ease of use in VNA calibration, especially in the field. We solve your performance and cost problems.

3.5 mm Type
(three-in-one)
(DC to 9 GHz)



NEW

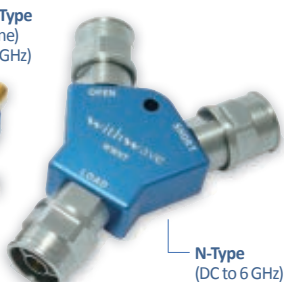
- T-Probe (DC to 20 GHz)
- GSG, GS Configurations
- 0.8, 1.5, 2.5 mm pitch range
- Pogo pin structure



3.5 mm Type
(All-in-one)
(DC to 9 GHz)



N-Type
(DC to 6 GHz)



Specifications

- Return loss (Load) : < -38 dB
- Phase deviation (Open, Short) : < 1.5 degree
- Providing calibration coefficient for user-defined calibration

For more information on these products go to :

withwave
Versatile RF & MW Solutions

sales@with-wave.com | www.with-wave.com

Around the Circuit

erations, since 1986. She was named vice president of the AMETEK test business unit in 2008 and promoted in 2012 to her most recent position as vice president and business unit manager of Hughes-Treitler within AMETEK Aerospace & Defense.



▲ **Takaki Murata**

Peregrine Semiconductor Corp., founder of RF SOI (silicon on insulator) and pioneer of advanced RF solutions, announced the promotion of **Takaki Murata** to vice president and general manager of the high performance analog (HPA) business unit. A long-time veteran of Murata, Takaki has a Ph.D. in electrical engineering and 12 years of experience at Murata, in a range of different assignments including: LTCC material development, SAW filter development, antenna sales engineering, RF front-end sales engineering, corporate accounting and inductor business strategic planning.



▲ **Dr. Alexander Chenakin**

Micro Lambda Wireless Inc. announced it has appointed **Dr. Alexander Chenakin** as vice president, Advanced Technologies. Dr. Chenakin is well recognized in the field of frequency synthesis and is referred to as the inventor of QuickSyn technology. In 2009, he received the ARMMS RF & Microwave Society's best contribution award for his work on fast-switching frequency synthesizers. His professional achievements have been widely presented in trade publications and international conferences. He is a senior member of the IEEE and holds a number of patents in frequency synthesis. Dr. Chenakin has held previous positions at Phase Matrix, National Instruments and Anritsu.



▲ **Carl Frank**

Anokiwave Inc., an innovative company providing highly integrated core IC solutions for mmW markets and AESA based solutions, announced the latest addition to its leadership team with the appointment of **Carl Frank** to the position of chief operating officer, a new position within Anokiwave, effective immediately. Frank will report directly to chief executive officer, Robert Donahue. As the Anokiwave COO, Frank will be responsible for the execution of Anokiwave's worldwide growth strategy, as well as assume responsibility for the worldwide marketing, sales, and operations organizations.

REP APPOINTMENTS

Custom MMIC, a developer of performance driven monolithic microwave integrated circuits (MMIC), has announced the appointment of **Repwave** as their new technical representative in Canada. Repwave was founded in 2003 and has an established team of high-tech profession-



UNMATCHED DYNAMIC RANGE. UNMATCHED PERFORMANCE.

VDI's Mini VNAX modules are one-quarter the volume of standard modules making them well suited for probe station and antenna measurement applications.

BRIDGING THE THz GAP JUST GOT SMALLER.

VDI's VNA Extenders provide high performance frequency extension of vector network analyzers from 50GHz-1.5THz. These modules combine high test port power with exceptional dynamic range and unmatched stability.

VDI's mini-modules are reduced in size, but yield the same industry leading performance as our original designs. The compact form factor and simplified power supply make them the recommended solution for most applications. Mini-modules are currently available in standard waveguide bands for 50-330GHz with higher frequency bands coming soon.

Waveguide Band (GHz)	WR15 50-75	WR12 60-90	WR10 75-110	WR8 90-140	WR6.5 110-170	WR5.1 140-220	WR3.4 220-330	WR2.2 330-500
Dynamic Range (BW=10Hz, dB, typ)	120	100	120	120	120	120	115	110
(BW=10Hz, dB, min)	100	120	100	100	100	100	100	100
Magnitude Stability (±dB)	0.15	0.15	0.15	0.15	0.25	0.25	0.3	0.5
Phase Stability (±deg)	2	2	2	2	4	4	6	8
Test Port Power (dBm)	6	6	6	0	0	-4	-9	-17



Virginia Diodes, Inc.

979 2nd St. SE, Suite 309
Charlottesville, VA 22902
434.297.3257

vadiodes.com



High Performance PLO Solutions

RFS Series Fixed Frequency PLLs | 1 GHz - 6 GHz

Reference Signal Included - No External Programming - Fixed Frequency

Part Number	Freq (MHz)	Output Power (dBm) (typ)	Spurs (dBc)	PN @1kHz (dBc/Hz) (typ)	PN @10kHz (dBc/Hz) (typ)
RFS1030-LF	1030	3	-65	-93	-98
RFS2450-LF	2450	3	-65	-85	-95
RFS3500A-LF	3500	3	-65	-85	-93
RFS4500A-LF	4500	2	-65	-85	-86
RFS5900A-LF	5900	3	-65	-80	-86

SFS Series Fixed Frequency PLLs | 500 MHz - 15 GHz

No External Programming - Ultra-Low Noise - Small Size

Part Number	Freq (MHz)	Output Power (dBm) (typ)	Spurs (dBc)	PN @1kHz (dBc/Hz) (typ)	PN @10kHz (dBc/Hz) (typ)
SFS1600E-LF	1600	5	-65	-85	-120
SFS2500C-LF	2500	6	-70	-84	-111
SFS6400A-LF	6400	6	-65	-88	-88
SFS10625H-LF	10625	0	-70	-99	-105
SFS12000H-LF	12000	0	-65	-97	-103

WWW.ZCOMM.COM

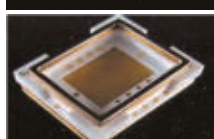
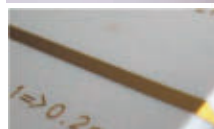
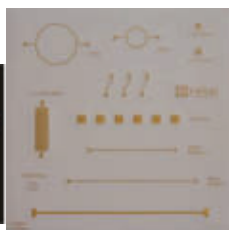
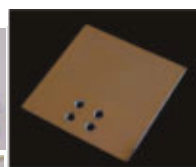
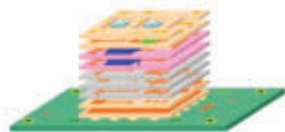
P: (858) 621-2700 | E: sales@zcomm.com

ISO 9001:2008



mm-wave? Yes, we can !!!

“LTCC is great and High Q already”



Er	6.1 (+/-0.1)
Tanδ @60 GHz	0.0013
MSL loss @67GHz	0.45 dB/cm
Rth. (W/m·K)	4.7
TCE (ppm/deg.C)	2.9
FI Strength (MPa)	100
Cond. Material	Au, Ag(*) (*)w/o. plating
min Line & Space	60/60 μm
Embed Resistor	10 to 300k Ω
Layer Thickness	50 to 100 μm

Contact: fujimoto@hirai.co.jp
or hanatani@hirai.co.jp
www.hirai.co.jp/ceramic_e.html



Around the Circuit

als offering state-of-the-art components and related technologies of the RF/microwave and wireless markets.

Maury Microwave Corp., a global leader in calibration, interconnect, measurement and modeling device characterization solutions, announced it has signed an agreement with **Hi-Tech RF & Microwave Solutions** of Maarssen, the Netherlands, to act as Maury Microwave's Master European Reseller. Hi-Tech will support European sales and service for the company. Hi-Tech will work for Maury as a dedicated sales management arm and technical support system for Europe, working with the current Maury sales channel. Hi-Tech will be responsible for recruiting, managing, quoting, and supporting the Maury channel for pre- and post-sales.

PCTEL has entered into a product representation agreement with Antioch, Ill.-based **EPI Technologies**. EPI will be the exclusive representative for their SeeHawk Engage portfolio in the upper Midwest. The portfolio consists of User Equipment (UE)-based mobile network performance test and engineering tools.

RFMW Ltd. and **Akoustis Technologies Inc.** of Huntersville, N. C., have announced a distribution agreement effective immediately. Akoustis Technologies Inc. is a manufacturer of innovative BulkONE™ bulk acoustic wave (BAW) high band RF filters for mobile wireless and general purpose RF catalog components. RFMW Ltd. is a specialized distributor providing customers and suppliers with focused distribution of RF and microwave components as well as specialized component-engineering support. Under the agreement, RFMW is franchised worldwide for Akoustis' complete product offering.

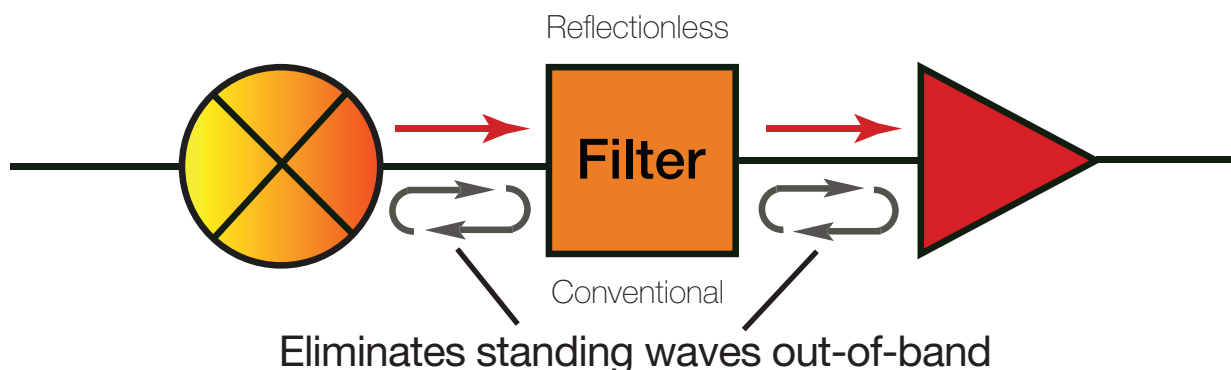
Dynawave, a designer and manufacturer of RF & microwave connectors, adapters, bulk cable and cable assemblies, announced the appointment of **Ultra-RF Technical Sales**, as their new manufacturer's representative in the Southern California region. Ultra-RF will support the full range of Dynawave products and cover from San Luis Obispo County to San Diego County and to the east covering San Bernardino, Riverside and Imperial Counties.

PLACES

Imec, a leading nanoelectronics research center, announced the opening of Imec Florida, a new entity focusing on photonics and high-speed electronics IC design based in Osceola, Fla. Imec Florida kicked off with the signing of a collaboration agreement with the University of Central Florida (UCF), Osceola County and the International Consortium for Advanced Manufacturing Research (ICAMR), that is setting up fab facilities for the development and production of highly innovative III-V-on-silicon solutions for a broad range of applications including sensors, high-speed electronics and photonics. Imec Florida will be established as a design center facilitating the collaboration between Imec's headquarters, based in Leuven, Belgium, and U.S.-based semiconductor and system companies, universities and research institutes.

NOW! Revolutionary **ABSORPTIVE/REFLECTIONLESS FILTERS**

DC to 21 GHz!



Stops Signal Reflections Dead in Their Tracks!

\$6⁹⁵
ea. (qty. 1000)

Mini-Circuits is proud to bring the industry a revolutionary breakthrough in the longstanding problem of signal reflections when embedding filters in RF systems. Whereas conventional filters are fully reflective in the stopband, our new X-series reflectionless filters are matched to 50Ω in the passband, stopband and transition band, eliminating intermods, ripples and other problems caused by reflections in the signal chain. They're perfect for pairing with non-linear devices such as mixers and multipliers, significantly reducing unwanted signals generated due to non-linearity and increasing system dynamic range by eliminating matching attenuators². They'll change the way you think about using filters in your design!

Jump on the bandwagon, and place your order online today for delivery as soon as tomorrow. Need a custom design? Call us to talk to our engineers about a reflectionless filter for your system requirements.



- ✓ High pass, low pass and band pass models
- ✓ Patented design eliminates in-band spurs
- ✓ Absorbs stopband signal power rather than reflecting it
- ✓ Good impedance match in passband stopband and transition
- ✓ Intrinsically Cascadable³
- ✓ Passbands from DC – to 21 GHz⁴
- ✓ Stopbands up to 35 GHz

 **Tiny 3x3mm QFN**

¹ Small quantity samples available, \$9.95 ea. (qty. 20)

² See application note AN-75-007 on our website

³ See application note AN-75-008 on our website

⁴ Defined to 3 dB cutoff point

Protected by U.S. Patent No. 8,392,495 and Chinese Patent No. ZL201080014266.1. Patent applications 14/724976 (U.S.) and PCT/USIS/33118 (PCT) pending.





WELCOME TO EUROPEAN MICROWAVE WEEK 2016

Andrew Gibson
General Chairman of EuMW 2016
Ivar Bazzay
President, Horizon House Publications

For complete coverage of the EuMW conference, event news, exhibitor product information and special reports from the editors of *Microwave Journal*, visit our online show daily at www.mwjjournal.com/eumw2016.

Welcome to ExCeL London for the 19th European Microwave Week (EuMW) from 3 to 7 October, when Europe's premier microwave event returns to the UK capital after an absence of 15 years. A generous venue rich in facilities, ExCeL London now has the means to provide the interaction, flow and intimacy that EuMW demands. During the week it will be home to three conferences: the 46th European Microwave Conference (EuMC), the 11th European Microwave Integrated Circuits Conference (EuMIC) and the 13th European Radar Conference (EuRAD), together with the European Microwave Exhibition and affiliated workshops and short courses.

London has been home to Newton, Faraday, Maxwell, Franklin, Babbage and Fleming who were all Fellows of the Royal Society.

In a similar vein, EuMW 2016 welcomes the current and future generations of RF and microwave engineers/scientists, be they speakers, delegates, exhibitors or visitors. Such inclusivity is reflected in this year's motto—Microwaves Everywhere—which recognizes the way microwave technology is fully integrated into our lifestyles, continuously opening up new frontiers that will govern how individuals and objects communicate, sense and move.

Whether these frontiers are technological or geographical they will be crossed and addressed at EuMW 2016. There are four special and three focused sessions drawing attention to interesting technical topics and links with other microwave communities. There are sessions updating advances in THz imaging and multipactor effects as well as the new topic of surface waves, together with selected papers

ATC's 400 Series SMT Capacitors for Precision Tuning Solutions

Tightest Tolerances Available in the Industry (to ± 0.01 pF)

- ▶ Ideal for Critical RF/Microwave Tuning Applications
- ▶ Saves Time, Eliminates Need for End Process Tuning
- ▶ Reduces Your Manufacturing Cost
- ▶ Superior Reliability



Features:

- Capacitance: 0.1 pF to 68 pF
- Tightest Tolerance to ± 0.01 pF
- EIA 0201, 0402 and 0603 Case Sizes
- Voltage Rating: up to 200 WVDC
- Stable NPO Dielectric
- Unit-to-Unit Performance Repeatability
- RoHS Compliant / Lead-Free

Typical Applications:

- Filter Networks
- Matching Networks
- High Q Frequency Sources
- Tuning
- Coupling
- Bypass
- DC Blocking



A M E R I C A N
ATC North America
sales@atceramics.com

T E C H N I C A L
ATC Europe
sales@atceramics.com

C E R A M I C S
ATC Asia
sales@atceramics-asia.com

 **THE
ENGINEERS'
CHOICE®**
ISO 9001 REGISTERED

www.atceramics.com

See us at EuMW Stand 222

from the Asia Pacific Conference, the European EMC Conference, the UK ARMMS RF & Microwave Measurement Society (www.armms.org) and a special group of papers highlighting activities from countries in South, Central and North America.

The invited speakers for the opening and closing sessions of EuMC, EuMIC and EuRAD are leaders in their respective fields who will consider cutting edge concepts. Details can be found in Attending EuMW 2016 on page 78 where the content of all three

conferences is outlined. Complementary to the conferences are the workshops and short courses, which will cover key themes including: 5G communications; GaN, CMOS and SiGe technologies and their applications in the mmWave and THz bands; additive manufacturing; power amplifiers; developments in space based technologies; and automotive, multistatic and space based radar.

London can definitely be classified as a complex urban environment, so could be used as a practical example during the 2016 Defence, Security and Space Forum, which this year focuses on defence and security in Complex Urban Environments. The Forum will take place on Wednesday 5 October and more information can be found on page 94.

EuMW 2016 also aims to create the right environment for students and young engineers looking for a career in the RF and microwave sector to meet companies and network via the Career Platform. They will also be able to impress in a competitive environment through the Student Challenge poster competition where groups of students develop new ideas based on papers presented at the conference. Similarly, the Student Design Competition is a design and measurement contest where the students present the performance of their prototypes in a special event held during the week.

The well-established Women in Engineering event, co-sponsored by the IEEE MTT-Society, will feature a panel session focused on "Inspiring Women in Engineering," where those aiming for the stars will be inspired by a visit to the Greenwich Royal Observatory at the end of the session.

Those who want to observe the latest products and services from the leading RF and microwave companies across the globe can get close-up and personal at the European Microwave Exhibition that spans the middle of the week from 4 to 6 October. Accessed adjacent to the registration area on the Boulevard via entrance S11 Halls 20 to 23 will be filled to capacity with over 300 exhibiting com-

Greenray's New T1241 TCXO



Ultra-low g-Sensitivity and Low Phase Noise for Mobile and Airborne Apps.

Greenray's new T1241 TCXO is designed as a reference for **military and instrumentation** applications that require **ultra low g-Sensitivity** and **reliable, superior phase noise performance** in high vibration and shock environments.



The T1241, available from 50 to 100MHz, delivers **reduced acceleration sensitivity** down to 7×10^{-11} of applied acceleration force. Typical phase noise is -155dBc/Hz (@10kHz).

The T1241 features a rugged, SMT package, supply voltage of +3.3V or +5V, and input current is 30mA max. EFC for precise tuning or phase locking apps is standard.

For more information about our full line of high performance oscillators, call Greenray at (717) 766-0223. You can also visit us at www.greenrayindustries.com.



For Industry, for Defense.



©2016 Greenray Industries, Inc.

AR's Hybrid Power Modules

700 MHz to 6 GHz In One Package



CW Hybrid Power Modules (HPM's) For EW, Wireless & Communications

The HPM's are 50 ohm high gain amplifier blocks that provide up to 50 watts of output power in a connectorized housing for applications where performance, size and weight are critical. These products are available in highly linear Class A or more efficient Class AB designs to give you the ultimate flexibility for your particular application. They are price competitive for wireless and communication applications and meet the stringent requirements for counter IEDs and electronic warfare military systems. For wireless applications, these amplifiers can test systems, higher power amplifiers or transistors, and be used for accelerated life testing and stress screening (HALT & HASS).

If you require complete benchtop amplifier systems including power supplies and remote control capabilities we can provide output powers in excess of 350 watts.

To obtain more detailed information on these and other products call AR RF/Microwave Instrumentation at 215 723 8181 or visit us at www.arworld.us/covered.

Come See Us at European Microwave Week
ExCel London, London, UK, October 4-6, 2016, Booth: 78-79

ISO 9001:2008
Certified

We don't just build great products.
We build great products that last.



rf/microwave instrumentation

Other **ar** divisions: modular rf • receiver systems • ar europe

USA 215-723-8181. For an applications engineer, call 800-933-8181.

In Europe, call ar United Kingdom +44 1908 282766 • ar France +33147917530 • ar Deutschland +49 6101 802700 • ar Benelux +31 172 423000

Download the AR RF/Microwave Mobile App: www.arworld.us/arApp

Copyright © 2016 AR.

The orange stripe on AR products is
Reg. U.S. Pat. & TM. Off.





European Microwave Week



panies taking up around 7800 square metres of gross space.

The invaluable European Microwave Week Microwave Application Seminars (MicroApps) offer engineers the practical solutions that can make a difference. They will take place in the

MicroApps Auditorium on the show floor for the entire three days of the exhibition and provide a platform for education and discussion. The Exhibition Halls will also be the home of the conference Poster Sessions and Copper Mountain sponsored coffee

breaks, feature the Publisher's Corner and the ever popular CST sponsored Cyber Café.

There will be more than coffee available at the welcome reception on Tuesday evening, which provides networking opportunities and a convivial atmosphere that actively encourages delegates and industry to interact and socialize. On Wednesday evening socializing will move from ExCeL London to the River Thames for a cruise, including a cocktail reception on board a river boat as it tours London's famous landmarks after dark. Mixing business and pleasure can be enjoyed throughout the week through the strong calendar of social events.

To bring EuMW 2016 to London and to fruition, from paper submission and review to the on-site organization at the venue, has been a major undertaking. So, on behalf of the Local Organising Committee we would like to thank the Technical Programme Committees of the three conferences along with the reviewers who worked tirelessly to shape the conference programmes. We would like to acknowledge the EuMA Board for its continued advice and guidance and thank the Horizon House personnel assigned to EuMW for their indispensable expertise and support in organising this major event. Recognition should also go to the organisers of workshops, special sessions and student events and we also acknowledge the significant financial and in-kind sponsorship of many industrial companies and organisations.

Microwaves may be everywhere but in the first week of October the focus of the microwave community will be trained on ExCeL London and we look forward to seeing you there. ■



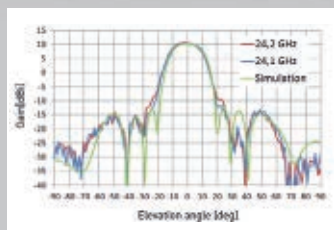
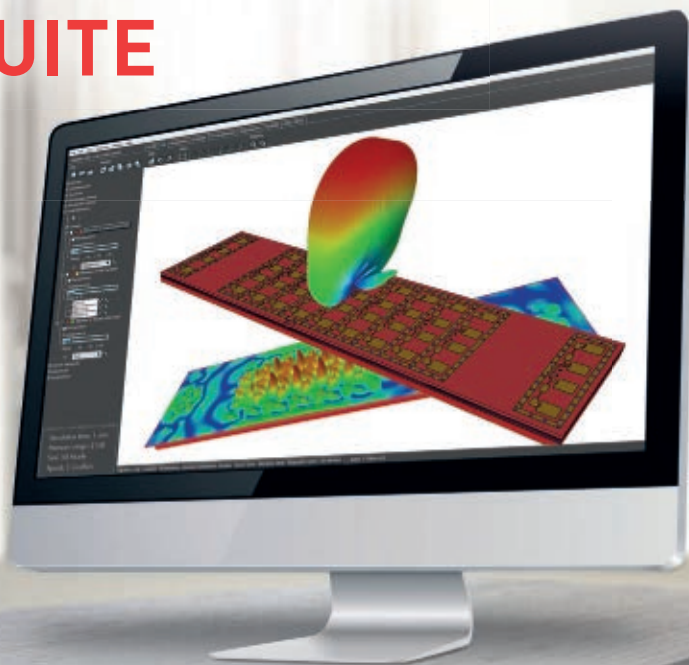
Andrew Gibson



Ivar Bazzzy

EMPIRE XPU

→ 3D EM DESIGN SUITE



24 GHz Radar Antenna

- New Intuitive 3D Design
- Super Fast (XPU, JIT)
- Memory Efficient





UP TO 8 THROWS



WIDE FREQUENCY RANGE



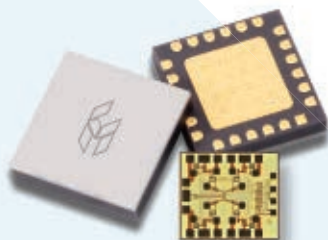
FAST SWITCHING SPEED



LOW INSERTION LOSS



SMALL FORM FACTOR



MMIC Switches

- Switching speeds from 1.8 nS
- Frequencies up to 28 GHz
- Models up to SP8T
- Insertion loss as low as 1.0 dB
- Isolation as high as 50 dB

More frequency coverage, more throws, more board space = more possibilities.

The latest additions to our GaAs MMIC switch family might just change your approach to the switching stage in your signal chain. Our new designs free up valuable real estate and design time by enabling you to eliminate the discrete switching circuits in many of your radar and EW subsystems.

Download datasheets and S-parameters and start designing today.

CustomMMIC.com

See us at EuMW Stand 121





Attending European Microwave Week 2016

Richard Mumford, Microwave Journal *International Editor*

London may be steeped in history but it is also a vibrant, modern cosmopolitan city. Architecturally, the centuries



Photo Courtesy of ExCeL London.

old St Paul's Cathedral, Houses of Parliament and the Tower of London share the city's skyline with this century's London Eye and The Shard. Ancient artifacts take centre stage at the Victoria and Albert and the Natural History Museums, while the more contemporary works can be seen at the Design Museum and Tate Modern.

Similarly, the likes of Newton, Faraday and Maxwell pioneered technological evolution, while today's RF and microwave engineers and scientists have the opportunity to shape the development of the interactive, information age by meeting the challenges of 5G, the Internet of Things, satellite communications, defence/military systems and the development of autonomous cars, to name a few. Such cutting edge technology will be the topics of conversation, conference sessions and the product offerings of exhibiting companies.

Illustrating the intellectual and geographical reach of the week's programme around

Connect with us:
European Microwave Week
October 3 – 7, 2016
ExCel London, Booth 102



Plug, test, smile.

When it comes to test and measurement, SUCOFLEX 500 assemblies guarantee the highest level of satisfaction. Not only are they extremely flexible and easy to use, thanks to their unique design, they also deliver best-in-class phase and amplitude stability with flexure, movement, temperature and tensile stress.

For more positive facts: [› smile.hubersuhner.com](http://smile.hubersuhner.com)



Photo Courtesy of ExCeL London.



Photo Courtesy of ExCeL London.

1000 papers were submitted for review to the three conferences from more than 50 countries. The technical programme includes 92 technical sessions, 450 oral papers and 136 posters, four special sessions and three focused sessions.

Firmly established as the premier RF and microwave event in Europe, EuMW 2016 is expected to attract in excess of 1500 unique conference delegates, around 4500 attendees, with the exhibition featuring more than 300 exhibiting companies, spread over about 7800 square metres (gross).

Not just numbers, the attendees are individuals that should be encouraged to network, interact and enjoy

each other's company, and where better to start than at the ever popular EuMW Welcome Reception, sponsored by Keysight Technologies. On Tuesday 4 October the reception will be held in the Platinum Suite. The evening will begin with a cocktail reception at 18:30, when guests will be addressed by the 2016 EuMW Chairman, Andrew Gibson, who will hand over to the 2017 EuMW Chairman for Nuremberg, Arne Jacob, followed by Keysight Technologies, after which a three course seated buffet for 1000 people will be served.

From the conference programme, through poster sessions, to new products on display, the main aim is to ensure a productive and informative

week for all. To help visitors achieve these aims the following quick reference guide is designed to complement the Conference Programme and Exhibition Show Guide, where you will find more detailed information.

There is virtual access for the first time too via the EuMW app, which is designed to be a digital companion leading up to, and during the week. For the exhibition it will enable users to navigate the show floor with the interactive map, filter and search for selected exhibitors and contact exhibitors directly to book a meeting. For the conferences, users can follow and build their own personal agenda, access abstracts, post questions and leave feedback.

Look to Norden for your Radar Component Needs



**77 Ghz
RADAR TxRx**



**12-Chanel 10 Watt
X-Band TxRx**



**KA-Band
Transceiver**



For more information on these products go to:
www.nordengroup.com or
call **530.642.9123**

See us at EuMW Stand 120

L-3 NARDA-MITEQ... YOUR ULTIMATE POWER SOURCE

10
watts



high-power
amplifier

150
watts



high-power
attenuator

400
watts



high-power
coupler

500
watts



high-power
termination

3.5
kW



high-power
switch



narda  **MITEQ**

Your Source for High-Power Microwave and RF Components

L-3 Narda-MITEQ offers the most extensive line of standard catalog high-power microwave and RF components today. With over 60 years of technological innovation and expertise, L-3 Narda-MITEQ can modify or customize a unique high-power solution to meet any specific requirements you may have. So count on L-3 Narda-MITEQ – *your best resource for high-power components.*

Learn more about all we have to offer by visiting us at nardamiteq.com, or call us at (631) 231-1700.

Narda-MITEQ

  L3com.com

See us at EuMW Stand 180

In Stock

Capacitors

Reliable * Fast Turnarounds
* Competitive Pricing

RF/Microwave

Hi- Ω /Low ESR/ESL EIA Capacitors



0201 0402 0603 0805

- Case Sizes: EIA
- Low ESR/ESL 
- TC = NPO
- Modeling Data Available

Hi- Ω Low ESR Capacitors



- Case Sizes: 0505, 1111
- Q > 10,000
- Low ESR/ESL 
- TC = NPO / P90
- Modeling Data Available

Available in Non-Magnetic Terminations

HF/UHF

High Power Applications



- High Power Capacitors Case Sizes:
- Up to 25kV 2225
- High Current 3838
- TC = NPO 6040
- Values: 1pF - 10,000pF 7676
- Custom Assemblies 1313

Available in Non-Magnetic Terminations

Aerospace * Aviation * Military
Commercial * Medical
Telecommunications

- Unmatched customer service
- Modeling Available
- Design kits in stock
- Inventory programs

Call us today

631-425-0938

sales@passiveplus.com

www.PassivePlus.com



THE CONFERENCES

Each with their own dedicated time slots throughout the week there are three focused conferences:

- **The European Microwave Integrated Circuits Conference (EuMIC)** – 3 to 4 October
- **The European Microwave Conference (EuMC)** – 4 to 6 October
- **The European Radar Conference (EuRAD)** – 5 to 7 October
- **Plus Workshops and Short Courses** – 3 to 7 October
- In addition, the **Defence, Security and Space Forum** will take place on Wednesday 5 October

Rohde & Schwarz sponsored on-line registration opened on 1 June 2016 and remains open up to and during the event until 7 October 2016. There will be onsite registration from Sunday 2 October from 16:00-19:00 and at 08:00 each morning from Monday 3 to Friday 7 October 2016.

Those who have pre-registered should bring their badge barcode and confirmation with them to the registration area where they can print out their badge by scanning their barcode at the Fast Track desk.

Those who have not pre-registered can do so on site. There will be onsite registration terminals located within the registration area, located on the Boulevard, where delegates can enter their details and either pay immediately by swiping their credit or debit cards through the card readers attached to the terminals. Alternatively, there is a cashier desk for those who require a printed receipt.

Once in possession of a badge, delegates can collect their delegate bags, sponsored by Infineon Technologies and Leonardo-Finmeccanica, from collection points in the registration area. The bags will include a USB stick containing the conference proceedings.

THE EUROPEAN MICROWAVE CONFERENCE

EuMC is Europe's leading forum for presenting microwave and related technologies. 630 papers were submitted, which enabled the TPC to produce a wide programme that includes

49 EuMC and 12 joint technical sessions, 15 workshops, five short courses and three special sessions alongside a special event, and the student challenge. One of the special sessions is devoted to the Asia Pacific Microwave Conference.

The technical sessions cover the latest microwave techniques including filters, power amplifiers, antennas, biological applications and many other areas. The opening session includes a presentation by Glyn Thomas, Payload Director of Airbus entitled, "Quantum Flexible Payloads for Telecoms Satellites." At the closing session, fascinating insights into the worlds of microwave instrumentation and measurements will be given by Mark Pierpoint of Keysight Technologies, and Nick Ridler of NPL. The conference prizes will also be presented.

EUROPEAN MICROWAVE INTEGRATED CIRCUITS CONFERENCE

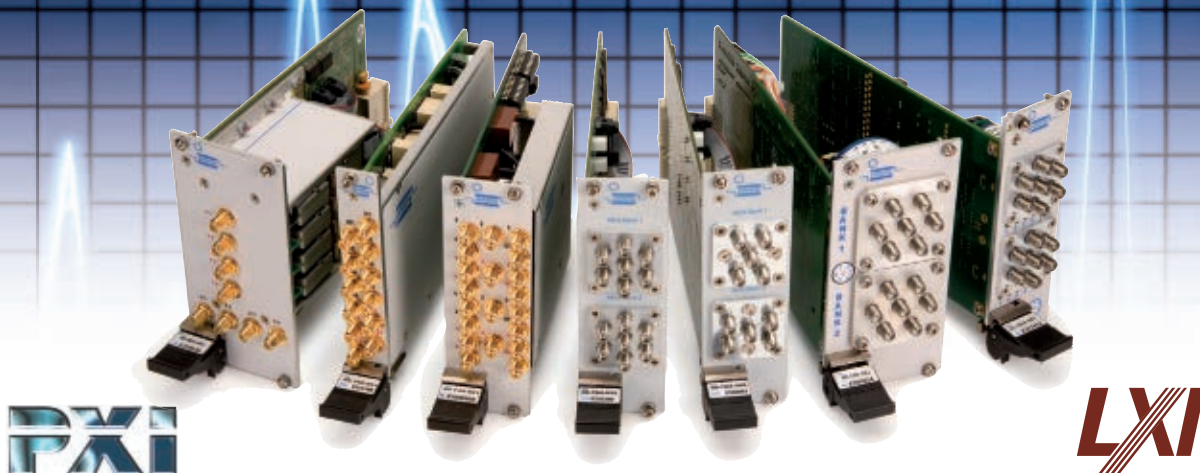
Jointly organised by the GAAS[®] Association and EuMA, the aim of the conference is to promote the discussion of recent developments and trends, and to encourage the exchange of scientific and technical information covering a broad range of high frequency related topics, from materials and technologies to integrated circuits and applications, that will be addressed in all of their aspects: theory, simulation, design and measurement.

The EuMIC opening plenary session will feature two keynotes that balance a futuristic research-oriented agenda with the more practical perspectives of industrial designers. Dylan Williams of NIST, USA will speak on "THz Transistors and Calibration Challenge," while Liam Devlin from Plextek Ltd., UK will deliver a talk entitled, "MMICs – Custom or COTS."

The closing session will include the traditional foundry session gathering several key representatives of RF and microwave semiconductor foundries, as well as a keynote talk by a world renowned expert on power amplifiers, Steve C. Cripps of Cardiff Univer-

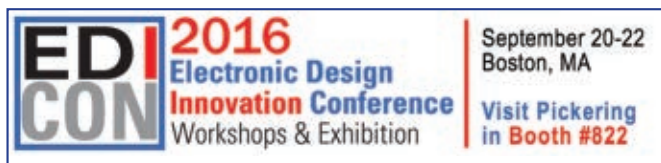
Switching & Simulation for Every Application

Get the RF & Microwave Switching You Need for Your Application



Increase the Efficiency of Your Test & Measurement System

- DC to 65 GHz
- Key Switching Topologies
- Usable in PXI and Ethernet LXI Chassis
- 6 GHz Solid State
- 200+ RF & Microwave Modules
- LED Indicators Available on Many Modules



Switching | Programmable Resistors | Instrumentation | Custom Design | Connectivity & Cables



Learn More – Scan the QR Code
or go to pickeringtest.com/radio

781-897-1710 | ussales@pickeringtest.com

pickering Pickering Interfaces

See us at EuMW Stand 36

Sealed with
EXCELLENCE.



See us at EuMW Stand 102

RADIO FREQUENCY
TEST PROBES

HFS-856

Frequencies up to 12GHz

The HFS-856 offers precise contacting of Switch Connectors (MM8030, MM8430, MS-156 and MS-180) and also miniature plug connectors (U.FL) which are used in products such as Mobile Phones, GPS and Wireless Networks.

www.ingun.com



sity, UK, who will consider “Balanced Microwaves,” stressing the need for access to a mature and reliable multilayer integrated process for microwave designers.

During the closing ceremony, the prize for the best contributed paper to EuMIC 2016 will be awarded and the EuMIC Young Engineer Award will be presented to a young engineer or researcher who authored an outstanding paper presented at the EuMIC Conference. Three GAAS® Ph.D. student fellowships will also be celebrated.

THE EUROPEAN RADAR CONFERENCE

This conference is the major European event covering the present status and future trends in the field of radar technology, system design, and applications that covers a wide variety of topics, ranging from radar components and systems, radar echo modeling, advanced signal processing techniques, up to the most innovative radar architectures and concepts and the latest applications.

This year, 171 papers were submitted from which the 100 accepted papers were organised into 13 oral sessions and one poster session. EuRAD delegates can also attend five sessions shared with EuMC, related to millimetre-wave antenna arrays and millimetre and THz radar applications as well as antennas and propagation and electronic scanned array design.

During the opening session Dr. Paul Holbourn of Selex ES, will present, “Captor for Typhoon: Past, Present and Future,” that focuses on the development of the Captor radar for Typhoon, which is the most significant European airborne radar. Three focused short courses will be presented by renowned experts on very innova-



Photo Courtesy of ExCeL London.

tive and interesting fields, dealing with electronic scanned array design and multibeam antennas and beam-forming networks.

Expert workshops covering a range of topics and led by renowned experts in the field include: Automotive Radar chaired by Holger Meinel, Radar Imaging chaired by Professor Motoyuki Sato, Radar Performance in Clutter chaired by Professor Simon Watts, Bistatic and Multistatic Radar chaired by Professor Mike Cherniakov and Digital Beamforming Space Borne Synthetic Aperture Radar chaired by Professor Steven Gao.

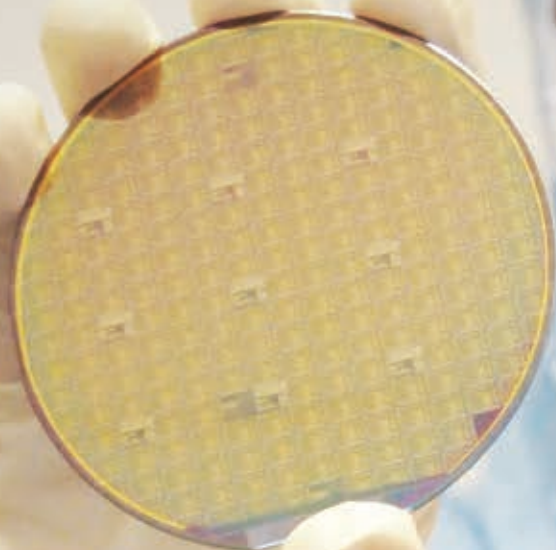
During the closing session Professor Hugh Griffiths will talk on “Early History of Bistatic Radar,” which will describe Appleton’s 1924 experiments to measure the height of the ionosphere (also the first FM radar), Watson Watt’s celebrated Daventry Experiment in 1935, and the German WWII Klein Heidelberg system, which used the British Chain Home radars as its illumination source and which was the first proper operational bistatic radar.

The Exhibition

The European Microwave Exhibition will be housed in halls 20 to 23, which is accessed from the registration area on the Boulevard via Entrance S11. Taking place from 4 – 6 October, and larger than in 2015, it will be the hub of activity generated by the multitude of companies eager to display and demonstrate their latest introductions.



GaAs - GaN - InP
500 MHz - 400 GHz



Your MMIC One-Stop Shop

European Independent Foundry providing MMIC solutions
from custom designs to catalogue products.

Your success. Our business.



European Microwave Week



The FREE to attend exhibition will feature companies large and small, established and emerging. Of course, European companies are to the fore and UK companies are making their presence felt on home soil. The U.S. and Asia are well represented with the

Chinese Pavilion expanding in 2016, demonstrating the country's continued emergence as a force in the RF and microwave sector and its desire to reach overseas markets.

Significant this year is the participation, for the first time, of the Cen-



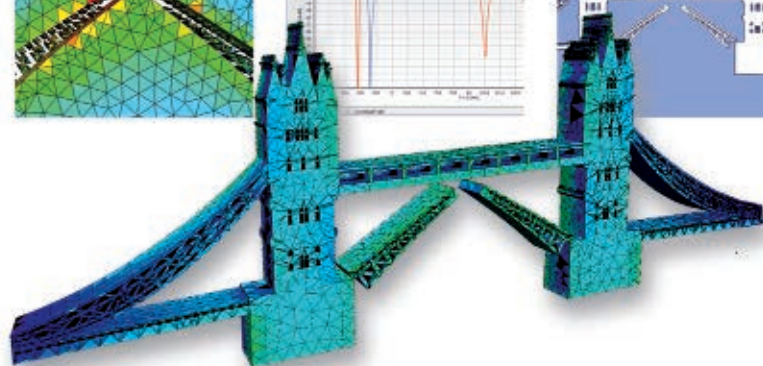
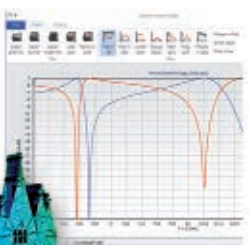
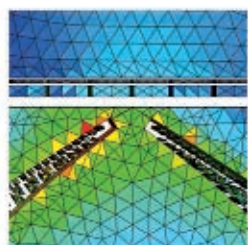
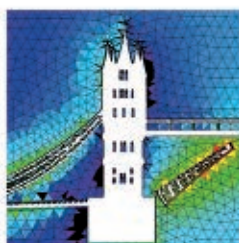
Photo Courtesy of ExCeL London.

tre national de la recherche scientifique (CNRS), which is the largest fundamental research organization in France. Conducting research in a wide range of scientific and technological sectors the organisation will feature eight of its research institutes.

With its focused international audience EuMW has established itself as an event that leading manufacturers often choose to launch new products onto the European and global market. To find out which companies will be exhibiting at ExCeL London see the latest exhibitor list, starting on page 172.

By nature engineers are practical so the popular exhibitor workshops offered by leaders in their respective fields, including Keysight Technologies, Rohde & Schwarz and National Instruments offer attendees the opportunity to see live demonstrations and gain hands-on experience.

The educational/instructional theme will continue on the show floor with the sixth European Microwave Week Microwave Application Seminars (MicroApps). The National Instruments, Rohde & Schwarz and Horizon House sponsored, free-to-attend seminars will take place in the MicroApps Auditorium for the entire three days of the exhibition. Designed to provide engineers with insight into products and techniques that will aid them in their everyday work EuMW exhibitors will present technical presentations describing state-of-the-art applications, products, design techniques and processes of interest to the RF and microwave community. Continuing the educational theme, the show floor will also be home for both the Student Challenge and the Stu-



THERE'S MAGIC IN FAST AND ACCURATE RF DESIGNS



See us at EuMW 2016 in London, UK, Booth 55

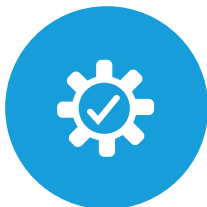
µWave Wizard™: The hybrid full-wave EM-tool for sophisticated designs of antennas, filters, couplers, multiplexers, ...
Mician GmbH, Schlachte 21, 28195 Bremen, Germany, Tel.: +49 42116899351, Fax: +49 4211 6899352, www.mician.com



Need Cool Efficient GaN?



Qorvo's 50V GaN gives you unparalleled advantages



Operating Efficiency



System Cost Savings



True 50V Operation



MRL 9 Trusted Source



Highest Reliability

Part Number	Psat (W)	Freq (GHz)	Output Power (P3dB)	PAE (%)	SS Gain (dB)
QPD1008	125	DC-3.2	51	70	18
QPD1008L	125	DC-3.2	51	70	18
QPD1015	65	DC-3.7	48	70	20
QPD1015L	65	DC-3.7	48	70	20
QPD1009	15	DC-4	42	72	24
QPD1010	10	DC-4	40	70	25

Connect with us at EuMW or visit qorvo.com to learn more

dent Design Competition, while the Career Platform will be on the Mezzanine floor of the Conference Centre.

The exhibition space will also be the home of the conference poster sessions, coffee breaks, sponsored by Copper Mountain, and the publisher's

corner. Once again CST is sponsoring a cyber café located on the show floor for all delegates, exhibitors and visitors to use, as well as free Wi-Fi access to emails for delegates in all conference areas.

Exhibition Opening Hours

Tuesday 4 October: 9:30 to 18:00 (followed by the Welcome Reception)

Wednesday 5 October: 9:30 to 17:30

Thursday 6 October: 9:30 to 16:30

GETTING TO THE ExCeL LONDON

London can easily be reached by plane and is served by six international airports and a very convenient railway system. Details of how to reach ExCeL London can be found at <http://excel.london/visitor/getting-here>.

By Plane

London has six international airports. London City Airport is recommended as it is less than a mile from ExCeL London. It takes just 5 minutes by taxi or 15 minutes by the Docklands Light Railway (DLR). The airport has 350 flights per day, from over 40 international destinations including Amsterdam, Dublin, Madrid, Nice, Frankfurt, Rome and Zurich.

London City Airport

Average journey time by public transport: 15 mins.

Depart London City Airport, taking the DLR west towards Canning Town. Change at Canning Town, heading east on the DLR towards Beckton. Arrive at Prince Regent for ExCeL London (East).

Gatwick Airport

Average journey time by public transport: 1 hour.

Depart Gatwick train station, heading towards London Victoria on the Gatwick Express or Southern Trains. From London Victoria take the London Underground and head east on the Circle (yellow) or District (green) line. Change at Westminster, heading east on the Jubilee line (grey). Change at Canning Town, heading east on the DLR towards Beckton to arrive at Prince Regent.

Heathrow Airport

Average journey time by public transport: 1 hour, 30 minutes.

real boards
real easy
real fast

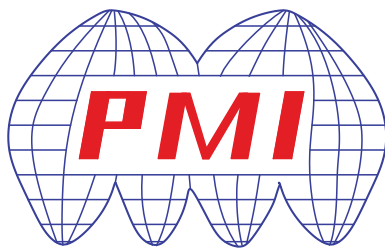


ProtoLaser. It's the real deal.

Design your circuit, load virtually any type of substrate, send your file, and you'll have real working circuit boards in minutes. So real in fact, you'll achieve consistent, high resolution geometries that chemical etching can't even touch. From prototypes to medium-run production, the ProtoLaser will liberate you from the board house.

www.lpkfusa.com/pls • 1-800-345-LPKF

LPKF
Laser & Electronics



Planar Monolithics Industries, Inc.

