

Micro[®]wave Journal

.com



BETTER COMMUNICATION SOLUTIONS



Public Safety



Satcom, mmWave
& Military



Aeronautical/Space
Transportation



AMER, EMEA,
& D.A.S

MECA 5G Products & Equipment

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

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



Directional Couplers
MIL-DTL-15370 Available



Bias Tee & DC Blocks



Attenuators/Terminations



Power Divider/Combiner
MIL-DTL-23971 Available



Millimeter-Wave
Up to 40 GHz

Buy Online



RFPartsOnDemand.com



Tower Top & D.A.S. Equipment



Hybrids



Isolators



e-MECA.com
Since 1961

MECA Electronics, Inc.

Microwave Equipment & Components of America

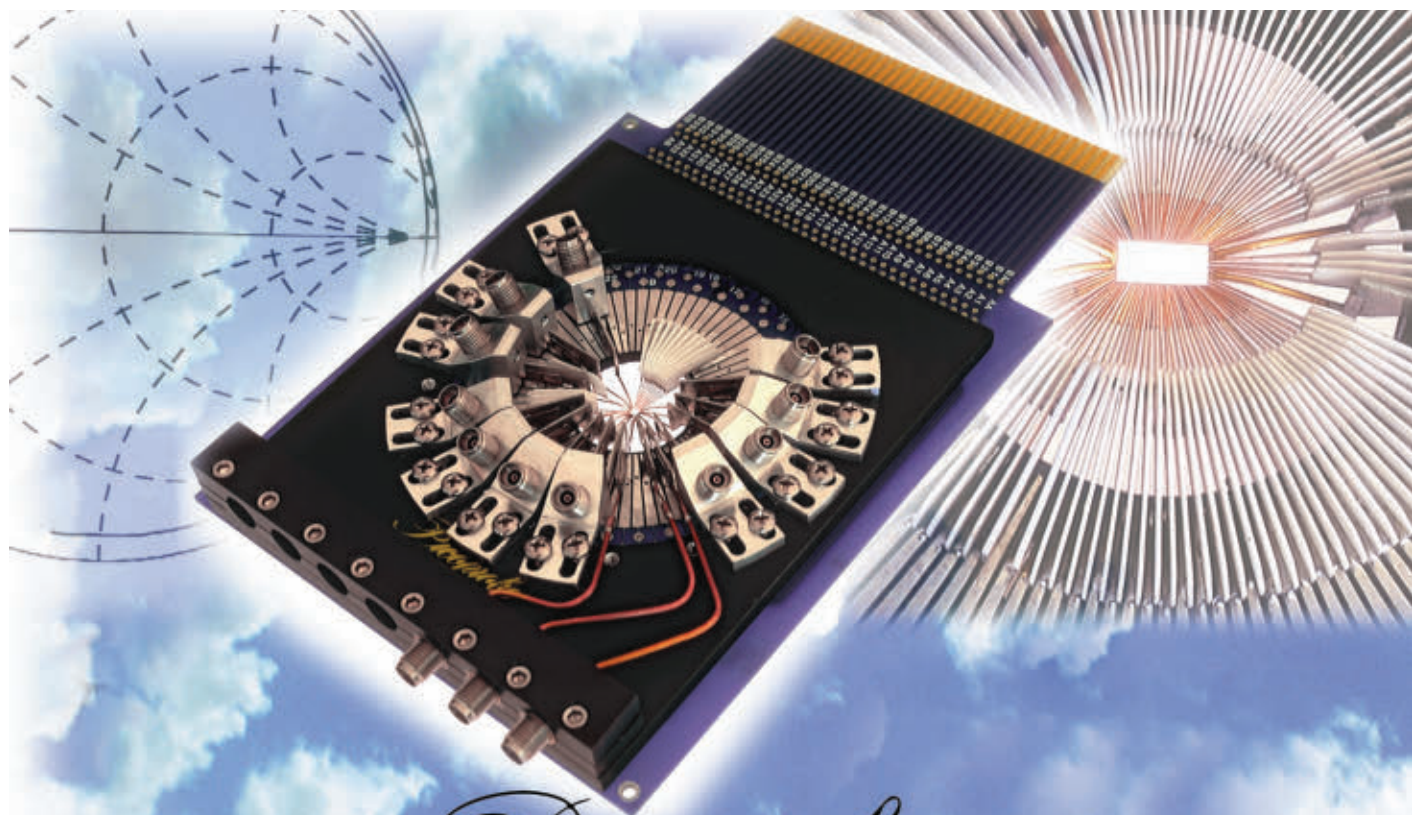
The Professional's Choice for RF/Microwave Passive Components

459 E. Main St., Denville, NJ 07834

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



ibwave



Picoprobe®

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

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

NEW!

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

EP2K1+ 2 to 26.5 GHz

EP2W1+ 0.5 to 9.5 GHz

EP2C+ 1.8 to 12.5 GHz

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

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

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

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

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

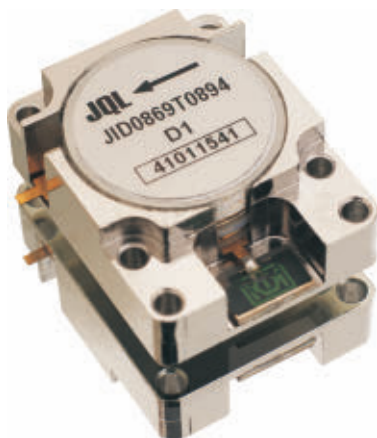
 **RoHS Compliant**
Product availability is listed on our website.

 **Mini-Circuits®**

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

448 rev R

Technology On the Move™



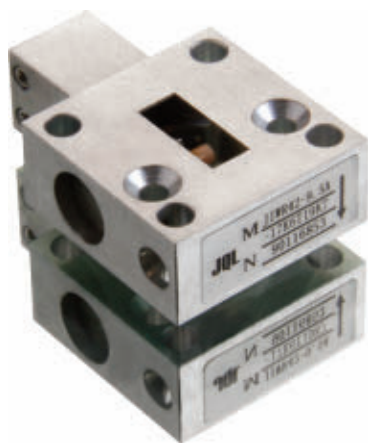
Drop-in Isolators



Cavity Filters



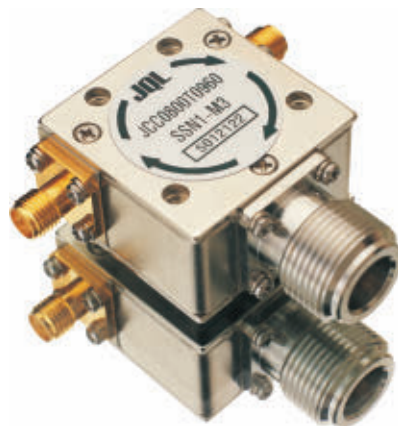
Surface Mount Circulators



Waveguide Isolators



Power Combiners



Coaxial Circulators



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



A DOVER COMPANY

TAKE THE RIGHT ROUTE

- 1 MHz to 27 GHz
- 2 to 20 Throw
- Switching Speed 50 to 500 nsec
- Power Handling 10 to 40 dBm



Microwave
Products
Group



ENABLING COMMUNICATION AND SIGNAL CONTROL

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

Modular, non-ITAR GaN Amplifiers

The Power You Need at the SWaP You Want

*Introducing a new SWaP Industry Standard
in the 0.1 to 6.0 GHz range.*

Teledyne Microwave Solutions' family of GaN-based amplifiers maximizes power density and efficiency and lowers the industry's form factor threshold in the 0.1 to 6.0 GHz range. Leveraging a 50+ year heritage of engineering expertise, these modular, wideband amps can be designed to meet your exacting specifications drawing from our large, ever-expanding repository of parts.

For the most demanding applications...

With a calculated MTBF over 40,000 hours, these GaN amplifiers are manufactured to optimal thermal requirements to deliver the highest reliability and performance in the harshest airborne and land-based environments.


Market-leader: Small Size vs Power

- ▶ 2.5"L x 2"W x .42"H
- ▶ Optimal Ruggedization
- ▶ Wider bandwidths provide design flexibility



TELEDYNE MICROWAVE SOLUTIONS
Everywhere you look™

800.832.6869
Microwave@Teledyne.com
TeledyneMicrowave.com

The Power of Consolidation  Cougar • Defence • LabTech • MEC • Microwave • Paradise Datacom

DELIVERY WITHIN THREE DAYS

SHOP OUR MILLIMETERWAVE STOCK ROOM



Active Multipliers



Faraday Isolators



Harmonic Mixers



Power Dividers



Horn Antennas



WG to Coax Adapters



Omni-Directional Antennas



Amplitude Detectors



Directional Couplers



Power Amplifiers



Taper Transitions

VISIT US
ONLINE
FOR MORE

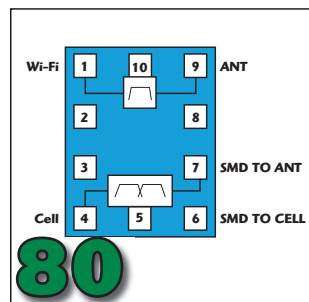
WWW.SAGEMILLIMETER.COM



MADE IN USA

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

 **SAGE**
Millimeter, Inc.



2016 Editorial Index

A complete listing of 2016 Microwave Journal articles organized by subject and indexed alphabetically by author can be found at mwjournal.com/edindex2016

Editor's Note

- 20** **Mergers Mold 2016**
Patrick Hindle, Microwave Journal Editor

Cover Feature

- 22** **Automotive Radar Sensors Must Address Interference Issues**
Dr. Steffen Heuel, Rohde & Schwarz

MVP: Most Valuable Product

- 38** **Variable Gain Amplifiers for Wireless Infrastructure**
Integrated Device Technology Inc.

Technical Feature

- 64** **Advances in RF Energy for Medical Applications**
Franck Nicholls and Jose Fernandez Villaseñor, M.D., NXP Semiconductors

Special Report

- 80** **Filter Technology Trends in Mobile Wi-Fi Modules**
Kevin Gallagher, Qorvo

AUGMENTED REALITY: HOW IT WORKS

STEP 1

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

STEP 2

Launch the app to view enhanced content on any page with the [layar](http://www.layar.com) logo.

STEP 3

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

Look for the Layar logo on participating pages.

AR pages may expire after 30 days.

