

Vol. 56 • No. 2

February 2013

Microwave Journal

BEYOND THE

MVP

Vubiq
60 GHz
Module

100 GHz Frontier



horizon
house®

Founded in 1958

mwjournal.com

BETTER BUILDINGS. BETTER CARE.



For next-generation DAS, there's only one name for passives.

It's simple. Better signals equal better care. Today's hospitals personify the need for next-level Distributed Antenna Systems (DAS). And the engineers that are building them turn to MECA for passive components. American ingenuity and 52 years of experience have resulted in the deepest, most reliable product line of ready-to-ship and quick-turn solutions, such as:

Power Dividers Up to 16 way and 18 GHz

Attenuators Up to 60dB and 500W

Terminations Up to 500W

Couplers Up to 40dB and 1kW

Integrated Rack Units Delivered in 3-6 weeks

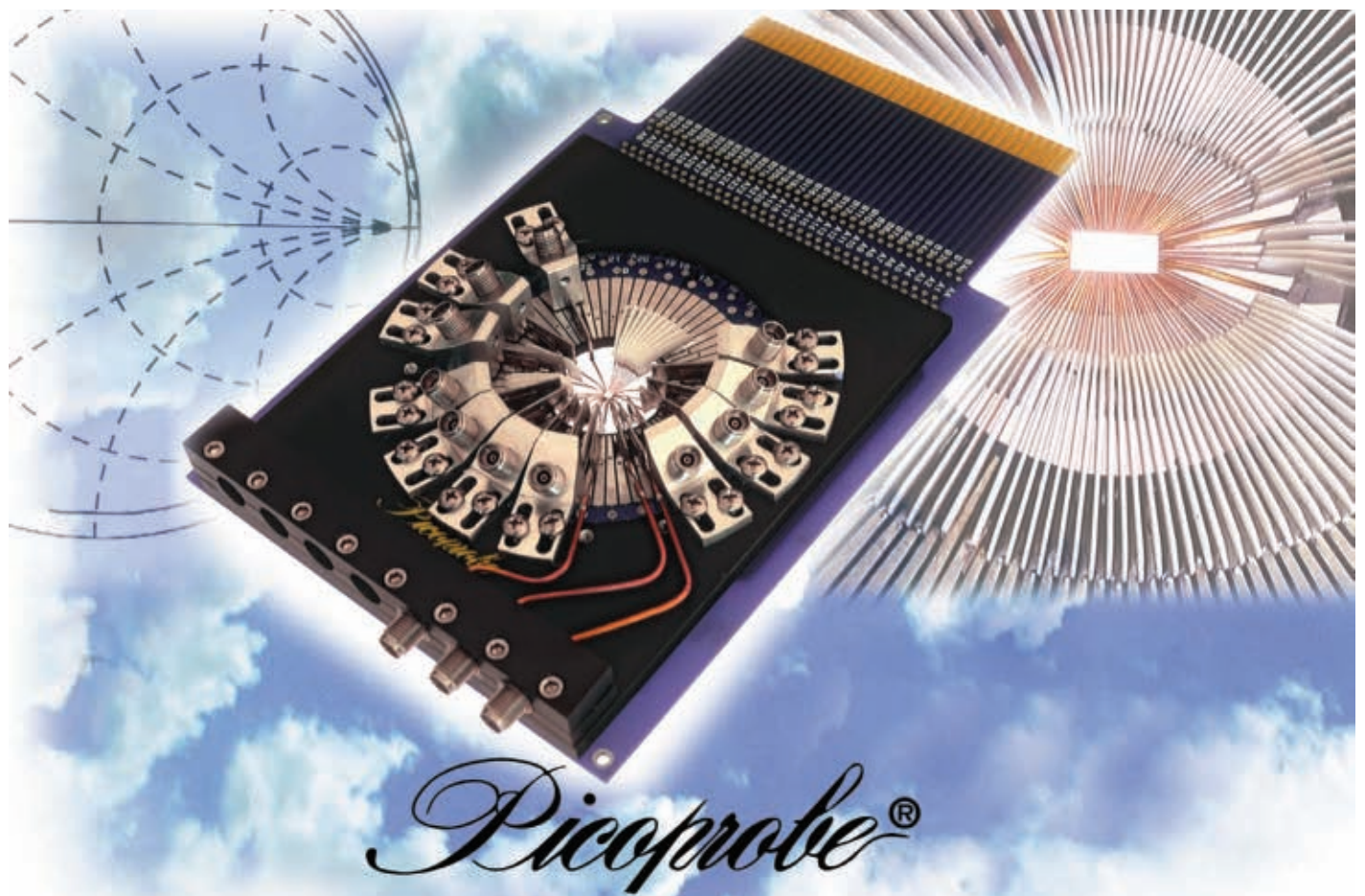
They come with an industry leading 3 year guarantee and true MECA pride.

Ready to build a better DAS? Start with a visit to www.e-MECA.com.



Microwave Electronic Components of America
The Professional's Choice for RF/Microwave Passive Components





Picoprobe elevates probe cards to a higher level...

(...110 GHz to be exact.)

Since 1981, GGB Industries, Inc., has blazed the on-chip measurement trail with innovative designs, quality craftsmanship, and highly reliable products. Our line of custom microwave probe cards continues our tradition of manufacturing exceptional testing instruments.



Through unique modular design techniques, hundreds of low frequency probe needles and a variety of microwave probes with operating frequencies from DC to 40, 67, or even 110 GHz can be custom configured to your layout.



Our patented probe structures provide the precision and ruggedness you require for both production and characterization testing. And only Picoprobe® offers the lowest loss, best match, low inductance power supplies, and current sources on a single probe card.

Our proven probe card design technology allows full visibility with inking capability and ensures reliable contacts, even when probing non-planar structures.

Not only do you get all the attractive features mentioned, but you get personal, professional service, rapid response, and continuous product support--all at an affordable price so your project can be completed on time and within budget.

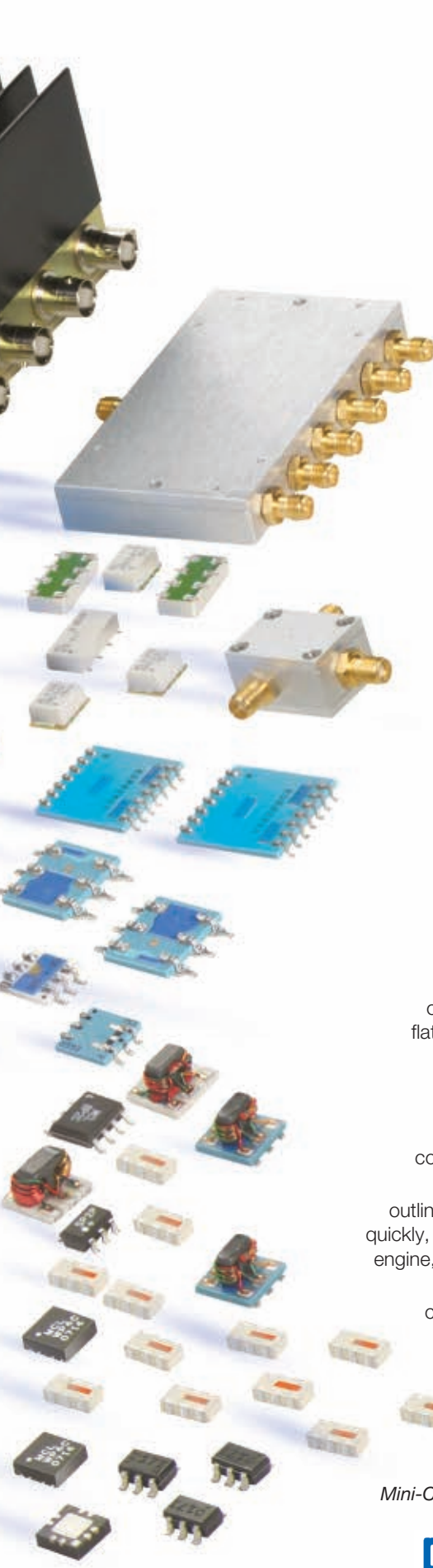
Typical Specs	10GHz	20GHz	40GHz
Insertion Loss	0.6 dB	0.8 dB	1.3 dB
Return Loss	22 dB	18 dB	15 dB



For technical assistance, custom product designs, or off-the-shelf delivery, call GGB Industries, Inc., at (239) 643-4400.

GGB INDUSTRIES, INC. • P.O. BOX 10958 • NAPLES, FL 34101
 Telephone (239) 643-4400 • Fax (239) 643-4403 • E-mail email@ggb.com • www.picoprobe.com





POWER SPLITTERS/ COMBINERS

NOW! from **2 kHz to 18 GHz** as low as **79¢**

The Industry's Largest Selection includes THOUSANDS of models, from 2 kHz to 18 GHz, at up to 300 watts power, and in coaxial, flat-pack, surface-mount, and rack-mount housings for 50 and 75 Ω systems.

From 2-way through 48-way designs, with 0°, 90°, or 180° phase configurations, Mini-Circuits power splitters/combiners offer outstanding performance for insertion loss, isolation, and VSWR. Decades of experience with multiple technologies make it all possible, from core & wire, microstrip, and stripline, to semiconductors and LTCC ceramics.

Get easy-to-find, detailed data and performance curves, S-parameters, outline drawings, PCB layouts, and everything else you need to make a decision quickly, at minicircuits.com. Just enter your requirements, and our patented search engine, Yoni2, searches actual test data to find the models that meet your needs.

All Mini-Circuits catalog models are in stock, continuously replenished, and backed by our 1-year guarantee. We even list current stock quantities and real-time availability, as well as pricing, to help our customers plan ahead and make quick decisions.

So why wait? Take a look at minicircuits.com today!

 **RoHS Compliant**
Product availability is listed on our website.

Mini-Circuits...we're redefining what VALUE is all about!

 **Mini-Circuits®**
ISO 9001 ISO 14001 AS9100

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

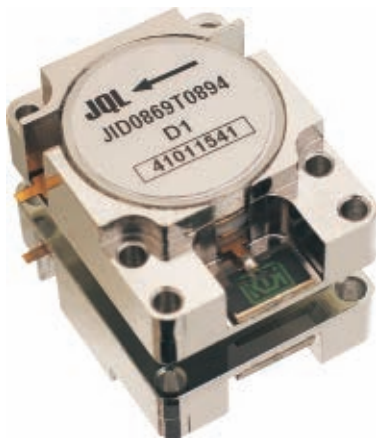
 **Yoni2®**
U.S. Patents
7739260, 7761442

The Design Engineers Search Engine finds the model you need, Instantly • For detailed performance specs & shopping online see minicircuits.com

IF/RF MICROWAVE COMPONENTS

448 rev K

Technology On the Move™



Drop-in Isolators



Cavity Filters



Surface Mount Circulators



Waveguide Isolators



Power Combiners



Coaxial Circulators



Tel: 1(888)236-9828(US&Canada)
1(630)930-9917(Worldwide)
www.jqlelectronics.com sales@jqlelectronics.com

Mars Rover Artwork Courtesy of NASA/JPL-Caltech



SPACE HERITAGE

Supporting
Space Exploration
through the Development
of Innovative
Technology.

K&L Microwave has contributed
to the aerospace industry for
forty years and has been part
of the following programs:

Apollo 17

Mars Science Lab

Mars Opportunity Rover

Mars Spirit Rover

Iridium Satellite Constellation

CHIRP

GPS-3

GPS-R

V-Sensor

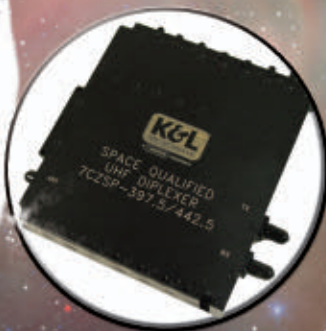
Thuraya

MSV

OCEANSAT 2

COSMO

SKYNET 5



Voltronics, the Trimmer Capacitor Company, is now located
at the K&L Microwave facility in Maryland. An experienced
manufacturing and engineering staff is available to offer the
same well-respected and extensive line of products.



www.voltronicscorp.com



BSC FILTERS • DOW-KEY MICROWAVE • NOVACAP • SYFER TECHNOLOGY
DIELECTRIC LABORATORIES • K&L MICROWAVE • POLE/ZERO • VOLTRONICS



www.klmicrowave.com



Always Searching for Better and More?

Dfine offers custom design and manufactures full line passive components for wireless communication, which can be your unrepentant choice of the year.

We would like to work with you side by side with your build-in projects or back you up with your extensive distribution. We're looking for dedicated representatives worldwide as well.

- ✦ 4G / LTE / WiMax
- ✦ Base Station
- ✦ DAS / In-building network
- ✦ Wireless backhaul
- ✦ Ptp communication
- ✦ Network optimization



Filter & Diplexer:

GSM / CDMA / PCS / DCS / UMTS;
Low PIM;
DIN / N connector



Coupler:

0.7-2.7GHz coverage;
Low loss and high directivity



Power Splitter:

0.7-2.7GHz coverage;
2,3,4,6,8ways;
Low loss;
Great money for value



IDU & ODU:

From 1.5GHz to 15GHz;
Multi-channel;
Easy maintenance



Control the comb. Control the clarity.

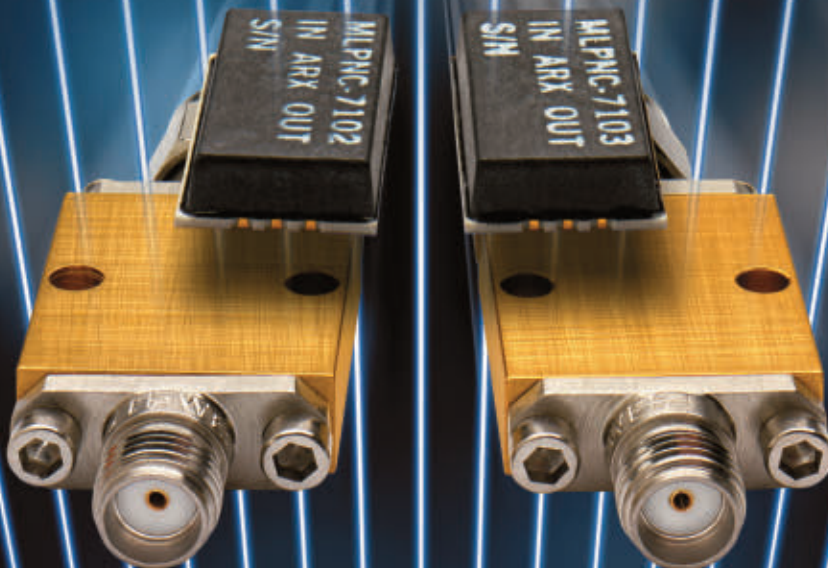


The sensitivity and the distance you've been striving for from your radar or surveillance receiver is now within reach. New GaAs comb generators from Aeroflex / Metelics are a best-in-class, non-linear-transmission-line (NLTL) innovation that provides 10 to 18 dB lower phase noise for better sensitivity than Si step recovery diode (SRD) comb generators. Offering phase noise as low as -135 dBc/Hz at 100 Hz offset from the 12 GHz harmonic, the MLPNC series creates clean, low conversion loss harmonics to 30 GHz over variable input frequencies from 400 to 1300 MHz. Their variable input power from 21 to 23 dBm make them easy to drive and operate. They provide ultimate system design flexibility and the opportunity to simplify your system architecture.

Visit our website or call

888-641-7364.

www.aeroflex.com/metelicscomb



Non-linear-transmission-line (NLTL) GaAs Comb Generators

Part Number	Power (dBm)		Output Harmonics (dBm)*		
	Minimum	Maximum			
MLPNC-7102-SMA800	21 @ 400 MHz	23 @ 600 MHz	> -8 @ 4 GHz	> -16 @ 12 GHz	> -20 @ 20 GHz
MLPNC-7102-SMT680	21 @ 400 MHz	23 @ 600 MHz	> -8 @ 4 GHz	> -16 @ 12 GHz	> -20 @ 20 GHz
MLPNC-7103-SMA800	21 @ 800 MHz	23 @ 1300 MHz	> -5 @ 6 GHz	> -15 @ 18 GHz	> -20 @ 30 GHz
MLPNC-7103-SMT680	21 @ 800 MHz	23 @ 1300 MHz	> -5 @ 6 GHz	> -15 @ 18 GHz	> -20 @ 30 GHz

* Contact the factory for additional information or for products not covered in the table.



AEROFLEX
A passion for performance.



Microwave Journal

FEBRUARY 2013 VOL. 56 • NO. 2

COVER FEATURE

22 Making Connections Beyond 110 GHz

David J. Vondran, OML Inc.

Explores the millimeter-wave trend from research toward global commercial viability

MVP: MOST VALUABLE PRODUCT

44 60 GHz Integrated Waveguide Transceivers

Vubiq Inc.

Introduction to low cost 60 GHz integrated waveguide transmitters and receivers

EDI CON 2013 SHOW COVERAGE

74 Nurturing Design Innovation for China's Future

Guy Séné, Agilent Technologies

Discusses how design innovation will be critical to China's ongoing industrial and economic development, and how EDI CON 2013 will provide the solutions and technology necessary to encourage design and development

76 EDI CON Program Preview

David Vye, Microwave Journal Editor

A look into the upcoming EDI CON show that will take place in Beijing, China on March 12-14, including a sneak peek into the conference program and workshops

TECHNICAL FEATURES

80 802.11ac Design Considerations for Mobile Devices

Eid Alsabbagh, Haoyang Yu and Kevin Gallagher, TriQuint Semiconductor

A look at 802.11ac design considerations for mobile devices and how to achieve key performance

90 RF Characteristics of Coplanar Waveguide Fabricated on Flexible PES

Young Yun, Jang-Hyeon Jeong, Hong-Seung Kim and Nak-Won Jang, Korea Maritime University

Fabrication of a coplanar waveguide on a PES substrate for application to a flexible RFIC, and investigates its RF characteristics

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 3256, Northbrook, IL 60065-3256 or e-mail mwj@omeda.com. Subscription information: (847) 291-5216. 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.

©2013 by Horizon House Publications Inc.



Posted under Canadian international publications mail agreement #PM40612608

High pressure,
time sensitive, mission critical.
It's all in a day's work.



See how FieldFox
measures up —
watch the video.
Scan the code or visit
<http://qrs.ly/gb20ppv>



Your team depends on you for mission-critical accuracy. And you can depend on the compact Agilent FieldFox spectrum analyzer. At only 6.6 lbs., it ensures peak accuracy without warm-up time and its precise measurements agree with trusted benchtop results. Which means, you'll always be ready to accelerate your team's success.

FieldFox Spectrum Analyzers

Four models up to 26.5 GHz

MIL-PRF-28800F Class 2 rugged

Agrees with benchtop measurements

± 0.5 dB amplitude accuracy (full band)

**Agilent and our
Distributor Network**
Right Instrument.
Right Expertise.
Delivered Right Now.



element14

800-463-9275
www.newark.com/agilent

Learn about interference analysis and
more with our application note series
www.newark.com/Agilent_FieldFox

© Agilent Technologies, Inc. 2012

Anticipate — Accelerate — Achieve



Agilent Technologies

Microwave Journal

102 Screen Printed RFID-Enabled Temperature Sensor Fabricated on Flexible Substrates

Kamil Janeczek, Malgorzata Jakubowska, Grażyna Koziol and Wojciech Steplewski, Tele & Radio Research Institute

Presents the measurement results, reaction time and lifetime for a screen printed RFID-enabled sensor fabricated on flexible substrates

PRODUCT FEATURE

112 High Performance Driver Amplifiers

Analog Devices Inc.

Introduction to ADI's driver amplifiers operating from 3.3 to 5 V and -40° to +105°C

TECH BRIEFS

118 Highly Integrated 60 GHz Radio Transceiver Chipset

Hittite Microwave

120 Planar K-Band Receiver

Space Labs Inc.

122 Wideband Frequency Mixer

Mini-Circuits

Departments

17... Mark Your Calendar

18... Coming Events

55... Defense News

59... International Report

63... Commercial Market

66... Around the Circuit

124... Software & Mobile Apps

126... New Products

134... The Book End

136... Ad Index

136... Sales Reps

138... MWJ Puzzler

The image of the USS Enterprise (a registered trademark of Paramount Pictures) and the circular waveguide components used in the re-configured starship on this month's cover was rendered in SolidWorks, a 3D CAD design software from Dassault Systèmes.

STAFF

PUBLISHER: CARL SHEFFRES

EDITOR: DAVID VYE

MANAGING EDITOR: JENNIFER DIMARCO

TECHNICAL EDITOR: PATRICK HINDLE

ASSOCIATE TECHNICAL EDITOR: DAN MASSÉ

STAFF EDITOR: LAURA GLAZER

EDITORIAL ASSISTANT: BARBARA WALSH

CONSULTING EDITOR: HARLAN HOWE, JR.

CONSULTING EDITOR: FRANK BASHORE

CONSULTING EDITOR: PETER STAECKER

CONSULTING EDITOR: DAN SWANSON

WEB EDITOR: CHRIS STANFA

AUDIENCE DEVELOPMENT MANAGER:

MICHELLE BARRY

TRAFFIC MANAGER: EDWARD KIESSLING

MARKETING AND EVENT COORDINATOR:

KRISTEN ANDERSON

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

F.M. Bashore

Dr. C.R. Boyd

M. Goldfarb

J.L. Heaton

Dr. G. Heiter

H. Howe, Jr.

Dr. T. Itoh

Dr. J. Lasker

Dr. S. Maas

Dr. G.L. Matthaei

Dr. D.N. McQuiddy

Dr. J.M. Osepchuk

Dr. J. Rautio

Dr. U. Rohde

M. Schindler

Dr. P. Staecker

F. Sullivan

D. Swanson

Dr. R.J. Trew

G.D. Vendelin

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

www.mwjournal.com

Printed in the USA

Fast. Accurate. USB-capable.

Power sensors from Rohde & Schwarz.

Depending on the application, the focus of power measurements can be on measurement accuracy, measurement speed or both. The R&S®NRP family offers the best characteristics on the market in each case:

- Universal power sensors: ideal combination of accuracy and measurement speed plus the widest dynamic range
- Wideband power sensors: high video bandwidth and automatic pulse analysis
- Thermal power sensors: outstanding linearity and highest accuracy

The frequency range of the sensors extends from DC to 67 GHz with a maximum dynamic range of 90 dB.

For more details, visit: www.rohde-schwarz.com/ad/nrp



Free Webinars

Technical Education Training

The Effects of Jamming on GPS/GNSS Signals

Sponsored by: Rohde & Schwarz

On Demand after 2/6

Innovations in EDA

by: Agilent Technologies

Antenna Design Automation with Scripting and Parameterized EM Analysis

On Demand after 2/7

Market Research Webinar

Technology Trends for Radar Systems

Sponsored by: Rohde & Schwarz

2/12, 11:00 AM ET

Agilent in Aerospace/Defense

Electronic Warfare Testing: Capture, Measurement and Emulation

2/21, 1:00 PM ET

Agilent in Wireless Communications

NFC Test Challenges for Mobile Device Developers

2/26, 1:00 PM ET

Innovations in Network Analysis

by: Agilent Technologies

The Fastest Near-Field Measurement Technique to Test Antennas in Under a Second

2/27, 1:00 PM ET

Technical Education Training

MIMO Radar: Demystified

Sponsored by: Rohde & Schwarz

2/28, 11:00 AM ET

Web Survey
What would you cut?
What DoD programs are vulnerable?

Look for our multiple choice survey online at mwjournal.com

December Survey
What was the biggest industry news in 2012?

Freescall introduces its first GaN RF product for cellular infrastructure applications [16 votes] (13%)

Samsung Galaxy Appeal indicates shift from GaAs to CMOS PAs [34 votes] (28%)

Underwriter: M/A-COM Technology prices IPO at \$19/share [12 votes] (10%)

Teledyne Technologies completes acquisition of LeCroy Corp. [14 votes] (12%)

Peregrine Semiconductor announces pricing of initial public offering [45 votes] (37%)

Executive Interview

Joy Weiss, President of the Dust Networks product group at Linear Technology, talks about opportunities for wireless sensor networks and the emerging M2M market.



White Papers

Complex Modulation with Low Cost Arbitrary Waveform Generators

White Paper, Agilent Technologies

Overcoming High Speed Interconnect Challenges

White Paper, Anritsu

Overview of Tests on Radar Systems and Components

Application Note, Rohde & Schwarz

Introduction to Radar System and Component Tests

White Paper, Rohde & Schwarz

T&M Solutions for Software Defined Radios

Application Note, Rohde & Schwarz

Check Out These Channels

Channels

Cellular/4G/LTE/WiMAX

Test & Measurement

Industrial/Scientific/Medical



6GHz Mixer Delivers 32dBm OIP3

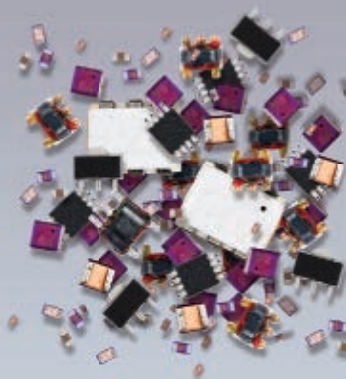
LTC5544



**Excellent
Performance at 5.8GHz**

**IIP3 = 25.8dBm
Conversion Gain = 6.4dB
NF = 12.8dB**

OR



Take Your Chances

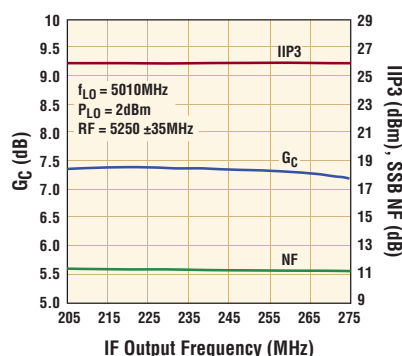
High Level Integration with LO Buffer, IF Amplifier and Balun Transformer

With its high level of integration, the LTC[®]5544 brings an unprecedented level of compactness, ease of use and outstanding performance that you can count on.

▼ Features

- 4 to 6GHz Frequency Range
- 32.2dBm OIP3 at 5.8GHz
- 14.6dBm P1dB
- 2dBm LO Drive
- 50 Ω Matched Single-Ended RF and LO Inputs
- Outstanding Blocking Performance
- IF Output up to 1GHz

Wideband Conversion Gain, IIP3, NF at 240MHz IF

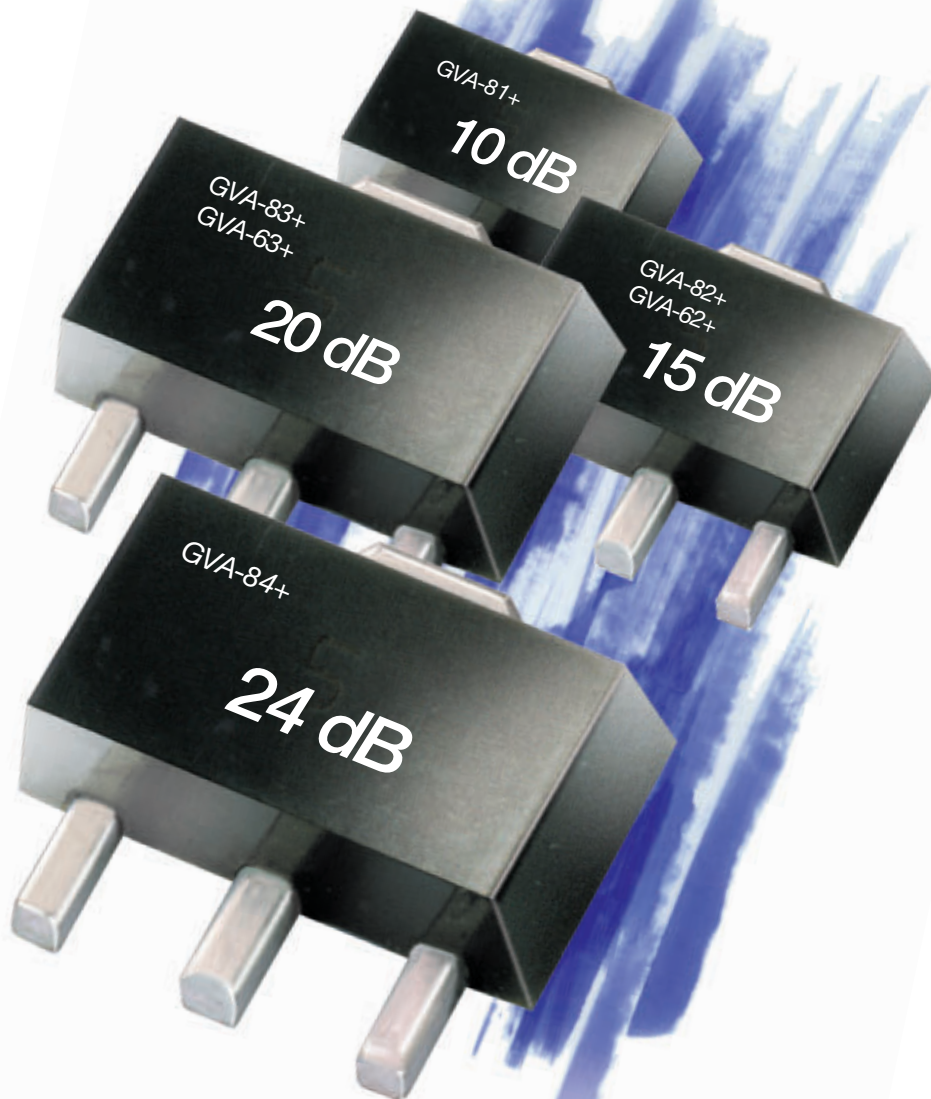


▼ Info & Free Samples

www.linear.com/product/LTC5544
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.





+20 dBm Power Amplifiers with a choice of gain

GVA AMPLIFIERS

DC* to 7 GHz from 94¢ ea. (qty. 1000)

2 New Models!

The GVA-62+ and -63+ add ultra-flat gain to our GVA lineup, as low as ± 0.7 dB across the entire 100 MHz-6 GHz band! All of our GVA models are extremely broadband, with a wide dynamic range and the right gain to fit your application. Based on high-performance InGaP HBT technology, these patented amplifiers cover DC* to 7 GHz, with a gain selection of 10, 15, 20 or 24 dB (at 1 GHz). They all provide better than +20 dBm typical output power, with typical IP3

performance as high as +41 dBm at 1 GHz. Supplied in RoHS-compliant, SOT-89 housings, low-cost GVA amplifiers feature excellent input/output return loss and high reverse isolation. With built-in ESD protection, GVA amplifiers are unconditionally stable and designed for a single 5V supply. Just go to minicircuits.com for technical specifications, performance data, export info, pricing, and everything you need to choose your GVA today!

*Low frequency cut-off determined by coupling cap, except for GVA-62+ and GVA-63+ low cutoff at 10 MHz.

US patent 6,943,629

Mini-Circuits...we're redefining what VALUE is all about!

Mini-Circuits®
ISO 9001 ISO 14001 AS9100

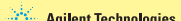
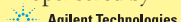
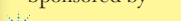
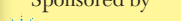
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661



The Design Engineers Search Engine finds the model you need, Instantly • For detailed performance specs & shopping online see minicircuits.com

IF/RF MICROWAVE COMPONENTS

MARCH 2013

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
24	25	26	27	28	1	2
3	4	5  isQED Symposium 2013 Santa Clara, CA	6 Webinar: GPS Interference & Spoofing Sponsored by  ROHDE & SCHWARZ	7 Webinar: GaN on SiC Sponsored by  Agilent Technologies	8	9
10	11	12  Electronic Design Innovation Conference 电子设计创新会议 2013 Beijing, China	13 Webinar: Signal Analyzer Fundamentals Sponsored by  Agilent Technologies	14	15	16
17	18	19  SATellite 2013 Washington D.C.	20 Webinar: Linearizing GaN Amplifiers Sponsored by  Scintera  SUMITOMO ELECTRIC	21 Webinar: Understanding Probability of Intercept Sponsored by  Agilent Technologies	22	23
24	25	26  ACES The Applied Computational Electromagnetics Society Monterey, CA	27 Webinar: Techniques for Precise Power Measurements Sponsored by  Agilent Technologies	28 Webinar: LTE Advanced Fundamentals: Part 2 Sponsored by  Agilent Technologies	29  5 TH International Conference on Personal Satellite Service Toulouse, France	30
31	1	2 Webinar: Sponsored by  AWR  CREE	3 Webinar: LTE Advanced Fundamentals: Part 1 Sponsored by  Agilent Technologies	4	5	6

Go to: mwjournal.com/events



Efficient
Solid State
RF Amplifiers
1MHz - 6 GHz

24/7 Custom
Engineering
Support

Large Volume
Manufacturing,
Stock Shipping

RF Amplifier
Modules



Rack Mount
Systems



Integrated RF
Subsystems



764 S. Clearwater Loop
Post Falls, ID 83854 USA

Ph 208.777.0555
Fax 480.393.5947

www.lcfamps.com

Coming Events

CALL FOR PAPERS

EuMW 2013

February 17, 2013

IRMMW-THz 2013

April 1, 2013

AMTA 2013

May 1, 2013

mwjournal.com

FEBRUARY

ISSCC 2013

**IEEE INTERNATIONAL SOLID-STATE CIRCUITS
CONFERENCE**

February 17–21, 2013 • San Francisco, CA
<http://isscc.org>

NATE 2013

**18TH ANNUAL CONFERENCE AND EXPOSITION FOR
THE NATIONAL ASSOCIATION OF TOWER ERECTORS**
February 18–21, 2013 • Fort Worth, TX
<http://natehome.com/annual-conference>

MWC 2013

MOBILE WORLD CONGRESS
February 25–28, 2013 • Barcelona, Spain
www.mobileworldcongress.com

MARCH



ISQED 2013

**INTERNATIONAL SYMPOSIUM ON QUALITY
ELECTRONIC DESIGN**
March 4–6, 2013 • Santa Clara, CA
www.isqed.org

IWCE 2013

**INTERNATIONAL WIRELESS COMMUNICATIONS
EXPO**
March 11–15, 2013 • Las Vegas, NV
www.iwceexpo.com

EDI CON 2013

ELECTRONIC DESIGN INNOVATION CONFERENCE
March 12–14, 2013 • Beijing, China
www.ediconchina.com

SATELLITE 2013

March 18–21, 2013 • Washington D.C.
www.satellitetoday.com/satellite2013

ACES 2013

**29TH INTERNATIONAL REVIEW OF PROGRESS IN
APPLIED COMPUTATIONAL ELECTROMAGNETICS**
March 24–28, 2013 • Monterey, CA
<http://aces.ee.olemiss.edu/conference/2013>

PSATS 2013

**5TH INTERNATIONAL CONFERENCE ON PERSONAL
SATELLITE SERVICES**
March 28–29, 2013 • Toulouse, France
www.psats.eu

APRIL

WAMICON 2013

**IEEE WIRELESS AND MICROWAVE TECHNOLOGY
CONFERENCE**
April 7–9, 2013 • Orlando, FL
www.wamicon.org



MICROWAVE & RF 2013

April 10–11, 2013 • Paris, France
www.microwave-rf.com

IWS 2013

IEEE INTERNATIONAL WIRELESS SYMPOSIUM
April 13–18, 2013 • Beijing, China
www.iws-ieee.org

SPACOMM 2013

**5TH INTERNATIONAL CONFERENCE ON ADVANCES
IN SATELLITE AND SPACE COMMUNICATIONS**
April 22–26, 2013 • Venice, Italy
www.iaria.org/conferences2013



MAY

CTIA WIRELESS 2013

May 21–23, 2013 • Las Vegas, NV
www.ctiawireless.com

NCMMW 2013

**NATIONAL CONFERENCE ON MICROWAVE AND
MILLIMETER WAVE**

MWIE 2013

MICROWAVE INDUSTRY EXHIBITION
May 21–24, 2013 • Chongqing, China
www.cnmmw.org

JUNE



RFIC 2013

**IEEE RADIO FREQUENCY INTEGRATED CIRCUITS
SYMPOSIUM**
June 2–4, 2013 • Seattle, WA
www.rfic2013.org

IMS 2013

**IEEE MTT-S INTERNATIONAL MICROWAVE
SYMPOSIUM**
June 2–7, 2013 • Seattle, WA
www.ims2013.org

**81ST ARFTG MICROWAVE MEASUREMENT
SYMPOSIUM**

June 7, 2013 • Seattle, WA
www.arftg.org

AUGUST



EMC 2013

August 5–9, 2013 • Denver, CO
www.emc2013.org

SEPTEMBER

IRMMW-THz 2013

**38TH INTERNATIONAL CONFERENCE ON INFRARED,
MILLIMETER AND TERAHERTZ WAVES**
September 1–6, 2013 • Mainz, Germany
www.theconference2013.com



OCTOBER

AMTA 2013

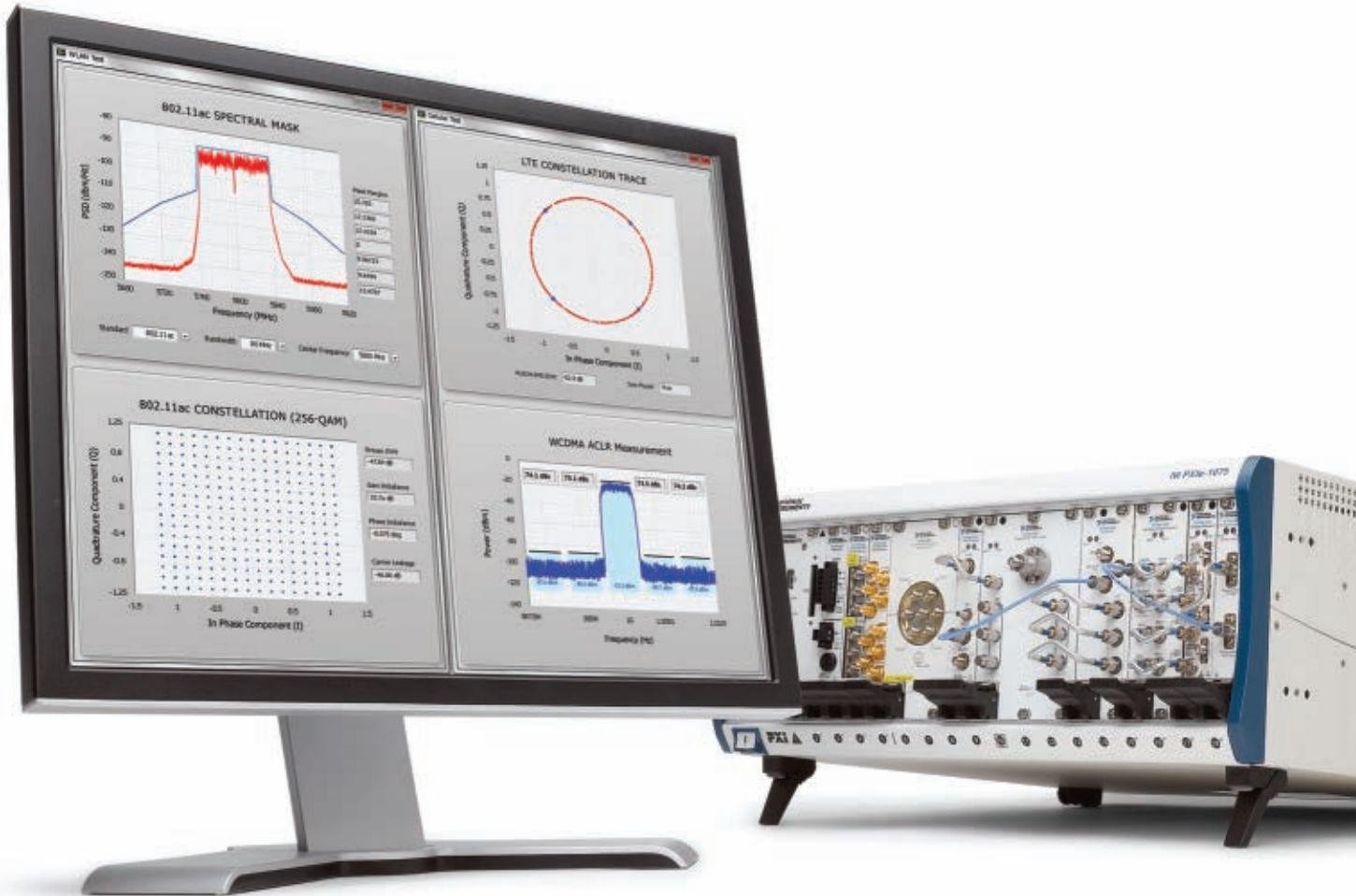
**35TH ANNUAL SYMPOSIUM OF THE ANTENNA
MEASUREMENT TECHNIQUES ASSOCIATION**
October 6–11, 2013 • Columbus, OH
www.amta2013.org

IEEE COMCAS 2013

**INTERNATIONAL CONFERENCE ON MICROWAVES,
COMMUNICATIONS, ANTENNAS AND ELECTRONIC
SYSTEMS**
October 21–23, 2013 • Tel Aviv, Israel
www.comcas.org

Redefining RF and Microwave Instrumentation

with open software and modular hardware



Achieve speed, accuracy, and flexibility in your RF and microwave test applications by combining National Instruments open software and modular hardware. Unlike rigid traditional instruments that quickly become obsolete by advancing technology, the system design software of NI LabVIEW coupled with NI PXI hardware puts the latest advances in PC buses, processors, and FPGAs at your fingertips.

WIRELESS TECHNOLOGIES

National Instruments supports a broad range of wireless standards including:

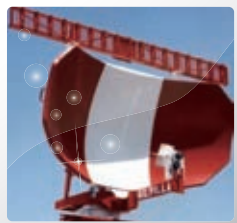
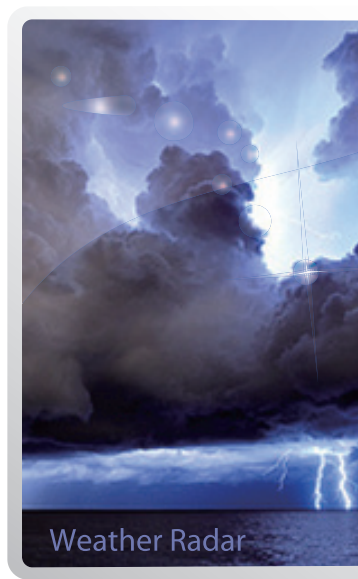
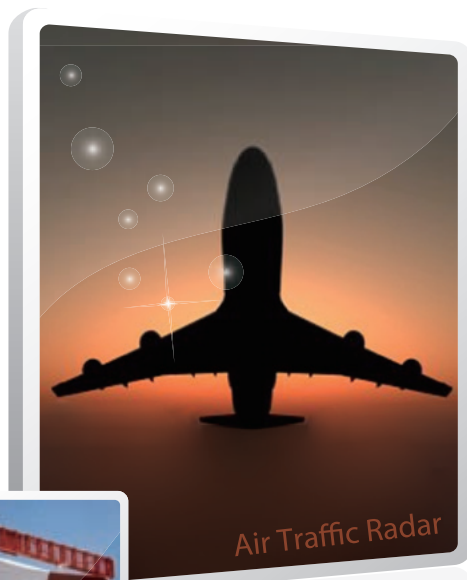
LTE	GSM/EDGE
802.11a/b/g/n/ac	CDMA2000/EV-DO
WCDMA/HSPA/HSPA+	Bluetooth

>> Learn more at ni.com/redefine

800 813 5078

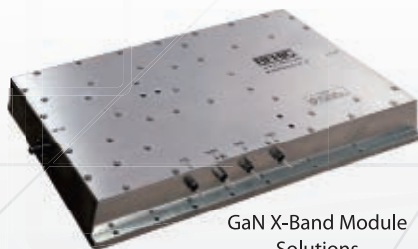
©2012 National Instruments. All rights reserved. LabVIEW, National Instruments, NI, and ni.com are trademarks of National Instruments. Other product and company names listed are trademarks or trade names of their respective companies.



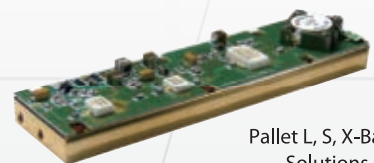


For these applications customers

Goodbye! **Tube**

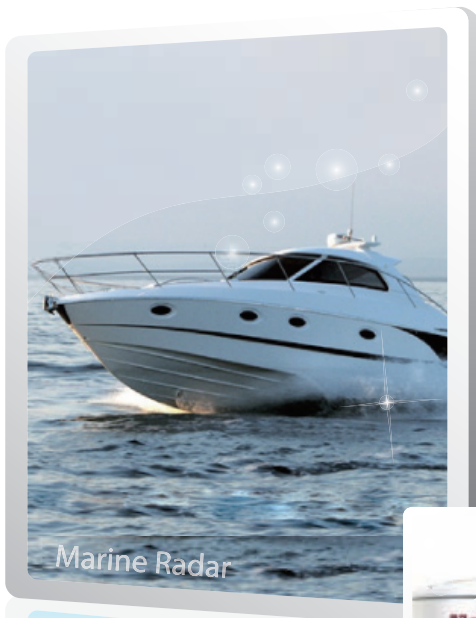
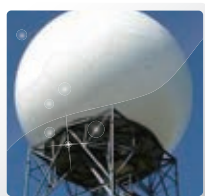


GaN X-Band Module
Solutions



Pallet L, S, X-Band
Solutions

RFHIC has the most cost effective S, C, X-band SSPA solutions

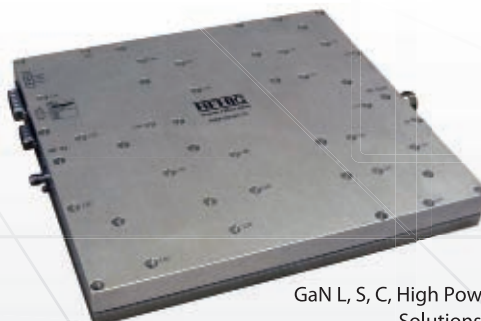


have one thing in common:

Hello! RFHIC GaN



GaN SMT/SMD Type L, S, X-Band
Solutions



GaN L, S, C, High Power Amplifier
Solutions

RFHIC = No Trade-off between Performance and Cost



RF & MW is our business & passion

Korean Facilities

Tel : 82-31-250-5078 / E-mail : rfsales@rfhic.com

US Facilities

Tel : 919-655-1121 / E-mail : sales@rfhicusa.com

RFHIC
www.rfhic.com

Making Connections Beyond 110 GHz

Research pioneers are exploring the vast spectrum resources above 110 GHz, which is commonly referred to as the millimeter-wave (mm-wave) frontier that spans from 30 GHz to 1 THz. These pioneers already have demonstrated the feasibility of mm-wave technology for solving emerging problems in advanced wireless communication, astronomy, imaging, biomedical and homeland security fields. In the next phase, these pioneers will stake their claim with the development of new mm-wave products. It is this mm-wave trend from research toward global commercial viability that drives the technology covered in this article.

Preparation for this exploration begins with background information on why the mm-wave spectrum is attractive for exploration. The journey continues with practical lessons learned from the ALMA Project (the gigantic antenna array in Chile), which is the first global success story on the mm-wave frontier. This retrospective will ensure we do not duplicate the mistakes of previous pioneers by revealing what is important to know for our upcoming journey. Finally, the foundation is being set today for the mm-wave ecosystem with standards that address metrology concerns in the physical layer. This framework is how engineers will achieve faster time-to-market and lower cost through competitive forces, instead of manufacturer dependent efforts. At the completion of this article, future pioneers and entrepreneurs can

also stake their own claim by developing exciting new mm-wave products to accelerate the deployment of mm-wave solutions.

SPECTRUM RESOURCES BEYOND 110 GHz

The excitement of commercializing mm-wave technology is motivating research beyond 110 GHz as the data rates are faster with more available spectrum. These applications include fixed wireless links, THz nano cells, WLAN/WPAN, kiosk downloading, short range device connections and board-to-board communication. There are two new expedition teams that are forming to further delve into these applications. The first group is IEEE 802.15 WPAN™ Terahertz Interest Group (IGthz).¹ The second group is IWPC Mobile Multi Gigabit (MoGIG) Wireless Networks and Terminals.² The IGthz is primarily pursuing THz communications and related network applications operating in the THz frequency bands between 275 GHz and 3 THz. The mission of MoGIG is to answer the question of what will happen to mobile wireless networks in the coming years when they run out of spectrum to support the massive increases in data demand.

As a benchmark, WiGig™ can deliver wireless data transfer rates up to 7 Gbps using 2.16

DAVID J. VONDRAN
OML Inc., Morgan Hill, CA

COAXIAL AND WAVEGUIDE SWITCHES

RLC has the exact solution you're looking for.