High Power Solid-State Switches

PMI offers a full line of High Power Solid-State Switches that range from 10 MHz up to 50 GHz with power handling up to 130 Watts CW, 5 kW peak. A wide range of standard models with various options are available.

Amplifiers – Solid State

**Attenuators – Variable/
Programmable**

**Couplers (Quadrature,
180° & Directional)**

Detectors – RF/Microwave

**DLVAs, ERDLVAs
& SDLVAs**

**DTOs, VCOs, PLO, DROs,
& Frequency Synthesizers**

**Filters & Switched
Filter Banks**

**Form, Fit, Functional
Products & Services**

**Frequency Discriminators
& IFMs**

**Integrated MIC/MMIC
Assemblies (IMAs)**

IQ Vector Modulators

Limiters – RF/Microwave

Log Amplifiers

**Millimeter Wave
Components
(Up to 50 GHz)**

Miscellaneous Products

Monopulse Comparators

**Multifunction Integrated
Assemblies (MIAs)**

**Phase Shifters & Bi-Phase
Modulators**

**Power Dividers/Combiners
(Passive & Active)**

Pulse Modulators (SPST)

**Rack & Chassis Mount
Products**

**Receiver Front Ends
& Transceivers**

**SDLVAs, ERDLVAs
& DLVAs**

**Single Side Band
Modulators**

SMT & QFN Products

Switch Matrices

Switched Filter Banks

Switches – Solid State

Systems – Fly Eye Radars

Threshold Detectors

USB Products

Model: P2T-10M6G-45-R-5V-SFF-HIP20W

Frequency	0.01 to 6.0 GHz
Isolation	20 dB Min - Measured 73 dB at 0.01 GHz 23 dB at 6.0 GHz
VSWR	2.0:1 Typ.
Insertion Loss	2.8 dB Max. – Measured 2.54 dB
RF Input Power	20 Watts CW Max – Tested to 25 W CW
Switching Speed	100 ns Max – Measured 61.6 ns
Temperature	-55 °C to +85 °C Operating



Package Size:
1.20" x 1.00" x 0.50"
Connectors: SMA (F)
DC Voltage:
+5 VDC @ 45 mA

Model: P2T-500M10G-60-R-515-SFF-10WCW

Frequency	0.5 to 10.0 GHz
Isolation	60 dB Min - Measured 88 dB
VSWR	2.0:1 Max - Measured 1.6:1
Insertion Loss	2.5 dB Max - Measured 1.15 dB
RF Input Power	10 Watts CW Max - Tested at 10 W CW
Switching Speed	100 ns Typ – Measured 86 ns
Temperature	-54 °C to +85 °C Operating



Package Size:
1.20" X 1.00" X 0.50"
Connectors: SMA (F)
DC Voltage:
+5 VDC @ 43 mA
-15 VDC @ 38 mA

Model: P2T-500M18G-80-T-515-SFF-4W

Frequency	0.5 to 18.0 GHz
Isolation	70 dB Min - Measured 75.21 dB
VSWR	2.0:1 Max - Measured 1.86:1
Insertion Loss	3.5 dB Max - Measured 3.14 dB
RF Input Power	4 Watts CW Max - Tested at 4 W CW
Switching Speed	200 ns Max - Measured 60 ns
Temperature	-40 °C to +85 °C



Package Size:
1.00" X 1.00" X 0.50"
Connectors: SMA (F)
DC Voltage:
+5 VDC @ 116 mA
-15 VDC @ 144 mA

Model: P2T-6G18G-40-R-570-TFF-1D6KW

Frequency	6.0 to 18.0 GHz
Isolation	40 dB Min - Measured 40 dB
VSWR	2.0:1 Max - Measured 1.99:1
Insertion Loss	2.2 dB Max - Measured 2.04 dB
RF Input Power	100 Watts CW / 1.6 KW Peak - Tested to 130 Watts CW
Switching Speed	200 ns Max - Measured 165 ns
Temperature	-40 °C to +85 °C



Package Size:
2.00" sq X 0.50"
Connectors: TNC (F)
DC Voltage:
+5 VDC @ 265 mA
-70 VDC @ 17 mA



Visit us at:
Hynes Convention Center, Boston, MA
September 20-22, 2016
Booth # 804

West Coast Operation:

4921 Robert J. Mathews Pkwy, Suite 1
El Dorado Hills, CA 95762 USA
Tel: 916-542-1401
Fax: 916-265-2597

East Coast Operation:

7311-F Grove Road
Frederick, MD 21704 USA
Tel: 301-662-5019
Fax: 301-662-1731

sales@pmi-rf.com • www.pmi-rf.com

ISO9001-2008 REGISTERED

See us at EuMW Stand 77



European Microwave Week



When using the Heathrow Express, you can pre-book tickets at a discounted price. Take the Heathrow Express, heading to London Paddington. From Paddington take the London Underground and head east on the Bakerloo line (brown). Change at Baker Street,

heading south on the Jubilee Line (grey). Change at Canning Town, heading east on the DLR towards Beckton to arrive at Prince Regent.

Stansted Airport

Average journey time by public transport: 1 hour, 10 minutes.

Depart Stansted, heading to London Liverpool Street on the Stansted Express then head west on the London Underground on the Central Line (red). Change at Bank for the DLR towards Beckton to arrive at Prince Regent.

Luton Airport

Average journey time by public transport: 1 hour, 40 minutes.

Depart Luton or Luton Parkway, heading south towards London Blackfriars on the Thameslink Service. From Blackfriars take the London Underground and head west on the Circle (yellow) or District (green) line. Change at Westminster, heading east on the Jubilee line (grey). Change at Canning Town, heading east on the DLR towards Beckton to arrive at Prince Regent.

Southend Airport

Average journey time by public transport: 1 hour, 34 minutes.

Depart Southend Airport, heading towards London Liverpool Street on the Abellio Greater Anglia service. From Liverpool Street take the London Underground and head west on the Central Line (red). Change at Bank for the DLR towards Beckton to arrive at Prince Regent.

Parking

If you are using satellite navigation to drive to the venue, we recommend using postcode, E16 1DR. For more information and to see a map of the route, please visit tfl.gov.uk/. All onsite parking is pay and display, with the exception of the Royal Victoria multi-storey car park where payment can be made at three pay points at the end of your visit. All machines accept cash and credit card.

Public Transport Train

Rail services in the UK are run by a set of private train operating companies. London's main railway stations are: Charing Cross (27 minutes from ExCeL London), Euston (32 min.), King's Cross/St Pancras International (32 mins), Liverpool Street (26 min.), London Bridge (16 mins), Maryle-

FASTER, QUIETER, SMALLER SIGNAL SOURCES QUICKSYN SYNTHESIZERS

Design smaller and more efficiently with National Instruments QuickSyn synthesizers. The revolutionary phase-refining technology used in QuickSyn synthesizers enables blazing fast switching speeds, very low spurious and phase noise performance, wide frequency range, and small footprint.

ni-microwavecomponents.com/quicksyn



QuickSyn Lite Synthesizer



© 2016 National Instruments. All rights reserved.

See us at EuMW Stand 4



www.rosenberger.com

Test, Measurement & Calibration

RF and microwave components from Rosenberger play a key role in a variety of test, measurement and calibration applications. RF high precision connectors, adaptors & devices, PCB connections – solderless, modular system or even spring loaded products – calibration kits, microwave test cables, VNA test port cables or automated test equipment products – renowned companies trust the precision and quality of Rosenberger test & measurement products.

See us at EuMW Stand 60

Fields of Application

- Microwave measurements & VNA calibrations
- Lab testing
- Factory testing
- PCB connections
- Semiconductor test applications & high-speed digital testing
- Network testing
- Test & measurement equipment
- Service and support



European Microwave Week



bone (31 mins), Moorgate (26 min.), Paddington (32 min.), Victoria (40 mins) and Waterloo (17 min.).

Train tickets can be booked via:
www.thetrainline.com or www.nationalrail.co.uk or www.eurostar.com/uk-en.

London Underground

The Jubilee Line and the DLR are the quickest routes to ExCeL London. Alight at Canning Town on the Jubilee Line and change onto a Beckton-bound DLR train, getting off at Prince Regent for ExCeL London (east en-

trance) Visit tfl.gov.uk for information on routes and timetables.

River & Cable Car

The river route is serviced by MBNA Thames Clippers with departures from major London piers every 20 minutes. When travelling to ExCeL London alight at North Greenwich Pier for the O2, where you can use the Emirates Air Line Cable Car for a quick journey to the venue campus. See full list of fares at www.thamesclippers.com.

HOTEL RESERVATIONS

Horizon House has teamed up with Connex Hotels and Events to offer the ability to book accommodations for this exhibition at the most competitive rates. Simply visit the booking page at www.connexhotelsandevents.com/eumw2016-london.html or email sally@connexhotelsandevents.com.

SHOPPING & SIGHTSEEING

London is the city that has everything. There are so many places to shop, tour, eat, drink, etc. Top attractions include The British Museum, The Coca-Cola London Eye, St Paul's Cathedral, The National Gallery, The Natural History Museum, The Science Museum, The Tate Modern, Tower of London, Victoria & Albert Museum and Westminster Abbey.

For information on other top attractions, visit www.visitlondon.com.

Finally, ExCeL London has put together a number of guides that will help you to plan your time away from European Microwave Week: ExCeL. london/exhibitor/after-hours. ■



www.dowkey.com
 +1.800.266.3695
ASKDK@DOWKEY.COM



YOUR SWITCH SOLUTION™ SINCE 1945

THE EXPERT AND LEADER IN
RF SWITCHES AND SYSTEM INTEGRATION



Reliant Switch™ Series:
 0.03 dB Insertion Loss Repeatability
 & 10 Million Cycle Life

COTS Switch Matrix Products:
 with many software features &
 fast switching time

**Next Generation Waveguide
 Space Products:**
 Switches & Assemblies



**For complete coverage of
 the EuMW conference, event
 news, exhibitor product
 information and special
 reports from the editors of
 Microwave Journal, visit our
 online show daily at**

[www.mwjjournal.com/
 eumw2016](http://www.mwjjournal.com/eumw2016)

Size
Energy Costs

>

Performance

>

Power Density

<

<

*Introducing the Industry's Highest Output
Power GaN Transistor for L-Band Radar*

The CGHV14800F is a 50 V, L-Band GaN HEMT with output power of 900 W from 1.2 – 1.4 GHz

Request a sample by going to <http://go.wolfspeed.com/eumw2016>



VISIT US AT EUROPEAN MICROWAVE AT STAND 156 TO LEARN MORE ABOUT OUR PORTFOLIO OF RADAR PRODUCTS



WOLFSPEED.COM

Wolfspeed: leading the industry in RF GaN-on-SiC devices with more than 100 billion field hours.

Powering More. Consuming Less.™



Photo Courtesy of Shmuel Auster

THE 2016 EuMW DEFENCE, SECURITY AND SPACE FORUM

Richard Mumford
Microwave Journal *International Editor*

A forum on Wednesday, 5 October focused on defence and security in complex urban environments.
Rooms 8 to 11, ExCeL London

In the 21st century the scope of the defence, security and space sector goes beyond conventional combat zones and border control. Today technology has to address cyber security, secure communications, tracking and sensing of targets in different environments and adapt to operation in varied terrain and densely populated areas.

To reflect the activity of industry, academia and government addressing these issues and driving technology forward, the emphasis of this year's Forum is on Complex Urban environments, encompassing the challenges and opportunities for indoor/enclosed and urban communications and sensing technologies. The Forum has the scope to cover topics including: Smart City initiatives; 3D tracking technologies in complex and indoor environments; sensing complex targets in dense target environments; congested spectrum and network issues, including brown out issues in mmWave sensing; integrated mmWave sensing and universal RFID technologies.

The Forum will feature executives from industry, academia, the military and space agencies. It will be held in combination with the opening of EuRAD and will conclude with a round-table discussion and cocktail reception.

THE FORUM FORMAT

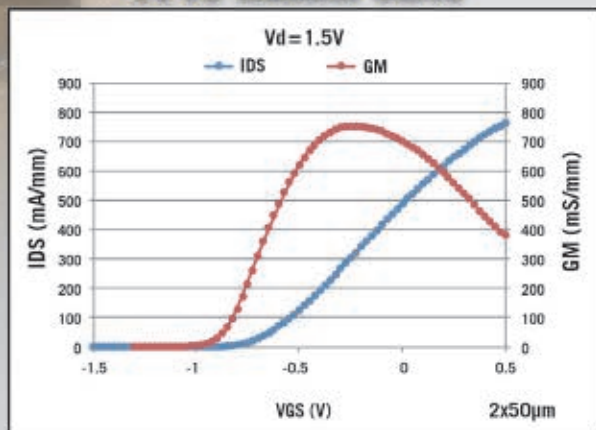
Below is a brief outline of each session. A full listing of the presentations at the time of going to press can be found on pages 98 & 99.

For the fifth year, the EuMW Defence, Security and Space Forum will incorporate the EuRAD Opening Session, which begins the day's proceedings from 09:00 to 10:40. After a coffee break the theme of this year's Forum will be dealt with comprehensively during the Complex Urban Sensing and Communication Session (11:20 to 13:00) where speakers from industry and academia will present RF solutions and systems that address the challenges imposed by operation in complex urban environments. This session will be presented by the

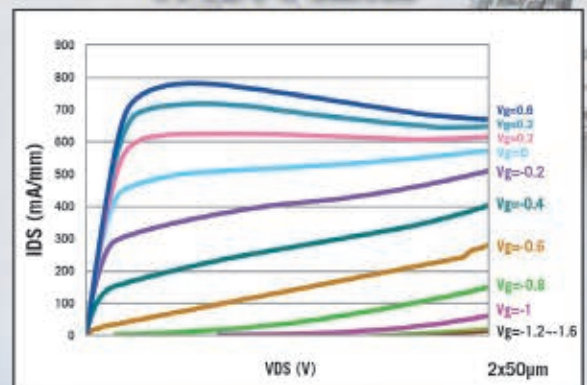
PP10-10/-11 0.1 μ m Power pHEMT

- 0.1 μ m high performance power / low noise process
- 50 μ m and 100 μ m thickness are standard
- Useable gain to 110GHz
- 4V operation - $P_{sat} > 800\text{mW/mm}$, $> 50\%$ PAE, and 13dB Gain at 29GHz

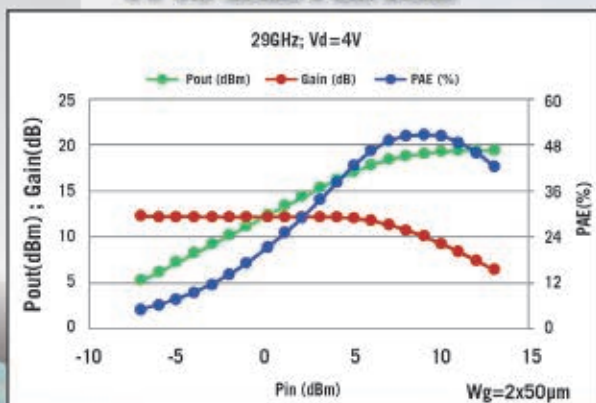
PP10 Transfer Curve



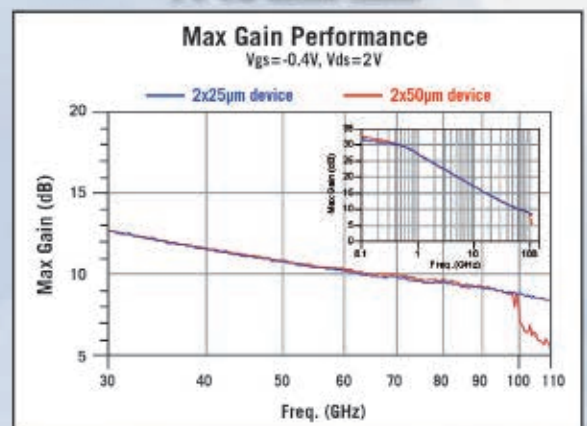
PP10 I-V Curves



PP10 Load Pull Data

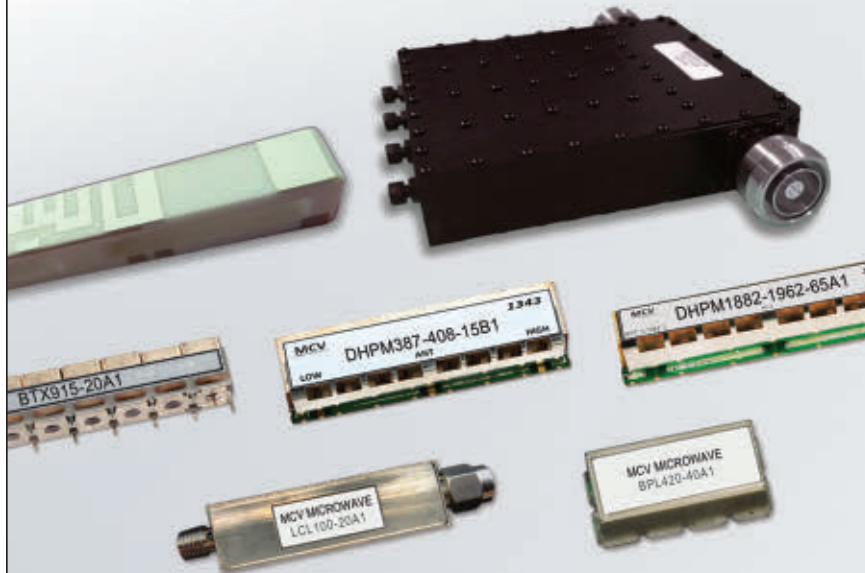


PP10 Max Gain





MCV
MICROWAVE



QUICK-TURN

CUSTOM PROTOTYPE RF/MICROWAVE FILTERS & ANTENNAS

WIRELESS INFRASTRUCTURE

PUBLIC SAFETY

MILITARY & SPACE

SATELLITE RECEIVER

PRODUCTS

LTE DAS and In-Building Network Filter Solutions

High Power/Low PIM Filters and Duplexers

Bandpass, Band Reject Filters, Highpass, Lowpass Filters, Multiplexers

Ultra-high Q Dielectric Resonators and Meta Materials

Narrow Band and Broad Band Antennas

Call for a FREE Consultation

858.450.0468

mcv-microwave.com



European Microwave Week

key technical leaders in the various fields, providing a real world perspective into developing technologies and systems for urban sensing and communication.

Providing sustenance for the mind as well as the body, the Strategy Analytics Lunch & Learn Session (13:10 to 14:10) will add a further dimension by offering a market analysis perspective, illustrating the status, development and potential of the market.

The afternoon *Microwave Journal* Industry Panel Session (14:20 to 16:00) offers an industrial perspective on the key issues facing the defence, security and space sector. In accordance with the theme for 2016, the panel will address: Complex Urban Environments, encompassing the challenges and opportunities for indoor/enclosed and urban communications and sensing technologies.

Completing the technical sessions the EuMW Defence & Security Executive Forum (16:40 to 18:20) will provide a platform for high level speakers from leading defence and security companies to present their views and experiences on RF microwave technology trends and its use in urban environments. The presenters are complemented by speakers from government agencies and research organisations who will offer their perspective of military, security and industry needs, programmes, budgets and research into next generation systems.

The event will conclude with a cocktail reception (18:20 to 19:00) that will afford delegates the opportunity to network and discuss the issues raised throughout the Forum in an informal setting.

REGISTRATION AND UPDATES

Registration fees are £10 for those who have registered for a conference and £40 for those not registered for a conference. Register online at www.eumweek.com. As information is formalized, the Conference Special Events section of the EuMW website will give further details and will be updated on a regular basis. ■

RIDE THE WAVE

RF PRODUCTS AND FOUNDRY SERVICES



GAAS & GAN
EUROPEAN
SOURCE



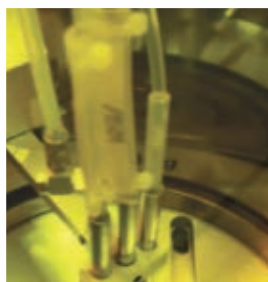
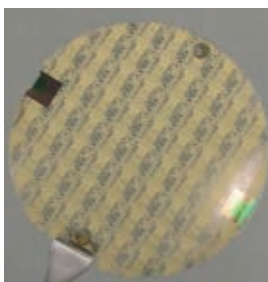
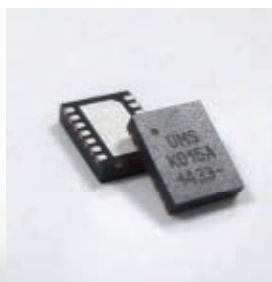
CUSTOM AND
STANDARD
SOLUTIONS



MIXED SIGNAL
AND POWER
PRODUCTS



LONG TERM
PARTNERSHIP



See us at EuMW Stand 7a





The 2016 Defence, Security and Space Forum At European Microwave Week

Wednesday, 5 October

A focused Forum addressing the application of RF and microwave technology to Complex Urban Environments.

The emphasis will be on complex urban environments, encompassing the challenges and opportunities for indoor/enclosed and urban communications and sensing technologies. The Forum has the scope to cover topics including: Smart City initiatives; 3D tracking technologies in complex and indoor environments; sensing complex targets in dense target environments; congested spectrum and network issues.

Programme:

09:00 – 10:40 EuRAD Opening Session

11:20 – 13:00 Complex Urban Sensing and Communication

Speakers from industry and academia will present RF solutions and systems that address the challenges imposed by operation in complex urban environments. Confirmed speakers include:

- New Transceiver Technology Applied to Standoff Submillimetre-Wave Imaging Radar – *Ken Cooper, JPL*
- Indoor and Urban Environment Location of Moving People and Vehicles Using Signals of Opportunity – *Pierfrancesco Lombardo, University of Rome*
- Communication Satellite Impact on TV and Data Broadcasting Through Urban Environments – *Erdem Demircioğlu, Turksat International*
- Analyzing Doppler Spectrum Using WiFi for Trained-Once Device-Free Crowd Counting and Occupancy Estimation – *Alfonso Farina, Leonardo Company*

13:10 – 14:10 Strategy Analytics Lunch & Learn Session

This session will add a further dimension by offering a market analysis perspective, illustrating the status, development and potential of the market.

14:20 – 16:00 Microwave Journal Industry Panel Session

The session offers an industrial perspective on the key issues facing the defence, security and space sector. In accordance with the theme for 2016, the Panel will address: *Complex Urban environments, encompassing the challenges and opportunities for indoor/enclosed and urban communications and sensing technologies.*

Confirmed speakers include:

- Spectral Detection and Visualisation with Distributed RF Receivers – *Raymond Shen, Keysight Technologies*
- Addressing Communications in Urban Environments with UltraCMOS and Intelligent Integration – *Andrew Christie, Peregrine Semiconductor*
- GaN Integration in Defense and Security Applications – *Dean White, Qorvo*
- How do Mobiles Develop the 6th Sense? – An Introduction to LTE-based Device-to-Device (D2D) Communication Principles – *Meik Kottkamp, Rohde & Schwarz*

Sponsored by:



Register at
www.eumweek.com



**EUROPEAN
MICROWAVE
WEEK**
LONDON, UK
3-7 OCTOBER 2016
www.eumweek.com

ExCeL London • Rooms 8 to 11



Photos Courtesy of Simuel Auster

16:40 – 18:20 **EuMW Defence & Security Executive Forum**

High-level speakers from leading defence and security companies present their views and experiences on RF microwave technology trends and its use in urban environments. Confirmed presentations include:

- Challenges for Maritime Border Surveillance Radar
– *Tony Brown, EASAT*
- Challenges in the 'Future Borders' Concept - Combining Technology, People and Processes
– *Roger Cumming, Fenley-Martel (ex UK Home Office)*
- Challenges in Urban Sensing and Communications
– *Ian Beresford, QinetiQ*

18:20 – 19:00 **Cocktail Reception**

Registration and Programme Updates

Registration fees are £10 for those who have registered for a conference and £40 for those not registered for a conference.

As information is formalized, the Conference Special Events section of the EuMW website will be updated on a regular basis.

Organized by:



Frequency Matters.



Microwaves in Europe: Leaving Unanswered Questions

Richard Mumford

Microwave Journal *International Editor*

As the UK waits in the departure lounge for the final flight of Brexit Airways, both the UK and the remaining 27 Member States of the European Union are fastening their seatbelts for a journey into the unknown. Just what is on the Horizon (2020) for Europe as a whole and the RF and microwave industry in particular? This report aims to set the scene, evaluate current activities and initiatives, and proffer possible scenarios.

On 23 June 2016 the Union of Europe took on a different landscape as the United Kingdom decided not to remain united with the other 27 Member States and voted to leave the EU. The big question is what happens next and what the impact will be regarding economy, trade, research and industry. Indeed, the only certainty is the unpredictability of the unknown.

The UK's leap of faith is also a leap in the dark—no Member State has left the European Union before and the UK has to ne-

gotiate the terms and conditions for packing its bags, the responsibilities it will continue to undertake and the “maintenance” it is prepared to pay for doing so. Ultimately and inevitably, it will be the politicians and lawyers who decide who gets custody of the proverbial dog and CD collection and who pays for further education!

“The UK’s leap of faith is also a leap in the dark...”

Even the staunchest “Brexiters” recognise that the UK will need to continue to trade and cooperate with the rest of the EU, especially if it wants to have a voice on global issues. In so many areas, the UK has led and helped

shape the world we live in. RF and microwave technology has been no exception, with the pioneering work of Newton, Faraday, Maxwell and others woven into the fabric of our technological history. That rich tapestry of innovation continues today with the UK hosting centres of excellence and technology hubs, allied to the endeavour of scientists and engineers working to develop state-

of-the-art technology, a fair proportion of which is in collaboration with European colleagues, either under commercial agreements or as part of Horizon 2020.

The European Commission has committed its intent, finances and organisational structure to enable Europe to play a significant role and strive to take the lead in technology that will shape the global future such as 5G, the Internet of Things (IoT), materials technology and the automated car, all of which are key areas of development for our industry. The UK cannot afford to divorce itself from cooperative programmes and agreements that already exist or risk being secluded from future partnerships or initiatives. So, following the UK's decision, what is the likely scenario regarding technology development in Europe, in general, and the impact on the RF and microwave industry, in particular?

HORIZON2020
INITIATIVES
BREXIT
5G UK
Europe



We saw it coming. Dial us in.

**SemiGen brand:**

Limiters
PINs
Beam Lead PINs
Schottky Diodes
Step Recovery Diodes
Point Contact Diodes
Capacitors *Space Qualified*
Attenuator Pads
Inductor Coils

**MIL-STD 883 Hybrid
and PCB Assembly****Popular Bonding
Supplies in Stock**

A lack of skilled assemblers, mergers, acquisitions, device and bonding tool shortages... they can drive a program manager mad. Dial into our high quality services, components, and supplies today and be ready for whatever comes next.

Call or visit us to request device samples and pricing.

603-624-8311 | SemiGen.net

EDI 2016
CON Electronic Design
Innovation Conference
Workshops & Exhibition
Booth 505

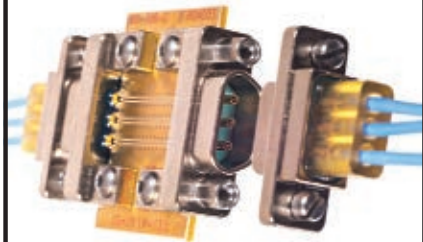

SemiGen
Get the Edge

Proven Interconnect PERFORMANCE

Industry-leading INNOVATION



SuperMini Board-to-Board
DC to 67 GHz blind-mate
connectors assure interconnect
performance for PCBs stacked
as tightly as 3 mm.



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

Our connectors have the lowest VSWR,
insertion loss and RF leakage.

- SuperSMA
- 2.92 mm (K)
- 1.85 mm (V)
- 1.0 mm (W)

CONTACT US FOR A QUOTE

www.southwestmicrowave.com

See us at
EuMW Stand #179


**SOUTHWEST
MICROWAVE**

SpecialReport

EU law continues to apply in the UK until the country leaves the union. To start the process, the UK government must invoke Article 50 (the exit clause) of the Lisbon Treaty. At the time of going to press, the latest indication from the UK government is that the withdrawal process will not be triggered until the end of 2016 at the earliest. After that, negotiating the terms of departure and untangling financial ties with Brussels is expected to take approximately two years.

One issue that was a key argument for those proposing that the UK leave the European Union was that it contributes more to the EU than it receives. However, one exception is in the field of science and innovation, where the seven year Horizon 2020 Programme that began in 2014 and which has just entered the 2016 to 2017 Work Programme (outlined later in this article) has a total budget of around €80 billion to fund, support and take to market the results of collaborative science and innovation, with specific emphasis on the involvement of small and medium-sized enterprises (SME) and industry. As the name suggests, the programme extends until 2020 when it will be succeeded by Framework Programme 9.

It is believed that the UK's existing Horizon 2020 commitments will be honoured and that valid funding/agreements between the EU and the UK will continue. However, there may be a question mark over future plans being considered in Horizon 2020, where they involve bids for multi-year funding from the UK. To address this issue, the UK government is being urged to continue participation in Horizon 2020, which it can do by becoming an "associate country" and paying a share of the programme's costs in proportion to gross domestic product. Non-EU Member States such as Norway and Turkey currently take part in Horizon 2020 as associate countries.

Significant for the RF and microwave industry, membership of organizations such as the European Space Agency (ESA) is unaffected, as it is not an EU institution, but an intergovernmental one that negotiates directly with Member States about projects and funding at annual ministerial conferences. Some EU countries are only "cooperating members," while some non-EU countries like Switzerland and Norway have full membership.

While the UK's exit from the EU has been the headline grabbing focus of attention since the decision was taken, life, collaboration, investment, research and technological development go on. So, what significant initiatives are being taken and what are the prospects for the future?

HORIZON 2020

As previously highlighted, Horizon 2020 is the EU's largest research and innovation funding programme. It has now entered its next phase with the Horizon 2020 Work Programme for 2016-2017, which provides a budget of almost €16 billion.

In line with the agenda of the European Commission President Jean-Claude Juncker, the two-year programme is designed to contribute to the jobs, growth and investment package to strengthen Europe's global competitiveness. Research and innovation investments will cover both the immediate requirement to stimulate the re-industrialisation of Europe as well as the objective of building a solid knowledge base that will be vital for being in a position to take a lead in next-generation innovation.

**“...take a lead
in next
generation
innovation.”**

Through the European Research Council (ERC), researchers will be able to investigate the best ideas that could lead to innovative growth-enhancing breakthroughs. In 2016 alone, almost €1.7 billion—worth around 1000 grants—will be made available through ERC calls.

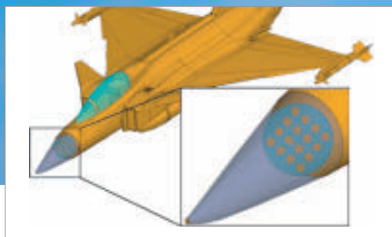
Importantly for industries such as RF and microwave, around €2 billion of the Work Programme 2016-17 funding will go to SMEs, including €740 million through a dedicated instrument which should benefit over 2000 highly innovative SMEs. On top of that, financial instruments, targeted in particular at SMEs, will increase the opportunities for funding to support research and innovation. These investments will be intensified with the support of the European Fund for Strategic Investments (EFSI).

The programme will support a range of cross-cutting initiatives, many

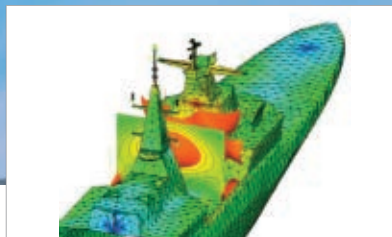
One Product - Multiple Solvers

Fully hybridized for optimal EM simulation efficiency

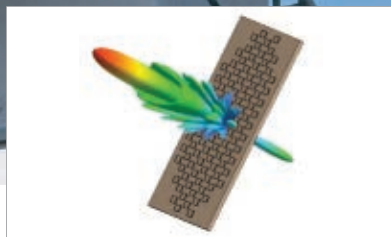
Visit us on
**Booth
#219 at
EuMW
2016**



Radome Analysis



Antenna Placement



Antenna Array

FEKO for Antenna Design & Placement

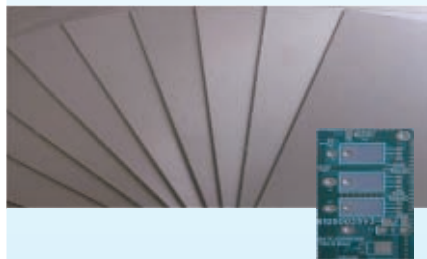
FEKO includes several computational methods for the efficient analysis of different antenna types: aperture, horn, dielectric, planar, broadband, windscreen, large finite arrays and radomes. Hybridization between solvers has defined us as a leader in antenna placement on aircraft, vehicles, satellite and ships.

Join the thousands of Altair customers applying Simulation-driven Innovation to design the next generation of antennas.

Learn more: altairhyperworks.com/FEKO



The Manufacturer of High-frequency Microwave Laminate



ZYST RF Circuit Materials— ZYFXXXD/ ZYFXXXCA

Product Feature:

Dk: 2.14~2.65(ZYFXXXD);
2.55~3.50(ZYFXXXCA)

Low loss

IPC-4103

Low Z-axis CTE for reliable PTHs

Price better than alternatives

Low fabrication cost

Dimensionally Stable

High Peel Strength

Lead free, RoHS compliant

Fast bulk delivery

Typical Applications:

- Military radar, missile guidance systems
- Base station antenna
- Filters, couplers, low noise amplifier
- Digital broadcasting antenna
- Automotive Radar
- Satellit/Cellular Communications
- Satellite TV
- GPS, Beidou

Changzhou Zhongying SCI & TEC Co., Ltd.

Add: No.28 Feilong West Road, Zhonglou
Development Zone, Changzhou,
Jiangsu, P.R.China

Tel: (+86-519) 83253355

Fax: (+86-519) 83253350

Email: pcb@czyst.cn; Sales@czyst.cn

www.czyst.net www.czyst.cn

of which directly and indirectly impact the RF and microwave industry: technologies and standards for automatic driving (over €100 million), to improve safety and energy efficiency while reducing congestion and emissions; the IoT (€139 million), to address digitalisation of EU industries; and the modernisation of Europe's manufacturing industry (€1 billion); and Smart and Sustainable Cities (€232 million), to better integrate environmental, transport, energy and digital networks in urban environments.

LEADING INITIATIVES & OVERVIEWS

Horizon 2020 is designed to generate an environment that encourages research and innovation. In an industry so diverse as RF and microwave, it is impossible to cover every activity. There are areas where the industry is particularly proactive and specific key technologies where Europe is leading the way, together with smaller scale efforts of engineers and designers endeavouring to make a difference and push the boundaries.

The following offers a snapshot of pioneering activity in key projects, together with overviews from the three 2016 European Microwave Week (EuMW) Conference chairmen who are well placed to offer matchless insight into key areas of development and identify future trends.

“...meeting
the needs of
tomorrow's
connected
society...”

5G

This month's cover story is titled “The 5G mmWave Radio Revolution” (see page 22). Such a potent word as “revolution” is used all too frequently, but to see 5G reach the goals it is aiming for and to achieve its full potential will be worthy of any plaudits. In his cover story, Amitava Ghosh of Nokia Bell Labs illustrates the technical challenges that are being addressed and mentions some of the research and development work being carried out.

5G will be a critical factor in formulating a “digital society,” and Europe

has demonstrated its determination to lead global development of this vital technology. Showing its intent, in December 2013, the European Commission signed an agreement with the 5G Infrastructure Association to establish a Public Private Partnership on 5G (5G PPP), which is the EU flagship initiative to accelerate research in 5G technology.


The European Commission has identified 5G standards as one of the five priority areas under the Digitising European Industry initiative and has earmarked public funding of €700 million through Horizon 2020 to support this activity, which EU industry is set to match by up to five times, to more than €3 billion.

At the Mobile World Congress (MWC) 2015, the European Commission and Europe's tech industry presented the EU's vision of 5G technologies and infrastructure. Earlier this year at MWC 2016, the European Commissioner for the Digital Economy and Society, Günther H. Oettinger, announced that Europe has started work on a 5G Action Plan that aims to put Europe at the forefront of deployment of standardised 5G networks from 2020.

Industry has responded with the 5G Manifesto, which was signed by the CEOs of 17 European telcos, equipment vendors and satellite operators, illustrating that 5G will involve mobile, fixed and satellite network technologies. Five non-telecom companies will also participate in the next phase, including Airbus Defence & Space and Thales Alenia Space.

The manifesto commits to delivering a roadmap of trials and demonstrators by January 2017, to achieve interoperability of networks and use cases for the period 2018 to 2020, prior to full deployment. It also outlines that commercial 5G services will require a large amount of harmonised spectrum and calls on the EU to foster standardisation of 5G spectrum and to ensure that sufficient spectrum is licensed in time and at reasonable prices.

Although the 5G Manifesto was published after the UK voted to leave the EU, it is signed by all four of the UK's mobile operators (or their parent companies) and specifies 28 EU Member States. Funding is likely to be an issue for the UK once it leaves the EU. Spectrum allocation is be-



The spark is in you.
(We're just here to help you ignite it.)



Keysight X-Series Signal Analyzers	UXA	PXA	MXA	EXA	CXA
Max. Frequency	50 GHz	50 GHz	26.5 GHz	44 GHz	26.5 GHz
Max. Bandwidth	1 GHz	510 MHz	160 MHz	40 MHz	25 MHz
Multi-touch UI	Yes	Yes	Yes	Yes	Yes

Your next breakthrough. It's what drives Keysight X-Series signal analyzers. With multi-touch, they're the benchmark for accessible performance—easily linking cause and effect to put you closer to the answer. Plus with apps, software and upgradability, you'll be ready to make inspired connections for years to come.

See the video and get inspired.
www.keysight.com/find/X-Series-inspired

USA: 800 829 4444 CAN: 877 894 4414

© Keysight Technologies, Inc. 2016.

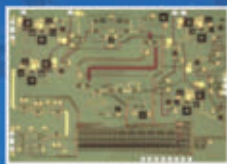
See us at EuMW Stand E2



Unlocking Measurement Insights

Agilent's Electronic Measurement Group is now **Keysight Technologies**.

RF&MICROWAVE MULTI-FUNCTIONAL CHIPS AND ASSEMBLIES UP TO 65 GHz



GaAs PHEMT MMIC Low Noise Amplifier, 2-18 GHz
Electrical Specifications: TA = +25°C, VDD = +5V, IDD = 67 mA

Model	Freq. (GHz)	Gain (dB)	Gain Flatness (dB)	P _{1dB} (dBm)	NF (dB)
KK03014	2-6	16	±0.2	13.3	2.4
KK03016	6-12	16.5	±0.2	13.6	2.4
KK03018	12-18	17.2	±0.4	15	2.4

GaAs PHEMT MMIC Frequency Conversion MFC, 4-8 GHz
Electrical Specifications: TA = +25°C, LO = +15dBm, VDD = +5 V, IDD = 34 mA

Model	Freq. RF In (GHz)	Freq. RF Out (GHz)	Conversion Gain (dB)	LO to RF Isolation (dB)	LO to RF Rejection (dB)	RF to RF Isolation (dB)	Stand. P. Loss (dBm)
KK03033	4-8	20-22	9	60	50	5	+1

GaAs PHEMT MMIC Amplitude-Phase Controlled MFC, 8-12 GHz
Electrical Specifications: TA = +25°C, VDD = +5V

Model	RF In (GHz)	Freq. RF Out (GHz)	Gain (dB)	P _{1dB} (dBm)	Rejection Out of Band (dB)	Phase Error (deg)	Linearity (dBm)	Modulation Loss (dB)
AK04012	8-12	8	9	10	12 dBm	6 dB	-1.1 dBm	30
	Tr. Band	8-12	8.5	16.5	12 dBm	10 dB	-1.1 dBm	30



Down Converter

- Low Spurious and High Channel-Channel Isolation



Front-end Assembly

- Ultra-low Spurious and High Reliability



Switch Filter Bank

- Sharp Filter Rejection and High Isolation



SOLVA

- Rapid Rise Time and Ultra Wide Dynamic Range



LTCC T/R Module

- Compact Size and Light Weight



T/R Assembly

- Multi-layer High-density Integration



OEM&ODM and Custom Design Available

For detailed info and other products pls contact at
Daisy Huang / Project Manager daisy527@163.com
Tel: 86-28-81705322 Fax: 86-28-81700845
Website: <http://www.seekorrf.com>

See us at EuMW Stand 40

SpecialReport

ing coordinated at a global level, so it appears inevitable for the departed UK to harmonise its regulations with those agreed to by the EU if it wants to be a major player.

Those drawing up the 5G Action Plan, which is expected to be presented in September 2016, will consider the recommendations in the 5G Manifesto as well as feedback from a public consultation that closed in July.

In the meantime, 5G development in Europe cannot afford to delay or lose momentum with crucial research and testing underway across Europe. For example, the 5G Innovation Centre (5GIC) at the University of Surrey, UK, aims to drive the delivery of mobile communications and wireless connectivity capable of meeting the needs of tomorrow's connected society and digital economy. Research is conducted in close collaboration with 5GIC's members, who represent all aspects of the wireless communications and future internet domains and include the major telecom service providers, infrastructure vendors, device and car manufacturers.

Similarly, in Finland, the 5G Test Network Finland (5GTNF) test environment, which is a joint venture between industry, academia and the Finnish government, is promoting research and technology development by interconnecting 5G test networks belonging to the 5th Gear Programme funded by Tekes. The 5GTN is a scalable test environment enabling future business model piloting and service development in real life use cases that provide a platform for testing and developing the 5G system's technology components.



RF and Microwaves

Sector Overview by Ian Hunter, EuMC 2016 Chair, with contributions from EuMC 2016

TPC Chairs: Steve Nightingale, Ian Robertson and Al Abunjaileh

We who work in the RF and microwave industries may sometimes forget how essential these technologies have become to society. Imagine turning the clock back to a world without wireless communications, radar, GPS or satellite communications.

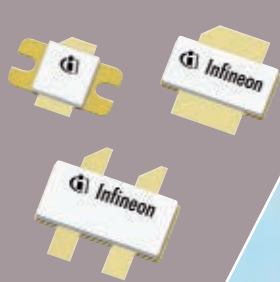
The development and maturity of RF and microwave technologies has led to increased system capability becoming available to both the civilian

and defence business sectors. In the defence sector, for example, a mobile ground platform may include a number of RF and microwave systems, including communications radios, high capacity data radios, ECM equipment to counter radio controlled threats, as well as other sensor systems that can detect what is in the air, in the vicinity on the ground and buried in the ground. This complexity has introduced a higher probability of interference between the different systems. This in turn has led to an increase in the requirement for interference mitigation technologies, such as fixed and electronically tuneable filters, signal cancellation techniques and use of time division multiplexing methods.

The mobile communications industry continues to drive filter and power amplifier technology, especially for base stations. Antenna sharing drives demand for filter-combiners, both single and multi-band. More flexible architectures and 5G are driving the need for tuneable and adaptive filters. Miniaturisation remains a main objective, with many variations of ceramic filters being developed. Highly linear power amplifiers, which will operate with maximum efficiency, even with signals with high peak-to-average ratio, remain of critical importance to the industry.

Higher demands on data for Sat-Comm systems require higher flexibility in terms of coverage, frequency bands and connectivity. This derives the need for advanced antenna and payload systems. While a traditional transparent payload system would cover Europe using a single beam, for example, there is now a demand for regenerative payloads with multi-beam antennas. These are now progressively used commercially to allow for frequency reuse (i.e., higher bandwidth) and ultimately could focus the capacity on desired markets, reducing the cost per bit. It is expected that the market will drive the satellite systems to be more complex with the development of flexible payloads and active antennas to increase the operational revenue of the satellite system.