59 YEARS OF PUBLISHING EXCELLENCE



Upgrade Your Mixer

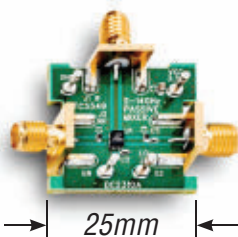
2GHz–14GHz, 0dBm LO Drive

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

▼ Features

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

Demo Board



▼ Info & Free Samples

www.linear.com/product/LTC5549

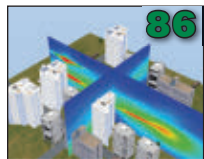
1-800-4-LINEAR

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

Microwave Journal

CONTENTS

mwjournal.com



Product Features

- 86 Electromagnetic Exposure Simulation Software**
Microwave Vision Group (MVG)
- 92 High Voltage and High Current Waveform Amplifier**
Accel Instruments

Tech Briefs

- 96 24 GHz Transceiver for Industrial Sensors and Automotive Radar**
United Monolithic Semiconductors (UMS)
- 96 6.5 to 40 GHz Microwave Power Modules**
L-3 Electron Devices
- 98 Tunable Frequency and Bandwidth Filter**
K&L Microwave

Departments

| | | | |
|----|----------------------|-----|--------------------|
| 17 | Mark Your Calendar | 102 | Web & Video Update |
| 18 | Coming Events | 108 | New Products |
| 43 | Defense News | 118 | Book End |
| 47 | International Report | 120 | Advertising Index |
| 51 | Commercial Market | 120 | Sales Reps |
| 54 | Around the Circuit | 122 | Fabs and Labs |

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

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

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

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

STAFF

PUBLISHER: CARL SHEFFRES
EDITOR: PATRICK HINDLE
TECHNICAL EDITOR: GARY LERUDE
MANAGING EDITOR: JENNIFER DiMARCO
ASSOCIATE TECHNICAL EDITOR: CLIFF DRUBIN
MULTIMEDIA STAFF EDITOR: LESLIE NIKOU
MULTIMEDIA STAFF EDITOR: BARBARA WALSH
CONTRIBUTING EDITOR: JANINE LOVE
CONSULTING EDITOR: HARLAN HOWE, JR.
CONSULTING EDITOR: FRANK BASHORE
CONSULTING EDITOR: DAVID VYE
CONSULTING EDITOR: RAYMOND PENGELLY
ELECTRONIC MARKETING MANAGER:
CHRIS STANFA
DIGITAL CONTENT PRODUCTION SPECIALIST:
LAUREN TULY
AUDIENCE DEVELOPMENT MANAGER:
CAROL SPACH
TRAFFIC MANAGER: EDWARD KIESSLING
DIRECTOR OF PRODUCTION & DISTRIBUTION:
ROBERT BASS
ART DIRECTOR: JANICE LEVENSON
GRAPHIC DESIGNER: SACHIKO STIGLITZ

EUROPE

INTERNATIONAL EDITOR: RICHARD MUMFORD
OFFICE MANAGER: NINA PLESU

CORPORATE STAFF

CEO: WILLIAM M. BAZZY
PRESIDENT: IVAR BAZZY
VICE PRESIDENT: JARED BAZZY

EDITORIAL REVIEW BOARD

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

EXECUTIVE EDITORIAL OFFICE

685 Canton Street, Norwood, MA 02062
Tel: (781) 769-9750
FAX: (781) 769-5037
e-mail: mwj@mwjournal.com

EUROPEAN EDITORIAL OFFICE

16 Sussex Street, London SW1V 4RW, England
Tel: Editorial: +44 207 596 8730 Sales: +44 207 596 8740
FAX: +44 207 596 8749

SUBSCRIPTION SERVICES

Send subscription inquiries and address changes to:
Tel: (847) 291-5216
e-mail: mwj@halldata.com



www.mwjournal.com

Printed in the USA

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.

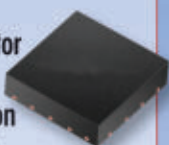
We provide many value-added services driven by customer requirements – because we know RF and microwave.

- 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



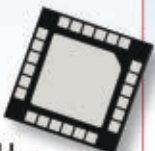
RF OSCILLATORS

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



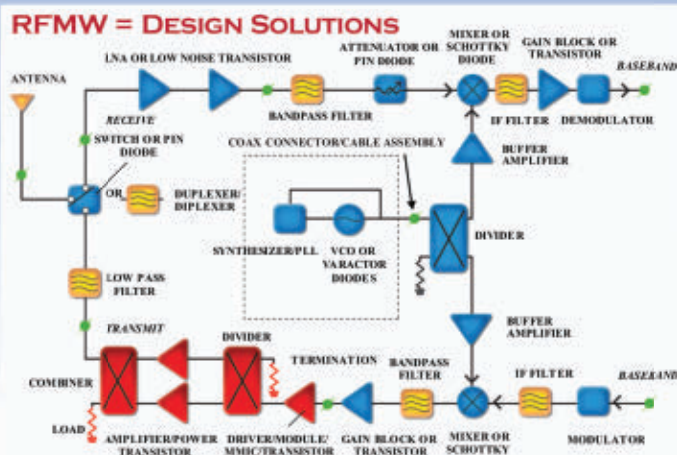
RF ATTENUATORS

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



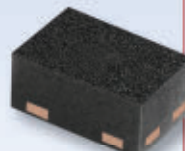
TEST & MEASUREMENT

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



RF DIODES

- PIN
- Schottky
- Varactor
- Limiter
- Gunn



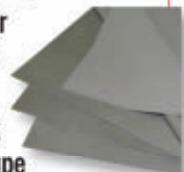
RF CABLE ASSEMBLIES

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



EMI / RFI

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



www.RFMW.com

Toll Free: 1-877-367-7369 • Fax: 1-408-414-1461

Canada 1-877-367-7369 • RFMW Mexico 1-408-414-1450 • RFMW Asia 65 6316 3389 • RFMW CO UK 44 208 848 4732 • RFMW Italia 39 0774 359035
RFMW France 33 1 83 64 53 97 • RFMW Deutschland 49 8031 7969240 • RFMW Israel Ltd. 972 9 740 6884

eLEARNING free webinars

PAM4 Demands Accurate S-Parameters

Sponsored by: Anritsu

12/1

Simulating Electromagnetic Shielding in Electronics and Transportation Applications

Presented by: CST

12/1

MMIC Design Overview

Sponsored by: National Instruments

12/6

Designing Antennas Using COMSOL Multiphysics®

Sponsored by: COMSOL

12/8

Accurate Simulations of Multistage Axial VIRCATORS Operating in S-Band Using CST PARTICLE STUDIO

Presented by: CST

12/8

Radome Simulation

Presented by: CST

12/15

Demystifying 5G and the Evolution to Massive MIMO for Increased Capacity and Profit

Sponsored by: Rohde & Schwarz

12/15

Coreless Packaging Technology for Compact, High-Performance Mobile Devices

Presented by: CST

12/20

Web Survey

Which of these medical procedures using RF/microwave technology have you experienced?

Look for our multiple choice survey online at mwjournal.com

October Survey

Where will 3D printing see the greatest near-term adoption in the RF/microwave industry?

Antennas (51%)

Packages (14%)

Passive Components (8%)

Semiconductors (8%)

Waveguide (15%)

Other (3%)



Katharina König, managing director and granddaughter of **SPINNER** founder, Dr. Georg Spinner, explains how the company has emerged as a global enterprise and how Dr. Spinner's technology driven philosophy has developed and adapted to the 21st century.



LOOK FOR
BLOGS
FROM:

NI's James Kimery,
5G Technology

Qorvo's Brent Dietz, "Bottom
10 IoT Gifts"