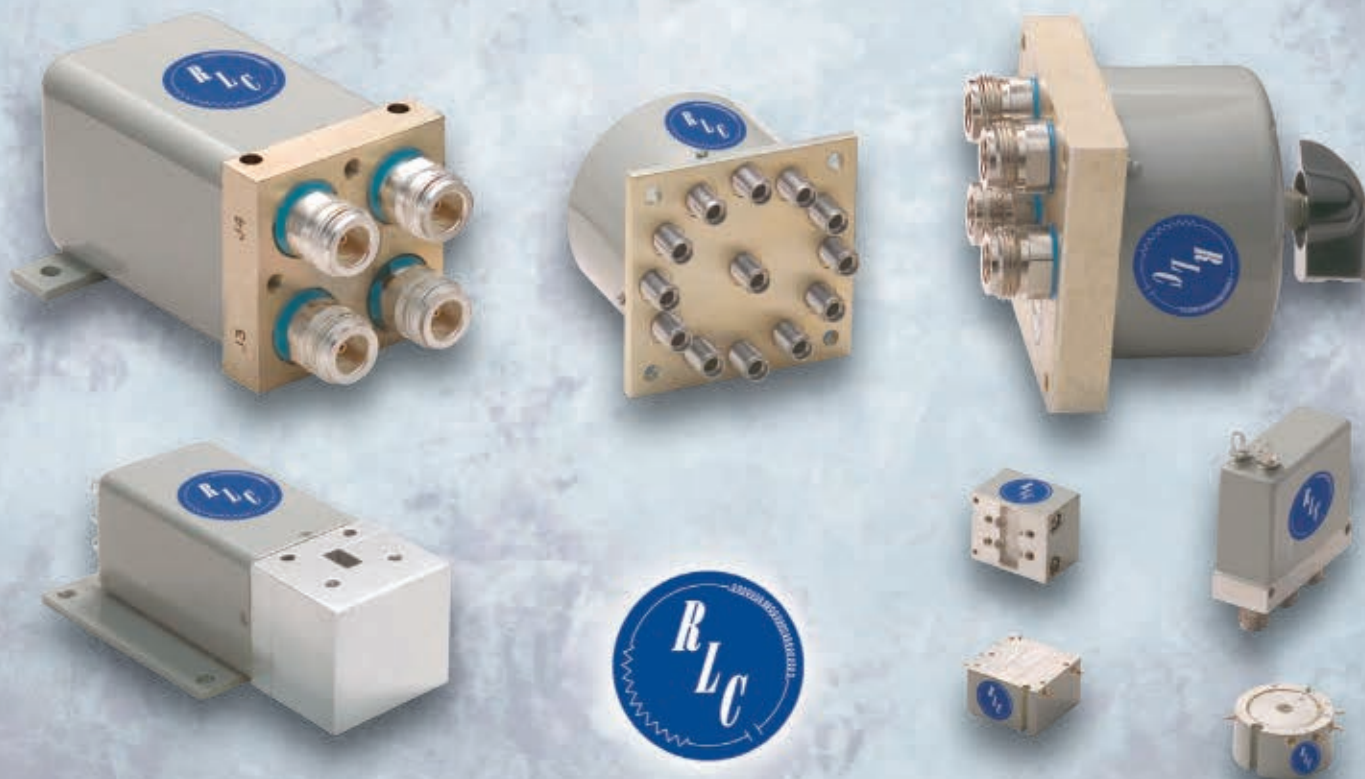
RLC Electronics manufactures a complete range of RF switches including coaxial in the frequency range from DC to 65 GHz and rectangular or double ridge waveguide. The operating modes on all designs are failsafe, latching and manual.

- SPDT to SP12T
- Transfer
- Low VSWR
- High Isolation

Control options are DC voltages as low as 5V, TTL, BCD, RS232, and RS422. All switches have excellent repeatability and lifetimes in excess of one million operations. Many types are QPL listed per MIL-DTL-3928.

- Low Insertion Loss
- High Power
- Low Passive Intermodulation
- Surface Mount Options

For more detailed information on coaxial and waveguide switches, 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.





Promises Made,
Promises Kept.



Single Layer Ceramic Capacitors

- Broadest Variety Available
- Gold, Tin, Silver and Platinum Terminations
- 150 pF X7R from 10x10 mils
- 1,000 pF from 25x25 mils
- Custom Diced to Your Value and Size



Mounting Shorts

- Instant Bonding Pads
- Height Matching Reduces Lead Length and Inductance
- Any Size Available
- Available in Alumina or Aluminum Nitride



Sub-Mounts

- Alumina, Aluminum Nitride, Quartz, Kovar
- Custom Patterns and Shapes
- Thickness from 3 to 100 mils and Beyond
- Thickness Accuracy to 5 microns

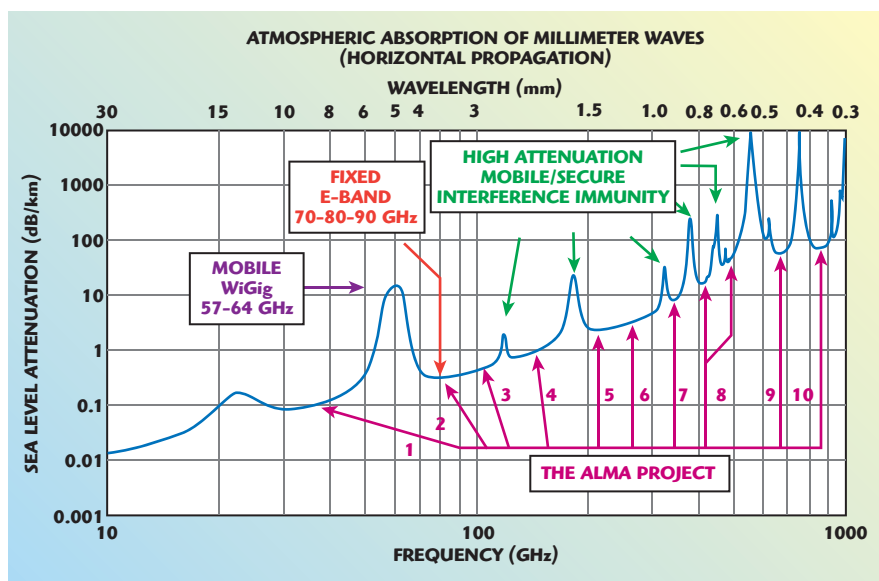


A Veteran Owned,
Solar Powered Small Business

ISO 9001:2008
RoHS and REACH Compliant
Established 1976

439 Commerce Lane, West Berlin, NJ 08091
856 335 2277 • www.compexcorp.com

Cover Feature



▲ Fig. 1 Atmospheric absorption properties of mm-wave signals vs. frequency and wavelength.

GHz of bandwidth in the 60 GHz band.³ This performance currently represents a ten times faster improvement over RF WLAN technologies using 80+ MHz of bandwidth. By further exploring beyond 110 GHz, engineers are planning the next decade in data transfer technology. In addition, smaller antenna sizes and emerging beam steering technology are enabling development efforts toward more commercially attractive mobile solutions with smaller size and less weight. Operating on the mm-wave frontier will also simplify deployments and hopefully reduce costs. Generally speaking, more bandwidth and shorter wavelengths in the largely untapped mm-wave spectrum are the key ingredients in achieving the next tier in multi-gigabit transfer rates. One regulatory hurdle to keep in mind is that transmissions must coexist with existing spectrum usage from radio astronomy, Earth exploration and space research applications. These regulatory applications span the 275 to 600 GHz spectrum. Coexistence places a burden on development efforts to demonstrate compliance and risk mitigation of interference concerns.

ATMOSPHERIC ABSORPTION

An important design consideration in spectrum allocation is the atmospheric absorption properties of mm-wave signals. As shown in **Figure 1**, there are natural molecular resonances that create operating windows for either minimum or maximum signal

propagation characteristics.⁴ Selection of a “valley” corresponds to minimum attenuation that is conducive to applications requiring relatively longer transmit/receive paths. One notable valley example is point-to-point radios where E-Band is a popular deployment. Conversely, selecting a “peak” will shorten transmission paths, which may be a desirable attribute for minimizing interference in a dense signal environment. One notable peak example is for mobile applications: WiGig (802.11ad). Across the entire mm-wave spectrum, it is important to note that moisture content (e.g., relative humidity, fog, rain) degrades the propagation characteristics. These characteristics will influence the line-of-site (LOS) transmission path and, subsequently, whether the application is fixed or mobile.

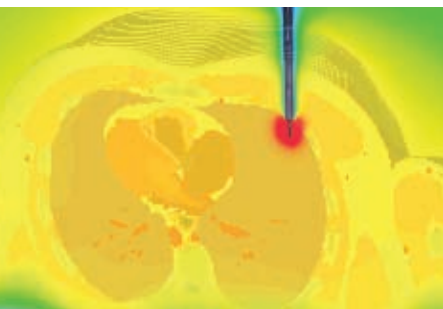
LESSONS FROM THE ALMA PROJECT

The Atacama Large Millimeter/sub-millimeter Array (ALMA) is an array of 66 high-precision radio telescopes in the Atacama Desert of northern Chile. An international partnership of Europe, North America and Japan in cooperation with the Republic of Chile have successfully deployed this mm-wave system with spectrum coverage from 30 to 950 GHz.⁵ The spectrum allocation of the ten bands are shown in both **Figure 1** and **Table 1**. The purpose of this antenna system is to empower scientists from around the world to unravel longstanding and



Make the Connection

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



Simulation of cancer treatment
by RF thermoablation

■ 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 biomedical applications? You can read about how CST technology was used to simulate biomedical devices at www.cst.com/biomed.

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.**



Cover Feature

important astronomical mysteries. These discoveries are now possible by gathering data in mm-wave frequency ranges previously not exploited.

On the mm-wave frontier, the ALMA Project is arguably the first international success story. Given this success, future mm-wave endeavors can leverage this initial industry experience. In addition to the underlying mm-wave technology, the lack of standards was a primary cause of confusion and delay in the deployment.

These standards span the full gamut of the application from band designators to waveguide interfaces. Equally painful was the absence of traceable standards for independently verifying critical system performance criteria. It was easy to grant a sole-source justification due to lack of standards, but the trickle-down effect of products without standards initiated a painful era of incompatibility issues across the globe. In terms of electrical performance, waveguide irregularities were

TABLE I	
THE 10 FREQUENCY BANDS OF THE ALMA ANTENNAS	
ALMA Band	Frequency Range (GHz)
1	31 to 45
2	67 to 90
3	84 to 116
4	125 to 163
5	162 to 211
6	211 to 275
7	275 to 373
8	385 to 500
9	602 to 720
10	787 to 950

shown to cause undesirable degradations; subsequently, the needs for anti-cocking and further flange alignment features were documented. These are the primary mm-wave lessons from the ALMA Project that require addressing before further exploration and commercialization can happen.

BACKGROUND ON COAXIAL/ WAVEGUIDE INTERFACES

In the overlap spectrum from 50 to 110 GHz, engineers today can choose between coaxial or waveguide interfaces; however, above 110 GHz is almost exclusively the domain of waveguide (primarily related to the short wavelengths). Engineers are most familiar with the popular coaxial interface for device characterization tasks where broadband sweeps are necessary, including DC for biasing active devices. The well-known cut-off frequency of the coaxial lines (for TE waveguide mode) is calculated from the difference between the inner and outer diameter dimensions. It is important to choose dimensions that will not support waveguide modes in the coax line since coaxial transmission depends on the TEM mode.

Beyond 110 GHz though, engineers will instead implement a banded waveguide interface where the aperture propagates the transmission without a center conductor. Similar to coaxial calculations, the narrow and broad wall dimensions set the boundaries for lower and upper cut-off frequencies (for TE₁₀ operation). For any given waveguide dimension, the dominant TE₁₀ mode is limited to approximately a 50 percent bandwidth.



narda today

**The Engineer's Choice
for Power Dividers**

*"Your equipment has been in
use at our RF lab since 1990.
Your stuff is reliable, robust
and accurate...we do not
want to do without it."*

Narda's diverse selection of in-stock Power Dividers offer excellent phase and amplitude balance, low input VSWR, a large choice of power handling, and high isolation between ports.

- Passive Combining At Up to 125 Watts Per Non-Coherent Signal
- An Excellent Choice for a Wide Array of Aerospace, Defense, and Wireless Applications
- Choice of 2, 3, 4, 8 and 16-Way Configurations
- Custom Configurations Available

Scan
using
your
Smart Phone
or Tablet
to learn
more!



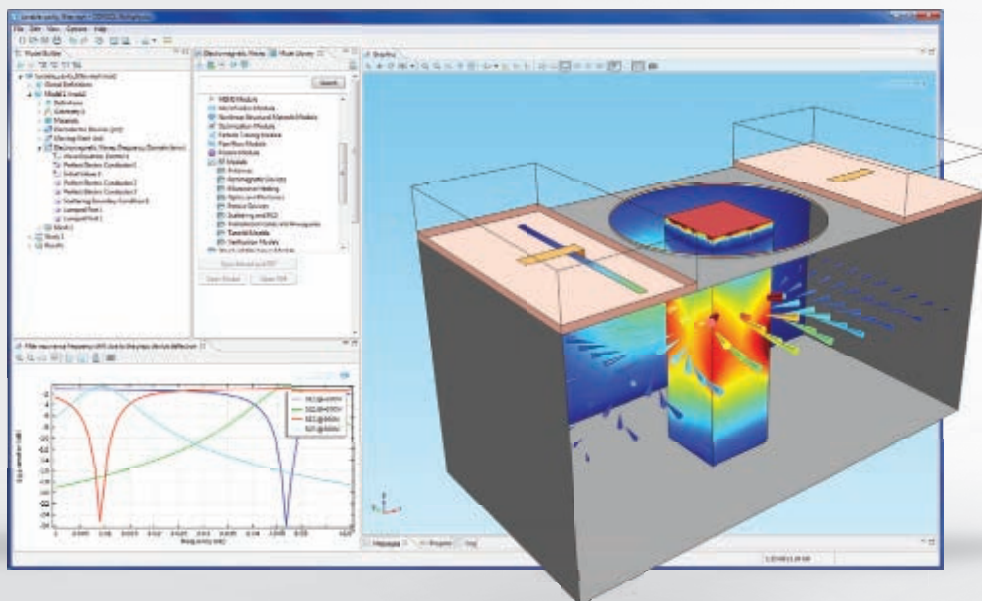
narda

Engineering, without compromise since 1954.

an  communications company

www.nardamicrowave.com • 631.231.1700

TUNABLE CAVITY FILTER: A piezo actuator is used to tune the resonant frequency of a cavity filter used in a miniaturized satellite. Other applications include broadcasting and wireless communication.



Verify and optimize your designs with COMSOL Multiphysics®

Multiphysics tools let you build simulations that accurately replicate the important characteristics of your designs. The key is the ability to include all physical effects that exist in the real world. Download a free product booklet at www.comsol.com/booklet

Product Suite

COMSOL Multiphysics

ELECTRICAL

AC/DC Module
RF Module
MEMS Module
Plasma Module

MECHANICAL

Heat Transfer Module
Structural Mechanics Module
Nonlinear Structural Materials Module
Geomechanics Module
Fatigue Module
Acoustics Module

FLUID

CFD Module
Microfluidics Module
Subsurface Flow Module
Pipe Flow Module

CHEMICAL

Chemical Reaction Engineering Module
Batteries & Fuel Cells Module
Electrodeposition Module
Corrosion Module

MULTIPURPOSE

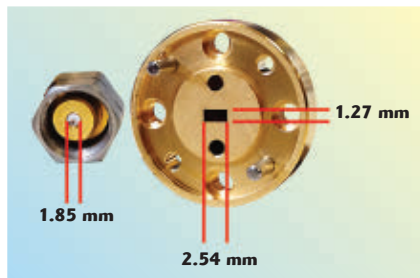
Optimization Module
Material Library
Particle Tracing Module

INTERFACING

LiveLink™ for MATLAB®
LiveLink™ for Excel®
CAD Import Module
ECAD Import Module
LiveLink™ for SolidWorks®
LiveLink™ for SpaceClaim®
LiveLink™ for Inventor®
LiveLink™ for AutoCAD®
LiveLink™ for Creo™ Parametric
LiveLink™ for Pro/ENGINEER®
LiveLink™ for Solid Edge®
File Import for CATIA® V5



Cover Feature



▲ Fig. 2 Size comparison of 1.85 mm coaxial interface and WR-10 flange.

This is not normally a handicap since transmission application bands are relatively narrow. As a visual example, **Figure 2** shows a side-by-side comparison between 1.85 mm coaxial (70 GHz, maximum) and WR-10 waveguide interfaces (75 to 110 GHz).

WAVEGUIDE FLANGE REFERENCE

Table 2 shows the popular rectangular waveguide bands and their respective cut-off frequencies and aperture

dimensions. The table also contains a close-up aperture view for relative comparison purposes. As a rule of thumb, an engineer can quickly identify the WR number with a quick caliper measurement of the broad wall in mils (thousandths of an inch), divided by 10. For example, a broad wall measurement of 100 mils corresponds to WR-10.

WAVEGUIDE FLANGE TERMINOLOGIES

Similar to a coaxial connection, the two mating flanges utilize the outer permanent waveguide alignment pins/holes to align the apertures. The alignment pins cleverly alternate pin/hole match at the mating interface. For vector network analyzer calibration purposes, tightening the #4-40 flange screws with 15 in-oz of torque (± 1.5 in-oz) completes the connection for signal propagation. A damage threshold for deployed systems is a maximum torque of 5.5 in-lb for the #4-40 screw. It is important to note that any misalignment of the apertures, including normal waveguide irregularities, will create a mismatch and degrade the electrical performance.

MIL-DTL-3922/67D

An example waveguide connection is shown in **Figure 3**. The outer waveguide dimensions are traceable to the MIL-DTL-3922/67D (often called UG-387) standard that was defined in the 1960s to ensure radar interoperability. At that time, the flange technology was defined through 110 GHz (WR-10). In the physical layer sense, the craftsmanship of the flange is truly an amazing engineering and manufacturing achievement. Given no formal standard is in existence today beyond 110 GHz, industry has extrapolated the guiding principles in this venerable standard to flanges beyond 110 GHz with some modifications.



▲ Fig. 3 Typical waveguide connection showing alignment pins.



DowKey Microwave CORPORATION
A DOWKEY COMPANY

www.dowkey.com

OUR EXPERIENCE, YOUR SWITCH SOLUTION
WHEN PERFORMANCE COUNTS FROM START TO FINISH

SINCE 1945



VISIT US AT
SATELLITE SHOW
WASHINGTON D.C.

MARCH 19-21
BOOTH 7110

ABOUT OUR NEXT GENERATION



LEARN MORE

• SWITCH MATRIX

for **-160 dBc Low PIM Switches**
Applications Sensitive to Passive Intermodulation

3rd Order Intermodulation for two carrier @ approximately 43.0 dBm

Product Description	First Carrier Frequency	Second Carrier Frequency	PIM Frequency	PIM Level
Standard	1930 MHz	1990 MHz	1870 MHz	110 dBc Min.
Low PIM	1930 MHz	1990 MHz	1870 MHz	160 dBc Min.

NOW available with SMA & N type connectors



CERAMIC & MICROWAVE PRODUCTS
Enabling Communication and Signal Control

This is no place for beta testers.



VNA Master™ Handheld Vector Network Analyzers



There's a lot riding on the accuracy of your field measurements. Why take a chance on an unproven instrument, when the success of your mission or even national security could be at stake? Count on Anritsu—now in our ninth generation providing handheld Vector Network Analyzers (VNAs) that take the precision of a test lab into the field. Only Anritsu offers you:

- ▼ 350 μ s sweep speed—over twice as fast as any other handheld VNA.
- ▼ Full performance over the specified temperature range to +55° C, even while battery powered.
- ▼ Best dynamic range across a wide range of frequencies—over 100 dB at 3 GHz and greater than 85 dB at 20 GHz.
- ▼ Best handheld spectrum analyzer dynamic range – greater than 116 dB!



*Designed and
Manufactured
in America*



Anritsu's VNA Master™ family is made in the USA, by the company that pioneered the handheld VNA. Why would you choose anything else? Find out more and download our complimentary field guide, **Advanced VNA Cable Measurements**.

Download it now at www.anritsu.com/en-us/analyzers

Call 1-800-ANRITSU to place an order or schedule a demo, or
visit www.anritsu.com.

Sales Offices: USA and Canada 1-800-ANRITSU, Europe 44 (0) 1552-433433,
Japan 81 (45) 223-1111, Asia-Pacific (852) 2301-4980, South America 55 (21) 2527-8922,
www.anritsu.com, ©2013 Anritsu Company

Anritsu

When it matters...



GORE® Electronic Materials

Enhance performance
and increase design
flexibility in your
electronic systems with
the latest EMI shielding
and RF grounding
solutions from Gore.

gore.com/emi

EMI GASKETS AND
GROUNDING PADS



Cover Feature

TABLE II POPULAR MILLIMETER-WAVE RECTANGULAR TE ₁₀ WAVEGUIDE INTERFACES				
Waveguide Spectrum	TE ₁₀ Cutoff Frequency (GHz)	Rectangular Waveguide Interface View	Internal Dimensions Width × Height (mils)	Internal Dimensions Width × Height (μm)
50-75 GHz	39.9 GHz		148 × 74	3760 × 1880
WR-15				
WM-3760				
60-90 GHz	48.4 GHz		122 × 61	3099 × 1550
WR-12				
WM-3099				
75-110 GHz	59 GHz		100 × 50	2540 × 1270
WR-10				
WM-2540				
90-140 GHz	73.8 GHz		80 × 40	2032 × 1016
WR-08				
WM-2032				
110-170 GHz	90.8 GHz		65 × 32.5	1651 × 825.5
WR-06				
WM-1651				
140-220 GHz	115.7 GHz		51 × 25.5	1295 × 647.5
WR-05				
WM-1295				
170-260 GHz	137.2 GHz		43 × 21.5	1092 × 546
WR-04				
WM-1092				
220-325 GHz	173.5 GHz		34 × 17.0	864 × 432
WR-03				
WM-864				
325-500 GHz	263 GHz		22 × 11.0	570 × 285
WR-02.2				
WM-570				

FLANGE ALIGNMENT LIMITATIONS

More than a decade ago, mm-wave pioneers began sharing test data and analyzing fundamental limitations in the waveguide flanges complying with the MIL-DTL-3922/67D standard.⁶ These degradations are still noticeable today starting in WR-08 (90 to 140 GHz). As we approach THz applications, a better solution to accelerate exploration of the mm-wave frontier is necessary.

When the two flat surfaces of a flange make contact, the quality of the connection depends on the precise alignment of the aperture. In general, the ideal alignment creates the least

amount of mismatch and undesirable signal reflections. A thorough analysis of alignment quality requires both two and three dimensional mastery of true position and tolerances.

As shown in **Figure 4**, there is a potential for misalignment in terms of four main mechanisms (assumes flat face alignment): broad wall offset, narrow wall offset, rotational and diagonal. The most significant electrical degradation occurs with broad wall and narrow wall offsets. Furthermore, the electrical degradation in the interface quality is proportional to offset: larger offsets cause more degradation.

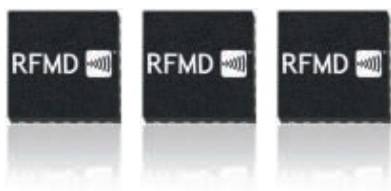
To verify flange compliance, engineers will typically use state-of-the-art

NEXT-GENERATION ANTENNA TUNING, ENABLING SMALLER, HIGH PERFORMANCE ANTENNAS

COMPLETE RF SOLUTIONS—INCLUDING
POWER AMPLIFIER, SWITCH, FILTER, AND
ANTENNA TUNING CONTENT—FOR NEXT-
GENERATION LTE SMARTPHONES AND TABLETS



LOW INSERTION LOSS
PRIMARY & DIVERSITY
TX/RX PATHS
SCALABILITY



ULTRA-HIGH EFFICIENCY RF PLATFORMS

CARRIER
AGGREGATION

OPTIMIZED
FOR USE WITH
MULTIPLE
BASEBANDS

ENVELOPE
TRACKING

RF PLATFORM COVERS ALL FD-LTE,
TD-LTE, HSPA, CDMA EV-DO, AND EDGE
FREQUENCY BANDS IN COMMERCIAL
USE TODAY, FROM BANDS 1-41



When failure is not an option...



GORE® Wire and Cable

When reliability, durability, and performance can be compromised by harsh environments, GORE® Wire and Cables offer the best solution.

gore.com/electronics

WIRE AND CABLE



Cover Feature

mechanical and optical inspection tools. These visual techniques will reveal true dimensions of a single flange; however, actual alignment of two flanges is more difficult to ascertain. Engineers can simulate the possible alignment qual-

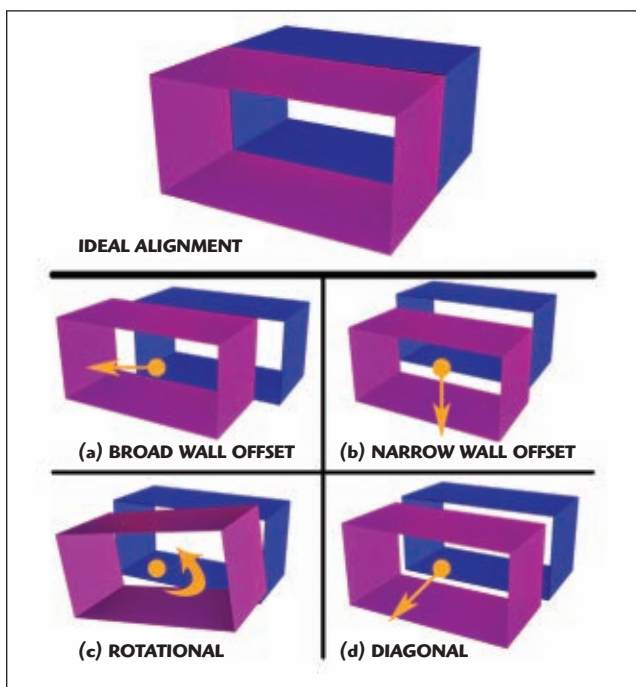
ity from these visual measurements, but electrical performance is only “viewable” with S-parameter measurements that reveal the true alignment quality. These alignment compliance techniques will become more impor-

tant as applications approach the THz range.

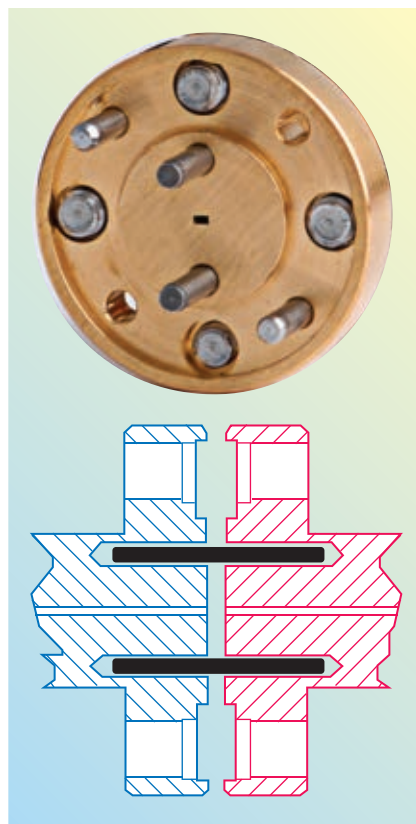
TECHNOLOGY THAT IMPROVES FLANGE ALIGNMENT

At frequencies beyond 110 GHz, the coupling between waveguide flanges is a complex task requiring parallelism between front and rear faces along with dimensional precision in related machining activities. In practical terms, engineers need to avoid binding between pieces or worst-case, permanent damage.

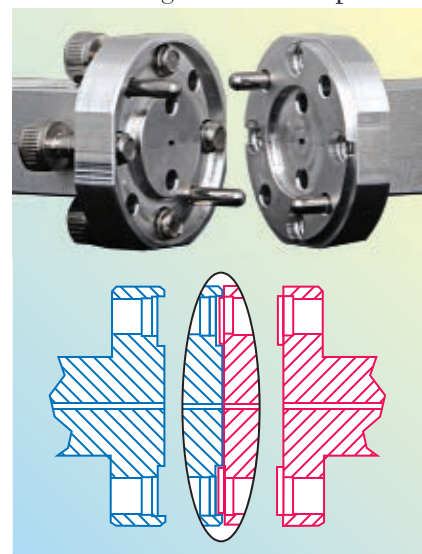
This binding scenario can happen when tolerances are too tight. Ideally, engineers want best electrical performance; therefore, avoidance of loose tolerances that adversely impacts alignment is a conflicting prerequisite. Finding a balance in terms of metrology, machining and manufacturing will ensure repeatable



▲ Fig. 4 Flange misalignment mechanisms.



▲ Fig. 5 WR-03 flange shows precision alignment pins and aperture alignment (side view).



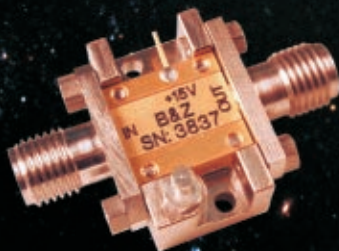
▲ Fig. 6 WR-03 innovative boss and jack interface can improve aperture alignment when mating (side view).

AMPLIFIERS

HIGH PERFORMANCE
100 kHz to 50 GHz

- **To Your Specification**
- **Reasonable Prices**

*Most can be
delivered in
one week!*



Visit our Web Site at www.bnzttech.com
Fill Out the Custom Specification form
Receive a Quotation within 24 hours!

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)

Add: 766 San Aleso Avenue, Sunnyvale, CA 94085
Tel: (408) 541-9226 Fax: (408) 541-9229
www.cernex.com cernex@cernex.com

Cover Feature

and precise connections for applications beyond 110 GHz.

ANTI-COCKING

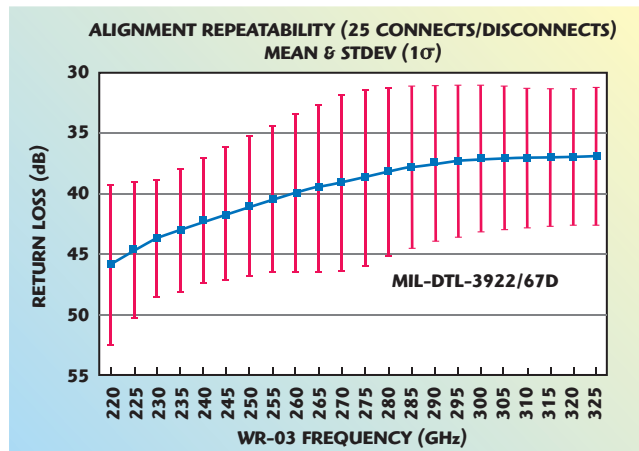
When initially coupling the two flanges together, the mating of the two faces is critical to avoid gaps. Cocking is the terminology given to the effect of the two mating surfaces not touching at all points. In the mating process, the captive waveguide screws are equally tightened, but uneven or over torque can cause cocking. To counteract uneven tightening, an outer ring is added to the flange as an anti-cocking feature to improve parallelism of the mating surfaces. This outer ring is visible in Figure 3. By adding a simple anti-cocking feature, superior flange-to-flange contact is possible, especially for alignment of the two flat faces in the uneven tightening scenario.

PRECISION ALIGNMENT PINS

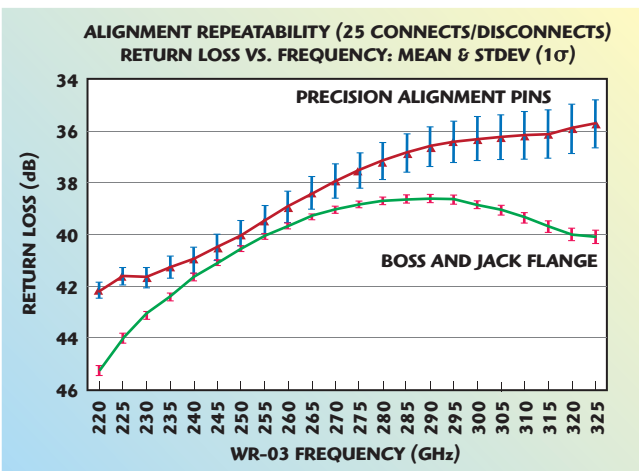
With shorter wavelengths on the mm-wave frontier, misalignment becomes susceptible to the mechanical tolerances in manufacturing the flanges. For that reason, a modern improvement to the flange is, as shown in Figure 5, the introduction of precision alignment dowel pins/holes both over and under the waveguide aperture. Compared to the conventional flange, the addition of dowel pins and precision holes

improve upon the coarse tolerances from the outer permanent alignment pins/holes. Manufacturers typically promote this flange as a modified version of MIL-DTL-3922/67D to maintain backward compatibility with the original standard.

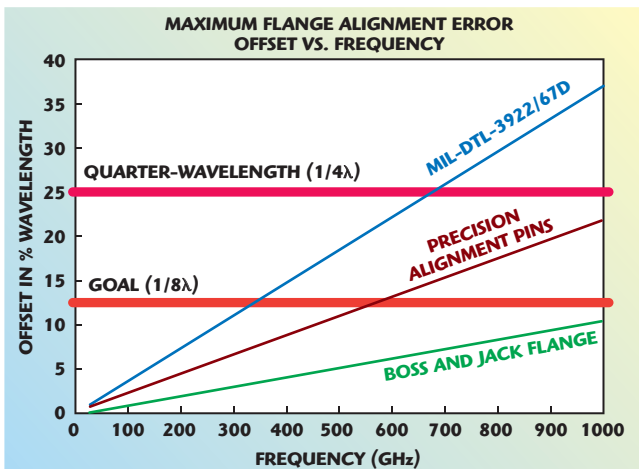
This remedy involves improving alignment with additional tighter



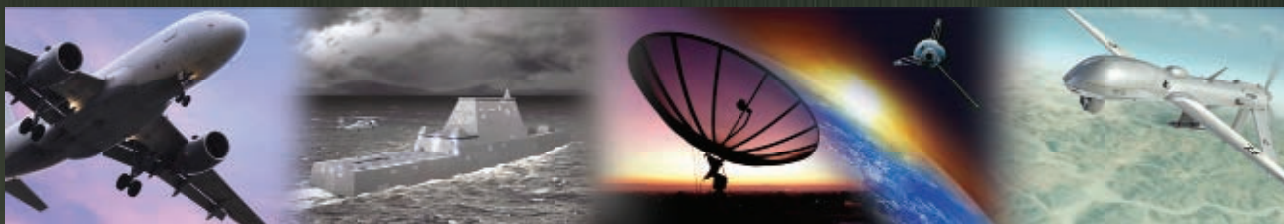
▲ Fig. 7 Return loss comparison in WR-03 for three flange variants.



▲ Fig. 8 Repeatability comparison in WR-03 for three flange variants.



▲ Fig. 9 Alignment comparison vs. mm-wave spectrum for three flange variants.



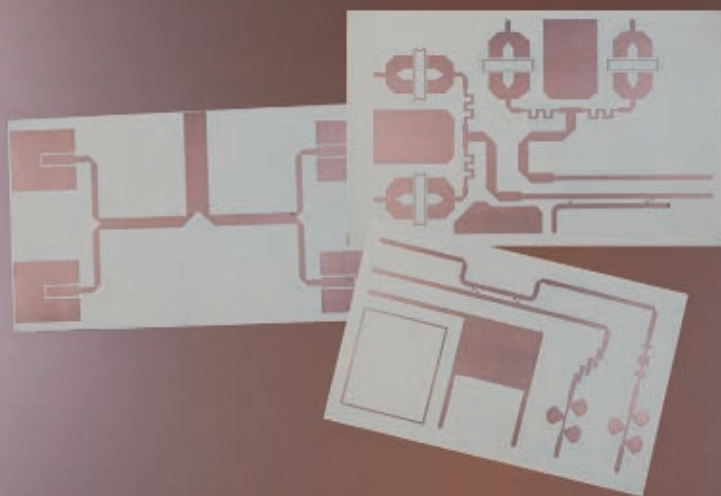
Reliability matters.

Gain a tactical advantage.

Mission-critical applications have relied on Rogers' microwave materials for years. The superior electrical & mechanical characteristics of Rogers' high reliability laminates provide the stable, consistent performance over time and temperature that's so critical for aerospace and defense applications.

Rogers' high performance printed circuit board materials have been supporting mission critical applications with a proven record of reliability for over 45 years. Can you afford anything else?

Visit www.rogerscorp.com/military to learn more about Rogers' aerospace and defense microwave material solutions.



RT/duroid® 6202PR laminates

- Reduced planar resistor variation
- Low thermal coefficient of dielectric constant
- Low coefficient of thermal expansion

RT/duroid 5880LZ laminates

- Dielectric constant of 1.96
- Low z-axis coefficient of thermal expansion
- Light weight

RT/duroid 6035HTC laminates

- Highest thermal conductivity (1.44 W/mk) for 3.5Dk printed circuit board laminates
- Low loss 0.0013
- Low profile, thermally stable copper options

NEW Product Introduction

2929 Bondply

- Unreinforced, thermoset based thin film adhesive system
- Dielectric constant of 2.9 and low loss target (<0.003)
- Predictable control of post bond thickness



Become a member of our Technology Support Hub

www.rogerscorp.com/acm/technology



The world runs better with Rogers.®



ROGERS
CORPORATION

Advanced Circuit Materials

tolerance alignment pins/holes, but this approach fundamentally suffers from the build-up of three mechanical tolerances: waveguide interface #1, waveguide interface #2 and alignment dowel pins/holes (refer to Figure 5). The advantage of this approach is 100 percent compatibility with the existing MIL-DTL-3922/67D standard. The effort to standardize this flange variant involves finalizing precision alignment placement and tolerances.

BOSS AND JACK FLANGES

Other variants of flange interfaces are available, but generally speaking they fundamentally suffer from the build-up of three tolerances. One patented flange design from OML being considered overcomes this tolerance build-up limitation with an innovative interface.⁷ In contrast to using precision alignment pins, this waveguide interface improves alignment by using a concentric mating mechanism consisting of a boss and jack interface

(see **Figure 6**). This design simplifies the tolerance build-up to just two interfaces by eliminating the need for alignment pins.

Using the boss and jack technology, the mating process simplifies to connecting one flange to the other using the permanent outer waveguide alignment pins/holes for coarse alignment and then the concentricity feature for final alignment. Precision pins are not necessary when using boss and jack as the alignment mechanism. Similar to other flange variants for calibration, tighten the flange screws with 15.5 in-oz of torque (± 1.5 in-oz) to complete the connection for signal propagation. For primarily compatibility purposes, precision pins are available in the boss and jack flange to support connecting to other flange variants. The outer waveguide pins control the rotational alignment, which is not a significant source of electrical degradation. The boss and jack technology is 100 percent compatible with the MIL-DTL-3922/67D standard.

FLANGE DESIGN COMPARISON

To evaluate the representative differences between the various mm-wave waveguide flanges, an experiment in WR-03 (220 to 325 GHz) was conducted on a single flange that incorporates the three main design elements: MIL-DTL-3922/67D, precision alignment pins and boss and jack variants.⁸ In this experiment, a one-port short, offset-short, offset load (SS_0L_0) calibration is performed on each version using a mm-wave vector network analyzer system. To reveal the quality of the interface, return loss is measured using a gated time domain technique. In addition to precision, the evaluation of repeatability is possible by comparing results for 25 connect and disconnect sequences.

As a baseline in **Figure 7**, the MIL-DTL-3922/67D flange exhibits poor return loss plus an undesirable inconsistency. In contrast, **Figure 8** shows the performance benefits of the alignment improvements from the other two flange variants. These results demonstrate that the precision alignment pins flange will improve on performance and repeatability; however, the boss and jack flange exhibits the best overall performance. In general, these results in the mm-wave bands are indicative of the improve-

POWER UP!

Soar with the highest power density solid state RF amplifiers available.



Model BME2969-200

2-6GHz, 200 Watts*
Solid State Power Amp Module

- Highest Power Density to Footprint Ratio
- High Efficiency Over the Entire Bandwidth
- RF Input/Output Sample Ports
- Internal DC to DC Converters
- Optional T/R Switch Available
- Maintains Output Power with Real-World Load Conditions

***300 Watts Coming Soon!**

Comtech's latest development expands on its proven innovative integrated GaN RF Power Amplifier designs by further increasing the RF power density, while improving overall operating efficiency.

These highly integrated designs are ideal for use in communication, electronic warfare, and radar transmitter systems where space, cooling, and power are limited. Applications include ground, surface, and airborne platforms.

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

Comtech...Simply More.



ISO 9001:2008 / AS9100C: 2009



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

- Use this tool to find the RF inductor with the highest impedance at a specific frequency
- Enter your operating frequency and any other requirements, then press GO.

INPUTS Operating Frequency MHz *3,000 MHz max. Use . for decimal*
 Optional Minimum Impedance Ohms
 Optional Desired Inductance ☐ Any ☐ nH

Measurements at 900 MHz

Part number	Impedance Ω	DCR max Ω	Inductance pH	SRF MHz	rms Amps	Graph	Sample
						(r.m.s.)	(g)
0805HT-R47	120652	3.10	407	610	0.20		
0805CS-331	20883	1.40	330	55.0	0.31		
0805CS-271	17733	1.30	270	47.0	0.31		
1206CS-271							
1206CS-331							
1206CS-391							
0805HT-639							
1008HT-672							
1008CS-181							

RF Inductor Comparison Tool

Operating frequency: 1000 MHz (2000 MHz max) Data sheet are measured at:

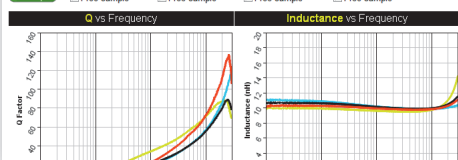
0603CS 6402CS 0302CS 1008CS

Operating frequency: 1000 MHz (maximum)

Operating frequency: 1000 MHz (2000 MHz max) Calculate Update

0603CS-100 0402CS-100 0302CS-100 1008CS-100

Part number	0603CS-100	0402CS-100	0302CS-100	1008CS-100
Inductance	37 nH	9.80 nH	9.7 nH	71 nH
Q factor	72	5.7	5.7	71
Impedance	63 Ohms	63 Ohms	63 Ohms	62 Ohms
ESR	0.08 Ohms	1.14 Ohms	1.09 Ohms	0.86 Ohms
SFR	> 3000 MHz	> 3000 MHz	> 3000 MHz	> 3000 MHz
Models	Sample SPICE	Sample SPICE	Sample SPICE	Sample SPICE
Get Samples	Get sample	Get sample	Get sample	Get sample

coilcraft.com/tools

coilcraft.com/mobile

- Find power inductors that have the actual inductance value you need at a specific current
- Enter your desired inductance value and current, then press GO.

INPUTS Desired Inductance (uH) Current (Amps) (Use . for decimal)

Part number	Actual Indebtedness or IA	DCR Change	Length max	Width max	Height max	Price (\$)	Graph L1-L2 (4 max)
XAL7030-822	7.309	0.04873	8.0	8.0	3.1	\$0.80	
LPS630-682	6.920	0.099	5.0	5.0	3.0	\$0.55	
XAL7030-682	6.815	0.04257	8.0	8.0	3.1	\$0.80	
XAL6112-682	6.752	0.34	4.1	4.1	1.2	\$0.35	
XAL5050-682	6.708	0.02945	8.0	8.0	5.1	\$0.83	

- These results do not imply an exact match to your requirements.
- We recommend that you request a free sample before an order is placed

Sort results by: Footprint DCR - Sort

Your inputs: Any 4.7 1 30 Update

Part number	Mounting	Other	L (mil)	DCR (mΩ)	I sat (A)	I rms (A)	SRF (MHz)	L (nH)	W (mm)	H (mm)	Price @ 1,000
030203C-4N7	SM		4.70	0.0740		0.83	12070	0.86	0.53	0.45	\$0.44

Step 1,2,3 Enter the **operating conditions** (all fields required)

Frequency	$I_{L \text{ rms max}}$	$\Delta I_{L \text{ peak-peak}}$
500 kHz	3.50 Amps	0.20 Amps

Calculate

Results (estimated)				
	Inductor 1	Inductor 2	Inductor 3	Inductor 4
	EPI3015-472	D03316P-472	XPL7030-472	LPS4414-472
	300 mW, max, at 1,000 Hz	300 mW, max, at 1,000 Hz		300 mW, max, at 1,000 Hz

- Use this tool to find the RF inductor with the highest Q factor at a specific frequency.
- Enter your inductance value and operating frequency, then press GO.

INPUTS Inductance nH 47 Frequency MHz 1900 (Use . for decimal) **GO**

Measurements at 1900 MHz					Graph Q, L, Z, ESR	Request samples (8 max)
Part number	Q factor	Inductance nH	Nominal L nH	SRF MHz		
0805HS-390	126	19.66	39	2000		
0805HS-470	104	22.55	47	1650		
0805HS-560	92	24.95	56	1550		

Part number	Description	Quantity	Delete
XAL7070-222MEB	SMT power inductor	2.2 μ H 1 Update	
XAL7070-682MEB	SMT power inductor	6.8 μ H 8 Update	
XAL7070-122MEB	SMT power inductor	1.2 μ H 5 Update	

Your reference number or PO (Optional)

Need a larger quantity? Any other comments or questions?

[Add more parts](#) [Finished](#)



WWW.COILCRAFT.COM

Cover Feature

ments that will soon become available from the standardization process.

In WR-03, the boss and jack flange demonstrates on average a 5 dB improvement in return loss characteristics due to the improved alignment. Using standard deviation as an indicator, the repeatability comparison shows an improvement of approximately 70 percent. The experiment using a single flange machined using ± 0.5 mil tolerances enables this comparison to extract a meaningful side-by-side comparison of the

alignment benefits in WR-03. Scaling these flange design elements to lower frequencies with larger aperture dimensions will have proportionally lesser effects. Similarly, scaling these flange design elements to higher frequencies with smaller aperture dimensions will proportionally improve alignment performance. As this experiment demonstrates, the improvement in flange technology will create a solid foundation on which future measurements are more precise and repeatable.

WAVEGUIDE STANDARD ABOVE 110 GHz (IEEE P1785)

With all the mm-wave flange alignment improvements in circulation, the need for standardization is apparent. Above 110 GHz, there currently does not exist a standard for the interconnect interface. As previously described, the industry is working around this situation by maintaining backward compatibility with the existing 110 GHz standard (i.e., MIL-DTL-3922/67D) while adding additional alignment features to address precision and repeatability issues (e.g., alignment dowel pins). The industry goal of standardization, similar for coaxial measurements, is to build an ecosystem that encourages competition and produces correlation across many supplier configurations.

Beginning in 2008, the Microwave Theory and Techniques Society (MTT-S) of the IEEE has been defining a new rectangular waveguide interface standard in the P1785 Working Group.⁹ This standard is organized into three main components. The first goal is to define the waveguide dimensions (by frequency band), including the transition to the metric system. The second goal, and perhaps most important task, is to complete a flange standard. The third goal is to define the framework for summarizing the performance and the expected uncertainty of the interfaces. These goals are similarly organized and intertwined with the existing MIL-DTL-3922/67D standard. This on-going standardization effort is currently celebrating its fifth anniversary since inception.

FLANGE STANDARD

The flange standard is one of the main focuses of the P1785 Working Group. In this labor-intensive process, industry experts evaluate compatibility criteria and the relationship between mechanical tolerances, alignment mechanisms and electrical performance. As previously noted, degradation typically becomes noticeable in WR-08 (90 to 140 GHz) and beyond; especially as multiple waveguide interfaces are often cascaded in the system signal path. As a practical consideration, the evaluation also requires an analysis of available machining technology and its fundamental dimensional limitations.



LE Lark Engineering Co.™
sales@larkengineering.com

THE FILTER SOURCE

NEW FROM LARK ULTRA-THIN Filters

When size is critical, Lark is offering a full line of "Ultra-Thin" filters for the Commercial and Military markets. Lark's new "Ultra-Thin" package offers superior performance in less than 0.09" High package. The Ultra-Thin filter series offers Low Insertion Loss and Ultimate rejection levels of 60 dB while maintaining better than 1.5:1 VSWR. These units are lightweight and ruggedized for today's AIR, SEA & LAND applications.

Product Specifications:

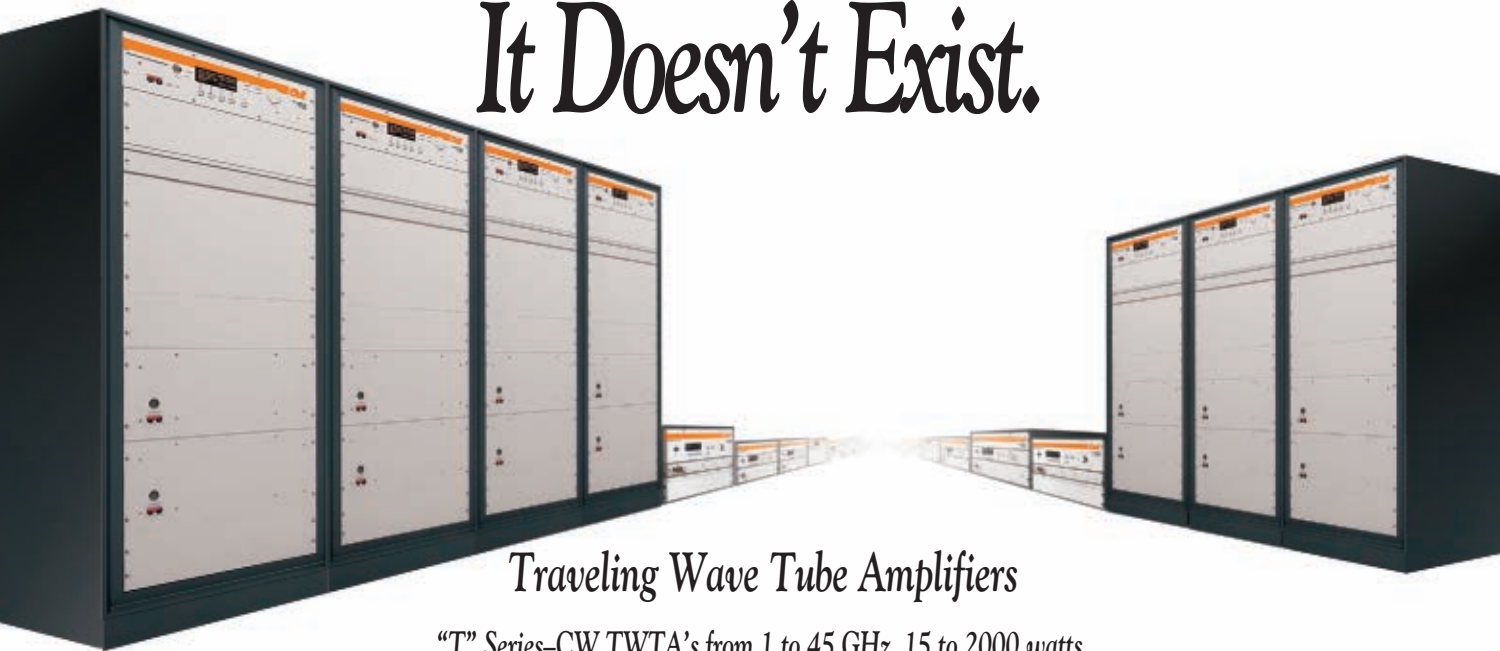
- Available in Bandpass, Highpass, Lowpass & Band Reject
- Frequency Range: 20 MHz to 7.0 GHz
- Passbands: Up to 100%
- VSWR: 1.5:1 typical
- Ultimate Rejection: 60 dB
- Meets Mil-Std-202 conditions
- Temperature Range: -55° C to +85° C

Lark is a leading (OEM) supplier of RF and Microwave Filters, Multiplexers and Multifunction Assemblies for the Military, Aerospace and Commercial markets. The company began operations in 1986 with the goal to design and manufacture quality products that satisfy the customer's needs and requirements. Our products can be found in today's military radar systems, aircraft, shipboard, hand held radios, GPS, ISM, PCN, PCS and many other military and commercial applications. Our commitment to quality and customer service has been a cornerstone of the company since its inception.