In the area of RFICs and MMICs, it is very clear that the trend continues towards high power with GaN technology and high levels of integration and higher frequencies with silicon technology. For very high power applica-



Rugged LDMOS & GaN RF power transistors

Cellular, radar, commercial avionics, ISM & broadcast applications

Infineon's latest generation of RF Power products enable the design of compact, broadband and efficient RF power amplifiers. Our LDMOS & GaN technologies provide the most advanced, rugged, and stable solutions for pulsed and CW applications

- > 450 MHz to 2700 MHz
- > 5 W to 1000 W
- > High ruggedness & efficiency
- > High RF consistency
- > Broadband performance
- > Optimized for DPD systems
- > Reference designs

600 W L-Band GaN HEMT

- > $P_{3dB} = 610$ W
- > 1200 – 1400 MHz
- > 70% Efficiency
- > 18 dB Gain
- > Evaluation board
– 1200 – 1400 MHz



GTVA126001FC

Radar and commercial avionics LDMOS product line

Product	Operating frequency (MHz)	Matching	@ P_{1dB}			@ P_{3dB}			Pulse	V_{DD} (V)	Package type
			P_{OUT} (W)	Gain (dB)	Eff (%)	P_{OUT} (W)	Gain (dB)	Eff (%)			
PTVA030121EA	390 – 450	Unmatched	12	25.0	69	14	22.0	73	12 μ s, 10% DC	50	H-36265-2
PTVA035002EV	390 – 450	Unmatched	400	19.5	65	500	17.5	67	12 μ s, 10% DC	50	H-36275-4
PTVA102001EA	1030 / 1090	I/O	200	18.0	57	230	16.0	58	128 μ s, 10% DC	50	H-36265-2
PTVA104501EH	960 – 1215	I/O	450	17.0	57	490	15.0	55	128 μ s, 10% DC	50	H-36288-2
PTVA101K02EV	1030 / 1090	I	920	18.0	56	1090	16.0	57	128 μ s, 10% DC	50	H-36275-4
PTVA120251EA	500 – 1400	Unmatched	30	16.0	56	40	14.0	59	300 μ s, 10% DC	50	H-36265-2
PTVA120501EA	1200 – 1400	I	54	16.5	55	63	14.5	57	300 μ s, 10% DC	50	H-36265-2
PTVA123501EC/FC	1200 – 1400	I/O	375	16.0	56	415	14.0	57	300 μ s, 12% DC	50	H-36248-2/ H-37248-2
PTVA127002EV	1200 – 1400	I/O	700	16.0	55	800	14.0	58	300 μ s, 10% DC	50	H-36275-4

Radar and commercial avionics GaN product line

Product	Operating frequency (MHz)	Matching	@ P_{3dB}			Pulse	V_{DD} (V)	Package type
			P_{OUT} (W)	Gain (dB)	Eff (%)			
GTVA104001FA	960 – 1215	I	410	18.5	70	128 μ s, 10% DC	50	H-37265J-2
GTVA107001FC	960 – 1215	I	750	17	70	128 μ s, 10% DC	50	H-37248-2
GTVA126001FC	1200 – 1400	I	610	18	70	300 μ s, 10% DC	50	H-37248-2
GTVA123501FA	1200 – 1400	I	370	18	72	300 μ s, 10% DC	50	H-37265J-2

New solutions for radar & ISM applications

700 W Avionics GaN HEMT

- > GTVA107001FC
- > $P_{3dB} = 750$ W
- > 960 – 1215 MHz
- > 70% Efficiency
- > 17 dB Gain



H-37248-2

350 W L-Band GaN HEMT

- > GTVA123501FA
- > $P_{3dB} = 370$ W
- > 1200 – 1400 MHz
- > 72% Efficiency
- > 18 dB Gain



H-37265J-2

180 W S-Band GaN HEMT

- > GTVA311801FA
- > $P_{3dB} = 180$ W
- > 2700 – 3100 MHz
- > 50% Efficiency
- > 12 dB Gain



H-37265J-2

New GaN solutions for cellular applications

Product	Operating frequency (MHz)	P_{1dB} typ (W)	Gain typ (dB)	Eff typ (%)	Test signal	Supply voltage typ (V)	Package type
GTVA261701FA	2620 – 2690	170	18	47	WCDMA	48	H-37265J-2
GTVA262601FA	2620 – 2690	260	18	40	WCDMA	48	H-37265J-2
GTVA263202FC	2620 – 2690	160 + 160	18	40	WCDMA	48	H-37248-4
GTVA220701FA	1800 – 2200	70	20	70	WCDMA	48	H-37265J-2

ISM (2.4 GHz) product line

Product	Operating frequency (MHz)	Matching	@ P_{1dB}			@ P_{3dB}			Test signal	V_{DD} (V)
			P_{OUT} (W)	Gain (dB)	Eff (%)	P_{OUT} (W)	Gain (dB)	Eff (%)		
PXFD252207NF	2400 – 2500	I/O	210	16.7	57	250	14.7	57.5	CW	28

General purpose transistors (700 MHz – 2200 MHz)

Product	Operating frequency (MHz)	Matching	P_{1dB} typ (W)	Gain typ (dB)	Eff typ (%)	Test signal	Supply voltage typ (V)	$R_{\theta JC}$ (°C/W)	Package type
PTFC270051M	900 – 2700	Unmatched	7.3	20.3	60	CW @ 2170	28	3.84	SON-10
PTFC270101M	900 – 2700	Unmatched	12	20.0	60	CW @ 2140	28	4.04	
PTVA120121M	500 – 1400	Unmatched	12	21.0	65	CW @ 821	50	4.97	
PTVA120252MT	500 – 1400	Unmatched	25	19.8	64	CW @ 960	48	2.6	SON-16

LDMOS integrated RF power amplifiers (700 MHz – 2200 MHz)

Product	Operating frequency (MHz)	P_{1dB} Typ (W)	Gain typ (dB)	Eff typ (%)	P_{OUT} avg (W)	Test signal	Supply voltage typ (V)	$R_{\theta JC}$ (°C/W)	Package type
PTMC210204MD	1800 – 2200	10+10	30.5	19	2.5	WCDMA	28	9.7/3.1	HB1DSO-14

See our entire portfolio of RF Power solutions at www.infineon.com/rfpower or contact us at highpowerRF@infineon.com

2017 INTERNATIONAL MICROWAVE SYMPOSIUM

4 – 9 JUNE 2017 HONOLULU, HAWAII

CALL FOR PAPERS

COME JOIN US IN HONOLULU AND ENJOY THE FLAGSHIP MICROWAVE THEORY AND TECHNIQUES SOCIETY (MTT-S) CONFERENCE IN THE ALOHA STATE OF HAWAII

The IEEE Microwave Theory and Techniques Society's 2017 International Microwave Symposium (IMS2017) will be held 4 - 9 June 2017 at the Hawai'i Convention Center in Honolulu, Hawai'i as the centerpiece of Microwave Week 2017. IMS2017 offers technical sessions, interactive forums, plenary and panel sessions, workshops, short courses, industrial exhibits, application seminars, historical exhibits, and a wide variety of other technical and social activities including a guest program. As usual, the Microwave Week 2017 technical program also comprises the RFIC Symposium (www.rfic-ieee.org) and the ARFTG Conference (www.arftg.org).

With over 8000 participants and 500 industrial exhibits of state-of-the-art microwave products, Microwave Week is the world's largest gathering of radio-frequency (RF) and microwave professionals and the most important forum for the latest research advances and practices in the field. IMS2017 offers something for everyone:

- The first-ever IMS Hackathon and IMS 3-Minute Presentation Competitions
- A 5G Summit showcasing next-generation wireless technologies
- An Executive Forum to discuss the latest in 5G and Internet of Things (IoT)
- RF Boot Camp – a three-quarter day course on RF/microwave basics
- The first-ever IMS Exhibitor Workshops for exhibitors to present the technology behind their products
- Networking events for Young Professionals and Women in Microwaves
- Student Design, Student Paper, Best Industry Paper, and Best Advanced Practice Paper Competitions
- Project Connect for under-represented minority engineering students, and the PhD Student Initiative for new PhD students
- *Teaching that inspires...students that aspire* – an exciting STEM program exposing middle school and select high school students, as well as their teachers, to RF/microwave technology

IMS2017 will include a comprehensive portfolio of events featuring recent 5G developments, including a plenary session, focus session, workshops, panel session, and a technology-development pavilion.

Paper Submission: Authors are invited to submit technical papers describing original work and/or advanced practices on RF, microwave, millimeter-wave, and terahertz (THz) theory and techniques. The deadline for submission is 5 December 2016. A double-blind review process will be used to ensure anonymity for both authors and reviewers. Detailed instructions on submitting a double-blind compliant paper can be found at www.ims2017.org. Papers will be evaluated on the basis of originality, content, clarity, and relevance to IMS.

Emerging Technical Areas: IMS2017 enthusiastically invites submission of papers that report state-of-the-art progress in technical areas that are outside the scope of those specifically listed in this Call for Papers, or that may be new to IMS, but are of interest to our attendees.

Workshops, Short Courses, Focus and Special Sessions, Panel and Rump Sessions: Topics being considered for these areas include Next-Generation Wireless Systems (5G and beyond), Internet of Space, Latest Technologies for RF/Microwave Measurements, and Advances in RFIC Technology. Please consult www.ims2017.org for a more detailed list of topics and instructions on how to prepare a proposal. Proposals must be received by 6 September 2016.

MicroApps and Exhibitor Workshops: The Microwave Application Seminars (MicroApps) serve as a forum for IMS exhibitors to present technology behind their commercial products and special capabilities. New for IMS2017 are Exhibitor Workshops, which offer IMS exhibitors a chance to present in-depth technical topics, via two-hour sessions, in a meeting room off the exhibit floor. Both presentation formats are open to all conference and exhibit attendees – MicroApps are free of charge and Exhibitor Workshops require a nominal fee. Please visit www.ims2017.org for details on submitting MicroApps and Exhibitor Workshop presentation ideas.



Symposium Chairs

W. Shiroma (General Chair), K. Miyashiro (Co-Chair),
V. Lubecke (Vice Chair)

Technical Program

O. Boric-Lubecke (Co-Chair), R. Miyamoto (Co-Chair),
T. Itoh (Senior Advisor), A. Crahan (Administrator)

Electronic Paper Management

J. Hacker, M. DeLisio, S. Owens

Workshops and Short Courses

C. Hang, Y.-C. Shih, K. Leong, B. Wu, C. Song,
L. Dunleavy, K. Hall, S. Kumar

Panel, Rump, Focus, and Special Sessions

C. Jackson, R. Kagiwada, A. Oki, T. LaRocca,
Y. Wang, C. Rodenbeck

Interactive Forum

D. Bibb, G. C. Huang, R. Perron

Plenary Session and 5G Summit

V. Lubecke, D. Choudhury, T. LaRocca,
D. Zuckerman

Technical Program Competitions

R. Gough, E. Yavari, X. Gao, A. Rahman, P. Orel,
S. Rosenau, J. Bandler, E. Kiley

TPC At Large

J. Lin, H. Okazaki

Publicity, Promotions, and Publications

M. Watanabe, K. Kogasaki, J. Roque, A. Scacchitti

Website and Program Book

C. Brough, D. Goshi, M. Moorefield

Social Media

K. Cho, J. Hofer, M. Visitacion, J. Warner

Microwave Magazine

I. Mostafanezhad, A. Singh

Local Arrangements / Operations

J. M. Akagi, A. Noveloso, Z. Bardai,
M. Tamamoto, J. T. Akagi, B. Lei, G. Uyeda,
A. Ohta, A. Combs

Finance and Registration

D. Goshi, K. Leong, T. Fujishige, R. Alongi,
N. Jordan

Student Volunteer Coordination

A. Morishita, J. Dang, T. Chun

Focus Groups

R. Pang, R. Iwami, B. Lei

Young Professionals

A. Zamora, K. Lu, W. Tonaki, T. Sharma,
K. Allen

Women in Microwaves

C. Kitamura, J. Nakatsu, A. Pham,
S. Yamada

STEM and Project Connect

C. Ishii, K. Matthews, D. Ah Yo, R. Mukai,
A. Noveloso, K. Lau, G. Zhang

MicroApps and Exhibitor Workshops

J. Guzman-Vazquez, G. Uekawa, J. Weiler,
B. Wu

Historical and University Exhibits

A. Combs, J. Hausner, J. Navarro, K. Sarabia

Global Ambassadors

K. Wu, D. Zimmerman

Conference and Exhibition Management

E. Vega, L. Wood, S. Horn, D. Waldron

Senior Advisors

T. Weller, S. Kanamalluru

tions, power-combined GaN modules are becoming an attractive potential replacement for vacuum devices, whilst at the high frequency end devices are pushing into E-Band. In silicon, a number of centres of excellence are now demonstrating outstanding single-chip radar sensors well beyond 100 GHz and with integrated antenna arrays. Also, the EU DOTSEVEN project is addressing how to progress towards 0.7 THz SiGe HBT technology.

Recent developments in transceiver design at millimetre wave frequencies and above are being focused on, particularly with regards to packaging and interconnects. Significantly too, as device developments to address the “THz gap” such as the THz Quantum Cascade Laser are reported associated measurement challenges remain.

MATERIALS TECHNOLOGY

When Professors Andre Geim and Konstantin Novoselov of the University of Manchester, UK, discovered graphene in 2004, they unleashed a material with almost limitless potential across a multitude of applications, including semiconductor, electronics

and composites, many of which impact RF and microwave industries.

“...bring a new dimension to future technology...”

With its roots in Europe, it was considered paramount for the continent to remain at the forefront of its development, so as part of its Future and Emerging Technologies (FET) scheme, the European Commission launched the Graphene Flagship in October 2013. The ramp-up phase began with 76 academic and industrial partners in 17 countries and finished at the end of March 2016 with 152 partners in 23 countries, one third being industrial partners.

The next stage, which aims to move the project forward in its mission to transfer graphene and related materials from the laboratory into society, has begun with the Core One phase under the Horizon 2020 phase of the Flagship. With €45 million per year of

EU funding, the Core One phase runs from 1 April 2016 to 31 March 2018.

The Flagship's overriding goal is to take graphene, related layered materials and hybrid systems from a state of raw potential to a point where they can revolutionize multiple industries. This may bring a new dimension to future technology and put Europe at the heart of the process.



ICs & Semiconductors

Sector Overview by
Thomas Brazil,
EuMIC 2016 Chair

The 11th European Microwave Integrated Circuits (EuMIC) conference provides the opportunity to assess and reflect on developments in the essential material, device and circuit technologies that underpin the full spectrum of high frequency electronics.

The application drivers are clear, primarily arising from the continuing global explosion in data exchanged using radio-based technologies, with the next phase (5G) of mobile communications now coming firmly into view. This evolution will address not only a need for exceptionally high local rates of data transfer but also the requirements for highly distributed, generally low data rate nodes often associated with the deployment of the IoT. The trend towards mass market exploitation of millimetre wave bands to achieve these goals is especially apparent.

Of course, many other markets are also critically dependent on high frequency electronic components and circuits, ranging from the automotive sector, which is of high strategic importance to Europe, through space/defence and photonics to personal/wearable devices.

In terms of technologies to address these markets, there are at least three major groups. The well established GaAs-based technologies now offer a mature, commercially attractive option with good design support and rapid turn-around from foundries. In recent years, there has also been intense interest in wide bandgap GaN-based technologies.

A critical subsystem in RF or microwave-based communications links is the transmitter power amplifier, and GaN-based designs show particular promise in this application. For example, within the past year, a 2 W GaN-based power amplifier using a travel-



mm-Wave Test Systems and Fixture Solutions

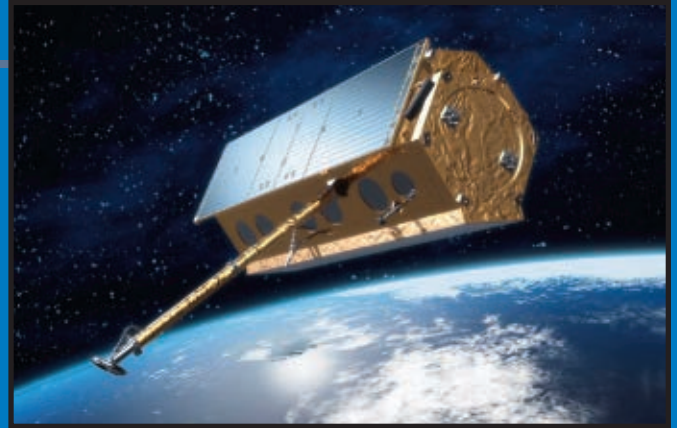
Serving your K- to V-Band Testing Needs

Accel-RF's **millimeter-wave Automated Accelerated Reliability Test Systems** and **fixture solutions** are available in standard frequency ranges from **18 to 67 GHz**. These systems deliver an unbeatable combination of capabilities needed for **accelerated aging** and **parametric testing** of RF semiconductor devices. Accel-RF offers the world's only line of fully integrated, modular platform, plug-and-play, automated accelerated life test systems.



info@accelrf.com | www.accelrf.com

Instantly Improve the Performance of Your Phased Array Radar!

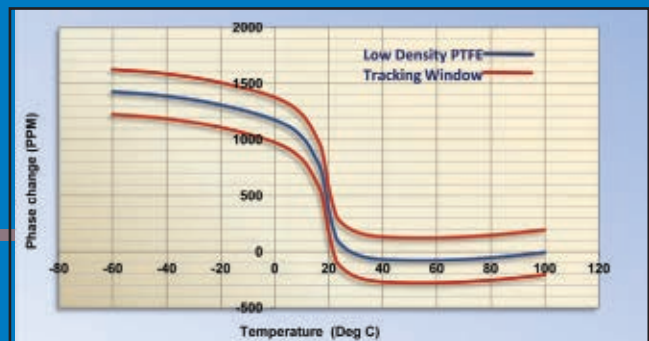
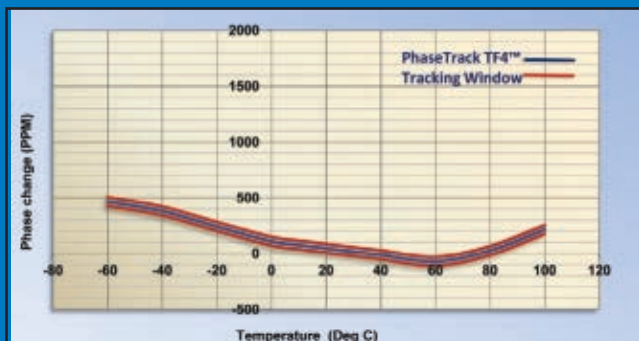


Phased Array Radar system performance has long been limited by the phase change over temperature of coaxial cables.

Not anymore!

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

Typical PhaseTrack TF4™ Performance Typical Low Density PTFE Performance



- Available NOW in various flexible coaxial cable and semi rigid coaxial cable assembly sizes
- Perfect for all Ground, Naval, Airborne or Spaceflight Phased Array Radar applications
- Frequency ranges to 40 GHz
- Wide range of connector types available
- Best Phase Tracking and Absolute Phase Change performance available

TIMES MICROWAVE SYSTEMS
An Amphenol Company



World Headquarters: 358 Hall Avenue, Wallingford, CT 06492 • Tel: 203-949-8400, 1-800-867-2629 Fax: 203-949-8423
International Sales: 4 School Brae, Dysart, Kirkcaldy, Fife, Scotland KY1 2XB UK • Tel: +44(0)1592655428
www.timesmicrowave.com

See us at EuMW Stand 12

ling wave concept has been demonstrated over a full 25 GHz bandwidth, from 75 to 100 GHz.

The need to manage linearity while maintaining high efficiency and dealing with demanding thermal issues means that circuit design is not straightforward in amplifier applications. GaN-based devices and MMICs, in particular, are still maturing, and this is reflected in continuing challenges in areas such as characterisation and modelling. Indeed, there is an entire session at this year's EuMIC devoted to the modelling of thermal and trapping effects in GaN-based and GaAs-based HEMTs.

A third strong area of technology is provided by devices and circuits based on Si and SiGe. LDMOS devices have been around for many years at lower frequencies, but the most remarkable growth has been driven by the excellent RF and microwave performance attainable at low cost by aggressively scaled MOS devices. Achieving efficient power amplifiers in MOS technology remains a challenge, although concepts based on stacking devices are under active investigation.

Also significant is the recently-completed DOTSEVEN project, part-funded by the 7th Framework Programme of the EU, which was an ambitious effort to achieve room temperature operation of SiGe HBTs up to 0.7 THz. A further dimension to the use of Si technology is the increasing trend to complement traditional RF and microwave circuit design with CMOS-based digital and mixed-signal functionality in areas such as digital baseband predistortion and RF digital-to-analog converters (DAC). In conclusion, ICs and semiconductors continue to show rapid progress, providing key enabling capability for vast new and existing markets.

AUTOMOTIVE

Europe has a strong and influential automotive industry that has always been at the forefront of technology and innovation. The automotive industry is the largest private investor of R&D in Europe with four out of the top five companies investing most in R&D in Europe being automotive companies.

Cars and trucks are so much more

“Europe has leading chip and radar sensor developers...”

than just a mode of transport. They have the potential to be the vehicle for technological development from infotainment to connectivity and automated driving. And it is the RF and microwave industry that is in the driving seat when it comes to providing that technology, from chips to sensors and the means of connecting the vehicle to outside communications. Europe has leading chip and radar sensor developers, test companies and others working independently and with the automotive manufacturers to put the technology on the road at a competitive cost.

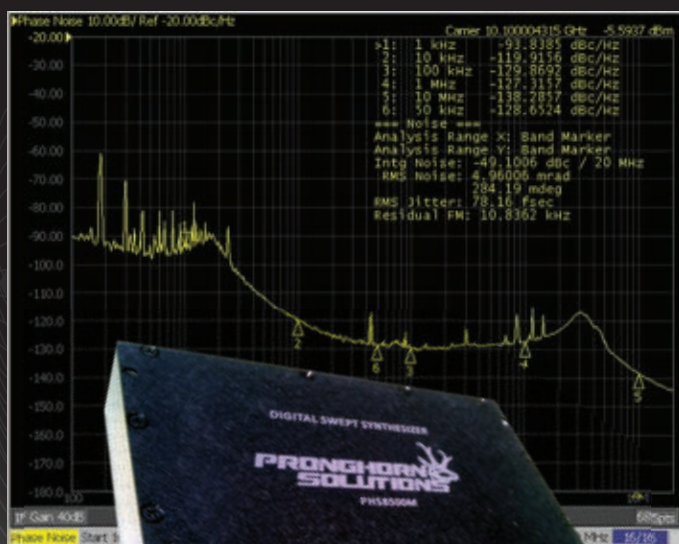
With initiatives such as the Advanced Radar Tracking and Classification for Enhanced Road Safety (ARTRAC), the EU has endeavoured to move development from the 24 GHz radar band sensor and use €1.12 million of EU funding to establish the worldwide harmonized frequency allocation for automotive radar systems in the 77 to 81 GHz (79 GHz) frequency range.

Of course the “buzz” is being created by “automated driving” and the “autonomous car.” A study commissioned by the German Federal Ministry of Economics estimates that the German market for driver assistance systems and automated vehicles will be worth €8.8 billion and create nearly 130,000 jobs by 2025. As part of the IoT, intelligent transport systems and connected vehicles will not only increase road safety, but can also help reduce congestion, raise fuel efficiency and improve social inclusion and accessibility.

Keen to avoid the all too familiar “developed in Europe but produced outside” scenario the European Road Transport Research Advisory Council (ERTRAC) is promoting a pan European approach, acknowledging its role in ensuring a harmonised approach towards implementation of higher levels of automated driving functionalities. Version 5 of the “ERTRAC Automated Driving Roadmap” was published last year. Its objective is to identify challenges to implementing higher levels of automated driving functions. To do

THE IDEAL SYNTHESIZER FAMILY FOR ANY APPLICATION

- Benchtop / Handheld / Modular Platforms
- Lowest Phase Noise
- USB, SPI, LAN programmable, SCPI compliant, COM Interface
- <10 Watt Power Consumption
- <100 Microseconds switching speed
- Programming transferrable between models



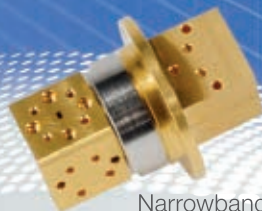
pronghorn-solutions.com | +1 (720) 808-9832 | sales@pronghorn-solutions.com

Millimeter Wave Rotary Joints

100 110 GHz



Broadband
Rectangular WG
Rotary Joint



Narrowband
Rectangular WG
Rotary Joint



Broadband
Circular WG
Rotary Joint



Broadband
Coaxial
Rotary Joint

General Test & Measurement Applications

- Antenna Measurement
- Wideband Network Analysis
- 2G/3G Industrial Material Scanners
- Industrial Sensors (Level Measurement)
- Space-Born Spectrometers

Radar Applications

- Pulse
- FMCW
- UWB



HIGH FREQUENCY PERFORMANCE WORLDWIDE

SPINNER designs and builds cutting-edge radio frequency systems, setting performance and longevity standards for others to follow. Many of today's mainstream products are rooted in SPINNER inventions. Headquartered in Munich, Germany, the global frontrunner in RF components remains the first choice in simple-yet-smart RF solutions.

SPINNER GmbH | Germany | rs@spinner-group.com | www.spinner-group.com



so, the whole industrial sector needs to evolve and adapt at a fast pace to stay ahead of global competitors.



Radar Sector

Overview by David
Daniels, EuRAD 2016
Chair

(Thanks to many distinguished colleagues who contributed their views and insights)

The 13th European Radar Conference highlights the advancing scientific and technical capability of the European radar industry. In the space sector, the European Space Agency has an active programme of earth observation by means of the Sentinel mission, comprising a fleet of satellites, some carrying the C-SAR sensor, which offers medium and high resolution imaging in all weather conditions. ESA has also developed ground radar for the detection of space debris.

Active electronically scanned array (AESA) radar technology is now relatively mature, with numerous systems in service on air, land, sea and space, examples being the Captor-E radar for the Typhoon fighter and the Searchmaster, an airborne surveillance radar.

There is an increasing drive to expand the multi-functionality of systems, both within traditional radar frequency bands and by the adoption of wideband or multi-band technologies. These developments present major technical and engineering challenges in implementing optimised solutions within cost and installation constraints. Major enablers are a modular, scalable approach, which limits non-recurring expenditure, and a drive to reuse technologies in as many applications as possible.

The development of lightweight antennas and faster processors, along with the need to equip smaller platforms, underlines the growing indispensability of synthetic aperture radar (SAR) technology. The developing use of UAVs in the defence portfolio is an area where innovation and cost reduction will assist the growth of suitable radar systems.

“...multi-tasking
still challenges
radar resource
management...”

For the commercial market, automotive radars are growing in importance and volume of manufacture. Europe is at the forefront of development and implementation of 24 GHz and 77 GHz radar chips for cars. Companies in niche markets such as security, sensing and measurement are also active, and radars for drone detection, IED detection, airport security scanning and pedestrian detection are either in development, trials or production.

The technology of active array radar systems is well established, but few operational systems exploit all the possibilities of adaptivity and space time adaptive processing (STAP), and the workload associated with multi-tasking still challenges radar resource management. Future engineering challenges relate to improving the capability of cognitive radar in complex and rapidly changing environments.

Invisipin®

ULTRA Hi RF - Compliant Connector



INFINITELY CONFIGURABLE • INDIVIDUALLY SOLDERABLE • HI COMPLIANCE RANGE

Specifications

- > 50 GHz Bandwidth @1 dB
- 20 mΩ C-Res (typical)
- Up to 4 Amps

Configurations

- 0.23mm to 0.64mm diameter pins
- Pitches from 0.4mm to >1mm



(Coaxial Configuration)

*Available in tape and reel (machine placeable) or fully integrated into custom products.

R&D
Interconnect Solutions®

www.RDIS.com/MJ

MJ@RDIS.com

610-443-2299

©2015 R&D Interconnect Solutions. All rights reserved. R&D Interconnect Solutions, Invisipin, and RDIS.com are trademarks of R&D Interconnect Solutions.

The Leader in Switching Solutions

The global provider of ultraminiature, hermetically sealed and solid state switching products for over 50 years.

Our products meet a wide range of applications in the aerospace, commercial, defense, industrial, RF, Space and Test & Measurement markets.



MICROWAVE COAXIAL SWITCHES

- SPDT, Transfer, Multi-Throw
- Switches and Switch Matrices
- SP3T-SP10T
- Low PIM Switching
- DC to 40 GHz
- Custom products



RF SWITCH MATRIX

- Multiple Standard and Custom configurations
- USB/Ethernet Mini-Switch Modules

ELECTROMECHANICAL RELAYS

- DC-16 GHz
- Signal Integrity Up to 40 Gbps
- New Loopback Relay

INDUSTRIAL SOLID-STATE RELAYS

- Single, Dual and 3-Phase products
- Soft Start Motor Controllers
- High Current, High Voltage

MILITARY SOLID-STATE RELAYS

- Silicon Carbide DC Relays (270Vdc, 20A)
- Robust Design, Wide Temperature Range



See us at EuMW Stand 19



800-596-3855 • www.teledynereleys.com
800-351-7368 • www.teledynecoax.com



**TELEDYNE
RELAYS**
Everywhere you look™



**TELEDYNE
COAX SWITCHES**
Everywhere you look™

SIVERSIMA

siversima.com

YOUR PARTNER IN ADVANCED mmWAVE & MICROWAVE SOLUTIONS

Converters & Customized Transceivers



- E-band and V-band Converters
- Plug and Play Evaluation Kit
- Access to Reference Design

Radar Sensors



- Front End 5GHz, 10GHz, 24GHz and 77 GHz
- For Harsh and Demanding Environments
- Radar Development Kit

SpecialReport

The increasing use of advanced DSP leads to the exploitation of waveform diversity opportunities to accurately control waveform spectral characteristics and optimise target identification. Improvements in low noise amplifiers and high dynamic range fast analog-to-digital converters (ADC) aid receiver performance, while GaN technology for high power transmitter modules impacts the market for solid-state transmitters by significantly increasing reliability.

Much academic research is being carried out into multiple input, multiple output (MIMO) radar in order to overcome the issues of fading and obscuration and the low target RCS associated with monostatic radars. This and passive bistatic radar (PBR) are receiving much attention, and PBR has demonstrated detection and tracking of air targets at ranges in excess of 100 km, as well as the detection of missile launches.

Extremely high spatial resolutions are now being obtained from SAR and ISAR imaging on airborne and satellite platforms and enable ground target monitoring. Polarimetry, interferometry and coherent change detection (CCD) techniques enable the detection of vehicle movement, ground and vegetation changes.

In summary, the European radar industry and scientific community make a major international contribution to the field of radar and continue to harness and develop new technology and concepts for implementation in both defence and consumer applications.

CONCLUSION

This special report could not ignore the elephant in the room that is the UK's decision to leave the European Union, which has cast a large shadow of uncertainty and raised questions concerning the consequences of that decision.

The UK may be leaving the EU, but it is not leaving Europe, and for its prosperity and growth it needs to trade and cooperate with its close neighbours to achieve common goals. It is a significant player that can continue to contribute its expertise and resources. That is particularly true for industrial development and the advancement of research and innovation.

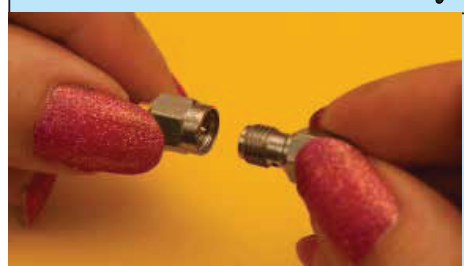
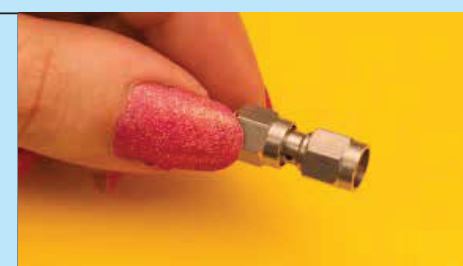
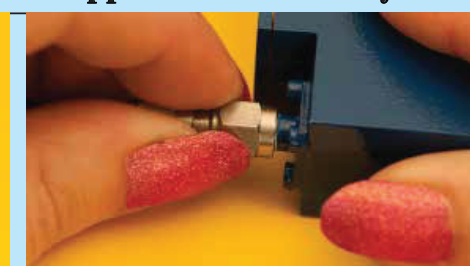

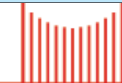

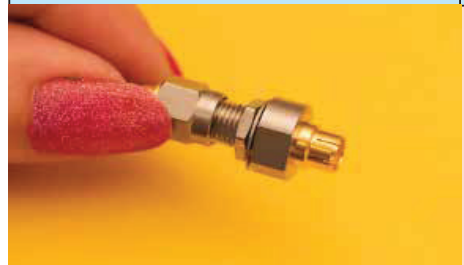


Europe is playing a major role in leading edge technologies such as 5G, IoT, materials technology and automated driving. Under Horizon 2020, the mechanisms, both financial and technical, are in place to encourage and support development and, more importantly, bring these technologies to market. Those initiatives will continue, as will the contribution of UK partners to the projects currently being collaborated on. Hopefully, negotiations will ensure that such vital cooperation can be maintained for future programmes.

Whether breaking up is hard to do remains to be seen, but at this early stage, all parties appear to be committed to an amicable separation. Uncertainty and the subsequent difficulty in planning the next step and beyond is the main concern. Hopefully, the options will become clearer in the coming months and years, leading to greater confidence and stability. ■

Procedure for how to use the N, TNC and 7/16 Push-On male. Push-On Connectors mate with any standard female connector of the same connector style.

		
<p>1. Convert your standard Assembly into a Push-On Assembly using the Nf to Nm Push-On Adapter.</p>	<p>2. Put your fingers firmly onto the knurls of the "Lock Nut".</p>	<p>3. Push "Lock Nut" forward and engage the Push-On end of the Adapter with the mating female. Back nut must be released.</p>
		
<p>4. The Connection has been completed, easy and fast. The connector has been locked on safely.</p>	<p>5. To unlock (when "Back Nut" is in unlocked mode) push the "Lock Nut" forward and stop reverse movement by setting your fingers onto the "Back Nut".</p>	<p>6. Keep fingers on "Back Nut" to ensure that "Lock Nut" cannot slide back and pull the connector off.</p>

Procedure for how to use the SMA male and SMA female Push-On connectors. SMA Push-On Connectors mate with any standard connector of the same but opposite connector style.

		
<p>1. Convert your standard cable assembly into a Push-On Assembly by threading the standard female side of the adapter onto the male connector of the assembly.</p>	<p>2. Your standard SMA male cable assembly is converted into an SMA male Push-On Assembly.</p>	<p>3. Just slide the Push-On SMA male Connector onto any standard SMA female. The connection is securely completed in seconds.</p>
	<div>  Spectrum Elektrotechnik GmbH </div> <div> <p>Please contact us at: www.spectrum-et.com Email: sales@spectrum-et.com Phone: +49-89-3548-040 Fax: +49-89-3548-0490</p> </div>	
<p>4. To disconnect, just pull the connector off.</p>		<p>1. Convert your standard cable assembly into a Push-On Assembly by threading the standard female side of the adapter onto the male connector of the assembly.</p>
		
<p>2. Your standard SMA male cable assembly is converted to a Push-On SMA female Cable Assembly.</p>	<p>3. Just slide the Push-On SMA female Connector onto any standard SMA male. The connection is securely done in seconds.</p>	<p>4. To disconnect, just pull the connector off.</p>

LDS Molded Interconnect Devices Fit For mmWave

Aline Friedrich and Bernd Geck

Leibniz Universität Hannover, Hannover, Germany

Malte Fengler

LPKF Laser & Electronics AG, Garbsen, Germany

Molded interconnect devices (MID) are the three-dimensional (3D) response to the increasing market demand for components to be smaller and allied to efficient and flexible circuit carrier manufacturing. For several years, different methods have been developed to allow integration of circuit patterns as well as radiating and shielding elements on nearly arbitrary shaped plastic parts, providing the full 3D design scope for the developer. 3D flexibility is becoming more and more important—indispensable—to address the challenges facing the design of modern radio frequency systems. Decreasing space for installation, increasing functionality, together with higher frequency coverage are contradicted by the uncompromising limitations of production costs.

The available manufacturing methods for 3D MIDs can facilitate optimal manufacturing processes depending on the specific application. For instance, when using these methods for RF device fabrication, the 3D plastic parts replace the RF laminates that are typically used. This means that the established requirements on the RF properties of the substrate material, as well as the applied metallization, have to be met by the 3D manufactured parts. This is especially significant for future applications in the millimeter wave (mmWave) fre-

quency range. One manufacturing method for MIDs that is already common for large scale production of antennas in consumer devices (e.g., smartphones, tablets, laptops), is the laser direct structuring (LDS) method.¹ Injection molded plastic parts combined with laser activated surfaces that allow selective metallization open up almost unlimited design scope. Because present LDS fabricated applications mainly cover frequencies up to 6 GHz, this article evaluates the suitability of the LDS method for RF applications up to the mmWave range.

LDS MANUFACTURING FOR 3D MIDS

The LDS process with its laser based selective metallization processes provides great flexibility for developing electronic devices. This includes the 3D design scope in the development process, as well as the adaptability of a design during ongoing manufacturing. The substrate to be metallized by the LDS method is typically fabricated in an injection molding process using thermoplastic or thermoset materials that are doped with a special filler of mixed metal oxides. Using conventional injection molding, high volume production of the desired 3D substrate is possible. Additionally, there are LDS capable materials available that can be processed with additive manufacturing processes such as fused deposition modeling

Making the Connection to Millimeter Wave Solutions



OML can extend the frequency of your Vector Network Analyzer so that you can conduct industry-leading millimeter wave measurements. Offering three configurations (T/R, T & S) ranging from 50 to 500 GHz these modules allow capabilities to measure full S-parameters. With options such as variable attenuation, amplification in RF & LO paths, low power and Intermodulation; OML frequency extension modules can help you with your solution.

Innovation in Millimeter Wave Solutions
www.omlinc.com
(408) 779-2698



LOW LEAKAGE LEVEL LIMITERS

(Leakage Level as low as -10 dBm)
0.01 - 18 GHz

New



- Maximum Input Power 1W CW, 100 W Peak
- Options for Leakage Levels
 - 10 dBm
 - 5 dBm
 - 0 dBm
 - + 5 dBm
- Removable connectors for circuit board assembly
- Ideal for LNA Protection

MODEL	FREQ. RANGE (GHz)	NOMINAL ¹ LEAKAGE LEVEL (dBm)	TYPICAL ² LEAKAGE LEVEL (dBm)	TYPICAL ³ THRESHOLD LEVEL (dBm)
LL00110-1	0.01 - 1.0	-10	-	-11
LL00110-2		+ 5	-	- 6
LL00110-3		0	-	- 1
LL00110-4		+ 5	-	+ 4
LL0120-1	0.1 - 2.0	-10	-	-11
LL0120-2		+ 5	-	- 6
LL0120-3		0	-	- 1
LL0120-4		+ 5	-	+ 4
LL1018-1	2 - 18	-	-10 TO -5	-10
LL1018-2		-	- 5 TO 0	- 5
LL1018-3		-	0 TO +5	0

Notes:

1. DC Supply required: +5V, 5mA Typ.
2. Typical and nominal leakage levels for input up to 1W CW.
3. Threshold level is the input power level when output power is 1dB compressed.

Other Products: Detectors, Limiters, Amplifiers, Switches, Comb Generators, Impulse Generators, Multipliers, Integrated Subassemblies

Please call for Detailed Brochures



155 Baytech Drive, San Jose, CA 95134
Tel: (408) 941-8399 . Fax: (408) 941-8388
Email: Info@herotek.com
Website: www.herotek.com
Visa/Mastercard Accepted

Technical Feature

(FDM) for development prototypes. Another method of making a substrate suitable for the LDS process is using an LDS varnish called LPKF Proto-Paint. With this varnish nearly arbitrary substrate materials can be metallized by the LDS method.²

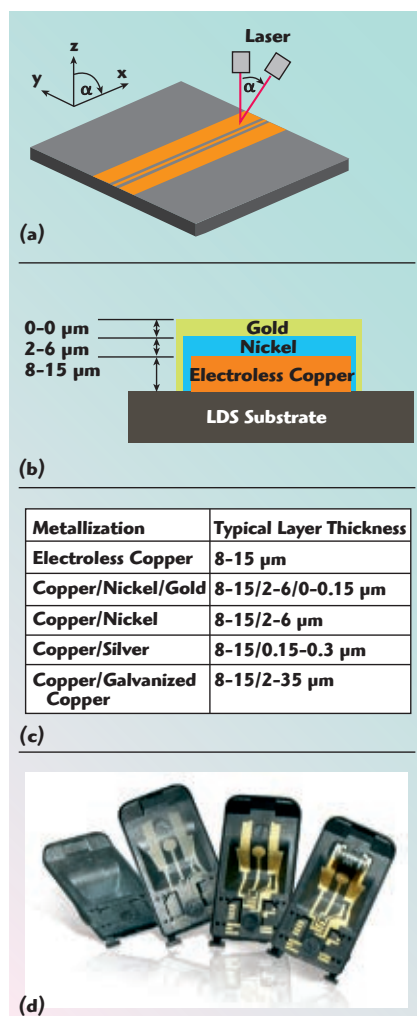
Based on a CAD dataset including the mechanical and the electrical designs of the part, the circuit pattern is transferred to the molded part by laser structuring and forms the structures to be metallized. High speed 3D LDS laser systems can structure nearly arbitrary 3D shapes while achieving fine pitches down to 150 μm , as well as large circuit patterns for radiation, heat and current transportation. With the structuring parameters like laser beam width, overlap of the structured lines, pulse repetition rate, laser inclination angle (α) and laser power, the mechanical characteristics of the

plastic surface, such as adhesion and roughness, as well as the electrical properties of the metal layer can be influenced (see **Figure 1a**). In that way, the specific requirements of an application can be considered in the structuring process, within certain limits. The laser beam causes a micro rough surface and activates the mixed metal oxide that serves as a catalyst for a subsequent metallization. In an electroless plating process, a first layer of copper is deposited only on these activated areas. The copper layer has a conductivity of about 30 MS/m. Due to the laser ablation, micro cavities are formed on the surface and ensure a strong bond between the copper and the substrates, with adhesion strengths of 0.8 N/mm or higher. In additional plating processes, the surface is typically finished using electroless nickel and immersion gold (ENIG). The resulting layer configuration is depicted in **Figure 1b**, showing its typical layer thicknesses. The different available metallization compounds (see **Figure 1c**) enable the metallization best suited for a specific application to be chosen.

Depending on the plastic resin used, an LDS MID can be used for state-of-the-art SMT processes by applying various low or high temperature soldering methods, such as reflow. **Figure 1d** shows an LDS part in different fabrication steps: injection molded plastic, laser structured, metallized with standard LDS ENIG and the final assembly (left to right). The recommended minimal line width is 150 μm with a minimal gap width down to 150 μm . Depending on the geometric shape of the substrate part and the laser focus size, smaller line and gap widths can also be achieved. Due to a 3D laser-based digital process, the laser beam can travel along nearly free formed shapes within an xyz scan volume of 200 mm \times 200 mm \times 80 mm. An optical z-axis allows the structuring of steep areas with high accuracy to an inclination angle of up to 70°.

RF PROPERTIES

The typical LDS process is based on a thermoplastic material and a metallization of the laser structured surfaces. When developing RF devices, field simulation software is typically used to optimize the required characteristics. Since



▲ Fig. 1 LDS process laser-substrate geometry (a) typical ENIG metallization (b) metallization compounds and thicknesses (c) and sample part at various steps (d).

RF-LAMBDA

THE LEADER OF RF BROADBAND SOLUTIONS

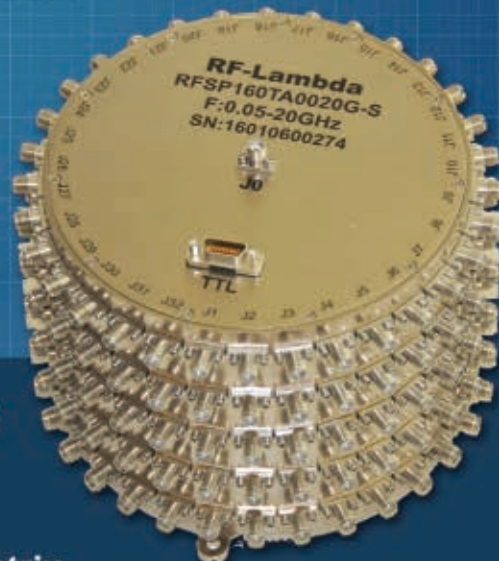
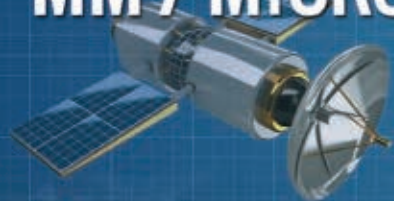
WWW.RFLAMBDA.COM

ITAR & ISO9000
Registered Manufacture



Thousand
in stock

RF SWITCHES MM / MICROWAVE DC-50GHz



160 CHANNELS
mm/Microwave

0.05-20GHz

Filter Bank Switch Matrix

For Phase Array Radar Application Satellite communication.



PN: RFSP32TA5M43G

SP32T SWITCH 0.5-43.5GHz



PN: RFSP16TA5M43G

SP16T SWITCH 0.5-43.5GHz

www.rflambda.com
sales@rflambda.com

1-888-976-8880
1-972-767-5998

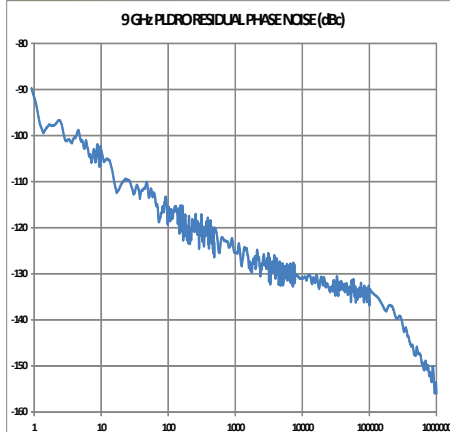
Plano, TX, US
San Diego, CA, US
Ottawa, ONT, Canada





We have specialized in Low Phase Noise Fixed Frequency Sources since 1998.

A plot of our new quieter PLDRO line.



- Crystal reference phase noise to -130 dBc/Hz @ 100 Hz @ 100 MHz
- Dual loop output frequency resolution +/- 0.001 Hz
- Internal reference stability to +/- 10 ppb
- 5 - 1000 MHz External reference
- Frequency: 10 MHz to 35 GHz
- Power output: +10 to +24 dBm
- Wide operating temperature range: -55° to +85°
- Spurious: < -90 dBc

We welcome your custom requirements.



Nexyn offers the best performance and reliability on the market.

1287 Forgewood Ave.
Sunnyvale, CA 94089
Tel: (408) 962-0895
Fax: (408) 743-5354
sales@nexyn.com

www.nexyn.com

Technical Feature

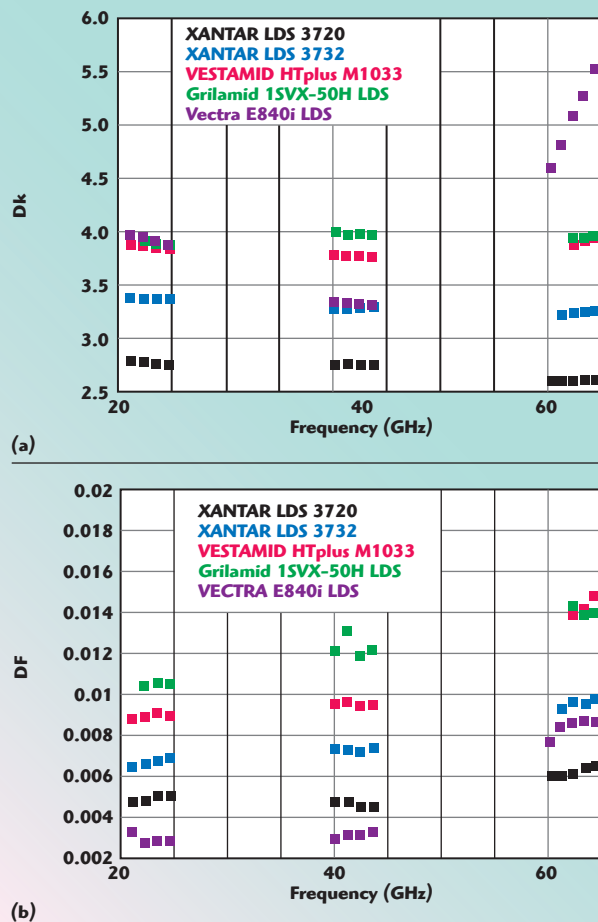
the exactness of this modeling increases the accuracy of the simulated results, the efficiency of the development process can be significantly influenced by knowledge of the RF properties. To provide this information for the user of the LDS method, a detailed evaluation of

the RF properties is carried out: first, the dielectric properties of the available LDS substrate polymers are assessed. Second, the RF conductor characteristics for the different LDS metalization compounds are evaluated based on measurement and simulation.