Rogers, Laminate PCB
Technology

microwavejournal.com/blogs

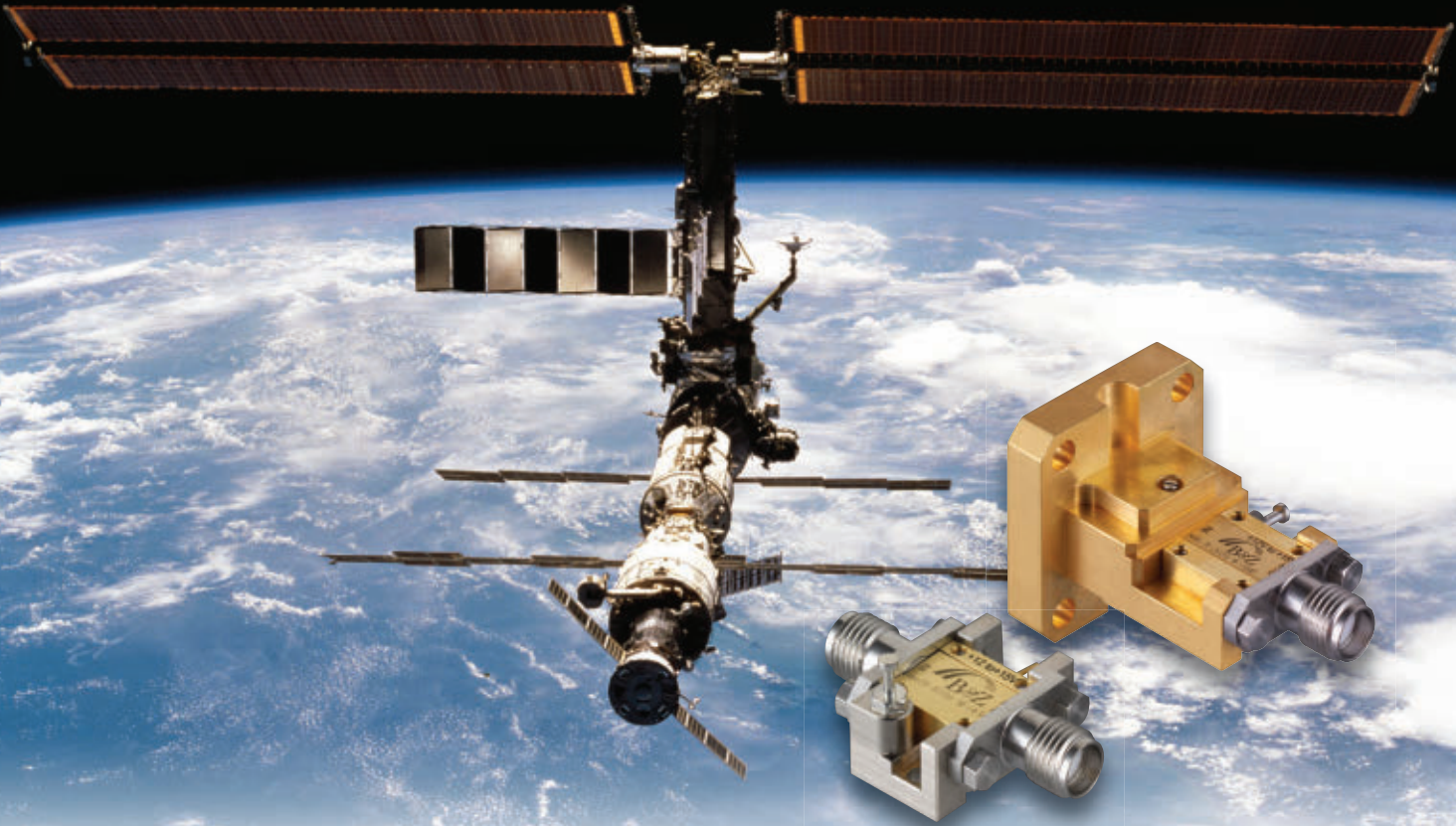
WHITE PAPERS



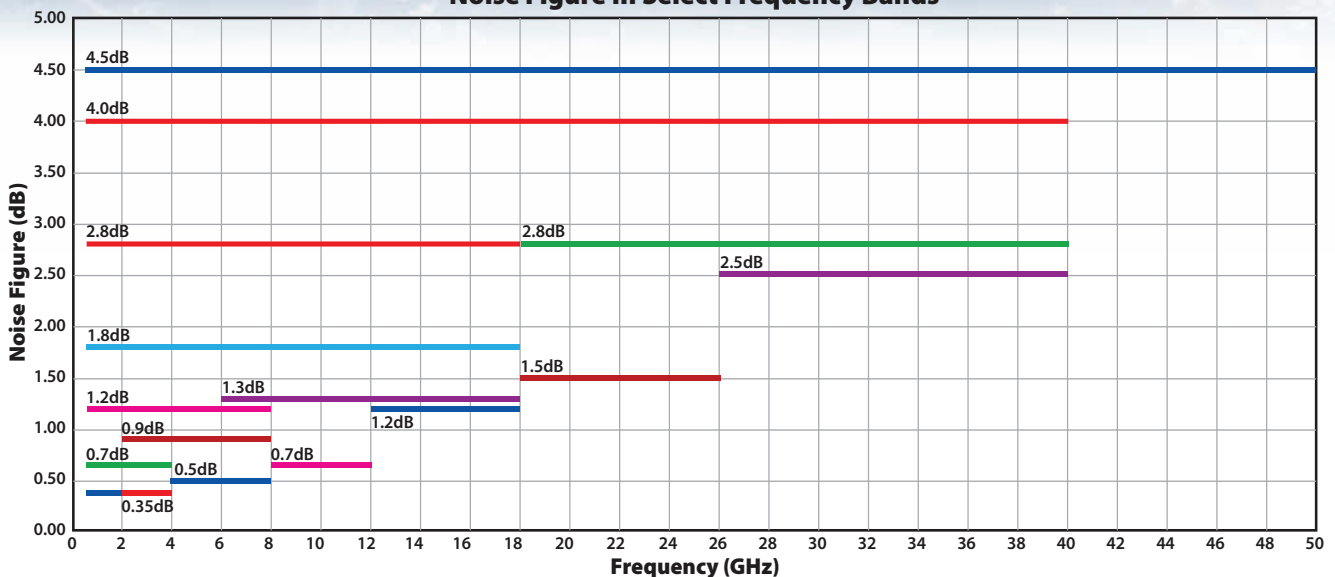
Understanding the Basics of
MIMO Communication
Technology

NEW

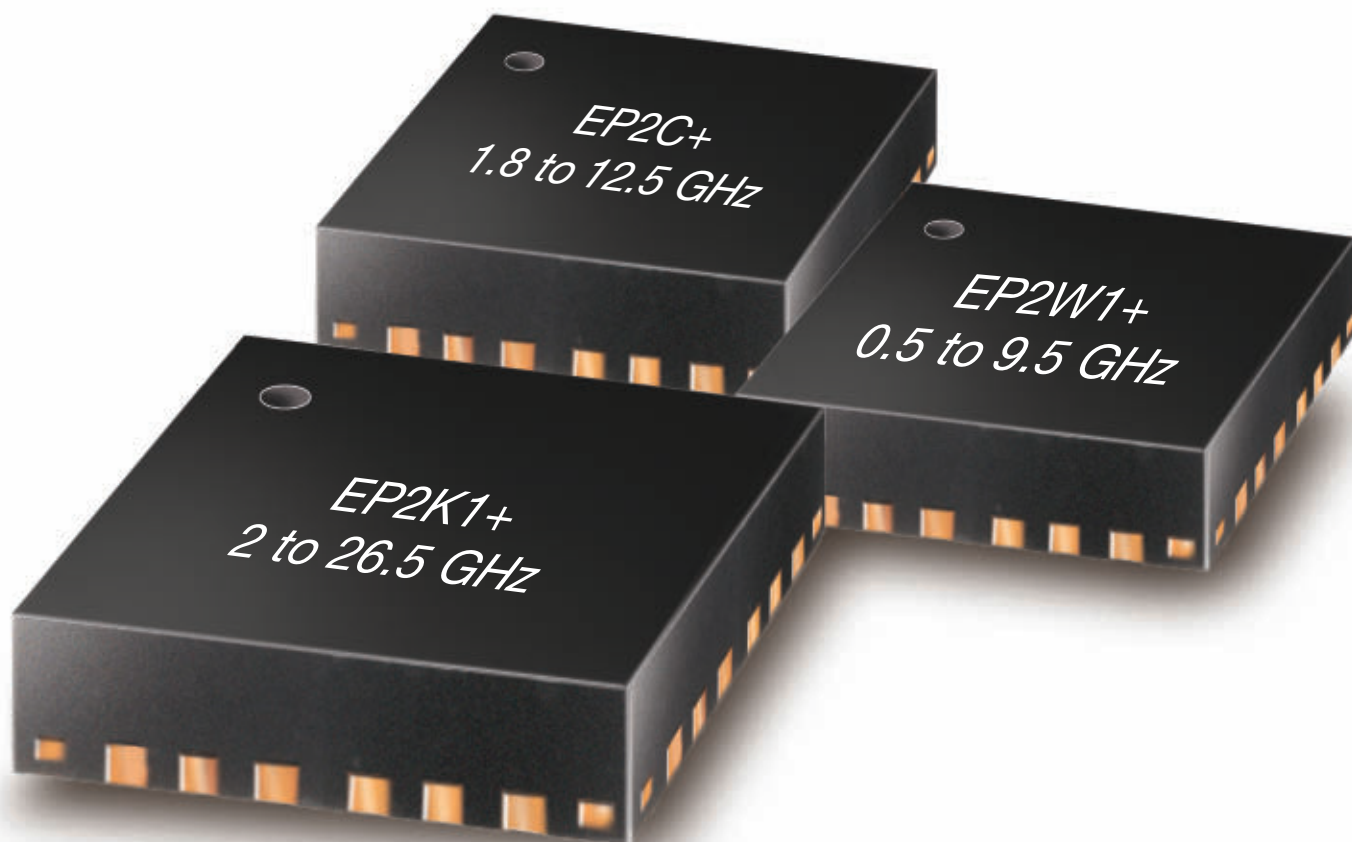
Has Amplifier Performance or Delivery Stalled Your Program?



Noise Figure In Select Frequency Bands



Ultra-Wideband MMIC SPLITTER/COMBINERS



Single Unit Coverage as Wide as **2 to 26.5 GHz**

Models from **\$5⁵⁶**
ea. (qty. 1000)

THE WIDEST BANDWIDTH IN THE INDUSTRY IN A SINGLE MODEL!

Our new EP-series ultra-wideband MMIC splitter/combiners are perfect for wide-band systems like defense, instrumentation, and all cellular bands through LTE and WiFi. These models deliver consistent performance across the whole range, so you can reduce component counts on your bill of materials by using one part instead of many! They utilize GaAs IPD technology to achieve industry-leading performance, high power handling capability and efficient heat dissipation in a tiny device size, giving you a new level of capability and the flexibility to use them almost anywhere on your PCB! They're available off the shelf, so place your order on minicircuits.com today, and have them in hand as soon as tomorrow!

- Series coverage from 0.5 to 26.5 GHz
- Power handling up to 2.5W
- Insertion loss, 1.1 dB typ.
- Isolation, 20 dB typ.
- Low phase and amplitude unbalance
- DC passing up to 1.2A

EP2K-Series, 4x4x1mm

EP2W-Series, 5x5x1mm



JANUARY

MARK YOUR CALENDAR

4

Call for Papers Deadline



The 18th annual IEEE Wireless and Microwave Technology Conference (WAMICON 2017) held in Cocoa Beach, Florida, April 24-25, will address up-to-date multidisciplinary aspects of wireless and RF technology. Prospective authors are invited to submit original and high-quality work for presentation at WAMICON 2017 and publication in IEEE Xplore.

www.wamicon.org

15-18

Radio Wireless Week 2017

Phoenix, Ariz.



RWW 2017 will consist of five related conferences that focus on the intersection between radio systems and wireless technology, creating a unique forum for engineers to discuss hardware design and system performance of state-of-the-art wireless systems and their end-use applications.

www.radiowirelessweek.org



31-2/2



Santa Clara, Calif.

DesignCon is the premier conference for chip, board and systems design engineers in the high speed communications and semiconductor communities. Now in its 22nd year, DesignCon offers state-of-the-art design methodologies, applications and technologies, as well as unparalleled networking opportunities.

www.designcon.com

24

Sponsored by:
Anritsu
envision: ensure

25

Sponsored by:
IDT

9

Call for Papers Deadline



The IEEE Radio Frequency Integrated Circuits Symposium (RFIC 2017) held during Microwave Week June 4-6, 2017 in Honolulu, Hawaii, will solicit papers describing original work in RFIC circuits, system engineering, design methodology, RF modeling and CAD simulation, RFIC technologies, devices, fabrication, testing, reliability, packaging and modules to support RF applications. <http://rfic-ieee.org>

Registration Opens in January



April 25-27, 2017
Shanghai Convention & Exhibition Center of International Sourcing
Shanghai, China

Conference Features

- Keynotes/presentations from industry executives and government officials
- Networking/Welcome Reception
- Peer-reviewed technical presentations
- Educational workshops
- Expert panels

www.ediconchina.com

FOR DETAILS, VISIT MWJOURNAL.COM/EVENTS

PORTABLE ISOTROPIC 3D ANTENNA ISOLOG 3D MOBILE



9kHz - 6GHz

High Gain and Low Noise

Built-in Bypass-Preamp

Works with any RF Analyzer

Battery or DC Powered

Phone: +49 6556 93033
Mail: mail@aaronia.de
Web: www.aaronia.com

MADE IN GERMANY

Coming Events

CALL FOR PAPERS

WAMICON 2017
January 4, 2017
RFIC 2017
January 9, 2017
IEEE EMC + SIPI 2017
January 16, 2017
EuMW 2017
February 13, 2017
mwjournal.com



JANUARY

RWW2017

January 15–18, 2017 • Phoenix, Ariz.
www.radiowirelessweek.org

DesignCon 2017

January 31–Feb. 2, 2017 • Santa Clara, Calif.
www.designcon.com



FEBRUARY

Mobile World Congress 2017

Feb. 27–March 2, 2017 • Barcelona, Spain
www.mobileworldcongress.com



MARCH

Satellite 2017

March 6–9, 2017 • Washington, DC
www.satshow.com

ICMIM 2017

March 19–21, 2017 • Nagoya, Aichi, Japan
<http://icmim-ieee.org>

GOMACTech 2017

March 20–23, 2017 • Reno, Nev.
www.gomactech.net

Microwave & RF 2017

March 22–23, 2017 • Paris, France
www.microwave-rf.com

IWCE 2017

March 27–31, 2017 • Las Vegas, Nev.
www.iwceexpo.com

EMV

March 28–30, 2017 • Stuttgart, Germany
<http://www.mesago.de/en/EMV/home.htm>



APRIL

WAMICON 2017

April 24–27, 2017 • Cocoa Beach, Fla.
www.wamicon.org

EDI CON China 2017

April 25–27, 2017 • Shanghai, China
www.ediconchina.com

Expo Electronica

April 25–27, 2017 • Moscow, Russia
www.expoelectronica.ru



MAY

AUVSI's Xponential

May 8–11, 2017 • Dallas, Texas
www.xponential.org

CS ManTech 2017

May 22–25, 2017 • Indian Wells, Calif.
<http://csmantech.org>

Space Tech Expo USA 2017

May 23–25, 2017 • Pasadena, Calif.
www.spacetecheexpo.com



JUNE

RFIC 2017

June 4–6, 2017 • Honolulu, Hawaii
<http://rfic-ieee.org>

IMS2017

June 4–7, 2017 • Honolulu, Hawaii
<http://ims2017.org>

EW Europe

June 6–8, 2017 • Olympia, London
www.eweurope.com

89th ARFTG Conference

June 9, 2017 • Honolulu, Hawaii
<http://www.arftg.org>

Sensors Expo & Conference

June 27–29, 2017 • San Jose, Calif.
www.sensorsexpo.com



AUGUST

IEEE EMC + SIPI

August 7–11, 2017 • National Harbor, Md.
www.emc2017.emccs.org

RFIT 2017

August 30–Sept. 1, 2017 • Seoul, South Korea
www.rfit2017.org



SEPTEMBER

EDI CON USA 2017

September 11–13, 2017 • Boston, Mass.
www.ediconusa.com

IEEE AUTOTESTCON

September 11–14, 2017 • Schaumburg, Ill.
www.autotestcon.com



NXP has developed a broad portfolio of RF power transistors for ISM applications at frequencies from 1 to 2450 MHz. These high VSWR devices are designed for use in the harshest environments.