Military • Aerospace • Commercial
sales@larkengineering.com • 949.240.1233
www.larkengineering.com

ISO 9001:2008 Certified ISO 14001:2004 Certified

If You Can't Find The Power You Need Here, It Doesn't Exist.



Traveling Wave Tube Amplifiers

"T" Series—CW TWTA's from 1 to 45 GHz. 15 to 2000 watts.

"TP" Series—Pulsed TWTA's from 1 to 18 GHz. 1000 to 10,000 watts.

When it comes to the largest selection of Traveling Wave Tube (TWT) Amplifiers, AR has no equal. We cover a wider range of high-power, broadband amplifiers for your specific test application than any other brand.

CW models also have the capability to faithfully reproduce AM, FM, and pulse modulation input signals. Features that are included at no extra cost are our "Sleep mode" which prolongs the tube life, rugged construction for the rigorous treatment in test labs, modular supplies to reduce repair turn-around, and well thought out digital displays to help you monitor essential amplifier conditions.

So before you choose a look-alike traveling wave tube amplifier, examine all the features and benefits that come along at no extra charge with an AR amplifier. If you want a TWTA that will take you farther, you'll choose the one with the AR logo on it ... the company that stands behind our products with the global service and support that you demand.

To learn more, visit www.arworld.us or call us at 215-723-8181.

www.arworld.us/twta

ISO 9001:2008
Certified



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 441-908-282766 • ar France 33-1-47-91-75-30 • ar Benelux 31-172-423-000



www.arworld.us

Copyright © 2013 AR. The orange stripe on AR products is Reg. U.S. Pat. & TM. Off.

Cover Feature

SCALING TO MM-WAVE FREQUENCIES

More experimental results for the three flange variants are available for further analysis.¹⁰ The P1785 Working Group is conducting additional experiments and extrapolating overall performance with respect to dimensional tolerances to consider how flanges will operate at even higher frequencies. As shown in **Figure 9**, the three flange variants will predictably exhibit

greater alignment errors as frequency increases.¹¹ This undesirable behavior is the primary motivation in defining the flange standard.

In the 325 to 500 GHz band, for example, the WR-02.2 (WM-570) waveguide has aperture dimensions of 22×11 mils ($570 \times 285 \mu\text{m}$). On the vertical axis, the offset in percent-wavelength is plotted. For reference, quarter-wavelength (25 percent) is a natural limit to avoid due to the 180°

phase shift (the impedance difference between short and open on the Smith Chart). Given this constraint, the practical goal is to limit alignment errors to below the eighth-wavelength threshold (12.5 percent). This goal implies that the MIL-DTL-3922/67D is not capable of repeatable and precise measurements beyond 325 GHz. In contrast, the boss and jack variant represents the flange with potential for the overall highest performance.

As the previous experimental results demonstrate, using a ± 0.5 mil machine tolerance will produce measurable differences between the three flange variants. As another practical constraint, the current state-of-the-art machining capabilities are ± 0.2 mil, which is also a flange standard consideration. For a 1 THz flange, the aperture dimensions are 10×5 mils so a ± 0.5 mil machining tolerance converts into a 10 percent wavelength error for the boss and jack variant, which is perhaps an acceptable balance for convenience, performance and cost. Time will tell whether this practical approach becomes woven into the flange standard.

These examples illustrate the key takeaway that machining tolerances will determine overall electrical performance on the mm-wave frontier. The primary cause of degradation is due to narrow and broad wall offsets in the aperture alignment. The motivation to improve measurement precision and repeatability is fueling the efforts to release a standard as soon as possible to address this issue. To date, the boss and jack approach, with the least amount of tolerance build-up, has been shown to offer the best alignment performance in the flange interface. These superior alignment techniques and subsequent electrical performance will scale to other mm-wave and sub-mm-wave bands.

UPDATE ON STANDARDIZATION PROCESS

After five years of investment, the P1785 Working Group is on the verge of releasing standards. As an update, the frequency band and waveguide dimensions activity is nearly complete, including the conversion to the metric system. In addition, the protocols and criteria for evaluating flanges are nearing completion. This effort is particularly labor intensive with experts

Excellence is not gained in one day!

Customizing RF and Microwave Filters with excellence is what

Anatech Electronics is all about

With over 40 years of experience

Notch Filters

Duplexers

Bandpass Filters

Lowpass & Highpass

Many filter types can be designed

Such as switched filter banks, multiplexers, multi-band combiners, and many more

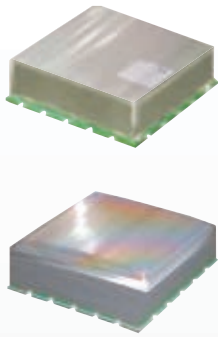
For more information...

CALL OR E-MAIL US TODAY! ANATECHELECTRONICS.COM

973.772.4242 • sales@anatechelectronics.com

AMCrf

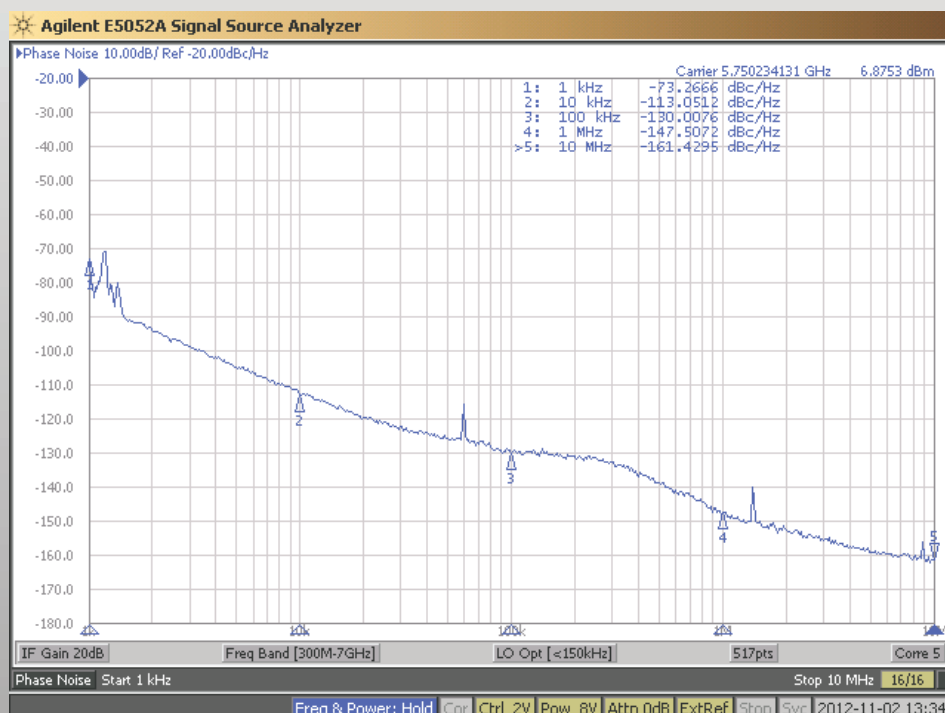
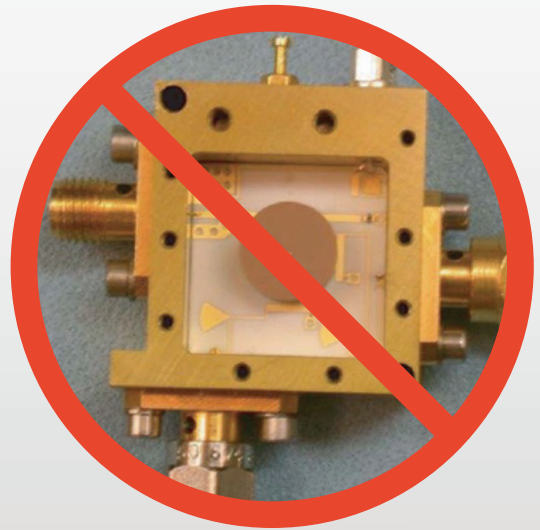
OUR WEB STORE
AMCRF.COM



SAY NO TO THE DRO!

*Spending hundreds of dollars on fifty year old technology? Come on, get rid of that expensive paperweight! APA **Wireless** Surface Mount CRO's offer:*

Lower cost
Smaller size and weight
No mechanical tune screw
Greater tuning bandwidth
Consistently pure performance up to 6GHz



VISIT US AT **APAWireless.com**

evaluating compatibility, mechanical tolerance, electrical performance (both simulated and measured) and uncertainties. Lastly, the recommendations for summarizing the performance and expected uncertainties are also undergoing review. These three main activities are correlated so release depends on thorough analysis.

The industry goal of standardization will help build an ecosystem that encourages competition and produces

correlation across many supplier configurations. At first glance, this progress may seem slow, but this proven IEEE methodology grants vital industry participation in the standardization process. Once completed, measurements will no longer depend on a sole supplier. Instead, a metrology standard for traceable measurements will encourage competition so mm-wave growth can accelerate. Indeed, the future of mm-wave innovation is

about to become much brighter as we journey beyond the current frontier.

CONCLUSION

Pioneers have identified some key hurdles in exploring the mm-wave frontier. This article attempts to explore the answers to three important questions: why, what and how. As a first step, the commercialization process and ecosystem growth depends on the development and deployment of standards that ensure measurement precision and repeatability, irrespective of individual suppliers. At the physical layer, a solid foundation begins with the waveguide flange.

There are formidable engineering challenges to overcome, but the P1785 Working Group is close to releasing standards. Its effort will address measurement inconsistencies due to waveguide flange alignment, including machining tolerances and natural irregularities in the waveguide interface. With a physical layer standard for connection, engineers can focus on innovation and discoveries instead of the cause for inconsistency, incompatibility and inaccuracies in their measurement tasks. In this way, the mm-wave ecosystem can continue to evolve along with the deployment of exciting new mm-wave applications. ■

References

1. www.ieee802.org/15/pub/1Gthz.html.
2. www.iwpc.org/WorkingGroups.aspx, MoGIG.
3. WiGig Wireless Gigabit Alliance, "WiGig White Paper: Defining the Future of Multi-Gigabit Wireless Communications," www.wigig.org, July 2010.
4. H. Liebe, "MPM—An Atmospheric Millimeter-Wave Propagation Model," *International Journal of Infrared and Millimeter waves*, Vol. 10, No. 6, pp. 631-650, 1989.
5. www.almaobservatory.org/en/technology/front-end.
6. C. Oleson and A. Denning, "Millimeter Wave Vector Analysis Calibration and Measurement Problems Caused by Common Waveguide Irregularities," *ARFTG Conference Digest (56th)*, November 2000.
7. Y. Lau, A. Denning, "An Innovative Waveguide Interface for Millimeter Wave and Sub-millimeter Wave Applications," *ARFTG Conference Digest (69th)*, June 2007.
8. Y. Lau and D. Vondran, "An Innovative Waveguide Interface and Quarter-Wavelength Shim for the 220-325 GHz Band," *ARFTG Conference Digest (80th)*, December 2012.
9. IEEE P1785 Working Group: "Waveguides for Millimeter and Sub-millimeter Waveguides," <http://grouper.ieee.org/groups/1785>.
10. Y. Lau, "Understanding the Residual Waveguide Interface Variations on Millimeter Wave Calibration," *ARFTG Conference Digest (76th)*, November 2010.
11. US Patent for Innovative Waveguide Interface (reference US2008/0303613A1).

26 to 65 GHz High Frequency Components

Ideal for Test and Measurement Optical Communications Microwave Radio Links

These high quality, high frequency components are market priced and readily available. You will find Attenuators, DC Blocks, Terminations, Adapters and Bias Tees in the 26 to 65 GHz frequency range. All are RoHS compliant. For more information call, or e-mail us:

Call 734-426-5553 or inmet@aeroflex.com

Pictured left to right:

- 2.4mm DC Block
7 kHz - 50 GHz
- 2.92mm Attenuator
DC - 40 GHz
- 2.92mm Bias Tee
7 kHz - 40 GHz
- 2.92mm Termination
DC - 40 GHz
- 2.4mm Termination
DC - 50 GHz
- 1.85mm Attenuator
DC - 50 GHz

Aeroflex / Inmet
Ann Arbor, Michigan
www.aeroflex.com/inmet



AEROFLEX
INMET
An ISO 9001 Certified Company

AEROFLEX
A passion for performance.

You Have Our Undivided **ATTENTION**

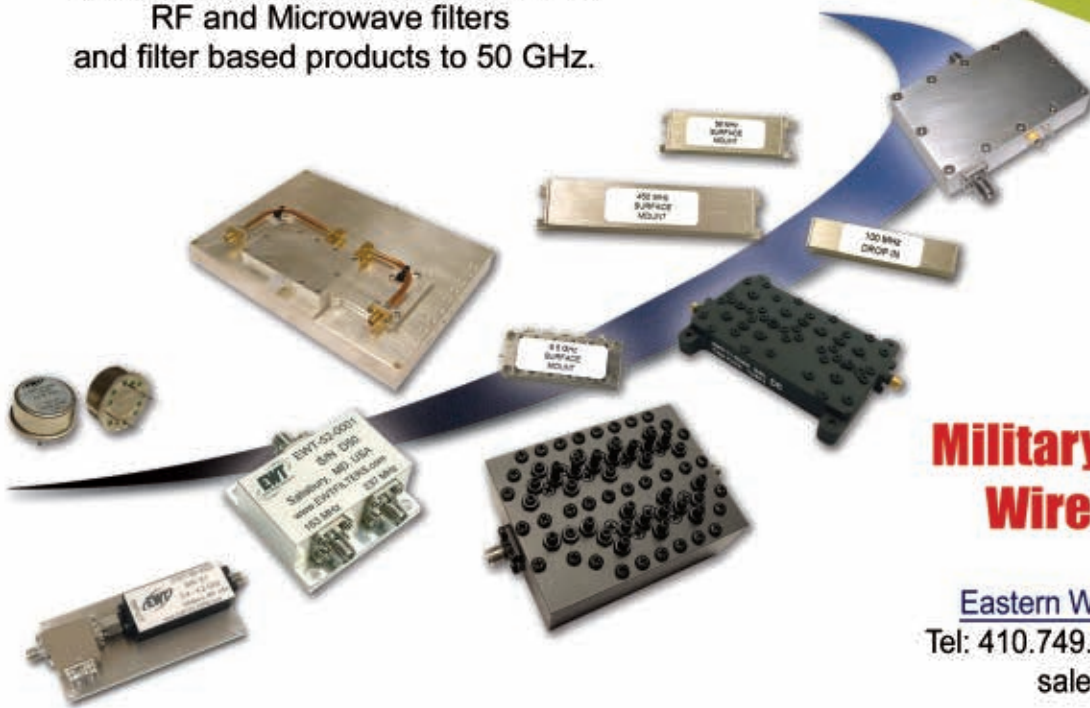


EW

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



60 GHz Integrated Waveguide Transceivers

In most countries, the 60 GHz band is allocated for unlicensed use with up to 7 GHz of bandwidth (57 to 64 GHz in the U.S. and Korea, and 57 to 66 GHz in Japan and Europe, as examples). This is 7 to 9 GHz of spectrum for use in unlicensed applications. As a point of comparison, the 2.4 GHz unlicensed band in the U.S. is 83.5 MHz wide (on the order of 1 percent of the bandwidth available at 60 GHz). The applications that can be supported by such wide bandwidths are multi-gigabit communications for backhaul links, high definition uncompressed video transmission and high resolution radar systems, to name a few.

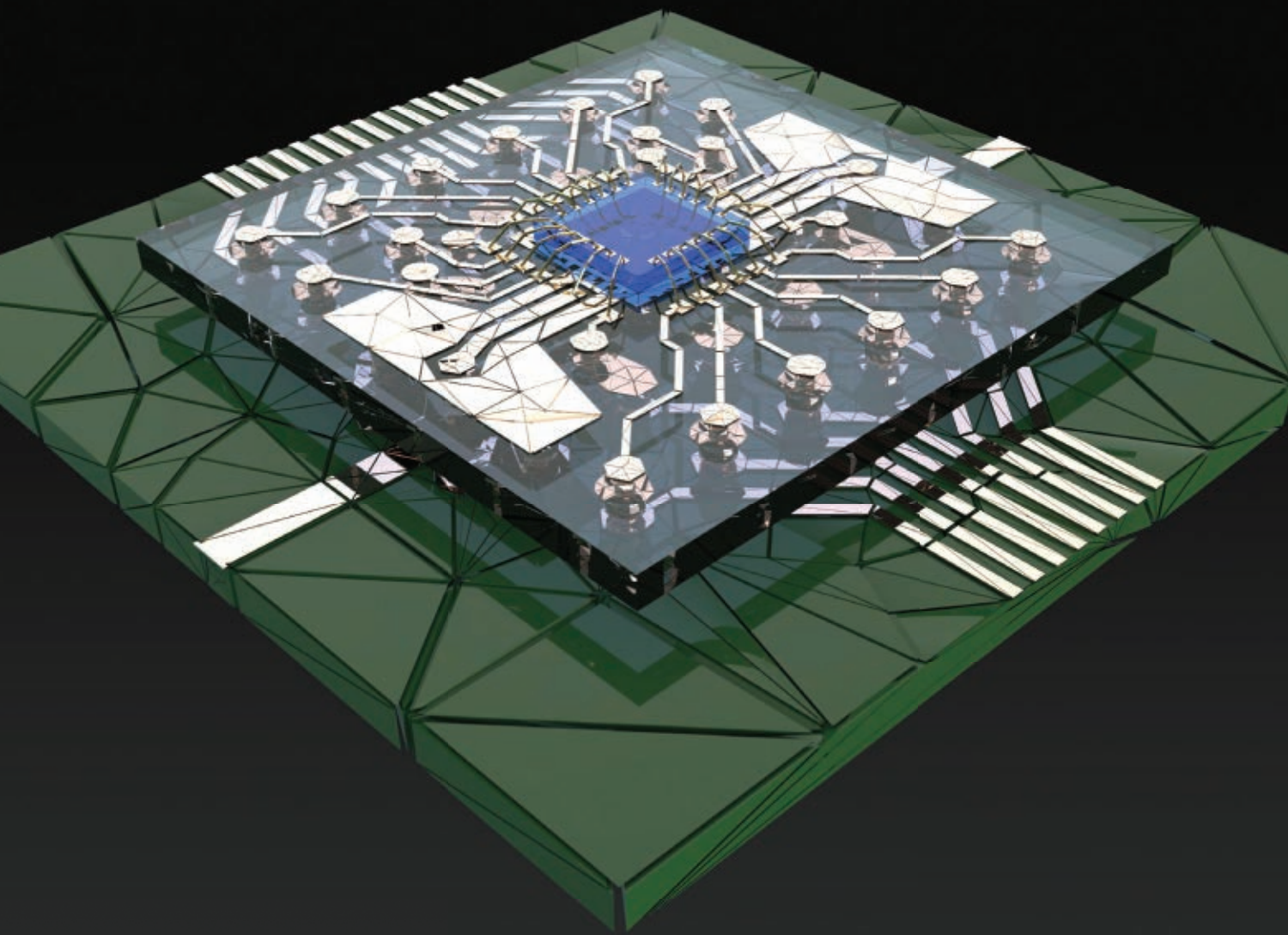
Integrated circuits (IC) are now available that can operate up through the 60 GHz millimeter-wave spectrum. Typical RF ICs that operate at the lower frequencies can be built into standard IC packaging such as SOIC, QFN and TSSOP. As the frequency of operation increases and into the realm of millimeter waves above 30 GHz, the problems of bond wire self and mutual inductance, parasitic capacitance and PCB trace parasitics start to dominate and limit performance. In order to provide useable components at millimeter waves, some vendors provide a built-in antenna, such as a patch antenna, that is directly connected with very short traces to the IC die pads in order to reduce the parasitic effects. In order to reduce the parasitic lead ef-

fects, flip-chip mounting technology is also used.

The problem of getting 60 GHz energy on and off the die is not trivial, and special consideration must be given to creating efficient designs that can facilitate easy development at the component level. Since the antennas that are typically used in fully packaged solutions are small and fairly low-gain with associated wide beam patterns, the resulting operating distance that can be achieved is quite short (on the order of 10 m or less). These compact, short range antennas work fine for applications such as indoor wireless links, small radar sensors or even as high-bandwidth versions of near-field communications. But many applications require longer range requiring highly directional, larger aperture antennas. High-gain antennas significantly increase operating range while reducing multipath and interference.

The most efficient method for interconnecting or coupling a variety of different millimeter-wave antennas is to use industry standard waveguide flange couplings. For the 60 GHz band, the EIA designated waveguide size is WR15 (which covers 50 to 75 GHz), and the standard flange is designated as the UG-385/U. 60 GHz research-

VUBIQ INC.,
Aliso Viejo, CA



3D EM and circuit design in one integrated workflow.

Analyst 3D FEM EM simulator — seamlessly integrated within the Microwave Office environment — let's you go from circuit concept to EM verification with one click. Spend your time designing, not drawing. It's 3D EM power with Microwave Office efficiency. Grab a test copy at awrcorp.com/analyst.

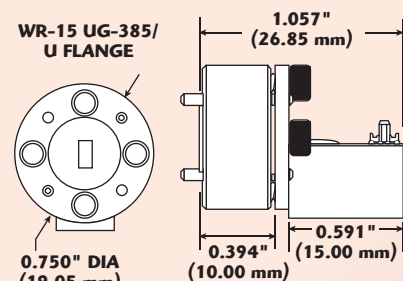
Stop waiting and start designing™

ANALYST™
3D FEM EM

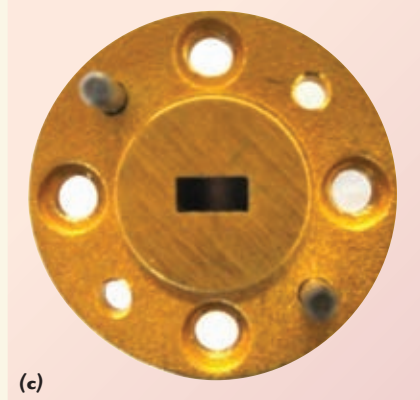
Most Valuable Product



(a)



(b)



(c)

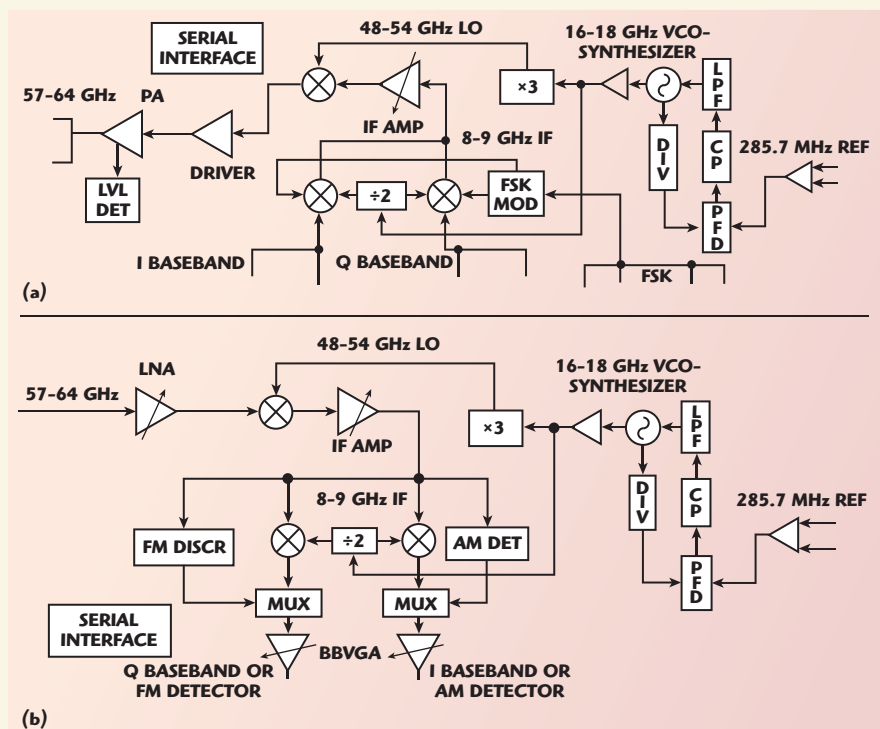
▲ Fig. 1 Vubiq waveguide module (a), dimensions (b) and flange close up (c).

ers and developers need to connect external antennas, of any arbitrary size and gain, to the RF front end of the system. Efficiently coupling the signals at these frequencies into and out of the waveguide port from an integrated circuit is a challenge. There are vendors that have successfully built MMIC type amplifiers, mixers and other separate millimeter-wave functions using ceramic substrates packaged in precision machined waveguide block type assemblies. These blocks are good for basic

research in a laboratory environment, but not for an integrated and low-cost solution intended for commercial product development.

LOW COST WAVEGUIDE MODULE

To answer the need for easily attaching a variety of antennas to low cost integrated 60 GHz transmitters and receivers, Vubiq Inc. introduced its 60 GHz waveguide modules, the V60TXWG2 transmitter and V60RXWG2 receiver. Figure 1 shows a photo and a dimensional drawing



▲ Fig. 2 V60TXWG2 transmitter block diagram (a) and V60RXWG2 receiver block diagram (b).



FROM 500 MHz TO 110 GHz SIMPLE OR COMPLEX WE MANUFACTURE THE COMPONENTS YOU NEED



OSCILLATORS



**TRANSCIVERS &
FREQUENCY
CONVERTERS**



**CUSTOM
ASSEMBLIES**



AMPLIFIERS

WWW.NORDENGROUP.COM

PHONE (530) 642-9123

FAX (530) 642-9420

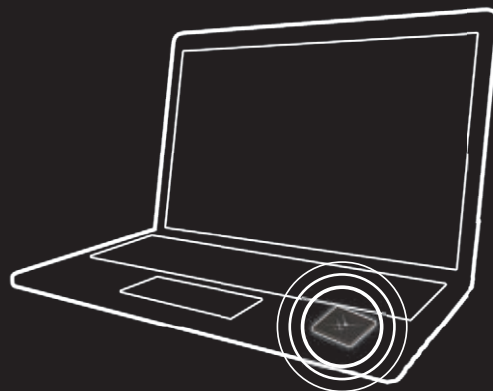
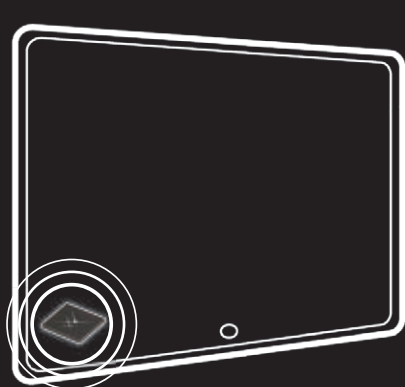


SKYWORKS®

presents

SkyOne™

***Reducing Front-end Complexity, Size and Time to Market
for Demanding Next Generation Mobile Platforms***



SKY78010 and SKY78011

- Fully optimized and 100% RF tested
- World's best linearity and PAE for smart RF integration
- Ultra-compact 7 x 9.8 x 1.0 mm package—significantly smaller than the industry's most advanced approach
- 2G quad-band and 3G/4G penta-band GPIO control interface
- Three additional RF paths TRX1–TRX3 to antenna
- Separated Vbatt and Vcc to support DC/DC

Patented FEMs Integrate All RF and Analog Content from Transceiver to Antenna

- SP12T antenna switch
- SKY78010: Bands I, II, IV, V, VIII
- SKY78011: Bands I, II, III, V, VIII
- 2G DCS/PCS dual RX filter/diplexer

***Visit us at GSMA Mobile World Congress • Hall 6, Stand E24
Barcelona, Spain • February 25–28, 2013***

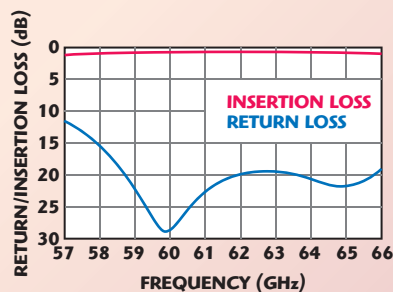
USA: 781-376-3000 • Asia: 886-2-2735 0399 • Europe: 33 (0)1 43548540 • Email: sales@skyworksinc.com

www.skyworksinc.com • NASDAQ: SWKS •   

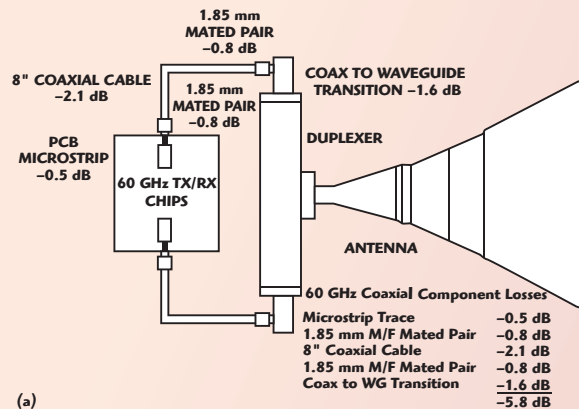
Most Valuable Product

of the Vubiq waveguide module.

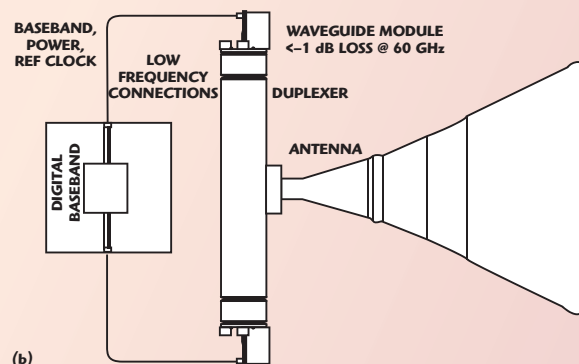
The waveguide module design incorporates a simple low frequency I/O connector (Samtec ST4) for interfacing the required voltages, reference clock and modulation signals (up to 2 GHz response). The modules incorporate SiGe BiCMOS radio chips with the ability to produce +12 dBm P1dB transmit output power, 6 dB receive noise figure and take up less than one cubic inch (<16 cm³) of total volume. The on-chip synthesizer produces RF carrier frequencies from 56.5 GHz up through 64 GHz in 500 MHz channel step increments. The transmitter up-



▲ Fig. 3 Waveguide module insertion loss and return loss across the 60 GHz band.



(a)



(b)

▲ Fig. 4 Typical loss values of coaxial components (a) and waveguide module (b) in a 60 GHz backhaul link.

The Best Filters on Earth... and Mars!

IF/RF/Microwave Filters - Wireless, Military, Space, GPS and Commercial



High-Quality, Custom Solutions

All products made in USA

A proud member of the Mars Rover project



- Passive filter experts since 1982
- DC to 20 GHz, μ W to kW, many technologies
- Filters, duplexers, triplexers, multiplexers
- Ceramic resonators from our factory in San Diego, CA
- Designs for adverse environments and missions
- AS-9003 compliant Quality System
- Prompt service, on-time delivery worldwide



TEL 858.259.2600

www.imcsd.com

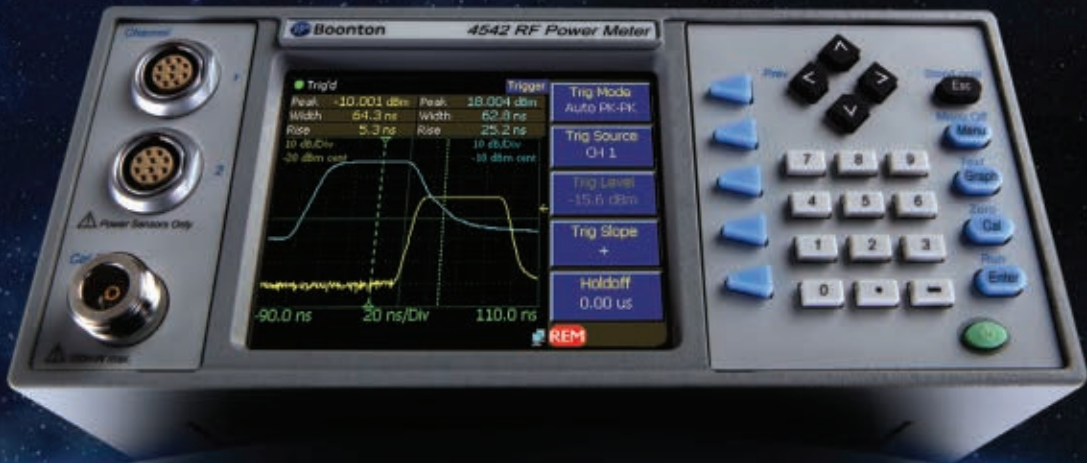
converts I and Q input signals in the form of analog baseband capable of up to 1.5 GHz modulation bandwidth. The receiver down-converts from 60 GHz to analog baseband I and Q signal outputs. In addition, the receiver incorporates selectable AM and FM detectors. See **Figure 2** for the transmitter and receiver IC block diagrams. The Vubiq waveguide module design exhibits very low loss and is a connectorized module with DC and modulation signals applied at the input signal connector, with modulated 60 GHz energy produced at the output waveguide flange.

Figure 3 shows the return loss and insertion loss modeled from the actual IC die output pads to the waveguide flange port. Less than 1 dB loss is incurred in the module across the band from 57 through 66 GHz. Careful design, modeling and design for manufacturing (DFM) were applied throughout the process of creating these modules. The result is a set of high performance 60 GHz transmitter and receiver modules that are designed for high-volume production.

A COMPARISON: COAX VERSUS WAVEGUIDE AT 60 GHz

It is critical to keep losses as low as possible at millimeter-wave frequencies in order to achieve the best

Bigger where it counts...



in the Performance.

Boonton's 4540 Peak Power Meter delivers the outstanding performance needed for today's demanding radar and communication applications. By incorporating advanced technology from our flagship 4500B peak power analyzer, the smaller, economically priced 4540 outperforms higher priced competitors in many areas. It's fast update rate enables tuning high power amplifiers and processing large amounts of statistical data for CCDF measurements. Advanced trigger technology provides a rock solid view of fast rise time signals and the wide dynamic range allows measuring low duty cycle pulses. The 4540 power meter provides automatic settings for a large number of technologies including WCDMA, WiMAX, WLAN, Wi-Fi, LTE, and Radar.

- Frequency range: 9.9kHz to 40 GHz
- Time resolution: 200 ps
- Video bandwidth: 70MHz
- Rise time: <7ns
- Effective sampling rate (RSS): 5GSamples/second
- Statistical analysis including CCDF
- GPIB, USB (device) and LAN standard

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

Boonton: Redefining How You Use Power Meters.



4530 RF Power Meter Series

4500B RF Peak Power Analyzer

4240 RF Power Meter

Scan QR Code



Most Valuable Product

signal-to-noise ratio in communications systems. At 60 GHz in particular, oxygen absorption adds specific attenuation at 15 dB/km (at sea level) to the traditional free space loss equation. For point-to-point links, every dB counts to work over the longer ranges required in applications such as high-bandwidth gigabit backhaul.

As a general comparison, coaxial connectors, transmission line and coax-to-waveguide transition components

exhibit significant losses and are expensive. The types of coaxial connectors that are used up to 67 GHz are the 1.85 mm threaded "V" connector and the newer MMPX series, which is an unthreaded snap connector. A quick analysis shows that using a coaxial transmission line can add 5 to 6 dB of additional losses at each end of a link, totaling to more than 10 dB of additional link budget loss as compared with the waveguide approach. **Figure 4a** illustrates

the loss build up for a coaxial component design of a full duplex link at 60 GHz for backhaul applications. The total additive losses for the link are in excess of 10 dB, which would be equivalent to losing half the range capability for a typical 300 meter link.

The Vubiq waveguide module brings the source of the 60 GHz energy directly to the waveguide aperture which translates to significantly reduced losses at the system level. **Figure 4b** shows how the interconnections between the digital baseband board and the millimeter-wave front-end waveguide module of a full duplex link terminal are limited to the lower frequency baseband signals, power and reference clock and

real boards
real easy
real fast

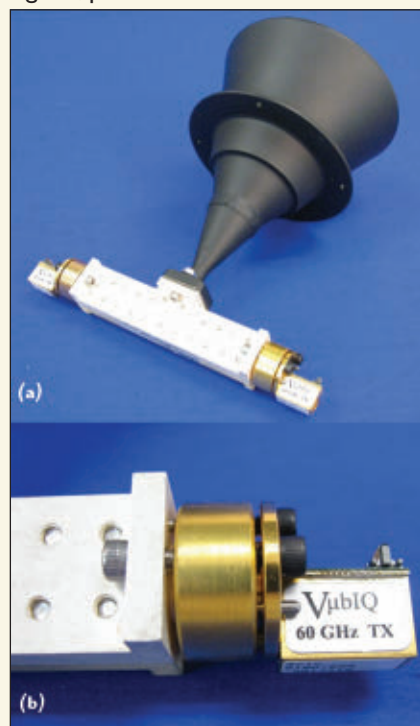


ProtoLaser S. It's the real deal.

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 S will liberate you from the board house.

www.lpkfusa.com/pls • 1-800-345-LPKF

LPKF
Laser & Electronics



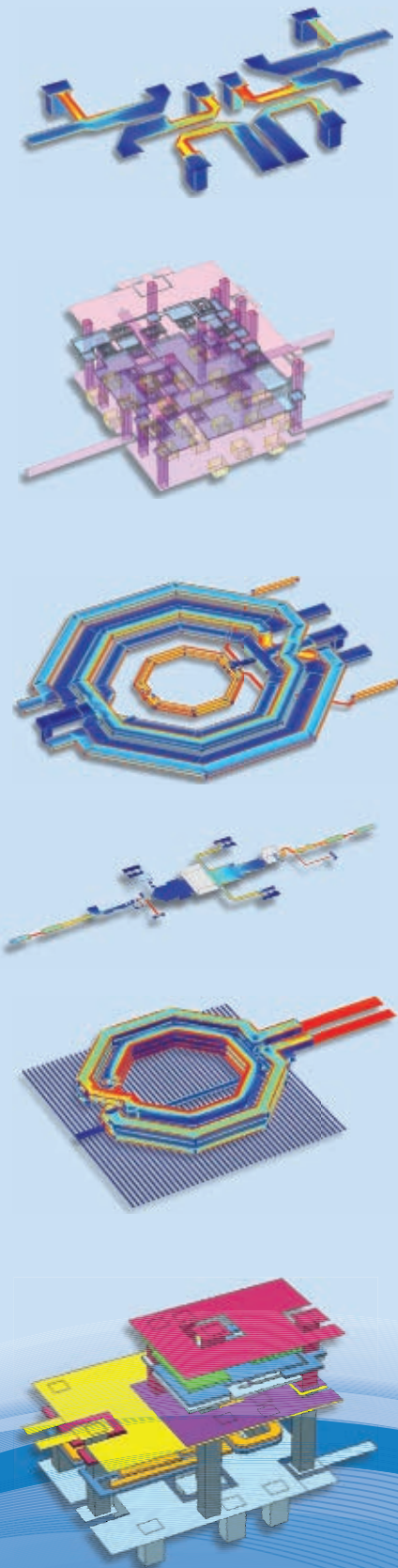
▲ **Fig. 5** Waveguide modules with duplexer/antenna (a) and close up of the TX module (b).



▲ **Fig. 6** V60WGD02 development system.



Accurate.
Integrated.
Robust.



EM Software, it's who we are.

www.sonnetsoftware.com • 1-877-7-SONNET

Most Valuable Product

do not include more complex RF interconnections. The loss incurred at 60 GHz in this approach is exactly the loss of the waveguide module which is less than 1 dB.

In **Figure 5a**, a full duplex RF front end is shown with a waveguide transmitter module, waveguide receiver module, a wideband duplexer and a 35 dBi horn antenna. This arrangement is designed for use in a full duplex, gigabit Ethernet link with greater than a 500

meter range at 1.25 Gbps. **Figure 5b** shows a close up of the transmitter module interfaced to the WR15 flange of the duplexer.

DEVELOPMENT SYSTEM FOR QUICKLY GETTING ON THE AIR

The waveguide modules are controlled via a Serial Peripheral Interface (SPI) port. Users who want to have a fast, out-of-the-box experience for getting 60 GHz on the air in minutes

can also obtain the Vubiq Development System (V60WGD02 – see **Figure 6**) that provides a USB powered interface set of boards and a simple software control GUI that allows for easy setup in the lab.

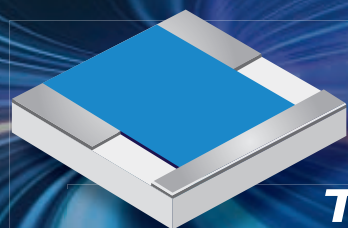
The TX and RX boards in the development system provide power supply regulation, reference clock generation and a USB to SPI interface to the waveguide modules. Each board has MCX coaxial connectors for easy interfacing to analog baseband signals. Each board contains a low phase noise reference clock (285.7 MHz) but can also use an external reference source for phase locking the TX and RX together if desired.

The aperture produces a pattern equivalent to about a 7 dBi gain antenna, which is approximately a 70 degree wide beam pattern. Bench top testing of various modulation schemes and bit rates can be done in this manner with easy TX to RX alignment since the patterns are so wide. For longer range testing, a directional gain antenna significantly increases the gain. Directional adjustment is made at the tripod head for pointing.

The control GUI that comes with the system is a graphical, easy-to-use screen for completely setting up the transmitter and receiver functions. The GUI screen also provides monitoring of synthesizer lock, module and board temperatures, and power supply voltages.

The future of millimeter-wave technology is accelerating into the present by the introduction of highly integrated silicon that can operate into the spectrum above 30 GHz. With the standards bodies and regulatory agencies promoting the latest technologies for millimeter-wave operation, in particular the unprecedented global bandwidth available for unlicensed operation at 60 GHz, the future of broadband wireless networking is well in hand. High performance must be matched with low cost, practical components for the 60 GHz band – and Vubiq is playing a vital role in providing much needed components and engineering development systems.

**Vubiq Inc.,
Aliso Viejo, CA
(949) 226-8482,
www.vubiq.com.**



Temperature Variable Attenuators

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

- Case size 0.150" x 0.125" x 0.200"
- Choice of three temperature coefficient of attenuation (TCA) values: -0.003, -0.007, -0.009
- Attenuation values from 1-10 dB
- Planar design with solderable or wire bondable terminations
- Lower signal distortion, phase change and intermodulation compared with active circuit temperature compensation

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

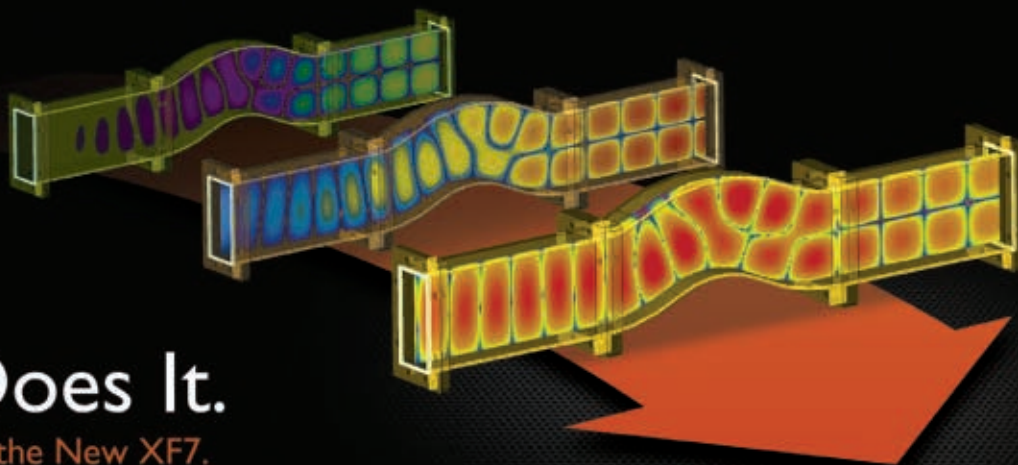


State of the Art, Inc.
RESISTIVE PRODUCTS

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



Easy Does It.

► Introducing the New XF7.

XF7 simulating a TE_{20} to TE_{10} tri-bend mode converter.

Electromagnetic Applications:

Antenna Design & Analysis:
WiFi, Wireless LAN, WiMAX,
Arrays, Mobile

Antenna Placement:
On-Platform, Human Interaction

Biomedical:
Imaging, Implantables

EMI/EMC Testing

Metamaterials/Special Materials

Microwave Devices:
Waveguides, Rotman Lens

Photonics and Optical

Radar and Scattering, RCS

Signal Integrity

Static Discharge

Wireless Propagation



XF7dtd® 3D Electromagnetic Simulation Software is powerful enough to handle the toughest simulations. It's tremendously fast by leveraging NVIDIA's most modern CUDA-enabled GPUs. And it's easy to use and engineered to replicate real-world processes.

Power, Speed, and Usability — Release 7.3 Now Available!

Recent enhancements:

- Waveguide ports
- Stretch and twist geometry
- Static solver now solves for all good conductors
- XStream® GPU Acceleration for Thin Wire, Magnetized Ferrite, and Periodic Boundary Condition
- ODB++ PCB import within CAD Merge, allowing retention of previous modifications to the PCB
- Time Domain Reflectometry (TDR) and Time Domain Transmission (TDT) output types

Release 7.3 highlights at: www.remcom.com/xf7-waveguides

Find resources for your specific electromagnetic application at:
www.remcom.com/electromagnetic-applications



+1.888.7.REMCOM (US/CAN)
+1.814.861.1299
www.remcom.com

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

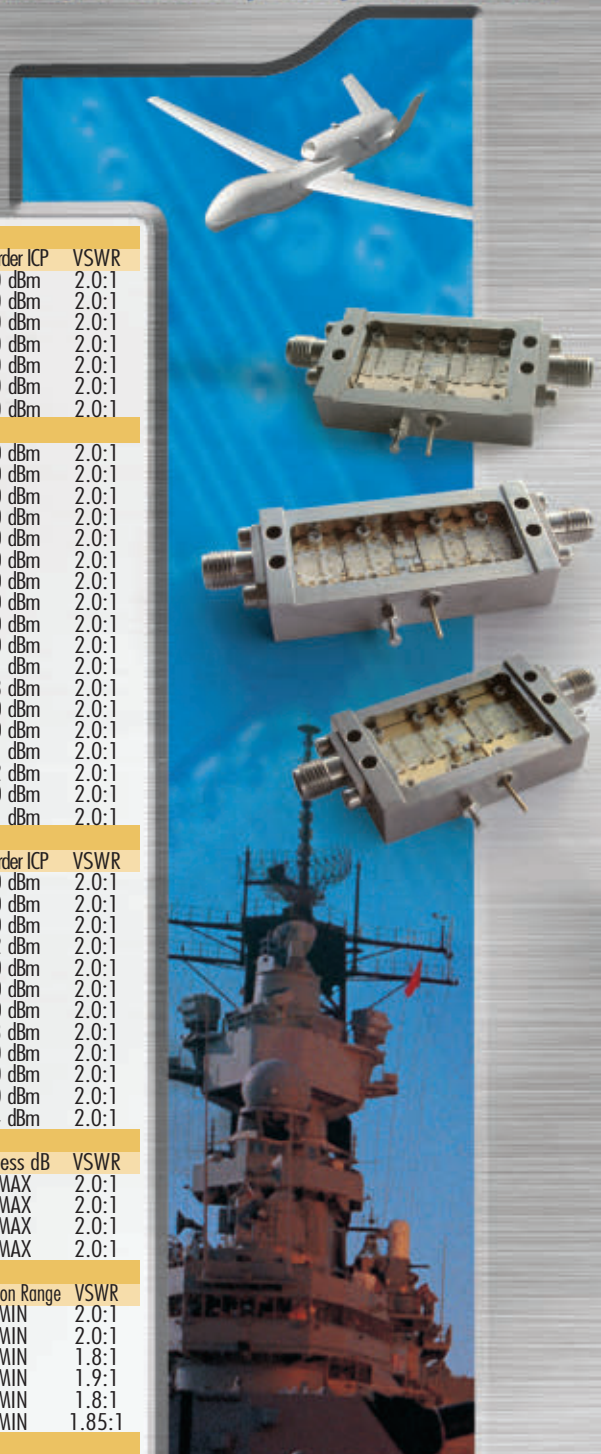
Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure dB	Power-out @ P1-dB	3rd Order ICP	VSWR
CA001-2110	0.01-0.10	18	4.0 MAX, 2.2 TYP	+10 MIN	+20 dBm	2.0:1
CA001-2211	0.04-0.15	24	3.5 MAX, 2.2 TYP	+13 MIN	+23 dBm	2.0:1
CA001-2215	0.04-0.15	23	4.0 MAX, 2.2 TYP	+23 MIN	+33 dBm	2.0:1
CA001-3113	0.01-1.0	28	4.0 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





AEHF Team Completes Major Integration Milestone Ahead of Schedule

The U.S. Air Force and Lockheed Martin have integrated the system module for the fourth Advanced Extremely High Frequency (AEHF) satellite six months ahead of schedule. The milestone marks the completion of the first major phase in the satellite's assembly. Integration and test are key indicators that Lockheed Martin and the Air Force are successfully streamlining processes to achieve affordability goals.