Dielectric Properties

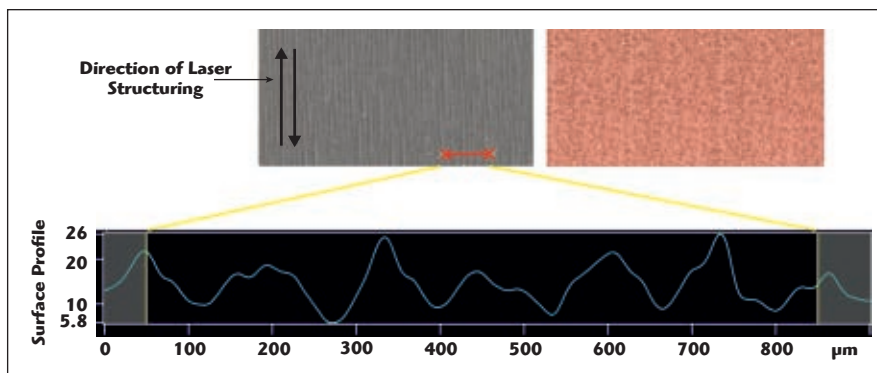
The complex permittivity is the main influencing factor of typical dielectric materials in an RF application. Besides the frequency related geometric dimensions, the losses induced in the substrate material can be derived from the complex permittivity. Because the dielectric properties are frequency related, the evaluation has to

reflect the frequency range covered by the specific application. **Figure 2** shows the permittivity values (Dk) for five different LDS materials with their associated dielectric losses (DF). The measurements used an open resonator method.³ The permittivity values



▲ Fig. 2 Dielectric constant and dissipation factor of different LDS materials.

TABLE 1		
MEASURED SURFACE ROUGHNESS FOR LDS COPPER AND ROLLED COPPER		
Test Sample	S_a	S_z
Xantar LDS 3730: 8 to 12 μm Electroless Copper	6.4 μm	66.3 μm
Rogers 4003C: 17.7 μm Rolled Copper Foil	1.7 μm	22.3 μm



▲ Fig. 3 Laser structured test sample with surface profile.

MORION US

80 YEARS OF STABILITY

Ultra-Low Phase Noise OCXOs

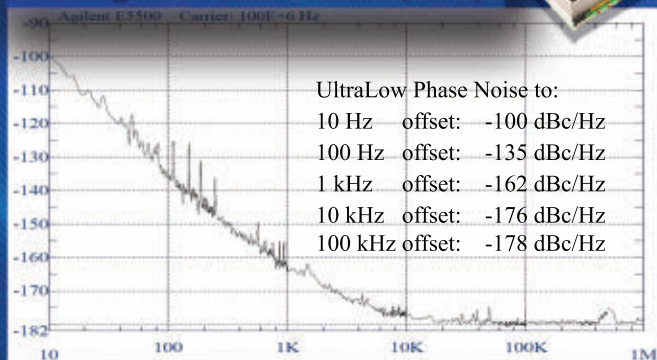
100 MHz

MV354

+5V

New

- Temperature Stability: 5E-8
- Aging: $\pm 1\text{E-7}$ per Year
- Package: 21.1 x 14.0 x 7.5 mm (SMD)

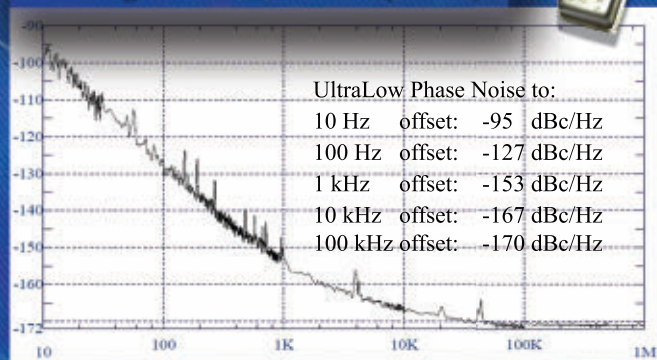


MV269

+3.3 / +5V

New

- Temperature Stability: 2.5E-8
- Aging: $\pm 1\text{E-7}$ per Year
- Package: 20.3x12.7x9.5 mm (DIL14)

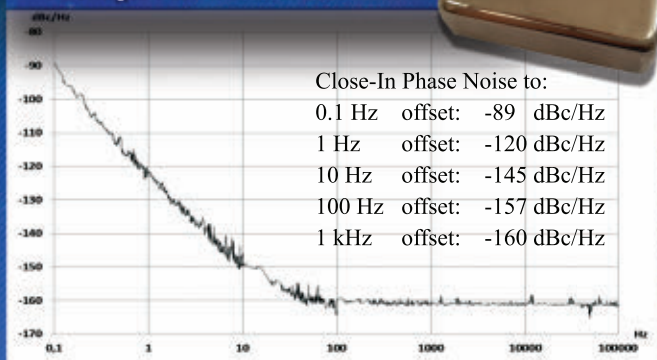


Ultra-Low Close-In Phase Noise OCXOs

10 MHz

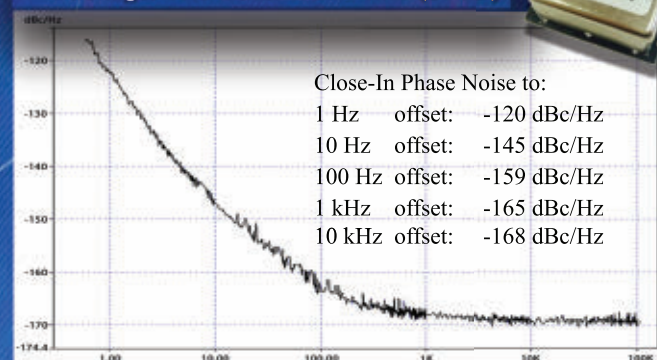
MV341

- Temperature Stability: 1E-9
- Allan Deviation: $< 2\text{E-13}$ per Sec.
- Package: 50.8 x 50.8 x 12.7 mm



MV272M

- Temperature Stability: 1E-9
- Allan Deviation: $< 4\text{E-13}$ per Sec.
- Package: 41.0 x 30.0 x 17.0 mm (SMD)



Located in California's Silicon Valley, Morion US supplies customers with high performance, high reliability crystal oscillator and crystal filter products for telecommunications, navigation and test & measurement applications.

Morion US is a company for which quality and reliability of products supplied are uncompromised. This is the essence of Morion US, LLC.

Our technologies are based on more than 80 years experience in precision quartz products, including those for Military and Space. We have a highly skilled workforce, excellent manufacturing and R&D capabilities.

Morion US, LLC
1750 Meridian Ave. #5128
San Jose, CA 95150
+1 408 329-8108
sales@morion-us.com
www.morion-us.com



are in a range of about 3 to 5.5 for frequencies from 1 to 67 GHz. These values are in the same range as for the basis polymer and do not differ significantly from that of typical RF substrate materials. The measured dissipation factor ranges from 0.003 to 0.014. The dissipation factor of some LDS materials is slightly higher than for typical RF materials.

With materials like Vectra E840i LDS, a liquid crystal polymer (LCP); polyetheretherketon (PEEK), Cyclic Olefine Copolymer (COP); and also polycarbonate (PC) based materials such as Xantar LDS 3720/3732/3730, the induced material losses are comparable to those of typical RF laminates. LDS materials are generally suitable for RF applications and similar to a typical RF laminate, the choice of a LDS substrate material must be made by considering the specific application, taking into account both the RF and mechanical requirements.

Conductor Properties

Another important aspect for a circuit carrier in RF applications is the

applied metallization. In addition to the electrical properties, the mechanical properties and the geometrical shape have to be considered. These characteristics influence each other. The metallization of an RF device is typically used to guide the electromagnetic waves. The condition of the metal structure influences the losses induced in the conductor. The main influencing aspects are the electric conductivity of the metal material, the geometric dimensions and the geometric surface condition. Since LDS metallization typically consists of more than one layer (e.g., Cu and ENIG), the effective conductivity is influenced by the specific surface current distribution. Especially for higher frequencies, the main surface currents will be in the outer cross section of the metal structure due to the skin effect. However, this is not automatically the outer surface of the metalized structure. The main current distribution can also be displaced to the cross section connected to the substrate material.

Evaluating the condition of a surface, roughness parameters like the

arithmetic mean roughness, R_a or S_a , and the maximum height, R_z or S_z , are usually used. Typical values of these surface roughness values for LDS metallized surfaces are shown in **Table 1**. For comparison, the same parameters for a Rogers 4003C substrate with a 17.5 μm rolled copper layer are included. The measurements were made using the Keyence One-Shot-3D-Measurement Macroscopic VR-3000. As shown, the S_a and S_z values of the LDS fabricated metal layer are considerably higher than for the RF substrate. When evaluating the surface properties of the LDS metallization, these higher values defined by R_z/S_z and R_a/S_a are not complete because the exact shape of the surface will influence the losses. This fact has already been evaluated for other rough metal surfaces,^{4, 5} where parameters other than the surface roughness values are defined to model the conductor losses. In the case of LDS manufacturing, the laser causes grooves where the laser beam activates the surfaces to be metallized. This leads to a waviness that depends on the laser beam width, the overlap, the pulse repetition rate and the laser power used for the structuring. **Figure 3** depicts one example of a laser structured plastic part where the grooved surface from the laser is analyzed. A 3D profile view of the surface shows this slight surface modulation. This modulation has a high impact on the resulting surface roughness values, while the influences on the RF losses may be lower due to the specific shape of the surface.

Therefore, the RF losses are evaluated based on a field simulation carried out with the ANSYS Electromagnetics Suite 16.2.0. The grooved surface structure is modeled with a sinusoidal surface curvature for a coplanar waveguide (CPW) and a microstrip line (MSL). The modulation is evaluated for a laser structuring parallel (x-direction) and across (y-direction) the transmission line. The transmission lines are evaluated without this surface modulation for comparison. All metal surfaces are defined as sheets with a finite conductivity boundary condition and the conductivity of LDS copper (30 MS/m). The substrate material used is an LDS polycarbonate MEP Xantar LDS 3730 with a dielectric constant of about $D_k = 3$ and a dissipation



MICROWAVE OSCILLATORS

DIELECTRIC RESONATOR TECHNOLOGY



Designing and Manufacturing microwave & mm-wave components and sub-assemblies ranging from 10 MHz to 50 GHz for 25 years, Exodus Dynamics has become a proud supplier to many of the nation's top aerospace and defense companies. With rugged designs, supported by a 2 year warranty, our products are designed, built and test-proven to last a lifetime. Typical features include:

- Ultra Low Phase Noise for Radar Applications
- Optional Operating of -55° to +105°C
- Vibration/Shock Upgrades
- 24 Hour Turnaround (standard products)
- Optional Output Power up to +30 dBm




Dielectric Resonator Oscillators | Frequency Amplifiers | Frequency Converters | Frequency Multipliers

AEROSPACE | INDUSTRIAL | DEFENSE | TELECOM | GOVERNMENT

www.exodusdynamics.com | Phone: 719-445-2999 | Sales@ExodusDynamics.com

4205 Series

USB/TTL controlled
Available in 0-31.5,
63.5, and 95 dB



DC to 6 GHz Programmable Attenuator Solutions



8320, 8321, 8331 Series

Ethernet controlled
Configurations up to 12 channels
Electromechanical & solid-state designs

Bring your 3G/4G testing to a solid state

If it's time to bring your test systems to the digital age, look to the leaders in solid-state programmable attenuation.

With 60 years of industry leadership and product development, Weinschel, part of API Technologies Corp., offers DC to 6 GHz MMIC digital attenuation solutions including USB/TTL controlled attenuators and Ethernet controlled rack mountable subsystems.

Designed with budget and performance concerns in mind, these devices offer superior RF characteristics suitable for automated bench testing in wireless backhaul, fading simulation, and other high-performance wireless applications.

- **Excellent solid-state repeatability and performance**
- **Uninterrupted RF when changing attenuation value**
- **Labview based USB Control Center Software included**

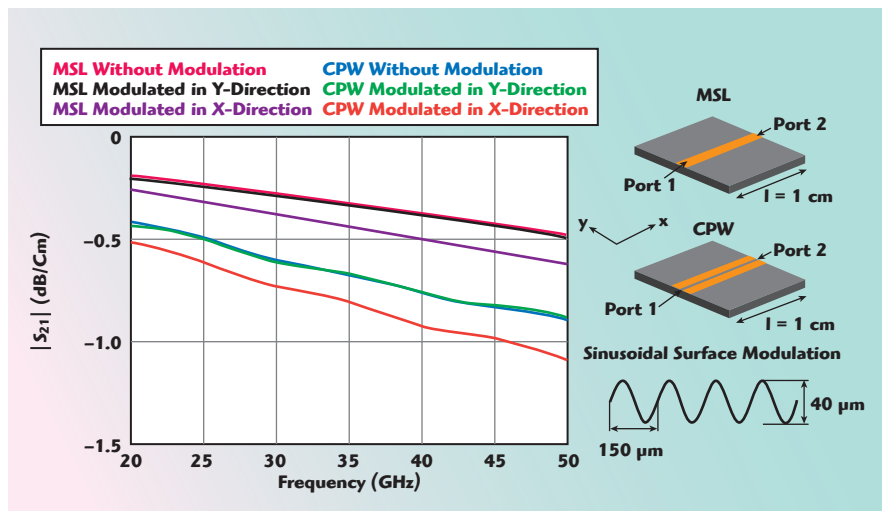


api 
technologies corp.
WEINSCHTEL

301-846-9222 | 800-638-2048 | weinschel-sales@apitech.com | weinschel.apitech.com

See us at EuMW Stand 39

Weinschel is now part of API Technologies Corp.



▲ Fig. 4 Simulated insertion loss for the laser induced surface modulated CPW and MSL.

factor of about $DF = 0.005$ at 25 GHz. The resulting simulated insertion loss in dB/cm and the corresponding simulation models are shown in **Figure 4**. For a surface modulation with a periodicity of $150\ \mu\text{m}$ and a peak-to-peak amplitude of $40\ \mu\text{m}$, the conductor losses are increased to about 0.11 dB for the MSL and 0.18 dB for the CPW for structuring in the y-direction at 50

GHz. In case of structuring parallel to the transmission line (x-direction), no apparent difference can be observed compared to the simulated flat conductor. This shows that this part of the LDS surface roughness does not have the high impact expected. To reduce the losses, structuring in parallel to the direction of propagation (x-direction) is recommended.

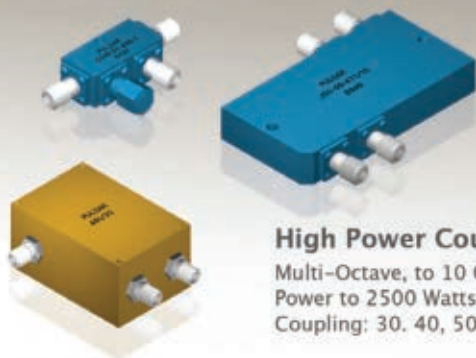
Conductor Losses of a Coplanar Waveguide

Measurements on a CPW prove the results evaluated by simulation. Different laser angles (α) are used to structure the test samples metallized with different metallization compounds afterwards. Each metallization compound is based on a layer of electroless LDS copper. With the different laser angles, the three dimensional fabrication process can be evaluated, although a planar transmission line has to be used due to the limitations in the measurement setup. Each test sample consists of four transmission lines with different lengths, a short and an open line to allow for multiline TRL calibration.⁶ The test structures are metallized on a plate made of MEP Xantar LDS 3730 with a height of about 1 mm. Five samples are fabricated for each configuration. The measurements are carried out on a wafer prober using GSG measurement probes with a pitch of $400\ \mu\text{m}$. The frequency range evaluated is from 1 to 67 GHz. **Figure 5** depicts

directional couplers & hybrids

Quick Delivery
Customization available

Up to 60 GHz
& 2500 Watts



High Power Couplers
Multi-Octave, to 10 GHz
Power to 2500 Watts
Coupling: 30, 40, 50 dB

Stripline Couplers

Octave, Multi-Octave
0.5–60 GHz
Coupling: 6, 10, 20, 30 dB
Single and Dual Couplers
SMA and N Connectors
High Isolation
Low Insertion Loss

Hybrids

90° & 180°
Multi-Octave Coverage
0.3–40 GHz
Low Loss
Excellent Ampl. Balance
SMA and N Connectors
High Power Available

PULSAR
MICROWAVE CORPORATION



www.pulsarmicrowave.com

48 Industrial West, Clifton, NJ 07012 | Tel: 973-779-6262 • Fax: 973-779-2727 | sales@pulsarmicrowave.com

Your Trusted Resource For System Sub-Assemblies

FAST 1 μ sec. SYNTHESIZER WITH MODULATION



MAIN FEATURES

- High Speed: 1 μ sec
- Wide Frequency Range: 2 to 20 GHz
- Modulation Span: 1 GHz
- Analog & Digital Modulation Input
- High Reliability
- Pure Locked Mode (PLM)

APPLICATIONS

The Models SM6218 and SM6220 Fast Synthesizer, with Frequency Modulation capability, were developed as an enhancement to our existing Series SF60 1 μ sec CW Synthesizer family.

The unit generates a wideband modulated signal while locked to the reference oscillator, thus achieving perfect frequency span and center frequency. This is in a contrast to common frequency source solutions where the wideband modulation mode is done in a "free running" mode and the frequency accuracy is very limited.

The SM Series of units offer a higher performance and cost effective alternative to signal generators currently used in Electronic Warfare (EW) Simulators and Test Systems and especially those which require improved frequency accuracy, phase noise and frequency modulation capabilities.

In addition, the design allows the flexibility to customize performance to application specific requirements.

KRATOS | General Microwave
Microwave Electronics Division

227A Michael Drive, Syosset New York 11791

Tel: 516 - 802 - 0900, Fax: 516 - 802 - 0897

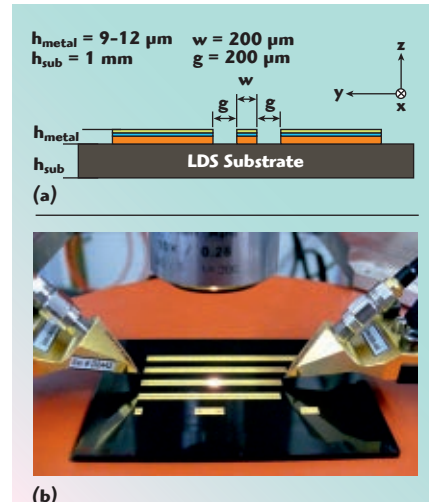
E-mail: kratosgeneralmicrowave@kratosdefense.com

www.kratosmed.com

the measurement setup with a test sample as described.

Considering the skin depth ($\delta_{1\text{ GHz}} = 2.9\text{ }\mu\text{m}$ for LDS copper) and the electromagnetic fields of a coplanar waveguide, it becomes obvious that the main surface currents will be concentrated in the outer cross section of the structure. The current distribution is dependent on the specific RF structure. **Figure 6** shows the insertion loss in dB/cm for all evalu-

ated test samples, with the metallization compound and laser parameter depicted in the legend. The laser structuring is done in parallel to the direction of propagation (x-direction) with a laser angle of 45° and 0° . For comparison, a CPW fabricated in a photolithographic process out of a single rolled copper layer on Rogers 4003C is shown. The LDS substrate material used has a loss tangent (DF) of approximately 0.005 at 20 GHz,



▲ Fig. 5 CPW structure (a) and measurement setup (b).

compared to approximately 0.0027 at 10 GHz for the Rogers 4003C. Consequently, the higher losses are also due to the dielectric losses as well as conductor losses. At 60 GHz, the CPW test samples with copper show a loss of about 0.9 dB/cm, while the nickel surface finish causes a loss of about 1.7 dB/cm. The sample on Rogers 4003 with the rolled copper foil induces a loss of about 0.75 dB/cm. The results show that there is only a slight difference between the losses of the typical RF substrate and the LDS sample with the copper metallization. The LDS samples with the nickel and nickel/gold layer induce higher losses due to the poor conductivity of nickel.

The investigations of the different metallization compounds of LDS fabricated RF test samples show that the surface roughness of LDS copper does not have the high impact on the losses as may have been expected. This is due to the specific shape of the laser structured surface, with its laser induced grooves, leads to a kind of surface modulation that only slightly influences conductor loss. Because the coplanar samples are manufactured with different laser inclination angles ($\alpha = 0^\circ$ and $\alpha = 45^\circ$), this applies to 3D fabricated structures.

CONCLUSION

3D manufacturing methods are becoming more important for the fabrication of RF devices. The flexibility of an arbitrarily shaped and selective metallized injection molded part can be used to meet often contradictory re-

Complete Connections for Your 5G Applications!

1.0mm Series

Test Cables

Multi Coax & Phase Matched Cables

Frontlynk Technologies Inc.

Tel: +886-6-356-2626 Fax: +886-356-6268

www.frontlynk.com

E-mail: info@frontlynk.com

You Have Our Undivided **ATTENTION**

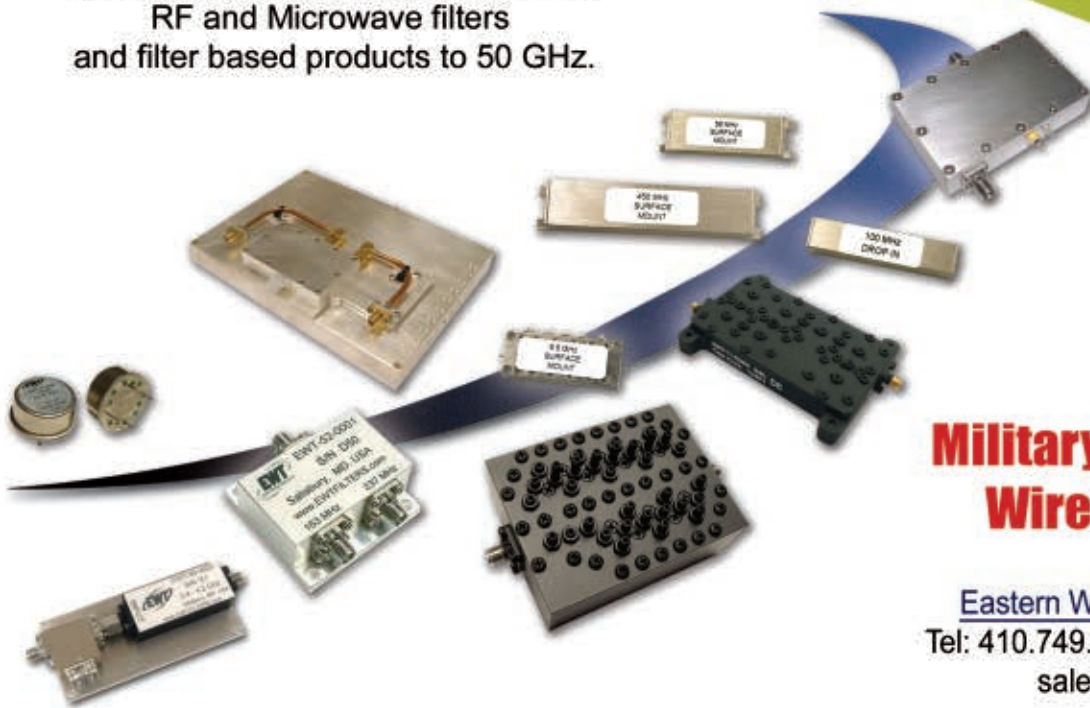


EW

www.ewtfilters.com

We understand how critical your applications are. That's why you'll always have our *Undivided Attention*.

Offering more than 40 years of experience
in custom design & manufacturing of
RF and Microwave filters
and filter based products to 50 GHz.

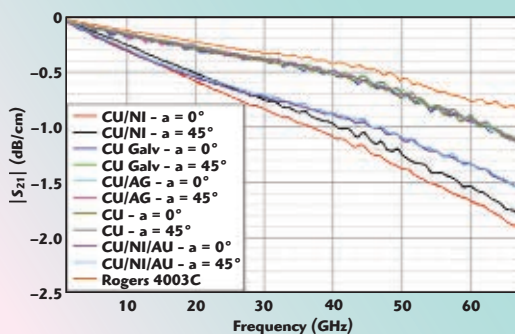


**Military • Commercial
Wireless • Space**

Eastern Wireless TeleComm, Inc.

Tel: 410.749.3800 Fax: 410.749.4852

sales@ewtfilters.com



◀ Fig. 6 Measured CPW insertion loss on Xantar LDS 3730 compared to Rogers 4003 with a rolled copper layer.

quirements. When replacing the typical RF substrate with a 3D manufactured plastic part, it becomes clear that the RF properties of the 3D fabricated components have to be evaluated to guarantee proper functionality, an ef-

ficient development process and a long lifetime. As these properties are frequency dependant, evaluation depends on the specific frequency of application. In this article, the 3D LDS process was evaluated for RF applications up to 67 GHz. The results show that the complex permittivity of the LDS polymer materials is only slightly changed due to the LDS additive. There are materials available that have comparable properties to those of typical RF substrate materials.

The conductor losses in different metallization compounds were evaluated. The surface roughness values of the LDS metallization may lead to the assumption that the roughness will cause high conductor losses. A detailed mechanical surface evaluation together with different field simulations showed that the laser structuring causes a grooved surface that has only a slight impact on the resulting RF losses. Measurement of the insertion loss of LDS manufactured CPW structures compared to typical rolled copper metallization on an RF laminate verified these results. The metallized surfaces were evaluated for structuring with different laser angles. In that way, the results are adaptable to 3D fabrication, even though the test samples were planar, due to limitations in the measurement setup.

LDS fabrication is suitable for RF applications in the mmWave range. The evaluated data of the frequency related losses and the available design scope show that 3D LDS technology is a good solution for fabricating RF devices, helping to meet future challenges. ■

References

1. N. Heining, "3D LDS Components for New Production Opportunities," *Microwave Journal*, Vol. 55, No. 2, February 2012.
2. LPKF Laser & Electronics AG, "A Shortcut to 3D-MID Prototypes," *Microwave Journal*, Vol. 56, No. 11, November 2013.
3. www.damaskosinc.com/cavity.htm, 2016.
4. P. G. Huray, "The Foundations of Signal Integrity," New York, NY, USA: Wiley, 2009, Ch. 6, pp. 216–277.
5. S. Hall, S. G. Pytel, P. G. Huray, D. Hua, A. Moonshiram, G. A. Brist and E. Sijercic, "Multigigahertz Causal Transmission Line Modeling Methodology Using a 3-D Hemispherical Surface Roughness Approach," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 55, No. 12, pp. 2614–2624, December 2007.
6. R. B. Marks, "A Multiline Method of Network Analyzer Calibration," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 39, pp. 1205–1215, July 1991.

Ensuring the success of your project

Industry Leading Performance
Competitive Pricing
Same Day Shipping
Free Application Support

 **Polyphase**
Microwave
A Technology Service Corporation Company

We stock a complete line of components including:

- Quadrature Modulators
- Quadrature Demodulators
- Single-Sideband Mixers
- Image Reject Mixers
- Caseless Mixers
- Customized Products

812-323-8708 • sales@polyphasemicrowave.com

polyphasemicrowave.com/mj

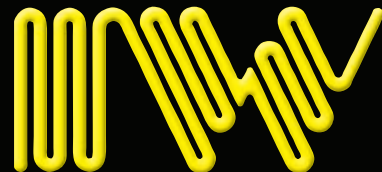


When system engineers call for ultra-reliable, high performance military grade cables and connectors, ***the obvious choice is...***

Today's advanced military platforms depend on the quality, selection, support and service that are the hallmarks of IW's product lines. We offer a range of jacket materials, armoring, and a wide variety of connectors including SMA, TNC, N, SC, 2.4 mm, and 7 mm to provide highly reliable, application specific solutions.

Call us today with your project specs and we'll show you the most reliable way to **get connected** in the industry.

AS9100 Rev. C & ISO9001:2008 certified.



INSULATED WIRE, INC.

203.791.1999

www.iw-microwave.com

sales@iw-microwave.com

Visit
Us At
EUMW London
October 4-6
Booth
#85



Scan code to find
out how you can
get connected

We're how the microwave industry **gets connected!**



Design of Waveguide Windows for mmWave Components

Yong Fang, Baoqing Zeng, Xiaoyun Zhao and Jun Dong
 University of Electronic Science and Technology of China
 Hai Zhang
 Nanchang Institute of Technology, China

A millimeter wave (mmWave) waveguide window employs a direct coupled filter network, which includes LC resonators and J inverters. ABCD matrix theory and full-wave simulation are used in the design. It is wideband and low-cost. Back-to-back waveguide sealed windows are built and measured. In the frequency range of 75 to 100 GHz, return loss is greater than 15 dB, insertion loss is less than 0.7 dB and the leakage rate is lower than 8×10^{-8} Pa.m³/s.

Millimeter wave components, usually constructed with waveguide interfaces, are widely used in millimeter wave systems. In order to improve reliability, the waveguide interfaces are sealed. There are several types of waveguide sealed windows frequently in use. One is a pillbox;¹⁻⁵ however, detailed synthesis methods are not provided.^{1,2,4} Liu³ employs an ABCD matrix method for design, but the pillbox requires a complex welding process. Another is a resonance type,^{6,7} but its bandwidth is limited. Further approaches, such as multilayer waveguide windows,⁸ need different dielectric windows with different thicknesses that increase insertion loss.

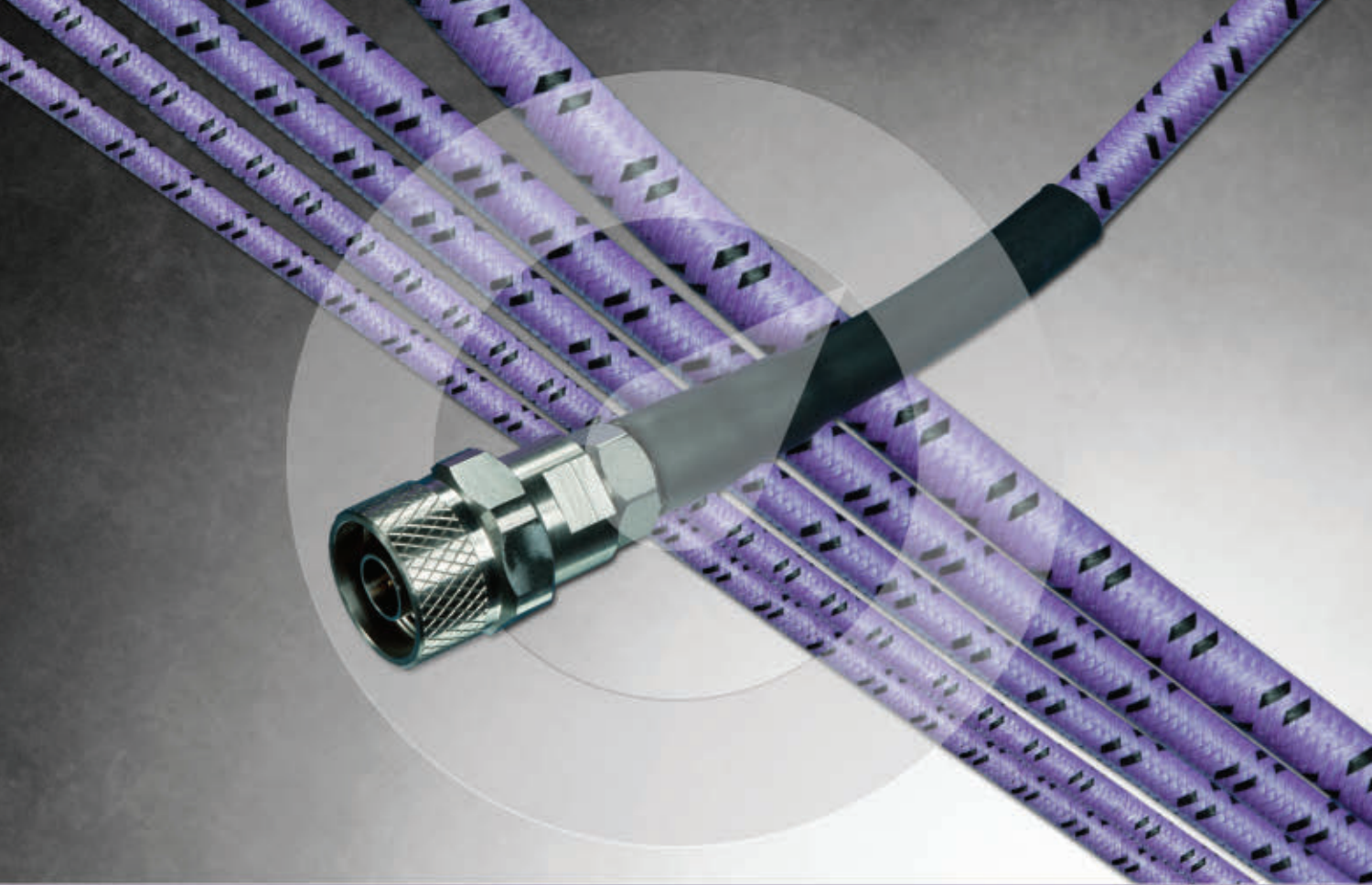
In this article, a new double-layer waveguide window (DLWW) for mmWave components is designed to improve reliability while reducing cost. In addition, the bandwidth of the sealed window is increased relative to other designs. This design is carried out for W-Band back-to-

back waveguide sealed windows by employing a direct coupled filter network design method using ABCD matrices and full-wave simulation.

SYNTHESIS AND FULL-WAVE SIMULATION

DLWW Circuit Description

The back-to-back waveguide sealed windows (see **Figure 1**) are designed using a broadband direct coupled filter synthesis method.⁹⁻¹¹ Each DLWW is composed of two RT/Duroid 5880 substrates (thickness = 0.127 mm, $\epsilon_r = 2.2$) and one quarter-wavelength waveguide (between the two substrates). The direct coupled filter model (see **Figure 1b**) is used for this design. The substrate is equivalent to a dielectric resonator (composed of C_1 and L_1), whose resonant frequency is determined by the parameters of substrate. The quarter-wavelength waveguides, which determine the



Performance Over Time

You can't afford to wonder if your cables are impacting your results. You expect your cables to be reliable. You need your cables to last.

But, with 75% of cables failing during installation or operation, your cable selection needs to be more than an afterthought. Choosing authentic GORE® Microwave/RF Test Assemblies is the only way to be sure your cables will stand up to the rigors of everyday use in demanding applications.

GORE® PHASEFLEX® Microwave/RF Test Assemblies – for proven performance, time and again. Learn what sets GORE® Microwave/RF Test Assemblies apart at:

www.gore.com/test

*Insist on authentic
GORE® Microwave/RF
Test Assemblies – the
proven purple performer.*



precision

repeatability

durability

GORE, PHASEFLEX, the purple cable and designs are trademarks of W. L. Gore & Associates.

Follow us on



Higher Performance
at Lower Cost
through Innovative
Engineering



Visit us at EDI CON Booth 210



POWER AMPLIFIERS

- ▶ New High Linearity Class A/B
- ▶ Wide Frequency Range
- ▶ Output Power 1W to 150W
- ▶ Compact Size
- ▶ Competitive Price & Fast Delivery



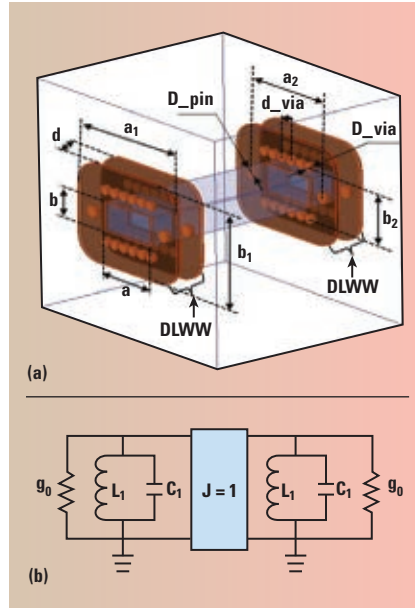
LNA with EMI Shielding

- ▶ EMI Leakage < -80 dBc DC to RF
- ▶ 0.1 – 6 GHz Frequency Range
- ▶ 1.3 dB Noise Figure
- ▶ Compact Size
- ▶ Competitive Price & Fast Delivery

Contact us with your
custom requirements
and let us lower your
cost without sacrificing
performance or quality

516-931-1760
www.agilemwt.com
ISO 9001:2008 CERTIFIED

Technical Feature



▲ Fig. 1 Back-to-back DLWW structure (a) and equivalent model (b).

coupling coefficient are equivalent to an admittance inverter of value $J = 1$.

DLWW Synthesis

The ABCD matrix and scattering parameters are used to determine the DLWW parameters. According to Figure 1, the two-port matrix of the dielectric resonator is

$$\begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ j & (\omega C_1 - 1/\omega L_1) \end{bmatrix} \quad (1)$$

and the two-port matrix of the quarter-wavelength waveguide is

$$\begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} = \begin{bmatrix} \cos(\beta l) & jZ_0 \sin(\beta l) \\ jY_0 \sin(\beta l) & \cos(\beta l) \end{bmatrix} \quad (2)$$

where l is the length of quarter-wavelength waveguide, and β is the propa-

gation constant.

The cascaded dual-port ABCD matrix of the DLWWs is

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \quad (3)$$

The input return loss (S_{11}) of the DLWW is expressed as

$$S_{11} = \frac{A + B/Z_0 - CZ_0 - D}{A + B/Z_0 + CZ_0 + D} \quad (4)$$

Therefore, the transmission power ratio is

$$P_L/P_I = 1 - |S_{11}|^2 \quad (5)$$

where P_L is the power delivered to the load and P_I is the available power from the source.

As shown in Figure 1b, this model provides the parameters of the network, namely, the resonant frequency (f_0) and the loaded quality factors (Q_L) of each dielectric resonator.

$$f_0 = 1/(2\pi\sqrt{L_1 C_1}) \quad (6)$$

$$Q_L = 2\pi f_0 C_1 \quad (7)$$

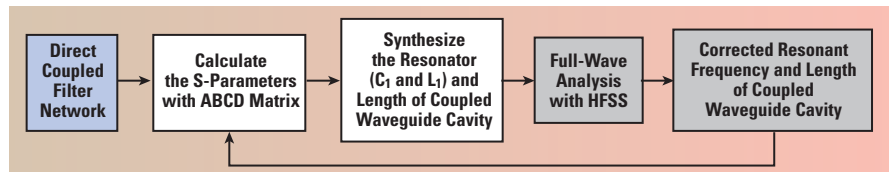
The dielectric resonator's f_0 and Q_L can also be deduced from its scattering parameters through full-wave simulation.¹¹

$$f_0 = \text{frequency at which } S_{11} \approx 0 \quad (8)$$

$$Q_L = \frac{f_0}{2} \frac{\partial \text{Im}(Y_{11})}{\partial f} \quad (9)$$

where Y_{11} is the input admittance of the dielectric resonator.

The synthesis procedure for the DLWW is shown in Figure 2. First,



▲ Fig. 2 Waveguide window synthesis procedure.

**GREAT SERVICE ISN'T EXPENSIVE...
...IT'S PRICELESS.**



**EXCELLENT
SERVICE**

**EXCELLENT
DELIVERY**

**EXCELLENT
QUALITY**



RF COAXIAL RELAYS



SMA, N AND PCB LAUNCH

STANDARD AND CUSTOM DESIGNS

RELCOMM
TECHNOLOGIES, INC.



- Mission Critical Communications:
 - Security, Safety and Intelligence
 - Commercial Telecom Infrastructure
 - Military Defense Fixed, Mobile & Shipboard
- Instrumentation:
 - Test and Measurement

RF Relay Store.com is the answer to your urgent small quantity needs.

RF Coaxial Relays available from Stock at www.rfrelaystore.com

sales@relcommtech.com • www.relcommtech.com • 410-749-4488



EXCELLENCE BY DESIGN

The Largest Selection of Waveguide Components For Same-Day Shipping



Waveguide Bandpass Filters



Waveguide Detectors



Waveguide Power Amplifiers



Waveguide Sections



Waveguide Standard Gain Horns



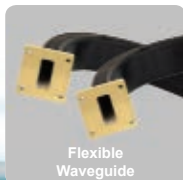
Waveguide Terminations



Waveguide Variable Attenuators



Waveguide to Coax Adapters



Flexible Waveguide



Waveguide Up/Down Converters

- Frequencies from L-band to W-band
- Leading Edge Performance
- Sizes from WR-10 to WR-430
- High Precision Machining
- Multiple Flange Styles
- All In-Stock and Ready to Ship

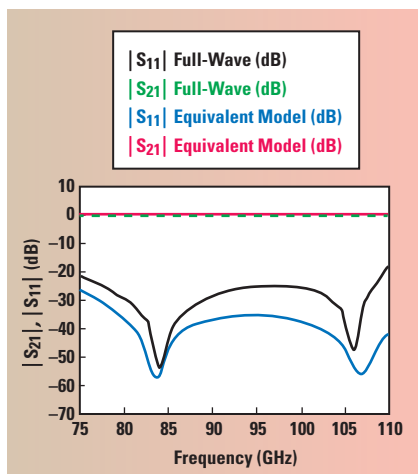
PE PASTERNAK
THE ENGINEER'S RF SOURCE

Technical Feature

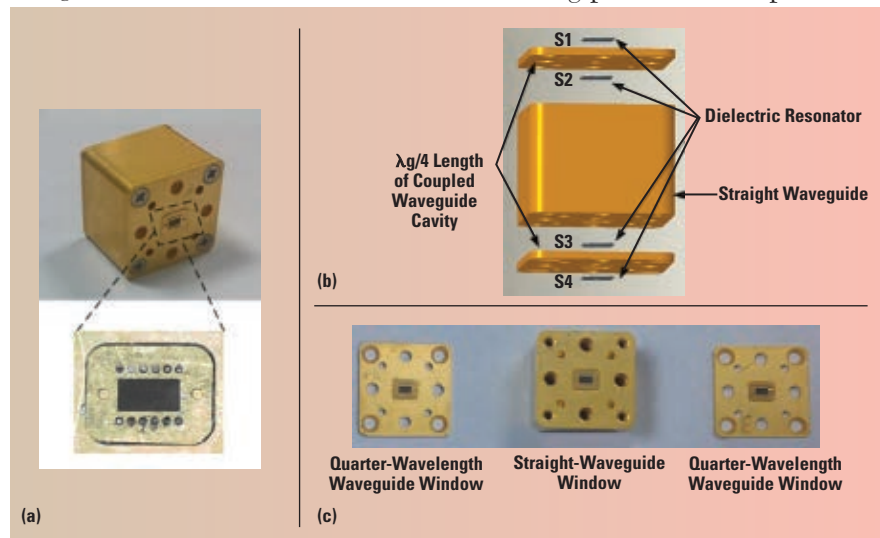
the direct coupled filter model is used to synthesize the DLWW. Then, the scattering parameters are derived using its ABCD matrix. Third, the dielectric resonator's (f_0, Q_L) and the length of coupled waveguide cavity are determined when S_{11} reaches a minimum. The full-wave model is then established and simulated. Finally, the direct coupled filter network parameters are corrected through full-wave simulation.

DLWW Full-Wave Simulation

The Ansoft HFSS full-wave simulator is used to accurately calculate the size of the dielectric resonator and the coupling cavity. The design parameters are defined in Figure 1a and their numerical values are: $a = 2.54$ mm, $b = 1.27$ mm, $a_1 = 5.54$ mm, $b_1 = 4.27$ mm, $a_2 = 4$ mm, $b_2 = 2.26$ mm, $d = 0.86$ mm, $d_{\text{via}} = 0.508$ mm, $D_{\text{via}} = 0.4$ mm and $D_{\text{pin}} = 0.5$ mm. **Figure**



▲ Fig. 3 DLWW model vs. simulation.



▲ Fig. 4 Photo (a) and exploded view (b) of back-to-back waveguide windows. Exploded view of welded quarter-wavelength waveguides and straight waveguide (c).

3 shows predictions from the equivalent model and the full-wave simulation. The full-wave simulation takes into account the loss of the transmission medium, so the curves are not exactly the same. From 75 to 108 GHz, the return loss is greater than 20 dB for the full-wave simulation curves.

FABRICATION AND TEST

Window Fabrication

The fabricated waveguide windows are composed of two DLWWs and one 15 mm length of straight waveguide (see **Figure 4a**). The dielectric resonators are fabricated using a PCB process with RT/Duroid 5880, giving the DLWWs the advantages of low complexity and low-cost in manufacturing. The waveguide is gold-plated aluminum alloy. The flange of the waveguide is WR10.

As shown in **Figures 4b** and **4c**, dielectric resonators S_2 and S_3 are welded onto the straight waveguide, and dielectric resonators S_1 and S_4 are welded onto the quarter-wavelength waveguides for the sealing. The solder is Au-Sn with a thickness of 0.025 mm. The welding temperature is 280°C. Two quarter-wavelength waveguide windows and one straight waveguide window are assembled with screws to form the back-to-back waveguide window (see **Figure 5**).