For more information, visit www.richardsonrfpd.com/NXP-ISM.



Your Global Source for RF, Wireless, Energy & Power Technologies
www.richardsonrfpd.com | 800.737.6937 | 630.262.6800

Mergers Mold 2016



Patrick Hindle
Microwave Journal *Editor*

We have been talking about the great era of semiconductor consolidation since 2014 and it continued through 2016. There have been big moves in the industry such as the TriQuint and RFMD merger, Broadcom's acquisition of Avago and Analog Devices' acquisition of Hittite. And this year Analog Devices is also merging with Linear Technology—becoming a giant semiconductor player in the wireless and IoT markets.

Another big move was NXP's acquisition of Freescale, then NXP's RF power business spun off to become Ampleon. I thought things would slow down after that, but then Qualcomm came along to acquire NXP. And Infineon is acquiring Wolfspeed (formerly Cree) for its GaN technology. With the Chinese government still pumping billions into acquiring semiconductor companies and the pressure for the larger scale to provide low cost products, expect this trend to continue.

GaN has finally become mainstream and competitive with LDMOS in the lower cost commercial markets. A significant GaN milestone was the 36,000 GaN amplifiers that were shipped to Lockheed Martin for its Space Fence radar system. Our August supplement featured this system development which is one of the largest phased arrays and computing centers in the world today. Another milestone was the adoption of GaN in some cellular infrastructure applications. Our February 2017 issue will highlight Ericsson's progress in this area. GaN is addressing its higher cost with a 6-inch wafer fab coming online at Qorvo, and GaN on Si from MACOM possibly go-

ing to 8-inch wafers. Infineon tried to use GaN on Si for RF applications but was blocked by MACOM's acquisition of the rights in that market. Expect Infineon to beef up Wolfspeed's fab to compete in the higher volume commercial sectors.

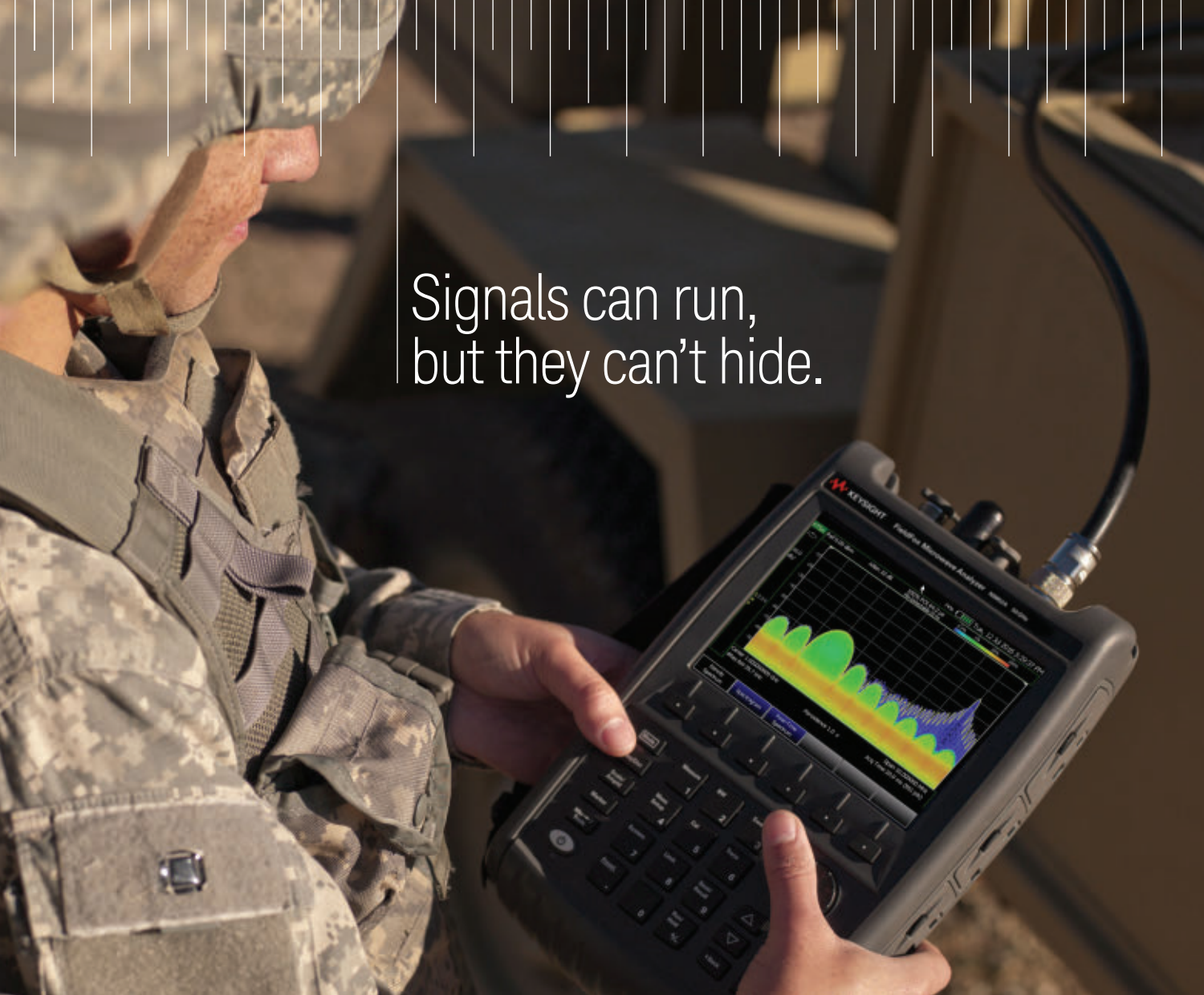
The RF Energy Alliance continued to make progress in reducing the cost of solid-state amplifier technology with a standard, low cost 300 W, 2.45 GHz module with near 70 percent efficiency. The challenge will be mainly cost as the technology works for these applications but is far more expensive than the current solution.

3D packaging and printing for RF applications really took off in 2016. Our February cover story featured 3D packaging research at Leti, where they are creating a new generation of mmWave interposer packages with enhanced electrical and mechanical properties at a reasonable cost.

Our October cover story discussed The MITRE Corporation's work on a new generation of 3D printing techniques and materials that realize complex geometries for wideband phased array and metamaterial designs using low-cost, commercial desktop printers. They demonstrated the technology by making 3D printed monopole Wi-Fi antennas and are now working on a complex, electrically-functional phased array and metamaterial structure. And our August Fabs and Labs covered the Printed Electronics Research Collaborative at University of Massachusetts Lowell where they are using 3D printers to manufacture frequency selective surfaces, antennas, waveguides, phased arrays and even tunable devices printed on plastic materials.

One of the biggest happenings of the year was on July 14, when the FCC established rules for microwave and mmWave broadband operations above 6 GHz in the U.S. The move effectively quadrupled the amount of radio bandwidth available to the mobile industry and paved the way for future 5G systems. Professor Ted Rappaport of NYU WIRELESS was the first to show that mmWaves were viable for cellular communications with his past urban channel modeling tests, and this year he conducted similar tests in a rural setting showing the viability of line-of-sight and non-line-of-sight transmission of mmWave communications at 73 GHz. NYU WIRELESS used this data to generate the first rural path loss model for mmWave frequencies, demonstrating pretty remarkable distances that can be achieved using mmWaves (near theoretical limits). With 5G mmWave trials happening so quickly, it will be very interesting to see how fast companies can commercialize mmWave technology and bring the cost down to a level that is practical for wide use.

Microwave Journal launched two significant ventures this year. EDI CON USA took place for the first time Sept. 20-22 in Boston, Mass., with a successful event covering RF/microwave, high-speed digital and EMC/EMI design topics. We also launched the first *Signal Integrity Journal* online covering signal integrity, power integrity and EMC/EMI topics (www.signalintegrityjournal.com). This is the only industry journal available covering these topics that address the needs of the digital design community. We hope everyone had a good year. Happy Holidays! ■



Signals can run,
but they can't hide.

Introducing Keysight FieldFox handheld analyzers with real-time spectrum analysis (RTSA) up to 50 GHz. Now you can capture every interfering signal in real time with one integrated, lightweight unit. FieldFox with RTSA empowers you to detect, locate and fix with benchtop accuracy. At only 7.1 lbs, it's also an all-in-one cable and antenna tester (CAT) + vector network analyzer (VNA) + spectrum analyzer + RTSA and more. This means you can forget about carrying separate devices for every function you need. Go out there, get the job done in real time, and carry the precision of one.

Keysight FieldFox Handheld Analyzers with RTSA

Now 16 new models with RTSA from DC to 50 GHz

Detect pulses as narrow as 22 ns;
63 dB spurious-free dynamic range

CAT + VNA + spectrum analyzer + RTSA and more

Benchtop precision, MIL-Class 2 rugged

Download RTSA app note today.
www.keysight.com/find/FieldFoxRTSA

USA: 800 829 4444 CAN: 877 894 4414

© Keysight Technologies, Inc. 2016.



Unlocking Measurement Insights

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

Scan page
using **layar** app

Automotive Radar Sensors Must Address Interference Issues

Dr. Steffen Heuel
Rohde & Schwarz, Munich, Germany

Autonomous driving is a current global trend that will continue to accelerate in the future. A key enabling technology in this area is automotive radar sensors, which are a significant step toward more driving comfort, crash prevention and even automated driving. Driver assistance systems are already common and many are supported by radar.

Today's 24 GHz, 77 GHz and 79 GHz automotive radar sensors clearly need to be able to measure and resolve different objects while offering high range, radial velocity and azimuth resolution in any urban or rural environment. A very important feature is immunity to interference from other automotive radar sensors. This topic has not been greatly focused on since the market adoption of radar sensors is low at the present time. However, the proliferation and expected growth is continually increasing and the Advanced Driver Assistance Systems (ADAS) market is expected to grow by up to 10 percent per year.

Considering that 72 million new cars are registered each year with a potential average of three (or more) automotive radar sensors per car, about 200 million more automotive radar sensors could be on the streets in the not too distant future. Consequently, the 24 GHz and 76 to 81 GHz spectrum will be heavily occupied. Automotive radar sensors will need to cope with mutual interference and offer signal diversity and interference mitigation techniques.

The occasional accidents involving automated cars that are under research and develop-

ment have been reported in the press. In May 2016, questions about the security of self-driving cars and the safety of the technologies rose again after the first fatal accident involving a partially automated car. It is therefore essential to ensure the functionality of the sensing equipment in any environment in the presence of mutual interference.