AEHF, the next generation of protected military satellite communications satellites, provides vastly improved global, survivable, highly secure, protected communications for strategic command and tactical warfighters operating on ground, sea and air platforms. The system also serves international partners including Canada, the Netherlands and the United Kingdom.

The AEHF-4 system module includes the satellite's payload structure module and electronic components that are critical to controlling its communications payload and ensuring the satellite's health and safety throughout its on orbit mission life. The AEHF payload provider, Northrop Grumman, will now integrate the satellite's advanced communications payload with its system module. The fully integrated system module will then be returned to Lockheed Martin's Sunnyvale, CA facility for final satellite integration and test.

"We look forward to integrating the advanced communications payload and ultimately delivering this satellite in support of strategic and tactical protected communications users worldwide," said Col. Rod Miller, the U.S. Air Force's AEHF program manager.

Lockheed Martin is currently under contract to deliver four AEHF satellites and the Mission Control Segment. The program has begun advanced procurement of long-lead components for the fifth and sixth AEHF satellites. AEHF-1 and AEHF-2 have both launched and are in orbit. Lockheed Martin has completed work on AEHF-3 and is now preparing the satellite for a September 2013 launch date.



Source: Lockheed Martin

Northrop Grumman Awarded U.S. Army Global Tactical Advanced Communications Systems

Northrop Grumman Corp. has been awarded the Global Tactical Advanced Communications Systems and Services contract from the U.S. Army Program Executive Office Command, Control and Communications-Tactical (PEO C3T). The award enables Northrop Grumman to compete for task orders under the five-year, multiple-award, indefinite delivery, indefinite quantity (ID/IQ) contract, which has a total value of \$10 billion. Northrop Grumman is one of 20 companies that were selected for this contract.

Contractors on the program will bid on task orders to provide tactical command, control and communications (C3) systems hardware, software, engineering and logistics that support the networked battle command needs of the warfighter.

"Northrop Grumman has been supporting PEO C3T since the late 1980s and we are proud of our record as a reliable partner able to respond rapidly to customer requirements," said Kevin Sculley, vice president of integrated mission systems, Northrop Grumman Information Systems. "We have demonstrated our ability to manage large ID/IQ contracts and to provide innovative and affordable C3 solutions – qualities we will apply to this program."

"Northrop Grumman has been supporting PEO C3T since the late 1980s and we are proud of our record as a reliable partner able to respond rapidly to customer requirements."

Raytheon Awarded \$254 M for Tomahawk Missile

The U.S. Navy awarded Raytheon Co. a \$254.6 million contract to procure Tomahawk Block IV tactical cruise missiles for fiscal year 2013. The contract calls for Raytheon to build and deliver Tomahawk Block IV cruise missiles, conduct flight tests and provide life-cycle support. Production and delivery of the missiles are scheduled to begin in 2013.

"Tomahawk Block IV enables the warfighter to precisely engage heavily defended and high-value targets from extremely long distances, which is critical to maintaining national security," said Capt. Joe Mauser, U.S. Navy Tomahawk program manager. "With more than 2000 combat missions and 500 successful tests com-



A major enhancement to the Tomahawk Block IV missile includes a two-way satellite data-link that enables a strike controller to redirect the missile...

ity, effectiveness and accuracy. No other tactical cruise missile in the world can come close to matching it," said Harry Schulte, vice president of Air Warfare Systems for Raytheon Missile Systems. "This missile provides unparalleled capability and has greatly contributed to the security of our country and our allies."

pleted, Tomahawk has proven its outstanding reliability and effectiveness."

A major enhancement to the Tomahawk Block IV missile includes a two-way satellite data-link that enables a strike controller to redirect the missile in-flight to pre-programmed alternate targets or more critical targets.

"Tomahawk has an excellent record of reliability,

Raytheon UK Wins First Contract for New Lightweight GPS Anti-Jam Capability

Raytheon UK has been awarded a significant contract by the UK Ministry of Defense for delivery of a new GPS Anti-Jam Antenna System. The contract is for an undisclosed number of advanced systems for deployment in operational theaters spanning multiple vehicle platforms. This urgent operational requirement (UOR) contract is the first award for Raytheon's GPS Anti-Jam (AJ) Land product family.

Bob Delorge, chief executive, Raytheon UK, commented, "Raytheon UK has a track record of on-time delivery for GPS AJ systems, having delivered over 7000 units for air and naval capabilities in the UK and U.S. Many of the military platforms used in operations are protected by the proven Raytheon GPS anti-jam technology and the first order for our Land GPS AJ product family marks a significant success."

The contract will see the deployment of the systems under a very short timescale, with final delivery of the capability expected to be completed six months from the contract award.

CUSTOMIZED DESIGN QUOTES IN 24 HOURS
www.pulsarmicrowave.com

DC-85 GHz

PULSAR
MICROWAVE CORPORATION





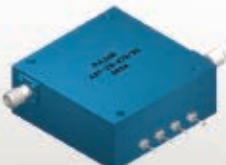
Power Dividers, DC-60 GHz
2-32 Way



Directional Couplers
Single and Dual, to 60 GHz
High Power, to 2500 watts



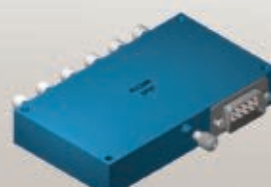
Hybrids, to 40 GHz
90° & 180°



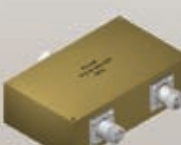
Attenuators, to 18 GHz
Digital, Analog, Linearized



Bias Tees, to 85 GHz
30 KHz to 85 GHz



Switches, to 18 GHz
SP1T-SP8T



High Power Combiners
to 500 watts

Also Available
Phase Shifters, DC Blocks, Mixers,
Modulators, and Image Reject Mixers

48 Industrial West, Clifton, NJ 07012 | Tel: 973-779-6262 | Fax: 973-779-2727 | sales@pulsarmicrowave.com

ISO 9001:2008 Certified



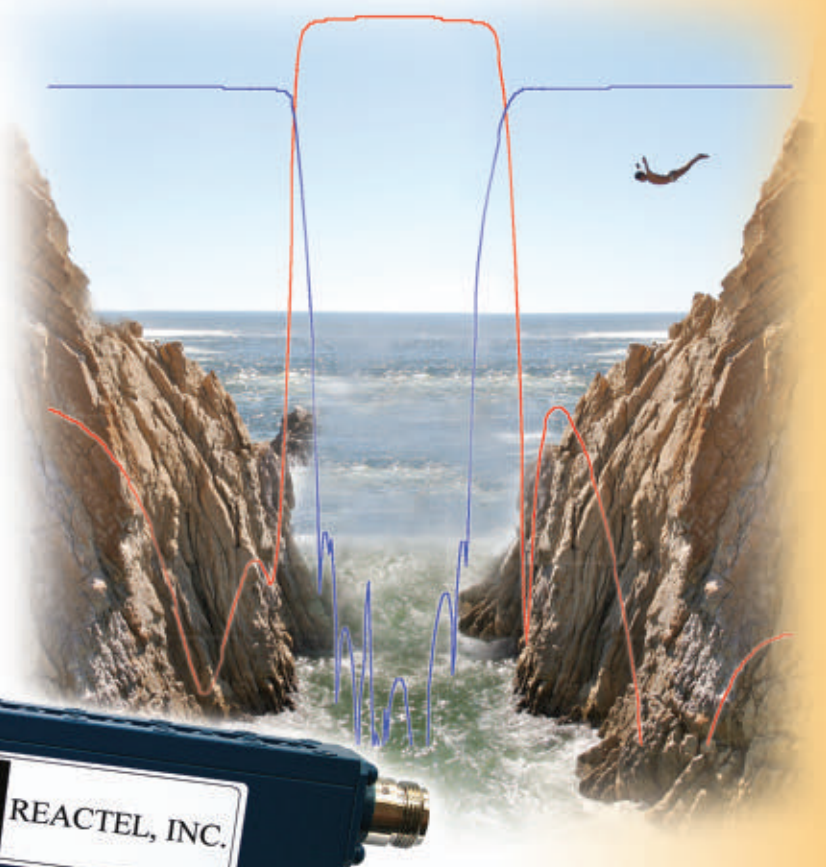
Reactel, Incorporated

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.

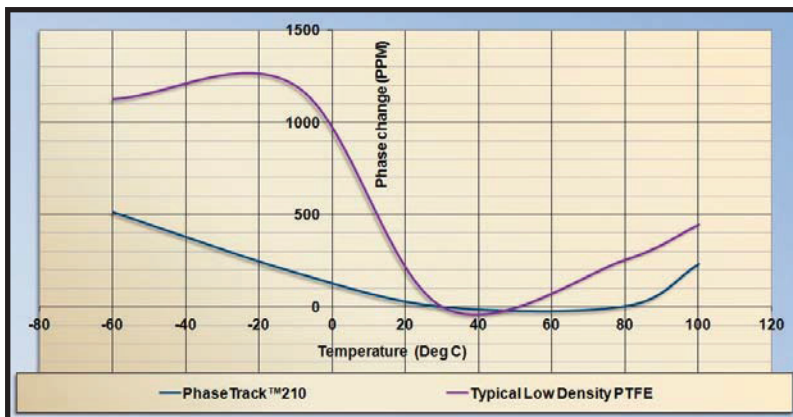


@reacteljim

Phase Knee a Problem?



Solve it quickly with **PhaseTrack®**



Eliminate that chronic phase change knee at room temperature with the ultimate in phase stability: **PhaseTrack®**



Times Microwave TF4 dielectric material is the key ingredient, making our PhaseTrack products the best choice for phase critical interconnect applications. PhaseTrack cable dielectric was developed to eliminate the "PTFE knee" in the phase/temperature performance of cables for phase-critical applications.

The PhaseTrack cable assembly product line consists of flexible cables in a range of sizes and styles, using TF4 dielectric technology.

Contact us today and we'll help solve your knee problem!



GSA Confirms LTE is Mainstream

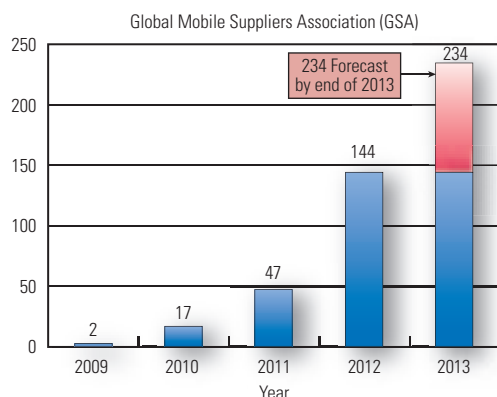
The Evolution to LTE Report (January 8, 2013) produced by the Global mobile Suppliers Association (GSA) confirms that 145 operators have launched commercial services in 66 countries. According to the report, 97 networks were commercially launched during 2012 and LTE-enabled mobile broadband services are available in 37 more countries than 12 months ago. One hundred and four new operators committed over the past year to investing in LTE network deployments, raising the total number of committed operators to 330 in 104 countries and the GSA forecasts that 234 LTE networks will be commercially launched in 83 countries by the end of 2013.

Alan Hadden, president of the GSA, said: "With 145 LTE networks commercially launched and over 560 user devices announced in the market supporting millions of customers worldwide, LTE technology is mainstream and firmly established as the fastest developing mobile system technology ever."

The majority of network deployments use the FDD mode of the LTE standard, operating in paired spectrum. 1800 MHz (3GPP band 3) has emerged as the dominant band for LTE network deployments in virtually all regions of the world. The report confirms that 58 operators, i.e., 40 percent of all commercial LTE operators, use 1800 MHz spectrum either as a single band system, or as part of a multi-band deployment, in 39 countries. At least another 22 LTE 1800 network deployments are in progress in the Asia Pacific region, Europe, the Middle East, Africa and Latin America.

The second most popular band in which LTE systems are deployed is 2.6 GHz (band 7). The TDD mode of the LTE standard has also gained strong traction and interest across the world. A total of 13 operators have launched commercial services using LTE TDD, which is the optimal solution for use in unpaired spectrum. Six TDD systems are deployed in band 38 (2.6 GHz), five systems are in band 40 (2.3 GHz) and there is one deployment each in band 41 (2.5 GHz) and bands 42/43 (3.5 GHz).

**Commercial LTE Network Launches
Cumulative Totals**



Source of Data: GSA Evolution to LTE report – January 8, 2013
www.gsacom.com

New Partnership to Support UK Defence Industry

The Defence Growth Partnership (DGP) is a new partnership between industry and government. The UK government, working closely with industry, is determined to support the sector and already plays a leading role in promoting defence exports and encouraging defence SMEs. The DGP will continue this work but will also look at how links between civil and military technologies can be better exploited. In addition, it will look at the skills required for the sector and how there can be more flexibility in the workforce between the defence sector and advanced manufacturers.

The UK's defence industry is a significant contributor to the UK's economy, contributing more than £22 billion of annual revenues, of which £5.4 billion is from exports. It directly employs more than 107,000 people.

UK business minister Michael Fallon said, "The UK's defence sector is world class – employing the latest technology and advanced engineering to products relied upon by armed forces around the world.

In doing so, it provides many thousands of highly skilled jobs in the UK and is an important part of the nation's industrial base. Along with other parts of the economy, the sector is facing tough times. This new partnership between government and industry will help address the barriers to growth for the sector."

"The MoD has active engagement with the defence industry which faces testing times as defence budgets come under pressure across the world."

UK minister for defence equipment, support and technology Philip Dunne commented, "The MoD has active engagement with the defence industry which faces testing times as defence budgets come under pressure across the world. It is important for government and business to understand each other and work together. The Defence Growth Partnership will help us to confront these challenges and build on existing relationships and industry successes to date – helping the UK defence industry maintain its position as the world's second largest exporter of new defence products and services."

Cisco and NXP Invest in Cohda Wireless to Enable the Connected Car

Cisco and NXP Semiconductors have each made an investment in Cohda Wireless to advance intelligent transportation systems (ITS) and car-to-X communications. The investment brings together the expertise of the three organizations to make the Internet of Everything



International Report

a reality for the automotive industry, creating a safer and more enjoyable driving experience while improving the traffic flow.

Car-to-car (C2C) and car-to-infrastructure (C2I) communications enable active safety systems and C2I communication holds great potential for ITS management and reducing greenhouse gas emissions from vehicles. C2C and C2I communications require highly reliable and secure data exchange between fast moving vehicles and infrastructure in a range of conditions.

*...make the
Internet of
Everything a reality
for the automotive
industry...*

NXP and Cohda Wireless have built a market-ready, flexible wireless communication solution for onboard-units based on Cohda's existing advanced radio technology. This makes it a key element to connect to Cisco's vision of a ubiquitous and highly-secure Internet of Everything. Onboard and road side units developed using technologies from the three companies have been tested to global standards in major field trials.

The three companies will apply their collective expertise and technologies to help automotive OEMs, suppliers, enterprises and consumers to connect vehicles with ITS

infrastructure. This will be spearheaded by producing the first automotive-qualified IEEE 802.11p products for on-board and road side units that are ready for C2C and C2I deployments across the globe.

EURIPIDES Announces 2013 Spring Call

EURIPIDES, the EUREKA cluster for smart systems and electronic systems integrated in packaging, launched its 2013 Spring Call for project proposals. A first project outline is to be presented by February 26, 2013, while the deadline for the submission of full project proposals by potential participants is May 16, 2013.

Along with CATRENE, ITEA2 and Celtic+, EURIPIDES is one of the four EUREKA clusters in information and communication technologies (ICT). The markets that the Spring Call addresses include communication, automotive industry, aeronautics, secure societies, advanced manufacturing, health (medical) and green energy.

EURIPIDES launches two calls per year in order to facilitate the application process for potential partners in a project and grants access to public funding for successful applicants. All 40 EUREKA member countries and associated countries can financially support EURIPIDES projects. Partners are funded directly by their respective governments, according to national procedures.

TESEQ, IFI & MILMEGA – RF, MICROWAVE & TWT EXPERTS AMPLIFIERS 10 KHz – 40 GHz UP TO 10 kW

Three strong brands joined forces in 2012 under the Teseq umbrella to offer the industry's widest product range: Teseq, IFI and Milmega! Our product portfolio includes Milmega's famous solid state microwave amplifiers, Teseq's rugged Class A power amplifiers and IFI's high power RF solid state and Tetrode tube amplifiers, as well as their well-known TWT amplifiers up to 40 GHz. Teseq now covers any application in the EMC, telecommunications and defense industries. Our strong global service network with local accredited calibration labs ensures fast turn-around for calibration and repair. We back our commitment to quality and reliability with a warranty up to 5 years.

Teseq – IFI – Milmega, the new power amplifier team to remember!

What we offer:

- Amplifiers for EMC, ISM, telecom and defense
- Solid-state class A and class AB models
- CW, pulsed and combined TWT amplifiers
- Tetrode tube amplifiers

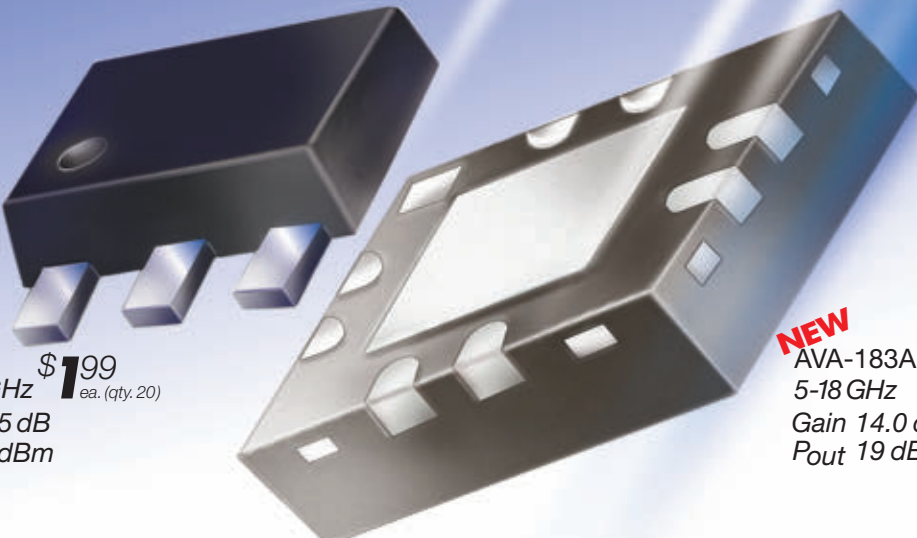
What makes us unique:

- Rugged, reliable design for EMC testing with any load
- Higher power at lower frequency to compensate for antenna gain
- Compact design with modular architecture
- Up to 5 years warranty
- Local service through Teseq's own service organizations



50 MHz to 18 GHz

NOW, JUST TWO AMPLIFIERS COVER IT ALL!



PHA-1+ \$1.99
0.05-6 GHz ea. (qty. 20)
Gain 13.5 dB
Pout 22 dBm

NEW AVA-183A+ \$6.95
5-18 GHz ea. (qty. 20)
Gain 14.0 dB
Pout 19 dBm

The **PHA-1+** is a highly advanced E-PHEMT amplifier poised to be the workhorse for your wireless applications! An ultra-high dynamic range, low noise, and exceptional IP3 performance (42 dBm typical at 2 GHz), make it ideal for LTE or TD-SCDMA (see website for ACLR and EVM data). Good input and output return loss—across almost 7 octaves—extend its use to CATV, wireless LANs, base station infrastructure, and more, with no external matching required for 50 Ω systems!

Our new **AVA-183A+** delivers excellent gain flatness (+/-1.0 dB) across its entire frequency range! High isolation (37 dB typical) makes it very useful as a buffer amplifier in a wide variety of applications, from satellite to P2P, EWF, & radar—with no external matching required for 50 Ω systems. Just go to minicircuits.com for electrical, mechanical, & environmental specifications, performance curves, and S-parameters—these models are in stock and ready to ship today!

 RoHS compliant

Keep a few extras on hand! Order Designer Kit K1-AVA+, and get 10 of each for only \$88.95!

Mini-Circuits...we're redefining what VALUE is all about!

 **Mini-Circuits®**
ISO 9001 ISO 14001 AS9100

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

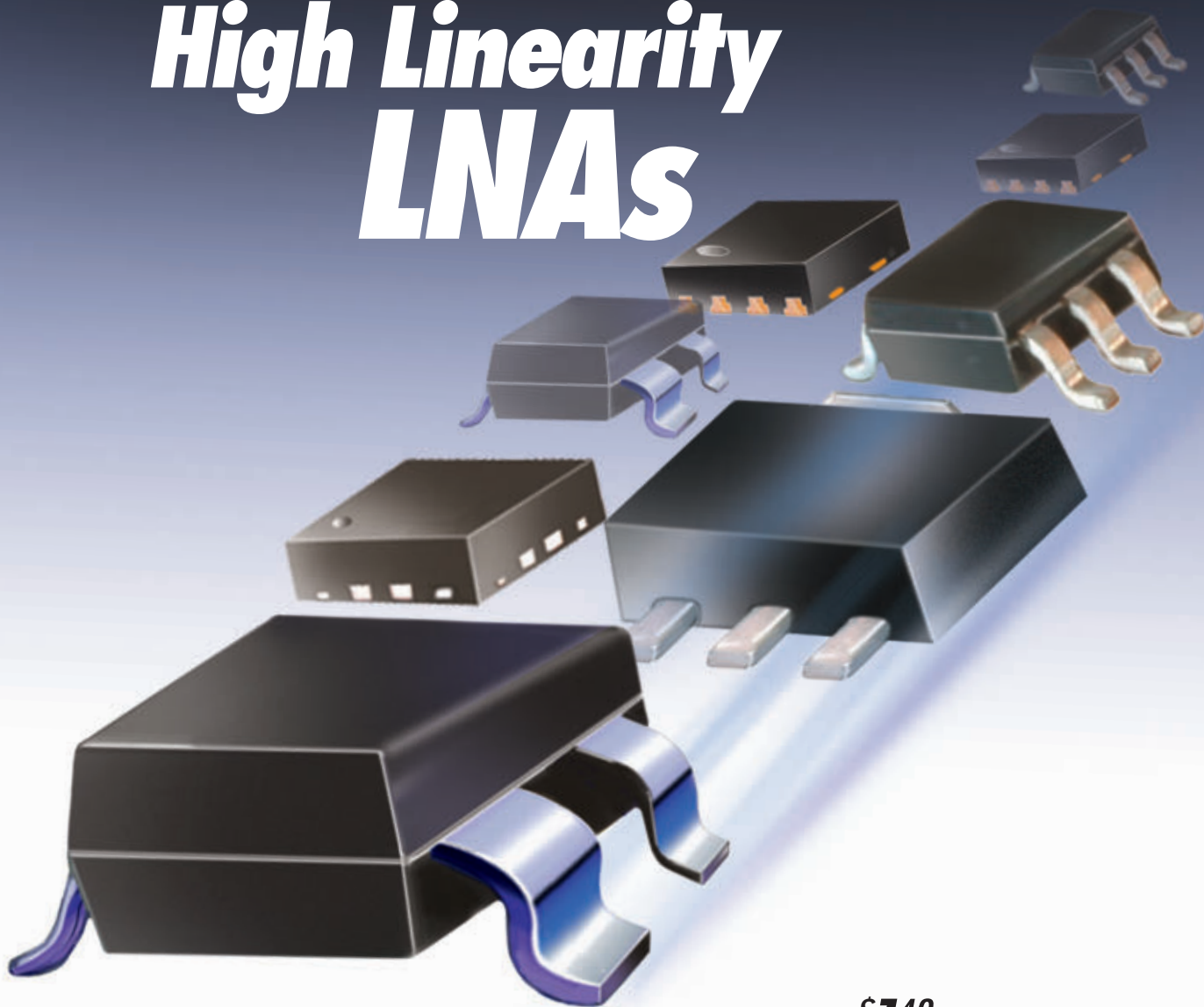

U.S. Patents
7739260, 7761442

The Design Engineers Search Engine finds the model you need, Instantly • For detailed performance specs & shopping online see minicircuits.com

IF/RF MICROWAVE COMPONENTS

478 rev J

High Linearity LNAs



\$149

NF as low as 0.5 dB • IP3 up to 43 dBm • DC current 20 mA and up from **1** ea. (qty. 20)

Pick your parameters, and meet your needs at Mini-Circuits!

With over 20 low noise/high linearity amplifier models to choose from, you'll likely find the output power, gain, DC current, and broad bandwidths required to upgrade almost any 3-to-5V circuit—from cellular, ISM, and PMR to wireless LANs, military communications, instrumentation, satellite links, and P2P—and all at prices that preserve your bottom line!

Our catalog models are in stock and ready to ship, so why wait? Go to minicircuits.com for all the details, from data sheets, performance curves, and S-parameters to material declarations, technical notes, and small-quantity reels—as few as 20 pieces, with full leaders and trailers. Place an order today, and see what these tiny, high-performance amplifiers can do for your application, as soon as tomorrow!

RoHS compliant

Model	Freq. (MHz)	Gain (dB)	NF (dB)	IP3 (dBm)	P _{out} (dBm)	Current (mA)	Price \$ (qty. 20)
PMA2-162LN+	700-1600	22.7	0.5	30	20	55	2.87
PMA-5452+	50-6000	14.0	0.7	34	18	40	1.49
PSA4-5043+	50-4000	18.4	0.75	34	19	33 (3V) 58 (5V)	2.50
PMA-5455+	50-6000	14.0	0.8	33	19	40	1.49
PMA-5451+	50-6000	13.7	0.8	31	17	30	1.49
PMA2-252LN+	1500-2500	15-19	0.8	30	18	25-55 (3V) 37-80 (4V)	2.87
PMA-545G3+	700-1000	31.3	0.9	33	22	158	4.95
PMA-5454+	50-6000	13.5	0.9	28	15	20	1.49



Model	Freq. (MHz)	Gain (dB)	NF (dB)	IP3 (dBm)	P _{out} (dBm)	Current (mA)	Price \$ (qty. 20)
PGA-103+	50-4000	11.0	0.9	43	22	60 (3V) 97 (5V)	1.99
PMA-5453+	50-6000	14.3	0.7	37	20	60	1.49
PSA-5453+	50-4000	14.7	1.0	37	19	60	1.49
PMA-5456+	50-6000	14.4	0.8	36	22	60	1.49
PMA-545+	50-6000	14.2	0.8	36	20	80	1.49
PSA-545+	50-4000	14.9	1.0	36	20	80	1.49
PMA-545G1+	400-2200	31.3	1.0	34	22	158	4.95
PMA-545G2+	1100-1600	30.4	1.0	34	22	158	4.95
PSA-5455+	50-4000	14.4	1.0	32	19	40	1.49

Mini-Circuits...we're redefining what VALUE is all about!

Mini-Circuits®
ISO 9001 ISO 14001 AS9100

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

Yeni2
U.S. Patents
7739260, 7761442

The Design Engineers Search Engine finds the model you need, Instantly • For detailed performance specs & shopping online see minicircuits.com

IF/RF MICROWAVE COMPONENTS

506 rev C



Worldwide Pay-TV Subscriber to Reach 907 Million

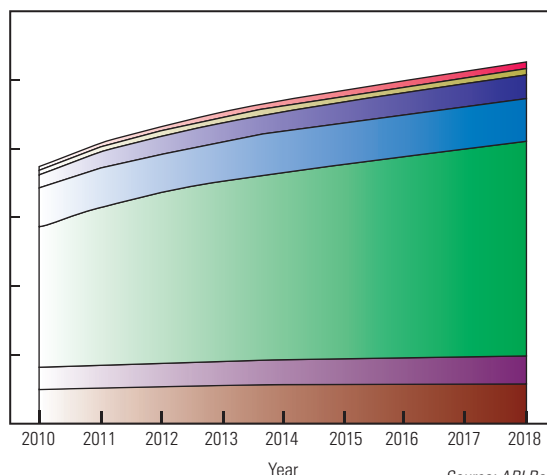
Global pay-TV market added nearly 47 million subscribers in 2012, reaching a total of 864 million subscribers. “The growth in satellite, cable and IPTV markets was strong, although digital terrestrial TV growth was flat in 2012. ABI Research expects that the pay-TV market will continue to grow in 2013 to reach 907 million subscribers,” said Jake Saunders, VP and practice director of core forecasting.

Worldwide IPTV subscriber base has been increasing rapidly over the past few years. In 2013, the worldwide IPTV subscriber base is expected to add over 9 million subscribers to reach 79.3 million. More than half of the net addition will be from Asia-Pacific; China alone is expected to add more than 3 million subscribers.

The cable TV market will remain strong, especially due to the growth in Asian Pacific markets such as China and India. Cable TV will maintain the largest market share of the overall pay-TV market in 2013. However, rapidly growing IPTV will cause cable’s market share to decline to 65.4 percent in 2013 from 66.2 percent in 2012.

At present, 33 percent of worldwide pay-TV subscribers are using High Definition (HD) TV services. HDTV penetration is the highest in North America followed by Western Europe; accounting for 84 percent and 76 percent of total pay-TV subscriptions respectively. As many of the countries in different regions are trying to switch over to digital transmission, the number of HD channels and packages offered by the operators increase. “Worldwide HD service adoption is expected to grow. ABI Research forecasts that 38 percent of global pay-TV subscribers will be subscribing to HDTV services in 2013,” noted Khin Sandi Lynn, research analyst.

**Pay-TV Subscribers by Geography
World Market, Forecast: 2010-2018**



An Estimated 103 Million 4G LTE Mobile Devices Shipped in 2012

Apple’s iPhone 5 and Samsung’s Galaxy smartphones have provided LTE-enabled handset shipments a substantial lift in 2012 – even if it has not necessarily assisted the 4G mobile operators with “each and every” LTE handset sold. When 3G handsets came into the market in 2003 and 2004, there was pretty much a 1:1 correlation between a 3G handset sold and a subscription upgraded from 2G to 3G. “That is not happening with every LTE handset sale,” said Jake Saunders, VP of forecasting at ABI Research. “But carriers should not be panicking – it is seeding the market with 4G handsets. A number of purchasers are simply coveting their favorite ‘brand’ and/or carrying out a much needed update to one of their key fashion accessories.”

All this purchasing momentum is expected to have boosted LTE-enabled handsets to 91 million units by YE-2012 and the balance coming from other mobile devices. Almost 95 percent of handsets shipped can be attributed to the North American and Asia-Pacific market. LTE USB dongles may have found their way under the Christmas tree for consumers and also put on IT Department Purchase Orders for businesses, but at 6 million units, it was overshadowed by LTE smartphone sales. Media tablet sales are proving robust. However ABI Research estimate only 3.35 million media tablets shipped with LTE since the majority of media tablet purchasers are proving price sensitive and happy to settle for Wi-Fi-only.

“New sign-ups and conversion of 3G subscribers with LTE-capable handsets should gather pace in 2013 and 2014. By 2017 we are anticipating 785 LTE million subscribers, up from 58 million at the end of 2012 – generating US\$14 billion in annual service revenues,” added Phil Solis, research director.

WiGig Alliance Endorses Publication of IEEE 802.11ad Standard

The Wireless Gigabit (WiGig) Alliance, which formally contributed to the IEEE 802.11ad standard process, has heralded its publication as a critical moment in bringing a global wireless ecosystem of interoperable, high performance devices that work together seamlessly.

“We congratulate IEEE and the WiGig member companies on the completion and publication of the 802.11ad standard and look forward to seeing its adoption across the industry,” said Ali Sadri, president and chairman of the WiGig Alliance. “Our members have worked closely with IEEE on developing the standard. We are excited to say that the WiGig MAC/PHY specification is completely aligned with the published 802.11ad standard. Gaining approval from a global standardization body gives WiGig Alliance additional international



Commercial Market

recognition and moves us one step closer to widespread industry adoption.”

WiGig is on track to become the most important next generation wireless networking technology. Speeds of up to 7 Gbps using the unlicensed 60 GHz frequency band, combined with advanced protocol adaption layers (PAL), will mean its applications go beyond that of a straight forward access technology. The same implementation of a WiGig Alliance PAL specification can operate on top of the published 802.11ad standard or the WiGig MAC/PHY specification.

Femtocell Bounce in 2H 2012 Suggests Market Could Be Turning a Corner

While the femtocell market struggled in the first half of 2012, the market has bounced back in the second half of the year. ABI Research's latest femtocell forecast update suggests that 2012 ended up with shipments reaching slightly above 2 million units. The shipments in the second half more than doubled from the first half, making up for some of the lost momentum.

The forecast covers the enterprise and consumer femtocells market, with enterprise femtocells making up one-third of the total shipments. On the other hand, revenues

from enterprise femtocells made up to two-thirds of the total revenue for femtocell access points. Airvana, Alcatel-Lucent, and NEC/Ubiquisys remained the top vendors in terms of shipments, making up 78 percent of the total shipments in 2012.

“The appetite for femtocells continues to persist as suggested by this second half bounce, which can be attributed largely to inventory levels needing a refresh, but also due to renewals of contracts driven by newer versions of access points. This is also evident in the continued growth in contracts which have reached a total of 130 globally, as per our estimates,” says Aditya Kaul, practice director, mobile networks.

Kaul adds, “The lack of operator willingness to use femtocells as a competitive network quality differentiator, rather than a defensive churn reduction tool, continues to plague the market. Nevertheless, it is encouraging to see demand back up, with new markets such as Latin America and Russia lighting up. Competitive factors in certain markets are causing domino effects with one operator leading and the others following. This is enough to keep the momentum going forward, with new business models, like femtocells as a service, adding to that momentum and bringing lower tier operators into the fold. Overall the market looks like it might be turning a corner.”

COST-EFFECTIVE HERMETIC MICRO D CONNECTORS

Standard 9 to 51 pin configurations available
or let us design to your custom requirements



SPECIAL HERMETIC PRODUCTS, INC.

Hi-Rel By Design

CONTACT US TODAY

(P) 603-654-2002 (F) 603-654-2533

www.shp-seals.com email: sales@shp-seals.com

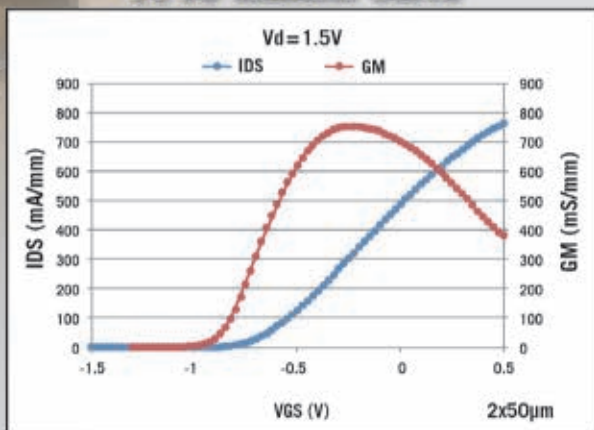
CERTIFIED ISO 9001:2008



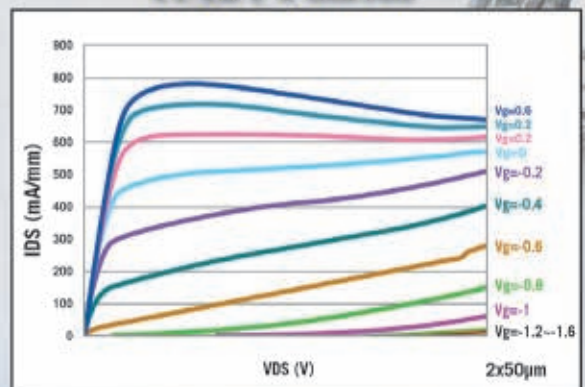
PP10-10/-11 0.1 μ m Power pHEMT

- 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

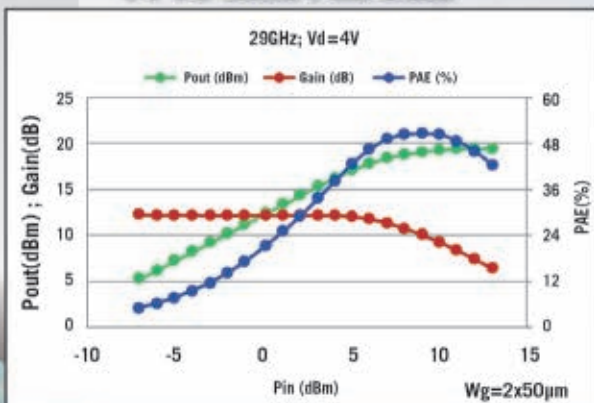
PP10 Transfer Curve



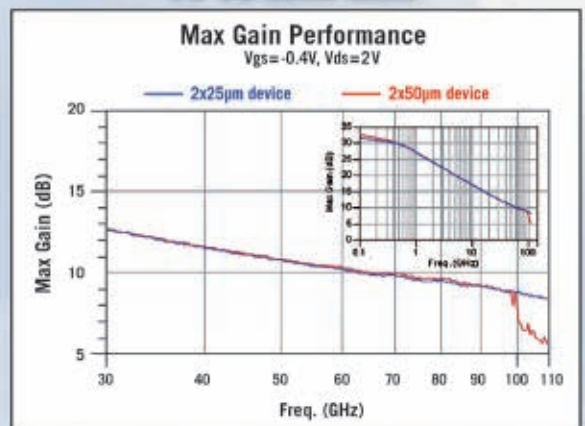
PP10 I-V Curves



PP10 Load Pull Data



PP10 Max Gain





Around the Circuit

Laura Glazer, Staff Editor

MERGERS & ACQUISITIONS

ITT Exelis has signed a definitive agreement to acquire **C4i Pty. Ltd.** (C4i) based in Melbourne, Australia, from the **Longreach Group Ltd.** for an enterprise value of approximately USD 16.8 million. Pending Longreach Group shareholder approval, the transaction is expected to close in the first quarter of 2013 subject to customary closing conditions and regulatory approvals. The acquisition is not material to Exelis 2012 results. C4i provides advanced communications software that is central to the needs of air traffic management systems and mobile communications solutions for commercial, homeland security and defense systems around the globe.

COLLABORATIONS

Cobham has been selected by **Inmarsat** as a “Launch Partner” to provide land-based satellite communication terminal antennas specifically designed to support the global service introduction of Inmarsat’s Global Xpress® (GX) network. Cobham will ensure availability of its GX land terminals at service introduction of the new Ka-Band satellite network, which will be the first to provide global superfast broadband.

Ericsson has helped **MTN South Africa** launch a commercial LTE network which will be rolled out across the country. Along with its RBS 6000 family of base stations, the company is supplying the Evolved Packet Core, Home Subscriber Server (HSS) for user data management, Operating Support Systems (OSS), project management and services. This is the first commercial LTE network built by Ericsson in Africa and the launch comes after the pilot network has been running for more than a year.

NEW STARTS

Boeing has developed an advanced method to test wireless signals in airplane cabins, making it possible for passengers to enjoy more reliable connectivity when using networked personal electronic devices in the air. Boeing engineers created a new process for measuring radio signal quality using proprietary measurement technology and analysis tools. This enables engineers to more efficiently measure how strong a signal is and how far it spreads, ensuring safe yet powerful signal penetration throughout an airplane cabin. Once the new method was established, testing that previously took more than two weeks to conduct was reduced to 10 hours.

The **New America Foundation’s** Open Technology Institute (OTI) has completed the first phase of construction on a next generation wireless network located in the Cass Corridor section of Detroit, MI. OTI will use the Detroit network to test Commotion — a new, open-source wireless technology — ahead of its public release in early 2013. The Detroit Commotion testbed is supported by a grant from the John S. and James L. Knight Foundation,

whose mission is to promote informed and engaged communities, and by the U.S. Department of State, which sees the potential of the technology in places like Egypt or Syria where dictators have cut off access to the Internet.

PCTEL Inc. announced that it is combining the Antenna Products Group and Connected Solutions into PCTEL Connected Solutions. The consolidation of the company’s product and service groups into two businesses reflects the similarity in customers and focus between the scanning receiver business and network services and, similarly, the shared customers and product solutions between Connected Solutions (formerly Telworx) and the Antenna Products Group. The company anticipates that PCTEL Connected Solutions will contribute approximately 70 to 80 percent of the total revenue in 2013 with RF Solutions contributing the balance.

AWARDS

Rogers Corp. announced that it has received the 2012 Innovation Excellence Award from the Connecticut Technology Council (CTC). The annual award recognizes significant technology leadership and innovation by Connecticut-based technology companies. Rogers is the ninth company to receive the Innovation Excellence Award from CTC, Connecticut’s industry association for the technology sector. Previous winners include ATMI Inc. of Danbury, Pitney Bowes of Stamford, FuelCell Energy of Danbury, Open Solutions Inc. of Glastonbury, Sonalysts Inc. of Waterford, United Technologies Corp. of Bristol, and Tangoe Inc. of Orange.

STMicroelectronics has been awarded the prestigious 2012 Corporate Award from the IEEE Standards Association (IEEE-SA) in recognition of its outstanding leadership and contributions to the development and advancement of standards in electrical and electronics engineering. In addition to making technical contributions, ST holds membership on the IEEE-SA Corporate Advisory Group, and has employees who hold individual memberships on the IEEE-SA Standards Board and the IEEE-SA Strategic Planning & Portfolio Management Committee.

CONTRACTS

Harris Corp. has been awarded an \$85 million indefinite delivery, indefinite quantity (IDIQ) contract to provide the **U.S. Air Force** with Falcon multiband manpack tactical radios and accessories. In conjunction with the contract, Harris also received initial delivery orders of \$33 million. The company has also received a \$7 million order to deliver Falcon® tactical radios to a nation in Central Asia. The radios will provide interoperable communications to support the International Security Assistance Force in Afghanistan.

Raytheon BBN Technologies has been awarded \$16 million under the Deep Exploration and Filter of Text

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



HIGH POWER

PRODUCTS

POWER DIVIDERS

Model #	Frequency (MHz)	Insertion Loss (dB) [Typ./Max.] [◊]	Amplitude Unbalance (dB) [Typ./Max.]	Phase Unbalance (Deg.) [Typ./Max.]	Isolation (dB) [Typ./Min.]	VSWR (Typ.)	Input Power (Watts) [Max.] *	Package
2-WAY								
CSBK260S	20 - 600	0.28 / 0.4	0.05 / 0.4	0.8 / 3	25 / 20	1.15:1	50	377
DSK-729S	800 - 2200	0.5 / 0.8	0.05 / 0.4	1 / 2	25 / 20	1.3:1	10	215
DSK-H3N	800 - 2400	0.5 / 0.8	0.25 / 0.5	1 / 4	23 / 18	1.5:1	30	220
P2D100800	1000 - 8000	0.6 / 1.1	0.05 / 0.2	1 / 2	28 / 22	1.2:1	5	329
DSK100800	1000 - 8000	0.6 / 1.1	0.05 / 0.2	1 / 2	28 / 22	1.2:1	20	330
DHK-H1N	1700 - 2200	0.3 / 0.4	0.1 / 0.3	1 / 3	20 / 18	1.3:1	100	220
P2D180900L	1800 - 9000	0.4 / 0.8	0.05 / 0.2	1 / 2	27 / 23	1.2:1	5	331
DSK180900	1800 - 9000	0.4 / 0.8	0.05 / 0.2	1 / 2	27 / 23	1.2:1	20	330
3-WAY								
S3D1723	1700 - 2300	0.2 / 0.35	0.3 / 0.6	2 / 3	22 / 16	1.3:1	5	316

◊ In excess of theoretical split loss of 3.0 dB
* With matched operating conditions

HYBRIDS

Model #	Frequency (MHz)	Insertion Loss (dB) [Typ./Max.] [◊]	Amplitude Unbalance (dB) [Typ./Max.]	Phase Unbalance (Deg.) [Typ./Max.]	Isolation (dB) [Typ./Min.]	VSWR (Typ.)	Input Power (Watts) [Max.]	Package
90°								
DQS-30-90	30 - 90	0.3 / 0.6	0.8 / 1.2	1 / 3	23 / 18	1.35:1	25	102SLF
DQS-3-11-10	30 - 110	0.5 / 0.8	0.6 / 0.9	1 / 3	30 / 20	1.30:1	10	102SLF
DQS-30-450	30 - 450	1.2 / 1.7	1 / 1.5	4 / 6	23 / 18	1.40:1	5	102SLF
CSDK3100S	30 - 1000	0.8 / 1.2	0.05 / 0.2	0.2 / 3	25 / 18	1.15:1	50	378
DQS-118-174	118 - 174	0.3 / 0.6	0.4 / 1	1 / 3	23 / 18	1.35:1	25	102SLF
DQK80300	800 - 3000	0.2 / 0.4	0.5 / 0.8	2 / 5	20 / 18	1.30:1	40	113LF
MSQ80300	800 - 3000	0.2 / 0.4	0.5 / 0.8	2 / 5	20 / 18	1.30:1	40	325
DQK100800	1000 - 8000	0.8 / 1.6	1 / 1.6	1 / 4	22 / 20	1.20:1	40	326
MSQ100800	1000 - 8000	0.8 / 1.6	1 / 1.6	1 / 4	22 / 20	1.20:1	40	346
MSQ-8012	800 - 1200	0.2 / 0.3	0.2 / 0.4	2 / 3	22 / 18	1.20:1	50	226
180° (4-PORTS)								
DJS-345	30 - 450	0.75 / 1.2	0.3 / 0.8	2.5 / 4	23 / 18	1.25:1	5	301LF-1

◊ In excess of theoretical coupling loss of 3.0 dB

COUPLERS

Model #	Frequency (MHz)	Coupling (dB) [Nom.]	Coupling Flatness (dB)	Mainline Loss (dB) [Typ./Max.]	Directivity (dB) [Typ./Min.]	Input Power (Watts) [Max.] *	Package
KDS-30-30	30 - 512	27.5 ± 0.8	± 0.75	0.2 / 0.28	23 / 15	50	255 *
KFK-10-1200	10 - 1200	40 ± 0.75	± 1.0	0.4 / 0.5	22 / 15	150	376
KBS-10-225	225 - 400	10.5 ± 1.0	± 0.5	0.6 / 0.7	25 / 18	50	255 *
KDS-20-225	225 - 400	20 ± 1.0	± 0.5	0.2 / 0.4	25 / 18	50	255 *
KBK-10-225N	225 - 400	10.5 ± 1.0	± 0.5	0.6 / 0.7	25 / 18	50	110N *
KDK-20-225N	225 - 400	20 ± 1.0	± 0.5	0.2 / 0.4	25 / 18	50	110N *
KEK-704H	850 - 960	30 ± 0.75	± 0.25	0.08 / 0.2	38 / 30	500	207
SCS100800-10	1000 - 8000	10.5 ± 1.5	± 2.0	1.2 / 1.8	8 / 5	25	361
KBK100800-10	1000 - 8000	10.5 ± 1.5	± 2.0	1.2 / 1.8	8 / 5	25	322
SCS100800-16	1000 - 7800	16.8 ± 1.5	± 2.8	0.7 / 1	14 / 5	25	321
KDK100800-16	1000 - 7800	16.8 ± 1.5	± 2.8	0.7 / 1	14 / 5	25	322
SCS100800-20	1000 - 7800	20.5 ± 2.0	± 2.0	0.45 / 0.75	12 / 5	25	321
KDK100800-20	1000 - 7800	20.5 ± 2.0	± 2.0	0.45 / 0.75	14 / 5	25	322

* Add suffix - LF to the part number for RoHS compliant version.
* With matched operating conditions

Unless noted, products are RoHS compliant.



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

(DEFT) program, sponsored by the **Defense Advanced Research Projects Agency** (DARPA) and the **U.S. Air Force Research Laboratory**. Drawing on decades of experience in speech and language technologies, Raytheon BBN scientists will tackle two significant goals of the DEFT program: to develop new techniques to infer meaning, discover relationships, and detect anomalies in text; and to research and develop tools

to integrate new, individual facts into existing large information stores.

XTAR LLC has gained significant contracts in the growing airborne intelligence, surveillance, and reconnaissance (AISR) market over the last 12 months. These contracts represent more than 100 MHz of bandwidth and are valued at more than \$8 million. Under these various contracts, XTAR will provide high-powered X-Band capacity on its XTAR-LANT and XTAR-EUR payloads to support critical services on manned aircraft using advanced antennas designed specifically

for airborne applications. This capacity will provide service over a coverage area extending from North and South America to Africa and the Middle East. Contract terms vary from six months to as long as 72 months.

API Technologies Corp. has received a \$1 million order to provide electromagnetic integrated solutions (EIS) for a major military radio program. This order includes both filtered and unfiltered specialty connectors and will be used in multiple radio configurations for both U.S. and foreign military sales. No additional information is available due to the secure nature of this program.

NEC Corp. has signed a global framework contract with **Telenor**, Norway's leading fixed and mobile telecommunications operator, for the supply of its compact iPASOLINK microwave communications system, including the '5000ips' long-haul, large capacity microwave system and related services such as installation and commissioning. Additionally, NEC Corp. announced that **NEC Europe Ltd.**, a wholly owned subsidiary, has signed a multi-million, multi-year global framework contract giving **Tele2 Sverige AB** the possibility to expand and upgrade its mobile access network in 10 countries across Europe. Starting in Russia, NEC will provide its iPASOLINK series of microwave radio solutions, training and maintenance support services.