Test Results

To accurately test performance, a straight waveguide (length of 15 mm) is designed. **Figure 6** shows measured scattering parameters compared with

Design & Buy Online with

The Pasternack Cable Creator™

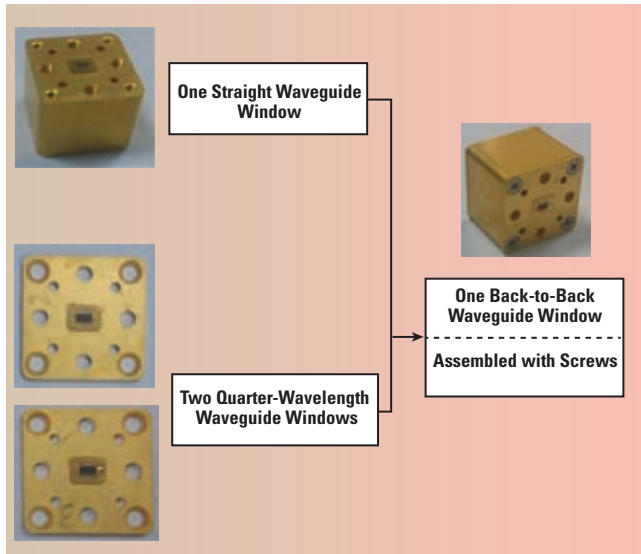
***Over 250,000 Possible Cable Assembly Configurations
Available – All Shipped the Same Day.***



Customize RF cable assemblies to your exact specifications with the new Pasternack Cable Creator. This easy to use tool provides instant pricing, detailed datasheets, and online ordering with same day shipping on any cable assembly built from our inventory of 1,300 connectors and 120 cable types. Another RF solution brought to you by the RF engineers at Pasternack.

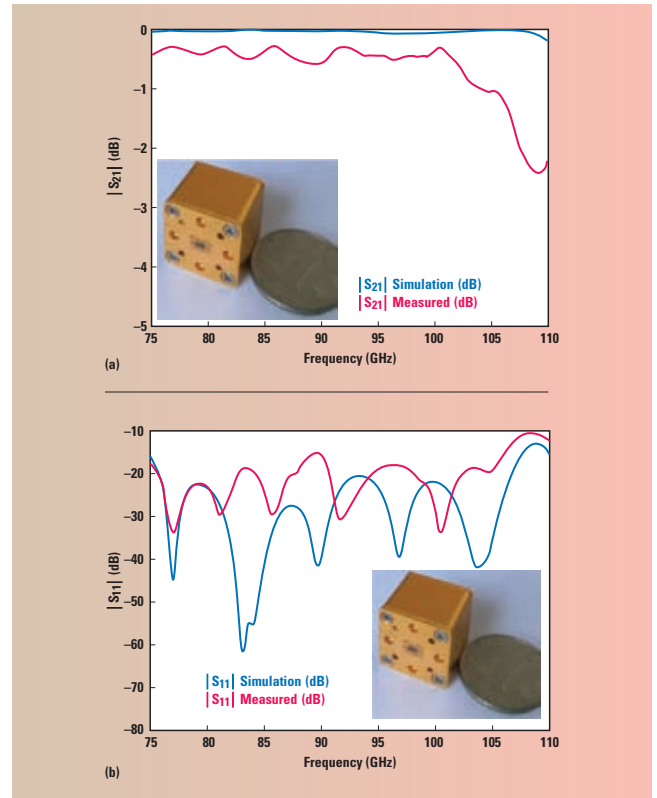
866.727.8376
visit pasternack.com today!

PE PASTERNAK®
THE ENGINEER'S RF SOURCE



▲ Fig. 5 Back-to-back waveguide assembly.

simulated results using Ansoft HFSS. Simulated return loss is higher than 20 dB and insertion loss lower than 0.2 dB in the frequency range of 75 to 100 GHz. Measured return loss is higher than 15 dB and measured insertion loss (after deducting the straight waveguide insertion loss) is better than 0.7 dB from 75 to 105 GHz. The leakage rate measured on several back-to-back devices, using a helium spectrometer leak tester, is less than 8×10^{-8} Pa.m³/s.



▲ Fig. 6 Simulated and measured S-parameters of back-to-back waveguide windows, $|S_{21}|$ (a) and $|S_{11}|$ (b).



E-band Spectrum Compact

70 - 87 GHz

World's smallest microwave spectrum analyzer for 2GHz - 40GHz now available in the E-Band (70GHz - 86GHz) range! An irreplaceable tool for every field engineer performing link alignment, troubleshooting, interference detection and many other tasks.



For more information, please visit: www.safetehnika.com/en/ebandspectrumcompact

The MegaPhase logo features a stylized orange and yellow 'S' shape inside a red circle, with a thin orange line passing through it.

MegaPhase®

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

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

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

Plus, nobody beats our response time.

MegaPhase can even customize to your needs with lightning speed. And no RF component provider offers a better value. So don't be passive. Give us a call or visit our website.

**With the right connections,
anything is possible.**



122 Banner Road, Stroudsburg, PA 18360-6433

Tel: 1-877-634-2742 | 570-424-8400

Solutions@MegaPhase.com | www.MegaPhase.com

CONCLUSION

A novel waveguide window for millimeter-wave module sealing is demonstrated. Its development was motivated by the desire for low complexity and low-cost in manufacturing. The structure is wideband compared with the resonance type windows. Measured results show that its return loss is greater than 15 dB and its insertion loss is less than 0.7 dB from 75 to 100 GHz for the back-to-back windows. The leakage rate is less than 8×10^{-8} Pa.m³/s. ■

ACKNOWLEDGMENTS

This work was supported by the National Natural Science Foundation of China (Grant No. 61101065).

References

1. A. Srivastava, O. J. Kwon, M. Satorov, A. Sharma, A. Tanwar and G. S. Park, "Broadband THz Vacuum Window Using Impedance Matching Approach," *35th International Conference on Infrared Millimeter and Terahertz Waves*, September 2010, pp. 1.
2. I. Freidovich, B. Prokofiev, A. Balabanov, A. Yegorov, A. Zakirov and A. Grigoriev, "Waveguide Window for a Broadband Multibeam Ka-Band Klystron," *IEEE 14th International Vacuum Electronics Conference*, May 2013, pp. 1–2.
3. S. Liu, "A RF Window for Broadband Millimeter Wave Tubes," *International Journal of Infrared and Millimeter Waves*, Vol. 17, No. 1, January 1996, pp. 121–126.
4. L. Earley, E. Smirnova and P. Ferguson, "Experimental Measurements and Field Modeling for a W-Band Window," *IEEE 5th International Vacuum Electronics Conference*, April 2004, pp. 244–245.
5. A. M. Cook, C. D. Joye, T. Kimura, E. L. Wright and J. P. Calame, "Broadband 220-GHz Vacuum Window for a Traveling-Wave Tube Amplifier," *IEEE Transactions on Electron Devices*, Vol. 60, No. 3, February 2013, pp. 1257–1259.
6. M. E. Hill, R. S. Callin and D. H. Whittum, "High-Power Vacuum Window in WR10," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 49, No. 5, May 2001, pp. 994–995.
7. S. Bashaiah, P. K. Sharma and K. C. J. Raju, "Fabrication of High Dielectric Constant and Low Loss X-Band Ceramic Waveguide Window for High Power Applications," *5th International Conference on Computers and Devices for Communication*, December 2012, pp. 1–4.
8. M. C. Lin, "A Multilayer Waveguide Window for Wide-Bandwidth Millimeter Wave Tubes," *International Journal of Infrared and Millimeter Waves*, Vol. 28, No. 5, May 2007, pp. 355–362.
9. S. B. Cohn, "Direct Coupled Resonator Filters," *Proceedings of the IRE*, Vol. 45, No. 2, February 1957, pp. 187–196.
10. R. Levy, "Theory of Direct-Coupled-Cavity Filters," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 15, No. 6, June 1967, pp. 34–348.
11. R. M. Barrio-Garrido, S. Llorente-Romano, A. Garcia-Lamperez and M. Salazar-Palma, "Design of Broadband Directly Coupled Non-Centred Resonant Irises Filters," *33rd European Microwave Conference*, October 2003, pp. 219–222.

AMTA 2016

Antenna Measurement Techniques Association 38th Annual Symposium

October 31–November 4, 2016
Austin, Texas USA
Hyatt Regency Austin Hotel



www.amta2016.org



Host:

ETS·LINDGREN®
An ESCO Technologies Company

Co-Hosts:



KEYSIGHT
TECHNOLOGIES



ENGINEERING
TEXAS A&M UNIVERSITY



ETS-Lindgren is proud to host the 38th Annual Symposium of the Antenna Measurement Techniques Association (AMTA), a non-profit, international organization dedicated to the development and dissemination of theory, best practices and applications of antenna, radar signature, and related electromagnetic measurement technologies. To learn more about AMTA, visit www.amta.org.

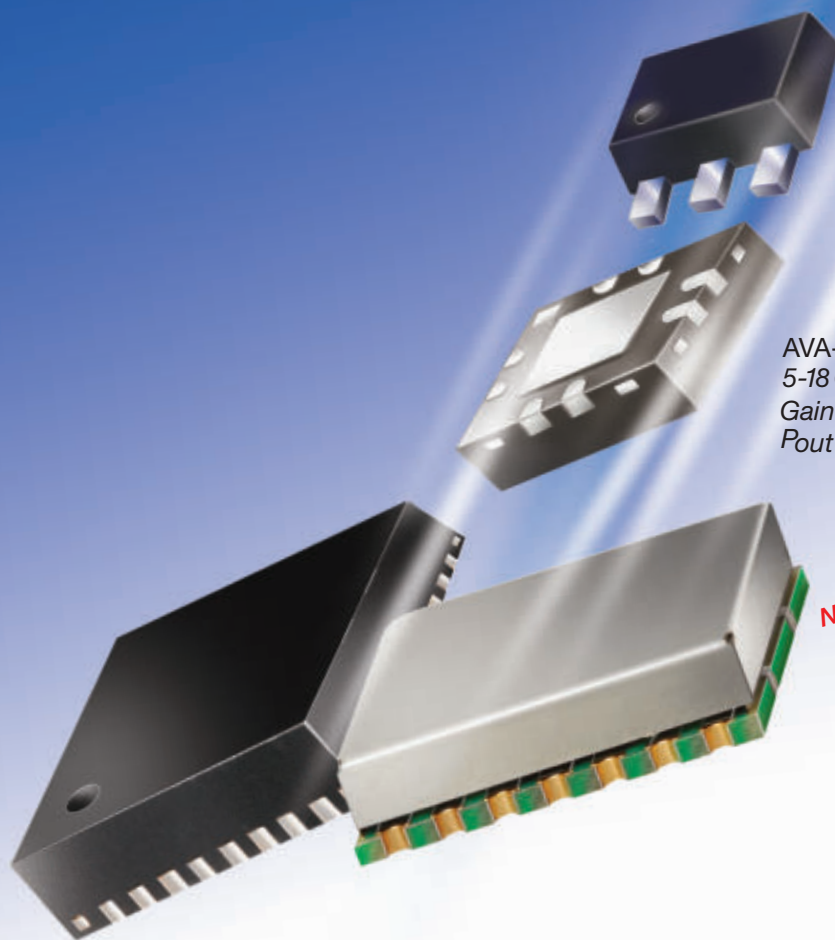
SYMPOSIUM HIGHLIGHTS

- High-quality Papers Presented on a Continuous Basis over Four Days – No Parallel Sessions
- Special Sessions on Antenna Measurements for Automotive, Wireless, UAVs, Aerospace, Adaptive/Smart Applications and More
- NEW "Boot Camp" Full Day Tutorial on Antenna and Related Measurement Fundamentals
- Practical Full Day Short Course – New Frontiers in RF Material Measurements
- Exhibits Showcasing Antenna and Measurement Related Products and Services
- Technical Tour, Social Events, and Daytime Companion Tours to Austin Highlights

**View the preliminary technical program online
at www.amta2016.org**

50 MHz to 26.5 GHz

MICROWAVE MMIC AMPLIFIERS



PHA-1+ \$1⁹⁹
0.05-6 GHz ea. (qty. 20)
Gain 13.5 dB
P_{out} 22 dBm

AVA-183A+ \$6⁹⁵
5-18 GHz ea. (qty. 10)
Gain 14.0 dB
P_{out} 19 dBm

New
AVM-273HPK+ \$36⁹⁰
13-26.5 GHz ea. (qty. 10)
Gain 13.0 dB
P_{out} 27 dBm

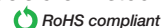
Mini-Circuits' **New AVM-273HPK+** wideband microwave MMIC amplifier supports applications from 13 to 26.5 GHz with up to 0.5W output power, 13 dB gain, ± 1 dB gain flatness and 58 dB isolation. The amplifier comes supplied with a voltage sequencing and DC control module providing reverse voltage protection in one tiny package to simplify your circuit design. This model is an ideal buffer amplifier for P2P radios, military EW and radar, DBS, VSAT and more!

The AVA-183A+ delivers 14 dB Gain with excellent gain flatness (± 1.0 dB) from 5 to 18 GHz, 38 dB isolation, and 19 dBm power handling. It is unconditionally stable and an ideal

LO driver amplifier. Internal DC blocks, bias tee, and microwave coupling capacitor simplify external circuits, minimizing your design time.

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

We've got you covered! Visit minicircuits.com for full specs, performance curves, and free data! These models are in stock and ready to ship today!



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



<http://www.modelithics.com/mvp/Mini-Circuits.asp>



www.minicircuits.com P.O. Box 350166, Brooklyn, NY 11235-0003 (718) 934-4500 sales@minicircuits.com

See us at EuMW Stand 56

478 rev Q

Achieving Metrology-Level Accuracy When Making THz Measurements

Andrej Rumiantsev, Toe Naing Swe
MPI Corp., Hsinchu, Taiwan
Andreas Henkel
Rohde & Schwarz, Munich, Germany

With significant expansion of emerging terahertz (THz) applications such as noninvasive spectroscopy, security and surveillance, short range automotive radar and 5G communications, the need for accurate, reliable and repeatable measurement data is crucial. This is especially true for the research and technology development of the devices, integrated circuits and new product building blocks serving the needs of THz applications.

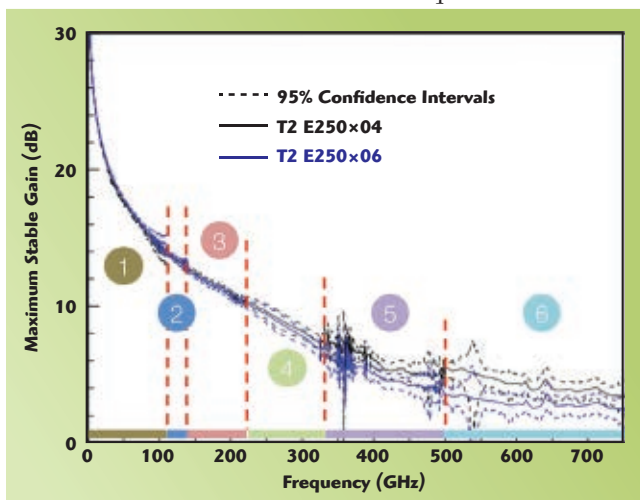
This article discusses solutions to address the challenges of wafer-level calibration and measurements at THz frequencies. Solutions

for measurement instrumentation, frequent system reconfiguration, operator skill affecting the accuracy and repeatability of calibration, and the need for metrology-level analysis of the measured data are described.

TEST INTEGRATION

Measurements at sub-THz frequencies usually require repeated and tedious system reconfiguration to switch between frequency bands. For example, the probe system and the vector network analyzer (VNA) have to be reconfigured and recalibrated six times to reach 750 GHz (see **Figure 1**). Characterizing a device under test (DUT) across frequency bands is becoming an extremely time consuming exercise. The conventional approach of mounting the sub-THz VNA frequency extenders on the probe system requires elevation of the chuck and microscope, which reduces the system's mechanical stability. At the same time, increasing the measurement frequency demands extremely accurate positioning of the RF probes on the DUT contact pads and calibration standards. As a result, the accuracy and repeatability of the system calibration decrease exponentially with increasing frequency, and characterization of the DUT becomes a very challenging task.

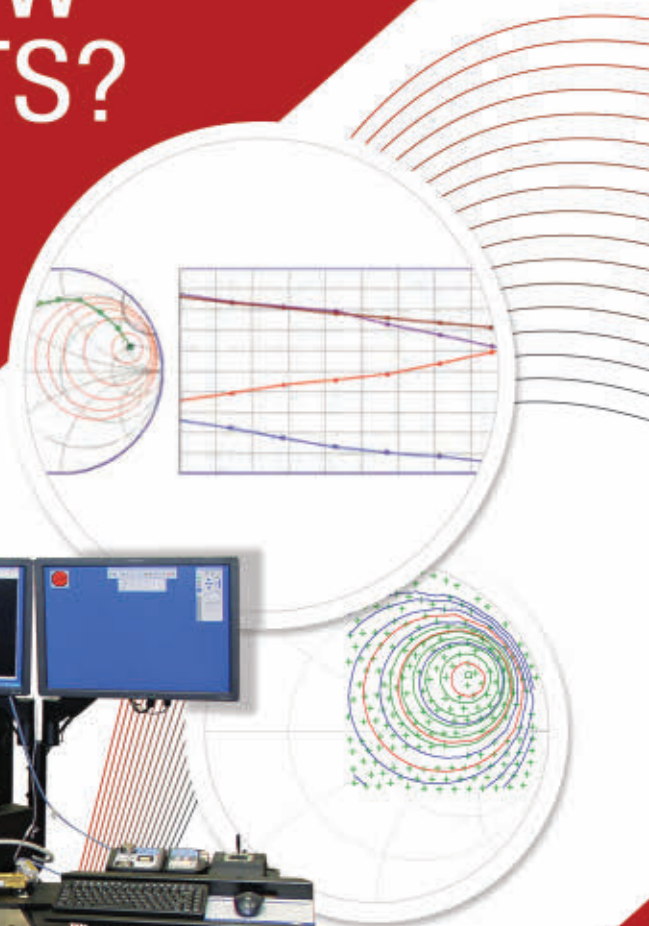
A manual system such as the MPI TS150-THz incorporates many features that address the challenges of wafer-level measurements at THz frequencies. These include seamless integration of any type of VNA frequency extender



▲ Fig. 1 MSG measurements of THz transistors with 95% confidence intervals; measuring to 750 GHz requires six system reconfigurations. Data courtesy of Dylan Williams, NIST.

SIMPLIFIED ON-WAFER MMW MEASUREMENTS? YES WE CAN!

Maury offers commercially proven turnkey on-wafer millimeter-wave measurement and modeling device characterization solutions capable of measuring S-parameters, single-tone and two-tone source and load pull, and extracting noise parameters, all with a single probe touchdown.



VISIT **MAURY**
AT **EUROPEAN**
MICROWAVE WEEK
BOOTH 1A
FOR LIVE DEMOS

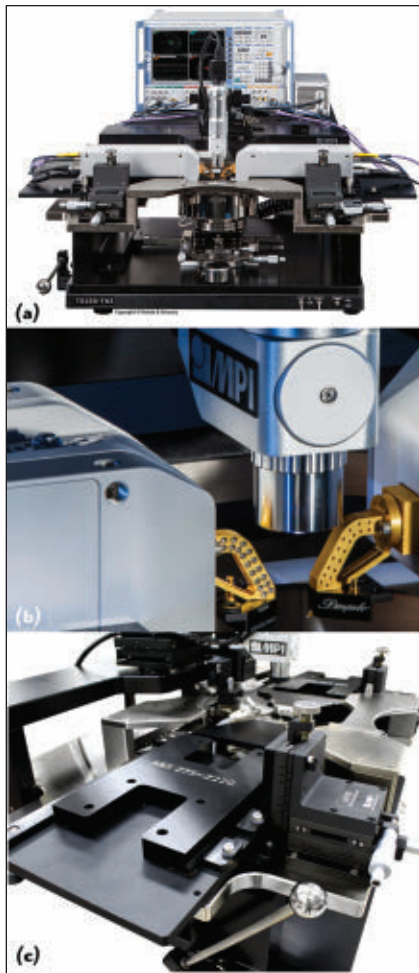


For the most up-to-date
information Visit us on
the Web at
MAURYMW.COM



Maury Microwave

Your Calibration, Measurement & Modeling Solutions Partner!



▲ Fig. 2 The MPI TS150-THZ integrated probe system configured for measurements to 330 GHz with the R&S ZVA VNA (a). GGB waveguide probes directly mounted at the output of the mmWave ZVA converters (b). Dovetail interface of R&S®ZVA-Z75 to R&S®ZVA-Z220 frequency converters (c). Photos courtesy of Rohde & Schwarz.

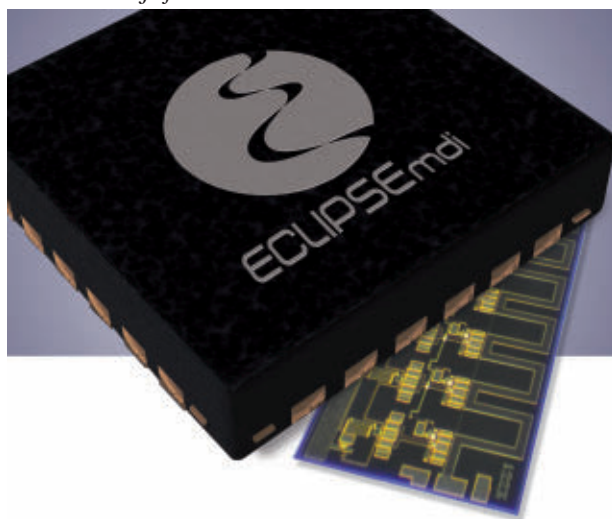
at any frequency band, to provide the maximum measurement dynamic range and reproducibility (see **Figure 2a**). This trade-off was resolved by combining the low profile and stable chuck Z-stage with the ridged probe platen resting below its surface. This allows direct mounting of THz RF wafer probes on the output waveguide port of the VNA frequency extenders (see **Figure 2b**), which maximizes measurement dynamic range. A dedicated dovetail interface of the VNA extenders holding plates makes swapping them easy (see **Figure 2c**). There is no need to unmount the interface plate from the extender. Due to its flat bottom, the interface and the VNA extender can be handled as one unit, located on the laboratory shelf or in a cabinet for later use.

WHY MULTILINE TRL?

The multiline thru-reflect-line (TRL) RF calibration method developed at the U.S. National Institute of Standards and Technology (NIST) has become the benchmark for metrology and industry laboratories focused on wafer-level RF measurements. Its key advantage over other calibration methods is the calculation of the calibration reference impedance, Z_{REF} , based on measurement of the traveling waves propagating through the calibration planar line standard. Traveling waves are purely physical phenomena defined by the type and design of the transmission lines and

are independent of the geometry and design of the RF probes. The multiline TRL algorithm enables accurate extraction of the propagation constant γ of the calibration lines. Therefore, the multiline TRL can set the measurement reference plane precisely and at an arbitrary position. The multiline TRL calibration kit can be designed and fabricated using the same semiconductor process as the DUT. Customized, on-wafer, multiline TRL calibration kits eliminate the need for de-embedding the DUT measurement results from the parasitic impedances of the device contact pads. With all these advantages, the multiline TRL is the only method that delivers trustable calibration results at frequencies above 110 GHz.

Three or more lines with different physical lengths should be used in the calibration to cover a wide frequency range. Together with the thru and reflection standards, the multiline calibration kit can include more than five elements. Measuring such a kit involves repeated readjustment of the micro-positioners and realignment of the probes to the contact pads to achieve repeatable measurements. It is often difficult to obtain accurate and repeatable multiline TRL calibration at millimeter wave (mmWave) frequencies on a manual probe system, especially if it is operated by several users with various levels of expertise. A system such as the TS150-THZ offers the option of an integrated digital



All the Power minus the noise.

Introducing two ultra small, super powerful low noise amplifiers EMD1710QFN4, 2-20 GHz and EMD1715QFN4, DC-20 GHz



Broadband performance ahead of its time.

HIGH POWER

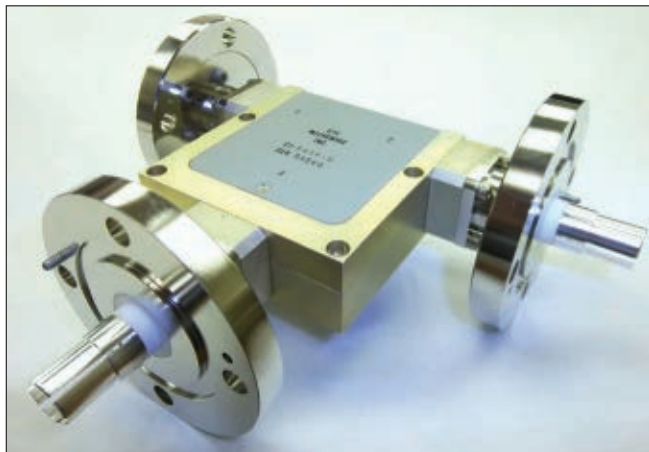
100 MHz
to 20 GHz



**For Military / Radar
Applications.**

Isolators/Circulators

325 MHz NEW HIGH POWER Circulator for Radar & UHF Frequencies



Model CT-1864-S is rated at 60kW peak and 600W average power at 325 MHz. The unit provides 20 dB minimum isolation, 0.2 dB insertion loss and 1.20:1 maximum VSWR. Its extremely compact design has flange to flange insertion length of only 6-3/4" and a height of 5-1/4". For use in radar applications, it has 1-5/8" EIA connectors. It is also available at other UHF frequencies and connector types.

The following models are examples of our High Power units

Model No.	Power	Connectors	Freq. Range
CT-1542-D	10 Kw Pk 1 Kw Av	DIN 7/16	420-470 MHz
CT-2608-S	3 Kw Pk 300 W Av	"Drop-in"	1.2-1.4 GHz
CT-3877-S	2.5 Kw Pk 250 W Av	"Drop-in"	2.7-3.1 GHz
CT-3838-N	5 Kw Pk 500 W Av	N Conn.	2.7-3.1 GHz
CT-1645-N	250 W Satcom	N Conn.	240-320 MHz
CT-1739-D	20 Kw Pk 1 Kw Av	DIN 7/16	128 MHz Medical

Broadband Units • Common Band Devices • High Isolation Units • Multiport Devices • Drop-In Devices • Wireless/PCN Devices • High-Power Industrial/Medical Iso Adaptors Waveguide Junctions • High-Power TV Units • VHF and UHF Devices

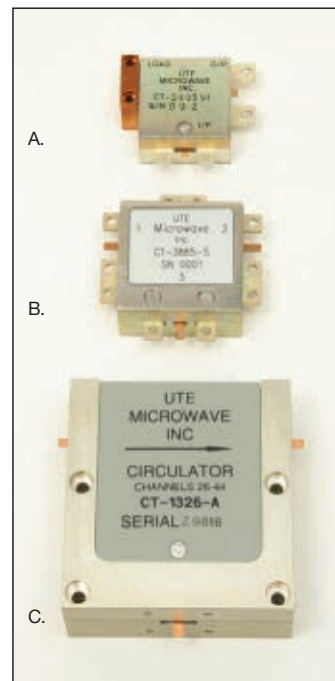
sales@utemicrowave.com

HIGH POWER Drop-in Series

A broad line of low loss HIGH POWER Drop-in circulators are available from VHF to Ku band including Kilowatt average power levels at VHF thru S band. L and S band radar are a specialty. A few of these are shown here.

- A) 2.7-3.1 GHz 1 kW pk, 100 W av
- B) 1.2-1.4 GHz 3 kW pk, 300 W av
- C) UHF TV Band 5 kW pk, 500 W av

**Our "POWER-LINE"
serves the
COMMUNICATIONS,
TELECOM,
MEDICAL, SCIENTIFIC,
TV, PCS and
INDUSTRIAL
markets.**

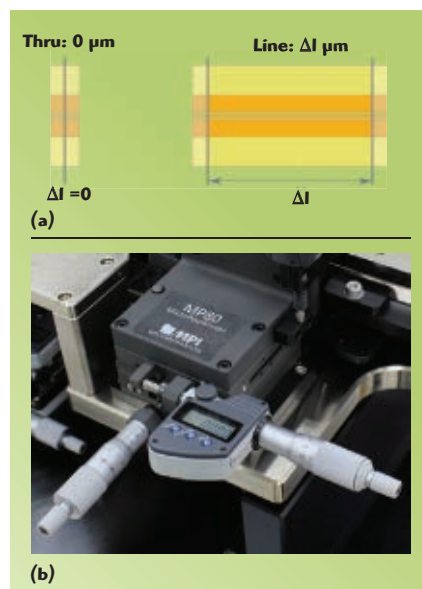


FEATURES:

- Power levels to 5 KW CW, 75 KW Pk.
- Low Intermod Units
- Low Loss Options
- Extended Octave Bandwidths
- Power Monitors and DC Blocks
- Iso Filter-Monitor Assemblies



3500 Sunset Ave., Asbury Park, NJ 07712
Tel: 732-922-1009 Fax: 732-922-1848
E-mail: info@utemicrowave.com



▲ Fig. 3 TRL definition of Δl for line standards (a). MP80-DX micro positioner with the digital micrometer on the X axis (b).

micrometer that simplifies the calibration process. The TRL algorithm always treats the thru standard as a zero-length line. The effective length of each subsequent line standard, Δl , is defined with respect to the length of the thru (see **Figure 3a**). The operator simply zeros out the digital micrometer after the initial adjustment of the probes, i.e., on the thru standard (see **Figure 3b**). Next, the distance between RF probes can be readjusted to the required value of Δl (see **Table 1**) with a precision better than 1 μm . As a result, the system improves the

TABLE 1			
CS15 ALUMINA CALIBRATION SUBSTRATE COPLANAR WAVEGUIDE LINES			
Standard Type	Physical Length (μm)	Effective Length, l (μm)	Δl (μm)
Thru	175	150	0
Line 1 (L2)	250	225	75
Line 2 (L3)	355	330	180
Line 3 (L4)	575	550	400
Line 4 (L5)	1025	1000	850
Line 5 (#10)	6600	6575	6425

accuracy and repeatability of calibration—even for inexperienced operators—while reducing setup times.

NIST UNCERTAINTY FRAMEWORK

StatistiCAL™ Plus is a software package developed at NIST that realizes both conventional multiline TRL and calibration solutions based on the orthogonal distance regression. The algorithms were developed at NIST and the Physikalisch-Technische Bundesanstalt (PTB) of Germany. The unique feature of this algorithm is the ability to estimate the uncertainty of its own results due to random errors. The StatistiCAL Plus algorithm features a high degree of robustness, as it is able to find solutions even with poor initial estimates. The NIST Microwave Uncertainty Framework extends StatistiCAL Plus, adding data post-processing related to calculating and propagating uncertainties through different models. The framework includes post processors that allow the uncertainties in

measured S-parameters to be propagated to transistor gain, power, material parameters and other derived measurements and metrics. Both software packages were developed for metrologists and microwave measurement experts with the intention of post-processing already measured data offline, i.e., without a link to the VNA, probe system and device characterization software. Their application in a typical industry or university measurement laboratory and the integration into a common automated measurement workflow requires enormous programming and extensive experience in microwave metrology.

Now, NIST multiline TRL metrology-level VNA calibration from StatistiCAL Plus can be accessed through integration with MPI's QAlibria® software. Both software packages work hand-in-hand in the system calibration and data analysis workflow (see **Figure 4**): QAlibria takes responsibility for interaction with the VNA, probe system and operator, while

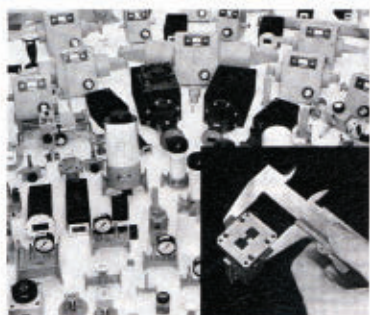
Waveguide Components

OFF-THE-SHELF OR CUSTOM DESIGNS



• Attenuators • Couplers • Switches • Loads • Terminations • Adapters • Assemblies • Horns • Ferrite Components

We're Ready When You Are... Next Day Delivery Of Catalog Components



From The Largest Inventory Of Waveguide Components In The Industry
RECTANGULAR, MM-WAVE, & DOUBLE-RIDGED COMPONENTS

CUSTOM DESIGNS

Custom designs are a Waveline specialty. If you don't see the product or design in our catalog, we probably have your "special" in our design files. Waveline now offers a complete line of Pin Diode Switches, Attenuators & Phase Shifters. Waveline has the expertise and capabilities to integrate waveguide and solid-state designs for subassemblies.

CALL OR WRITE

waveline

P.O. Box 718, West Caldwell, NJ 07006
(973) 226-9100 Fax: 973-226-1565
E-mail: wavelineinc.com



TACONIC®

Finding a better way

EZ-10

**Nanotechnology Based PTFE
Laminate**

- DF @ 10 GHZ = 0.0012
- For emerging high speed digital and E/W frequencies
- Near FR-4 fabrication

fastRise™

**Multilayer Non-Reinforced
Prepreg**

- DF @ 10 GHZ = 0.0014
- Low temperature thermosetting prepreg/alternative to thermo-plastic film
- Lowest loss RF prepreg

***Lowest Loss Materials
for Multilayer, Power
Amplifier & Rigid/Flex***

RF-35TC

**Thermally Conductive Low
Loss Laminate**

- DF @ 10 GHZ = 0.0011
- High adhesion to low profile coppers
- Diffuses heat away from transmission lines and surface mount components



Scan for more information

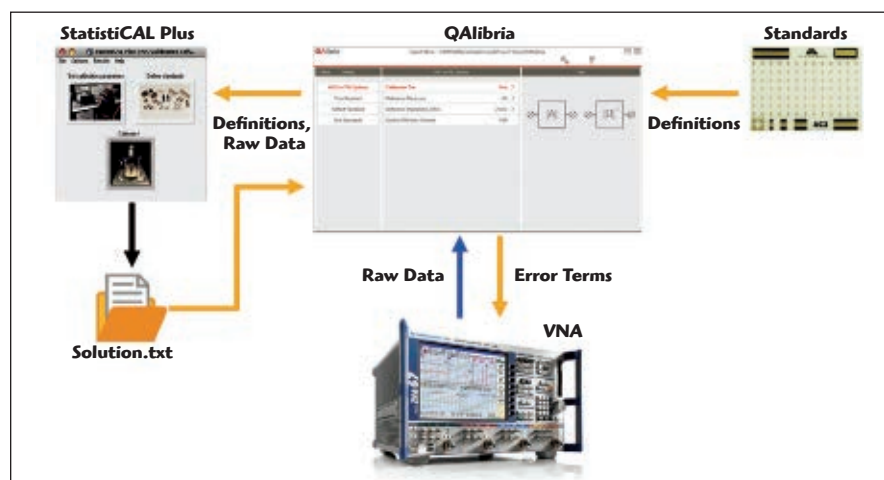
TSM-DS3

**Dimensionally Stable Low
Loss Laminate**

- DF @ 10 GHZ = 0.0011
- Enables large format high layer count PWBs
- Diffuses heat away from heat sources in PWBs

www.4taconic.com
1-800-833-1805

See us at EuMW Stand 235



▲ Fig. 4 System calibration data flow.

StatistiCAL Plus calculates calibration error terms and uncertainties, running in the background. With QALibria's multi-touch and multi-language graphical user interface, configuration mistakes are minimized, and accurate calibration results can be obtained, even by inexperienced users.

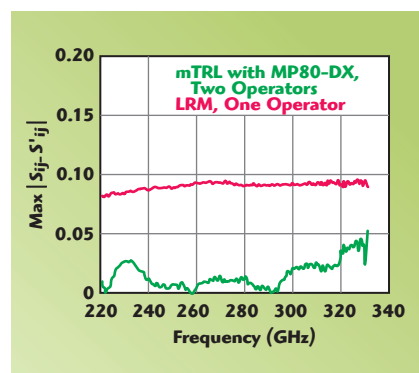
Calculating the multiline TRL error terms requires initial information about calibration standards, such as the type of the reflection standard (i.e., open, short or high reflection), physical length of the line standards and an initial estimate of the effective dielectric constant. The StatistiCAL algorithm requests the initial estimate for error terms as well as some specific settings for the NIST ODRPACK calculation engine. These definitions are automatically prepared by QALibria and saved locally as the StatistiCAL

Plus calibration menu file QALibria-MenuNIST.scm in the local folder: \MPI\QALibria\Data\StatistiCAL\.

This folder also contains the raw data of the calibration standards measured by QALibria (in the _input\ directory) and the calibration results calculated by StatistiCAL, which are automatically saved as the solution vector Solution.txt in the _output\ directory. Once the StatistiCAL Plus calculations are completed, QALibria loads the solution vector and sends the error terms to the VNA. The system is fully calibrated without any interaction from the operator.

REPEATABILITY AND REPRODUCIBILITY

The common features of MPI manual systems currently in the market include an air bearing stage,



▲ Fig. 5 Repeatability of a lumped LRM calibration vs. operator error for the multiple TRL calibrations performed on the TS150-THZ with the MP80-DX option.

a highly repeatable platen lift with three discrete positions and the auto-contact feature. This latter feature is particularly important for improving contact repeatability and reproducibility of the DUT measured data, independent of the operator's expertise. **Figure 5** shows the experimental results for the calibration repeatability of the lumped line-match (LRM) and the multiline TRL methods with the CS15 commercial alumina calibration substrates and waveguide RF probes from GGB Industries, Inc. The LRM was executed twice sequentially and by the same experienced operator. The difference between these two calibrations was calculated using the calibration comparison method. Because the calibrations were performed sequentially, system drift was minimized, and the outcome of the calibration comparison

Programmable ATTENUATORS

\$280
from

0 to 127dB 0.25dB Step * 1 to 8500MHz * Up to 128 x 128 Matrix



HJ Technologies
RF Solutions Expert

www.haojintech.com

Phone: +86(021)31198601 E-mail: hj@haojintech.com

Shielding Box
MIN Isolation 85dB



Fixed Attenuators
High Accuracy



Power Divider
600 - 6000MHz



PROTOTYPING DOESN'T HAVE TO BE SLOW AND UGLY.

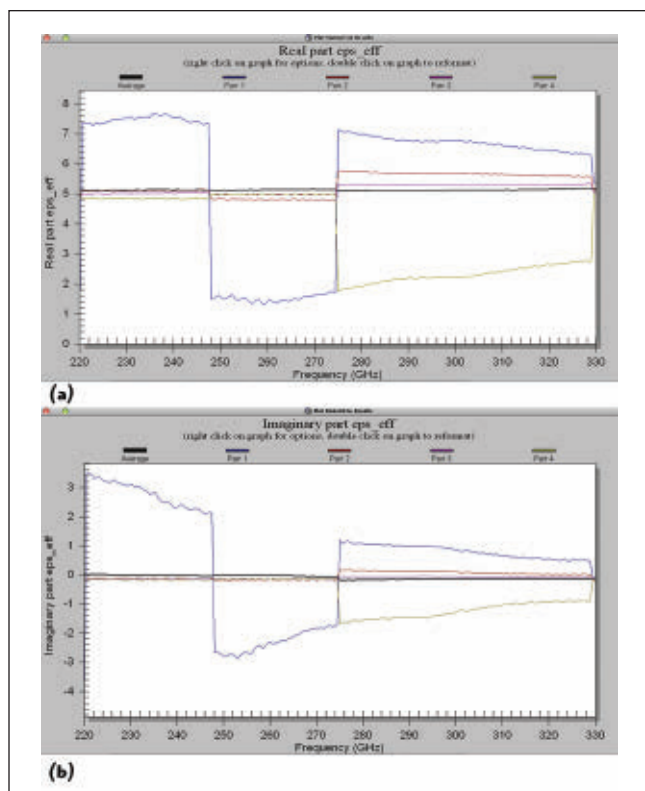


RAPID RESPONSE
CABLE ASSEMBLIES

- Custom cables ship in 5 days
- Online order placement (credit card or PO)
- Application available 24 hours a day

SV Amphenol
MICROWAVE

www.svmicrowave.com



▲ Fig. 6 Real (a) and imaginary (b) parts of the effective dielectric constant ϵ_{eff} calculated and displayed by StatistiCAL Plus (debug case).

son method primarily presents the repeatability error of the LRM calibration. Next, four multiline TRL calibrations were performed, two by an experienced operator and two by an inexperienced operator. Each time, the digital micrometer was used to define the Δl of each calibration line, per Table 1. The difference in the maximum repeatability error of the multiline TRL calibration performed by the two operators is significantly smaller than the single operator repeatability error of the LRM.

The multiline TRL enables accurate extraction of the propagation constant, γ , of the calibration lines and easy calculation of the effective dielectric constant, ϵ_{eff} . NIST StatistiCAL Plus can plot both the real and the imaginary parts of ϵ_{eff} for each line pair, together with the average values (see **Figure 6**). This is a handy feature for quick verification and debugging of calibration results. If required, the data can be exported as graphs or data files for further analysis. Another quick check of calibration success is to verify the corrected S-parameters of the line and reflection standards used for the calibration (see **Figures 7 and 8**).

When detailed analysis of the DUT data, including calibration and measurement uncertainties, is required, the StatistiCAL Plus solution vector can be directly loaded into the Calibrate DUT Plus tool from the NIST Uncertainty Framework (see **Figure 9**). The DUT parameters can be calculated, including the standard uncertainties with 95 percent confidence intervals. The covariance matrix of the calibration uncertainties should also be exported from the StatistiCAL Plus menu (see **Figure 10**).



ITC 2016

THE PREMIER EVENT FOR TELEMETRY PROFESSIONALS

NOVEMBER 7–10, 2016

Renaissance Glendale Hotel & Spa | Glendale, AZ

Our 2016 conference theme is “New Horizons in Telemetry.” The second decade of the 21st Century may be characterized by the changing landscape in all areas of telemetry. In aeronautical telemetry, the increasing sophistication of the systems we test increases the volume and importance of telemetry data. Spectral reallocations present new challenges and new opportunities. ITC 2016 addresses these issues and more in a comprehensive program that includes the following:

- 3½-day program with robust Technical Program, which includes 12 Short Courses and 20 Technical Sessions
- A special session devoted to how spectrum reallocation funds, derived from the AWS-3 auctions, are being used by test ranges
- Opening session on the New Horizons space mission to Pluto
- Exhibits from 100 of the industry’s traditional and newest suppliers

New Horizons in Telemetry

Scan QR code to download the ITC mobile app for conference info and program schedules:



Exhibit Space Still Available!

First-Time Exhibitors: Receive 50% discount on your booth space!

Register online today:

www.telemetry.org

T26/T34 Series High Reliable & Durable Test Cable

Advantages and Features:

- Super flexible & durable
- Outstanding VSWR performance
1.20:1 typ. @26.5GHz, 1.25:1 typ. @34GHz
- Cable attenuation
2.52 dB/m @26.5GHz, 2.95 dB/m @34GHz
- Qualified for over 150K flex cycles
- Excellent phase stability over flexure
 $\pm 2^\circ$ @26.5GHz, $\pm 2.5^\circ$ @34GHz
- Negligible changes of amplitude over flexure
 $\pm 0.04\text{dB}$ @26.5GHz, $\pm 0.05\text{dB}$ @34GHz

Applications:

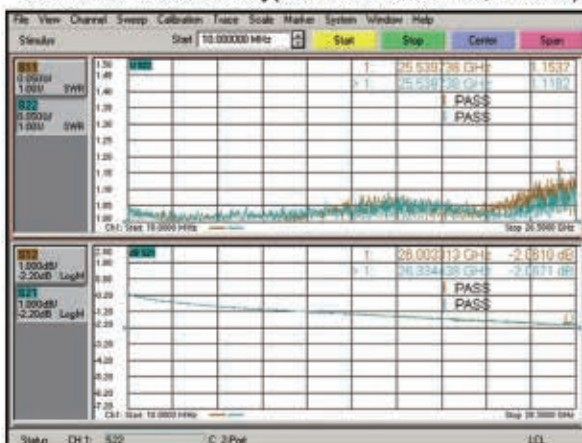
- RF field test
- Mobile, IPAD, WIFI, base station test
- High volume production test
- Point to point equipment test
- Research and development labs



Qualified for over
150K flex cycles

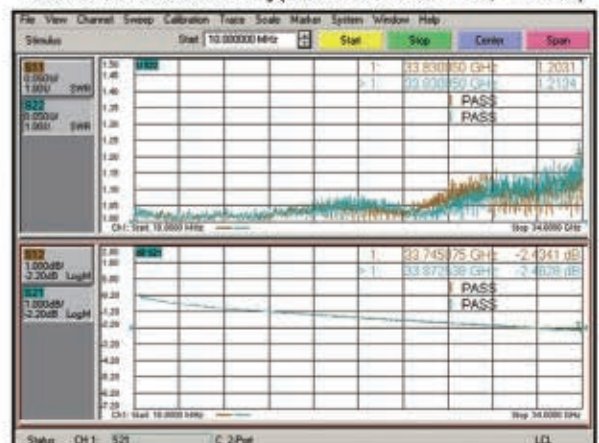
T26 Series DC~26.5GHz

Test Plot of T26 Assembly(3.5mm M - 3.5mm M, 1 Meter)



T34 Series DC~34GHz

Test Plot of T34 Assembly(3.5mm M - 3.5mm M, 1 Meter)



Micable is your quality fast and low cost solution!

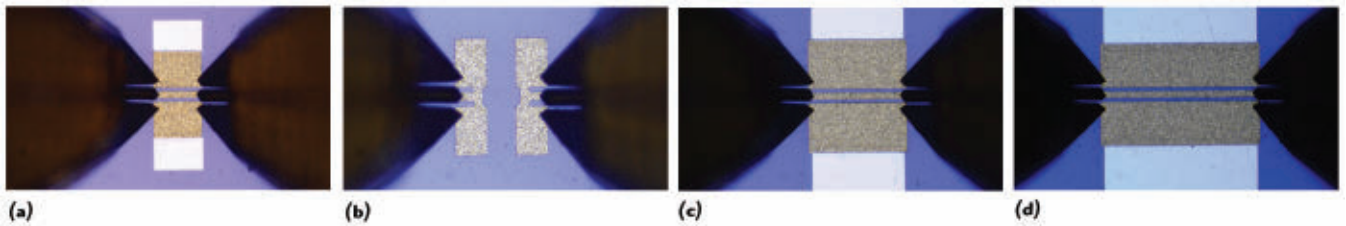
affiliated with **SSI**
Cable Corp.