This article presents the theoretical background of state-of-the-art and next generation automotive radar signals and sensors. It explains the impact of mutual interference and presents measurement possibilities to test and verify mitigation techniques in arbitrary RF environments with norm interferers. This approach helps researchers and developers engineer automotive radar sensors that function according to specification, even in harsh RF environments.

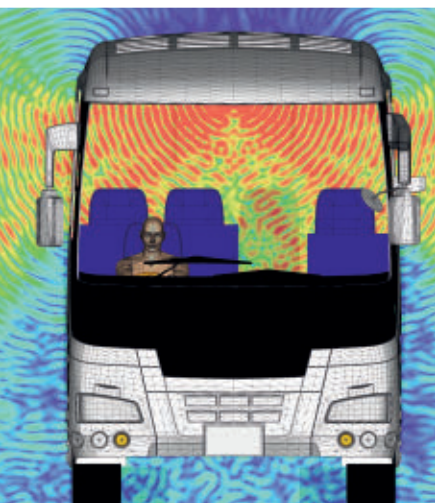
AUTOMOTIVE RADAR AND REGULATIONS

Several automotive radar sensors may interfere with each other when operating in the same portion of the frequency band¹ and in close proximity to each other (see **Figure 1**). Possible scenarios are the creation of artificial ghost targets or decreased probability of detection. Ghost targets do not exist in reality, but appear as real targets to the radar sensor. This may be caused by a copy of the transmitted signal. The copy is not from the original radar transmitter, but falls into the receiver bandwidth and is processed as a real echo signal. For this scenario to occur, timing, waveform



Make the Connection

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



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

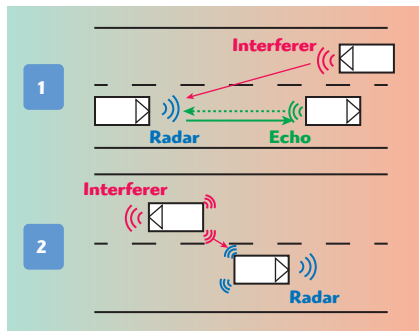
Involved in antenna development? You can read about how CST technology is used to simulate antenna performance at www.cst.com/antenna.

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

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

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





▲ Fig. 1 Interference scenarios.

and frequency between two or more radars have to match and the echo power has to exceed a certain limit.

Also, arbitrary RF signals with a certain power level that fall into the receiver bandwidth may increase the noise floor of the radar and reduce the Signal-to-Noise Ratio (SNR) of a target. This may cause targets with a small Radar Cross Section (RCS) to disappear since the SNR of these echoes is reduced. For this scenario to happen, a signal that spreads over

all frequencies after FFT signal processing has to fall within the receiver bandwidth.

The output power of automotive radar sensors is specified by the Electronic Communications Committee (ECC). Based on the ECC Decision (04) 03 entitled, "The Frequency Band 77 to 81 GHz to be Designated for the Use of Automotive Short Range Radars," the European Conference of Postal and Telecommunications Administrations (CEPT) designated the 79 GHz frequency range for Short Range Radar (SRR) equipment on a non-interference and non-protected basis. Moreover, a maximum mean power density of -3 dBm/MHz e.i.r.p. associated with a peak limit of 55 dBm e.i.r.p was defined, and the maximum mean power density outside a vehicle resulting from the operation of one SRR equipment shall not exceed -9 dBm/MHz e.i.r.p.

All standard automotive radar sensors operating in these bands have to fulfill this criteria. ETSI standards EN 301 091-1 and EN 301 091-2² already standardize several aspects related to test conditions, power emission and spurious emissions for 77 GHz radars, but do not mention anything about interference rejection. The same is true for the ETSI standards EN 302 264-1 and EN 302 264-2³, which regulate the 79 GHz band.

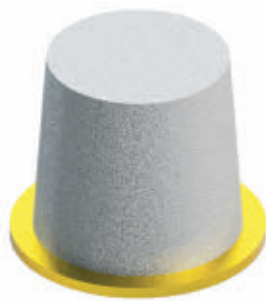
In the maritime domain, for example, navigational radars have to adhere to the International Electrotechnical Commission standard IEC 62388,⁴ which specifies the minimum operational and performance requirements, methods of testing and required test results conforming to performance standards of radiocommunications equipment and systems. One very important aspect in the IEC standard is the specification of interference rejection. However, for automotive radar specifications, there is no standard defining interference rejection or performance and test methods that navigational radars have been subject to for decades.

WAVEFORMS AND IMPACT OF INTERFERENCE

If an interfering signal falls into the radar receiver bandwidth, it should be detected as such and rejected in the signal processing. It is common for manufacturers to each have slightly

Invisipin®

ULTRA Hi RF - Compliant Connector



INFINITELY CONFIGURABLE • INDIVIDUALLY SOLDERABLE • HI COMPLIANCE RANGE

Specifications

- > 50 GHz Bandwidth @1 dB
- 20 mΩ C-Res (typical)
- Up to 4 Amps

Configurations

- 0.23mm to 0.64mm diameter pins
- Pitches from 0.4mm to >1mm



(Coaxial Configuration)

*Available in tape and reel (machine placeable) or fully integrated into custom products.

R&D
Interconnect Solutions®

www.RDIS.com/MJ

MJ@RDIS.com

610-443-2299

©2015 R&D Interconnect Solutions. All rights reserved. R&D Interconnect Solutions, Invisipin, and RDIS.com are trademarks of R&D Interconnect Solutions.

SMART DEVICES REQUIRE SMARTER AUTOMATED TEST SYSTEMS

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

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



NI PXI, LabVIEW, and TestStand

different waveforms, timings, bandwidths, antenna patterns and signal processing. This is an advantage in terms of interference rejection, but also results in the radar responding differently to interference.

There are mainly two different types of waveforms used in today's automotive radar sensors. Blind Spot Detection (BSD) radars often use the Multi-Frequency Shift Keying (MFSK) radar signal and operate mainly in the 24 GHz band. Radars operating in the

77 GHz or 79 GHz band often make use of Linear Frequency Modulated Continuous Wave (LFMCW) signals or Chirp Sequence (CS) signals, which are a special form of LFMCW signals. Using LFMCW, the radar transmits a frequency modulated signal (chirp) with a specific bandwidth f_{sweep} within a certain time, called the coherent processing interval T_{CPI} , as shown in **Figure 2**.

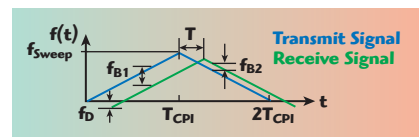
The radar down-converts the received signal with the instantaneous

transmit frequency and measures the beat frequency f_B , which describes the offset from the original transmitted waveform. Both radar parameters, range, R and radial velocity, v_r , contribute to the measured beat frequency. In order to resolve the target unambiguously for v_r and R , two beat frequency measurements are necessary (see **Figure 2**, where the beat frequencies are denoted as f_{B1} , f_{B2}). In multitarget situations, range and radial velocity cannot be resolved unambiguously by two consecutive chirps measuring different beat frequencies. This can be resolved by an additional chirp with a different slope.

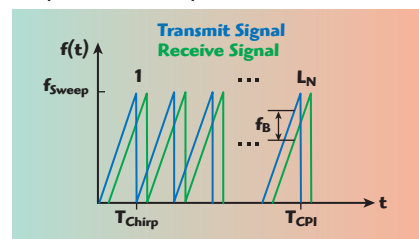
To enable a certain radial velocity resolution, T_{CPI} is typically in the region of 20 ms and the number of chirps for a single processing interval is greater than two. f_{sweep} defines the range resolution and varies between 100 MHz and above, and will be more than 1 GHz in the near future and probably 4 GHz or even 5 GHz in the distant future.

The chirp sequence waveform consists of several very short LFMCW chirps, each with a duration of T_{Chirp} transmitted in a block of length T_{CPI} (see **Figure 3**). Since a single chirp is very short, the beat frequency is mainly influenced by the signal propagation time and the Doppler frequency shift, f_D can be neglected.

Signal processing takes place following an initial down-conversion by the instantaneous carrier frequency and a Fourier transformation of each single chirp. Due to the high carrier frequency and the high chirp rate the beat frequency is mainly determined by range. The target range is calculated assuming a radial velocity, $v_r=0 \frac{m}{s}$. The



▲ Fig. 2 LFMCW radar signal with up-chirp and downchirp.



▲ Fig. 3 Chirp sequence.



World's Best RF & Microwave Simulation Models

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






Increase design accuracy with scalable Microwave Global Models™ for Passive Plus Broadband, High-Q and Ultra-low ESR capacitors

Experience powerful design capability and rapid RF design success!
FREE TRIALS are now available.

Request a FREE TRIAL, visit:
www.Modelithics.com/mvp/PPI



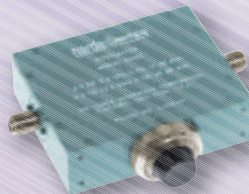
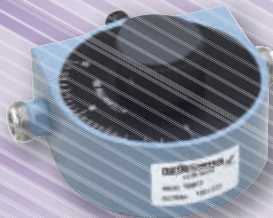
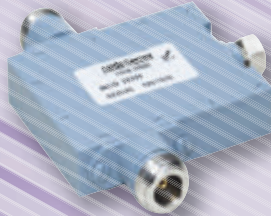


L-3 NARDA-MITEQ...DEPENDABLE VARIABLE ATTENUATOR PRODUCTS



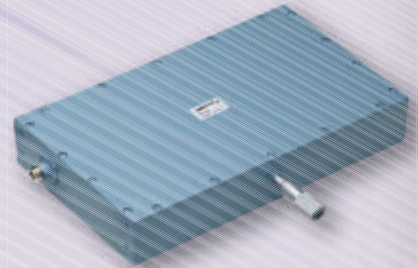
MINIATURE

Variable



BROADBAND

Variable



HIGH-POWER

Variable



narda  **MITEQ**

Innovative RF Variable Attenuator Products

L-3 Narda-MITEQ has the newest, most complete and dependable attenuator product line on the market today for demanding aerospace, defense and test applications. Our solutions include miniature, broadband and high-power products that are ready to ship now.

- Miniature Variable Products – Low minimum insertion loss, small compact enclosures with an adjustable attenuation range of up to 30 dB, and operational temperatures up to 105 °C
- Broadband Products – Smooth continuous operation and an adjustable attenuation range of up to 20 dB
- High-Power Products – Up to 10 dB or 20 dB adjustable attenuation at power levels up to 500 W

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

PIN DIODE LIMITERS

1 WATT CW 1 - 40 GHz

(Very High Frequency)

New



Many Models Available in Stock

- Very High frequency Wide Band
- 1 Watt CW Power Handling Capability
- Fast Response & Short Recovery Time (10 nsec typical)
- Hermetically Sealed Module

Typical Performance @ + 25 Deg. C

| MODEL | FREQ. RANGE (GHz) | MAXIMUM ¹ INSERTION LOSS (dB) | TYP LIM THRESHOLD (dBm) | MAX LEAKAGE ² @ 1W CW INPUT (dBm) |
|----------|-------------------|--|-------------------------|--|
| LP1-25A | 1 - 25 | 3.5 | +9 | +20 |
| LP2-25A | 12 - 25 | 3.5 | +9 | +20 |
| LP18-25A | 18 - 25 | 3.0 | +9 | +19 |
| LP18-40A | 18 - 40 | 4.0 | +9 | +19 |
| LP1-40A | 1 - 40 | 4.5 | +9 | +20 |
| LP2-40A | 2 - 40 | 4.5 | +9 | +20 |
| LP28-40A | 26 - 40 | 4.0 | +9 | +19 |

Notes: 1. Insertion Loss and VSWR (2 : 1) tested at -10 dBm.