Ducommun Inc. announced that it has received a contract from **The Boeing Co.** to produce titanium detail components and subassemblies for the Boeing 787 Dreamliner. Under the terms of the contract, production on the titanium assemblies will continue at the Ducommun AeroStructures facility in Cocksackie, NY.

PEOPLE

H. Richard (Dick) Johnson, co-founder of **Watkins Johnson Co.**, died December 9th surrounded by his loving family. Johnson and Dean Watkins began the Watkins-Johnson Co. in 1957 with Watkins as president and Johnson as VP. In 1987, when Johnson stepped down after 10 years as president and CEO to vice chairman of the board, W-J had about 3100 employees and annual sales of \$264 million. Johnson was an electri-

Microwave Sub-Assemblies
Advanced Innovative Designs
Custom Unique Designs
Rapid In Your System Today

Microwave Frequency Bands
L, S, C, X, Ku, K, Ka, Q, U, V
Frequencies up to 67 GHz

Advance Your System
With Our Microwave Circuit Designs
Amplifiers • Oscillators •
Filters • Up/Downconverters •
Variable Attenuators • PLLs and more ...
Analog, Digital, and
Control Functions

Phase Matrix, Inc.
A National Instruments Company

109 Bonaventura Drive
San Jose CA 95134
Tel: 408-428-1000
Fax: 408-428-1500
Web: www.phasematrix.com

THE CENTER FOR ALL YOUR RF DESIGNS

RFMW Ltd. is a premier RF & Microwave specialty distributor created to support your component selection, technical design and fulfillment needs. RFMW offers a complete range of services for commercial, military, and space requirements.

RFMW is a cut above the typical distributor.

We understand your need for on-time delivery and value because we face the same issues on a daily basis. Our focus on RF devices and technology enables us to meet your expectations with the highest service levels.

RFMW Value-Added Services.

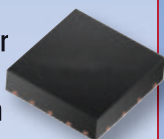
We provide many value-added services driven by customer requirements — because we know RF and microwave.

- DIE Services • Packaging • Electrical Test Capabilities
- Device Tape & Reel • Kitting • Hi-Rel Screening
- Solder Tinning • Documentation Related Services
- Obsolete Parts Replacement • Custom Product Development

From antenna to baseband, RFMW is the center for all your RF designs. Contact RFMW today or visit our website.

RF SWITCHES

- SPnT
- Semiconductor
- Mechanical
- High Isolation
- High Power
- GaN • Die



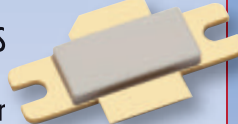
RF AMPLIFIERS

- Gain Blocks
- Coaxial Module
- Low-Noise
- Linear Drivers
- High Power
- Variable Gain



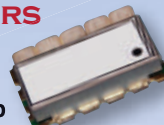
RF TRANSISTORS

- GaN
- LDMOS
- GaAs
- Bipolar
- High Power
- High Frequency



RF FILTERS

- Monoblock
- SAW / BAW
- HP / LP / BP
- Ceramic Resonator
- Duplexer / Diplexer
- Cavity



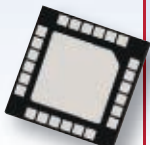
RF OSCILLATORS

- OCXO
- VCXO
- TCXO
- PLL Synthesizers
- RF Generators



RF ATTENUATORS

- Fixed
- Digital
- Coaxial
- Chip
- Voltage Variable
- Temperature Variable

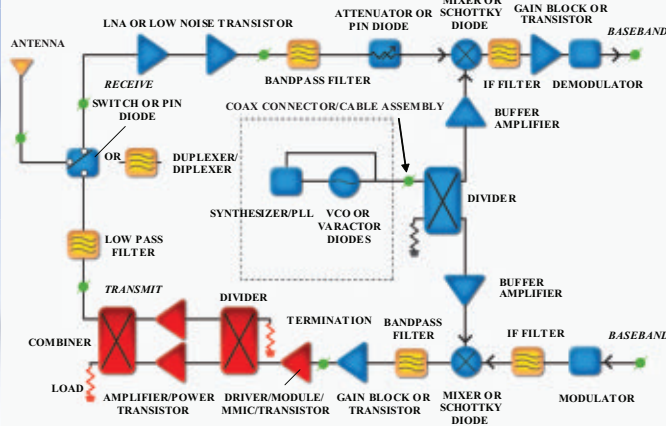


TEST & MEASUREMENT

- USB Controlled
- Signal Generators
- Power Meters
- Switches • Attenuators
- Vector Modulators
- Cable Assemblies
- Coax Components

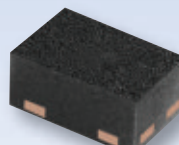


RFMW = DESIGN SOLUTIONS



RF DIODES

- PIN
- Schottky
- Varactor
- Limiter
- Gunn



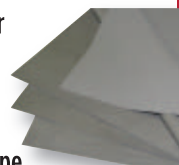
RF CABLE ASSEMBLIES

- High-Performance Test
- In-Box Solutions
- Pigtails
- Conformable
- Flexible
- Semi-Rigid



EMI / RFI

- RF Absorber
- RF Gaskets
- Wire Mesh
- Fingerstock
- Shielding Tape
- Filtration Panels
- Shielded Windows



RFMW Ltd. • 188 Martinvale Lane • San Jose, CA 95119 U.S.A.

Toll Free: +1-877-367-7369 • Fax: +1-408-414-1461 • Website: www.RFMW.com

• Canada (Western) +1-877-367-7369 • (Eastern) +1-877-367-7369 • RFMW Mexico +1-408-414-1450 • RFMW.CO.UK +44 (0) 20 8848 4732 • RFMW Italia +39 0774 689994 • RFMW Deutschland +49 (0) 8233 738 747 • RFMW Europe Ltd +44 20 8848 4732 • RFMW France +33 1 83 64 53 97 • RFMW Israel Ltd. +972 9 740 6884 •

Around the Circuit

cal engineering lecturer at UCLA and Stanford and served on panels of the National Security Agency Scientific Advisory Board. He was an IEEE fellow and a member of the National Academy of Engineering.

The board of directors of **Empower RF Systems** has approved the creation of a new role, executive chairman of the board, and the appointment of a new CEO. **Barry Phelps**, current CEO,

will be transitioning to the role of executive chairman of the board, remaining active and involved with the company and leading the management/oversight of board responsibilities. Phelps joined the board of directors in 2007 and moved into a full time role as CEO in 2009. **Jon Jacocks** has been promoted to president and CEO of Empower RF Systems. Jacocks joined Empower in November 2007 as the company's first VP of sales and he has served in that capacity for the past five years. Related to this, **Rob Lauria**, Empower's vice president of business development, will expand his role and responsibilities

to become vice president, business development and sales.



▲ Todd Witchall

Crane Aerospace & Electronics announced the appointment of **Todd Witchall** as vice president of finance and chief financial officer of the Electronics Group of Crane

Aerospace & Electronics. In this role, Witchall will report directly to Bob Tavares, president of Crane Electronics Group. Witchall will be responsible for finance, accounting and information technology for all of the Electronics Groups locations including Beverly, MA, Chandler, AZ, Ft. Walton Beach, FL, Redmond, WA, West Caldwell, NJ, Kaohsiung, Taiwan and San Jose, Costa Rica. His primary location will be Redmond, WA.

LPKF Laser & Electronics has announced the appointment of a new COO, **Christian Bieniek**. As the fourth member of the LPKF Board of Managing Directors, Bieniek will oversee the operational performance of the company, including all management, control and organizational processes. A native of Lower Saxony, the German state that is home to LPKF worldwide headquarters, Bieniek looks forward to returning home and representing the ever-growing LPKF Group.

Coaxial Components Corp., also known as Coaxicom, announced the appointment of **Chris Feys** to the company's quality assurance team. As QA manager, Feys will have overarching responsibility for all cable and connector assembly as well as product manufacturing quality control. Feys will also play an instrumental role in administering the ISO 9001:2008 and the AS 9100C processes for the company.

EDI CON 2013 organizers have announced the selection of **Dr. Song Junde**, professor at the Beijing University of Posts and Telecommunications, as the honorary chair of the inaugural technical conference and trade exposition. Junde was chosen in recognition of his many contributions to advancing microwave technology and the



WE'RE NOT JUST SELLING COMPONENTS, WE'RE DELIVERING SOLUTIONS

Sure, we sell lots of microwave and millimeter-wave components. But, let's face it, sometimes you're not looking for just a component, you're looking to create an entire system. Come to us for the complete solution. Give us a call and talk to one of our engineers. Together we'll design the system that exactly meets your needs.

Systems and Components from 10 to 110 GHz

Exceeding the Highest Industry Standards for Performance & Quality

Serving the mm-Wave Industry for Over 30 Years.











Receivers
Transceivers
Transmitters
Switch Matrices
Block Converters
Radar Subsystems
Coherent Converters
Communication Systems
Integrated Amplifier Assemblies

212 East Gutierrez Street, Santa Barbara CA 93101 | e-mail: sales@spaceklabs.com
www.spaceklabs.com | tel (805) 564-4404 | fax (805) 966-3249

RFHIC US Corporation is rapidly growing
and looking for **new team members...**

- **Application Engineer**
- **Assembly Technicians**
- **RF Power Device Designer**
- **RF Test Engineer**

Some of our team members' previous experiences.

AVAGO
CHNOLOGIES

Alcatel-Lucent

ERICSSON

ITT

Top Academic Research Institutes

Agilent Technologies

hp

HARRIS

HUGHES

Government RF Institutes

We work as a team according to a few core principles:

1. We believe that power lies in the reasoning, not in the position, of the individual.
2. We do not wait for the resources to show up to solve the problem; when required, we become the resources we need.
3. We believe in autonomy. We hate micromanagement, and love stewardship-based delegation and empowerment.
4. We have flexible work hours. Because we only hire the best, we trust our employees to structure their schedules to meet their professional goals and personal needs.

If you share our principles, please get to know our story: visit www.rfhicusa.com to learn more about us.
Want to be a part of our future? Send your resume and inquiry to careers@rfhicusa.com



920 Morrisville Parkway, Morrisville, NC 27560, USA



RF & MW is our business & passion

US Facilities

Tel: 919-655-1121 / E-mail: sales@rfhicusa.com

RFHIC
www.rfhicusa.com

Around the Circuit



▲ Song Junde

communications industry in China. In his role as honorary chair, Junde will be consulting on the final details of the technical program and will be delivering the Welcoming Message at the keynote plenary session on March 12th.



▲ Kevin W. Kobayashi

by the IEEE board of directors. The IEEE grade of Fellow was conferred on Kobayashi in recognition for his extraordinary contributions to monolithic microwave integrated circuits (MMIC). Less than one-tenth of one percent of

RF Micro Devices Inc. announced that RFMD Fellow **Kevin W. Kobayashi** has been named a Fellow of the Institute of Electrical and Electronics Engineers (IEEE)

the total IEEE voting membership is recognized each year by the IEEE Board of Directors for elevation to IEEE Fellow.

REP APPOINTMENTS

Carlisle Interconnect Technologies announced two top tier connector distributors – **Richardson RFPD Inc.** and **RFMW Ltd.** – now have inventory and full design support capabilities for both the TMP® and WMP® Push-on Connector Series. Common configurations are in stock and available for immediate delivery.

CTS Electronic Components Inc., a global leader in ceramic, quartz and piezoelectric technologies, announced it has recently added **Carpatec Complete Component (CCC) Solutions** as the representative company for CTS Electronics Components in Sweden.

Delta Microwave, a supplier of amplifiers, filters, filter/amplifiers, multiplexers, and integrated microwave assemblies, announced the appointment of **Wavelength Sales** as the company's exclusive representative in upstate NY.

Global electronic components distributor **Digi-Key Corp.** announced an agreement to distribute **GeneSiC Semiconductor's** industry-leading silicon-carbide technologies worldwide.

Eastern OptX has appointed two new sales representatives for Europe and Canada. Effective immediately, **AR Europe** will represent Eastern OptX in all areas of Europe except Germany and Italy. In Canada, Eastern OptX has appointed **Testforce** to represent Eastern OptX in all provinces.

NuWaves Engineering has added **MicroBee Systems** as its first domestic value-added reseller. MicroBee Systems will increase exposure of NuWaves' commercial-off-the-shelf (COTS) RF module-level products in the DoD test and training range market. NuWaves' products will be offered both independently and as part of higher-level integrated system solutions by MicroBee for flight test telemetry, vehicle tracking, and remote systems monitoring and control applications.



KRYTAR®

Microwave Components & Instruments
DC to 67 GHz



Directional Couplers
to 67 GHz



3 dB 90° Hybrid Couplers
to 40 GHz



Directional Detectors
to 50 GHz



Double Arrow 3 dB 180° Hybrid Couplers
to 26.5 GHz



Detectors
Zero Bias
Schottky
Planar Doped
Barrier Planar
Tunnel Diode
Threshold Detectors
to 40 GHz



**MLDD Power Divider/
Combiner** to 45 GHz



RF & Microwave Power Meter
100 KHz to 40 GHz



Adapters: DC to 50 GHz
In Series: SMA, 2.92 mm, 2.4 mm
Between Series: 2.29 mm to 2.4 mm



Coaxial Terminations
to 50 GHz



Broadband Limiters
Pin-Pin Diode
Pin-Schottky Diode to 18 GHz

MIL Qualified Components Available

KRYTAR® 1288 Anvilwood Ave. Sunnyvale, CA 94089

Toll Free: (877) 734-5999 • Fax: (408) 734-3017 • sales@krytar.com

www.krytar.com lists complete specifications and application ideas for all products





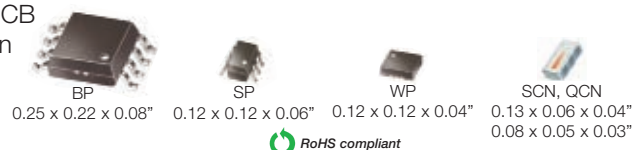
ultra small

2, 3 and 4 WAY SPLITTERS

100 kHz to 7.2 GHz from **96¢** ea. qty. 25

Choose from over a hundred models. Mini-Circuits rugged LTCC and semiconductor power splitters are available with narrowband and broadband coverage through 7200 MHz. Small in size and cost, but big on performance, they can handle as much as 20 W input power, with high isolation and low insertion loss. Yet they won't take up valuable circuit board space. Sizes as small as 0805 also contribute to minimal amplitude and phase unbalance, while retaining outstanding unit-to-unit repeatability.

Pay less and get more with our industry-leading, ultra small power splitters. They're a bottom-line plus for any economic situation, reducing costs while improving value. Just visit our website at minicircuits.com for comprehensive performance curves, data sheets, PCB layouts, and environmental specifications. You can even order direct from our web store, and have a unit in your hands as early as tomorrow!



Mini-Circuits...we're redefining what VALUE is all about!

Mini-Circuits®
ISO 9001 ISO 14001 AS9100

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

Yovi2
U.S. Patents
7739260, 7761442

The Design Engineers Search Engine finds the model you need, Instantly • For detailed performance specs & shopping online see minicircuits.com

IF/RF MICROWAVE COMPONENTS

Nurturing Design Innovation for China's Future



Guy Séné, President of Agilent Technologies' Electronic Measurement Group
Santa Clara, CA

China has undergone great change in the last decade and now stands as the world's second largest economy. Continuing this growth will require innovation in a broad range of markets. Design innovation, in particular, will be critical to China's ongoing industrial and economic development. Sometimes, however, innovation requires help. That's what the Electronic Design Innovation Conference (EDI CON) hopes to accomplish, when it debuts in March 2013 and it is what we at Agilent Technologies do on a daily basis – provide the solutions and technology necessary to nurture and encourage design innovation and development. It is this desire to inspire innovation, through its focus on applications, emerging technologies and practical engineering solutions, that makes Agilent proud and honored to serve as EDI CON's Platinum sponsor in its inaugural year.

The journey to realizing EDI CON began back in October of 2011, at the European Microwave Week in Manchester, England. It was there that talks began with Horizon House, an experienced and well-established event organizer, on the need for an event to provide design engineers and system integrators the latest information on RF, microwave and high-speed digital products and technologies. It was clear that Agilent should play a critical role in helping plan and participate in the event. As the world's largest test and measurement company, it is our job to help bring technology innovation to China so that digital, RF and microwave technologies can move forward.

Agilent has a long and well-established history in China, beginning when it was known as Hewlett-Packard (HP) and spanning almost 30 years. In 1981, David Packard visited China and came away with the foresight and wisdom to understand that China was an emerging market and a measurement company, like HP, could be a crucial player in its economic and societal development. That insight prompted the opening of HP's first office in Beijing in 1985. Today, Agilent has a significant presence in China, providing customers with sales, marketing and business support, as well as service. Agilent also has R&D and manufacturing organizations in Beijing, Shanghai and Chengdu. The company's largest software applications development organization is based in Beijing.

The partnership Agilent established with Horizon House to bring EDI CON to China is yet another way in which we will continue to play a role in China's ongoing development. This event will enable researchers, scientists and engineers in China to gain insight into challenges in digital, RF and microwave design. By bringing designers together with measurement scientists in a collaborative environment, EDI CON will be able to highlight and help foster emerging technologies and solutions for effectively addressing those challenges.

Now more than ever before, China needs an event like EDI CON. The technical problems facing today's wireless and digital product designers are getting more complex and difficult to solve. For example, in the wireless industry alone, design and test

are complicated by increasing device complexity and functionality, higher data rates, rapid growth in software content, increased focus on network security and higher integration of components and modules. Wireless engineers must also now confront different measurement requirements for different technologies, multiple technologies converging in single devices and the constant evolution of existing technologies and emergence of new technologies.

The challenges are no less daunting for digital product designers. Here, technologies are continuing to transition from analog to digital and devices require more integration and functionality – at a lower cost. Devices also require higher speed and lower power, prompted by the growth of video and social media. Additionally, consolidation is underway in the digital arena as design shifts into Asia. Each of these trends drive new challenges that engineers must learn to address effectively if they are to succeed. Many of these trends are key topics on the agenda for EDI CON 2013, which will take place at the Beijing International Convention Center on March 12-14, 2013, in Beijing, China.

EDI CON promises to be an exciting and transformative event for China, one that we support on many different levels. Agilent is not only the event's Platinum sponsor, we also will have a booth on the show floor and be presenting a number of technical papers. Additionally, I am honored to be delivering the keynote address. We look forward to a great event and hope to see you all there. ■

DiamondTM Rf Resistives

Sacrifice Nothing

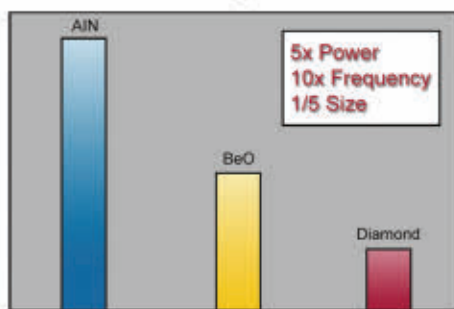
High Power, High Frequency, Low Capacitance, Small Size

20 Watts in 0402 Footprint

New, Easy-To-Use Configurations

Diamond Attenuators, Terminations and Resistors

Lowest Capacitance

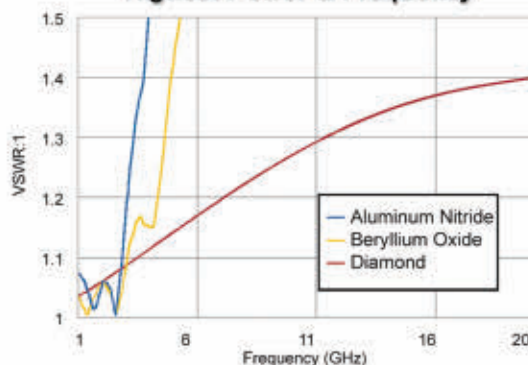


Common Substrate pF / Watt Comparison

Applications:

- Phased Array Radar
- Isolator/Circulator
- Phase Shifters
- Point-to-Point Radio
- Telemetry
- Satellite Communications
- High PAR Applications
- Wilkinson Dividers/Combiners
- RF Signal Scaling

Highest Power & Frequency



Advantages:

- Integrated Heat Sinks
- Tab Launched - Formed Tab
- High Power - Versions up to 125W
- Ultra Compact up to 20W in 0402 Case Size
- Environmentally Friendly (No BeO)
- Low Capacitance - As Low as 0.09pF
- Surface Mount

Design Kits &
Samples Available
sales@emc-rflabs.com

+1 772-286-9300 or
800-544-5594
www.emc-rflabs.com



EDI CON Program Preview

The Electronic Design Innovation Conference (EDI CON) to be held in Beijing, China next month will offer engineers and researchers practical training and insight into the state of technology driving RF, microwave and high-speed component design and system integration. The conference program will emphasize measurement, simulation and semiconductor technologies that support electronic component design for high-frequency systems from telecommunications to satellite navigation. EDI CON will serve the industry by providing access to the knowledge and expertise that engineers need to meet tomorrow's challenges.

The bulk of papers have been provided by companies at the forefront of our industry's technical innovations. As a result, the conference reflects global trends at the device and system levels. To understand technology trends in the context of market opportunities, the opening day will feature keynote presentations from multiple business and engineering perspectives.

KEYNOTE TALKS

- Honorary Chair, Dr. Song Junde, academic director at Beijing University of Posts and Telecommunications, will open the ceremonies with a talk on the "Present and Future of RF/Microwave and High-Speed Digital Devices and Systems," a look at the development and consumption of communication ICs in China and the systems driving this demand.
- Strategy Analytics' Beijing-based senior analyst Guang Yang will

share insights on the mobile communications industry, discussing R&D efforts in China, standardization and strategic analysis for 3G/4G, spectrum, and emerging wireless technologies.

- Guy Séné, president of Electronic Measurement Group, Agilent Technologies, will discuss Agilent's long history (starting as Hewlett Packard) in China and the company's vision for the future in his talk, "Nurturing Design Innovation for China's Future," previewed in this month's special report.
- Bertram Arbesser-Rastburg, head of the Electromagnetics and Space Environment Division of the European Space Agency and last year's European Microwave Week chair, will provide a look at the aerospace industry and share global developments with our Chinese audience.
- The second plenary session will feature executives from China Mobile Research Institute, ZTE Microwave Products Group and Beijing's Radio Institute for Metrology and Measurements (BRIMM).
- Deng Jie (ZTE) will discuss the mobile backhaul microwave radio market and his company's R&D efforts in this area.
- Dr. Liu Guangyi, chief researcher with the country's largest mobile carrier, China Mobile, will offer an operator perspective on the system technologies being presented in the conference as well as China Mobile's future product roadmap and its current leadership in small cells where the Beijing team is working to accelerate the field tri-

als of TD-LTE small cell systems across its network.

- Feng Keming, a director at BRIMM, will discuss his institute's research on ultrafast optoelectronic technology for terahertz metrology, advances in metrology standards and his department's development of highly precise microwave timing solutions for China's GNSS project.

TECHNICAL TRACKS

Peer-reviewed papers from industry experts offer insights on a range of topics related to wireless communications, high-speed computing and aerospace and defense systems. The design track explores the latest circuit and component design techniques and architectures with examples of key active and passive devices found in radio front-ends and transceivers for WiFi, small cell, 3G and LTE base-stations, backhaul networks, radars, etc. The measurements and modeling track looks at the tools and techniques used in support of virtual prototyping and design verification. The systems engineering track looks at various wireless systems and standards, receiver architectures, modulation techniques, etc., to provide broader overview of the networks driving component requirements and specifications. The commercial resources track provides a mix of vendor-based solutions and products for specific applications and engineering challenges.

DAVID VYE
Microwave Journal Editor

Keynote Talks Featuring:

- Honorary EDI CON 2013 Chair **Dr. Song Junde**, Academic Director at Beijing University of Posts and Telecommunications
- **Guang Yan**, Strategy Analytics, Senior Analyst for Mobile Communications
- **Guy Séné**, President of Electronic Measurement Group, Agilent Technologies
- **Bertram Arbesser-Rastburg**, Head of the Electromagnetics and Space Environment Division of the European Space Agency
- **Deng Jie**, General Manager, ZTE Microwave Products Group
- **Dr. Liu Guangyi**, Chief Researcher, China Mobile Research Institute
- **Feng Keming**, Director, Beijing Radio Institute of Metrology and Measurements

EDI CON would like to thank the Program Contributors

Agilent (Platinum Sponsor), Altera, **Anritsu**, **ANSYS**, Auriga Microwave, Avago, **AWR**, Azimuth, Blue Test, Cadence, Cascade Microtech, CETC 41, Continental Automotive GmbH, Cree, **CST**, eASIC, Elvira, EMC/Florida RF Labs, Emerson Network Connections, Freescale, Focus Microwaves, HWA-Tech, Insulated Wire, M/A-COM Technology Solutions, Maury Microwave, Microsemi, Mini-Circuits, MITEQ, MITRON, **National Instruments**, Nitronex, Nokia Siemens Networks, OMMIC, Peregrine Semiconductor, Rogers Corp., **Rohde & Schwarz**, SATIMO, Scintera, SI Time, Spirent, Tektronix, Tech-X, Texas Instruments, Times Microwave, TowerJazz Semiconductor, TriQuint Semiconductor, Wild River Technology, WIN Semiconductors, Xilinx

With research and academic contributions from:

ASTRI, China Academy of Telecommunication Research-Telecommunication Metrology Center, Beijing Institute of Radio Metrology & Measurements, Beijing University of Posts and Telecommunications, East China Jiaotong University, Electronic Information Institute of Sichuan University, Institute of Communication Networks and Satellite Communication, Kyung Hee University (Korea), St. Petersburg State Polytechnical University (Russia), Technische Universität Darmstadt (Germany), Tsinghua University

And special thanks to GaN Panel Sponsor Richardson RFPD

REGISTER TODAY!

www.EDICONCHINA.com

Design	Measurements & Modeling	Systems Engineering	Commercial Resources
Implementation of a Digitally-Controlled Oscillator for Jitter Cleanup <i>Yin-Chen Lu and R. Reist, SI Time</i>	Improvements in mm-wave Noise Figure Measurement Accuracy <i>Jon Martens, Anritsu</i>	Impact of Wideband I/Q Vector Impairments on 802.11ac <i>S. Dark and C. Behnke, National Instruments</i>	Agilent Education Forum RF Concepts for High Speed Digital Design <i>Kai Li, Agilent Technologies</i> Design of Equalization Circuit to Improve Performance at > 5 GHz Data Rates <i>Q. Lu, Agilent Technologies</i>
A Novel Ultra-Low Phase Noise Octave-Band Synthesizer Using X-Band Frequency Reference <i>Dr. Sergey Belchicov, Elvira</i>	Noise Figure Measurement of Non-Frequency Converting and Frequency Converting Devices Using a VNA <i>S. Neidhardt and V. Herrmann, Rohde & Schwarz</i>	Queueing Behavior of an 802.11 Wireless Communication System <i>Yi Cai, National Instruments</i>	
Design of a Novel Multi-Slot Antenna <i>Milton Lien, AWR</i>	Modeling of GaN HEMT Devices <i>Y. Tajima, Auriga Microwave</i>	Welch Periodogram Detector for QPSK Based AWGN Baseband and Passband Cognitive Radio System <i>M. Tahir Mushtaq, Institute of Communication Networks and Satellite Communication (IKS)</i>	Diamond Rf™ Resistives: The Answer to High Power and Low Capacitance <i>EMC/Florida RF Labs</i>
Ten-Element 4G Antenna Array for Tablets <i>Corbet Rowell, ASTRI</i>	Practical Considerations for High-Power X-Parameter Measurements of a 130 W LDMOS Power Transistor <i>Di Liu, Agilent Technologies</i>	Spectrum Re-Use Through Real-Time Signal Processing <i>Trang D. Nguyen, National Instruments</i>	Impact of Conductor Roughness on Insertion Loss and Propagation Constant of High Speed Signals <i>A. Horn, Rogers Corp.</i>
Wide Dynamic Range Multi-Nested Envelope Tracking Power Amplifier for LTE Application <i>Z. Wang, Nokia Siemens Networks</i>	Simulating FPGA Power Integrity Using an S-Parameter Model <i>H. Fahmy, J. Carrel, R. Anderson and C. Warwick, Agilent; H. Fu and R. Mayder, Xilinx</i>	GNSS and Their Wide Range of Applications <i>R. El Assir, Rohde & Schwarz</i>	Dynamic Measurements in Radar and Electromagnetic Spectrum (EMS) Warfare <i>Walt Shulte, Agilent Technologies</i>
A High-Efficiency, Small-Size GaN Doherty Amplifier for LTE Micro-Cell and Active Antenna System Applications <i>P. Xia and M. Jankovic, TriQuint Semiconductor</i>	Methods of Improving Time/Frequency Domain Measurements Suited for 3D-EM Simulation <i>A. Neves, Wild River Technology LLC</i>	'Design to Test' Platform Solution for Direct-Sequence Spread Spectrum (DSSS) Communication System for LEO SATCOM <i>Jinbiao Xu, Lei Yue and Fan Wang, Agilent Technologies</i>	Signal Analysis Using a Mixed Domain Oscilloscope <i>Tektronix</i>
A 60 GHz Four Channel CMOS Receiver with 7 GHz Ultra-Wide Bandwidth for IEEE 802.15.3c Standard <i>Chunyuan Zhou, Lei Zhang, Hongrui Wang and He Qian, Tsinghua University</i>	3D EMC Simulation of Automotive Multimedia Systems <i>R. Kakerow, Continental Automotive GmbH</i>	Optimizing TD-LTE Performance from RF to Subscriber QoE <i>Simon Wang, Spirent</i>	Technological Advances of Gallium Nitride <i>Bruce Green, Freescale Semiconductor</i>
Simulation, Modeling and Design Enablement of Integrated Passive Devices in CMOS Technologies <i>Brian Chen, Agilent Technologies</i>	Time-Domain Based Measurements and the Related Speed Improvements for EMI Testing <i>Karl-Heinz Weidner, Rohde & Schwarz</i>	System-Level Design of an LTE TDD Tri-Band Receiver <i>S. Lafi, F. Ditore and R. Vandyke, Agilent Technologies</i>	Challenges in the Design and Selection of Power Broadband Amplifiers <i>Wolfram Titze, Rohde & Schwarz</i>
Device Characterization Methods for Advanced RF/Microwave Design <i>Nikhil Ayer, National Instruments; Chun-Hsien Lien, AWR</i>	Signal Lines to Power Plane Coupling Caused by Common Mode Current in High Speed SerDes Interconnect Design <i>L.K. Teoh and H.Y. Lee, eASIC; C.T. Chiang, K. Krohne and A. Ciccimancini Scogna, CST</i>	Digital Upconversion VS IQ Modulation Using a Wideband Arbitrary Waveform Generator <i>B. Hoehne, Agilent Technologies</i>	Error Analysis of Equivalent Source Reflection Measurements <i>C. Igor, VNIIFTRI; C. Vladislav, MIET; A. Pivak, Rohde & Schwarz</i>
High Efficiency Inverse Class-F Amplifier Design for Envelope Tracking Line-Up Driver <i>Zhancang Wang, Li Wang, Rui Ma and S. Lanfranco, Nokia Network Systems</i>	Electrical Validation Considerations for MIPI D-PHY and M-PHY Physical Layer Transmitter Specifications <i>M.J. Chong, Agilent Technologies</i>	Correlation Between RF Receiver Architecture and RF Measurement <i>N. Ayer, National Instruments</i>	Modeling Magnetron Sources with VSim <i>Chuangdong Zhou, Tech-X</i>
PLL Frequency Synthesizers Based on the DDS in Feedback Loop <i>Andrew Polyakov, Peter Bobkovich and Andrey Kuzmenkov, Advantex</i>	Memory Polynomial Digital Pre-Distortion Measurement and Implementation <i>J. Xu, H. Wu and Z. Deng, Agilent Technologies</i>	Bluetooth-Based Room Localization Research Based on NB and SVM Approach <i>Pengming Wang and Qing Chen, East China Jiaotong University</i>	Cree GaN HEMT for Telecom <i>David Dai, Sanetronic</i>
A Fast-Switching, Low Noise Frequency Synthesizer Using a Frequency Offset Technique <i>Alexander Grechishkin, Nikolay Tikhomirov, Stanislav Romanov and Dmitry Rakhmanin</i>	Carrier Aggregation Performance Testing: Challenges and Opportunities <i>E. Ork, Azimuth</i>	Analysis of UHF RFID SD Tag Antennas <i>Abdul Karim, Technischi Universität Darmstadt (TUD)</i>	Linearizing GaN Microwave Power Amplifiers Using RF Pre-Distortion <i>Mendy Ouzillou, Scintera</i>
Wideband Branch Line Coupler with Sharp Skirt Selectivity Bandpass Filter Function <i>W.A. Arriola and I.S. Kim, Kyung Hee University</i>	Accurate Test of 28 Gb/s High-Speed Data Electrical Interface <i>H. Hu, Agilent Technologies</i>	Novel Architecture for 8x8 MIMO MMSE Detection with LabVIEW FPGA (LVFPGA) on Xilinx Virtex-5 Target <i>Y. Rao and I. Wong, National Instruments</i>	Accelerating USB 3.0 Protocol Development <i>D. Schoenecker, Agilent Technologies</i>
A Square-Law Microwave Transistor Detector with Extended Dynamic Range <i>Sergey Ivanov, A.P. Lavrov and Y. Matveev, St. Petersburg State Polytechnical University</i>	Comparison and Contrast of State-of-the-Art Time Domain Reflectometry Measurement Instruments <i>Takuya Hirato, Agilent Technologies</i>	Design and Implementation of FPGA-Based 4 GHz Bandwidth Digital IFM <i>Megha S. Badad, KS. Institute of Technology</i>	Discrete Active Devices: Recovery Time of Schottky-PIN Limiter <i>Chin Leong Lim, Avago Technologies</i>
New Design of a 5.8 GHz Microwave Rectifier Circuit <i>Chengyang Yu and Changjun Liu, Electronic Information Institute of Sichuan University</i>	Modeling of Antennas and Arrays Using Domain Decomposition Method <i>K. Zhao and N. Lambert, ANSYS</i>		RFID Product Lifecycle Testing Techniques <i>Zhang Zhihua, HWA-Tech</i>
	Equivalent Current Reconstruction Applications <i>F. Chauvet, SATIMO</i>		

Workshops: Wednesday, March 13, 2013

RF CMOS Foundry Workshop – Addressing RFIC Reliability
TowerJazz Semiconductor

Ultra CMOS Technology Enables Today's High-Performance
RF and Microwave Designs
Jian Zhou, Peregrine Semiconductor

Doherty Power Amplifier Theory and Design for Cellular Infrastructure Applications
Damon Holmes, Freescale Semiconductor

Design Methodology for GaAs MMIC 1 W X-Band PA
Dr. John Dunn, AWR

Single Connection Amplifier Characterization
Fabricio Dourado, Rohde & Schwarz

Vector Signal Test and Measurement
Sponsored by National Instruments
Yanbo Zhao, VI Service Network

High-Speed Interconnects
Bob Buxton, Anritsu

Smart Portable Test Equipment for ATE Applications
Chi Man Shum, Mini-Circuits

Time Domain Modeling of Drude and Lorentz Dielectrics with VSim
Chuangdong Zhou, Tech-X

Antenna Design and Platform Integration Workshop
Dr. Matt Commens, ANSYS

Integrated Antenna Design for a GSM Tracking Device
Dr. Klaus Kohne, CST

MIMO Beamforming in All Its Forms – Maximizing Efficiency in Limited Spectrum
Kang Chen, Spirent Communications

Agilent PA Workshop

A Doherty Power Amplifier with Envelope Tracking Design
Cheng-Cheng Xie, Agilent Technologies

GaN Panel

Sponsored by Richardson RFPD

GaN Based Power Transistors in the Cellular Infrastructure Market
Mario Bokatus, Freescale Semiconductor

Micro-Cell and Active Antenna System Applications
Peter Xia, TriQuint Semiconductor

GaN Power Transistors in COTS Plastic Packaging
Damian McCann, M/A-COM

A Robust 75 W, 48 V, 0.02 to 1 GHz Broadband GaN Amplifier
Xinjian Zhao, Nitronex

GaN Power Transistors for Avionics and Radar Market
Jerry W. Chang, Microsemi

as of 1/24/13

Workshops: Thursday, March 14, 2013

RF Signal Analysis Workshop
CETC 41

Understanding Cable Assembly Solutions for Specific Commercial and
Military Applications
Wei Liu, MITRON

How to Get the Best Performance Out of Your Cable Assembly
Insulated Wire

TD-LTE and TD-LTE-Advanced Workshop
Qin Zhang, Agilent Technologies

MW and MM Solutions (VNA, SpA, SG, Frequency Converters)
Christoph Wagner, Rohde & Schwarz

Getting More Than 12 Bit of Resolution from a 12-bit Oscilloscope
Ai-Lee Kuan, Agilent Technologies

How to Use a VNA to Analyze High Speed Backplane and Cable
Shaohan Lian, Agilent Technologies

RFIC Advances in Simulation for Transceiver Design
Xg Wang and Nebabie Kebebew, Cadence

Wafer-Level S-Parameter Calibration: How to Choose the Optimal Strategy for
Your Application
Andrej Rumiantsev, Cascade Microtech

How to Remove the Effect of Fixtures and Probes in High Speed Test
Yong Zhao, Agilent Technologies

Connectivity Workshop *Sponsored by Sanetronic*

Applications of Fiber Optic Links in RF and Microwave Systems
Howard Hausman, MITEQ

EDA Design Flow

Industry Best Practices for a High-Speed Digital Design Workflow
Colin Warwick, Agilent Technologies

Fully Integrating 3D Electromagnetic (EM) Simulation into Circuit Simulation
Jiang Dunn, AWR
HFSS-Inside
Matt Commens, ANSYS

GaAs Foundry Workshop

HBT Technologies for Multi-Mode, Multi-Band Power Amplifier Application
WIN Semiconductors
W-Band Chips-Set for Microwave Imaging
OMMIC

Nonlinear Device/Load-Pull Workshop

Load-Pull System Common Test Problems and Solutions
J. Lei, Focus Microwaves
Passive, Active, Hybrid-Active, Mixed Signal Active, Harmonic, Pulsed, NVWA/
Time Domain Load-Pull and Modeling Techniques
Maury Microwave

RF Front End Workshop

Wideband Tx, Rx and PPD-Feedback RF Solution
Lei Xu and Trung Tran, Altera
RF Front-End Solutions for High-Speed Designs
Aiguo Leng, TI

AWR/National Instruments DPD PA Workshop

Optimizing the Design and Verification of 4G RF Power Amplifiers
Peter Xu, NI
Simulating an NXP Doherty Power Amplifier with Digital Pre-Distortion
John Dunn, AWR

MIMO OTA Workshop & Panel *Sponsored by Spirent Communications*

MIMO-OTA Testing Methodologies: Reverb vs. Anechoic
Kang Chen, Spirent
MIMO OTA Measurement with Anechoic Chamber Method
Francois Chauvet
The Changing Face of Testing: Moving from Conducted to OTA
Panel Session with Experts from Spirent, Blue Test, ETS-Lindgren and IMS

REGISTER TODAY!
www.EDICONCHINA.com

802.11ac Design Considerations for Mobile Devices

The rapid growth of smart mobile devices is driving mobile data usage and Wi-Fi proliferation, creating an ever-increasing demand for faster wireless networks to support bandwidth-intensive applications, such as web browsing and video streaming. The new IEEE 802.11ac standard is designed to meet this demand, by providing major performance improvements over previous Wi-Fi generations, as shown in **Table 1**, which shows theoretical maximum data rates.

Mobile devices supporting 802.11ac are already becoming available. IMS Research predicts rapid adoption of 802.11ac and expects that over 400 million devices supporting the new standard will be shipped in 2016. For mobile devices, 802.11ac provides significant performance improvements over its predecessor, 802.11n. Single-antenna devices, such as smartphones, can achieve three times the data-transmission rate, compared with 802.11n, by using the wider 80 MHz channels with an advanced modulation (MCS 9), defined in 802.11ac. The additional performance means that 802.11ac will allow new types of WLAN usages as well as accelerating existing applications.

These new usages include simultaneous streaming of HD video to multiple clients throughout the home and instantaneous data sync and backup. 802.11ac achieves its performance improvements primarily by extending WLAN concepts initially introduced in previous 802.11 generations, such as 802.11n. In addition, 802.11ac uses the 5 GHz band, which

is less crowded than the 2.4 GHz band used by most previous WLAN generations. This facilitates higher WLAN throughput with less interference. The biggest factors contributing to 802.11ac performance advantages are:

Wider Channels

802.11ac introduces mandatory 80 MHz and optional 160 MHz channel bandwidths in the 5 GHz band, in addition to the 20 MHz and 40 MHz channels specified in 802.11n.

Increased Modulation Complexity

With 802.11ac, the maximum modulation complexity increases from 64 QAM to 256 QAM, with a 5/6 coding rate. This change alone provides a 33 percent boost in the data rate, compared with 802.11n. To take advantage of this benefit over existing Wi-Fi networks, some equipment makers are expected to provide support for 256 QAM 802.11ac modulation over the 2.4 GHz band, as well as the 5 GHz band.

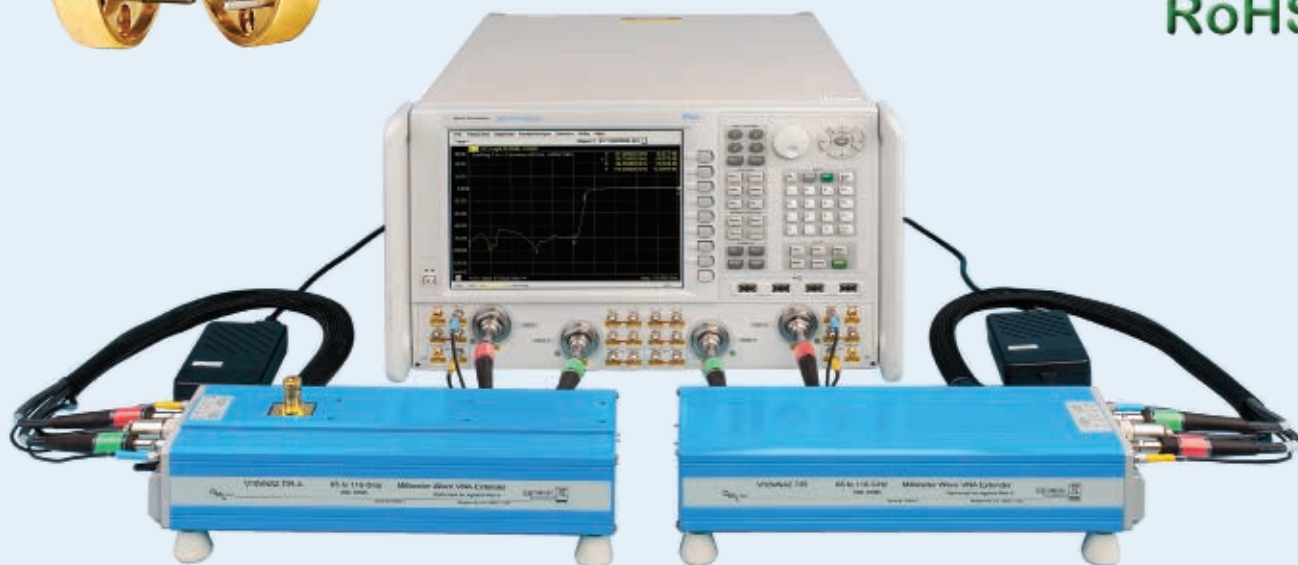
Expanded Support for MIMO and Beamforming

The number of simultaneous multiple-input multiple-output (MIMO) spatial streams increases from 4×4 to 8×8 , allowing for a total maximum aggregate WLAN throughput of 6.93 Gbps. The 802.11ac standard also

EID ALSABBAGH, HAORYANG YU AND
KEVIN GALLAGHER
TriQuint Semiconductor, Hillsboro, OR

Millimeter Wave S-Parameters

50 GHz to 500 GHz



Extend Network Analyzers to the mm-Wave Frontier:

- Best-in-class solutions: on-wafer, pulse (high power), amplifier, antenna, balanced/differential, multiport and material measurements
- Universally compatible with mm-wave ready VNA systems
- Lowest overall system cost by leveraging 20 GHz VNA models
- Industry-leading directivity & match delivers ultra-stable calibrations
- Unmatched 25 dB manual power control with optional attenuator
- Industry's first RoHS compliant models: WR-10, WR-05, WR-03 & WR-02.2
- Premium accessories: waveguide calibration kits, sections and S-bends
- Industry's best warranty (2-years) and best delivery for popular models

Visit www.omlinc.com for more information.

Innovation in Millimeter Wave Measurements

www.omlinc.com

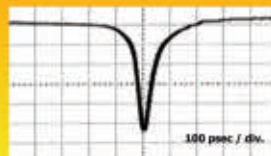
(408) 779-2698



Impulse Generators 100 - 2000 MHz

Application:

- > Clock Reference
- > Sampling Circuit
- > Sharp Biasing or Triggering Source
- > Optical Modulator Driving



MODEL	INPUT (DRIVING) FREQ. (MHz)	TYPICAL IMPULSE OUTPUT VOLTAGE (V)	TYPICAL IMPULSE PULSE WIDTH (P SEC)
GIM100A	100	-12	100
GIM200A	200	-18	90
GIM250A	250	-18	80
GIM500A	500	-15	60
GIM1000A	1000	-10	50
GIM1500A	1500	-8	45
GIM2000A	2000	-7	35

Your Source for the Most Complete Line of Comb & Impulse Generators

Other Herotek Products:
Detectors . Limiters . Amplifiers
Switches . Comb Generators
Multipliers . Subassemblies



The Microwave Products Source

Herotek, Inc.
155 Baytech Drive
San Jose, CA 95134
Tel: (408) 941-8399
Fax: (408) 941-8388
Email: Info @ herotek.com
Website: www.herotek.com



Technical Feature

TABLE I THE EVOLUTION OF THE 802.11 STANDARDS						
Protocol	Year Introduced	Maximum Data Transfer Speed	Frequency	Highest Order Modulation	Channel Bandwidth	Antenna Configurations
802.11a	1999	54 Mbps	5 GHz	64 QAM	20 MHz	1x1 SISO
802.11b	1999	11 Mbps	2.4 GHz	11 CCK	20 MHz	1x1 SISO
802.11g	2003	54 Mbps	2.4 GHz	64 QAM	20 MHz	1x1 SISO
802.11n	2009	65 to 600 Mbps	2.4 or 5 GHz	64 QAM	20 and 40 MHz	Up to 4x4 MIMO
802.11ac	2012	78 Mbps to 3.2 Gbps	5 GHz	256 QAM	20, 40, 80 and 160 MHz	Up to 8x8 MIMO; MU-MIMO

adds support for multi-user MIMO, allowing more efficient allocation of network capacity among multiple devices: each antenna of a multi-antenna device, such as a wireless router, can simultaneously communicate with a different single-antenna device such as a smartphone. 802.11ac supports standardized beamforming, which takes advantage of multiple antennas to increase signal strength and signal transmission range between communicating devices.

DESIGN CHALLENGES

While the new standard delivers significant performance improvements, it also creates a variety of new challenges for designers of mobile devices. These challenges make achieving the desired performance more difficult than ever. Key issues include:

- Maximizing linearity and achieving low dynamic Error Vector Magnitude (EVM)
- Generating high power output while minimizing power consumption
- Coexisting with cellular communications in the 2.4 GHz band

Each of these challenges is explained in more detail.

Linearity and Dynamic EVM

The increase in modulation complexity to 256 QAM contributes significantly to the increased performance of 802.11ac. With 256 QAM, the data rate is achieved by representing eight coded bits per Orthogonal Frequency Division Multiplexing (OFDM) symbol, compared with six bits with 64 QAM (the maximum supported by 802.11n). However, this higher-order modulation also creates significant design challenges.

As the data rate increases, signal quality becomes even more important. To successfully receive an 802.11ac 256 QAM signal, a receiver will require a significantly less distorted signal than with 802.11n 64 QAM. To deliver this signal, the power amplifier (PA) of the transmitting device will need to provide greater linearity.

This linearity requirement is reflected by a more stringent EVM specification. EVM is an important figure of merit used to measure the linearity of a transmitted OFDM signal. EVM is the magnitude of the difference between the measured vector and the ideal (reference) vector. In 802.11n, the maximum allowed system EVM for a transmitting device is -28 dB (4 percent), when using the highest allowed modulation (64 QAM) and a 5/6 coding rate. With the higher-order 256 QAM modulation supported by 802.11ac and a modulation bandwidth of 160 MHz, the maximum system EVM required is further tightened to -32 dB or 2.5 percent.

To meet this requirement, careful system budgeting is needed for each of the principal components of the device, such as the transceiver and the front-end module. The transceiver must provide sufficient linear drive for the front-end module; any shortcoming will need to be compensated by a higher gain from the PA. At the same time, the transceiver is expected to deliver a low EVM residual floor that is several dB below the overall system EVM requirement. Based on these assumptions, the PA is expected to achieve less than 2.5 percent EVM at the rated power.