Fuzhou Micable Electronic Technology Co., Ltd.
Tel: +86-591-87382856
Email: sales@micable.cn
Website: www.micable.cn

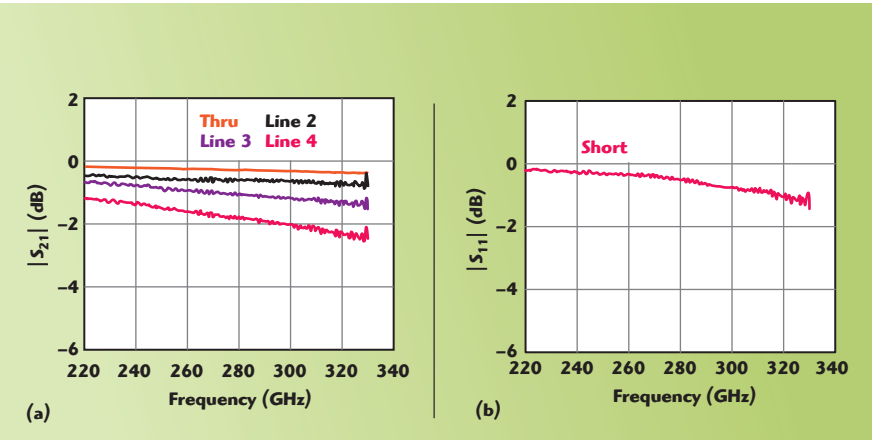
Seeking world-wide agents



USA Distributor Center:
SSI Cable Corporation
Tel: (360)426-5719
Email: bsmith@ssicable.com



▲ Fig. 7 Coplanar standards from the CS15 calibration substrate and probes from GGB Industries, Inc.: thru (a), short (b), line 2 (c) and line 3 (d).



▲ Fig. 8 Corrected results of the CS15 CPW line (a) and short (b) standards.

CONCLUSION

To demonstrate the system's capabilities, a four stage, 325 GHz MMIC

low noise amplifier (LNA) developed by the Fraunhofer Institute for Applied Solid State Physics IAF was

measured (see **Figure 11**). $|S_{21}|$ is shown with the ± 95 percent confidence intervals.

The expansion to THz frequencies of wafer-level measurements demands new approaches for system integration, calibration, operation and data analysis. Wafer probe systems designed from the ground up can incorporate many innovative features to simplify system operation and re-configuration and provide the maximum measurement dynamic range and reproducibility. For the first time, it is possible to simplify the system calibration, device measurement and data analysis at the metrology level, by integrating the NIST StatistiCAL Plus and the NIST Uncertainty Framework software packages. Modular



Frequency Matters.

www.mwjjournal.com/freqmatters

HOW THE IOT IS DRIVING THE 5G NETWORK

EuMW SHOW COVERAGE AND INDUSTRY NEWS

3D PACKAGING FOR RF

THE PATH TO THE 5G MILLIMETER WAVE RADIO REVOLUTION



Catch up on the latest industry news with the bi-weekly video update

Frequency Matters

from
Microwave Journal

▶

Scan page
using **layar** app

Sponsored By



ISO 9001 ISO 14001 AS 9100



MODULAR TEST SYSTEMS

Built Your Way and Delivered within 2 Weeks!

Signal Routing & Attenuation Control for Production Test, R&D and More!

Mini-Circuits' new ZTM-Series RF test systems dramatically accelerate custom solutions for a wide range of applications in test environments. Choose from our lineup of extra-long-life SPDT, SP4T, SP6T and transfer switches, and programmable attenuators with attenuation ranges of 0 to 30, 60, or 90, 110 or 120 dB. We'll build and ship a solution tailored to your exact requirements *within just 2 weeks!*

It's that simple! Give us a call and talk to our engineers about how Mini-Circuits' ZTM-Series custom rack mount test solutions can improve efficiency, increase throughput, and save cost in your business!

Features

- Rugged 19" Rack Mountable Chassis
- Customizable Front Panel Layout
- Light Weight
- USB and Ethernet Control
- User-friendly GUI and DLLs Included
- Qualified to 100 Million Switch Cycles
- Affordable Cost
- ***Delivery within 2 Weeks!***

Choose from hundreds of possible configurations!



SPDT Switches
DC – 18 GHz



SP4T Switches
DC – 18 GHz



SP6T Switches
DC – 12 GHz



Transfer Switches
DC – 18 GHz



0 – 30, 60, 90, 110 or 120 dB
Programmable Attenuators
1 MHz – 6 GHz



Configure your system online now for a fast quote!



www.minicircuits.com P.O. Box 350166, Brooklyn, NY 11235-0003 (718) 934-4500 sales@minicircuits.com

See us at EuMW Stand 56

527 rev. C



IEEE Wireless and Microwave Technology Conference
WAMICON 2017
Hilton Cocoa Beach
Cocoa Beach, Florida
April 24-25, 2017

JOIN US

The 18th annual IEEE Wireless and Microwave Technology Conference (WAMICON 2017) will be held in Cocoa Beach, Florida on April 24-25, 2017. The conference will address up-to-date multidisciplinary research needs and interdisciplinary aspects of wireless and RF technology. The program includes both oral and poster presentations as well as tutorials and special sessions. The conference also features an active vendor exhibition area and an array of networking opportunities.

CALL FOR PAPERS

The technical program is focused on Emerging Technologies for 5G Systems including active and passive components and systems as well as wireless communications. Prospective authors are invited to submit original and high-quality work for presentation at WAMICON 2017 and publication in IEEE Xplore.

Topics of interest include:

- 5G Power Amplifiers, Beamforming, mmWave and Antennas
- Internet of Things (IoT)
- Active Components and Systems
- Passive Components and Antennas
- Microwave Applications

Visit www.wamicon.org for complete submission details.

Important Dates

Papers Due: January 4, 2017
Author Notification: January 25, 2017
Final Papers Due: February 8, 2017

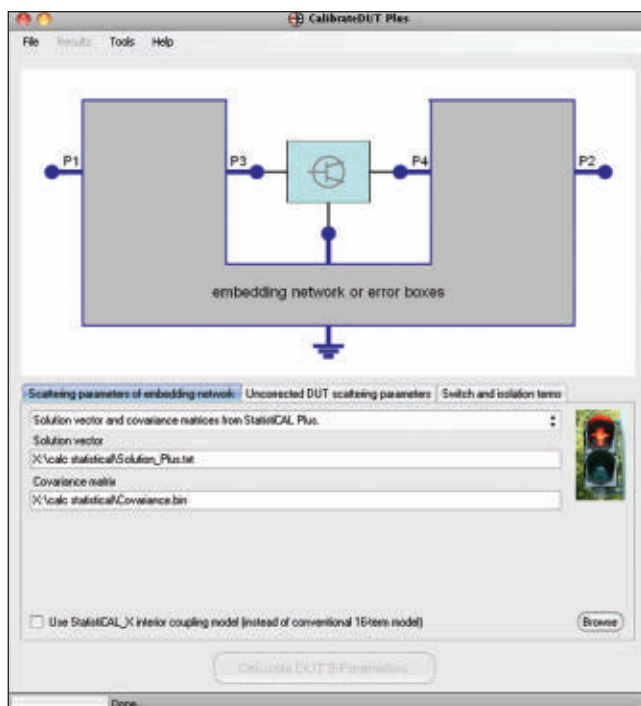


www.wamicon.org

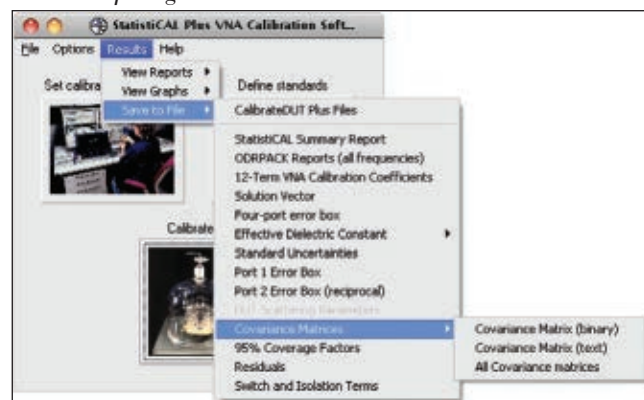
Exhibit/Sponsor Opportunities Available!
Email: jassurian@reactel.com
dzavac@tte.com

Application Note

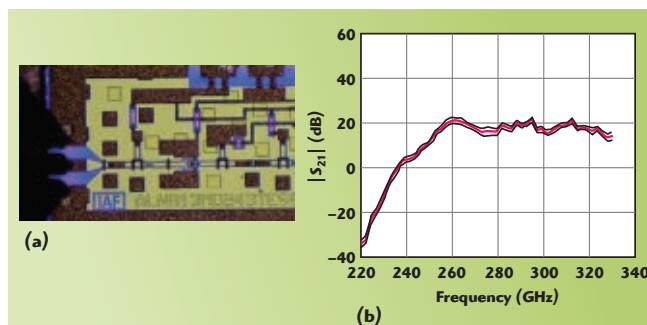
thermal and non-thermal chucks, advanced RF accessories (such as RF micro-positioners, RF cables, calibration substrates and RF probes), new calibration techniques and the integration of the VNA closer to the probe system yield a complete measurement solution that addresses the complexities and accuracy requirements of THz probing. ■



▲ Fig. 9 The CalibrateDUT Plus tool from the NIST Uncertainty Framework package.



▲ Fig. 10 Exporting the calibration residual errors covariance matrix from StatistiCAL Plus.

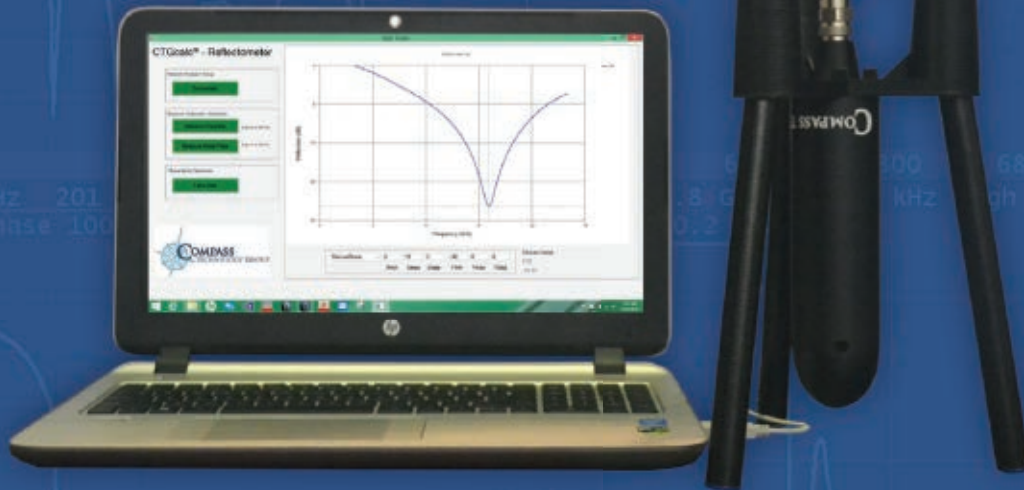


▲ Fig. 11 Fraunhofer Institute four stage, 325 GHz MMIC LNA (a) and measured S_{21} with the $\pm 95\%$ confidence intervals (b).



EXTEND YOUR REACH

Compass Technology Group using
R140 to measure reflection properties
of EMI absorber materials



R60 (new)



R140



R54

US Patent 9,291,657

FIRST *to* MARKET. FIRST *in* PRECISION.

Producing high-quality wireless components just got a lot easier. Whether you are challenged with testing speed, ease of reporting or space constraints, our **US Patent 9,291,657** no-test-cable-needed USB vector network analyzer **Reflectometer Series** is made for you.

Reflectometer Series Specs:

- ▶ Frequency Range: 85 MHz – 5.4 GHz/14 GHz or 1 MHz - 6 GHz*
- ▶ Measured Parameters: S_{11}
- ▶ Effective Directivity: ≤ 46 dB*
- ▶ Measurement Time: as low as 100 μ s/pt*
- ▶ Measurement Points: 100,001

*depending on model



Stand: 99

To see how others have used our products to extend their reach visit:
www.coppermountaintech.com/casestudies



**COPPER MOUNTAIN
TECHNOLOGIES**



Power Analyzer Reaches 70 GHz with >100 dB Dynamic Range

Anritsu
Morgan Hill, Calif.

The MA24507A Power Master™ frequency selectable millimeter wave (mmWave) power analyzer from Anritsu is the world's first frequency selectable RF power sensor. By utilizing Anritsu's patented Shockline nonlinear transmission line (NLTL) technology, Power Master combines the industry's widest power measurement range, fast measurement speeds and the ability for the user to define the frequency of the signal to measure—all with the convenience of a USB-powered instrument. With measurement capability to 70 GHz, the MA24507A opens up new test capabilities for growing mmWave applications, like 802.11ad, WirelessHD™ and 5G wireless backhaul.

THE SHOCKLINE ADVANTAGE

Anritsu's state-of-the-art Shockline-based receiver uses a patented NLTL technique to sample RF signals. This gives Anritsu instruments the ability to sample high frequency signals that would normally require expensive fundamental mixers or leaky step recovery diode samplers. NLTL technology has made Anritsu the leader in high frequency VNAs, with products like VectorStar® and ShockLine™ VNAs. With Power Master, NLTL enables accurate measurement of mmWave power in an instrument just slightly bigger than a smartphone.

Anritsu's Shockline receiver has a dynamic range greater than 100 dB at all frequencies. Most power sensors use a diode or thermal-based element to detect changes in RF power. While these methods provide highly accurate power readings, they have limited power measurement range. Diode sensors typically

do not measure signals below -60 dBm; even at that level, they require high measurement averaging to provide stable readings. Thermal sensors are even worse, generally tapping out around -30 dBm. Using the Shockline receiver to detect power, Power Master accurately reads many signals as low as -100 dBm. This is especially advantageous for over-the-air (OTA) testing of mmWave signals, which suffer high propagation losses through the air. Many mmWave receivers, like 802.11ad access points and automotive radar, may see signals below -90 dBm. With Power Master, users can read signals at those levels necessary for important tests like calibrating mmWave systems at both the transmitter and receiver, or measuring signal strength across various distances and through objects. This measurement flexibility creates a more robust test system by expanding the number of verification tests, which results in better designs and more reliable products.

COMPELLING FEATURES

PowerMaster allows the user to define the frequency band for measuring power. Thermal and diode-based sensors are inherently broadband, meaning they aggregate the power of all signals—regardless of the frequency—while making a measurement. That is not a concern for many controlled applications; however, in the field or when troubleshooting in the lab, it can hinder characterizing system behavior correctly. For example, when field testing signal strength for wireless backhaul networks, a diode or thermal power sensor will not differentiate between the intended RF signal from the other signals within the sensor's frequency range, which may

FIVE DAYS



THREE CONFERENCES



ONE EXHIBITION

EUROPEAN MICROWAVE WEEK 2016
EXCEL LONDON, UK
3 - 7 OCTOBER 2016



**EUROPEAN
MICROWAVE WEEK**
LONDON, UK
3-7 OCTOBER 2016
www.eumweek.com

EUROPEAN MICROWAVE WEEK 2016 REGISTRATION INFORMATION

EUROPE'S PREMIER MICROWAVE,
RF, WIRELESS AND RADAR EVENT

EuMA

European Microwave Association

Official Publication:



Organised by:



Supported by:



Co-sponsored by:



Co-sponsored by:



The 11th European Microwave
Integrated Circuits Conference

Co-sponsored by:



The 46th European Microwave Conference

Co-sponsored by:



The 13th European Radar Conference

Co-sponsored by:



Register online at
www.eumweek.com



RETURNING TO LONDON FOR THE FIRST TIME IN 15 YEARS

THE ONLY EUROPEAN EVENT DEDICATED TO THE MICROWAVE AND RF INDUSTRY

EuMW 2016 will be held in the dynamic and historically rich city of London. Bringing industry and academia together, European Microwave Week 2016 is a FIVE day event, including THREE cutting edge conferences and ONE exciting trade and technology exhibition featuring leading players from across the globe. Concentrating on the needs of engineers, the event showcases the latest trends and developments that are widening the field of applied microwaves. It also offers you the opportunity for face-to-face interaction with those driving the future of microwave technology.

EuMW 2016 will see an estimated 1,700 - 2,000 conference delegates, over 4,000 visitors and in excess of 300 international exhibitors (inc. Asia & US).

REGISTRATION TO THE EXHIBITION IS FREE!

Pivotal to the week is the European Microwave Exhibition, which offers YOU the opportunity to see, first hand, the latest technological developments from global leaders in microwave technology.

The exhibition will provide an unrivalled opportunity for visitors to view and ask questions related to the latest products, components and materials from our extensive selection of international exhibitors. It will also feature exhibitor demonstrations, Industrial Workshops and the annual European Microwave Week Microwave Application Seminars (MicroApps).

- **International Companies** - meet the industry's biggest names and network on a global scale
- **Cutting-edge Technology** - exhibitors showcase the latest product innovations, offer hands-on demonstrations and provide the opportunity to talk technical with the experts
- **Technical Workshops** - get first hand technical advice and guidance from some of the industry's leading innovators

BE THERE

Exhibition Dates	Opening Times
Tuesday 4th October	09:30 - 18:00
Wednesday 5th October	09:30 - 17:30
Thursday 6th October	09:30 - 16:30

FAST TRACK BADGE RETRIEVAL

Entrance to the Exhibition is FREE and attending couldn't be easier.

VISITORS

Registering for the Exhibition

- Register as an Exhibition Visitor online at www.eumweek.com
- Receive a confirmation email with barcode
- Bring your barcode with you to the Exhibition
- Go to the Fast Track Check In Desk and print out your visitor badge
- Alternatively, you can register onsite at the self service terminals during the Exhibition

Please note NO visitor badges will be mailed out prior to the Exhibition.



**EUROPEAN
MICROWAVE
WEEK**
LONDON, UK
3-7 OCTOBER 2016
www.eumweek.com

EUROPEAN MICROWAVE WEEK 2016 THE CONFERENCES

Don't miss Europe's premier microwave conference event. The 2016 week consists of three conferences and associated workshops:

- European Microwave Integrated Circuits Conference (EuMIC) 3rd – 4th October 2016
- European Microwave Conference (EuMC) 4th – 6th October 2016
- European Radar Conference (EuRAD) 5th – 7th October 2016
- Plus Workshops and Short Courses (From 3rd October 2016)
- In addition, EuMW 2016 will include the 'Defence, Security and Space Forum' on 5th October 2016

The three conferences specifically target ground breaking innovation in microwave research through a call for papers explicitly inviting the submission of presentations on the latest trends in the field, driven by industry roadmaps. The result is three superb conferences created from the very best papers. For a detailed description of the conferences, workshops and short courses please visit www.eumweek.com. The full conference programme can be downloaded from there.

FAST TRACK BADGE RETRIEVAL

Register online and print out your badge in seconds onsite at the Fast Track Check In Desk

CONFERENCE PRICES

There are TWO different rates available for the EuMW conferences:

- **ADVANCE DISCOUNTED RATE** – for all registrations up to and including 3rd September
- **STANDARD RATE** – for all registrations made after 3rd September

Please see the Conference Registration Rates table on the back page for complete pricing information.

All payments must be in £ Sterling – cards will be debited in £ Sterling.

Online registration is open now, up to and during the event until 7th October 2016

DELEGATES

Registering for the Conference

- Register online at www.eumweek.com
- Receive an email receipt with barcode
- Bring your email, barcode and photo ID with you to the event
- Go to the Fast Track Check In Desk and print out your delegate badge
- Alternatively, you can register onsite at the self service terminals during the registration opening times below:

- | | |
|--|---|
| - Sunday 2nd October (16:00 - 19:00) | - Monday 3rd October (08:00 – 17.00) |
| - Tuesday 4th October (08:00 – 18.00) | - Wednesday 5th October (08:00 – 17.00) |
| - Thursday 6th October (08:00 – 17.00) | - Friday 7th October (08:00 – 10.00) |

Once you have collected your badge, you can collect the conference proceedings on USB stick and delegate bag for the conferences from the specified delegate bag area by scanning your badge.

CONFERENCE REGISTRATION INFORMATION

EUROPEAN MICROWAVE WEEK 2016, 3rd - 7th October, London, UK

Register Online at www.eumweek.com

ONLINE registration is open from 1st June 2016 up to and during the event until 7th October 2016.

ONSITE registration is open from 16:00 on 2nd October 2016.

ADVANCE DISCOUNTED RATE (up to and including 3rd September) **STANDARD RATE** (from 4th September & Onsite)

Reduced rates are offered if you have society membership to any of the following*: EuMA, GAAS, IET or IEEE.

EuMA membership fees: Professional £19/year, Student £11/year.

If you register for membership through the EuMW registration system, you will automatically be entitled to discounted member rates.

Reduced Rates for the conferences are also offered if you are a Student/Senior (Full-time students 30 years or younger and Seniors 65 or older as of 1st August 2016).

ADVANCE REGISTRATION CONFERENCE FEES (UP TO AND INCLUDING 3RD SEPT.)

CONFERENCE FEES	ADVANCE DISCOUNTED RATE			
	Society Member (*any of above)		Non Member	
	Standard	Student/Sr.	Standard	Student/Sr.
<i>1 Conference</i>				
EuMC	£355	£100	£500	£140
EuMIC	£270	£90	£380	£130
EuRAD	£240	£80	£340	£120
<i>2 Conferences</i>				
EuMC + EuMIC	£500	£190	£710	£270
EuMC + EuRAD	£480	£180	£680	£260
EuMIC + EuRAD	£410	£170	£580	£250
<i>3 Conferences</i>				
EuMC + EuMIC + EuRAD	£610	£270	£860	£390

STANDARD REGISTRATION CONFERENCE FEES (FROM 4TH SEPT. AND ONSITE)

CONFERENCE FEES	STANDARD RATE			
	Society Member (*any of above)		Non Member	
	Standard	Student/Sr.	Standard	Student/Sr.
<i>1 Conference</i>				
EuMC	£500	£140	£700	£200
EuMIC	£380	£130	£540	£190
EuRAD	£340	£120	£480	£170
<i>2 Conferences</i>				
EuMC + EuMIC	£710	£270	£1,000	£390
EuMC + EuRAD	£680	£260	£950	£370
EuMIC + EuRAD	£580	£250	£820	£360
<i>3 Conferences</i>				
EuMC + EuMIC + EuRAD	£860	£390	£1,210	£560

WORKSHOP AND SHORT COURSE FEES (ONE STANDARD RATE THROUGHOUT)

FEES	STANDARD RATE			
	Society Member (*any of above)		Non Member	
	Standard	Student/Sr.	Standard	Student/Sr.
Half day WITH Conference registration	£75	£60	£100	£75
Half day WITHOUT Conference registration	£100	£75	£130	£100
Full day WITH Conference registration	£105	£80	£135	£100
Full day WITHOUT Conference registration	£135	£105	£180	£130

THE EUMW CRUISE ON THE RIVER THAMES - 5th Oct 16

Tickets for the cruise are limited and are available on a first-come first-served basis at the price of £25.00 for EuMW Delegates and £36.00 for guests.

Proceedings on USB Stick

All papers published for presentation at each conference will be on a USB stick, given out FREE with the delegate bags to those attending conferences. For additional USB sticks the cost is £50.

International Journal of Microwave and Wireless Technologies (8 issues per year)

International Journal combined with EuMA membership: £50 for Professionals or £43 for Students.

Partner Programme and Social Events

Full Details and contacts for the Partner Programme and other Social Events can be obtained via the EuMW website www.eumweek.com

SPECIAL FORUMS & SESSIONS

Date	Time	Title	Location	No. of Days	Fee	
Wednesday 5th October	11:20 - 19:00	Defence, Security & Space Forum	Rooms 8 to 11	1	£10 for delegates (those registered for EuMC, EuMIC or EuRAD)	£40 for all others (those not registered for a conference)

FIVE DAYS

THREE CONFERENCES

ONE EXHIBITION

EUROPEAN MICROWAVE WEEK 2016
EXCEL LONDON, UK
3 - 7 OCTOBER 2016



**EUROPEAN
MICROWAVE
WEEK**
LONDON, UK
3-7 OCTOBER 2016
www.eumweek.com

EUROPE'S PREMIER MICROWAVE, RF, WIRELESS AND RADAR EVENT

The Conferences (3rd - 7th October 2016)

- European Microwave Integrated Circuits Conference (EuMIC)
3rd – 4th October 2016
- European Microwave Conference (EuMC) 4th – 6th October 2016
- European Radar Conference (EuRAD) 5th – 7th October 2016
- Plus Workshops and Short Courses (From 3rd October 2016)
- In addition, EuMW 2016 will include the 'Defence, Security and Space Forum' on 5th October 2016

The FREE Exhibition (4th - 6th October 2016)

ENTRY TO THE EXHIBITION IS FREE! Register today to gain access to over 300 international exhibitors and take the opportunity of face-to-face interaction with those developing the future of microwave technology. The exhibition also features exhibitor demonstrations, industrial workshops and the annual European Microwave Week Microwave Application Seminars (MicroApps).

EuMA
European Microwave Association

Official Publication:



Organised by:



Supported by:



Co-sponsored by:



Co-sponsored by:



The 11th European Microwave
Integrated Circuits Conference

Co-sponsored by:



The 46th European Microwave Conference

Co-sponsored by:



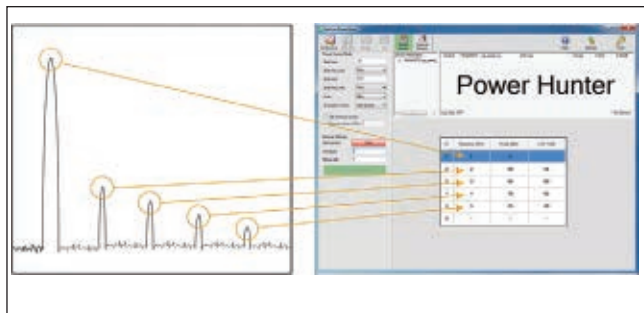
The 13th European Radar Conference

Co-sponsored by:



Register online now as a delegate or visitor at:

www.eumweek.com



▲ Fig. 1 The PowerXpert PC application enables users to search for CW peaks within any defined frequency channel up to 70 GHz.

make the measurement useless. With Power Master, a field technician can define the frequency channel in which to measure power, focusing on the signals of interest or identifying specific interference in nearby channels. In

the lab, an engineer verifying RF circuit designs can use Power Master for troubleshooting unexpected signal behavior caused by a dirty LO, bad components or outside signal interference.

Perhaps the most amazing benefit of the Shockline technology is its ability to fit all these features into a portable, USB-powered instrument that is convenient to use in the lab or field. Power Master is only slightly bigger than a smartphone, at approximately 6" x 3" x 1" and weighs less than 15 oz. For field testing, it is equipped with a standard 1/4" mounting port that is compatible with a variety of extenders, perfect for raising the sensor close to access points or above crowds. In the lab or EMI chamber, it can connect the sensor to a tripod to position it for OTA testing. The sensor is also equipped with mounting holes for on-wafer testing. Instead of purchasing expensive low loss cables to connect to the power meter, Power Master connects directly to a probe, improving measurement accuracy and reliability.

Power Master comes with the standard benefits of a USB power meter. Because no reference calibration is required, the sensor can stay connected to a test system at all times, eliminating the need to disconnect and reconnect the sensor between test procedures. The sensor can be controlled by remote commands via the USB interface or through PowerXpert™, Anritsu's free PC application for USB power measurement tools. PowerXpert has been updated with new features to search for up to six power peaks across user-defined frequency bands or simultaneously monitor the RF power of up to six separate frequency channels (see **Figure 1**).

Whether in the lab or the field, Power Master provides revolutionary power measurement capabilities. With the industry's best low power performance, frequency selectability and the convenience of a USB-powered instrument, Power Master is a "must have" for anyone testing Wi-Gig, WirelessHD, auto radar or other mmWave applications.

VENDORVIEW

Anritsu
Morgan Hill, Calif.
www.anritsu.com


Messe München
 Connecting Global Competence



Planet e: Where the future begins.

Electronics of tomorrow.
Today.

Tickets & Registration:
electronica.de/en/tickets

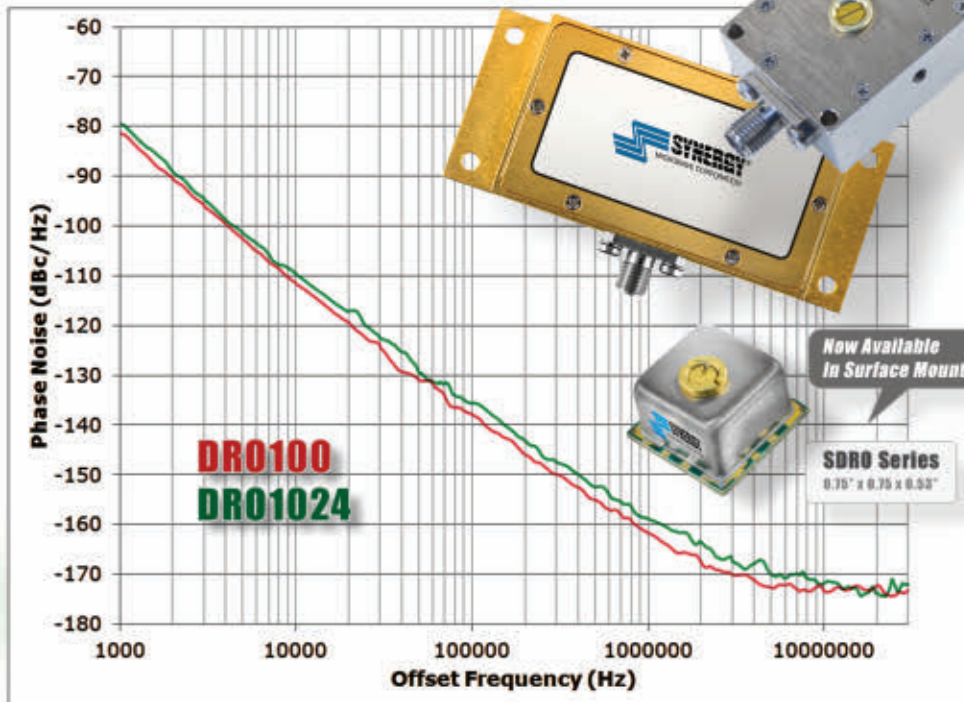
World's Leading Trade Fair for Electronic Components, Systems and Applications
 Messe München | November 8–11, 2016
electronica.de



electronica 2016
inside tomorrow

Exceptional Phase Noise Performance Dielectric Resonator Oscillator

RoHS Patented
Technology



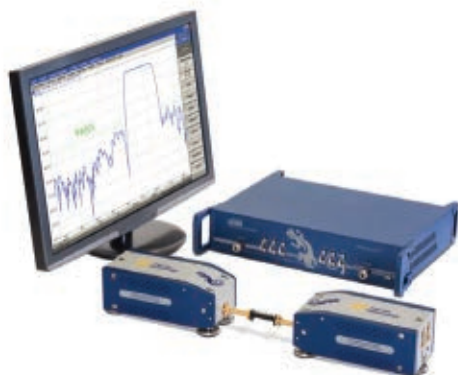
Model	Frequency (GHz)	Tuning Voltage (VDC)	DC Bias (VDC)	Typical Phase Noise @ 10 kHz (dBc/Hz)
Surface Mount Models				
SDRO1000-8	10	1 - 15	+8 @ 25 mA	-107
SDRO1024-8	10.24	1 - 15	+8 @ 25 mA	-111
SDRO1250-8	12.50	1 - 15	+8 @ 25 mA	-105
Connectorized Models				
DRO100	10	1 - 15	+7 - 10 @ 70 mA	-111
DRO1024	10.24	1 - 15	+7 - 10 @ 70 mA	-109

Model	Center Frequency (GHz)	Mechanical Tuning (MHz)	Supply Voltage (VDC / Current)	Typical Phase Noise @ 10 kHz (dBc/Hz)
Mechanical Tuning Connectorized Model				
KDRO145-15-411M	14.5	±4 MHz	7.5 V / 90 mA (Max.)	-88

Talk To Us About Your Custom Requirements.



Phone: (973) 881-8800 | Fax: (973) 881-8361
E-mail: sales@synergymwave.com
Web: WWW.SYNERGYMWAVE.COM
Mail: 201 McLean Boulevard, Paterson, NJ 07504



Affordable, mmWave VNA Solutions

Farran Technology
Cork, Ireland
Copper Mountain Technologies
Indianapolis, Ind.

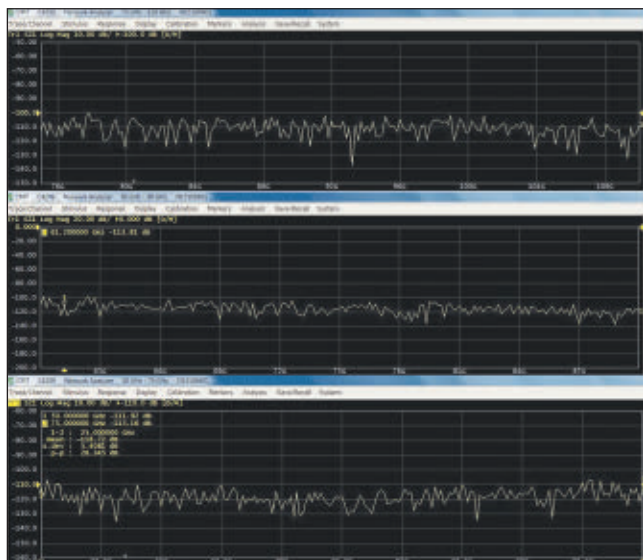
With the advent of the Internet of Things (IoT), WiGig and 5G technologies moving to higher frequencies and backhaul at 60, 70 and 80 GHz, the need for S-parameter testing at higher frequencies

is increasing. Traditional solutions also have to change to meet the requirements of today's applications: material characterization, on-wafer benchtop measurements, near and far field antenna and radar cross-section measurements, as well as automotive and non-automotive radar sensors.

To address these issues, Farran Technology and Copper Mountain Technologies have partnered to create CobaltFx—a new mmWave frequency extension solution, which the companies say is the first mmWave frequency extension solution that utilizes a 9 GHz VNA. CobaltFx's high dynamic range (see **Figure 1**) and directivity allows for highly accurate and stable mmWave S-parameter measurements in three dedicated waveguide bands; 50 to 75 GHz, 60 to 90 GHz and 75 to 110 GHz.

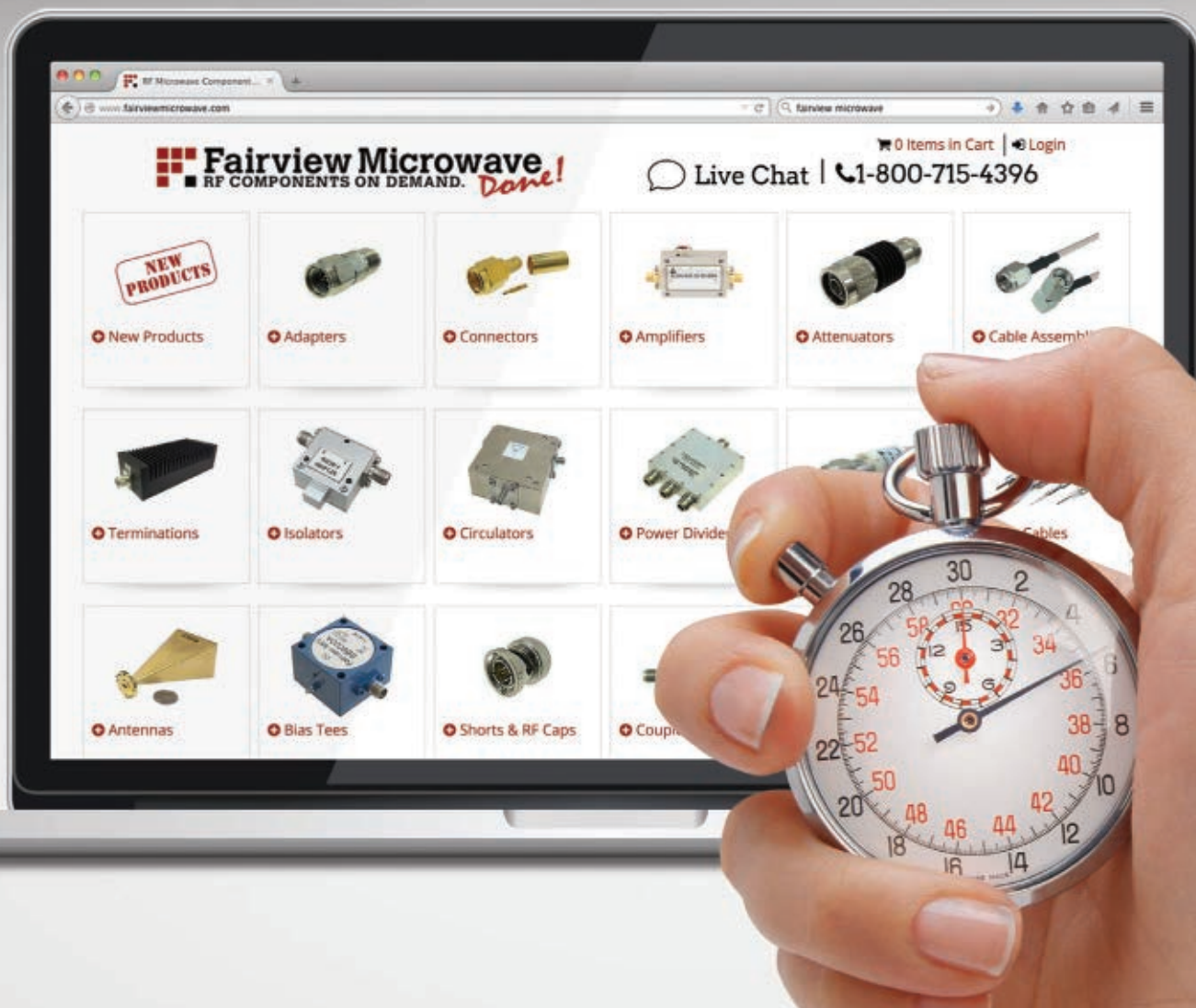
The C4209 VNA used in this system is from Copper Mountain Technologies' Cobalt series. It features fast sweep speeds down to 10 μ s per point and a dynamic range of up to 162 dB, all contained in a compact, USB form factor.

The C4209 works seamlessly with Farran Technology's mmWave FEV frequency extenders (see **Figure 2**) that are packaged in small,



▲ Fig. 1 Dynamic range of the CobaltFx.

The Right RF Parts. Right Away.

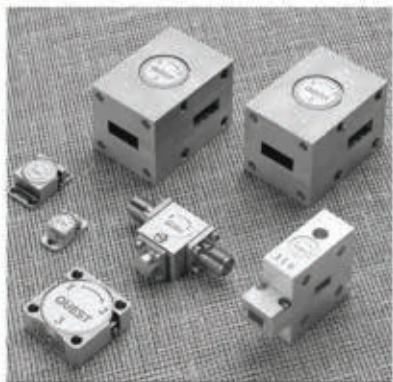


We're RF On Demand, with over one million RF and microwave components in stock and ready to ship. You can count on us to stock the RF parts you need and reliably ship them when you need them. Add Fairview Microwave to your team and consider it done.

fairviewmicrowave.com
1.800.715.4396

Fairview Microwave
RF COMPONENTS ON DEMAND. *Done!*

CIRCULATORS & ISOLATORS



QUEST for Quality
QUEST for Performance
QUEST for the **BEST...**
JOIN US

Quality products
with quick delivery
and competitive
prices are our
standard



225 Vineyard Court
Morgan Hill, California 95037

877-QUESTMW (783-7869)
(408) 778-4949 Phone
(408) 778-4950 Fax

circulators@questmw.com e-mail
<http://www.questmw.com> website

ProductFeature



▲ Fig. 2 Farran Technology's mmWave FEV frequency extenders are packaged in small and versatile enclosures.

versatile enclosures that allow for flexible port arrangements with respect to the waveguide. Waveguide ports are manufactured in accordance to the new IEEE 1785-2a standard and ensure alignment and repeatability of connection, allowing for long interval times between calibration. The system comes with a precision calibration kit containing flush short, offset piece and broadband load.

MEASUREMENT CAPABILITIES

The CobaltFx will perform full S-parameter measurements with full 12-term port calibration. Time domain measurements are also possible. Mounting feet can be removed or orientated on different faces, giving the maximum flexibility in waveguide positioning.

The CobaltFx incorporates various sweep features with up to 16 independent logical channels: each logical channel is represented on the screen as an individual channel window. Extensive trace functions are available, including the ability to view data trace, memory trace or both. Data trace modifications by math operations, autoscaling, electrical delay and phase offset are also standard functions. The system software is COM/DCOM compatible, which allows the system to be used as part of an ATE station. The system and software are also fully compatible with LabView applications, enabling flexibility in user-generated programming and automation.

Other features and specifications include: Test port output power is 0 to +5 dBm minimum and typically +5 to +8 dBm, while the test port input power is typically +10 to +15 dBm.

The system dynamic range, shown in Figure 2, is typically 110 to 120 dB, and the trace stability is ± 0.2 dB. The RF/LO port damage level is +10 dBm minimum.

Calibration kits (FEK-15/12/10-0006) are also supplied, which ensure accurate and repeatable measurements. They are compatible with TRL and SOLT calibration techniques and contain full characterization data for the components required by the CobaltFx system for calibration.

APPLICATIONS

The potential applications for the CobaltFx system are extensive. It can easily perform antenna range measurements requiring high dynamic range and a fast sweeping test system. During the measurement, antenna gain, pattern, efficiency and directivity can be verified as well as parameters of the radome, while directivity and reflectivity measurements are fundamental for evaluating the backscatter parameters of the target.

5G technology is considered to be a fundamental medium for the IoT, and unlocking the high frequency part of the frequency spectrum (>50 GHz) is key to this concept. CobaltFx is a cost effective solution to enable the integration of various devices, materials, antenna beam forming and channel propagation concepts for indoor and outdoor 5G communication.

Multi-Gigabit Wi-Fi technology operating at 60 GHz will expand the capacity for indoor Wi-Fi data transmission. With 3D and 4K video streaming within the wireless network and devices there is a need for chip-set and antenna technology to offer bandwidth and range that will reliably replace cable connectivity. High levels of integration of various technologies operating from single MHz to the 60 GHz range requires very accurate and thorough characterization of consumer electronics equipment. The CobaltFx system can address this application very cost-effectively.

With adaptive cruise control, collision mitigation and pedestrian detection systems already available; autonomous driving under development; and various non-automotive radar sensor applications for foreign object detection, perimeter and security detection, collision avoidance and

ProductFeature

moving object detection; the need for thorough characterization of devices and materials at 77 and 79 GHz has never been greater. CobaltFx offers a cost effective and flexible test and measurement solution for radar applications.

Every test laboratory in a commercial or industry orientated organization involved in production and testing of various components must have the means to evaluate their products. CobaltFx can carry out all these measurements and, with its flexibility and compactness, it easily fits on the lab bench.

On-wafer, S-parameter measurements provide for model generation of discrete semiconductor devices (diodes, transistors, MMICs). For accurate models, the data obtained during measurement must be accurate, and the system must allow for long time intervals between calibrations for development cost reduction. Such tasks require that mmWave test equipment is stable and accurate while being compact and flexible.

The increase in usage of mmWaves for high speed digital radio communications and radar sensors is driving the need for high frequency characterization of various materials: PCB laminates, antenna radomes and lenses, vehicle windscreens and various other dielectric composites. Accurate characterization is fundamental to understanding frequency dependent dielectric constant and loss tangents that allow for better modeling of structures, shorter development time and ultimately lower cost of the product. For material characterization, the CobaltFx system offers an accurate, compact and cost effective way of understanding the impact of various materials on the high frequency performance in today's and future mmWave components and systems.

Farran Technology
Cork, Ireland
www.farran.com

Copper Mountain Technologies
Indianapolis, Ind.
www.coppermountaintech.com

Covering Your Spectrum

- Fixed Attenuators
- Variable Attenuators
- Terminations
- Power Dividers/Splitters
- RF Adapters
- DC Blocks
- RF Tuners
- DC to 50 GHz
- 1 Watt to 2000 Watts
- Custom Solutions

*Providing the highest quality and cost-competitive
Broadband RF and Microwave Products
in the Industry since 1989.*

Visit our new website with interactive catalog and online RFQ!

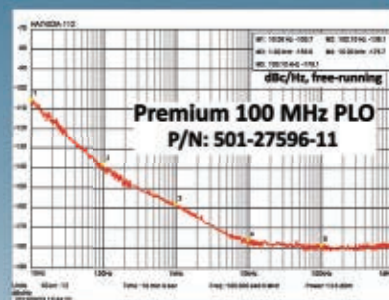
www.WeinschelAssociates.com

19212 Orbit Drive
Gaithersburg, MD 20879
Voice: 301.963.4630
Fax: 301.963.8640
RF@WeinschelAssociates.com

WEINSCHEL ASSOCIATES
BROADBAND RF
& MICROWAVE
SOLUTIONS

ULTRA LOW NOISE PHASE LOCK CRYSTAL OSCILLATORS

- 10 MHz to 260 MHz, fixed
- To -176 dBc/Hz, 100 kHz
- Ruggedized Construction
- PLL LBW from 1 Hz to 100 Hz
- Low G-Sensitivity to $2E-10/g$
- Package: 2.5 x 3.5 x 0.8 in



"Quietly the Best"



Wenzel Associates, Inc.
2215 Kramer Lane, Austin, Texas 78758
512-835-2038 • sales@wenzel.com
www.wenzel.com



10 mm Diameter Circulators and Isolators for Wireless Infrastructure

Skyworks Solutions, Inc.
Woburn, Mass.