Notes: 2. Power rating derated to 20% @ +125 Deg. C.

Other Products: Detectors, Amplifiers, Switches, Comb Generators, Impulse Generators, Multipliers, Integrated Subassemblies

Please call for Detailed Brochures



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

CoverFeature

| TABLE 1 | | |
|--------------------------------------|----------|-----------------|
| AUTOMOTIVE RADAR WAVEFORM COMPARISON | | |
| | LFCMW | CS (Fast LFCMW) |
| f_0 (GHz) | 77 | 77 |
| f_{sweep} (GHz) | 1 | 1 |
| T_{CPI} (ms) | 20 | 0.025 |
| $f_{\text{B,Upchirp}}$ (MHz) | 0.039027 | 10.6997 |
| $f_{\text{B,Downchirp}}$ (MHz) | 0.012342 | -10.6484 |

radial velocity is not measured during a single chirp, but instead over the block on consecutive chirps with duration T_{CPI} . A second Fourier transformation is performed along the time axis, which results in the Doppler frequency shift. After obtaining the Doppler frequency shift, the target range is corrected.

While a single T_{Chirp} is typically in the region of 10 μs to 100 μs , the number of signals L_N should be so high that the entire coherent processing interval, $T_{\text{CPI}} = L_N T_{\text{Chirp}}$ is again in the region of several dozen ms to achieve the desired radial velocity resolution.

The signal bandwidth is high, and the receiver bandwidth is very small in comparison. This can be achieved due to the fact that only the maximum beat frequencies for which the radar is designed are measured. To give two examples, **Table 1** shows the resulting beat frequencies of two automotive radar waveforms when measuring a target in 40 m range with a radial velocity of 50 m/s.

These calculations are according to the LFCMW equations and show that the occurring beat frequencies are in the range of 100 kHz for LFCMW, but are much higher for CS radars (several MHz). This causes the receiver bandwidth to be higher and may require different mitigation techniques compared to techniques applied when using LFCMW.

The advantage of CS compared to LFCMW is the unambiguity and the increased update rate, because a single coherent processing interval is sufficient to measure and resolve all targets in the observation range.

In LFCMW, at least three different chirp signals are necessary. On the other hand, in the CS waveform the processing complexity increases due to multiple FFTs and the receiver bandwidth scales according to the expected beat frequencies, which is why there is a need for interference rejection and mitigation techniques.

Figure 4 depicts the down-conversion and Fourier transformation process when an interference signal (red chirp) is present. The interfering chirp is down-converted together with the radar return of the object. In green is the constant beat frequency for a certain range as it would occur in an interference-free environment while measuring a single target. With the introduction of an interference signal, a time-dependent beat frequency is generated (red curve), which appears in addition to the wanted echo. Hence in the Fourier domain, the spectrum shows not only a single beat frequency but several frequencies.

In the optimal solution, the signal-to-noise ratio of the echo signal (green bar) is maximum. When the interference signal is present, the noise floor rises and the signal-to-noise ratio decreases depending on the receiver bandwidth, f_{LP} as indicated in the sketch. Aside from a decreased probability of detection, the lower signal-to-noise of an echo signal results in a

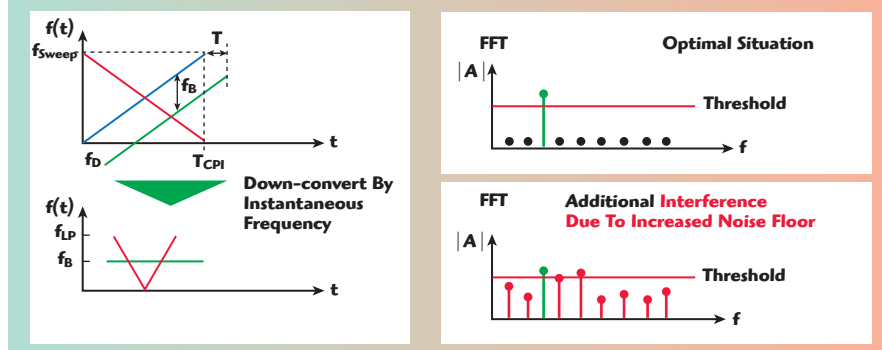


Fig. 4 Effect of interference signals.

AR's Hybrid Power Modules

700 MHz to 6 GHz In One Package



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

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

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

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

ISO 9001:2008
Certified

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



rf/microwave instrumentation

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

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

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

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

Copyright © 2016 AR.

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



less accurate range and a less accurate Doppler measurement.

The receiver noise floor and the signal-to-noise ratio of the object depend on the hardware, software and the object's RCS. Typical noise floor levels are about -90 dBm for an automotive radar operating at 77 GHz. One trend is to combine chirp sequence waveforms with other methods such as frequency shift keying in order to reduce the computational effort. However, at present, there are

no common definitions on normative interferers and interference rejection written in standards for automotive radar sensors.

T&M INTERFERENCE REJECTION

In order to verify the performance of interference rejection methods and to test the interference robustness of a radar sensor, a measurement was set up in the laboratory that allowed the generation of arbitrary RF signals. These signals can even include, for ex-

ample, transmitter position, antenna motion and pattern.

Figure 5 shows typical radar interference signals generated by Pulse Sequencer software, such as LFM CW, frequency shift keying and chirp sequence. It should be mentioned that the software is not limited to these signals or sequences, but can also create complex RF environments to the laboratory.⁵

Although these signals can be generated in the baseband, bringing these signals up to E-Band frequencies is a challenge. As most automotive radars use only frequency-modulated signals, one way is to use a state-of-the-art vector signal generator together with a multiplier. The advantages of this setup are less complex test setups and high signal bandwidth that can be reached more easily since the multiplier also scales the signal bandwidth.⁶ The scaling factor can easily be considered when designing the waveforms in the baseband.

Figure 6 shows a typical test setup for automotive radar sensors, using a vector signal generator in combination with a multiplier. The Pulse Sequencer software is used to generate the arbitrary RF environment in which signals are transferred to the vector signal generator over the local network or via a USB stick. The RF signals produced by the vector signal generator at 12.6 to 13.5 GHz are multiplied by a factor of six. An E-Band horn antenna can be connected to the output of the multiplier so that the E-Band signal can then be transmitted over the air towards the Device Under Test (DUT).

In this setup, the bandwidth applied at the vector signal generator also scales by a factor of six. To generate radar chirps with a signal bandwidth of 5 GHz, a baseband bandwidth of



BNC Berkeley Nucleonics Corp

Berkeley Nucleonics Corp., 2955 Kerner Blvd. San Rafael CA 94901
Email RFsales@berkeleynucleonics.com, Call 800-234-7858 or LIVE-Chat @ www.berkeleynucleonics.com

*We've changed the face (or at least the front panel)
of RF and Microwave Instrumentation*



Model 845-M



Model 845



Model 845-R

A 26.5 GHz high-performance Microwave Signal Generator in the palm of your hand? Impossible... until now!

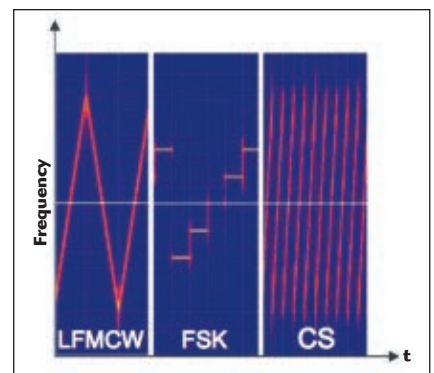
- From 9 kHz to 3 GHz, 4 GHz, 6 GHz, 12 GHz, 20 GHz & 26.5 GHz
- <10 μ s frequency switching time with very low phase noise
- Compact benchtop, 1U rackmount, synthesizer module & OEM packaging
- Full analog modulation or CW/LO only available



Phase Noise Test Systems



Real-Time Spectrum Analyzers



▲ Fig. 5 Typical CW radar signals.

Don't Let Your Temperatures Rise



Let ROGERS' Thermal Management Solutions *Keep You Cool*

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

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

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

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

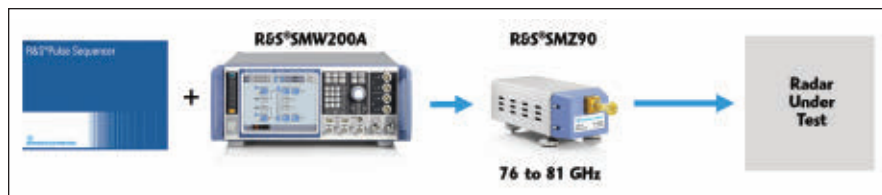


Advanced Connectivity Solutions

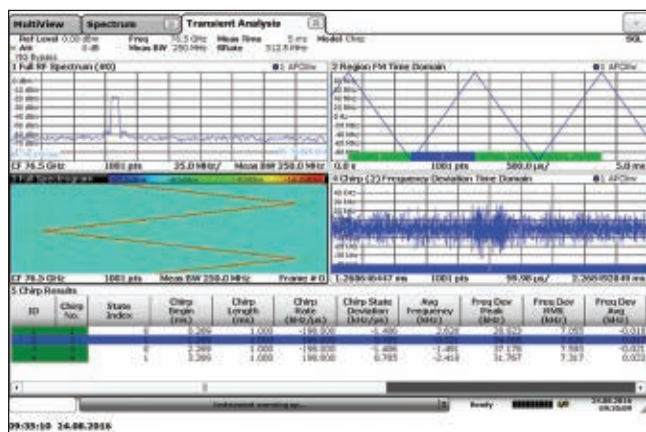
www.rogerscorp.com/acs

USA - AZ, tel. +1 480-961-1382

EUROPE - BELGIUM, tel. +32 9 235 3611



▲ Fig. 6 Interference test setup using a vector signal generator and multiplier.



▲ Fig. 7 Radar interference signal.

833.3 MHz is required ($833.3 \text{ MHz} \times 6 = 5 \text{ GHz}$). With the setup shown in Figure 6, a baseband bandwidth of 2 GHz is possible, which results in an RF signal bandwidth of up to 12 GHz ($2 \text{ GHz} \times 6 = 12 \text{ GHz}$).

The spectrum of the interference signal is in Figure 7. It is possible to observe the spectrum and the LFM CW signals with upchirps and downchirps. All chirp signal parameters have been analyzed directly with a signal analyzer equipped with transient analysis software. The chirp length is 1 ms and

extremely wideband OFDM signals in a price-sensitive sensor in real time. This will make it complicated to apply OFDM signals in the near future. This is also one of the reasons why it is so important to verify interference rejection algorithms, waveforms and the entire processing chain, starting with the mmWave region.

Not only is the cost-effective, real-time processing of very wideband OFDM signals challenging, generating amplitude-modulated interference signals in mmWave also requires

the signal frequency linearity is in the domain of several kHz, which is comparable to automotive radar sensor signals.