Test, Measurement & Calibration

RF and microwave components from Rosenberger play a key role in a variety of test, measurement & calibration applications. The product range includes

- **RF high precision connectors**, adaptors and devices, e.g. connector heads, opens, shorts or loads of all popular connector series such as RPC-N, -7.00, -3.50, -2.92, 2.40, -1.85 or -1.00 mm
- **Calibration and verification kits** for a number of coaxial standard test interfaces
- **Test cables & test devices**, e.g. VNA microwave test cables, high performance cable assemblies, airlines, interchangeable port connectors, T-calibration adaptors
- **Automated Test Equipment (ATE) products**
Multiport Mini-Coax connectors for semiconductor test equipment applications

New:

- I Monolithic compliant interconnects – 0.8 mm pitch
- I Ruggedized test port adaptors – for VNA applications

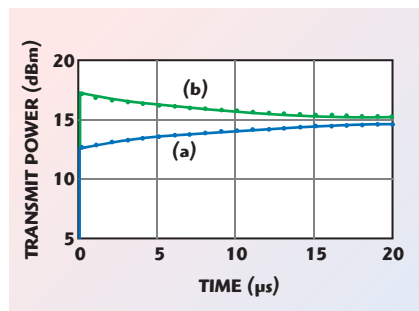
Exploring new directions

Europe

**Rosenberger
Hochfrequenztechnik GmbH & Co. KG**
Hauptstraße 1 – 83413 Fridolfing
Germany
Tel. +49 - 86 84-18-0
Fax +49 - 86 84-18-499
E-mail: info@rosenberger.de
www.rosenberger.com

North America

Rosenberger of North America, LLC.
P.O. Box 309
309 Colonial Drive
USA - Akron, PA 17501
Tel. +1 - 717-859 - 8900
Fax +1 - 717-859 - 7044
E-Mail: info@rosenbergerna.com
www.rosenbergerna.com

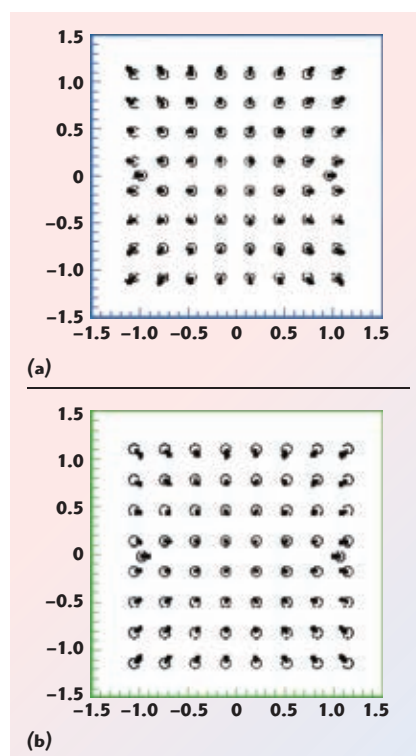


▲ Fig. 1 Slow turn-on (a) and overshoot (b) transient response of the transmit power.

When assessing PA linearity, it is essential to measure EVM in a way that is representative of actual use. Wi-Fi is a Time Division Duplexing (TDD) system, in which the PA continuously pulses on and off during use; it pulses on each time the device transmits data, then pulses off to save power. It is therefore important to measure EVM in this pulsed condition (dynamic EVM) rather than when the PA is always on (static EVM). In an ideal case, dynamic EVM should be the same as static EVM. But in reality, dynamic EVM is usually worse than static EVM due to the PA's transient response.

802.11ac defines a very strict transient response requirement. At the start of each packet, the transmitting device sends an OFDM training sequence used to calibrate the phase, amplitude and timing of the signal. The sequence consists of 10 short symbols and two long symbols. The short symbols include an automatic gain control (AGC) symbol used by the receiver to set its AGC amplifier so that it applies the correct gain to the received signal. The receiving device then assumes that the transmit power level remains constant until the end of the packet. The total transmission time for the training sequence is approximately 20 μ s.

If the PA of the transmitting device exhibits slow power turn-on or power overshoot during this critical period, the constellation after OFDM demodulation will expand or shrink respectively, resulting in poor dynamic EVM. **Figure 1** illustrates the transient PA transmit power responses, resulting from slow turn-on and power overshoot respectively; **Figure 2** shows the constellations that result from these transient responses. Theoretically, if all points were centered perfectly within the circles, EVM would be 0 percent. These figures are



▲ Fig. 2 64 QAM constellation after OFDM demodulation (a) slow turn-on results, (b) overshoot results.

based on lab test results with 64 QAM; the problem is even more pronounced when using 256 QAM.

Because of this effect, a PA used in an 802.11ac device must exhibit an extremely stable transient power response, in order to minimize dynamic EVM. By designing for stable response, very low dynamic EVM has been achieved in PAs and front-end modules. For example, the TriQuint TriConnect™ WLAN/Bluetooth front-end module achieves 2.2 percent EVM at 18 dBm with 802.11ac 256 QAM (MCS 9, 40 MHz channel bandwidth).

As WLAN performance requirements will inevitably continue to increase in the future, more sophisticated techniques will be required to further improve signal range and quality. An example of such a technique is digital pre-distortion, in which the transmitter chipset uses feedback from the PA to adjust the signal so that the system EVM is minimized. FEMs will need to include the capabilities necessary to provide this feedback.

Generating High Power Output While Minimizing Current Consumption

Designers of mobile devices must balance a range of conflicting re-

RF & Microwave Design and Manufacturing
Covering Frequencies from DC to 20 GHz
Serving the Industry Since 1993

"Quality Products at Competitive Prices"
"Custom Designs are Available"

Product Line:

- Solid State Variable Attenuators
- Solid State Switches
- Directional Couplers
- Hybrid Couplers (90/180 Deg)
- Power Dividers / Combiners
- DC-Blocks & Bias Tee's

5702-D General Washington Drive
Alexandria, Virginia 22312 USA
Tel: (703) 642-6332, Fax: (703) 642-2568
Email: sales@umcc111.com

www.umcc111.com

Industry's Leading DLVA's, ERDLVA's & SDLVA's

Offering Form, Fit and Functional Models to Replace other OEM Part Numbers

Amplifiers

Attenuators - Variable

DLVA & ERDLVA &
SDLVA's

DTO's

Filters

Form, Fit & Function
Products

Hybrids, Dividers &
Couplers

IFM's & Frequency
Discriminators

Integrated MIC/MMIC
Modules

I/Q Vector Modulators

Limiters & Detectors

Log Amplifiers

Pulse & Bi-Phase
Modulators

Phase Shifters

Rack & Chassis Mount
Products

Receiver Front Ends

Single Sideband
Modulators

SMT & QFN Products

Solid-State Switches

Switch Matrices

Switch Filter Banks

Threshold Detectors

USB Products



New Cutting Edge, State-Of-The-Art Designs

Featuring the Industry's Best Performance:

- 10MHz to 40GHz Frequency Ranges
- "CW Immune" Models Available
- Temperature Compensation
- Excellent Frequency Response
- Excellent Log Linearity
- Limited IF/RF Outputs
- Very Low TSS
- Ultra-Fast Response Times
- Ultra-Low DC Power Consumption Designs
- Small Packaging
- Hermetically Sealed Models
- Custom Designs & Low Quantity Requirements Accepted



PLANAR MONOLITHICS INDUSTRIES, INC.

7311-F Grove Road, Frederick, Maryland 21704 USA

Tel: 301-662-5019 | Fax: 301-662-1731

Email: sales@pmi-rf.com | www.pmi-rf.com

ISO9001:2008 Certified



New, Great!

LNA

Part No.	Freq. (GHz)	Gain (dB)	NF (dB)	OIP3 (dBm)	Package
ASL51T8	0.9	18	0.37	38	TDFN8
ASL41S9	0.9	18	0.55	38	SOT89
ASL52T8	2.0	21	0.65	34	TDFN8

LNA w/o extra component

Part No.	Freq. (GHz)	Gain (dB)	NF (dB)	OIP3 (dBm)	Package
ANM1730	1.7~3.0	25	0.5~0.8	35	MCM3P

Wideband PA

Part No.	Freq. (GHz)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	Package
AWB459	DC~3	19	24	41	SOT89
AWB589	DC~1	20	27	44	SOT89
AWB688	DC~1	21	30	44	SOIC8

GPS LNA

Part No.	Vd/Id (V/mA)	Gain (dB)	NF (dB)	OIP3 (dBm)	Package (mm)
ASL22N	3/8.5	29	1.1	16	UQFN6 (1x1)

CATV

Part No.	Vd/Id (V/mA)	Gain (dB)	Pout (dBm)	CSO/CTB (dBc)	Package
ASL39D2	5/300	19	105	60/66	SOIC8
ASL59D4	6.5/390	20	108	60/63	TSSOP24
ASL882	12/520	22	110	60/66	TSSOP24

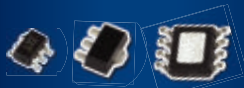
Optical Receiver

Part No.	Vd/Id (V/mA)	PhotoPin (dBm)	Pout (dBm)	CSO/CTB (dBc)	Package
ASA306C	4/210	-10~+2	85	60/62	QFN24

※ Voltage controlled attenuator included

Digital Attenuator (LSB 0.5 dB, 6-bit)

Part No.	Freq. (GHz)	Atten. Range (dB)	Typ. IL (dB)	IIP3 (dBm)	Package (mm)
AAT530B6	0.5~3.0	31.5	2.0	45	QFN16 (4x4)



ASB Inc.

Daejeon, South Korea
Tel: +82-42-528-7225

www.asb.co.kr

Contact us at sales@asb.co.kr

Technical Feature

requirements to optimize WLAN performance, while managing power consumption. The challenge with 802.11ac is to achieve a design that successfully meets requirements for very low EVM, along with high transmit power output, while minimizing current consumption to lengthen battery life.

The challenges are accentuated as mobile devices become more complex and need to support a wider range of cellular and WLAN standards. Greater levels of integration are needed to make the best use of limited space, simplify design and enable faster development of next-generation wireless products. An example is how TriQuint's integrated single-band WLAN modules can replace as many as four discrete components. This highly integrated Wi-Fi front-end module, shown in **Figure 3**, combines the discrete components required for WLAN transmit and receive chains into a single compact module. It houses a PA and a low noise amplifier (LNA) with a switched bypass mode, RF detector (V_{det}) and switch.

In these highly complex, integrated mobile devices, the WLAN signal must share the RF chain with crowded cellular bands. This in turn increases the need for filters and switches, resulting in greater signal losses in the transmission path of the PA. The resulting reduction in the signal-to-noise ratio makes it more difficult to achieve the required EVM. To compensate for these losses, the power output may be increased. However, as the PA approaches the power saturation level, linearity degrades. The relationship between power output and linearity typically resembles a "hockey-stick" curve; once a specific power level is exceeded, the EVM increases exponentially. The PA must therefore operate at a sufficiently backed-off power level to maintain the very low EVM required for complex 802.11ac modulation schemes.

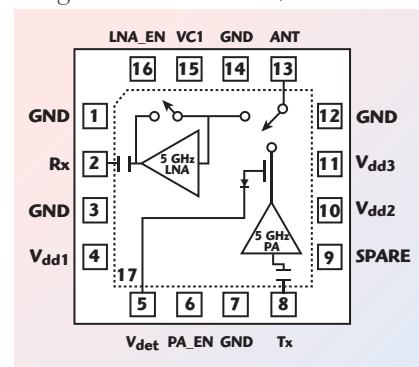
The challenge for FEMs and PAs is to meet the EVM requirement, while producing adequate power output and minimizing current consumption. Focusing solely on

WLAN performance, at the expense of power management, may compromise battery life. Conversely, focusing solely on power management may reduce WLAN performance. The trade-off between performance and power consumption varies depending on the application; for mobile applications, the preferred tradeoff between current consumption and transmit power has been in the range of 16 to 20 dBm.

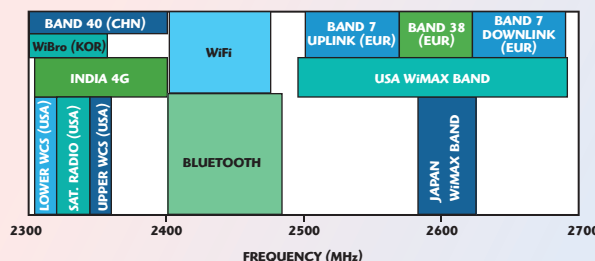
The selection of the manufacturing process technology is critical to meeting the needs of different applications. Many technologies are available for WLAN PA designs. GaAs design technologies have been developed to offer faster data-exchange rates, extended battery life and better amplification. For PAs, InGaP/GaAs HBT offers the greatest power handling capability and ruggedness, while GaAs PHEMT allows a high level of integration with switches and LNAs.

Coexistence with 2.4 GHz Cellular Networks

Though 802.11ac operates in the 5 GHz band, mobile devices will typically provide dual-band 5/2.4 GHz WLAN capability, for compatibility with existing Wi-Fi networks based on earlier standards such as 802.11n and 802.11g. To increase data rates over existing 2.4 GHz networks, some device



▲ Fig. 3 Highly integrated Wi-Fi front-end module.



▲ Fig. 4 Scarce spectrum is leading governments worldwide to re-form existing spectrum and squeeze new wireless bands.

HIGH POWER

100 MHz
to 20 GHz



**For Military/Radar
Applications.**

Isolators/Circulators

100 MHz HIGH POWER Circulator for Medical, Scientific and Industrial applications



A new HIGH POWER Circulator suitable for FM Broadcast, Scientific and Medical applications is now available. The unit provides 10 MHz bandwidth in the 85–110 MHz spectrum.

Specifications are 20 dB min. isolation, 0.3 dB max. loss and 1.25 max. VSWR. Operating power is 1 kW average and 25 kW peak. The 8-1/2" hex x 2" thick unit operates over a 15°–50° C temperature range. DIN 7/16 connectors are standard. Other units are available at higher frequencies.

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

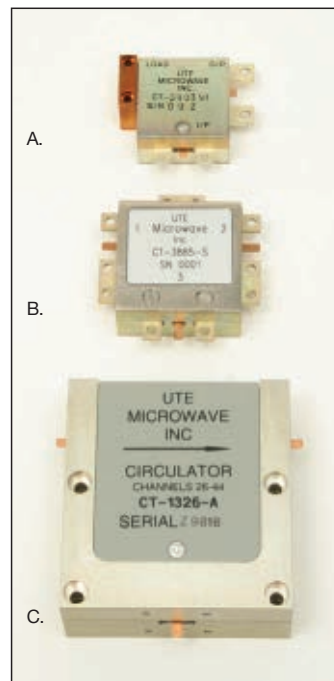
As one of the leading suppliers of ferrite components in the industry, UTE Microwave has pioneered innovative designs, quality craftsmanship and exceptionally high quality products. Custom designs, standards...many of them off-the-shelf, are the result of over 35 years of experience in the industry. UTE Microwave continues this tradition with new products for ever changing applications. Our broad line of HIGH POWER, low loss circulators and isolators spans the spectrum from below 100 MHz in coax/stripline units to waveguide devices at 18 GHz for both peak and average powers.

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

manufacturers are expected to implement 256 QAM modulation – a key element of the 802.11ac standard – over 2.4 GHz WLAN channels. This will significantly increase 2.4 GHz WLAN performance, compared with the less-complex modulation schemes previously available with the earlier Wi-Fi standards, though the data rates will not match those available in the 5 GHz band due to other constraints of the 2.4 GHz band, such as narrower channels.

While dual-band operation offers obvious advantages, it also introduces coexistence challenges. Operating in the 2.4 GHz band increases the potential for interference with cellular communications – notably LTE networks – that utilize closely adjacent frequency bands, as shown in **Figure 4**. Potential interference issues are multiplying quickly.

Designers, therefore, must address the potential for transmitted WLAN

signals to desensitize LTE reception on the device and for LTE signals to interfere with WLAN communications. The challenges will increase as mobile devices grow in complexity; many next-generation smartphones will support up to 14 radio frequency bands.

Solving this coexistence challenge requires RF filters that are capable of rejecting closely adjacent frequencies. At the same time, the filters must minimize insertion loss in the WLAN transmission pathway, to help maintain the high signal-to-noise ratio and correspondingly low EVM required for 256 QAM modulation. Bulk Acoustic Wave (BAW) filters are particularly effective at meeting these requirements, offering significant advantages over the Surface Acoustic Wave (SAW) and ceramic filters, traditionally used for cellular applications. In the GHz range, BAWs can achieve quality factors (Q-values) that are superior to other traditional acoustic technologies. As a result of the high Q-values, the filter skirts will be very steep, while insertion losses remain low, even at the edges of the passband. While the performance of conventional SAW filters degrades at higher frequencies and reaches its practical limits at 2.5 GHz, BAW filters can address frequencies up to 6 GHz. BAW devices also have significantly less temperature dependency and much greater electrostatic discharge (ESD) robustness.

CONCLUSION

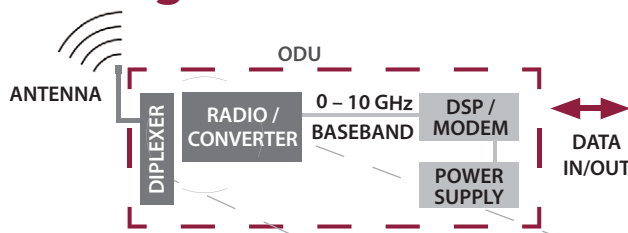
Double-digit growth is forecasted for devices enabled with 802.11ac, with annual shipments estimated to exceed 400 million by 2016. The 802.11ac standard provides substantial performance improvements over its predecessor, 802.11n. But achieving this performance will be more challenging than ever. Key design concerns include achieving low dynamic EVM, generating high power output while minimizing current consumption and coexisting with LTE cellular communications in the 2.4 GHz band. The good news is that highly integrated 802.11ac front-end modules and BAW filters are becoming available to help solve these challenges. ■

ATTENTION

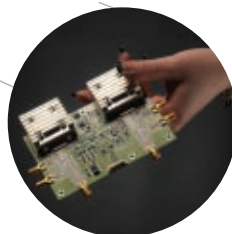
all Radio Link Manufacturers!



Want to boost back haul capacity and profit margins – SIMULTANEOUSLY?



Slash time-to-market with Sivers-IMA's performance enhancing E and V-band converter platforms. Our flexible platform enables next-generation radio links to provide transfer rates of up to 10 Gb/s – at radically reduced cost!



SIVERSIMA

SIVERS IMA IS AN ISO 9001:2008
CERTIFIED COMPANY

www.siversima.com | info@siversima.com

Explore the limits. T&M solutions for aerospace and defense.

Today's aerospace and defense technologies demand ever more sophisticated test and measurement solutions to stretch the limits of what is feasible. As a full-range supplier, Rohde & Schwarz offers a broad portfolio that proves its capabilities in even the most demanding applications. Our leading-edge expertise in microwave, RF and EMC helps customers assess performance, optimize platforms and get the most out of systems. Convince yourself.

www.rohde-schwarz.com/ad/space-pow



Technological highlights: power measurement

- Unrivalled range of easy-to-use USB sensors
- Highest precision and measurement speed
- Wideband sensors up to 40 GHz
- Thermal sensors up to 67 GHz
- Time domain measurement of radar pulses
- Ultra-fast statistical analyses



ROHDE & SCHWARZ

RF Characteristics of Coplanar Waveguide Fabricated on Flexible PES

A coplanar waveguide was fabricated on a polyether sulfone (PES) substrate for application to a flexible Radio Frequency Integrated Circuit (RFIC), and its RF characteristics were thoroughly investigated. According to the measured results, the coplanar waveguide on PES showed a very low loss, compared with a conventional silicon substrate. It showed an insertion loss lower than 0.6 dB/mm and an attenuation constant α lower than 0.065 Np/mm up to 50 GHz. The Q-factor of a coplanar waveguide on PES was 40.3 at a resonance frequency of 46.7 GHz. It showed a wavelength of 3.9 to 6.2 mm from 30 to 50 GHz, and an effective dielectric constant ϵ_{eff} of 2.35 to 2.9 from 10 to 50 GHz. The coplanar waveguide on PES showed a very weak frequency dispersion characteristic compared with silicon substrate. This work is the first known report of the investigation of RF signal transmission characteristics on PES substrate.

Flexible electronics have drawn significant attention, owing to their variety of applications such as flexible displays, smart tags and wearable products.¹⁻³ Especially for the development of a transparent flexible display for a mobile communication function, RF devices should be integrated into a transparent flexible substrate. Recently, polyether sulfone (PES) has drawn attention for application to transparent flexible display, due to its good heat-resisting property, high transparency and good flexibility.⁴⁻⁷ The glass transition temperature (T_g) of PES is 230°C and it shows stable electrical and mechanical properties at high temperature, which enables the fabrication of electron devices at a relatively high temperature.⁴⁻⁷ Because of a heat-resist-

ing property, the electrical and mechanical properties of the PES do not change at even 300°C. Therefore, unlike other flexible substrates such as polycarbonate (PC) and polyethylene terephthalate (PET), the soldering and bonding processes for the electron devices on PES can be easily performed, which facilitates the packaging process of electronic devices. In addition, a very thin PES substrate, with a thickness less than 100 μm , can be used to fabricate electronic devices due to

YOUNG YUN, JANG-HYEON JEONG,
HONG-SEUNG KIM AND
NAK-WON JANG
Korea Maritime University, Busan, Korea



SUCOFLEX 406 – sets new standards

SUCOFLEX 406 – the new ultra low loss cable

- Applicable up to 18 GHz
- Lowest loss in this class
- High level of phase stability in a broad range of temperature

SUCOFLEX 404

- Applicable up to 26.5 GHz
- Lowest loss on the market
- Best phase stability versus temperature



its tenacity, which is very effective for the miniaturization of RF components. Furthermore, the PES shows a contraction ratio less than 0.2 percent, even if it is exposed to a high temperature environment for a long time, which enables precise processes, such as a microelectromechanical system (MEMS) process. Besides the mentioned properties, the PES shows good water resistance.

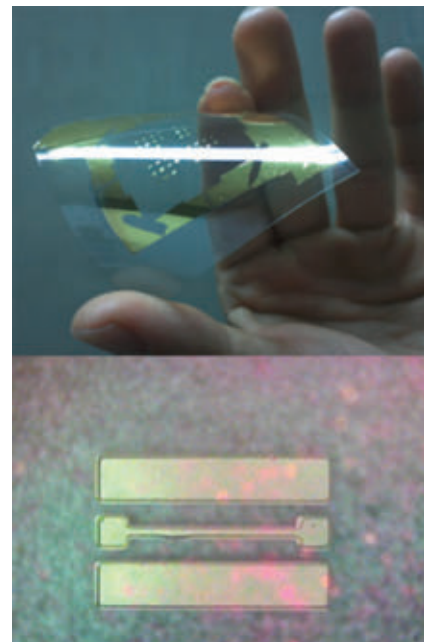
For these reasons, PES is suitable for applications such as a transparent

flexible display for mobile communications. Several groups have employed a PES substrate to evaluate the electrical properties of oxide films.⁸ For applications to mobile communication flexible displays, RF passive components as well as active devices could be integrated onto PES substrates. For integration of RF passive components on a PES substrate, the RF signal transmission characteristic on a PES substrate should be thoroughly investigated. To date, no known stud-

ies of the RF characteristics of PES substrates has been performed. In this work, a coplanar waveguide was fabricated on PES substrate and its RF signal transmission characteristics were thoroughly investigated.

LOSS CHARACTERISTICS OF A COPLANAR WAVEGUIDE FABRICATED ON PES

Figure 1 shows a photograph of the coplanar waveguide fabricated on PES. Pt/Au was deposited on a PES substrate 200 μm thick, and the thickness of the Au/Ti was 2 μm . The line width W is 20 μm , and the distance between line and ground plane is 80 μm . **Figure 2** shows the measured insertion loss per 1 mm and the attenuation constant α of the coplanar waveguide on PES. The insertion loss was measured with a 50 Ω impedance system and was normalized to the characteristic impedance of the coplanar waveguide. For comparison, data for the same size coplanar waveguide on silicon substrate is also plotted, because silicon substrate is the most popular semiconducting substrate for RFIC applications. As shown, the coplanar waveguide on PES shows very low loss, compared to the silicon substrate. It shows an insertion loss lower than 0.6 dB/mm, and an attenuation constant α lower than 0.065 Np/mm up to 50 GHz. The low loss of the coplanar waveguide on PES originates from its excellent electrical insulat-



▲ Fig. 1 Photograph of a coplanar waveguide fabricated on PES.

Microwave Control Products

Microwave Control Products

Features:

- Pin Diode Switches operating from 500 MHz to 40 GHz
- Low Loss - High Isolation
- Reflective or Absorptive
- SPST-SP10T Standard Products
- Pin Diode Phase Shifters-Analog or Digital
- Pin Diode Attenuators-Analog or Digital
- Hermetic packaging available on most products

MITEQ Microwave Control Product Application notes can be found at:
www.miteq.com/microwavecontrolproducts

 **MITEQ**
(631) 436-7400
components@miteq.com

www.miteq.com
Est. in 1969

WIDEBAND PLL + VCOs

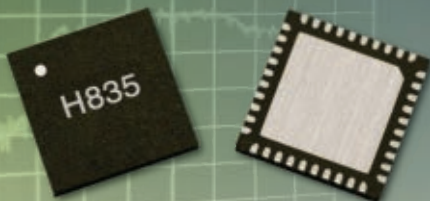
4 GHz with 4 Outputs Ideal for Next Generation MIMO Applications



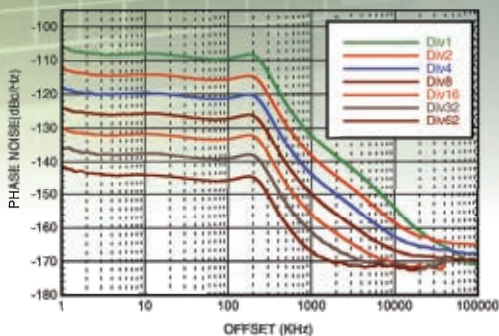
Analog, Digital & Mixed-Signal
ICs, Modules, Subsystems & Instrumentation



**Wideband PLL & VCO,
33 - 4100 MHz, 4 Outputs**

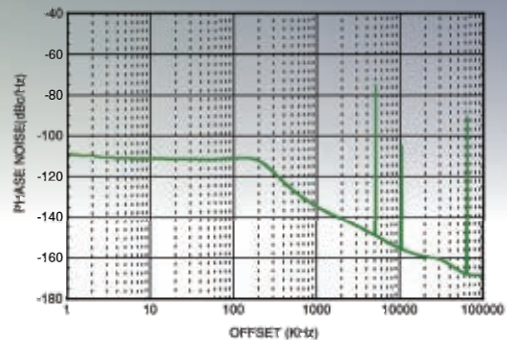


Closed Loop Fractional Phase Noise
at 3600 MHz, Divided by 1 to 62



- ◆ Maximum Phase Detector Rate: 100 MHz
- ◆ PLL FOM:
-230 dBc/Hz Integer Mode
-227 dBc/Hz Fractional Mode
- ◆ <160 fs Integrated RMS Jitter (1 kHz - 100 MHz)
- ◆ Low Noise Floor: -165 dBc/Hz
- ◆ 4 Single-Ended or 2 Differential Outputs

Fractional Spurious Performance at 2646.96 MHz,
with Exact Frequency Mode ON or OFF



Part Number	Frequency (MHz)	Function	Closed Loop SSB Phase Noise @ 10 kHz Offset	Open Loop VCO Phase Noise @ 1 MHz Offset	Pout (dBm)	RMS Jitter Fractional Mode (fs)	Integrated PN Fractional Mode (deg rms)
HMC829LP6GE	45 - 1050 1400 - 2100 2800 - 4200 Fo	Wideband PLL+VCO	-108 dBc/Hz @ 4 GHz	-134 dBc/Hz @ 4 GHz	4	159	0.229 @ 4 GHz
HMC830LP6GE	25 - 3000	Wideband PLL+VCO	-114 dBc/Hz @ 2 GHz	-141 dBc/Hz @ 2 GHz	6	159	0.114 @ 2 GHz
HMC832LP6GE	25 - 3000	Wideband RF VCO (+3.3V)	-114 dBc/Hz @ 2 GHz	-139 dBc/Hz @ 2 GHz	7	159	0.114 @ 2 GHz
HMC833LP6GE	25 - 6000	Wideband PLL+VCO	-114 dBc/Hz @ 2 GHz	-141 dBc/Hz @ 2 GHz	-4	159	0.11 @ 2 GHz
HMC834LP6GE	45 - 1050 1400 - 2100 2800 - 4200 Fo 5600 - 8400	Wideband PLL+VCO	-108 dBc/Hz @ 4 GHz	-134 dBc/Hz @ 4 GHz	5	159	0.23 @ 4 GHz
					2		
					-10		
NEW! HMC835LP6GE	33 - 4100	Wideband PLL+VCO	-105 dBc/Hz @ 4 GHz	-133 dBc/Hz @ 4 GHz	7	160	0.23 @ 4 GHz



2 Elizabeth Drive • Chelmsford, MA 01824
978-250-3343 tel • 978-250-3373 fax



Visit Us: www.hittite.com
Contact Us: pll@hittite.com

Receive the latest product releases - click on "My Subscription"

ing properties. In the case of coplanar waveguide on silicon substrate, there is a current flowing from the line to the ground plane, through the silicon substrate, due to the relatively high conductivity of silicon substrate, which causes a relatively high loss of electromagnetic energy.⁹ In the case of coplanar waveguide on PES, there is no current flowing from line to ground plane through the PES substrate, due to its excellent electrical insulating characteristic.

The quality (Q) factor of the coplanar waveguide on PES was also investigated. There are several methods to calculate the Q-factor.¹⁰ Here, the transmission line Q-factor was derived from a resonator using a quarter wavelength long line at the resonance frequency f_0 . The Q-factor was extracted by the ratio of -3 dB bandwidth to f_0 , in other words, $Q = f_0/\Delta f_{3dB}$. **Figure 3** shows the insertion loss S_{21} of a quarter wavelength coplanar waveguide fabricated on

PES. The Q-factor was 40.3 at a resonance frequency of 46.7 GHz. **Table 1** shows the Q-factors of transmission lines on PES and silicon substrate. As shown in this table, the transmission line on PES shows a Q-factor much higher than silicon substrate. The results indicate that the RF passive components on PES substrate can be used in applications at millimeter wave as well as microwave, due to its very low loss.

BASIC RF CHARACTERISTICS OF COPLANAR WAVEGUIDE FABRICATED ON PES

Figure 4 shows the wavelength of the coplanar waveguide on PES to be 3.9 to 6.2 mm from 30 to 50 GHz. In a highly integrated RF circuit, bulky passive components as well as transis-

Low Noise Amplifiers

“Need Gain”

MITEQ has it with Low Noise!

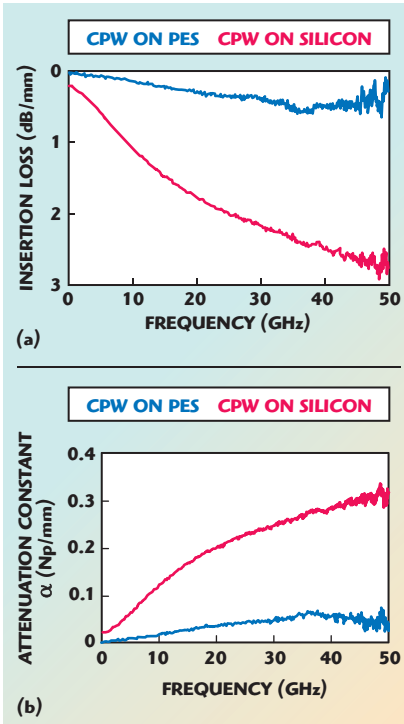
Features:

- Amplifiers from 1 kHz to 65 GHz
- Utilizing GaAs FET/BiPolar/MMIC technologies
- Narrow Band to Ultra-Wideband designs
- Coaxial/Waveguide and Surface Mount Packaging
- Large array of Catalog offerings
- Integrated RF Input limiter protection
- Custom designs are welcomed

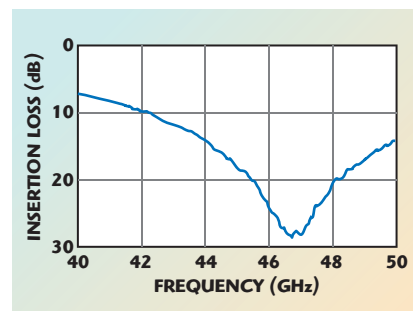
MITEQ Amplifier Application notes can be found at:
www.miteq.com/amplifiers

MITEQ
(631) 436-7400
components@miteq.com

www.miteq.com
Est. in 1969



▲ Fig. 2 Loss characteristics of coplanar waveguide on PES and silicon substrates.



▲ Fig. 3 Measured insertion loss of a quarter wavelength coplanar waveguide fabricated on PES.

Bring your 3G/4G Testing to a Solid State



4205 Series

USB/TTL Controlled

Available in 0-31.5,
63.5, 95 dB



DC to 6 GHz Programmable Attenuator Solutions



8331 Series

Ethernet Controlled

Configurations up to 12 channels

Electromechanical & Solid-State designs

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, Aeroflex / Weinschel's newest DC to 6 GHz MMIC digital attenuation solutions include 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.

800-638-2048 / 301-846-9222

www.aeroflex.com/weinschel

weinschel-sales@aeroflex.com

AEROFLEX
A passion for performance.



tors could be integrated onto the PES substrate. One of the largest RF components is a branch-line coupler, which

is usually fabricated on PCB, not on semiconducting substrate due to its large size. To evaluate the integration

capacity of RF passive components on PES substrates, the size of branch-line couplers consisting of $\lambda/8$ transmission lines¹² was calculated from the wavelength and is listed in **Table 2**. As shown, the size of branch-line couplers is much less than 1 mm² over a frequency range of 30 to 50 GHz, which indicates that bulky passive components can be integrated onto a PES substrate with a small chip size in the millimeter wave frequency range.

Figure 5 shows the characteristic impedance Z_0 of coplanar waveguides on PES as a function of line width. A characteristic impedance Z_0 of 50 to 160 Ω is obtained for a line width range of 10 to 110 μm . From this result, it can be seen that coplanar waveguides of various characteristic impedances can be realized on a PES substrate by only changing the line width W . They can be used for matching between RF components of various impedances.

Figure 6 shows the propagation constant β of the coplanar waveguide on PES. The coplanar waveguide on PES shows a β of 0.35 to 1.61

TABLE I

Q FACTOR OF A 20 μm WIDE LINE ON PES AND SILICON SUBSTRATES

Item	Q Factor	Frequency (GHz)	Type	Method
PES	40.3	46.7	Coplanar Waveguide	$f_0/\Delta f_{-3\text{dB}}$
Silicon ⁹	6.3	40	Microstrip Line	$f_0/\Delta f_{-3\text{dB}}$
Silicon ¹¹	13	47	Microstrip Line	$\omega L/R$
Silicon ¹¹	23	47	Coplanar Waveguide	$\omega L/R$

Microwave Fiber Optics

“Are You Linked In”?

Features:

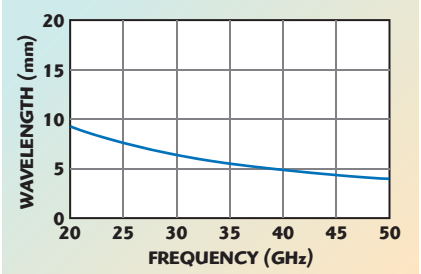
- Analog RF over Fiber Transmitters, Receivers, and Complete Links
- Operating BW's up to 20 GHz
- Low Noise Figure
- Wide Dynamic Range in excess of 100 dB
- Available Wavelengths of 1550/1310/1490 nm
- No external controls circuits required
- Operational status monitor pins
- Packages from small hermetic modules to outdoor and rack enclosures

MITEQ Fiber Optic Application notes can be found at: www.miteq.com/fiberoptics



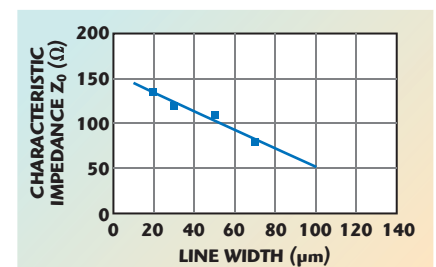
MITEQ
(631) 436-7400
components@miteq.com

www.miteq.com
Est. in 1969



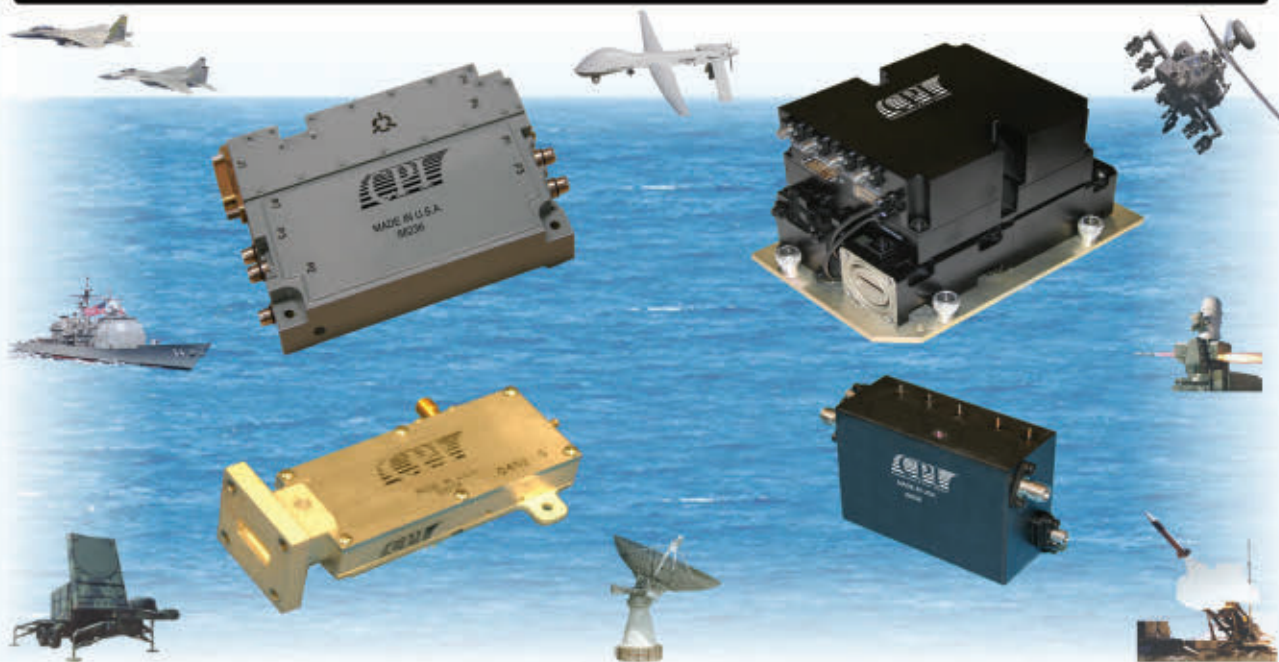
▲ Fig. 4 Measured wavelength of a coplanar waveguide on PES.

TABLE II SIZE OF BRANCH-LINE COUPLERS CONSISTING OF $\lambda/8$ TRANSMISSION LINES ON PES	
Frequency (GHz)	Size of Branch-line Couplers (mm ²)
30	0.619
40	0.36
50	0.239



▲ Fig. 5 Measured characteristic impedance of coplanar waveguides on PES.

Integrated Microwave Assemblies



Advanced Technology - Extensive Experience - Superior Performance



Communications & Power Industries

Communications & Power Industries' Beverly Microwave Division (BMD) offers product technology that includes Integrated Microwave Assemblies and Control Components. BMD's broad experience and extensive capabilities in the areas of high power microwave component design for military and non-military radar, satellite, communications, and EW systems makes it uniquely suited to design and manufacture a wide range of components and multi-function assemblies in small, lightweight packages. Coupling that with our experience in other transmission lines and technologies gives us a technical capability that is unparalleled in the microwave industry.

- * Multi-function components
- * RF front ends
- * Switches & attenuators
- * High level assemblies & modules
- * Design capability up to 40 GHz
- * Power handling to 1 MW+ peak
- * Integral driver & associated electronics
- * The industry's most extensive high power test facility

**Communications & Power Industries
Beverly Microwave Division**

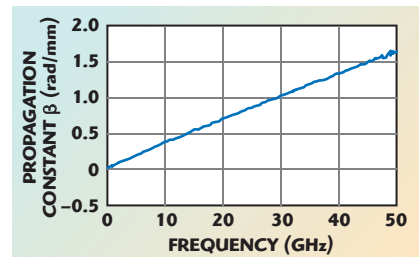
150 Sohier Road
Beverly, MA 01915
Phone: (978) 922-6000
Fax: (978) 922-2736

marketing@bmd.cpii.com
www.cpii.com/bmd

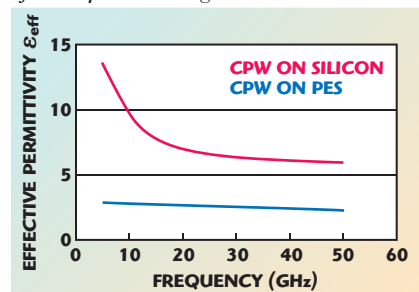
Technical Feature

rad/mm from 10 to 50 GHz. **Figure 7** shows the high frequency effective permittivity ϵ_{eff} of the coplanar waveguide on PES. For a comparison, the ϵ_{eff} of the coplanar waveguide on silicon substrate is also plotted. As shown, the ϵ_{eff} of the coplanar waveguide on PES is lower than that of the silicon substrate. The coplanar waveguide on PES shows an ϵ_{eff} of 2.35 to 2.9 from 10 to 50 GHz, while the coplanar waveguide on silicon substrate shows an ϵ_{eff} of 5.9 to 13.6 from 10 to 50 GHz. Due to the

lower ϵ_{eff} , the physical length of coplanar waveguide on PES is longer than on a silicon substrate for the same electrical length. **Table 3** shows the length of a $\lambda/8$ coplanar waveguide on PES and silicon substrate. The coplanar waveguide on a silicon substrate shows strong frequency dispersion characteristics. This tendency originates from the existence of various propagation modes on the oxide/silicon substrate. The skin-effect and slow-wave mode of propagation exists, in addition to the quasi-transverse



▲ Fig. 6 Measured propagation constant β of the coplanar waveguide on PES.



▲ Fig. 7 Effective permittivity ϵ_{eff} of the coplanar waveguide on PES and silicon substrates.

electromagnetic (quasi-TEM) mode on oxide/silicon substrates, which causes a large change of ϵ_{eff} between 1 and 20 GHz.⁹ On the other hand, the coplanar waveguide on PES shows a very weak frequency dispersion characteristic, compared to a silicon substrate, because the quasi-TEM mode propagates dominantly on the metal/high-insulating substrate structure.¹³ The above results indicate that the coplanar waveguide on PES is suitable for broadband applications, due to its very weak frequency dispersion characteristic.

CONCLUSION

In this work, a coplanar waveguide was fabricated on a PES substrate and its RF characteristics were thoroughly investigated for the first time. The coplanar waveguide on PES showed a very low loss compared with a conventional silicon substrate. It showed an insertion loss lower than 0.6 dB/mm and an attenuation constant α lower than 0.065 Np/mm up to 50 GHz. The transmission line Q-factor was derived from a resonant tank built using a one-quarter wavelength long line at the resonance frequency f_0 . According to a measured result, it was found that the Q-factor of a coplanar waveguide on PES was 40.3 at a resonance frequency of 46.7 GHz. The coplanar waveguide on PES showed a wavelength of 3.9 to 6.2 mm from 30 to 50 GHz, which means that bulky passive RF components can be integrated onto a PES sub-

Frontlynk®
Connectors and Cables up to

110 GHz

Glass Bead
Hermetic Connector
Available!!!

Great Performance
Mass Customization
Fast Delivery
Right in Taiwan

SMA N High Frequency SMPM 1.0 mm

DC to 26 GHz 40 GHz to 110 GHz

FRONTLYNK TECHNOLOGIES INC.
Tel: +886-6-356-2626 Fax: +886-6-356-6268
http://www.frontlynk.com E-mail: info@frontlynk.com
German Speaking: bsw TestSystems & Consulting AG
Tel. +49-(0)7031-410089 28 E-Mail: info@bsw-ag.com



CERAMIC FILTERS

LOW PASS BANDPASS HIGH PASS

45 MHz to 15 GHz from **99¢** ea. qty. 3000

Over 185 ~~767~~ models...only 0.12 x 0.06" These tiny hermetically sealed filters utilize our advanced Low Temperature Co-fired Ceramic (LTCC) technology to offer superior thermal stability, high reliability, and very low cost, making them a must for your system requirements. Visit our website to choose and view comprehensive performance curves, data sheets, pcb layouts, and everything you need to make your choice. You can even order direct from our web store and have units in your hands as early as tomorrow!

Now available in small-quantity reels at no extra charge:

Standard counts of 20, 50, 100, 200, 500, 1000 or 2000. Save time, money, and inventory space!

Wild Card KWC-LHP LTCC Filter Kits only \$98



Choose any 8 LFCN or HFCN models
Receive 5 of ea. model, for a total of 40 filters
Order your KWC-LHP FILTER KIT TODAY!

RoHS compliant U.S. Patents 7,760,485 and 6,943,646

Mini-Circuits...we're redefining what VALUE is all about!

Mini-Circuits®
ISO 9001 ISO 14001 AS9100

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661



The Design Engineers Search Engine finds the model you need, Instantly • For detailed performance specs & shopping online see minicircuits.com

IF/RF MICROWAVE COMPONENTS

504 Rev B

strate with a small area in the high frequency range. The sizes of conventional branch-line couplers consisting of $\lambda/8$ transmission lines on PES are smaller

than 0.619 mm^2 from 30 to 50 GHz. Compared with a silicon substrate, the coplanar waveguide on PES showed lower ϵ_{eff} . The coplanar waveguide on PES shows an ϵ_{eff} of 2.35 to 2.9 from 10 to 50 GHz, which caused a physical length of transmission line longer than for a silicon substrate. The coplanar waveguide on PES showed a very

weak frequency dispersion characteristic compared with a silicon substrate, which means that the coplanar waveguide on PES is suitable for broadband applications. The results indicate that the PES is a promising candidate for application to flexible RFIC at high frequencies. This work is the first known report of an investigation of RF signal transmission characteristics on a PES substrate. ■

ACKNOWLEDGMENT

This research was financially supported by the Ministry of Education, Science Technology (MEST) and National Research Foundation of Korea (NRF), through the Human Resource Training Project for Regional Innovation. This research was also supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (2010-0007452).

References

1. M.S. Oh, D.K. Hwang, K.M. Lee, S. Im and S. Yi, "Low Voltage Complementary Thin-film Transistor Inverters with Pentacene-ZnO Hybrid Channels on AlO_x Dielectric," *Applied Physics Letters*, Vol. 90, No. 17, April 2007, pp. 173511-1 – 173511-3.
2. Y.W. Choi, I.D. Kim, H.L. Tuller and A.I. Akinwande, "Low-voltage Organic Transistors and Depletion-load Inverters with High-K Pyrochlore BZN Gate Dielectric on Polymer Substrate," *IEEE Transactions on Electron Devices*, Vol. 52, No.12, December 2005, pp. 2819-2824.
3. Y. Sun, and J.A. Rogers, "Inorganic Semiconductors for Flexible Electronics," *Advanced Materials*, Vol. 19, pp. 1987-1916, 2007.
4. Y.C. Chen, "IR Welding of Glass Filled Polyether Sulfone Composite," *Tamkang Journal of Science and Engineering*, Vol. 4, No. 2, 2000, pp. 229-234.
5. E. Celik, H. Park, H. Choi and H. Choi, "Carbon Nanotube Blended Polyethersulfone Membranes for Fouling Control in Water Treatment," *Water Research*, Vol. 45, No. 1, January 2011, pp. 274-282.
6. H.L. Wu, C.M. Ma, F.Y. Liu, C.Y. Chen, S.J. Lee and C.L. Chiang, "Preparation and Characterization of Poly (ether sulfone)/Sulfonated Poly(ether ether ketone) Blend Membranes," *European Polymer Journal*, Vol. 42, No. 7, July 2006, pp. 1688-1695.
7. R. Rajasekaran, M. Alagar and C.K. Chozhan, "Effect of Polyethersulfone and N, N'-bismaleimido-4, 4'-diphenyl Methane on the Mechanical and Thermal Properties of Epoxy Systems," *eXPRESS Polymer Letters*, Vol. 2, No. 5, 2008, pp. 339-348.
8. C.C. Kuo, C.C. Liu, S.C. He, J.T. Chang and J.L. He, "The Influence of Thickness on the Optical and Electrical Properties of Dual-Ion-Beam Sputtering-deposited Molybdenum-doped Zinc Oxide Layer," *Journal of Nanomaterials*, Vol. 2011, Article ID 140697, pp. 1-5.
9. J.R. Long, "Passive Components for Silicon RF and MMIC Design," *IEICE Transactions on Electronics*, Vol. E86-C, No. 6, June 2003, pp. 1022-1031.
10. D.M. Pozar, *Microwave Engineering*, Addison-Wesley, Reading, MA, 1990.
11. C.H. Doan, S. Emami, A.M. Niknejad and R.W. Broderick, "Design of CMOS for 60 GHz Applications," *2004 IEEE International Solid-State Circuits Conference Digest*, Vol. 1, pp. 440-538.
12. T. Hirota, A. Minakawa and M. Muraguchi, "Reduced-size Branch-line and Rat-race Hybrids for Uniplanar MMICs," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 38, No. 3, March 1991, pp. 270-275.
13. J. Zhang, and T.Y. Hsiang, "Dispersion Characteristics of Coplanar Waveguides at Subterahertz Frequencies," *Progress In Electromagnetics Research Symposium Proceedings*, Vol. 2, No. 3, March 2006, pp. 232-235.

TABLE III

LENGTHS OF $\lambda/8$ COPLANAR WAVEGUIDES ON PES AND SILICON SUBSTRATES

Frequency (GHz)	PES (mm)	Silicon (mm)
30	0.78	0.5
40	0.6	0.38
50	0.48	0.31



I²M has developed both, power dividers/ combiners and 3dB branch line couplers with bandpass filtering and DC block-

ing functions. The dividers/combiners (Model No. PD-UBPF-Frequency Range) have super wide bandpass filter property and the branch line couplers (Model No. 3BLC-EFT- Frequency Range) have elliptic function type filter selectivity.