Targeting wireless infrastructure, Skyworks Solutions has developed the world's smallest stripline junction circulators and isolators. The junction of this new product family is only 8.5 mm in diameter, with the contact pins on a 10.2 mm diameter circle. Both circulators and isolators are available for all standard wireless bands between 1.8 and 3.6 GHz (see **Table 1**). These devices are all housed in a surface-mount package with robust leads and shipped in tape and reel packaging.

NEW HIGH K FERRITE MATERIAL

The key to the extremely small junction size is a new, high dielectric ferrite material developed by Skyworks. Manipulating the garnet structure yielded much higher dielectric constants than previously available, which enabled the size reduction. Garnets are crystalline ma-

terials with ferrimagnetic properties. Yttrium iron garnet (YIG) is a synthetic form of garnet widely used in ferrite devices because of its favorable magnetic properties, such as narrow line absorption at its ferromagnetic resonance frequency. YIG is generally composed of yttrium, iron and oxygen and is doped with one or more other rare earth metals such as the lanthanides or scandium. Substituting ions of higher polarizability into the structure, while simultaneously keeping magnetocrystalline anisotropy low, achieves low magnetic and dielectric losses without compromising temperature, linearity and power stability. Magnetization up to 1950 G is possible with this new range of materials, with dielectric constants up to 31.

New nano-level powder processing techniques are integral to manufacturing these materials. Various aspects of the design, manu-

RF-LAMBDA

THE LEADER OF RF BROADBAND SOLUTIONS

ITAR & ISO9000
Registered Manufacture



PIN DIODE, GaAs AND GaN CONTROL PRODUCTS

SWITCH IN PIN DIODE, GaAs AND GaN TECHNOLOGY UP TO 67GHz



PN: RFSP4TA5M43G
FULL BAND 0.05-43.5GHz SP4T
SWITCH 50NS SPEED



PN: RFSP2TRDC18G
HIGH POWER 10W DC-18GHz HOT
SWITCHABLE SP2T SWITCH



PN: RFSP2TR5M06G
HIGH POWER 100W DC-6GHz HOT
SWITCHABLE SP2T SWITCH



PN: RFSP8TA0018G
HIGH IP3 500DBM 0.02-18GHz
SP8T PIN DIODE SWITCH



PN: RFPST1826N6
DIGITAL CONTROL PHASE SHIFTER 360
DEGREE 64 STEP 18-26GHz

DIGITAL AND VOLTAGE CONTROL PHASE SHIFTER UP TO 40GHz



PN: RFPST0618N6
DIGITAL CONTROL PHASE SHIFTER
360 DEGREE 64 STEP 6-18GHz



PN: RVPT0818GBC
VOLTAGE CONTROL PHASE
SHIFTER 360 DEGREE 8-18GHz



PN: RVPT0408GBC
VOLTAGE CONTROL PHASE
SHIFTER 360 DEGREE 4-8GHz

DIGITAL AND VOLTAGE CONTROL ATTENUATOR UP TO 50GHz



PN: RFDAT0040G5A
DIGITAL STEP ATTENUATOR
0.1-40GHz 5 BITS 31DB



PN: RFVAT0218A30
VOLTAGE CONTROL ATTENUATOR
2-18GHz 30DB IP3 500DBM



PN: RFVAT0050A17V
VOLTAGE CONTROL ATTENUATOR
0.01-50GHz 17DB



PN: RFDAT0018G8A
DIGITAL STEP ATTENUATOR 0.1-18GHz
8 BITS 128DB IP3 500DBM

www.rflambda.com
sales@rflambda.com

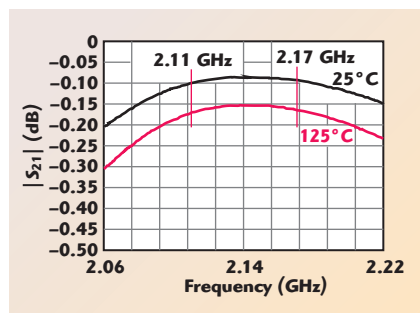
1-888-976-8880
1-972-767-5998

Plano, TX, US
San Diego, CA, US
Ottawa, ONT, Canada

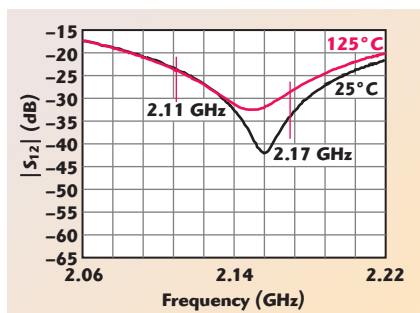


TABLE 1
WIRELESS INFRASTRUCTURE CIRCULATOR AND ISOLATOR PRODUCTS

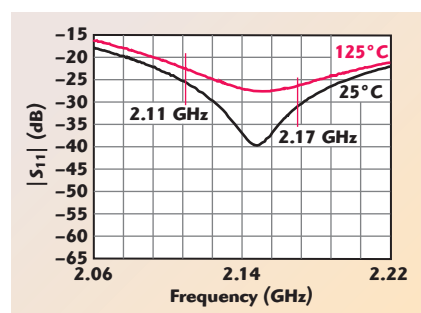
Part Number	Type	Cellular Band	Start Frequency (MHz)	Stop Frequency (MHz)	Insertion Loss, Max (dB)	Return Loss, Min (dB)	Isolation, Min (dB)
SKYFR-001387	Circulator	3	1805	1880	0.25	20	20
SKYFR-001436	Isolator	3	1805	1880	0.25	20	20
SKYFR-001388	Circulator	2	1930	1990	0.25	20	20
SKYFR-001437	Isolator	2	1930	1990	0.25	20	20
SKYFR-001389	Circulator	1	2110	2170	0.25	20	20
SKYFR-001438	Isolator	1	2110	2170	0.25	20	20
SKYFR-001390	Circulator	40	2300	2400	0.25	20	20
SKYFR-001439	Isolator	40	2300	2400	0.25	20	20
SKYFR-001461	Circulator	7	2620	2690	0.25	20	20
SKYFR-001460	Isolator	7	2620	2690	0.25	20	20
SKYFR-001452	Circulator	42	3400	3600	0.25	20	20
SKYFR-001512	Isolator	42	3400	3600	0.25	20	20



▲ Fig. 1 Band 1 isolator insertion loss (SKYFR-001438).



▲ Fig. 2 Typical isolation of the isolator.



▲ Fig. 3 Typical return loss of the isolator.

facturing and application of these materials are patented (US 8696925 and US 9263175).

PERFORMANCE AND PACKAGING

The SKYFR-001438 shows the typical performance from this new product family. A single junction isolator in a 10 mm diameter housing, the SKYFR-001438 operates from 2110 to 2170 MHz (Band 1). Typical insertion loss is 0.12 dB and is specified to be a maximum of 0.25 dB over the operating temperature range from -40° to +125°C (see **Figure 1**). Isolation (see **Figure 2**) and return loss (see **Figure 3**) are both typically 25 dB at room temperature. The typical intermodulation distortion (IMD)

performance is 65 dBc with two 10 W CW tones.

Skyworks' patented "robust lead" package allows the circulators and isolators to be populated on a printed circuit board (PCB) using automated surface-mount assembly. The package has a unique vertical lead that connects the center conductor of the circulator to the customer's PCB. The silver plated lead is firmly encased inside high temperature plastic, ensuring a robust design with excellent coplanarity. The main body of the device is also silver plated for excellent solderability; it can be attached to the PCB using a standard reflow profile. All robust lead devices are shipped in tape and reel packaging for automated placement.

The 10 mm circulator and isolator product family is extremely reliable. Skyworks subjected this new platform to extensive reliability testing, including thermal shock, humidity, vibration and high temperature soak. These devices will withstand up to 50 W average CW RF forward power when mounted on a PCB with good thermal grounding. The isolators include an aluminum nitride (AlN) termination and can handle up to 30 W of reverse power.



Skyworks Solutions Inc.
Woburn, Mass.
www.skyworksinc.com

EDI CON China
comes to Shanghai!



2017

Electronic Design **Innovation** Conference

电子设计**创新**大会

Reserve your booth now to reach engineers in China working on
RF, microwave, and high-speed digital designs

April 25-27, 2017

Shanghai Convention & Exhibition
Center of International Sourcing

Shanghai, China



Conference includes: technical sessions, workshops,
panels, short courses, poster sessions, and plenary keynotes.

Partnerships:

China Electrotechnical Society's (CES) Electromagnetic Technology
Conference & Exhibition (EMC China)
China Radar Industry Association (CRIA) conference

Sponsorships: Gold, silver, bronze, and exhibit sponsorships
now available.



Fifth year for the conference

**EDI CON China 2016 saw
35% increase in unique attendees**

**Exhibition of more
than 100 companies**

Sign up now to choose your booth! **EDICONCHINA.com**

Host Sponsor:



Diamond Sponsor:



Corporate Sponsor:



Organized by:



See us at EuMW Stand 240

EDI CON China returns to Beijing, April 17-19 2018.



USB/Ethernet-Controlled Miniature Switch Modules

Teledyne Relays has developed three new series of miniature switch matrices that combine Teledyne's 50 Ω electromechanical coaxial switches with remote control. The MMA series controls up to four SPDT switches with three frequency band options: DC to 18 GHz, DC to 26.5 GHz or DC to 40 GHz. The MMB series controls up to four transfer switches covering DC to 18 GHz. The MMC series controls one or two SPMT switches (SP3T, SP4T, SP5T or SP6T) with three frequency range options: DC to 18 GHz, DC to 26.5 GHz or DC to 40 GHz. Switch matrix RF interfaces

are SMA or 2.92 mm connectors. The operating temperature range is -40° to $+65^{\circ}\text{C}$, and the switch actuators have a typical life of five million cycles.

Remote operation is accomplished with TCP/IP commands to the matrix's Ethernet interface. Switch control is also accessible using a USB virtual serial port and the provided command set. The interfaces enable the coaxial switch to be set to the desired position and the position read back to verify switching. The miniature switch modules features a graphical user interface (GUI) that enables the user to control the switches through graphical icons and visual indi-

cators, instead of text-based interfaces or typed command labels. The interface is compatible with multiple system platforms, including NI's LabVIEW, which enables quick device interfacing and integrating switch control with existing programming.

Teledyne Relays has a heritage in military programs that spans more than 50 years. Teledyne Relay products are also used in industrial, commercial and medical applications.

Teledyne Relays
Hawthorne, Calif.
www.teledynereleys.com

IntelliConnect

A different kind of Interconnect Solutions Provider

CABLE ASSEMBLIES

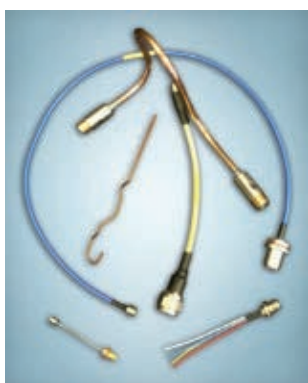
IntelliConnect supply a vast range of cable assemblies including:

- Low loss/high frequency microwave cable assemblies
- Phase matched semi-rigid cable assemblies
- Conformable cable assemblies
- Cryogenic cable assemblies
- Multi-pin cable harnesses

All cable assemblies are fully tested and inspected to customer specification.

Full Certificate of Conformity to ISO 9001:2008

 Manufactured in the UK



For further information, please call us on **+44 (0)1245 347145**, email sales@intellconnect.co.uk or visit our website.

www.intellconnect.co.uk

ABMS • BMA • C • N • SMA • TNC • Dustcaps
Waterproof RF Connectors • Cable Assemblies



Find Reps, Engineers and Used Equipment.

Post your listing on the new MWJ classified section.



Microwave Journal
Frequency Matters.

www.mwjjournal.com/classifieds

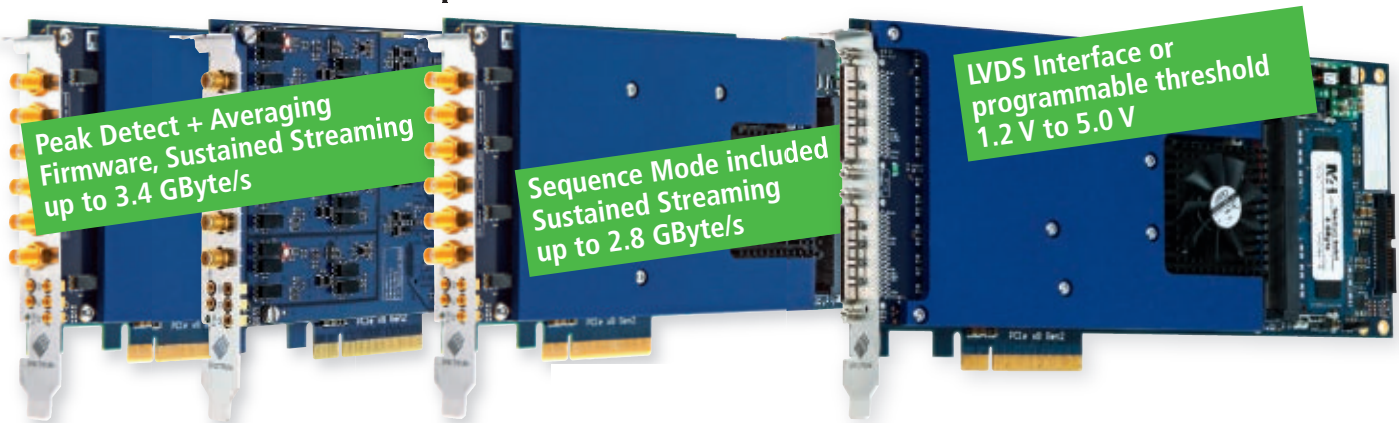
PCI Express x8 Gen2



4 Channel Digitizer
8 Bit up to 5 GS/s
14/16 Bit 500 MS/s

4 Channel Arbitrary
Waveform Generator
up to 1.25 GS/s 16 Bit

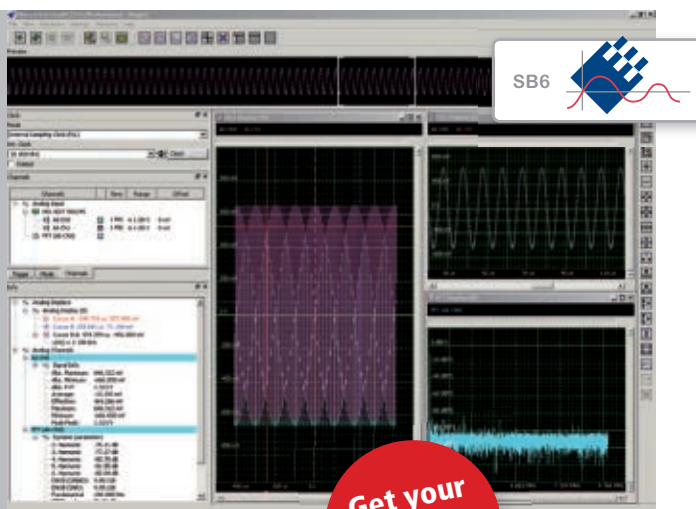
Digital Data Acquisition Card
720 MBit/s 32 Channels



- 4 GByte on-board memory
- full Linux + Windows support
- 2 years warranty

PXI Express x4 Gen2

4 Channel Digitizer
14 Bit 500 MS/s 16 Bit 250 MS/s



SBench 6 –
professional data
acquisition and analysis
Software

Get your
free base
version



SPECTRUM

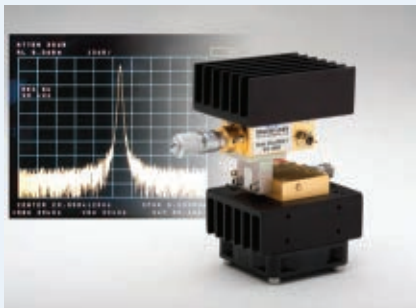
SYSTEMENTWICKLUNG MICROELECTRONIC GMBH

Spectrum Systementwicklung Microelectronic GmbH

www.spectrum-instrumentation.com

US: Phone (845) 988 0955 sales@spectrum-instrumentation.com
Asia / Europe: Phone +49 (4102) 695-60 info@spec.de





Tunable, Wideband, Ka-Band Source with High Output Power

Spacek Labs has developed a wideband, tunable frequency source with high output power, the first in a planned product family. Model GK-300VA-1 produces 500 mW output power over a 4 GHz bandwidth centered at 30 GHz. The Gunn oscillator is tuned using a locking micrometer that inserts a dielectric rod into the iris-coupled resonant cavity. The 30 mW output power of the Gunn source is then amplified to 500 mW with a solid-state output amplifier. The Gunn oscillator is biased with +7 VDC at 0.5 A, and the power amplifier requires +8 VDC at

0.6 A. The output interface can either be coax or waveguide.

Model GK-300VA-1 is the latest addition to Spacek Labs' complete line of Gunn oscillators that cover 18 to 110 GHz. Combining broadband Gunn oscillators with power amplifiers creates a high power option for these affordable sources. The output signal can be modulated by adding a varactor to the Gunn oscillator, adding the capability for carrying data with a 100 MHz deviation and a 50 MHz modulation rate. The frequency, bandwidth and output power of the sources can be custom-

ized to address more potential applications than just using a stand-alone Gunn oscillator.

Formed in 1982, Spacek Labs is a small, woman-owned business manufacturing microwave and millimeter wave components and subsystems. Products are manufactured at the company's facilities in Santa Barbara, Calif. with all manufacturing and test equipment in house except for testing shock and vibration.

Spacek Labs Inc.
Santa Barbara, Calif.
www.spaceklabs.com



OFFER TO SELL NON-STRATEGIC TECHNOLOGIES

Prism Microwave – Driving RF Filter Innovation and Leadership

Prism Microwave, Inc. seeks to sell the following non-strategic technologies:

- **Positive Train Control filter** – innovative filter technology providing optimum performance and reliability in a package that minimizes size and weight
 - Key performance benefits include lower insertion loss and higher levels of interference mitigation than currently available designs
 - Available in 160, 220 and 450 MHz
- **Multi-Band Duplexers** – VHF and UHF high and low power duplexers
 - Designed and developed for a wide range of applications
 - Characterized by strong performance across key technology parameters
- **Multi-Bank DAS Combiners** – offer significant operator benefits
 - Characterized by very low PIM and insertion loss
 - Suitable for use in combining radios to multi-bank antennas in active DAS remotes or passive DAS systems
- Sale includes all intellectual property associated with the technologies, including technical drawings and specification and test results

Interested parties please contact Mr. James Weinberg at JamesWeinberg@prismrf.com

September Short Course Webinars

Innovations in EDA

How to Design Phased Arrays for 5G, Radar and Satellite

Presented by: Keysight Technologies

Live webcast: 9/1/16

Technical Education Training

Specifying Flexible Building Blocks for Automated Production Test Systems

Sponsored by: Mini-Circuits

Live webcast: 9/7/16

Technical Education Training

The Promise and Perils of mmWave

Sponsored by: National Instruments

Live Webcast: 9/8/16

Technical Education Training

SiGe and RF SOI for Sub-6 GHz LNA Applications

Sponsored by: GLOBALFOUNDRIES

Live webcast: 9/13/16

Technical Education Training

Vector Network Analyzers as a Tool for Signal Integrity in High Speed Digital Systems

Sponsored by: Anritsu

Live webcast: 9/15/16

Technical Education Training

On the Road to 5G, Advances in Enabling Technology: A Materials Perspective

Sponsored by: Rogers

Live webcast: 9/28/16

Register to attend at mwjournal.com/webinars

Past Webinars On Demand

Technical Education Training Series

- Improving Base Station Design – RF Innovations
- The Power of Testing IoT Devices in All Phases of the Product Lifecycle
- Radar Signal Generation with up to 2 GHz Bandwidth for Single-Channel and Multichannel Receiver Testing
- Faster Analysis of Complex RF Signals
- 802.11ax – High Efficiency Wireless Improving User Throughput in Dense User Environments
- Practical Antenna Design for Advanced Wireless Products
- Expanding the Possibilities of Cellular Wireless Infrastructure with GaN
- Designing Next-Gen Cellular and Wi-Fi Switches Using RF SOI Technology
- Improving Reliability and Efficiency with Solid State Spatial Combining Technology
- Effect of Conductor Profile Structure on Propagation in Transmission Lines
- Minimize Your Y-Factor Noise Figure Measurement Uncertainty
- Doherty at Eighty
- Millimeter Wave and E-Band Vector Network Analyzer Solutions
- Making Noise Work for You
- RF and Microwave Heating Simulation and Application Design
- Critical Aspects of Dielectric Constant Properties for High Frequency Circuit Design
- Demystifying MIMO Radar and Conventional Equivalents

RF/Microwave Training Series

Presented by: Besser Associates

- Introduction to Radar
- RF and Microwave Filters
- Mixers and Frequency Conversion

CST Webinar Series

- Hybrid Simulation for Electrically Large Aerospace Platforms
- Simulation of Implanted Medical Devices

Innovations in EDA

Presented by: Keysight Technologies

- Advances in High Power RF Design
- 5G Physical Layer Modeling: A Communication System Architect's Guide
- Designing X-Band PAs Using SMT Plastic Packaged GaN Transistors

Keysight Technologies Webcast

- LTE in the Unlicensed Spectrum
- Using a Multi-Touch UI to Streamline Signal Analyzer Measurements
- Testing Voice Over LTE on Your Device

Keysight RF and Microwave Basics Education Series

- Simulating, Generating and Analyzing Custom-Modulated Satellite Signals

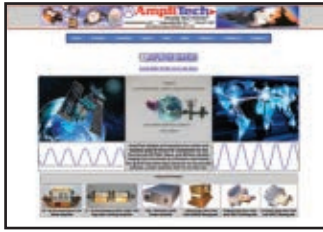
Keysight FieldFox Series

- Wireless Site Survey, Spectrum Monitoring and Interference Analysis

More Efficient Search Engine

The comprehensive search engine on AmpliTech's website has been significantly revamped to allow for searches based on particular specifications and partial model numbers, offering results that are closest to the entered parameters. The algorithm has also been changed to offer up the "next best" solution in case the customer has some flexibility in their specification requirements. More versatility now allows searches by using either a start or stop frequency as opposed to both. All of these advanced search features can be used in combination.

AmpliTech Inc.
www.amplitechinc.com



Benchtop PA Demo



AR's 350S1G6 provides wideband high linear output power over a frequency band of 0.7 to 6 GHz. Over 350 W of output power is achieved with only 1 mW of input power. This amplifier is designed using "Hybrid Microelectronics Technology," resulting in an amplifier with greater power density, smaller size and lower production cost than previously possible. Visit www.arworld.us/html/video-AR350S1G6%20Amplifier.asp for a full product demo.

AR RF/Microwave Instrumentation
www.arworld.us



Website Launch

Daisy RS has just launched a new website. The company is currently focusing its efforts towards the wireless power monitoring distribution industry. Daisy RS produces portable systems for various remote solutions (RS). The RS2026 is designed with a patented algorithm that provides exceptional performance and accuracy. Unlike large or bulky laboratory instruments with troublesome cables, the RS2026 employs wireless technology, making it lightweight, fast and convenient with an intuitive GUI interface for quick measurements with an Android, iPhone or tablet.

Daisy RS Inc.
www.daisyrsi.com



New Brand, New Website

Delta Electronics Manufacturing Corp. unveiled a new brand identity and website that captures the company's position as a global provider of precision interconnect and innovative solutions. The company's new identity was formally unveiled at IMS2016 in San Francisco, Calif., along with their re-designed website at www.deltarf.com. The new logo reflects the strengths behind the Delta brand and the precision inherent in the interconnect products they manufacture.

Delta Electronics Manufacturing Corp.
www.deltarf.com



New and Improved

K&L Microwave's website provides information and tools to speed the identification and specification of custom design solutions from the full range of company products. The latest update features a new look, mobile device support and improved LTE Band navigation to test set components for broadband emission monitoring. K&L is part of the Microwave Products Group, a premier global supplier of mission/system-critical engineered electronic components and subsystems. Research capabilities, access datasheets, submit quote requests and download catalog sections. Visit www.klmicrowave.com today.

K&L Microwave
www.klmicrowave.com



Insights Unlocked



Insights Unlocked, Keysight's newest blog features Keysight thought leaders who share their reflections, lessons and insights on the technology and business issues of interest to today's electronics industry. Current topics include success factors for technology refresh, an exploration of the myths and realities of 5G, an analysis of the benefits of corporate collaboration with universities, and best practices that foster innovation. Bookmark or follow www.keysight.com/find/insightsunlocked for regular updates.

Keysight Technologies Inc.
www.keysight.com



Web&VideoUpdate

Extensive Capabilities

Massachusetts Bay Technologies Inc. (MBT), an RF/microwave semiconductor diode and passive manufacturer, has launched a new website. The new site includes extensive product information to help customers understand MBT's complete product portfolio. Whether you are looking for a hi-rel diode, standard diode(s), or custom chip capacitors, the new website provides a detailed overview of MBT's capabilities. With the recent FAB closures in the RF/microwave diode marketplace MBT stands to deliver.

Massachusetts Bay Technologies
www.massbaytech.com



Competitor Cross Reference

Leaders in RF innovation and technology for more than 60 years, NXP offers an extensive portfolio of RF products for wireless infrastructure, broadcast, medical, mobile radio, aerospace and defense, cooking and industrial markets, from milliwatts to kilowatts. Access the company's competitor cross reference with other manufacturers part numbers to find an equivalent NXP RF part number match. Explore NXP's RF portfolio now at www.nxp.com/webapp/cross-check/competitorXRef.sp.

NXP Semiconductors
www.nxp.com/RF



Configure Your Product



Have you ever wanted to flexibly configure your loads and attenuators to make them a perfect fit for your projects? SPINNER loads and attenuators can be easily customized in three steps. First, select the power that needs to be absorbed, then choose the connector interface(s) and attenuation and you're done! Extra features such as an extended frequency range, recording of measurements or an integrated DC break can be optionally selected. This video presents the available options. Use SPINNER's sales article numbers to flexibly configure your product.

SPINNER Group
youtube.com/user/SPINNERGMBH



FEATURED WHITE PAPERS

The information you need, from industry experts



Testing of Wireless Designs to
Ensure Compliance



Product Development Flow for 5G/LTE
Envelope Tracking Power Amplifiers



Benefits of Time-Domain Electromagnetic
Simulation for Automotive Radar

Check out these new online Technical Papers
featured at MWJournal.com



Frequency Matters.



European Microwave Week



The following list is complete as of August 1, 2016.
Exhibitors in red have an ad in this issue.

AA-MCS.....	37	Dbwave.....	162	IMST GmbH.....	86
Aaronia AG.....	108	DCE Holne (R&D) Ltd.....	81	Infineon Technologies AG.....	146
AceAxis.....	72	Delta Electronics Mfg. Corp.....	121	Ingun Prüfmittelbau GmbH.....	102
AdTech Ceramics.....	152	Development Engineering Services.....	217	Innertron Inc.....	83
Advanced Power Components.....	151	Diamond Antenna Europe.....	121	Innovative Integration.....	10
Aerospace & Defense Technology.....	Pub Corner	Diamond Microwave.....	53	INOVEOS.....	116 & 117
AFT Microwave GmbH.....	149	DICONEX - DELTA OHM.....	198	Inseto (UK) Ltd.....	212
AIRMEMS.....	116 & 117	Distributed Micro Technology Ltd.....	222	Intellconnect (Europe) Ltd.....	128
Albatross Projects GmbH.....	192	Down-Key Microwave.....	175	Interlligent RF & Microwave Solutions.....	153
Alroy Microwave.....	72	Drallim Industries Ltd.....	229	Irom Tech Inc.....	87
Altair Engineering GmbH.....	219	Dynawave.....	33	Isola GmbH.....	23
Amari Copper Alloys.....	233	E&C Anechoic Chambers NV.....	192	Jet Metal Technologies.....	46
Amari Precision Tubes.....	233	e2v.....	155	JQL Electronics Inc.....	121
AMCAD Engineering.....	116 & 117	EBV ELEKTRONIK.....		K&L Microwave.....	175
American Standard Circuits Inc.....	52	GMBH & CO. KG.....	7	Keysight Technologies.....	2
American Technical		ECHO Microwave Co. Ltd.....	89	Knowles.....	178
Ceramics (ATC).....	222	Echoes s.r.l.....	74	KORTCOM.....	225
AMETEK CTS Germany GmbH.....	11	Ed Fagan Europe Ltd.....	81	Kuhne Electronic GmbH.....	73
Ampleon Netherlands B.V.....	145	EGiDE SA.....	138	KVG Quartz crystal Technology GmbH.....	121
Anadigics.....	121	Electro Rent Europe NV.....	171	LAAS.....	184d
Analog Devices.....	111	<i>Electronic Specifier Ltd.....</i>	<i>Pub Corner</i>	Lake Shore Cryotronics Inc.....	1C
AnaPico Ltd.....	160	EMC Technology/Florida RF Labs.....	33	Lanjan Electronics.....	191
Anritsu.....	8	EpsilonRF.....	72	Link Microtek Ltd.....	180
ANSYS UK.....	6	E-REON B.V.....	227	Linwave Technology Ltd.....	67
AO Technologies SAS.....	140	ERZIA Technologies SL.....	169	LPKF Laser & Electronics AG.....	24
API Technologies Corp.....	39	ESA, VSC and UPV (European Space Agency- Valencia Space Consortium - Universidad Politécnica de Valencia).....	239	M.T. SRL.....	213
Applied Thinfil Products.....	212	European Space Agency		MACOM.....	207
AR Europe.....	78	(RF Equipment & Technology.....)	32	Massachusetts Bay Technologies.....	180
Arance Electronics.....	121	<i>everything RF.....</i>	<i>Pub Corner</i>	Maury Microwave Corp.....	1A
Arralis Ltd.....	34	Exodus Advanced Communications.....	121	MCG-UNPA (Microwave Components Group-Public University og Navarre).....	238
ART-FI.....	101	Exxelia Supply.....	237	Melcom Electronics Ltd.....	37
Aspen Electronics Ltd.....	121	Farran Technology Ltd.....	154	Mician GmbH.....	55
Aspen Electronics Ltd., Test & Measurement Group.....	132	Filtron Broadband Ltd.....	151	Micran Research and Production CJSC.....	49
Aspocomp Group Plc.....	215	Flann Microwave Ltd.....	183	Micro Electronic Technology Development Application Corp.....	94A
Assystem.....	1E	Focus Technology Group.....	172	Micro Lambda Wireless.....	121
AT Wall Co.....	230	Forstar.....	33	Micro Systems Engineering GmbH.....	71
Atlanta Micro Inc.....	220	Fraunhofer FHR.....	28	Microlease.....	165
Aurora Software and Testing.....	188	Fraunhofer IAF.....	28	Microsemi.....	160
AVX Corp.....	21	French CNRS Research Laboratories Pavilion... 184		Microtek Components Ltd.....	33
BAE Systems.....	20	Frequensys Ltd.....	190	Microwave Applications Group.....	88
Bowel Integrated Circuits Co. Ltd.....	94G	Freshfield Microwave Systems.....	180	Microwave Development Labs.....	72
Bruco Integrated Circuits.....	25	Fuzhou Micable Electronic Technology Co. Ltd. 129		<i>Microwave Engineering Europe.....</i>	<i>Pub Corner</i>
BSC Filters Ltd.....	175	GCI Science & Technology.....	94E	Microwave Innovation Group (MiG).....	150
Cambridge University Press.....	54	Geometric Manufacturing Ltd.....	48	Microwave Journal.....	240/Pub Corner
Cascade Microtech Inc.....	1F	Glarun Technology Co., Ltd.....	94D	Microwave Marketing Ltd. (Linwave).....	67
Castle Microwave Ltd.....	85	Gotmic.....	121	<i>Microwave Product Digest.....</i>	<i>Pub Corner</i>
Century Seals.....	212	Greenray Industries.....	152	Microwave Products Group.....	175
Chengdu AINFO Inc.....	158	GREMA-UC3M(Group of Radiofrequency, Electro- magnetics, Microwaves and Antennas - Universidad Carlos III de Madrid).....	238	Microwave Vision Group (MVG).....	84
Chengdu Ganide Technology Co. Ltd.....	94H	Hangzhou Techwin Precision Instrument Co., Ltd.....	47	<i>Microwaves & RF.....</i>	<i>Pub Corner</i>
Chengdu Keylink Microwave Technology.....	94C	Herley-CTI.....	121	Mini-Circuits.....	56
Chengdu Seekon Microwave		<i>hf-Praxis.....</i>	<i>Pub Corner</i>	Mitsubishi Electric Europe BV.....	141
Communications.....	40	<i>High Frequency Electronics.....</i>	<i>Pub Corner</i>	Molex LLC.....	166
Chi-Shuai Enterprise Co. Ltd.....	45	Hi-Rel Group.....	70	MPI Corp.....	109
Cisteme.....	116 & 117	Holzworth Instrumentation.....	37	MtronPTI.....	180
Coaxicom.....	33	Huang Liang Technologies Co. Ltd.....	26	MWave Design Corp.....	120
Cobham Microwave.....	57	Huber + Suhner AG.....	102	National Instruments.....	4
Coilcraft.....	159	HXI LLC.....	180	Norden Millimeter.....	120
Competitiveness Cluster		Hytam.....	221	Nova Microwave.....	37
Elopsys/CCI Limousine.....	116 & 117	iBROW.....	75	NTT Advanced Technology Corp.....	214
Connecticut Coining Inc.....	226	<i>IEEE Microwave Magazine.....</i>	<i>Pub Corner</i>	NUOVA EUROTAR s.r.l.....	76
Connecticut Microwave Inc.....	72	IEEE-MTT 2017 Int'l Microwave Symposium.....	113	NXP Semiconductors.....	96
Consorcio Espacial Valenciano (VSC).....	239	IEMN184a.....	184c	OML.....	120
Consorzio Nazionale Interuniversitario Per Le Telecomunicazioni-CNIT.....	74	IEMP-LaHC.....	184c	OMMIC.....	148
Copper Mountain Technologies.....	99	IET/E&T.....	82	Pacific Millimeter Products.....	120
CST-Computer Simulation Technology AG.....	5	IETR.....	184b	Park Electrochemical Corp.....	231
Custom MMIC.....	121	IHP GmbH.....	189	Pasquali Microwave Systems Srl.....	209
Dare!! Instruments.....	190	IMEC.....	218	Passive Plus Inc.....	160
		Impellimax.....	120	Phase 2 Microwave Ltd.....	72
				Pickering Interfaces Ltd.....	36
				Pico Technology Ltd.....	174
				Planar Monolithics Industries Inc.....	77



European Microwave Week

Pole/Zero	175
Polomarconi Telsa	173
Premix Oy	210
Qorvo	67
Radar Systems Technology Inc.	120
Radiall	163
Reactel Inc.	160
Res-Net Microwave Inc.	121
RFMW Europe Ltd.	35
Rogers Corp.	204
Rohde & Schwarz	3
Rosenberger Hochfrequenztechnik GmbH & Co. KG.	60
Rosenberger Micro-Coax Ltd.	60
Sandvik Osprey Ltd.	200
Saras Technology Ltd.	216
Schmid & Partner Engineering AG.	134
Schott Electronic Packaging.	43-44
Sel-Tek Ltd.	118
Sematron UK Ltd.	160
Shanghai Hexu Microwave Technology Co. Ltd.	94J
Shanghai Huaxiang Comp Comm Eng Co. Ltd.	94B
Shenzhen Essun Instrument Co. Ltd.	157
Shenzhen Huayang Technology Development Co. Ltd.	232
Shenzhen Yulongtong Electron Co. Ltd.	94F
SIEPEL	190
Signal Microwave	120
Signatone Probing Division	118
Smith Microwave	67
Sonnet Software Inc.	228
Southwest Microwave Inc.	179
SpaceForest	1B
Spectratime (Orolia Switzerland)	121
Spectrum Elektrotechnik GmbH	114
Spinner GmbH	193
Sprague Goodman	33
SRI Connector Gage	33
STACEM	139
Sumitomo Electric Device Innovations	50
Sumitomo Electric Europe Ltd.	50
Sungsan Electronics & Communications Co. Ltd.	22
Synopsis Corporation Group	1D
Syntonic Microwave	120
Taconnic	235
Tech-X Corp.	27
Teledyne Microwave Solutions	19
Teledyne Relays	19
Temwell Corp.	80
The MOSIS Service	211
Times Microwave Systems	12
TNO Defense, Safety and Security	28
Transcom Inc.	26
Trans-Tech.	33
Tronser Inc.	131
United Monolithic Semiconductors (UMS)	7a
University of Bristol	224
Vacuum Brazing Consultants LTD	9
Varioprint AG	126
Vectawave	119
Vectron	67
VIA electronic GmbH.	43-44
Viper RF Ltd.	130
WIN Semiconductors Corp.	97
WIPL-D doo.	234
Wolfspeed, A Cree Company	156
Wurth Electronics UK Ltd.	201
XLIM	184e
XLIM Laboratory.	116 & 117

EXODUS ADVANCED COMMUNICATIONS

EXIT OUT OF ORDINARY

www.exoduscomm.com

European Microwave Week 2016,
to be held at ExCel London,
3rd - 7th October 2016. Booth/Stand: 121

High Power SSPA
Chip & Wire, Assemblies, Modules & Systems
Broadband, CW, Pulse & Linear Applications
1MHz to 47GHz, 3KW CW, 10KW Pulse
Block Up Converters
Low Noise Amplifiers



Exodus Advanced Communications, Corp.
3674 E. Sunset Road, Suite 100,
Las Vegas, Nevada 89120 USA
Tel : 1-702-534-6564
Fax : 1-702-441-7016
Email : sales@exoduscomm.com

Sales contacts
Inside Sales : Christy Strahan Anderson
Domestic/International Sales : Bill Liebman
Technical Sales : Effi Bainvoll



SAW

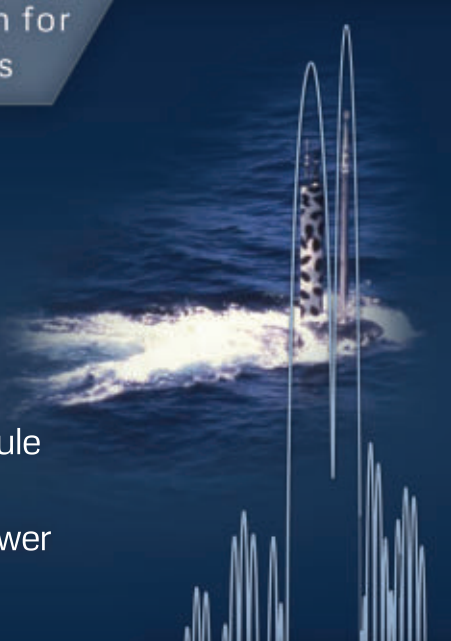
LFM pulse compression for
high-performance radars

SAW for
Defense & Space

*Need bandwidth?
DSP issues?*

1GHz bandwidth
40dB processing gain
100dB dynamic range

Unity-gain ovenized module
Passive, linear
Small size, weight, and power
Hi-rel, no obsolescence
Matched digital exciter



PHONON
CORPORATION

90 Wolcott Rd. Simsbury, CT 06070 (860) 651-0211

www.phonon.com/ghz



For complete coverage of the EuMW conference, event news, exhibitor product information and special reports from the editors of *Microwave Journal*, visit our online show daily at www.mwjjournal.com/eumw2016.

Product Showcase

Stands 1-19

Maury Microwave **Stand 1A** Measurement and Modeling Solutions



Exceptional companies have superior labs - complete your lab with Maury Microwave! Maury, a leader in measurement and modeling device characterization solutions, VNA calibration accessories and interconnections, will be showcasing active and hybrid-active harmonic load pull solutions, LXI-certified mechanical impedance tuners, pulsed IV/RF compact transistor modeling as well as coaxial and waveguide VNA calibration kits and metrology adapters, in-stock color-coded precision and daily-use adapters, and test-port, phase-stable and value cable assemblies. Visit Maury for details, demos, deals and NPLs. www.maurymw.com

Keysight Technologies **Stand 2** Handheld Analyzers with Real-Time Spectrum Analysis up to 50 GHz



Keysight Technologies now offers the industry's first handheld analyzers with real-time spectrum analysis (RTSA) up to 50 GHz. FieldFox

RTSA software, Option 350, is designed for engineers and technicians performing interference hunting and signal monitoring in surveillance and secure communications, radar, electronic warfare and commercial wireless applications. RTSA can capture burst signals in real-time, making them significantly easier to detect. By capturing a range of signals, FieldFox's new RTSA option provides a composite view, allowing easy identification of the source of interference.



www.keysight.com/find/FieldFoxRTSA

Rohde & Schwarz GmbH & Co. KG **Stand 3** True Multiport VNA up to 20 GHz



The new R&S ZNBT20 is the first true multiport vector network analyzer in the microwave range with up to 16 integrat-

ed test ports. The unique hardware architecture from the R&S ZNBT has been extended to 20 GHz. This allows users to characterize multiple DUTs in parallel and thus increase throughput tremendously. The R&S ZNBT offers the high measurement performance of a two-port network analyzer at each of its test ports. The high number of ports is relevant for the production of active and passive multiport components.



www.rohde-schwarz.com

National Instruments/AWR **Stand 4** Software Solutions



NI AWR Design Environment

Visit NI/AWR in Stand #4 to see recent advances in NI AWR Design Environment™ for the design of power amplifiers, filters, radar systems and more. Also, don't miss the opportunity to see their newest product, Antsyn™ antenna synthesis and optimization technology, a new cloud-based software as a service (SaaS) antenna design, synthesis and optimization solution. AntSyn enables both experts and relatively new antenna designers to input their antenna engineering requirements and produce antenna designs as outputs.



www.awrcorp.com/eumw2016

Teledyne Microwave **Stand 19** Solutions High Power GaN X-Band SSPAs



TMS' GaN-based SSPAs are available with 1 GHz bandwidth from 9 to 10 GHz, and offer 350 W, 550 W, and 1000 W peak out-

put power. Designed in a compact, environmentally sealed housing, these SSPAs can be used in airborne or ground-based environments. Features include superior spurious emissions performance, integrated

40 GHz
(KBL-Series)

Precision 75Ω
(CBL-Series)

Precision 50Ω
(CBL-Series)

Armored
(APC-Series)

Ultra-Flexible
(ULC-Series)

Flexible
(FLC-Series)

Precision VNA
Cables
(VNAC-Series)

TEST CABLES *up to 40 GHz!*

Reliability You Can Trust... from **\$68⁹⁵** ea. (qty.1-9)

Why do 10,000 customers trust Mini-Circuits test cables? Because they simply don't fail! Our test cables have been performance qualified to 20,000 flexures* and come backed by our 6-month product guarantee**, so you can be confident you're getting rugged construction, reliability, and repeatable performance you can depend on. Whether you're performing production

test, burn-in, over-temperature testing, hi-rel testing – you name it – chances are there's a Mini-Circuits test cable for your application in stock, ready for immediate shipment. Order some for your test setup at minicircuits.com today, and you'll quickly find that consistent long-term performance, less retesting and fewer false rejects really add up to bottom-line savings, test after test!

Model Family	Capabilities	Freq. (GHz)	Connectors†
KBL	Precision measurement, including phase, through 40 GHz	DC-40	2.92mm
CBL- 75+	Precision 75Ω measurement for CATV and DOCSIS® 3.1	DC-18	N, F
CBL	All-purpose workhorse cables for highly-reliable, precision 50Ω measurement through 18 GHz	DC-18	SMA, N
APC	Crush resistant armored cable construction for production floors where heavy machinery is used	DC-18	N
ULC	Ultra-flexible construction, highly popular for lab and production test where tight bends are needed	DC-18	SMA
FLC	Flexible construction and wideband coverage for point to point radios, SatCom Systems through K-Band, and more!	DC-26	SMA
NEW! VNAC	Precision VNA cables for test and measurement equipment through 40 GHz	DC-40	2.92mm (M to F)

* All models except VNAC-2R1-K+

** Mini-Circuits will repair or replace your test cable at its option if the connector attachment fails within six months of shipment. This guarantee excludes cable or connector interface damage from misuse or abuse.

† Various connector options available upon request.

Contact apps@minicircuits.com to discuss your special requirements.



CERNEX, Inc.