Researchers have already investigated using communications signals like OFDM in automotive radar⁷ and designed interference rejection algorithms.⁸ However, it may be complicated to process these extremely

wideband OFDM signals in a price-sensitive sensor in real time. This will make it complicated to apply OFDM signals in the near future. This is also one of the reasons why it is so important to verify interference rejection algorithms, waveforms and the entire processing chain, starting with the mmWave region. Not only is the cost-effective, real-time processing of very wideband OFDM signals challenging, generating amplitude-modulated interference signals in mmWave also requires

a more complex setup. One approach is depicted in Figure 8, which shows the IF and LO signals generated by a two RF channel vector signal generator. The LO signal is multiplied by a factor of six and shifts the IF signal to 76 to 81 GHz. A vector signal generator with an internal wideband baseband then allows the generation of arbitrarily modulated RF signals in the E-Band with a signal bandwidth of up to 2 GHz. Using vector signal generators incorporating calibrated internal wideband baseband hardware has benefits over solutions using multiple instruments since there is no need for calibration nor compensation of the I/Q frequency modulator response.

MEASUREMENT RESULTS

To verify the impact of additional radar signals that are present, a state-of-the-art 77 GHz sensor was used. The advantage of this sensor is the availability of IF and FFT raw data. This makes it possible to immediately verify the impact of interference signals on the FFT spectrum. As explained, one should see an increase in the noise floor depending on how much interference signal power is downconverted and falls into the receiver bandwidth. In these measurements, the sensor was configured to transmit an LFM CW signal with 200 MHz signal bandwidth as depicted in Figure 9, where the transient analysis option shows the duration, signal bandwidth, the linearity (frequency

Look to Norden for your Radar Component Needs



**77 GHz
RADAR TxRx**



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



**KA-Band
Transceiver**



**NORDEN
MILLIMETER**

For more information on these products go to:

www.nordengroup.com or

call **530.642.9123**



ANAB
NSF





Wireless Connectivity Solutions For Mobile Devices and Internet of Things Applications



| Automotive

AEC-Q100 Qualified 20 MHz to 3 GHz SPDT RF Switch: SKYA21001

For general purpose RF signal routing

AEC-Q100 Level 2 Qualified 0.1 to 6 GHz SPDT Switch: SKYA21003

For 3G / 4G LTE / 4G LTE-A in-cabin, cellular telematics and general purpose RF signal routing



| CATV

1218 MHz CATV MMIC Power Doubler: ACA1216

For HFC / FTTC node and ORM RF amplifiers that require highest bit delivery efficiency and low power consumption

1.218 GHz High Output GaN CATV Power Doubler Amplifier: ACA2429

For CATV head ends and HFC distribution systems



| Connected Home

2.4 GHz ZigBee® / Thread / Bluetooth® Smart Front-end Module: SKY66112-11

For in-home appliances, smart thermostats, smart lighting, sensors and Internet of Things (IoT) devices

2.4 GHz ZigBee® / Bluetooth® Low Energy / 802.15.4 Front-end Modules: SKY66113-11, SKY66114-11

For in-home appliances, smart thermostats, sensors, beacons, gateways and wearable devices

802.11ax High-power WLAN Front-end Modules: SKY85331-11 (2 GHz), SKY85743-11 (5 GHz)

For 802.11ax indoor / outdoor routers, access points, gateways, extenders and point to point networking products



| Mobile Devices

Multimode Multiband Power Amplifier Module for Dual Mode Quad-band GSM / EDGE - WCDMA / HSDPA / HSUPA / HSPA+ / LTE: SKY77661

For 2.5G and 3G / 4G handsets

0.7 to 2.7 GHz Triple SPST (3xSPST) Shunt MIPI® Switch in a WLCSP Package: SKY19237-001

For mobile device antenna tuning, impedance tuning and band switching



| Wearables

Low-power Bluetooth® Low Energy Front-end Module: SKY66111-11

Range extension for fitness trackers, sport and smart watches

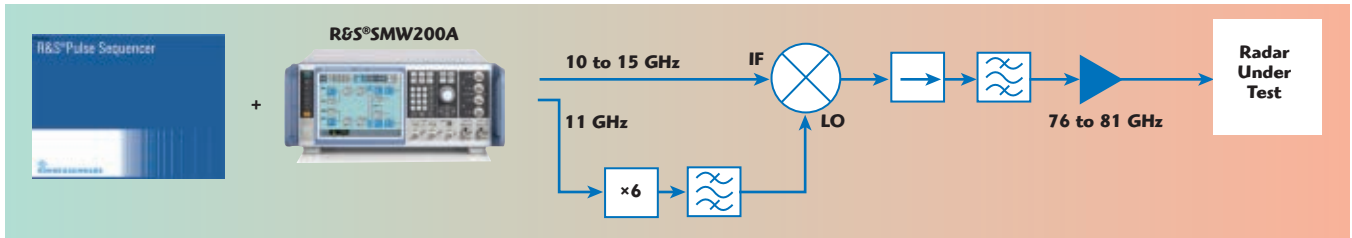
2.4 GHz ZigBee® / Bluetooth® Low Energy / 802.15.4 Front-end Modules: SKY66113-11, SKY66114-11

For in-home appliances, smart thermostats, sensors, beacons, gateways and wearable devices

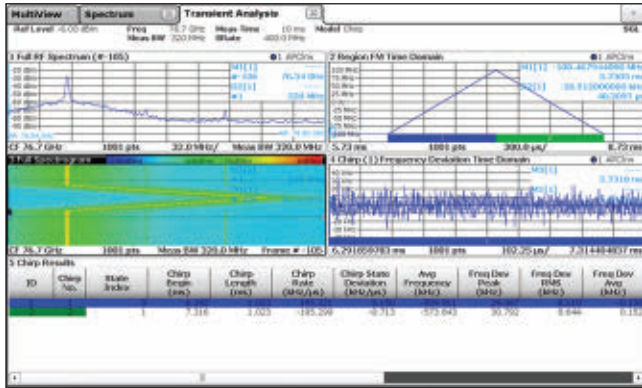
GNSS Low-noise Amplifier Front-end Module with GPS / GLONASS / BDS Pre-and Post-filters: SKY65913-11

For smartwatches, fitness / activity trackers, action cameras, personal navigation devices and GPS / GLONASS / BDS radio receiver applications

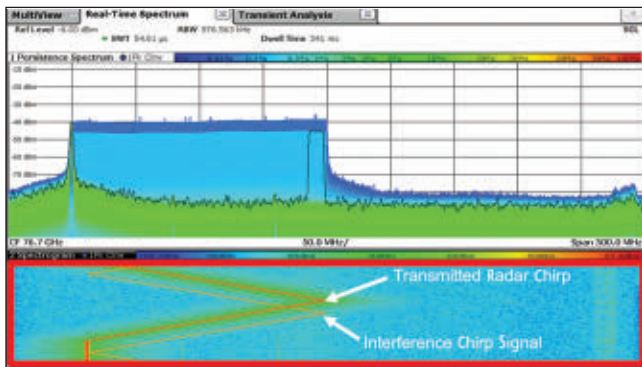




▲ Fig. 8 Interference test setup using a mixer.



▲ Fig. 9 Radar sensor analyzed with the transient analysis option.



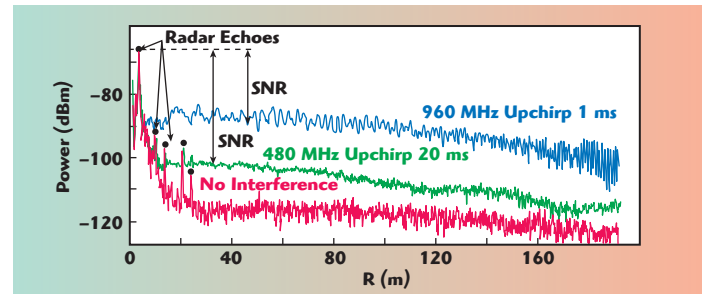
▲ Fig. 10 Real-time spectrum showing wanted signal (on left with single chirp) and continuously chirping interferer.

deviation time domain) of the transmitted chirps and spurious emissions in the RF spectrum.

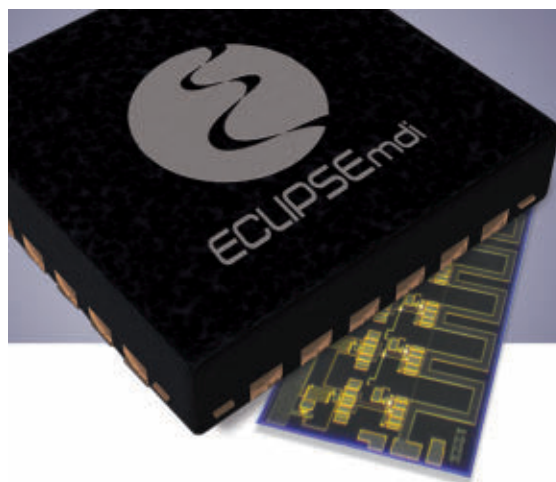
The Pulse Sequencer software was used to emulate the waveform and test the radar with an additional interference waveform. The real-time spectrum in persistence mode can be used to verify the two signals. **Figure 10** shows two RF signals, the chirp

which is transmitted by the radar sensor and the interference signal generated by the vector signal generator. While the radar sensor transmitted an upchirp and downchirp followed by an unmodulated CW signal, the interference signals just transmit upchirps and downchirps. The power level of the interfering chirp is about 5 dB less than the transmitted radar signal as shown in the persistence spectrum.

Figure 11 depicts a sample of spectrum measurements where the amplitude level over the range is plotted with and without interfering signals present. While measuring into free space without interference, this radar sensor measures a spectrum at a pow-



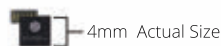
▲ Fig. 11 Radar sensor spectrum.



ECLIPSEmdi
sales@eclipsemdi.com | www.eclipsemdi.com

Maximum power.

Minimal noise.



Introducing the ultra small, super powerful low noise amplifier EMD1725D, DC-40 GHz.

Broadband performance ahead of its time.

RF-LAMBDA
THE LEADER OF RF BROADBAND SOLUTIONS

Made in USA

BROADBAND SSPA SOLID STATE POWER AMPLIFIERS

0.1-22GHZ ULTRA BROADBAND SSPA



RFLUPA01M22GA
4W 0.1-22GHZ



RFLUPA0218GA
10W 2-18GHZ

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



RFLUPA0706GD
30W 0.7-6GHZ



RFLUPA02G06GC
100W 2-6GHZ

6-18GHZ C, X, KU BAND



RFLUPA0618GC
25W 6-18GHZ



RFLUPA08G11GA
50W 8-11GHZ



RFLUPA06G12GB
25W 6-12GHZ

18-50GHZ K, KA, V BAND



RFLUPA18G47GC
2W 18-47GHZ



RFLUPA27G34GB
15W 27-34GHZ



RFLUPA28G42GA
2W 28-42GHZ



RFLUPA32G38GB
8W 32-38GHZ

BENCHTOP RF MICROWAVE SYSTEM POWER AMPLIFIER



RAMP00G06GA - 30W 0.01-6GHZ



RAMP39G48GA - 4W 39-48GHZ



RAMP01G22GA - 8W 1-22GHZ



RAMP27G34GA - 8W 27-34GHZ

www.rflambda.com
sales@rflambda.com

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

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



er level in the range of -115 dBm and some radar echo signals in close range.