The dividers/combiners and the couplers are produced in planar form, for example, in microstrip line and LTCC structures. We can design the dividers/combiners (up to 19.5GHz, 60% Fractional Bandwidth), the couplers (up to 12GHz, 50% Fractional Bandwidth), and bandpass filters from your specifications.

The devices provide a low cost solution to reducing noise, interference, and intermodulation problems for your system and circuit applications.

I²M is located in South Korea.

**Contact Dr. Ihn Seok Kim
(+82-10-9470-2656).**



Our web page:

<http://www.IsquareM.com>



HIGH FREQUENCY CONNECTIVITY *WITH A TWIST.*

SV Microwave's new QuarterBack line of connectors combines the high frequency performance of an SMP style connector with the mating durability and ease of a bayonet style connector.

- Positive Mating
- SMP (40 GHz) / SMPM (65 GHz)
- Quick Connect/Disconnect Applications
- Low Mating Forces
- High Vibration Environments
- Custom Configurations Available

Amphenol
SV MICROWAVE[®]
www.svmicrowave.com

Screen Printed RFID-Enabled Temperature Sensor Fabricated on Flexible Substrates

RFID tags are often used in supply chain management and storage of a wide range of goods. In many cases, it is necessary to control environmental conditions because many products are sensitive to low or elevated temperature. Currently, this is carried out mostly with the use of indicators or expensive and complicated sensors. The latter contains electronic components, which make them inflexible. Indicators exhibit durability to bending but cannot be read wirelessly. As a result, they have to be placed outside a package and can be destroyed. A screen printed RFID-enabled temperature sensor, both flexible and wirelessly read, was developed and tested. It was fabricated with silver paste on a foil or paper. This sensor works in the UHF frequency range and provides a maximum read distance of 80 cm. Its properties were investigated with regard to the materials used, as well as environment and storage temperature.

Radio Frequency Identification (RFID) is one of the most popular automatic identification systems. It is often used in supply chain management and logistics.^{1,2} Many types of goods, such as dairy products or medicines, are susceptible to the influence of elevated temperature. Therefore, it is required to control their transportation or storage conditions. Otherwise, it can lead to their deterioration or even loss.

Nowadays, the temperature in a product environment is measured by various techniques. Semi-passive RFID systems are one of them. Their main component is a temperature logger, which records the temperature level and sends it to a reader. However, this device contains a battery that limits its lifetime and makes its unit cost higher, compared to RFID tags manufactured with printing techniques, such as inkjet,^{3,4} screen printing^{5,6} or photogravure.⁷

The temperature is also controlled with indicators, which have a much lower unit cost

than loggers. Their color changes when the temperature increases.⁸ Their main disadvantage is the optical method to identify their state. It is inconvenient and makes the temperature control efficiency lower.

Currently, more and more studies are focused on RFID-enabled sensors, consisting of an antenna, a chip and an active element. These devices can be read wirelessly, so it is possible to place them inside a package to avoid their damage. Yao et al.⁹ described a low power temperature sensor with excellent power supply variation rejection ability for RFID tags. Other investigations were performed by Shenghua et al.¹⁰ and by Zhang et al.¹¹ A temperature sen-

KAMIL JANECZEK, MAŁGORZATA
JAKUBOWSKA, GRAŻYNA KOZIOŁ AND
WOJCIECH STĘPLEWSKI
*Tele & Radio Research Institute,
Warsaw, Poland*

The purest signals for A/D converter tests

For reliable results at the digital output, you have to feed the converter's input with the purest analog signals available during development. That's where the R&S®SMA100A comes in. With nonharmonics of typ. -100 dBc and a wideband noise figure of typ. -160 dBc up to 750 MHz, the R&S®SMA100A is at the top of its class in signal quality. This gives you maximum confidence in your converters' capabilities.

Interested? Then visit
www.rohde-schwarz.com/ad/sma/mwj



R&S®SMA100A (9 kHz to 3/6 GHz)

Technical Feature

sor integrated with a low power RFID tag chip was manufactured with 0.18 μm standard CMOS technology.

Other studies were presented by Guerin et al.¹² and by Yang et al.¹³ A platinum-deposited based wireless temperature sensor was described by Guerin et al. based on a resistance change with temperature variations, which was combined with the frequency of a backscattering modulated signal. Yang et al. fabricated a wireless sensor transmitter, produced by an inkjet printing technique. It was a register, fitted with a temperature sensor and other electronic components, like quartz oscillator or battery. Thus, it was not flexible.

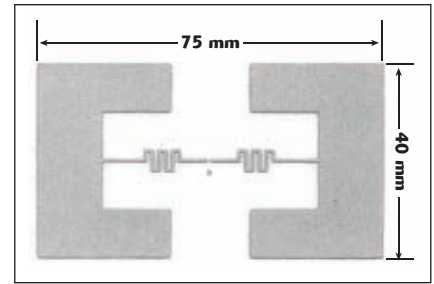
In this article, an RFID-enabled temperature sensor, manufactured on flexible substrates with screen printing techniques, is described. A UHF antenna was designed with the FEKO Suite and screen printed with a silver paste. A chip was assembled with a conductive adhesive and encapsulated with a fast flow underfill to increase its mechanical durability. An active element was printed with three types of silver pastes. The properties of the

prepared temperature sensors were examined by reaction time measurements, depending on a substrate material and testing temperature level. In addition, their lifetime and read distance were estimated.

EXPERIMENTAL

The UHF antenna, shown in **Figure 1** and used in the RFID-enabled sensor, was designed with the simulation software FEKO Suite. Its return loss was taken into consideration. In the simulation, it was assumed that the antenna was made from silver on a foil (dielectric permittivity of 2.9, dissipation factor of 0.005 and thickness of 125 μm).

Then the simulated antenna was manufactured using a screen printing technique with a polyester mesh screen 68T. A polyethylene naphthalate (PEN) foil (Teonex Q51, from DuPont Teijin Films) and a photo paper (Everyday 180 g/m², from Emtec) were used as substrate materials. The EL/Ag paste used for the antenna printing contained 70 percent weight silver flakes dispersed in a conductive polymer PEDOT:PSS in the form of an EL-P3040 paste (Agfa



▲ **Fig. 1** UHF antenna designed in this study.

Gavaert). After the screen printing process, the antennas were cured at 120°C for 15 minutes.

In the next step, an RFID chip in an SOT-323 package (Alien Technology) was attached to the antenna using a conductive adhesive Ecolit 3654 (Panacol), which was cured at 120°C for 10 minutes. Then these components were encapsulated with a fast flow underfill e1216 (Emerson & Cuming) and cured at 130°C for 10 minutes. Their shear force before and after encapsulation was measured with a Force Testing System Mecmesin i-1.

Finally, an active element of the RFID-enabled sensor was printed with the EL/Ag paste, a commercial silver paste PF-050 (OEM Electronics) and an SF paste. The last one consisted of 66 percent weight of silver flakes dispersed in a poly(methyl methacrylate)-poly(butyl methacrylate) (PMMA-PBMA) dissolved in butyl carbitol acetate with a concentration of 10 percent weight. After the printing process, all the pastes were cured at 120°C for 15 minutes.

The reaction time and long term stability of the active element of the fabricated RFID-enabled sensor were measured. The first parameter was defined as the time period to decrease the resistance of an active element below 100 Ω . It was estimated by continuous resistance measurements, during exposure to elevated temperatures (80° to 140°C). The stability of the active element resistance was evaluated by its measurements after storage in ambient conditions and in a refrigerator (-4°C) or in a freezer (-12°C). The read distance of an elaborated sensor was measured using an RFID reader tt8300 t+t netcom.

SENSOR CONCEPTION

The sensor was constructed, based on the idea that under elevated temperature, its resistance will change rap-

SAW Modules

Integrated Microwave Assemblies for IF signal processing with SAW's exceptional performance:

- state-of-the-art design
- high freq selectivity
- high dynamic range
- MIL & space qual
- minimal SWaP



SAW for Defense & Space

Radar Space Communications Electronic Warfare

Phonon CORPORATION
www.phonon.com/mod

90 Wolcott Rd. Simsbury, CT 06070 (860) 651-0211

When it comes to quick-turn switches, we're a machine.

AEROFLEX
CONTROL COMPONENTS



Over 3,000 models to choose from and you can have up to 10 pieces on your bench in 4 weeks or less. How do we do it? We're a machine.

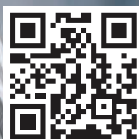
For decades we've been fine-tuning our approach to RF/Microwave solid-state switches and have repeatedly proven several core designs. Components are kept in stock so we can build, tune, and test exactly what you need to meet your octave and multi-octave SPST through SP6T and transfer switch requirements—switches with isolation as high as 80 dB and with insertion losses as low as 1.2 dB in compact, standard packages. Optional control features, hermetic sealing, and RoHS designs are available, too.

There's only one true switch factory. Visit our website to get your model started today.

732-460-0212

www.aeroflex.com/ACCQuick

DELIVERY
IN 4 WEEKS
OR LESS



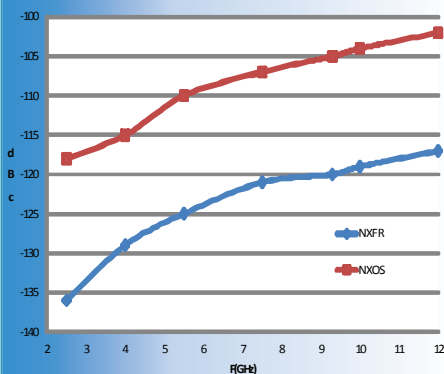
AEROFLEX
A passion for performance.



We have specialized in Low Phase Noise Fixed Frequency Sources since 1998.

A plot of our new quieter FRDRO line.

COMPARE NXOS AND NXFR SERIES FRDRO TYPICAL PHASE NOISE AT 10 kHz OFFSET



- 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

idly. The resistance decrease is permanent so it was not possible to increase it again. An electrical schematic of the designed sensor is shown in **Figure 2**.

The power wave reflection coefficient S_{11} can be expressed by the following equation:¹⁵

$$S_{11} = \frac{Z_{ant} - Z_{obc}^*}{Z_{ant} + Z_{obc}} \quad (1)$$

where Z_{obc} is the load impedance.

The antenna impedance Z_{ant} is equal to:

$$Z_{ant} = R_a + jX_a \quad (2)$$

where

$$R_a = R_{rad} + R_{str} \quad (3)$$

$$X_a = X_L + X_C \quad (4)$$

R_{rad} is the radiation resistance, R_{str} is the antenna loss resistance and X_L and X_C are the inductive and capacitive reactances of the antenna.

In the designed temperature sensor, a change in the antenna resistance R_a took place:

$$R'_a = R_{rad} + R_{str} + R_s \quad (5)$$

Along with an increase in the resistance R_s , the antenna loss resistance ($R_{str} + R_s$) increased. It resulted in a decrease of the power of the back-scattering signal received by an RFID reader. When R_s decreases rapidly, most of the signal transmitted to a reader was interpreted as an exposure of a sensor to elevated temperature.

The schematic diagram of a fabricated RFID-enabled temperature sensor is shown in **Figure 3**. The main part of the sensor is an active element, a layer of silver paste placed in a gap in an antenna circuit (see **Figure 4**). The two layers (PEN foil and an adhesive tape) on the top of the sensor were used to protect

the active element against external conditions, such as humidity or dust. They also prevent against rapid evaporation of the solvent contained in the silver paste.

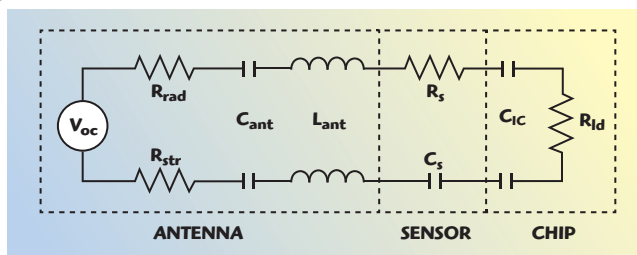
RESULTS AND DISCUSSION

Antenna Simulation

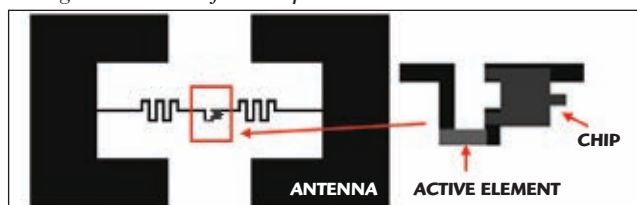
The UHF antenna was simulated by the FEKO Suite software in the frequency range of 0.5 to 1.5 GHz (see **Figure 5**). Its return loss was taken into consideration. The basic resonant frequency of the designed antenna was 876 MHz for the load impedance of $Z = (32 - j228) \Omega$. The bandwidth of the antenna was greater than 200 MHz, which fully covers the UHF frequency band 860 to 960 MHz.

Chip Assembly

The mechanical durability of the assembled RFID chips was tested by shear force measurements. For all non-encapsulated chips, regardless of the substrate used (foil or paper),



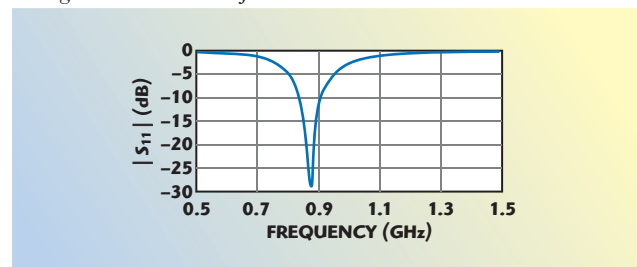
▲ Fig. 2 Schematic of the temperature sensor.



▲ Fig. 3 Schematic diagram of the RFID-enabled temperature sensor.



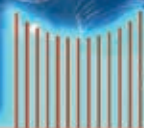
▲ Fig. 4 Cross-section of the sensor.



▲ Fig. 5 Simulated S_{11} vs. frequency for the load impedance $Z = (32 - j228) \Omega$.

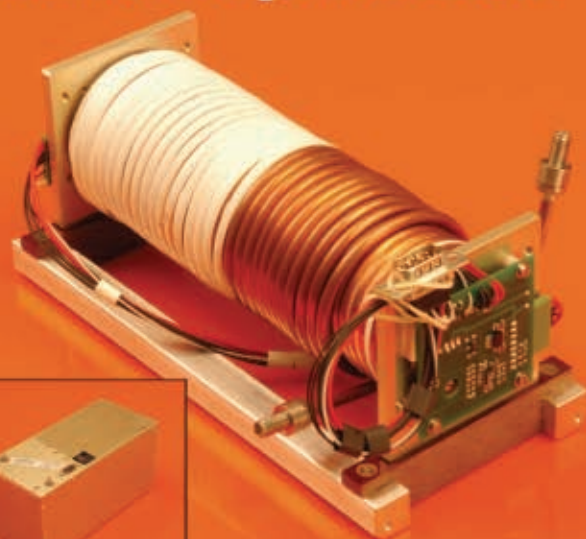
SQ-, TQ-, IQ-, BQ-, CQ- =
connecting 4, 7, 8, 10 or 12 coaxial RF-Lines at once

RQ23-DC26 =
connecting 23 coax RF-
& 26 Signal Lines at once



Spectrum
Elektrotechnik GmbH

Coaxial Delay Lines
Semi Rigid and flexible
and also temp. controlled



when Quality is needed

80905 Munich, Germany
P.O. Box 450533



KW to W mW
MHz to 71 GHz

Telephone: +49-89-3548-040
Facsimile: +49-89-3548-0490
Email: Sales@Spectrum-et.com

**P
H
A
S
E

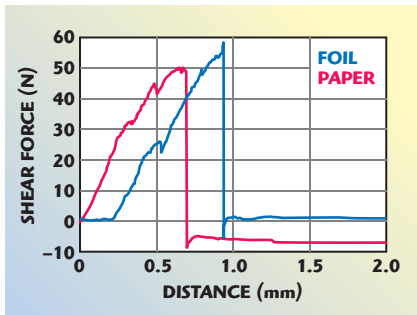
A
D
J
U
S
T
E
R
S**

360° @ 1 GHz

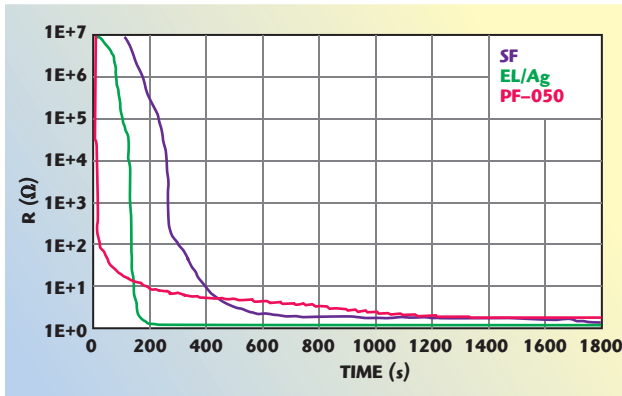


230° @ 12 GHz
350° @ 18 GHz
500° @ 26 GHz
590° @ 40 GHz
400° @ 50 GHz
600° @ 63 GHz
85° @ 2 GHz
520° @ 12 GHz
770° @ 18 GHz

www.spectrum-et.com



▲ Fig. 6 Shear force of the encapsulated chips assembled on foil and paper.



▲ Fig. 7 Resistance of an active layer depending on exposure time to 120°C.

the measured shear force was below 1 N. Its value was insufficient for practical applications and therefore the chips were encapsulated. It resulted in an increase of shear force up to 50 ± 7 N for the chips assembled on paper and up to 58 ± 11 N for the chip mounted on foil (see Figure 6).

The higher value of the shear force for encapsulated chips resulted from an increase of the bonding force between them and the substrate, resulting from a larger bonding surface. A type of substrate seemed to have an impact on a mechanical durability of the assembled chips. The surface of the polymer coated paper cracked during the shear test and this could contribute to a lower value of shear force in comparison to foil.

TABLE I

REACTION TIME OF A PF-050 SENSOR VERSUS TESTING TEMPERATURE

Temperature (°C)	Reaction Time (s)
80	1198 ± 48
100	187 ± 22
120	30 ± 10
140	10 ± 3

Sensor Properties

A basic parameter, describing properties of the investigated sensor, was the reaction time. As mentioned in the experimental section, the reaction time was defined as a period in which the resistance of an active element decreased below 100Ω . It was evaluated for the temperature of 80°, 100°, 120° and 140°C. Under the influence of a temperature increase, a paste started to polymerize as a result of a solvent evaporation. Thus, the resistance of an active layer decreased rapidly (see Figure 7).

The measured reaction time for active layers printed with the pastes: PF-050, EL/Ag and SF was equal to 30 ± 10 s, 135 ± 5 s, 315 ± 15 s, respectively. Its value depended strongly on the type of paste used, particularly on the solvent type. In the material (EL/Ag), a commercial paste (EL-P3040) was utilized as a polymer carrier. According to the manufacturer recommendation,¹⁴ its curing conditions should be 120°C for only 3 minutes. In the case of the paste (SF) the curing temperature of the printed layer was also 120°C, but the time was 15 minutes. The five times longer curing time could cause the solvent to evaporate from this material much slower and in consequence, the SF sensor exhibited longer reaction time.

The reaction time depended also on the testing temperature (see Table I). At higher temperatures, polymerization occurred faster because of faster solvent evaporation. This resulted in shorter reaction time. Based on the achieved results, a model describing the reaction time against temperature is proposed. It can be expressed as:

$$t = (2.6 \times 10^{19}) T^{-8.584} \quad (6)$$

where t is the reaction time and T is the temperature.

In the case of a sensor printed on paper, it was not possible to evaluate



Attenuators
Resistors
Terminations
Broadband Splitters
Broadband Couplers
Thermal Management
Dividers
Filters

• **Featured Products** •

Chip Attenuators - DC to 40GHz

- Power Ratings to 100W
- 11 Sizes- 0402 to 3725
- Values to 70dB
- 1/2dB Steps to 16.5dB
- Solder, Epoxy or Wirebond Terminals
- Millions in Stock!

Chip Resistors - DC to 40GHz

- Power Ratings to 175mW
- Values 10ohm - 2Kohm
- Sizes 0302 to 0805
- Solder or Epoxy Terminals
- 4 Weeks Max Lead Time
- Unique Design for RF & Microwave Circuits



Get Samples and See More at www.ims-resistors.com

TINY TOUGHEST MIXERS UNDER THE SUN

NOW
UP TO 20 GHz!



Rugged, tiny ceramic SIM mixers from **\$4⁹⁵** ea. qty. 1000 offer unprecedented wide band, high frequency performance while maintaining low conversion loss, high isolation, and high IP3.

Over 21 models IN STOCK are available to operate from an LO level of your choice, +7, +10, +13, and +17 dBm. So regardless of the specific frequency band of your applications, narrow or wide band, there is a tiny SIM RoHS compliant mixer to select from 100 kHz to 20 GHz. Built to operate in tough



environments, including high ESD levels, the SIM mixers are competitively priced for military, industrial, and commercial applications. Visit our website to view comprehensive performance data, performance curves, data sheets, pcb layouts, and environmental specifications. And, you can even order direct from our web store and have it in your hands as early as tomorrow!

Mini-Circuits...we're redefining what VALUE is all about!

U.S. Patent # 7,027,795  RoHS compliant

Mini-Circuits®
ISO 9001 ISO 14001 AS9100

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661



The Design Engineers Search Engine finds the model you need, instantly • For detailed performance specs & shopping online see minicircuits.com

IF/RF MICROWAVE COMPONENTS

428 rev H

TABLE II

AVERAGE LIFETIME OF SENSORS PRINTED ON FOIL FOR DIFFERENT TESTED PASTES

Storage Temperature (°C)	Lifetime (h)/Type of Paste		
	L-121	PF-050	EL/Ag
21	1146 ± 522	96 ± 48	820 ± 164
4	3540 ± 674	720 ± 232	4332 ± 704
-12	4836 ± 583	3564 ± 314	6254 ± 856

its properties. Solvents were absorbed by the substrate immediately after the printing process and, in consequence, the resistance of the active element decreased rapidly.

The second estimated parameter of sensors was their lifetime. It was evaluated depending on the storage temperature. The results shown in **Table 2** show that the lifetime, defined as a period in which the resistance of an active layer decreased below 100 Ω , increased when samples were stored in a colder environment. This was a result of a slower solvent evaporation.

The last tested parameter, which characterized the developed sensor, was the read distance. Its maximum value was 80 cm, placing the sensor

inside a package for practical applications.

CONCLUSION

In this article, the measurement results of reaction time and lifetime for a screen printed RFID-enabled sensor fabricated on flexible substrates are presented. It is stated that the measured reaction time depended on the type of paste used and testing temperature. Its value was from 10 to 1198 s, when the testing temperature increased from 80° to 140°C. At 120°C, the reaction time was equal to 30 ± 10 s, 135 ± 5 s, 315 ± 15 s for the pastes PF-050, EL/Ag and SF. The maximum read distance of the developed sensor was 80 cm. The sen-

sor was functional for at least for 3564 h (more than 148 days), which made them applicable in practical applications. ■

References

1. K. Finkenzeller, *RFID Handbook*, 2nd Edition, John Wiley & Sons, New York, NY, 2003.
2. K. Janeczko et al., "Thermal Characterization of Screen Printed Conductive Pastes for RFID Antennas," *Material Science and Engineering: B*, 2012 (available online).
3. K. Futera et al., "Low Cost Inkjet Printing System for Organic Electronic Applications," *Mechatronics*, Part VII, 2012, pp. 713-721.
4. T. Wei et al., "Preparation of a Carbon Nanotube Film by Ink-jet Printing," *Carbon*, Vol. 45, No. 13, November 2007, pp. 2692-2716.
5. M. Jakubowska et al., "Printed Transparent Electrodes Containing Carbon Nanotubes for Elastic Circuits Applications with Enhanced Electrical Durability Under Severe Conditions," *Material Science and Engineering: B*, Vol. 176, No. 4, March 2011, pp. 358-362.
6. K. Janeczko et al., "Investigation of UHF Antennas Printed with Polymer Pastes on Flexible Substrates," *IET Microwaves, Antennas & Propagation* (accepted for publication).
7. M. Pudas et al., "Gravure Printing of Conductive Particulate Polymer Inks on Flexible Substrates," *Progress in Organic Coatings*, Vol. 54, No. 4, December 2005, pp. 310-316.
8. Thermax Encapsulated Indicators, www.tmchallcrest.com/industrial.php?medical_product=68&sublvl_id=5&subcat_id=14.
9. L. Yao et al., "A Low Power Temperature Sensor for Passive RFID Tag," *Proceedings of the 12th International Symposium on Integrated Circuits*, 2009, pp. 699-702.
10. Z. Shenghua and W. Nanjian, "A Novel Ultra Low Power Temperature Sensor for UHF RFID Tag Chip," *2007 IEEE Asian Solid-State Circuits Conference Digest*, pp. 464-467.
11. Qi Zhang et al., "A Novel RFID Tag Chip with Temperature Sensor in Standard CMOS Process," *2010 IEEE International Symposium on Circuits and Systems Proceedings (ISCAS)*, pp. 1109-1112.
12. M. Guerin et al., "A Temperature and Gas Sensor Integrated on a 915 MHz RFID UHF Tag," *2010 IEEE International Conference on Wireless Information Technology and Systems Proceedings (ICWITS)*, pp. 1-4.
13. L. Yang et al., "Wearable RFID-enabled Sensor Nodes for Biomedical Applications," *58th Electronic Components and Technology Conference Digest*, 2008, pp. 2156-2159.
14. Datasheet of the paste EL-P3040.
15. P.V. Nikitin et al., "Power Reflection Coefficient Analysis for Complex Impedances in RFID Tag Design," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 53, No. 9, September 2005, pp. 2721-2725.

Covering Your Spectrum

- Fixed Attenuators
- Terminations
- Variable Attenuators
- Power Dividers/Splitters
- RF Adapters
- DC Blocks
- RF Tuners
- DC to 50 GHz
- 1 watt to 1000 watts
- Custom Solutions

A Tradition of Quality

A Commitment to Customer Service



19212 Orbit Drive
Gaithersburg, MD 20879
Voice: 877.948.8342
Fax: 301.963.8640
RF@WeinschelAssociates.com

www.WeinschelAssociates.com

i²® INTELLIGENT INTERACTIVE SYNTHESIZERS

UP TO 18 GHz

Product Features

- > Exceptional Phase Noise Performance
- > Ultra Low RMS Jitter, As Low As 3.7 Femtosecond
- > Fast Switching
- > Selectable Or Standard Programming Interface
- > Single Or Dual Supply Options
- > Surface Mount Or Connectorized

PATENTED TECHNOLOGY



REL^{CO}PRO®

For additional information, contact Synergy's
sales and application team.

Phone: (973) 881-8800 | Fax: (973) 881-8361

E-mail: sales@synergymw.com

Web: WWW.SYNERGYMWAVE.COM



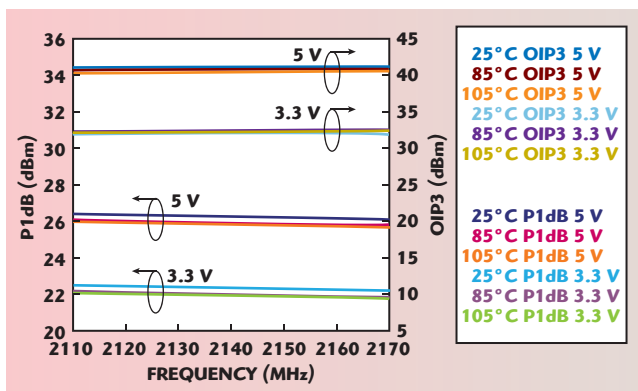


High Performance Driver Amplifiers

Today's radio designs, and other RF communication equipment, are being made to consume less power while occupying less physical space, which leads to less available board area for heat sinking. In addition, these systems are being deployed in more extreme environmental conditions where only passive cooling is being used, which leads to the need for very reliable ICs that can withstand greater temperature variations. When the factor of system output power scalability gets added

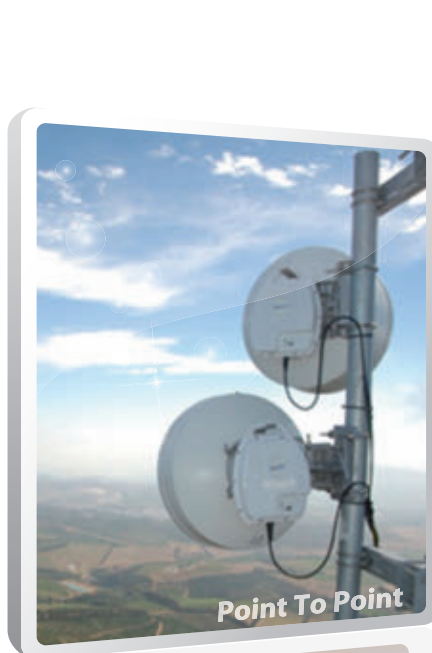
in, the need emerges for new equally scalable RF driver amplifiers. To satisfy all of these goals, Analog Devices has re-characterized the ADL5320 and ADL5321 $\frac{1}{4}$ W SOT-89 driver amplifiers for 3.3 to 5 V operation, as well as -40° to 105°C operation. The $\frac{1}{4}$ W drivers are now characterized in the same way as the newly released ADL5324 $\frac{1}{2}$ W SOT-89 driver amplifier.

Analog Devices' driver amplifiers incorporate a dynamically adjustable biasing circuit that allows for the customization of OIP3 and P1dB performance from 3.3 to 5 V, without the need for an external bias resistor. This feature gives the designer the ability to tailor driver amplifier performance to the specific needs of the design. The adjustable bias also allows for the drivers to be dynamically biased in order to conserve power consumption when the full performance of the driver amplifier is not required, such as when a system is in standby mode. This scalability reduces the need to



▲ Fig. 1 ADL5320 OIP3 and P1dB performance vs. voltage bias.

ANALOG DEVICES INC.
Norwood, MA



For these applications customers have one thing in common;

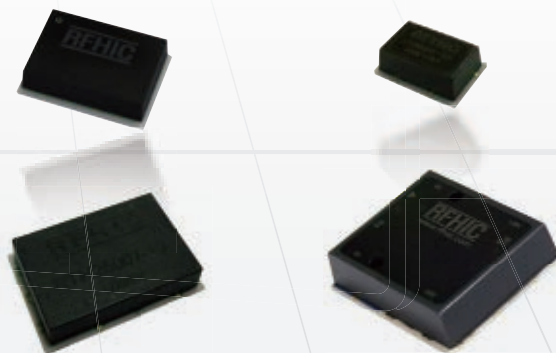
Goodbye! **GaAs & LDMOS** Hello! **RFHIC GaN**

No brainer for Point to Point (Under Development)

- More efficient than GaAs
- More reliable than GaAs.
- SMT Type Package Available
- In/Out Matching
- 6W~200W Peak Power
- Small Size

No brainer for Small Cell

- More efficient than LDMOS
- More reliable than LDMOS
- Cost comparable to LDMOS
- SMT Type Package Available
- In/Out Matching
- 2W~10W Average Power
- Small Size



GaN SMT/SMD Type Solutions

RFHIC = No Trade-off between Performance and Cost



RF & MW is our business & passion

Korean Facilities

Tel : 82-31-250-5078 / E-mail : rfsales@rfhic.com

US Facilities

Tel : 919-655-1121 / E-mail : sales@rfhicusa.com

RFHIC
www.rfhic.com

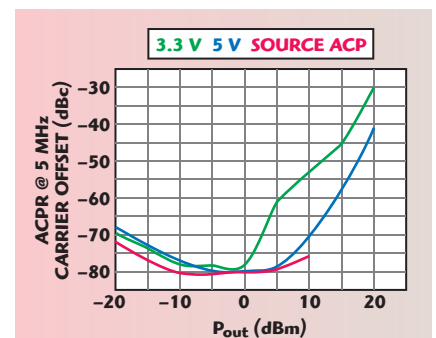
Product Feature

evaluate and inventory multiple driver amplifiers for different output power requirements, from 22 to 27 dBm output power levels for the ¼ W drivers, and from 24 to 29 dBm output power levels for the ½ W driver. The three drivers are also rated to operate across the widest temperature range of -40° to +105°C for reliable performance in designs that will experience higher temperatures, such as power amplifiers. The two ¼ W drivers, and

the ½ W driver amplifier, cover the wide frequency range of 400 to 4000 MHz and only require a few external components to be tuned to a specific band within that wide range. These high performance broadband RF driver amplifiers are well-suited for a variety of wired and wireless applications including cellular infrastructure, ISM band power amplifiers, defense equipment, and instrumentation equipment.

The ADL5320 GaAs HBT ¼ W driver amplifier operates from 700 to 2700 MHz, and consumes a low 5 V current of 104 mA. When operated at 5 V, the ADL5320 delivers a high level of performance at 880 MHz with an OIP3 of 45 dBm, a P1dB of 25.4 dBm, a gain of 16.9 dB and a low noise figure of 4.1 dB. When the bias voltage is reduced to 3.3 V, the driver only consumes 44 mA and delivers an OIP3 of 34 dBm, a P1dB of 21.5 dBm (see **Figure 1**), a gain of 15.6 dB, and a lower noise figure of 3.2 dB at 880 MHz. The driver amplifier can also be biased anywhere from 3.3 up to 5 V to meet system needs that are in between the performance stated at 3.3 or 5 V. This feature creates the opportunity for dynamic biasing of the driver amplifier where a variable supply is used to allow for full 5 V biasing under large signal conditions, and then reduced supply voltage when signal levels are smaller and lower power consumption is desirable. The driver can deliver 16 dBm of output power at 2140 MHz, while achieving an ACPR of -55 dBc at 5 V. If the bias is reduced to 3.3 V the -55 dBc ACPR output power only minimally reduces to 9 dBm (see **Figure 2**).

The ADL5321 GaAs HBT ¼ W driver amplifier operates from 2300 to 4000 MHz and consumes a low 5 V current of 90 mA. When operated at 5 V, the ADL5321 delivers a high level of performance at 2600 MHz with an OIP3 of 41 dBm a P1dB of 25.7 dBm, a gain of 14 dB, and a low noise figure of 4 dB. When the bias voltage is reduced to 3.3 V, the driver only consumes 37 mA and delivers an OIP3 of 31 dBm, a P1dB of 22 dBm, a gain of 12.6 dB and a lower noise figure of 3.5 dB at 2600 MHz. The driver amplifier can also be biased anywhere from 3.3 up to 5 V with its dynamically adjustable bias.



▲ Fig. 2 ADL5320 ACPR performance vs. voltage bias.

MOVE BEYOND TWTs

Upgrade to solid state reliability & performance



Model BME69189-20/50
6-18 GHz, 20 & 50 Watts*
Solid State Power Amp Module

- Full Power Across the Entire Bandwidth
- Maintains Output Power, Gain, and Efficiency with Real World Load Conditions
- Low Harmonic Distortion
- Superior Harmonics AND Input /Output VSWR
- Compact, Lightweight, and Usable in the Harshesht Environments
- 28 Vdc GaN Technology
- High Speed Blanking

***100 Watts Coming Soon!**

Take advantage of what low voltage, integration friendly solid state HPA's have to offer over TWT's and MPM's.

Comtech's latest development expands on its proven innovative integrated GaN RF Power Amplifier designs. These highly integrated designs are ideal for use in communication, electronic warfare, and radar transmitter systems where space, cooling, and power are limited. Applications include ground, surface, and airborne platforms.

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

Comtech...Simply More.



ISO 9001:2008 / AS9100C: 2009



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

SIX DAYS

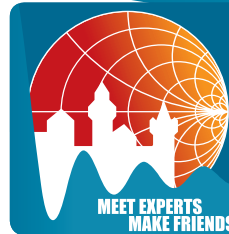


THREE CONFERENCES



ONE EXHIBITION

EUROPE'S PREMIER
MICROWAVE RF,
WIRELESS AND
RADAR EVENT



**EUROPEAN
MICROWAVE WEEK**
NCC NUREMBERG, GERMANY
6-11 OCTOBER 2013
www.eumweek.com

SUBMIT YOUR PAPER ONLINE NOW!

EUROPEAN MICROWAVE WEEK 2013

NÜRNBERG CONVENTION CENTER, NUREMBERG, GERMANY
OCTOBER 6-11, 2013



To electronically submit a technical paper for one or more of the three conferences, all you have to do is:

1. Log on to www.eumweek.com
2. Click on 'Conference Information' to view the individual conference topics
3. Click on 'Paper Submission' for author's instructions on how to submit a summary

That's all there is to it, so log on now!

www.eumweek.com

EuMA
European Microwave Association

Official Publication:



Organised by:



Supported by:



Co-sponsored by:



Co-sponsored by:



The 10th European Radar Conference

Co-sponsored by:



The 43rd European Microwave Conference

Co-sponsored by:



The 8th European Microwave Integrated Circuits Conference

Co-sponsored by:



Product Feature

The ADL5324 GaAs HBT $\frac{1}{2}$ W driver amplifier consumes a low 5 V current of 133 mA and also delivers very high performance at 2140 MHz with an OIP3 of 43.1 dBm, a P1dB of 29.1 dBm, a gain of 14.6 dB and a low noise figure of 3.8 dB. When the bias voltage is reduced to 3.3 V, the driver only consumes 62 mA and delivers an OIP3 of 34.4 dBm, a P1dB of 25.3 dBm, a gain of 13.6 dB and a lower noise figure of 3.2 dB at 2140 MHz. The driver amplifier can also be

biased anywhere from 3.3 up to 5 V with its dynamically adjustable bias. The driver can deliver greater than 17 dBm of output power at 2140 MHz, while achieving an ACPR of -55 dBc at 5 V. If the bias is reduced to 3.3 V, the -55 dBc ACPR output power only minimally reduces to 15 dBm.

The three drivers further simplify RF design by eliminating the need for complicated external tuning. The drivers only use 50 Ω lines at the input and output of the amplifier, and also

do not require an external bias resistor. The drivers only need one shunt capacitor at its input and one shunt capacitor at its output for frequency tuning. The usual AC coupling capacitors and DC bias choke inductor are also required, along with the standard bypass capacitance on the DC bias trace.

The driver amplifiers were also designed and packaged to simplify thermal considerations. The drivers have very low current consumption at either 3.3 or 5 V, which reduces the amount of heat that is created. The standard SOT-89 package also has a large backside ground paddle that allows for an efficient thermal transfer path from the amplifier. The datasheets show the recommended circuit board land pattern with added thermal transfer vias to further improve thermal transfer characteristics. This allows the driver to be kept within safe operating temperatures without the need for forced air cooling, and the driver is fully specified over the widest operating temperature range of -40° to +105°C. The drivers are also rated to a minimum HBM ESD rating of ± 2 kV (Class 2), which makes it equally robust in high volume manufacturing environments.

Another way Analog Devices helps improve RF design is with the amount of information provided in the company's datasheets. Data provided, such as critical parameter variation versus temperature, from -40° to +105°C, voltage supply, from 3.3 to 5 V, and operating frequency, from 400 to 4000 MHz, reduces the amount of qualification time a designer needs to spend. That reduction in qualification time can significantly improve a project's time-to-market. The comprehensive datasheet also allows the designer to accurately determine the least amount of power consumption achievable to meet the performance goals for his or her given application.

Analog Devices improves RF design in multiple ways: through innovative circuit design, simplified tuning requirements, and detailed datasheet information. These attributes allow RF designers to go to market quickly with solutions that meet their needs for smaller, lower power consuming systems.

**Analog Devices Inc.,
Norwood, MA,
www.analog.com.**

**DON'T LET THE SAME OLD
SUPPLIER SOLUTION RAIN ON YOUR
DEVELOPMENT PARADE.**

WE'VE GOT YOU COVERED!

High dynamic range
front-end assembly

narda Defense
Technology
Solutions

L3

With today's emphasis on superior performance in a smaller, lighter, more cost-effective package, why settle for yesterday's chip and wire solutions?

Narda Defense Technology Solutions has pioneered the development of high-performance, densely packaged integrated microwave assemblies and subsystems in footprints previously unachievable. By leveraging commonly available multi-layer board materials with unique interconnection techniques, and incorporating DSP and sophisticated monitor and control functions, our solutions are currently redefining "State of the Art." For more information, please visit our website at www.nardamicrowave.com/defense, or call us at (631) 231-1700.

- Module and Subsystem Solutions to 40 GHz
- Frequency Converters, LNAs, BUCs & SSPAs
- EW, Radar, Radio and SATCOM Applications
- Pin Diode Switch Products

narda Defense
Technology
Solutions

Stay in
touch with
the world
of EMI/EMC
news

Weekly Newsletter

Subscribe today at
www.interferencetechnology.com

interference^{ITEM™}
THE INTERNATIONAL JOURNAL OF
ELECTROMAGNETIC COMPATIBILITY | **technology**

interferencetechnology.com



Highly Integrated 60 GHz Radio Transceiver Chipset

The demand for high capacity data continues to grow at accelerating rates fueled by high data rate consumer applications, feature rich smartphones, video applications and the overall growth and use of the Internet. The 7 GHz of unlicensed spectrum available from 57 to 64 GHz offers wide bandwidth along with signal propagation properties that are ideal for short range multi-Gbps data communications. However, providing a complete radio at millimeter-wave frequencies can be a significant challenge requiring advanced materials and sophisticated design techniques.

Hittite has addressed many of the challenges by offering a highly integrated 60 GHz radio transceiver chipset, the HMC6000 and HMC6001, along with QFN packaged versions complete with integrated

antennas, the HMC6000LP711E and HMC6001LP711E. The HMC6000 and HMC6001 contain everything required to convert between 60 GHz and analog IQ baseband with no external components beyond a lower frequency crystal oscillator reference. The HMC6000LP711E and HMC6001LP711E integrate these chips with a 7.5 dBi gain antenna in a low cost 7 × 11 mm plastic QFN package to provide a complete air-interface solution. The HMC6000LP711E and HMC6001LP711E support RF bandwidths up to 1.8 GHz, and feature a transmit EIRP up to 23.5 dBm and receiver noise figure of less than 7 dB.

Now Hittite is offering an evaluation kit, the EKIT01-HMC6450, for these antenna-in-package (AiP) components. The EKIT01-HMC6450 AiP transceiver evaluation kit, with two pairs of HMC6000LP711E and HMC6001LP711E AiP solutions,

comes with software to control all of the functionality of the chips through an easy-to-use graphical user interface. This interface has both high level commands such as channel selection, gain and attenuation settings and filter control, as well as access to read and write from every low level register within the chips. The kit contains all of the supporting power supplies, reference clock and USB interface along with phase matched MCX to SMA connectors for the baseband differential interfaces to a customer's modem solution or test equipment. With the kit, a user can quickly set up a millimeter-wave link of up to 5 m at 60 GHz with universal analog I and Q interfaces for the rapid development of multi-Gbps data solutions.

VENDORVIEW

Hittite Microwave,

Chelmsford, MA, sales@hittite.com,

www.hittite.com.

GUARANTEED PHASE NOISE PERFORMANCE



Integrate with confidence. Holworth subjects every product we deliver to final performance testing which includes **NIST TRACEABLE PHASE NOISE**

**Phase Noise Analyzers
RF Synthesizer Modules**

 **holworth**
instrumentation
www.holworth.com

CALL FOR BOOK AUTHORS

You can enhance your professional prestige and earn substantial royalties by writing a book. With over 1,500 titles published, Artech House is a leading publisher of professional-level books in microwave, radar, communications and related subjects. We are seeking to publish new microwave engineering books and software in areas such as microwave and RF device design, wireless communications, advanced radar and antenna design, electromagnetic analysis, RF MEMS, sensors, and more.

We are currently seeking potential authors among engineers and managers who believe that they can make a contribution to the literature in their areas of expertise. If you have published technical papers, conducted professional seminars or solved important real-world problems, then you are an excellent candidate for authorship.

We invite you to submit your manuscript or software proposal for review. For a complete publications catalog and Author's Questionnaire please contact:

Mark Walsh, Senior Editor
1-800-225-9977
mwash@artechhouse.com

Artech House, Inc.
685 Canton St.
Norwood, MA 02062



ARTECH HOUSE

www.artechhouse.com



MOBILE™
WORLD CONGRESS

Barcelona | 25 – 28 February 2013



THE NEW MOBILE *HORIZON*

The mobile ecosystem continues to expand at lightning speed, with endless innovation and new applications of connected technology. Similarly, the industry's premier event is expanding in 2013. Mobile World Congress is relocating to a new world-class venue, Fira Gran Via, in the heart of the Mobile World Capital. With this convergence, the possibilities for global impact are endless.

An Event of:



Join us in Barcelona as together we explore the **New Mobile Horizon**

www.MobileWorldCongress.com



Scan to
Learn More

Official Media Partners

Bloomberg



TIME
FORTUNE

THE WALL STREET JOURNAL



Planar K-Band Receiver

One of Spacek Labs' receivers in its line of planar components and systems, Model P1R-29B3-2208Y, combines exceptional functionality with compact size. This system is a rugged, high performance, full K-Band (18 to 26.5 GHz) planar receiver. Each receiver operates over an LO band of 28 to 31 GHz. If a lower frequency LO band is desired, the unit can be equipped with an integrated LO frequency doubler for a 14 to 15.5 GHz LO band. The internal modular design of the housing allows any unit to be retrofitted with different

options with a minimum of effort and cost. This allows systems to be customized for any given application. The housing is designed to reduce EMI/RFI.

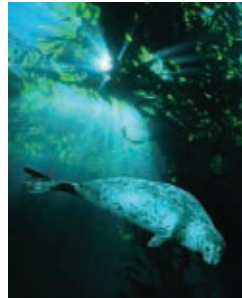
With K-Band communication and radar systems requiring increasingly better performance, this receiver can deliver. With a low noise figure of 3.5 dB, high conversion gain, and a flat response of 3 dB, this will make your systems performance exceed expectations. To achieve full K-Band operation, a wide IF bandwidth of 1 to 13 GHz, with filtering, is used. The unit can

operate using a wide range of LO drive levels. Options exist for LO drive levels from as low as 0 dBm to as high as +16 dBm.

This planar receiver has a large set of options to meet a wide variety of specifications. With Spacek's in-house design and manufacturing capabilities, the units can be modified to meet any of your design requirements.

**Spacek Labs Inc.,
Santa Barbara, CA
(805) 564-4404,
www.spaceklabs.com.**

**2013 IEEE Compound Semiconductor IC Symposium
October 13-16 at the Portola Hotel & Spa in Monterey, CA**



www.csics.org

Attend the Symposium to enjoy the technical and social program

Sharpen your skills in the short courses

Attend the Primer Course as an introduction or refresher

[Check the website for details on abstract submission](http://www.csics.org)

Topics for consideration include circuits and devices for RF, analog, digital, and opto-electronic ICs, mm-Wave CMOS, and Power Conversion Applications

[Abstracts due April 22nd, 2013!](http://www.csics.org)

SUPER ULTRA WIDEBAND AMPLIFIERS

up to +27 dBm output... 0.1 to 21GHz

\$845
from ea.

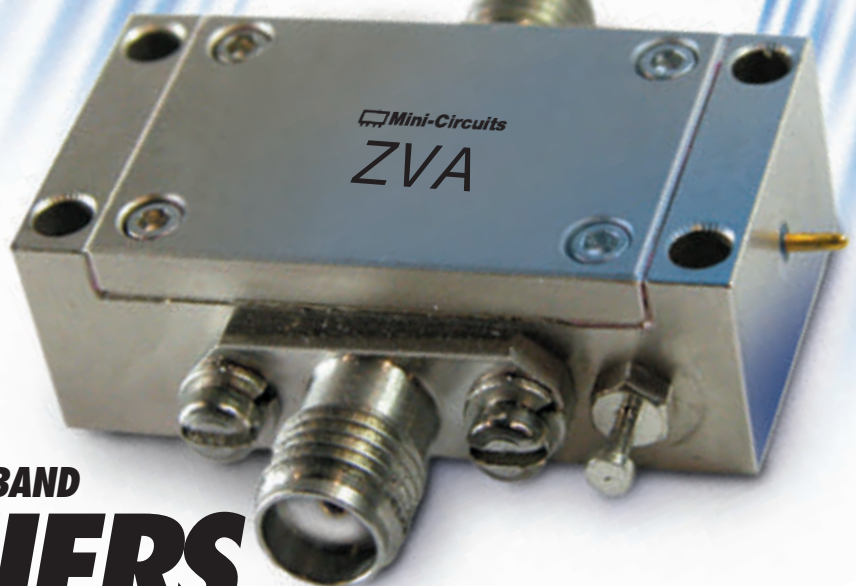
Ultra wide coverage and super flat gain make our ZVA family ideal for ECM, instrumentation, and test systems. With an output power up to 0.5 Watts, they're simply some of the most usable amplifiers you'll find, for a wide range of applications and architectures!

All of our ZVA models are unconditionally stable, ruggedly constructed, and able to withstand open or short circuits at full output. For more details, from data sheets to environmental ratings, pricing, and real-time availability, just go to minicircuits.com!

All models IN STOCK!

 RoHS compliant

Mini-Circuits...we're redefining what VALUE is all about!