RF, MICROWAVE & MILLIMETER-WAVE

COMPONENTS AND SUB-SYSTEMS

UP TO 325GHz



AMPLIFIERS UP TO 110GHz
FREQUENCY MULTIPLIERS/DIVIDERS
(UP TO 160GHz)

CONVERTERS UP TO 110GHz
ANTENNAS UP TO 220GHz

COUPLERS UP TO 220GHz
FERRITE PRODUCTS
(ISOLATORS/CIRCULATORS)
UP TO 160GHz

FILTERS/DIPLEXERS
SOURCES UP TO 160GHz

SWITCHES UP TO 160GHz
PHASESHIFTERS UP TO 160GHz



TRANSITIONS/ADAPTERS (UP TO 325GHz)
WAVEGUIDE PRODUCTS UP TO 325GHz

TERMINATIONS/LOADS UP TO 160GHz
MIXERS(UP TO 110GHz)

ATTENUATORS(UP TO 160GHz)
DETECTORS(UP TO 160GHz)

LIMITERS(UP TO 160GHz)
BLAS TEE (UP TO 100GHz)

POWER COMBINERS/DIVIDERS EQUALIZERS

CABLES
ASSEMBLIES/CONNECTORS (UP TO 100GHz)
SUB-SYSTEMS (UP TO 100GHz)



Cernex, Inc.
1710 Zanker Road, Suite 103
San Jose, CA 95112
Tel: (408) 541-9226
Fax: (408) 541-9229

www.cernex.com
cernex@cernex.com



Stands 19-56



bias control for GaN devices, modular architecture for flexible design and scalability and proprietary power-combining approach.



www.teledynemicrowave.com

Teledyne Relays RF121 Relay



Teledyne Relays announced its new RF121 relay. The RF121 is a high repeatability, SPDT, broadband, magnetic-latching RF relay with performance to 16 GHz and industry leading signal integrity to 40 Gbps. It is ideal for switchable RF attenuators, RF switch matrices, high frequency spectrum radios, ATE and other applications that require dependable high frequency signal fidelity and performance. The RF121 is available in through-hole and surface-mount stub pin configurations.

www.teledynereleys.com

LPKF Laser & Electronics ProtoLaser S4 Laser System



The LPKF ProtoLaser S4 laser system uses a green laser wavelength and can laser etch PCBs in minutes on a wide range of laminated substrates, FR4 and PTFE or woven PCB materials. Prototypes and small production batches can also be produced on short notice if required. The LPKF ProtoLaser S4 is even more precise than the mechanical systems and is therefore ideal for HF and microwave circuits, as well as digital and analog circuits.

www.lpkf.com

API Technologies Low PIM Attenuator



API Weinschel's portfolio of low PIM attenuators includes the newly introduced Model 264 LIM series for applications up to 10 GHz. These resistive-based designs offer size, weight and economic alternatives to airline coupler and cable-wound low PIM attenuator solutions. Maximum IM3 of -155

dBc is achieved for 30 and 40 dB units when testing with two carrier tones, each with an average power level of +43 dBm. Connector configurations include Mini DIN, 7-16 DIN and Type N.

www.weinschel.apitech.com

Micran Measurement Equipment



Micran is a modern innovative enterprise with a strong team of specialists, combining experience in the different spheres of microwave electronics, communications, radio location, test and measurement equipment and information security. This unique, talented, multi-disciplinary team is viewed very positively by our current customers and partners. They are always ready to bring their wide expertise to accept new challenges.

www.micran.ru

Mician EM Software Tools



Mician is recognized as a leading developer of EM software tools for the design and optimization of waveguide components, feed networks and horn antennas. Version 8, the latest release of Mician's signature product μ Wave Wizard, now includes a modeler for user defined elements and comes with a new ribbon based graphical user interface. Speed up of GUI launch for very large projects is now up to 10 times faster, and includes a new direct and iterative solver, and parallelization is possible.

www.mician.com

Mini-Circuits High Power Amplifier



The ZHL-100W-272+ is a high power amplifier module supply which can be used for a wide variety of laboratory testing applications. This rugged amplifier is capable of amplifying signals up to 100W output power over its entire operating frequency range



of 700 to 2700 MHz. Built-in safety features include over-temperature protection and the ability to handle short/open Mismatch at output while delivering up to 3 dB compression output power, preventing amplifier damage and providing excellent reliability.



www.minicircuits.com

Rosenberger **Stand 60**
Multifunctional Site Analyzer



For efficient on-site tests and measurements, Rosenberger introduces its new CPRI and RF PIMmultifunctional Site Ana-

lyzer α , the world's first analyzer for all kinds of mobile network infrastructure—with copper or fiber interface. With exchangeable filter units, this portable equipment is ultra-broadband and presents various options in terms of test and measurement functionality: CPRI PIM, RF PIM, RF Return Loss/VSWR, isolation and the most accurate distance to fault in the market.

www.rosenberger.com/pia

Planar Monolithics
Industries Inc. **Stand 77**
Vector Phase Shifter



PMI Model PS-2G18G-360-8D is a 2 to 18 GHz, 8-Bit, vector phase shifter ideal for frequency translation where continuous monotonic phase shifting is required.

This model features high speed switching (<410 ns measured), phase shift 360 with a ± 15 accuracy (typical), 18 dB maximum insertion loss and typically lower than 60 dB harmonic distortion. Package size: 4.25" x 3.50" x 1.00", SMA(F) connectors, DC-37P, sub miniature D multi-Pin control connector and operates using ± 12 to ± 15 V @ ± 100 mA maximum.



www.pmi-rf.com

IMST GmbH
3D EM Field Solvers



EMPIRE XPU is one of the leading 3D EM field solvers for RF and microwave antennas, components and systems. Due to

its unique just in time compilation it has proven to be the fastest simulation engine which allows the modeling of highly complex structures within minutes. The new version EMPIRE XPU 7.5 features a professional 3D Design mode and the XPU FDTD simulation technique reaching 14,000 million FDTD cells per second on a modern PC. www.empire.de

Huber+Suhner Inc. **Stand 102**
MXP – Multicoax Test Solution



In a world where performance, speed and density matter, the MXP multicoax solution is the perfect fit. The small form factor

and outstanding electrical characteristics combined with reliable mating and ease of use make our MXP an excellent solution for benchtop and system testing with a large selection of bandwidths. MXP50 (50 GHz), MXP40 (40 GHz) and MXP18 (18 GHz) cover current data rate requirements. The entire MXP family comes with the highly flexible and ultra-stable MULTIFLEX cable as a standard.



www.hubersuhner.com

MPI Corp. **Stand 109**
Fully Automatic Probe System



MPI TS2500-RF is designed specifically for advanced RF device testing in production. Available for ambient/hot temperature operation

modes, the TS2500-RF can reach max. speed of 10 dies/second. The unique wafer chucks and lift pins can safely handle wafers of thickness down to 50 μ m, enabling testing of thin III-Vs compound wafers. Advanced alignment features such as off-axis and chuck mounted upper-looking cameras make TS2500-RF an ideal platform for production testing with complex RF measurement configurations.

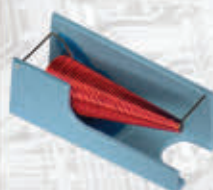
www.mpi-corporation.com

Inductors

High Frequency
High Quality

65+ GHz

Broadband Conicals



- Broad Bandwidth
- 65+ GHz Performance
- Resonance Free
- Low Insertion Loss

Air Coils



- Gold & Copper Wires
- 24 to 52 AWG.
- Diameter to .006 in.
- Precision Stripping

Mil-Spec Inductors



- High L & Q
- Small Package Size
- High Reliability
- SMT & Thru Mount

www.piconics.com

sales@piconics.com
P: 978-649-7501



**To be The best
& The number one!**

HIGH POWER WIDEBAND SOLID STATE POWER AMPLIFIER

Model	Frequency (GHz)	Output Power Min(dBm)
NTWPA-00000104100	0.00001-0.4	50
NTWPA-0000010011000	0.00001-0.01	60
NTWPA-0000010013000	0.00001-0.01	65
NTWPA-0000010015000	0.00001-0.01	67
NTWPA-001011000	0.01-0.1	60
NTWPA-001013000	0.01-0.1	65
NTWPA-001015000	0.01-0.1	67
NTWPA-008031000	0.08-0.3	60
NTWPA-008032000	0.08-0.3	63
NTWPA-0310700	0.3-1.0	58
NTWPA-03101000	0.3-1.0	60
NTWPA-00305100	0.03-0.512	50
NTWPA-00305200	0.03-0.512	53
NTWPA-000110100	0.001-1.0	50
NTWPA-00810100	0.08-1.0	50
NTWPA-00810200	0.08-1.0	53
NTWPA-0510100	0.5-1.0	50
NTWPA-0510200	0.5-1.0	53
NTWPA-0510500	0.5-1.0	57
NTWPA-05101000	0.5-1.0	60
NTWPA-0710100	0.7-1.0	50
NTWPA-0710200	0.7-1.0	53
NTWPA-0710500	0.7-1.0	57
NTWPA-1822100	1.8-2.2	50
NTWPA-1822200	1.8-2.2	53
NTWPA-1822500	1.8-2.2	57
NTWPA-2327100	2.3-2.7	50
NTWPA-2327200	2.3-2.7	53
NTWPA-2327500	2.3-2.7	57
NTWPA-0822100	0.8-2.2	50
NTWPA-0822200	0.8-2.2	53
NTWPA-0822500	0.8-2.2	57
NTWPA-0727100	0.7-2.7	50
NTWPA-0727200	0.7-2.7	53
NTWPA-2560100	2.5-6.0	50
NTWPA-2560200	2.5-6.0	53
NTWPA-2060100	2.0-6.0	50



Add: #20 Linhuai Street, Jiangning
Development Zone Nanjing, China

Postcode: 211106

Tel: (+86-25)84471796-807

Fax: (+86-25)84471786

Website: www.rflight.cn

E-mail: sales@rflight.cn



Stands 114-156



Spectrum Elektrotechnik GmbH

Stand 114

Push-Pull Connectors



Spectrum's most innovative designs are the push-pull connectors and adapters. They mate with standard connectors of types SMA, N, TNC and 7/16. The function is very simple. The push-ons slide onto the mating connector and can also lock automatically. For disconnecting just release and pull off. No special instructions have to be followed, no special handling is needed. Using these devices means saving time when testing products! Buying just the push-on adapter turns your assembly into a push-on assembly.

www.spectrum-et.com

OML Inc.

Stand 120

WR-10 VNA Compact Module



OML introduces the new VxxVNA3 Series compact version of its frequency extender for Vector Network Analyzers (VNA). Without compromising performance, OML's new compact, V10VNA3-T/R module covering 75-110 GHz, is now 6.16"(L) x 1.70" (H) x 3.72" (W). This innovative small compact design module is targeted for ease of use with probe station configurations while still fully compatible with VNA setups. Contact OML for more details.

www.omlinc.com

Infineon Technologies Americas Corp.

Stand 146

GaN RF Power Transistors



Infineon introduces a new family of GaN over SiC RF power transistors for L-Band radar and commercial avionics amplifier designs. The GTVA-123501FA offers 350 W (P3dB) of output power from 1200 to 1400 MHz, minimum of 70% drain efficiency and 17 dB of gain. The GTVA104001FA offers 400 W (P3dB) of output power across the entire 960 to 1215 MHz frequency band while providing minimum of 17.5 dB of gain and 70% drain efficiency. Engineering samples and broadband evaluation boards are now available.

www.infineon.com/rfpower

Greenray Industries Inc.

Stand 152

OCXO



Greenray Industries Inc. has announced the availability of the YH1485 OCXO. The new, high performance YH1485 oven controlled oscillator, available from 10 to 120 MHz with +10 dBm sinewave output, features low phase noise down to -180 dBc/Hz. The YH1485 is also available with low acceleration sensitivity down to $< 3 \times 10^{-10}/g$ for better performance during shock and vibration. Packaged in a compact, 1 in. square, low profile package, the YH1485 uses +15 VDC or +12 VDC supply. EFC (electronic frequency control) is provided for precise tuning or phase locking applications.

www.greenrayindustries.com

Wolfspeed HEMTs

Stand 156



Wolfspeed is a global supplier of gallium nitride on silicon carbide (GaN-on-SiC) high-electron-mobility transistors (HEMT) and monolithic microwave integrated circuits (MMIC). Wolfspeed introduces a new 50 V, 900 W GaN HEMT device that provides high output power for L-Band radar applications. The CGHV14800 provides 70% efficiency at pulsed PSAT, with a 3 μ s pulse width and 3% duty cycle. Visit Wolfspeed at Stand 156.

www.wolfspeed.com/rf



**For complete coverage of
the EuMW conference, event
news, exhibitor product
information and special
reports from the editors of
Microwave Journal, visit our
online show daily at**

[www.mwjjournal.com/
eumw2016](http://www.mwjjournal.com/eumw2016)

Stands 159-175



**Coilcraft
Chip Inductors**

Stand 159



Developed for use in mobile devices and cellular infrastructure equipment, Coilcraft's new 0402DF series chip inductors are available with inductance values ranging from 20 to 3300 nH, with a 5% tolerance for all values. They offer the lowest DCR currently available in a 0402 package and are fully optimized for use as a harmonic filter element for NFC applications. They can also be used as filter elements in band-stop and low pass filters, a one-pole filter or RF choke in cellular bands, and for ground-to-ground isolation.
www.coilcraft.com/0402df.cfm

**Reactel
Filters, Multiplexers &
Multifunction Assemblies**

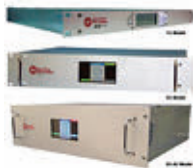
Booth 160



Reactel manufactures a line of filters, multiplexers & multifunction assemblies covering up to 50 GHz. From small, lightweight units suitable for flight to high power units capable of handling 10 kW, connectorized or surface mount. Reactel's talented engineers can design a unit specifically for your application. Visit Stand 160 to learn more.

VENDORVIEW
www.reactel.com

**Dow-Key Microwave Corp. Stand 175
Standard Matrix**



Designed for microwave, RF and audio test applications in the DC to 18 GHz frequency range, Dow-Key's Standard Matrix product line includes standard configurations ranging from 1 × 100 to 12 × 12. Packaged in a self-contained 19" rack-mountable enclosure and provided with remote interfaces such as RS232, RS-422, GPIB, USB and Ethernet along with a touch-screen LCD front panel display or keypad for manual override. Dow-Key uses its own line of coaxial switches for these matrices, providing low loss and excellent isolation. Visit Dow-Key at Stand 175.
www.dowkey.com

AMERICAN MICROWAVE CORPORATION



**LOG VIDEO
AMPLIFIERS**



**SOLID
STATE
SWITCHES**



**INTEGRATED
ASSEMBLIES**

**SOLID STATE
VARIABLE
ATTENUATORS**



**In Pursuit of Excellence
Through Engineering**

MIL 883 CAPABLE
ISO9001:2008 REGISTERED

**7309-A GROVE RD | FREDERICK, MARYLAND
PHONE 301.662.4700 | FAX 301.662.4938
AMERICANMIC.COM | SALES@AMERICANMIC.COM**

X-MWprobe

AFFORDABLE, ACCURATE PROTOTYPING

Order a prototype station kit
xmicrowave.com/proto

- Test, align & configure complete microwave assemblies
- Solderless probing & interconnects to 50 GHz
- Use actual components in prototyping (100's of Drop-Ins)
- Validate designs directly on the prototype plate
- Eliminate pitfalls from prototype to production

X microwave

○ (512) 355-7115
○ xmicrowave.com



PureSine RF Signal Generator

Introducing our all-new harmonic-filtered wideband premium signal generator.

Wideband 55 - 22,000MHz	Minimum Phase Noise
USB & Panel Control	Maximum Output Power
New Control Software	Ultra-Precision Reference
Compact and Reliable	Stepped Power Control
SCPI Automation Friendly	Vernier Power Control

SG6800HF - Only \$1949.00



12GHz Digital Step Attenuator

A USB SCPI-controlled RF attenuator with additional front user controls and display.

0 to 63dB Attenuation	100MHz - 12GHz
Simple Windows App	0.5dB Steps
USB Powered	Micro 2.75" Enclosure

Only \$799.00



DS INSTRUMENTS

CALL US (805) 242 6685

WWW.DSINSTRUMENTS.COM

Seals of Approval

NQA Registered ISO 9001:2008 & AS9100C

**Guaranteed Highest Possible
Hermeticity with Kovar®**



Metal Processing Co., Inc.
Specializing in Glass-to-Metal Seals

Kovar Feedthrus • Housings • Shrouds • Connectors

sales@metproco.com

www.metproco.com

978-649-1289



Stands 175-193



K&L Microwave

Stand 175

Ultra-Miniature Lumped Element Filter

Ultra-miniature lumped element filters provide reduced size and weight while affording ultimate flexibility. Bandpass, lowpass, highpass and notch filters, including elliptic and pole placed designs are available in very small surface mount packages. Integrated covers assure performance in sizes typically less than 0.2" wide by 0.15" tall. Join K&L at booth number 175 to discuss your custom requirement.

www.klmicrowave.com



Pole/Zero Corp.

Stand 175

Extended Range Filters

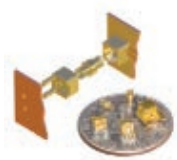


Pole/Zero is showcasing the production release of its new NANO-ERF® series of extended range filters that covers the entire 30 to 520 MHz tuning range in a single 28 x 28 x 0.216 (mm) surface mount package. Tuning speeds are 25 µsec typical, 35 µsec max with inband RF power handlings of +6 dBm. Pole/Zero's complete product line includes tunable filters, integrated cosite equipment and low noise and cosite power amplifiers. Visit Pole/Zero at Stand 175.

www.dovermpg.com/polezero

Southwest Microwave Inc. Stand 179

Blind-Mate Connectors



High-performance SuperMini Board-to-Board DC to 67 GHz blind-mate connectors optimize transmission line dependability for PCBs stacked as tightly as 3 mm. Ideal for defense, aerospace, communications, networking and test applications, these unique board-to-board, edge-mount to backplane, or board-to-panel interconnections maximize electrical performance between connector and circuit while accommodating axial misalignment of .010" and radial misalignment of ± 10° via superior bullet and receptacle designs. Low mating insertion force allows for high connector density and extended mating/de-mating cycles.

www.southwestmicrowave.com

Spinner GmbH

Stand 193

Low PIM Switches



At European Microwave Week, SPINNER will present its updated portfolio of low PIM test and measurement products. The company's low PIM switches, for example, have been taken to the next level. Also on display will be a computer-controlled switch matrix with multiple input and output ports for antenna testing. In addition, SPINNER will exhibit the latest generation of its EasyDock push-pull measurement adaptors, including both nonlocking and lockable versions for manual and automatic uses.

VENDORVIEW

www.spinner-group.com



Europe's Premier Microwave, RF, Wireless and Radar Event

European Microwave Week 2016

ExCeL London Exhibiton &

Convention Centre

London, UK

3-7 October 2016

- A 5-day International Event
- A 3-day Exhibition
- 3 Major Conferences over 5 days
- Associated Workshops
- Exhibitor Workshops & Seminars



Advanced Switch Technology
Switches for the Telecom Industry



WAVEGUIDE SWITCHES - COAXIAL SWITCHES - DUAL SWITCHES

WE ARE THE WAVEGUIDE & COAXIAL SWITCH EXPERTS
YOUR #1 SOURCE FOR MICROWAVE SWITCHES

QUALITY, SERVICE & QUICK DELIVERIES UNMATCHED IN THE INDUSTRY

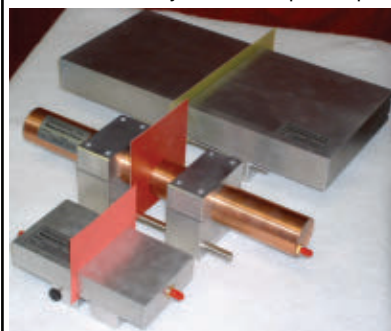
754 Fortune Crescent, Kingston, ON, K7P 2T3, Canada
Tel: 613 384 3939 - Fax: 613 384 5026
e-mail: info@astswitch.com

www.astswitch.com



Dielectric Testers

- Std Sizes ● ~100 MHz - 40 GHz
- Fast ● Easy ● No Sample Prep



ϵ , $\tan \delta$ - Cavity™ sflwr
Thin Sheets, Substrates, Resins, Foams
www.damaskosinc.com
(610)358-0200 fax(610)558-1019

KR Electronics

www.krfilters.com
ISO 9001:2008 Certified



Custom & Standard Filters
40+ Years of Military & Commercial Applications

Bandpass Anti-Aliasing Highpass Video Filters Diplexers Delay Equalized Surface Mount	Lowpass Notch Root Cosine Equalizers Linear Phase Absorptive Matched
--	---

KR Electronics, Inc.
Avenel, NJ
www.krfilters.com

sales@krfilters.com
Phone 732.636.1900
Fax 732.636.1982



SELECT THE RIGHT ADHESIVE

MASTERBOND®
ADHESIVES | SEALANTS | COATINGS
Celebrating our 40 year anniversary

+1.201.343.8983 • main@masterbond.com
www.masterbond.com

SECTOR MICROWAVE INDUSTRIES, INC.



WR10
WR15
WR22
WR28
WR34
WR42
WR51
WR62
WR75
WR90
WR102
WR113
WR137
WR159
WR187
WR222
WR250
WR300
WR350
WR400
WR450
WR500
WR550
WR600
WR650
WR700
WR750
WR800
WR850
WR900
WR950
WR1000

(631) 242-2300 FAX (631) 242-8158
www.sectormicrowave.com

REVOLUTIONARY HERMETIC SMP CONNECTORS

These SMPs meet the requirements of MIL-STD-348, but utilize unique housing interface features, which significantly improves reliability and production assembly yields. Proprietary techniques are used to independently control plating thickness on pin and housing.



For use with Aluminum, Kovar and other package materials

SHP SPECIAL HERMETIC PRODUCTS, INC.
PO BOX 269 - WILTON - NH - 03086
(603) 654-2002 - Fax (603) 654-2533
E-mail: sales@shp-seals.com
Web: www.shp-seals.com

ES MICROWAVE LLC.

Since 1985 we have offered our custom design filters and sub-assemblies in combine, interdigital and suspended-substrate technologies.

Broadband
Suspended-Substrate
Filters, Diplexers, Triplexers, Quadruplexers, Quintuplexers, Sextuplexers...



DC-40 GHz Filters
Multiplexers & Switch Filter Banks

ES Microwave, LLC
8031 Cassena Avenue, Gaithersburg, MD 20879
P: 301-519-9407 F: 301-519-9418
www.esmicrowave.com

The best Solution for RF Technology!

"LOWEST PRICE & HIGHEST QUALITY"

SRT
SRTechnology Corporate

TERMINATION
N=2WATT
18GHz
V.S.W.R. 1.18:1

Frequency Range : DC~18GHz
Impedance : 50 Ohm
Power Rating : 2 Watt
V.S.W.R. : 1.18:1
DC~4GHz : 1.05:1
4~8GHz : 1.10:1
8~18GHz : 1.18:1



Warranty 3years
Payment Term
Within 30 days from SRT date

sales@srtechnology.com +82-2-866-9083
www.srtechnology.com

TERMINATION
ATTENUATOR
CONNECTOR
CABLE ASSEMBLY
ADAPTOR

RF Amplifiers, Isolators and Circulators from 20MHz to 40GHz

- Super low noise RF amplifiers
- Broadband low noise amplifiers
- Input PIN diode protected low noise amplifiers
- General purpose gain block amplifiers
- High power RF amplifiers and broadband power amplifiers

- RF isolators and circulators
- High power coaxial and waveguide terminations
- High power coaxial attenuators
- PIN diode power limiters
- Active up and down converters

Wenteq Microwave Corporation
138 W Pomona Ave, Monrovia, CA 91016
Phone: (626) 305-6666, Fax: (626) 602-3101
Email: sales@wenteq.com, Website: www.wenteq.com



Electronics for Microwave Backhaul

Editors:
Vittorio Camarchia,
Roberto Quaglia,
Marco Pirola

Since the inception of mobile telephony, microwave radio has been the primary backhaul technology used to link base stations to the so-called core network. They now connect over 50 percent of the world's base stations, and backhaul represents over 85 percent of point-to-point radio usage. As cellular technology has evolved from analog to LTE, with data traffic increasing exponentially, microwave backhaul has had to keep pace to remain technically viable, and it faces continuing transformation as cells "densify" and data rates accelerate toward 5G nirvana.

Considering the historic and undiminished role for microwave radios in mobile infrastructure, and not finding a comprehensive technical treatment

elsewhere, Vittorio Camarchia, Roberto Quaglia and Marco Pirola decided to write "Electronics for Microwave Backhaul." The three combined their knowledge and experience and solicited contributions from technologists working in the industry to create a single volume that discusses the major building blocks of the radio, explaining the evolution and covering trends and future developments.

The first of seven chapters begins with a tutorial of the mobile network and the role played by the radio. This includes a treatment of propagation and fade margin. The second chapter provides the history of microwave radio and how radios perform compared to copper and fiber. Subsequent chapters delve into the architecture of the radio, techniques to increase capacity and the various subsystems: modem, receiver, transmitter and antenna. "Electronics for Microwave Backhaul" is thorough, readable and a good reference for de-

sign, marketing and sales engineers working in this segment.

All three editors received technical degrees from Politecnico di Torino, where Carmachia and Pirola serve as professors. Is it coincidental that Torino is not far from Milan, long a technology center for microwave radio development, including the well known names Ericsson, Huawei and SIAE Microelettronica?

To order this book, contact:

Artech House
www.artechhouse.com
ISBN-13: 978-1-63081-015-3
345 pages
\$179

Available in hardcover
and eBook formats

THE LATEST "WORDS" IN MICROWAVE DESIGN...

INTRODUCTORY PRICE \$134 / £99
Expires 10/31/2016



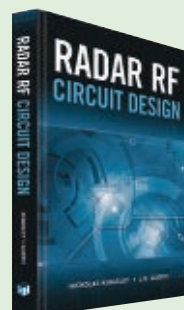
Modern RF and Microwave Filter Design

Prakash Bhartia and Protap Pramanick
Hardcover • 412 pp. • 2016
ISBN: 978-1-63081-157-0
\$179 / £133



Electronics for Microwave Backhaul

Vittorio Camarchia, Roberto Quaglia,
and Marco Pirola
Hardcover • 356 pp. • 2016
ISBN: 978-1-63081-015-3
\$179 / £133



Radar RF Circuit Design

Nickolas Kingsley and Joseph R. Guerci
Hardcover • 316 pp. • 2016
ISBN: 978-1-60807-970-4
\$169 / £128

US: Call 1-800-225-9977 (in the U.S. or Canada),
or 1-781-769-9750, ext. 4030
Fax 1-781-769-6334
E-mail to: artech@ArtechHouse.com

UK: Call +44 (0)20 7596 8750
Fax +44 (0)20 7630-0166
E-mail artech-uk@ArtechHouse.com

For complete descriptions and to order, visit

ArtechHouse.com

All orders plus shipping/handling and applicable taxes.



ARTECH HOUSE
BOSTON | LONDON

685 Canton Street, Norwood, MA 02062 USA
16 Sussex Street, London SW1V 4RW UK

See us at EuMW Stand 4A

Sponsors

Platinum

Raytheon

Gold

Georgia Tech **Research Institute**

Silver

SRC

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

MITRE

Banquet Sponsor

Rockwell Collins

Other Sponsors



str SYSTEMS & TECHNOLOGY RESEARCH

Technical Co-Sponsors



2016 IEEE International Symposium on **Phased Array Systems and Technology**

*Revolutionary
Developments in
Phased Arrays*

18–21 October 2016

Westin Waltham Hotel,
Greater Boston,
Massachusetts, USA
www.array2016.org

Conference Committee

Conference Chair:

Jeffrey S. Herd, (MIT LL)

Vice Chair:

William Weedon, Applied Radar

Honorary Chair:

Eli Brookner, Raytheon (retired)

Technical Program Chair:

Alan J. Fenn, MIT LL

Technical Program Vice Chair:

Wajih Elsallal, MITRE

Special Sessions Chair:

Sean Duffy, MIT LL

Plenary Session Chairs:

David Mooradd, MIT LL

Eli Brookner, Raytheon (retired)

Tutorials Chairs:

Jonathan Williams, STR

Jonathan Doane, MIT LL

Student Program Chairs:

Bradley T. Perry, MIT LL

Justin Kasemodel, Raytheon

Secretary:

Duane J. Matthiesen, Technia

International Liaison:

Alfonso Farina, Selex (retired)

Exhibits Chair:

Dan Culkin, NGC

Publicity Chairs:

Glenn Meurer, MITRE

Don McPherson, SRC, Inc.

Social Media Chair:

Gregory Charvat, Humatics, Inc.

Publications Chairs:

Raoul Ouedraogo, MIT LL

Will Moulder, MIT LL

Poster Sessions Chairs:

Greg Arlow, Lockheed Martin

Mark McClure, STR

Local Arrangements/Finance:

Robert Alongi, IEEE Boston

Website:

Kathleen Ballos, Ballos Associates

Advisors:

Ellen Ferraro, Raytheon

Robert J. Mailloux, Arcon

Hans Steyskal, Arcon

Chris McCarroll, Raytheon



Our Blog



ADVERTISER	PAGE No.	ADVERTISER	PAGE No.	ADVERTISER	PAGE No.
Accel-RF Instruments Corporation.....	108	HJ Technologies.....	146	Prism Microwave.....	168
Advanced Switch Technology.....	181	Holzworth Instrumentation.....	28	Pronghorn Solutions.....	110
Agile Microwave Technology Inc.....	132	Huber + Suhner AG.....	79	Pulsar Microwave Corporation.....	124
Altair Engineering, Inc.....	103	IEEE International Symposium on Phased Array Systems & Technology 2016.....	183	Qorvo.....	87
American Microwave Corporation.....	179	IEEE MTT-S International Microwave Symposium 2017.....	107	Quest Microwave Inc.....	160
American Technical Ceramics.....	73	IEEE WAMICON 2017.....	152	R&D Interconnect Solutions.....	112
AMTA 2016.....	138	IMST GmbH.....	76	Reactel, Incorporated.....	53
Analog Devices.....	47	Ingun Prüfmittelbau GmbH.....	84	RelComm Technologies, Inc.....	133
Anaren Microwave.....	41	Insulated Wire, Inc.....	129	RF-Lambda.....	43, 119, 163
Anokiwave.....	20-21	Intelliconnect (Europe) Ltd.....	166	Rflight Communication Electronic Corporation.....	178
Anritsu Company.....	13	ITC 2016.....	148	Richardson RFPD.....	19
API Technologies, Inmet.....	9	K&L Microwave, Inc.....	7	RLC Electronics, Inc.....	23
API Technologies, Weinschel.....	123	Keysight Technologies.....	35, 105	Rogers Corporation.....	65
AR RF/Microwave Instrumentation.....	75	KR Electronics, Inc.....	181	Rohde & Schwarz GmbH.....	COV 3
Arance Electronics.....	60	Kratos General Microwave.....	125	Rosenberger.....	91
Artech House.....	182	L-3 Narda-MITEQ.....	81	SAF Tehnika.....	136
B&Z Technologies, LLC.....	29	Linear Technology Corporation.....	31	Sage Millimeter, Inc.....	27
Boonton Electronics (a Wireless Telecom Group Company).....	COV 2	LPKF Laser & Electronics.....	88	Sector Microwave Industries, Inc.....	181
Cernex, Inc.....	176	MACOM.....	39	SemiGen.....	101
Changzhou Zhongying SCI & TEC Co., Ltd.....	104	Master Bond Inc.....	181	SignalCore, Inc.....	68
Chengdu Seekon Microwave Communications Co., Ltd.....	106	Maury Microwave Corporation.....	141	Sivers IMA AB.....	114
Ciao Wireless, Inc.....	50	MCV Microwave.....	96	Skyworks Solutions, Inc.....	67
Coilcraft.....	15	MECA Electronics, Inc.....	3	Southwest Microwave Inc.....	102
Comtech PST Corp.....	30	MegaPhase.....	137	Special Hermetic Products, Inc.....	181
Comtech PST Corp. (Hill Engineering Division).....	66	Mercury Systems, Inc.....	37	Spectrum Elektrotechnik GmbH.....	115
Copper Mountain Technologies.....	153	Metal Processing Co., Inc.....	180	Spectrum Systementwicklung Microelectronic GmbH.....	167
CPI Beverly Microwave Division.....	6	Micable Inc.....	149	Spinner GmbH.....	111
CST of America, Inc.....	25	MiCIAN GmbH.....	86	SRTechnology Corporation.....	181
Custom MMIC.....	77	Microwave Journal.....	150, 166, 169, 171	State of the Art, Inc.....	42
Damaskos Inc.....	181	MILMEGA, a unit of AMETEK CTS.....	52	SV Microwave, Inc.....	147
dBm Corp.....	36	Mini-Circuits.....	4-5, 16, 49, 57, 58, 71, 139, 151, 175, 185	Synergy Microwave Corporation.....	63, 157
Dow-Key Microwave Corporation.....	92	Modelithics, Inc.....	40	Taconic.....	145
DS Instruments.....	180	Morion US, LLC.....	121	Teledyne Coax Switches.....	113
Eastern Wireless TeleComm, Inc.....	127	MPI Corporation.....	56	Teledyne Microwave Solutions.....	61
Eclipse Microwave.....	142	National Instruments.....	11, 33	Teledyne Relays.....	113
EDI CON China 2017.....	54, 165	Nexyn Corporation.....	120	Times Microwave Systems.....	109
Electronica 2016.....	156	NI Microwave Components.....	90	Ulbrich Stainless Steels & Special Metals, Inc.....	32
Empower RF Systems, Inc.....	46	NoiseWave Corp.....	8	United Monolithic Semiconductors.....	97
ES Microwave, LLC.....	181	Norden Millimeter Inc.....	80	UTE Microwave Inc.....	143
ET Industries.....	18	OML Inc.....	117	Virginia Diodes, Inc.....	69
EuMW 2016.....	155	OMMIC.....	85	W.L. Gore & Associates, Inc.....	131
EuMW Defence, Security and Space Forum 2016.....	98-99	Passive Plus, Inc.....	82	Waveline Inc.....	144
Exodus Advanced Communications, Corp.....	173	Pasternack.....	134, 135	Weinschel Associates.....	161
Exodus Dynamics.....	122	Phonon Corporation.....	173	Wenteq Microwave Corporation.....	181
Fairview Microwave.....	159	Pickering Interfaces Inc.....	83	Wenzel Associates, Inc.....	161
Frontlynk Technologies Inc.....	126	Piconics.....	177	Werlatone, Inc.....	COV 4
G.T. Microwave Inc.....	48	Pivottone Communication Technologies, Inc.....	45	WIN Semiconductors Corp.....	95
Greenray Industries, Inc.....	74	Planar Monolithics Industries, Inc.....	89	Withwave, Inc.....	68
Herrotek, Inc.....	118	Polyphase Microwave, Inc.....	128	Wolfspeed, a Cree company.....	93
Hirai SK Corporation.....	70			Wright Technologies.....	34
				X-Microwave, LLC.....	179
				Z-Communications, Inc.....	70

Sales Representatives



Frequency Matters.

Eastern and Central Time Zones

Chuck Boyd
Northeast Reg. Sales Mgr.
(New England, New York,
Eastern Canada)
685 Canton Street
Norwood, MA 02062
Tel: (781) 619-1942
FAX: (781) 769-5037
cboyd@mwjournal.com

Michael Hallman
Eastern Reg. Sales Mgr.
(NJ, Mid-Atlantic, Southeast,
Midwest, TX)
4 Valley View Court
Middletown, MD 21769
Tel: (301) 371-8830
FAX: (301) 371-8832
mhallman@mwjournal.com

Pacific and Mountain Time Zones

Brian Landy
Western Reg. Sales Mgr.
(CA, AZ, OR, WA, ID, NV, UT,
NM, CO, WY, MT, ND, SD, NE &
Western Canada)
144 Segre Place
Santa Cruz, CA 95060
Tel: (831) 426-4143
FAX: (831) 515-5444
blandy@mwjournal.com

International Sales

Richard Vaughan
International Sales Manager
16 Sussex Street
London SW1V 4RW, England
Tel: +44 207 596 8742
FAX: +44 207 596 8749
rvaughan@horizonhouse.co.uk

Germany, Austria, and Switzerland (German-speaking)

WMS.Werbe- und Media Service
Brigitte Beranek
Gerhart-Hauptmann-Street 33,
D-72574 Bad Urach
Germany
Tel: +49 7125 407 31 18
FAX: +49 7125 407 31 08
bberanek@horizonhouse.com

Korea

Young-Seoh Chinn
JES Media International
2nd Floor, ANA Bldg.
257-1, Myungil-Dong
Kangdong-Gu
Seoul, 134-070 Korea
Tel: +82 2 481-3411
FAX: +82 2 481-3414
yschinn@horizonhouse.com

China

Shenzhen
Michael Tsui
ACT International
Tel: 86-755-25988571
FAX: 86-10-58607751
michaelt@actintl.com.hk

Shanghai

Linda Li
ACT International
Tel: 86-21-62511200
lindal@actintl.com.hk

Beijing

Oasis Guo
ACT International
Tel: 86-13011108861
oasisg@actintl.com.hk

Hong Kong, Taiwan, Singapore

Mark Mak
ACT International
Tel: 852-28386298
markm@actintl.com.hk

Japan

Katsuhiko Ishii
Ace Media Service Inc.
12-6, 4-Chome,
Nishiiko, Adachi-Ku
Tokyo 121-0824, Japan
Tel: +81 3 5691 3335
FAX: +81 3 5691 3336
amskatsu@dream.com

TINY! **Ultra-Wideband** **MMIC SPLITTER/COMBINERS**



Single Unit Coverage as Wide as **2 to 26.5 GHz**

Models from **\$5⁵⁶**
ea. (qty. 1000)

THE WIDEST BANDWIDTH IN THE INDUSTRY IN A SINGLE MODEL!

Our new EP-series ultra-wideband MMIC splitter/combiners are perfect for wide-band systems like defense, instrumentation, and all cellular bands through LTE and WiFi. These models deliver consistent performance across the whole range, so you can reduce component counts on your bill of materials by using one part instead of many! They utilize GaAs IPD technology to achieve industry-leading performance, high power handling capability and efficient heat dissipation in a tiny device size, giving you a new level of capability and the flexibility to use them almost anywhere on your PCB! They're available off the shelf, so place your order on minicircuits.com today, and have them in hand as soon as tomorrow!

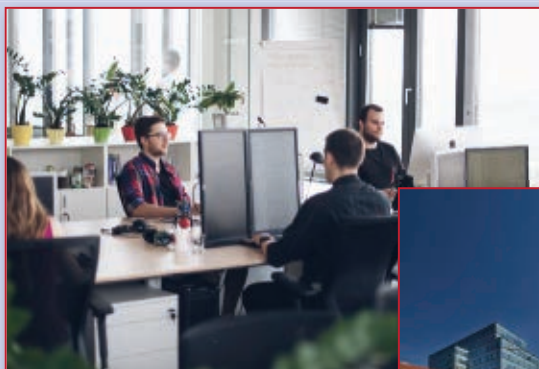
- Series coverage from 0.5 to 26.5 GHz
- Power handling up to 2.5W
- Insertion loss, 1.1 dB typ.
- Isolation, 20 dB typ.
- Low phase and amplitude unbalance
- DC passing up to 1.2A

 EP2K-Series, 4x4x1mm
 EP2W-Series, 5x5x1mm



FAB\$ and LAB\$

Custom Software Solutions with a Test and Measurement Heritage



The name Anritsu is familiar to most RF/microwave engineers. Not by chance, the company was formed the same year Marconi demonstrated the world's first wireless telegraph, in 1895. Over the course of its 121-year history, the company has become a \$1 billion stalwart of test and measurement (T&M), known for a full range of benchtop and portable equipment. Given this common notion of Anritsu, you may be surprised to learn that the company has an engineering center in Slovakia that consults on information technology (IT) and develops custom software for over 100 clients — only one of which is Anritsu — with projects that address multiple applications, such as telecommunications, aviation, e-commerce, retail and finance.

Anritsu Solutions SK (ASSK) was born in 1998, the confluence of several themes. Companies, particularly in Europe, that outsourced the development of embedded software or mobile/web apps wanted to minimize software development costs but not sacrifice close collaboration and clear communication with their external partners. This tension supported the growth of a technology sector in central and eastern Europe. The area is close to the rest of the continent, yet costs are lower; the work cultures are similar and a technical workforce is readily available. Anritsu had developed a software competency to support its own T&M needs and understood the technical aspects of the markets that were using the company's equipment.

Combining these seemingly unrelated threads, ASSK has grown to be the biggest engineering branch of Anritsu in the European region, with 85 engineers based at a modern office complex in the center of Bratislava, next door to Slovak University of Technology and 40 minutes from the Vienna airport. Not just offices, their 1100 m² facility houses a 20 m² Faraday cage for testing products isolated from interfering signals and a climate chamber for testing embedded systems under different temperature conditions.

Anritsu's T&M heritage leads to many engagements for telecom applications. In 2009, ASSK established one of the first LTE networks for RF conformance testing, and they continue to implement the latest LTE capabilities. Typical telecom projects involve passive and active monitoring, real-time traffic monitoring and interoperability testing. As one example, ASSK worked with one of the largest telecom operators in Europe on the rollout of a next-generation active testing platform, including VoIP/IP multimedia subsystems (IMS) monitoring. With this longstanding telecom experience, ASSK is well positioned to support the growth in the Internet of Things (IoT), whether developing embedded software for data acquisition or mobile/web applications for data processing and presentation. ASSK's reputation and reach extend well beyond telecom and Europe: they are developing a mobile app for the consumer sector with a Silicon Valley firm and have created embedded software for home appliances, such as a Bluetooth connected electric toothbrush.

As products become more complex and development cycles shorten, companies are being forced to focus on their strategic cores and establish partnerships to handle their other business processes. Gartner Group forecasts that the demand for IT and software outsourcing will grow at an average rate of six percent per year through 2018, and it is arguable that the mobile and IoT segments will grow faster. ASSK's goal, to be a trusted partner for companies needing their unique blend of software expertise and technical understanding has proven to be quite successful. Over an 18-year history, they have built long term relationships with their clients, who return for multiple engagements. They intend to keep it that way.

anritsu.com

Our expertise takes you to the top. EMC solutions from Rohde & Schwarz.

We provide everything you need for development, precompliance and compliance measurements to ensure successful EMC certification.

- Exceptionally fast EMI test receivers
- Efficient diagnostic tools for detecting EMI
- EMC software packages for interactive and fully automatic measurements
- Wide range of accessories for performing EMI measurements
- Compact and modular broadband amplifiers
- RF shielded chambers
- Complete EMC test systems

For more information, visit:

www.rohde-schwarz.com/ad/emc



ROHDE & SCHWARZ



WERLATONE®

WE ARE HIGH POWER

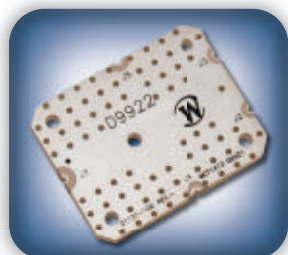
Surface Mount (SMT) & Drop-In Components

- Multi-Octave Designs
- Superior Electrical Performance
- Send Us Your Specs!
- Excellent Repeatability
- Compact Designs

Directional Couplers



0° Combiners



90° Hybrid Couplers



180° Combiners



Directional Couplers

Model	Type	Frequency (MHz)	Power (W CW)	Coupling (dB)	Insertion Loss (dB)	VSWR (ML)	Mounting Style	Size (Inches)
C8740	Dual	20-512	200	40	0.3	1.15:1	Tabs	1.5 x 0.95 x 0.55
C9655	Dual	20-1000	100	30	0.7	1.25:1	Tabs	1.5 x 0.95 x 0.55
C8631	Dual	20-1000	150	40	0.35	1.25:1	Tabs	1.5 x 0.95 x 0.55
C10561	Dual	20-1000	250	50	0.1	1.25:1	SMT	1.35 x 1 x 0.15
C7962	Bi	450-2500	100	30	0.2	1.20:1	SMT	1.15 x 0.7 x 0.07
C8025	Bi	500-3500	125	30	0.3	1.25:1	Drop-In	1.3 x 1 x 0.07
C8098	Bi	800-2000	200	30	0.7	1.20:1	Drop-In	1.3 x 1 x 0.07

0° Combiners/Dividers

Model	Type	Frequency (MHz)	Power (W CW)	Insertion Loss (dB)	VSWR	Isolation (dB)	Mounting Style	Size (Inches)
D9888	2-Way	1000-3000	500	0.35	1.35:1	15	SMT	2.8 x 2.2 x 0.27
D9922	2-Way	2000-6000	200	0.35	1.40:1	15	SMT	1.4 x 1.1 x 0.14

Hybrids

Model	Type	Frequency (MHz)	Power (W CW)	Insertion Loss (dB)	VSWR	Amplitude Balance (±dB)	Mounting Style	Size (Inches)
QH10738	90°	20-1000	150	0.8	1.40:1	0.25	Tabs	3 x 2.75 x 1
QH9056	90°	30-520	400	0.8	1.30:1	1.2	Drop-In	4 x 1.7 x 0.29
QH9304	90°	60-1000	150	1.0	1.40:1	1.0	Drop-In	2 x 1 x 0.16
QH8849	90°	80-1000	250	0.65	1.40:1	1.0	Drop-In	2.9 x 2.1 x 0.31
QH8100	90°	100-512	250	0.45	1.30:1	0.5	Drop-In	3.3 x 1.52 x 0.28
QH10245	90°	100-1300	150	0.75	1.30:1	0.75	SMT	2.5 x 1.7 x 0.16
QH8922	90°	150-2000	100	0.75	1.40:1	1.0	SMT	1.47 x 1.13 x 0.16
QH7900	90°	450-2800	125	0.55	1.35:1	0.45	SMT	1.5 x 1.1 x 0.095
QH7622	90°	500-3000	150	0.55	1.35:1	0.6	Drop-In	1.65 x 1.1 x 0.09
QH10541	90°	700-6000	100	0.5	1.35:1	0.6	SMT	0.66 x 0.86 x 0.09
QH10089	90°	800-2800	200	0.35	1.30:1	0.4	SMT	1.25 x 0.55 x 0.08
QH7741	90°	800-3000	200	0.3	1.40:1	0.45	Drop-In	1.35 x 0.65 x 0.09
H10125	180°	1000-3000	350	0.5	1.35:1	0.2	SMT	2.31 x 1.21 x 0.25
QH10637	90°	1000-6500	100	0.65	1.45:1	0.6	SMT	0.86 x 0.66 x 0.09
QH8193	90°	2000-6000	100	0.25	1.30:1	0.75	SMT	0.85 x 0.33 x 0.14
QH10148	90°	2000-6000	100	0.3	1.30:1	0.5	SMT	0.75 x 0.45 x 0.08
H10126	180°	2000-6000	100	0.8	1.35:1	0.4	SMT	1.15 x 0.6 x 0.14
QH10707	90°	2500-5500	200	0.25	1.25:1	0.35	SMT	0.65 x 0.4 x 0.12
QH10651	90°	3000-3500	150	0.2	1.20:1	0.25	SMT	0.56 x 0.35 x 0.1

Werlatone, Inc.

17 Jon Barrett Road
Patterson, NY 12563
T 845 278 2220
F 845 278 3440
sales@werlatone.com
www.werlatone.com