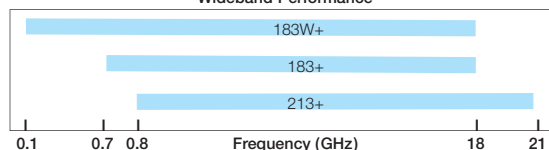


Electrical Specifications (-55 to +85°C base plate temperature)

Model	Frequency (GHz)	Gain (dB)	P1dB (dBm)	IP3 (dBm)	NF (dB)	Price \$* (Qty. 1-9)
NEW ZVA-183WX+	0.1-18	28±3	27	35	4.0	1345.00
ZVA-183X+	0.7-18	26±1	24	33	3.0	845.00
ZVA-213X+	0.8-21	25±2	24	33	3.0	945.00

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

Wideband Performance



Mini-Circuits®
ISO 9001 ISO 14001 AS9100

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

Ybvi2
U.S. Patents
7739260, 7761442

The Design Engineers Search Engine finds the model you need, Instantly • For detailed performance specs & shopping online see minicircuits.com

IF/RF MICROWAVE COMPONENTS

440 rev M



Wideband Frequency Mixer

Mini-Circuits has released a new wideband mixer, ZX05-24MH+, operating from 7.5 to 20 GHz with an LO power of +13 dBm. The ZX05-24MH+ has low conversion loss of 7 dB typical (at 30 MHz IF), IP3 of 16 dBm, high LO-RF isolation of 30 dB typical, LO-IF isolation of 15 dB typical and wide IF bandwidth from DC to 7.5 GHz. It has a rugged construction, small size and can be utilized as an up and downconverter. It is housed in a small coaxial package (0.74" ×

0.90" × 0.54") with SMA connectors and is RoHS compliant.

Maximum ratings include an operating temperature of -40° to 85°C, storage temperature of -55° to 100°C and RF power of 50 mW. The ZX05-24MH+ is well suited for applications such as fixed satellite, mobile and radio location.

Mini-Circuits offers a broad range of catalog mixers up to 20 GHz including state-of-the-art high dynamic range FET based designs with IIP3 up to +37 dBm and broadband surface-mount

designs covering 5 to 20 GHz. LO levels span 0 to +27 dBm and include both single function mixers and an integrated mixer such as image rejection and integrated LO and IF amplifiers.

VENDORVIEW

**Mini-Circuits,
Brooklyn, NY
(718) 934-4500,
www.minicircuits.com.**



**Microwave
Journal**

Frequency Matters.

Go *Mobile*

with the **NEW** MWJ APP

Get the free Microwave Journal Magazine App that includes the monthly issue, favorite archives and real-time industry news, blogs and interviews. Available on iTunes, Google Play and Amazon.

Download Now



Download your MWJ app now
at www.mwjjournal.com/MWJapp

SATELLITE®

Bridging the Gap Between Today and Tomorrow

2013

The SATELLITE Conference and Exhibition is the only event where the entire satellite-enabled communications community comes together under one roof and collaborates face-to-face with like-minded professionals. Here's what past attendees have said about SATELLITE:

"Well organized exhibit area, the important companies in the industry were in attendance."

– Edwin Rorie,
Telecommunications Specialist,
Defense Information
Systems Agency

"Brings together under one roof the satellite companies and organizations I am most interested in."

– Bill Flynn, Director, Navy
Programs, AMERICOM
Government Services

"The whole industry is there - if you can only make it to one satellite event in North America, this is it."

– Jeffrey Carl, Sr. Offer
Manager, AT&T

"It was the largest I've attended to date, with more exhibits and more of the latest technology on display."

– Kalu Kalu Oji, Chief Engineer
(ICT), Ministry of Foreign
Affairs

"Opportunity to meet in a very short time with customers and vendors otherwise scattered around the globe."

– Marshall Bloom, R CBPO,
Homeland Security

Register with
VIP Code MJ13
to qualify for Advance Discount pricing!

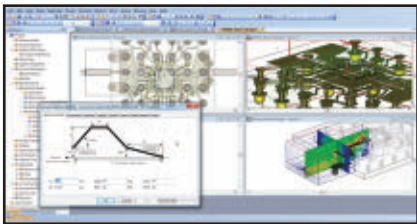
Conference: March 18-21, 2013 | Exhibition: March 19-21, 2013
Walter E. Washington Convention Center | Washington D.C.

Software and Mobile Apps

Design Environment Update



AWR, the innovation leader in high-frequency EDA software, has announced AWR Design Environment™



V10.04, its first new software release in 2013. This update includes new features and enhancements to Microwave Office®/Analog Office® high-frequency circuit design software, Visual System Simulator™ (VSS) system design software, AXIEM® 3D planar electromagnetic (EM) software and Analyst™ 3D finite element method (FEM) EM software. AWR's software product portfolio is designed to streamline circuit and system design for maximum productivity and product performance.

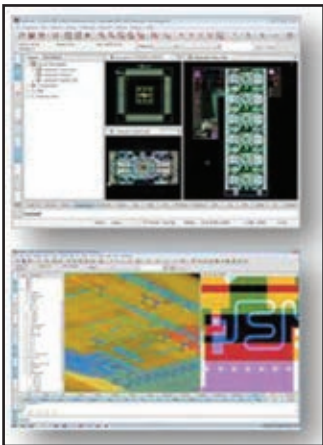
AWR Corp.

www.awrcorp.com

Design Automation Software



Intercept Technology released version 7 of its Pantheon PCB Layout software, which includes embedded design flows for RF and hybrid design. The new award winning Pantheon version includes a completely redesigned user interface with significant performance and productivity increases across the entire design team user flow. New features include icons and toolbars designed to maximize project window space, windows that can be undocked and placed outside the application window, a Project Explorer for faster location and selection of components and nets, and a quick search toolbar.



Intercept Technology

www.intercept.com

Updated Model Library

Modelithics announces the release of Modelithics® COMPLETE Library version 9.6 for Agilent's Genesys RF simulation software. It contains the complete updated and enlarged collection of passive and active component model libraries offered by Modelithics for Genesys to date. This new simulation model library release introduces over 30 new scalable Global Models for popular surface mount RLC component families from vendors such as Kemet, AVX, Coilcraft, Murata, Temex and Taiyo-Yuden. Version 9.6 of the COMPLETE library also offers 30 additional nonlinear models for diodes and transistors, including a new substrate-scalable SRD model.

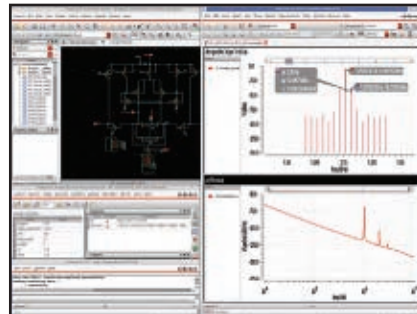


Modelithics Inc.

www.modelithics.com

Simulation Solution

Cadence announced the next major release of Spectre® RF, a production proven, accurate and high performance simulation solution for a broad set of applications. It provides a platform for exhaustive simulation with its unique and comprehensive analyses and support for industry standard models, integrated in the Virtuoso Analog Design Environment. The latest release, MMSIM 12.1, features new user interface enhancements, support for new passive components, improved scalable multi-core performance and improved support for S-parameter simulation.



Cadence Design Systems Inc.

www.cadence.com

Microwave Journal Mobile App

The Microwave Journal Magazine mobile app is now available on iTunes for Apple iPhones and iPads, on Google Play for Android phones and tablets, and on Amazon for the Kindle. The free MWJ app includes the monthly issue, archives and real-time feeds for industry news, blog postings and executive interviews. Get your MWJ app now at www.mwjjournal.com/MWJapp.

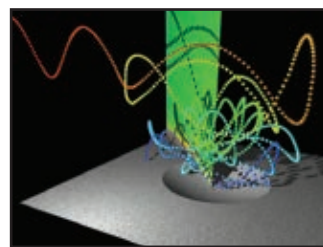
Microwave Journal

www.mwjjournal.com



Particle-in-Cell Simulation Tool

Tech-X Corp. announced the release of Vorpall 6.0. New in the release is the customization of Vorpall for targeted industries. With the VSimEM package for electrostatic and electromagnetic problems, VSimMD for the microwave device optimization, VSimPA for plasma acceleration simulations, VSimPD for plasma discharge simulations, VSimBase for the educational market and VSimPro, which provides the full features of Vorpall, the pricing and use of Vorpall is more flexible and more focused on meeting the needs of customers.



Tech-X Corp.

www.txcorp.com

eLEARNING center

February Short Course Webinars

Technical Education Training

The Effects of Jamming on GPS/GNSS Signals

Sponsored by: Rohde & Schwarz

Available On Demand after 2/6/13

Innovations in EDA

Presented by: Agilent Technologies

Antenna Design Automation with Scripting and Parameterized EM Analysis

Available On Demand after 2/7/13

Market Research Webinar

Technology Trends for Radar Systems

Sponsored by: Rohde & Schwarz

Live webcast: 2/12/13, 11:00 AM ET

Agilent in Aerospace/Defense

Electronic Warfare Testing: Capture, Measurement and Emulation

Live webcast: 2/21/13, 1:00 PM ET

Agilent in Wireless Communications

NFC Test Challenges for Mobile Device Developers

Live webcast: 2/26/13, 1:00 PM ET

Innovations in Network Analysis

Presented by: Agilent Technologies

The Fastest Near-Field Measurement Technique to Test Antennas in Under a Second

Live webcast: 2/27/13, 1:00 PM ET

Technical Education Training

MIMO Radar: Demystified

Sponsored by: Rohde & Schwarz

Live webcast: 2/28/13, 11:00 AM ET

Past Webinars On Demand

RF/Microwave Training Series

Presented by: Besser Associates

- Passive Components: Couplers, Dividers and Combiners
- Spur-Free Switching Power Converters for Analog and RF Loads

Technical Education Training Series

- VCO Fundamentals
- RF PCB Design
- Introduction to Antenna Simulation with COMSOL Multiphysics
- Radar Fundamentals II - Pulse Doppler Radar

CST Webinar Series

- Simulation of EMI in Hybrid Cabling for Combining Power and Control Signaling
- Chip/Package/Board: Constraint Driven Co-Design
- Simulation of Wearable Antennas for Body Centric Wireless Communication

Innovations in EDA/Signal Generation & Analysis Series

Presented by: Agilent EEsof EDA/Agilent Technologies

- Freescale's Power Amplifier Design Methodology Innovations
- Envelope Tracking Simulation and Analysis
- RF Module Design Using Amalfi CMOS PA
- Integrated Electro-Thermal Solution Delivers Thermally Aware Circuit Simulation

Agilent in Aerospace/Defense Series

- RF/uW Measurement Uncertainty: Calculate, Characterize, Minimize
- Using RF Recording Techniques to Resolve Interference Problems
- Essentials of OFDM and MIMO

Agilent in LTE/Wireless Communications Series

- Moving Forward to LTE-Advanced with Heterogeneous Networks
- 3GPP LTE Standards Update: Release 11, 12 and Beyond
- 10-Steps to Determine 3G/4G IP Data Throughput

RF and Microwave Education Series

Presented by: Agilent Technologies

- Signal Generator Fundamentals and New Applications

Optimize Wireless Device Battery Run-Time Series

Presented by: Agilent Technologies

- Impact of the Battery, Its Management, and Its Use
- Innovative Measurements for Greater Insights

FieldFox Handheld Analyzers Series

Presented by: Agilent Technologies

- Techniques for Precise Time Domain Measurements in the Field
- Calibration and Alignment Techniques for Precise Field Measurements
- Techniques for Precise Cable and Antenna Measurements in the Field

**Register to attend at
mwjournal.com/webinars**



New Waves: Components, Boards and Systems

FOR MORE NEW PRODUCTS, VISIT WWW.MWJOURNAL.COM/BUYERSGUIDE

FEATURING  **VENDORVIEW** STOREFRONTS

Termination



Aeroflex/Inmet's improved 50 W terminations are rugged 50 Ω coaxial terminations that offer low VSWR characteristics (1.35:1 at 12.4 GHz). Inmet's TN180-50W series of-

fers DC to 18 GHz broadband performance ideally suited for lab environments and high power combiner systems. The housing is anodized aluminum with fins for natural convection. A stainless steel type N male or female connector is standard. Other connector types and power levels are available.

Aeroflex/Inmet,
www.aeroflex.com.

Surface Acoustic Wave Filter



API Technologies Corp. announced a new transverse coupled resonator filter (TCRF). This new surface acoustic

wave (SAW) filter is designed for narrowband intermediate frequency filtering such as in satellite transponders, directional finders and anti-jam modems. It is capable of fractional bandwidths of 0.04 to 0.1 percent and is currently available from 80 to 1600 MHz. This TCRF is available in ceramic leadless chip carrier packaging. Other packaging styles are available for more rugged environments and applications.

API Technologies Corp.,
www.apitech.com.

Demonstration Board

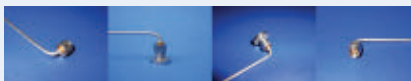


CML Microcircuits released a small demonstration platform for a complete software defined radio (SDR) for wireless data applications.

The DE9941 is a credit card-sized demonstration board for a complete linear modulation-based SDR for wireless data. It is designed to be small and low cost with minimal components/values. The small form factor is made possible by the high integration of key functions provided by CML's market-leading devices.

CML Microcircuits,
www.cmlmicro.com.

Right Angle Bend Assembly



Coaxicom's RAB assembly provides an alternative to the standard right angle SMA coaxial connector with a low-profile device, delivering increased electrical performance at higher frequencies. The 3221-1-L series of pre-bent right angle assemblies use the center conductor of

0.141" semi-rigid cable as the contact. "L" represents the overall length of the RAB. This fact, combined with Coaxicom's ultra-short SMA male, provides the same or a smaller profile than a right-angle connector, but without the performance penalty. Typical VSWR of these assemblies is 1.10 to 18 GHz.

Coaxial Components Corp.,
www.coaxicom.com.

Ku-Band BUC

Comtech Xicom Technology's new solid-state Ku-Band block upconverter, model



XTS-40KHE-B1, was designed for transportable satellite communications uplinks, offers 40 W of P1 output power and provides 20 W

of linear power. Breakthroughs in efficiency enable the self-cooled, feed-mountable amplifier to consume only 210 W when operated at linear power. Its features include temperature compensation, gain control, harmonic filtering, receive-band filtering and an output isolator. It comes in a compact outdoor unit (11.2" x 4.4" x 5.4") weighing less than 10 pounds.

Comtech Xicom Technology,
www.xicomtech.com.

Low Loss Cable Assemblies



EAM's low loss cable assemblies provide the highest level of electrical performance for applications requiring extremely low attenuation over a broad frequency range. By combining silver-plated copper center conductor, expanded PTFE tape dielectric, aluminum polyester or polyimide tape, silver-plated copper outer braid and FEP jacket, these low loss cable assemblies achieve outstanding electrical characteristics to 18 GHz (as low as .22 dB/ft.). Available in custom lengths with outer cable diameters of 0.195" and 0.335", these cables feature custom connectors with rugged stainless-steel solder-clamp construction.

Electronic Assembly Manufacturing Inc.,
www.eamcableassemblies.com.

Power Samplers



RFMW announces sales and technical support for Florida RF Labs' SXU series of RF power samplers. These wideband samplers offer a cost-effective solution by eliminating the

need for a termination commonly used with directional couplers, saving both PC board space and part count. Operating up to 4 GHz, power can be sampled 10, 20 or 30 dB down from the main line. Power handling is up to 50 W CW.

Applications include power monitoring for antenna feeds and PAs, switch networks and test instrumentation.

Florida RF Labs, distributed by RFMW Ltd.,
www.emc-rflabs.com.

Fractional-N PLL



Hittite has developed the HMC832LP6GE, a 3.3 V wideband fractional-N PLL with integrated VCO

that generates continuous fractional frequencies between 25 MHz and 3 GHz. The HMC832LP6GE offers low power consumption of 560 mW while featuring industry leading phase noise and spurious performance. It also includes innovative programmable performance technology that allows designers to further reduce current consumption if demands on the noise floor can be relaxed. It features industry leading phase noise (-110 dBc/Hz at 3 GHz) and spurious performance across all frequencies.

Hittite Microwave Corp.,
www.hittite.com.

Double Balanced Mixer



The new M1-0012 combines the DC IF capability common to other existing double balanced M1 mixers with

an extremely broad < 10 MHz to 12 GHz RF/LO band to make a unique mixer. In addition to the broad frequency range, the M1-0012 offers excellent isolations across the band. It is available in a connectorized, microstrip carrier, and both leaded and RoHS compliant surface mount packages. It features IF DC to 2 GHz, 7.5 dB typical conversion loss and ultra-broadband RF, LO and IF.

Marki Microwave Inc.,
www.markimicrowave.com.

High Pass Filter



Mini-Circuits' new high pass filter, the HFCN-103+, is an LTCC-based 7 section design that extends the upper frequency cutoff range of the existing HFCN series to 10 GHz. Systems that previously relied on large distributed filter elements to support these lower frequencies can save space and system complexity by integrating the HFCN-103+ into new designs. These filters are offered in an EIA 1206 package size and have a typical stop band rejection of 30 dB.

Mini-Circuits,
www.minicircuits.com.

2 W, 5 W, and 20 W **PRECISION ATTENUATORS**



NOW up to 26 GHz from **\$29⁹⁵** ea. (1-49)

 RoHS compliant

For rugged, reliable, and repeatable attenuation when accuracy is key, our customers have come to rely on Mini-Circuits Fixed Precision Attenuators, rated at 2W or 5W for DC-18 GHz signals. And now we've gone even further, with a new series of **2 W models up to 26 GHz**, and a new series of **20 W models from DC-18 GHz!** They feature stainless steel construction, precision attenuation from 1 to 50 dB, and SMA or N-type connectors for 50 Ω systems.

Inherent accuracy, and finely-graded attenuation levels, make our "BW" family invaluable on the bench or in the field. They're a ready solution for extending the range of test instrumentation or meeting circuit- and system-level requirements, such as better matching for high-VSWR components, reducing power to maximize sensitive applications, or protecting valuable circuitry. Just go to minicircuits.com—they're on the shelf and ready to ship today, at the low prices you've come to expect!

See minicircuits.com for specifications, performance data, and surprisingly low prices!
Mini-Circuits...we're redefining what **VALUE** is all about!

 **Mini-Circuits®**
ISO 9001 ISO 14001 AS 9100

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661


U.S. Patents
7739260, 7761442

The Design Engineers Search Engine finds the model you need, instantly • For detailed performance specs & shopping online see minicircuits.com

IF/RF MICROWAVE COMPONENTS

331 rev S

Featured White Papers

The information you need, from the technology leaders you trust.



Agilent Technologies

Agilent Technologies Complex Modulation Generation with Low Cost Arbitrary Waveform Generators: Agilent's Trueform Architecture for Wireless Applications

White Paper, Agilent Technologies

Anritsu

Overcoming High Speed Interconnect Challenges

White Paper, Anritsu



ROHDE & SCHWARZ

Overview of Tests on Radar Systems and Components

Application Note, Rohde & Schwarz

Introduction to Radar System and Component Tests

White Paper, Rohde & Schwarz

T&M Solutions for Software Defined Radios

Application Note, Rohde & Schwarz

Check out these new online Technical Papers featured on the home page of Microwave Journal at mwjournal.com.



Frequency Matters.

New Waves

Fiber Optic Transmitter



MITEQ introduced a new high reliability fiber optic transmitter with an operating bandwidth to 6 GHz. Transmitter model HRT-50K6G-28-20-M14 has a noise figure of 12 dB and is available in three different optical wavelengths (1550, 1490, 1310 nm). The

operating temperature range is -40° to $+85^{\circ}\text{C}$. With MITEQ's line of fiber optic receivers, it now is possible to have a complete fiber optic link that is sealed from the environment and has a spurious free dynamic range of 103 dB/Hz.

MITEQ Inc.,
www.miteq.com.

Power Divider



Narda Microwave-East introduced model 2372A-2, a high-power, two-way power divider that operates from 500 MHz to 2.5 GHz, handles up to 250 W CW input power (2 kW peak power) and is well suited for both commercial and military applications. It has insertion loss of less than 0.6 dB, amplitude balance of ± 0.25 dB or less,

phase balance of ± 5 deg., isolation of at least 13 dB from 500 to 700 MHz, 18 dB from 700 MHz to 2.5 GHz and VSWR of less than 1.5:1.

Narda Microwave-East,
www.nardamicrowave.com/east.

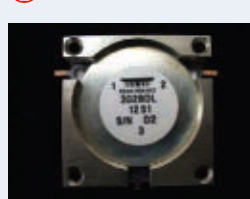
Bandpass Filter



NIC introduced a wideband LC bandpass filter centered at 3600 MHz with an operating BW of 133 percent. This filter is capable of passing signals between L- and C-Bands offering low insertion loss, while rejecting any signals in the UHF and X-Bands. Custom designs and different package configurations are available upon request.

Networks International Corp.,
www.nicke.com.

Drop-In Circulator



Renaissance's new broadband circulator is ideal for transmitter protection application. Operating over 962 to 1213 MHz, this device can withstand 2000 W peak and 20 W average power levels. It is designed to sustain temperatures from -55° to $+120^{\circ}\text{C}$ while the loss is maintained below 0.5 dB.

Renaissance Electronics/HXI,
www.rec-usa.com.

SPDT Switches



Skyworks unveiled three high power SPDT switches for multiple applications. The SKY12207-478LF (0.9 to 4 GHz; 50 W), SKY12208-306LF (0.02 to 2.7 GHz; 50 W) and SKY12210-478LF (0.9 to 4 GHz; 100 W) deliver transmit/receive and fail-safe switching functionality for TD-SCDMA and TD-LTE base stations, as well as

land mobile radios and military communication systems. These PIN diode switches handle continuous wave RF input power and provide very low insertion loss in the antenna-to-Rx mode, minimizing the effect on receiver noise figure.

Skyworks Inc.,
www.skyworksinc.com.



International Microwave Symposium
IEEE 2-7 June 2013, Seattle, WA MTT-S

EXPERIENCE

THE EXPERTS

INTELLECTUAL PROPERTY, PATENTS AND COMMERCIALIZATION: OPTIMIZING YOUR SUCCESS!

*Join IMS2013 for what is sure to be an exciting and fervent Plenary talk led by
Dr. Patrick Ennis, Global Head of Technology, Intellectual Ventures.*



Invention Capital: Why the World Needs More of it

Monday, 3 June 2013

"It is an exciting time to be a technologist. Every day, breakthroughs in research laboratories offer the promise of products and solutions to meet a range of global challenges and opportunities. However, it is very difficult to successfully commercialize technology; and unfortunately most efforts fail. We need to improve the success rate, otherwise billions of dollars of R&D funding will be wasted, and innovation-driven economies will stall. Invention Capital is a missing link in the value-creation chain."

Dr. Patrick Ennis will talk about how researchers from a variety of scientific and technical fields can optimize the value-creation chain. He will be sharing new models such as Open Innovation and Invention Capital that are necessary to successfully commercialize technology, in today's challenging environment

where the speed of technology development and adoption has so accelerated that even leading technology companies find it hard to just keep up. This is an opportunity for leading researchers to understand the latest trends in managing valuable IP and bringing it closer to commercialization.

IMS IS WHERE...

- state-of-the-art materials, devices, components, subsystems, design and test equipment are showcased by over 550 companies.
- researchers choose to present their work. The future of RF & Microwave debuts here first!
- new products are unveiled and new partnerships formed.
- your current and future customers go for product evaluation.
- your competitors know they need to be.

FOR EVENT DETAILS VISIT
[HTTP://IMS2013.MTT.ORG](http://IMS2013.MTT.ORG)



IEEE



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...

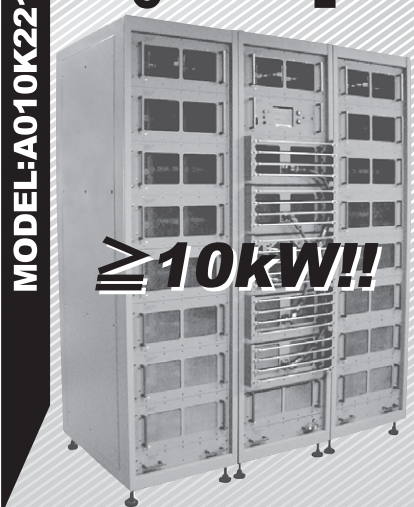


DC-40 GHz Filters
Multiplexers &
Switch Filter Banks

ES Microwave, LLC

8031 Cessna Avenue, Gaithersburg, MD 20879
P: 301-519-9407 F: 301-519-9418
www.esmicrowave.com

R&K Linear All Solid State RF High Power Amplifier



≥10kW!!

- All Solid State Amplifier
- Frequency Range : 10kHz ~ 220MHz
- Output Power : 10kW

<http://rk-microwave.com>

R&K R&K Company Limited

721-1 MAEDA, FUJI-City, Tel : +81-545-31-2600
SHIZUOKA-Pref. Fax : +81-545-31-1600
416-8577 JAPAN E-mail : info@rkco.jp

New Products

Amplifiers

Solid State Amplifiers



Models 15S1G6 and 50S1G6 are single band 15 and 50 W amplifiers that cover the 1 to 6 GHz frequency band. This type of amplifier is not unusual, but they all require dual bands (two separate amplifiers) to provide high output power and good gain flatness to provide one with a useable instrument. That is, until AR RF/Microwave Instrumentation created the single band Models 15S1G6 & 50S1G6. They provide linear output power with excellent gain flatness. **AR RF/Microwave Instrumentation, www.arworld.us.**

Drivers



Intended for commercial C-Band radar applications including weather radars, the PNs IGN5259M10 and IGN5259M15 and MPAG5259M25 operate over the instantaneous bandwidth covering 5.2 to 5.9 GHz. Under 300 μ s pulse width and 10 percent duty cycle pulsing conditions the IGN5259M10 typically sup-

plies a minimum of 10 W of peak output power while the IGN5259M15 typically supplies a minimum of 15 W of output power. The MPAG5259M25 is a 50 Ω matched device that produces more than 25 W of output power.

Integra Technologies Inc., www.integrattech.com.

Power Transistor



The T1G6003028-FS is constructed with TriQuint's 0.25 μ m process, which features advanced field plate techniques to optimize



power and efficiency at high drain bias operating conditions. It is ideally suited for military and commercial radar, professional and military radio communications, test instrumentation, wideband or narrowband amplifiers and jammer applications.

Key features include DC to 6 GHz frequency, output power (P3dB) of 30 W at 6 GHz, linear gain of > 14 dB at 6 GHz, operating voltage of 28 V, and low thermal resistance package.

TriQuint Semiconductor Inc., distributed by Richardson RFPD Inc., www.triquint.com.

MMIC Amplifier



RFMD's RFCA1008 is a high performance In-GaP HBT MMIC amplifier designed with the InGaP process technology for excellent reliability. The heterojunction increases breakdown

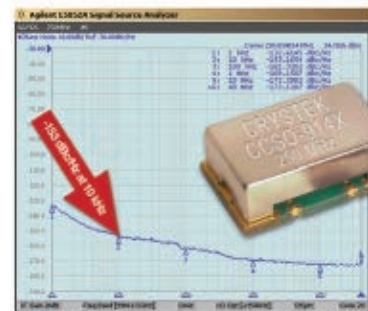


voltage and minimizes leakage current between junctions. A Darlington configuration is utilized for broadband performance. The RFCA1008 contains two amplifiers for use in wideband push-pull CATV amplifiers requiring excellent second order performance; the second and third order nonlinearities are greatly improved in the push-pull configuration.

RF Micro Devices, www.rfmd.com.

Sources

Clock Oscillator



Crystek Crystals announces the release of a 250 to 1090 MHz surface acoustic wave (SAW)

BOND

WIRE BOND

WEST BOND

www.westbond.com



Mobility makes You smarter.

However you fill in the blank, CTIA 2013™ is for those serious about wireless.

Presented by CTIA–The Wireless Association®, the proven authority leading the mobile movement since its inception. CTIA 2013 will continue to illuminate the future by showcasing the leaders, ideas and experiences that are transforming our dynamic industry.

CTIA2013™

THE Mobile Marketplace

May 21-23, 2013

Sands Expo & Convention Center Las Vegas, NV

CTIA2013.com

Prepare for tomorrow. Get smarter. Think big.



**IEEE Wireless and Microwave Technology Conference
WAMICON 2013
Caribe Royale Hotel & Convention Center
Orlando, FL
April 7-9, 2013**

JOIN US!

The 14th annual IEEE Wireless and Microwave Technology Conference (WAMICON 2013) will be held in sunny Orlando, Florida on April 7-9, 2013. The conference will address up-to-date multi-disciplinary research needs and interdisciplinary aspects of wireless communication systems and RF technologies. The program includes an outstanding combination of keynote speakers, oral presentations, poster presentations, tutorials and an exhibit area. The WAMICON technical program and conference structure promotes networking opportunities and focused technical discussions with peers on an international level. Past WAMI events have included attendees from the US, Canada, Europe and Asia with expertise in the fields of wireless and microwave technology from system level design to device and circuit implementation. Backgrounds included commercial as well as military wireless and microwave systems such as 3G/4G, WLAN, SDR, 802.xx, and UWB, SATCOM, Radar, etc., and from RF up to mm-wave frequencies.

A wide range of Exhibit and Sponsorship options are available. See more details at:

www.wamicon.org



**Exhibits and Sponsorships Available!
Email: ryan_baker@cree.com
jassurian@reactel.com**

New Products

clock oscillator (in single frequency band), the CCSO-914X. Crystek designed the module using proprietary circuitry and SAW resonator technology to provide ultra-low jitter/phase noise performance with true SineWave output. The resulting oscillator (250 MHz variant) features -153 dBc/Hz phase noise at 10 KHz offset and a noise floor of -173 dBc/Hz. The CCSO-914X-250.000 has been verified with Analog Devices' AD9467 – a 16-bit, monolithic, 1F sampling analog-to-digital converter (ADC).

Crystek Corp.,
www.crystek.com.

Hi-Rel Frequency Synthesizer



The THOR-14000-XA frequency synthesizer is designed to operate from 13.6 to 14 GHz in 1 MHz steps and features switching of ≤ 400 μ Sec band-edge to band-edge, and ≤ 300 μ Sec channel to channel. Locked to an external 10 MHz

reference, the device exhibits low phase noise (< -86 dBc/Hz at 10 KHz) and low current draw (+5 V DC at 335 mA). THOR units are capable of maintaining excellent performance over vibration, shock and temperature featuring a rugged, module-mount package (2.50" $\times$ 1.1" $\times$ 0.4").

EM Research,
www.emresearch.com.

Voltage Controlled Oscillator



Z-Communications announced RoHS compliant VCO model V846ME24-LF in the S-Band. It operates at 3100 to 3500 MHz with a tuning voltage range of 1 to 12 V DC and provides better than 1.1:1 tuning linearity. This high performance VCO features a spectrally clean signal of -114 dBc/Hz at 100 kHz offset and a typical tuning sensitivity of 62 MHz/V. It is designed to deliver

3 dBm of output power into a 50 Ω load while operating off a 5 V DC supply and drawing typically 22 mA of current.

Z-Communications Inc.,
www.zcomm.com.

Test Equipment

Delay Lines



Eastern OptX announced two new delay lines for radar testing. They feature ultra-wide bandwidth, low loss, high isolation and high dynamic range. The E-501 fixed delay line is an economical, high-performance turnkey product for radar testing as well as WiMAX, wireless communications and altimeter applications. The E-3001

variable delay line is a high performance, turnkey product for the radar test industry. It has multiple delay cells with front panel or computer control with up to eight switchable delays.

Eastern OptX,
www.eastern-optx.com.

Test System



The 50BA-002-95 SMA consists of two solid-state programmable attenuators in a mini-benchtop enclosure. The programmable attenuators can be set from 0 to 95 dB in 1 dB steps. The unit is controlled remotely via Ethernet or RS-232. In order to make this test system plug-and-play, JFW provides a GUI test program that allows

easy remote control of the 50BA-002-95 SMA. In addition to the basic remote commands, the test program has additional functionality that allows for handover testing and signal fading for wireless devices and handsets.

JFW Industries Inc.,
www.jfwindustries.com.

MICRO-ADS

Reliable....



What makes our switches so reliable? All AST switches come 100% sealed. That means all internal contacts stay dry, increasing the life and reliability of our switches. At AST we also automatically burn-in all our switches 4000 times to ensure that everything that leaves our plant is working according to our strict standards. Come and see why most major telecom companies use AST as their main switch provider.



www.astswitch.com

FAST PULSE TEST SOLUTIONS



Avtech offers over 500 standard models of high-speed pulse generators, drivers, amplifiers and accessories ideal for both R&D and automated factory-floor testing. Some of our standard models include:

AVR-EB4-B: for reverse-recovery time tests
AV-156F-B: for airbag initiator tests
AVO-9A-B: for pulsed laser diode tests
AV-151J-B: for piezoelectric tests
AVOZ-D2-B: for production testing attenuators
AVR-DV1-B: for phototriac dV/dt tests

Avtech Electrosystems Ltd.
<http://www.avtechpulse.com/>



SQUARE COAX SETUPS

• Std Sizes • Cal Std's • Loading Aids

03T ~1 MHz - 4 GHz, 10T ~1 MHz - 1.7 GHz
Other Sizes Available



μ, ϵ, σ - MuEpsIn sigma swfr

Solids, Loaded Honeycomb, Foam

Option for Thin Shielding Sheets

www.damaskosinc.com

(610)358-0200 fax(610)558-1019

KR Electronics
www.krfilters.com
ISO 9001:2000 Certified

Custom & Standard Filters to 3 GHz
35+ Years of Military & Commercial Applications

Bandpass	Lowpass
Anti-Aliasing	Notch
Highpass	Root Cosine
Video Filters	Equalizers
Diplexers	Linear Phase
Delay Equalized	Absorptive
Surface Mount	Matched

KR Electronics, Inc.
Avenel, NJ
www.krfilters.com

sales@krfilters.com
Phone 732.636.1900
Fax 732.636.1982

LOGUS

Waveguide & Coaxial Switches
WR10 thru WR975

WR75 WR137 WRD580 WR229

VALUE · QUALITY · FAST DELIVERY

LOGUS.com p: 561-842-3550
f: 561-842-2196

Modco VCO's for P25 and TETRA hand-held, mobile and base station radios. When optimum performance is required for critical applications Modco offers proven designs.

- VHF BAND
- UHF BAND
- 7/800MHZ
- TETRA VCO'S.

Typical Phase noise -123/-125 dBc @ 10kHz. Models are available with modulation port and low profile packages and priced from \$9.95

WWW.MODCOINC.COM

Waveguide and Coaxial Switches

We offer Switches for any application:
HI-REL, MILITARY, COMMERCIAL

From design to delivery, all under one roof.
Offering the Finest in Microwave Switches Since 1974.

The only bright spot to go!

Sector Microwave Ind., Inc.
(631) 242-2300 Phone (631) 242-6158 Fax
www.SectorMicrowave.com

Wright Technologies
Military Grade at Commercial Pricing

BATTLE TESTED

Products that are made to Last!

- Amplifiers & Multipliers
- Subsystems & Converters
- Form, Fit & Function
- Operational Frequencies .1 to 96 GHz
- HPAs, LNAs, Limiting Amps
- Temp Comp, AGC, RF Coupled Ports
- Bit Detector, Custom Filtering

(916) 773-4424 Ph. (916) 760-2770 Fx
www.wrighttec.com

2013 WEBSITE UPDATE COMING SOON!

Punctual....



Why are AST's delivery times better?
At AST we pride ourselves on telling our potential new customers that we have never been a day late. Our manufacturing techniques and our ability to keep many standard switches in stock, means that you will never have to wait for a switch again. In fact, in small quantities, we can ship to you in 1 business week. Come and see why AST is the only punctual switch provider.



www.astswitch.com

The Book End



Handbook of RF, Microwave and Millimeter-Wave Components

Leonid A. Belov, Sergey M. Smolskiy
and Victor N. Kochemasov

This book offers a detailed treatment of the operations principles, key parameters and specific characteristics of active and passive RF, microwave and millimeter-wave components. It covers both linear and nonlinear components that are used in a wide range of application areas, from communications and information sciences, to avionics, space and military engineering.

Handbook of RF, Microwave, and Millimeter-Wave Components is a practical book that presents descriptions and examples of the best materials and products used in the field, including lami-

nates, prepregs and substrates; microstrip, coaxial and waveguide transmission lines; fixed and rotating connectors; matching and adjusting elements; frequency filters; phase shifters; and ferrite gates and circulators. The book contains discussions on microwave switches and matrices, including MEMS technology, solid state and vacuum amplifiers, mixers, modulators and demodulators, and oscillation sources. There is also coverage of the stable frequency synthesizer structure and sources of modulated or noisy signals.

Handbook of RF, Microwave, and Millimeter-Wave Components

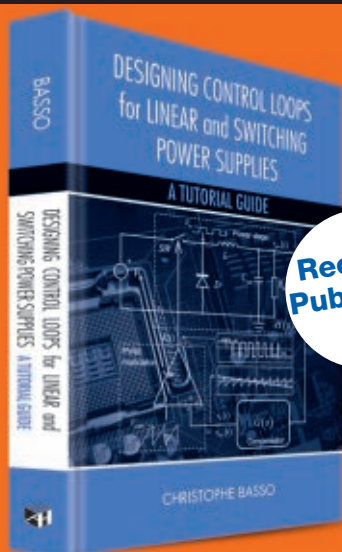
is intended for graduate and Ph.D. students that want a wide glance on the variety of engineering solutions in the field; however, this is a general book and is also very appropriate for industry specialists, dealers, manufacturers and customers as an overview of high frequency components. This is a good book for readers who want an overview of the various types of components and their function, but in covering so much ground, it does not contain a lot of detail on any specific component type.

To order this book, contact:

Artech House
685 Canton Street
Norwood, MA 02062
(800) 225-9977

or
16 Sussex Street
London, SW1V 4RW, UK
+44 (0)20 7596 8750

500 pages, \$165
ISBN: 978-1-60807-210-1



Stabilize Your Power Control Systems

Designing Control Loops for Linear and Switching Power Supplies: A Tutorial Guide

Christophe Basso

This practical book focuses on what you really need to know for compensating or stabilizing a given control system. You can turn instantly to practical sections with numerous design examples and ready-made formulas to help you with your projects in the field. Supported with over 450 illustrations and more than 1,500 equations, this authoritative volume:

- Demonstrates how to conduct analysis of control systems and provides extensive details on practical compensators;
- Helps you measure a system, showing how to verify if a prototype is stable and features enough design margin;
- Explains how to secure high-volume production by bench-verified safety margins;
- Covers the underpinnings and principles of control loops

Hardcover • 590 pp. • 2012 • ISBN: 978-1-60807-557-7 • \$139/£99

US: Call 1-800-225-9977 (in the U.S. or Canada),
or 1-781-769-9750, ext. 4030

Fax to: 1-781-769-6334

E-mail to: artech@ArtechHouse.com

UK: Call +44 (0)20 7596 8750

Fax to: +44 (0)20 7630-0166

E-mail to: artech-uk@ArtechHouse.com

For complete descriptions and to order, visit
ArtechHouse.com

All orders plus shipping/handling and applicable taxes.



685 Canton Street, Norwood, MA 02062 USA
16 Sussex Street, London SW1V 4RW UK

SIX DAYS

THREE CONFERENCES

ONE EXHIBITION

EUROPEAN MICROWAVE WEEK 2013
NÜRNBERG NCC, GERMANY,
OCTOBER 6 - 11, 2013



EUROPEAN MICROWAVE WEEK
NCC NUREMBERG, GERMANY
6-11 OCTOBER 2013
www.eumweek.com

EUROPE'S PREMIER MICROWAVE, RF, WIRELESS AND RADAR EVENT



The European Microwave Exhibition (8-10 Oct) will see:

- 7,500 sqm of gross exhibition space
- 5,000 key visitors from around the globe
- 1,700 - 2,000 conference delegates
- In excess of 250 exhibitors

Running alongside the exhibition are 3 separate, but complementary Conferences:

- European Microwave Integrated Circuits Conference (EuMIC)
- European Microwave Conference (EuMC)
- European Radar Conference (EuRAD)

Plus a one day Defence and Security Conference

EuMA
 European Microwave Association

Official Publication:

Microwave Journal

Organised by:

h horizon house

Supported by:

IET
 The Institution of Engineering and Technology

Co-sponsored by:

MTT-S

Co-sponsored by:

IEEE

EuRAD
 2013

The 10th European Radar Conference
 Co-sponsored by:

AESS



43RD EUROPEAN MICROWAVE CONFERENCE 2013

The 43rd European Microwave Conference
 Co-sponsored by:



EuMIC
 2013

The 8th European Microwave Integrated Circuits Conference
 Co-sponsored by:

ELECTRONIC DEVICES SOCIETY



Interested in exhibiting?
 Call +44(0) 20 7596 8742 or visit www.eumweek.com

ADVERTISER	PAGE No.
Advanced Switch Technology	133
Aeroflex / Control Components	105
Aeroflex / Inmet, Inc.	42
Aeroflex / Metelics, Inc.	9
Aeroflex / Weinschel, Inc.	95
Agilent Technologies, Inc.	11
Anatech Electronics, Inc.	40
Anritsu Company	29
APA Wireless Technologies	41
AR RF/Microwave Instrumentation	39
Artech House	118, 134
ASB, Inc.	86
Avtech Electrosystems	133
AWR	45
B&Z Technologies, LLC	33
Boonton Electronics (a Wireless Telecom Group Company)	49
Cernex, Inc.	34
Ciao Wireless, Inc.	54
Coilcraft	37
Compex Corporation	24
COMSOL, Inc.	27
Comtech PST Corp.	36, 114
CPI Beverly Microwave Division	97
CST of America, Inc.	25
CTIA 2013	131
Damaskos Inc.	133
DFINE Technology Co., Ltd.	8
Dow-Key Microwave Corporation	28
Eastern Wireless TeleComm, Inc.	43
EDI CON 2013	77
EMC Technology Inc.	75
ES Microwave, LLC	130
EuMW 2013	115, 135
Florida RF Labs Inc.	75
Frontlynk Technologies Inc.	98
GGB Industries, Inc.	3
GSMA Mobile World Congress 2013	119
Herotek, Inc.	82
Hittite Microwave Corporation	93
Holworth Instrumentation	118
Huber + Suhner AG	91
I ² M	100
IEEE Compound Semiconductor IC Symposium 2013	120
IEEE MTT-S International Microwave Symposium 2013	129
IEEE WAMICON 2013	132
Integrated Microwave	48
Interference Technology	117
International Manufacturing Services, Inc.	108
JQL Electronics Inc.	6
K&L Microwave, Inc.	7
KR Electronics, Inc.	133
Krytar	72
Lark Engineering Company	38

ADVERTISER	PAGE No.
LCF Enterprises	18
Linear Technology Corporation	15
Logus Microwave Corporation	133
LPKF Laser & Electronics	50
MECA Electronics, Inc.	COV 2
Microwave Journal	122, 125, 128
Mini-Circuits	4-5, 16, 61, 62, 73, 99, 109, 121, 127, 137
MITEQ Inc.	92, 94, 96
Modco, Inc.	133
Narda Microwave-East, an L3 Communications Co.	26, 116
National Instruments	19
Nexyn Corporation	106
Norden Millimeter Inc.	46
OML Inc.	81
Phase Matrix, Inc.	68
Phonon Corporation	104
Planar Monolithic Industries, Inc.	85
Pulsar Microwave Corporation	56
R&K Company Limited	130
Reactel, Incorporated	57
Remcom	53
RFHIC	20-21, 71, 113
RFMD	31
RFMW, Ltd.	69
RLC Electronics, Inc.	23
Rogers Corporation	35
Rohde & Schwarz GmbH	13, 89, 103, COV 3
Rosenberger	83
Satellite 2013	123
Sector Microwave Industries, Inc.	133
Sivers IMA AB	88
Skyworks Solutions, Inc.	47
Sonnet Software, Inc.	51
Spacek Labs Inc.	70
Special Hermetic Products, Inc.	64
Spectrum Elektrotechnik GmbH	107
State of the Art, Inc.	52
SV Microwave, Inc.	101
Synergy Microwave Corporation	67, 111
Teseg Inc.	60
Times Microwave Systems	58
Universal Microwave Components Corporation	84
UTE Microwave Inc.	87
W.L. Gore & Associates, Inc.	30, 32
Weinschel Associates	110
Werlatone, Inc.	COV 4
West Bond Inc.	130
WIN Semiconductors Corp.	65
Wright Technologies	133

Sales Representatives

CARL SHEFFRES, PUBLISHER

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) 769-9750
FAX: (781) 769-5037
cboyd@mwjournal.com

Michael Hallman
Eastern Reg. Sales Mgr.
(Mid-Atlantic, Southeast, Midwest)
4 Valley View Court
Middletown, MD 21769
Tel: (301) 371-8830
FAX: (301) 371-8832
mhallman@mwjournal.com

ED KIESSLING, TRAFFIC MANAGER

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

Israel

Oreet Ben Yaacov
Oreet International Media
15 Kineret Street
51201 Bene-Berak, Israel
Tel: +972 3 570 6527
FAX: +972 3 570 6526
obenyaacov@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

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

China

Michael Tsui
ACT International
Tel: 86-755-25988571
Tel: 86-21-62511200
FAX: 86-10-58607751
michaelT@actintl.com.hk

Hong Kong

Mark Mak
ACT International
Tel: 852-28386298
markm@actintl.com.hk

Frequency Matters.



Now! **MULTIPLY** **UP TO 20 GHz**



Frequency Multipliers from **\$5⁹⁵**
qty. 10-49

For your leading-edge synthesizers, local oscillators, and Satellite up/down converters, Mini-Circuits offers a large selection of **broadband doublers, triplers, quadruplers, and x12 frequency multipliers.**

Now generate output frequencies from 100 kHz to 20 GHz with excellent suppression of fundamental frequency and undesired harmonics, as well as spurious. All featuring low conversion loss and designed into a wide array of, off-the-shelf, rugged coaxial, and surface mount packages to meet your requirements.

Visit our website to choose and view comprehensive performance curves, data sheets, pcb layouts, and environmental specifications. And you can even order direct from our web store and have a unit in your hands as early as tomorrow! Mini-Circuits...we're redefining what VALUE is all about!

Mini-Circuits®
ISO 9001 ISO 14001 AS9100

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

Y&I
U.S. Patents
7739260, 7761442

The Design Engineers Search Engine finds the model you need, Instantly • For detailed performance specs & shopping online see minicircuits.com

IF/RF MICROWAVE COMPONENTS

455 rev F



Star Trek Trivia

ANSWERS AVAILABLE ONLINE AT
WWW.MWJOURNAL.COM



What year did the original Star Trek series air?



What does the "T" in James T. Kirk stand for?



What planet is Spock from?



What was the name of the Enterprise's captain in the original TV pilot?



What is the verbal cue Captain Kirk uses to get transported back to the Enterprise?



Prior to commanding the Enterprise-D, Picard was captain of what starship for 22 years?



Scotty was first introduced in which Star Trek story?



What is the name of the traditional Vulcan weapon that Spock and Kirk used to fight each other?



What was Dr. Leonard McCoy's nickname?



What type of material is used to power the warp drive on the Enterprise?



What is the non-lethal setting on the phaser weapon used in the original Star Trek?



Live long and _____

SPONSORED BY



WWW.CST.COM

Uplink & Downlink Bandwidth & Speed Rohde & Schwarz FSW

Please visit us at the
Mobile World Congress
in Barcelona
Hall 6 / Booth E30

The most advanced signal and spectrum analyzer for wireless applications

The highest analysis bandwidth, detailed analysis of multistandard scenarios, easy operation and a host of convenient new tools – all on the largest touch-screen available. The R&S®FSW is a high-performance analyzer for all types of mobile radio and wireless signals, for base stations and mobile devices alike.

- Analysis of LTE FDD/TDD, WCDMA, GSM/EDGE/EDGE Evolution, TD-SCDMA, CDMA2000®, 1xEV-DO in uplink and downlink
- Analysis of WLAN 802.11ac signals with 160 MHz bandwidth
- Detection of interference between different wireless technologies
- MultiView for simultaneous visualization of multiple measurements

The R&S®FSW. Create the future.

www.rohde-schwarz.com/ad/fsw-mr



ROHDE & SCHWARZ



WERLATONE®
DECADES AHEAD™

Mismatch Tolerant®

HIGH POWER, MULTI-OCTAVE PERFORMANCE

Custom Designs

Custom Connectors ! Model C9219



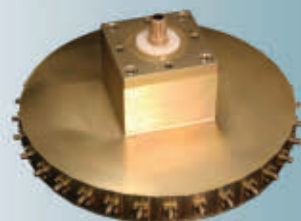
What's your Interface?

Multi-Port Couplers Model C7067



How many Ports?

Radial Combiners Model D6857



How many Inputs?

Big Stuff ! Model D8969



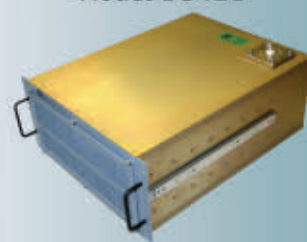
How much Power?

Isolated N-Ways Model D8182



Radial with Isolation?

Rack Mount Model D8421



19", 24"...?

- DIRECTIONAL COUPLERS
- POWER COMBINERS / DIVIDERS
- 90° HYBRID COUPLERS
- 180° HYBRID COMBINERS

Send Us Your Specs!

Custom Designs for Custom Applications

Model	Type	Frequency (MHz)	Power (W CW)	Insertion Loss (dB)	VSWR
C9219	Directional Coupler, Unflanged	640-660	3,500	0.1	1.15:1
C7067	Directional Coupler, 4 Coupled Ports	123-133	2,250	0.15	1.20:1
D6857	32-Way Combiner / Divider	1,200-1,400	4,000	0.5	1.35:1
D8969	2-Way Combiner / Divider	1.5-30	12,500	0.2	1.25:1
D8182	5-Way Combiner / Divider	1,175-1,375	1,500	0.4	1.35:1
D8421	8-Way Combiner / Divider	1.5-30	12,000	0.3	1.30:1

Werlatone, Inc.
17 Jon Barrett Road
Patterson, New York 12563
T 845.278.2220
F 845.278.3440
www.werlatone.com

Our Patented, Low Loss designs tolerate high unbalanced input powers, while operating into severe Load Mismatch conditions.

Semiconductors

First Response

Medical

In-Building

Military Comm and EW

Military & More