When an interfering signal is present, the noise floor increases to about -102 and -90 dBm depending on the interfering signal itself. It should be mentioned that this radar sensor does not apply any interference cancellation. Also, the noise floor increase strongly depends on the interference signal level and the interfering waveform itself as can be seen in the measurements. A decrease of 10 to 25

dB SNR has been proved, which can cause objects to be very easily lost during tracking or objects with low RCS, like pedestrians, going undetected.

CONCLUSION

Automotive radar supports the trend towards additional driving comfort, safety and even automated driving. The number of automotive radar sensors on the streets is increasing rapidly and will grow further in coming years. As a consequence, the allo-

cated spectrum in the 24 GHz, 77 GHz and 79 GHz bands needs to be shared among different types of sensors and signals. As a safety critical element, the radar sensor needs to cope with mutual interference, offer signal diversity and interference mitigation techniques to measure, detect, resolve and classify radar echo signals even in the highly occupied frequency spectrum. Regulations and standards on interference test and mitigation are available for navigational radars, for example, but are not yet required for automotive radars.

To address these needs, this article explained the theoretical background and impact of interference on state-of-the-art and next generation automotive radar. Test and measurement possibilities to verify interference mitigation techniques in arbitrary RF environments have been presented. The impact of interference has been verified using a state-of-the-art commercial 77 GHz radar sensor. These test setups should help researchers and developers ensure the functionality of their radar according to specification even in harsh RF environments. ■

References

1. MOSARIM Project, "D2.2 – Generation of an Interference Susceptibility Model for the Different Radar Principles," 25.02.2011, www.transport-research.info/project/more-safety-all-radar-interference-mitigation, July 8, 2016.
2. European Standard EN 301 091, "Electromagnetic Compatibility and Radio Spectrum Matters" (ERM); "Road Transport and Traffic Telematics" (RTTT); "Technical Characteristics and Test Methods for Radar Equipment Operating in the 76 GHz to 77 GHz Band," www.etsi.org, July 8, 2016.
3. European Standard EN 302 264, "Electromagnetic Compatibility and Radio Spectrum Matters" (ERM); "Short Range Devices;" "Road Transport and Traffic Telematics" (RTTT); "Short Range Radar Equipment Operating in the 77 GHz to 81 GHz Band;" "Part 2: Harmonized EN Covering the Essential Requirements of Article 3.2 of the R&TTE Directive," retrieved from www.etsi.org, July 8, 2016.
4. International Standard IEC 62388:2013, "Maritime Navigation and Radiocommunication Equipment and Systems – Shipborne Radar – Performance Requirements, Methods of Testing and Required Test Results," Ed. 2.0, 2013-06-26.
5. Rohde & Schwarz, "1MA267: Automotive Radar Sensors – RF Signal Analysis and Inference Tests," Application Note, www.rohde-schwarz.com/appnote/1ma267, July 8, 2016.
6. Rohde & Schwarz, "Pulse Sequencer Software," www.rohde-schwarz.com/us/software/smw200a/.
7. M. Braun, "OFDM Radar Algorithms in Mobile Communication Networks," Dissertation, Institut für Nachrichtentechnik, Karlsruher Instituts für Technologie, Karlsruhe, 2014.
8. MOSARIM Project Final Report, 2012-12-21, <http://cordis.europa.eu/docs/projects/cnect/1/248231/080/deliverables/001-D611final-reportfinal.pdf>, July 8, 2016.



QUINSTAR
TECHNOLOGY, INC.

V, E, and W-Band

Solid State Power Amplifiers Multipliers and Converters Integrated Modules

Millimeter Wave Products 18-140 GHz

- Components including amplifiers, converters, oscillators, antennas, control devices, waveguides
- Subsystems and integrated modules
- Custom products and engineering services

Designed & Manufactured in the USA
24085 Garnier St. Torrance, CA 90505
ISO9001 : 2008/AS9100C

sales@quinstar.com
tel: 1.310.320.1111
<http://www.quinstar.com>

RF SWITCH MATRICES

DC to 18GHz



USB & Ethernet Control Options models from **\$405^{ea.}**

- 0.25 dB Insertion Loss
- 85 dB Isolation
- 1.2 VSWR
- up to 10W Power Handling
- Extra-Long Switch Life
Up to 100 Million Cycles*
- Switch Cycle Counting Feature
with Automatic Calibration Alerts
- User-Friendly GUI and DLLs Included
- Compatible with Most Third Party Lab Software†
- Small size fits in your Laptop Case!
- Available from Stock

Visit minicircuits.com for detailed model specs, application notes, and more!
Place your order today for delivery as soon as tomorrow!

* Switches protected by US patents 5,272,458; 6,650,210; 6,414,577; 7,843,289; and additional patents pending.
† See data sheet for a full list of compatible software.





Variable Gain Amplifiers for Wireless Infrastructure

Integrated Device Technology Inc.
San Jose, Calif.

For wireless infrastructure applications, IDT has developed a family of transmit (Tx) variable gain amplifiers (VGA) with high gain and high linearity. Incorporating a new constant linearity K_{LIN} ™ RF VGA, the family provides a nominal 32 dB maximum gain with 29.5 dB gain control, and an output IP3 of +38.5 dBm. The devices incorporate a digital step attenuator (DSA) with 0.5 dB step resolution. Three parts cover the bands from 700 to 2950 MHz (see **Table 1**), all with similar gain, OIP3 and P_{1dB} performance. Device linearity is optimized over the respective frequency ranges for each VGA; however, gain flatness is optimized over a broader frequency to account for systems with extended digital predistortion (DPD) bandwidth requirements.

In wireless infrastructure base stations and remote radio units (RRU), RF VGAs are used in the transmit paths connecting the data converter to the power amplifier (PA) stages. The typical requirements for the components in the Tx path are:

- Low distortion
- High efficiency
- High ACLR
- Low spectral noise
- High signal-to-noise ratio

- Low DC power consumption
- Small PCB footprint
- Low cost

The IDT Tx VGAs meet or exceed wireless infrastructure requirements. Each Tx VGA in the F145x family consists of a K_{LIN} RF amplifier, DSA and a PA driver amplifier (see **Figure 1**) that are configured to provide an optimum balance between noise and linearity performance over the gain control range.

Common features of the three Tx VGAs include:

- Broadband operation
- 32 dB maximum gain, flat and temperature invariant
- 4 dB noise figure at maximum gain
- 23.4 dBm P_{1dB} , which is constant for the first 12 dB of gain reduction
- 38.5 dBm OIP3, also constant for the first 12 dB of gain reduction
- 29.5 dB total gain control range in 0.5 dB steps
- Serial peripheral interface (SPI) for gain control
- Internal matching and biasing
- High reliability MSL1 package with low thermal resistance
- Single +5 V supply voltage and 220 mA of DC current
- Standby feature for TDD applications
- High reliability, due to the assembly of a monolithic silicon die in a QFN package

K_{LIN} FEATURE

Unique to these Tx VGAs is the K_{LIN} feature. The K_{LIN} amplifier extends the OIP3 and output P_{1dB} performance over a wider range of input and output powers than conventional competitive devices. Unlike other products, the F145x Tx VGAs separate

TABLE 1
VGA FAMILY

| Part # | Frequency Range (MHz) | Max Gain (dB) | OIP3 (dBm) | P_{1dB} (dBm) |
|--------|-----------------------|---------------|------------|-----------------|
| F1451 | 700 to 1100 | 33.0 | 40 | 23.5 |
| F1455 | 1400 to 2300 | 32.8 | 38.5 | 23 |
| F1456 | 2100 to 2950 | 32.1 | 40 | 23 |

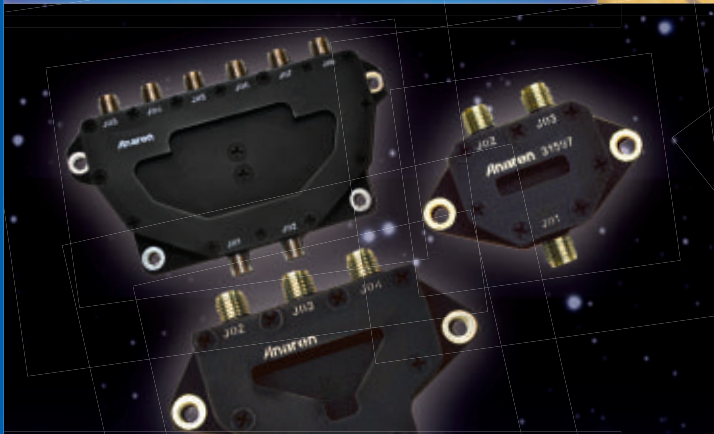


Anaren Precision Etched Ceramics (APECS) — offering thin-film tolerances & performance, at a thick-film price




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

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



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



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

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

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

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

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

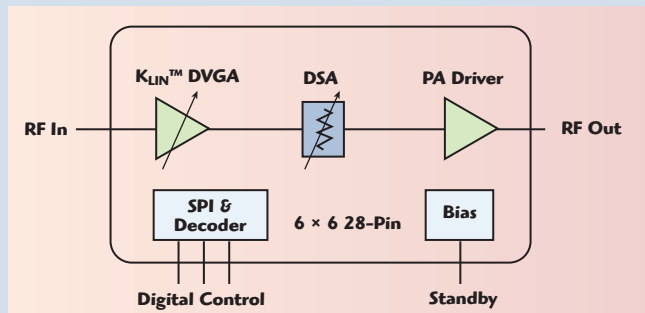


Anaren®

What'll we think of next?®

800-411-6596 > www.anaren.com

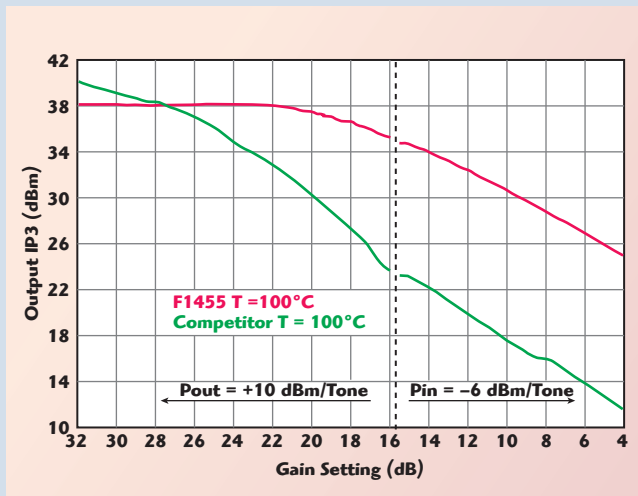
Most Valuable Product



▲ Fig. 1 Functional block diagram of Tx VGAs with the K_{LIN} constant linearity feature.

the gain control between both the K_{LIN} amplifier and the DSA. The first amplifier incorporates circuitry to improve the linearity of the device as gain is reduced from its maximum value. This results in an output IP3 characteristic that remains constant for approximately 12 dB of gain reduction (see **Figure 2**), providing greater dynamic range for the system. With this added dynamic range, the device is able to operate over a wider range of input power levels while maintaining a constant output P_{1dB} and OIP3. A conventional VGA, whose OIP3 characteristic falls off more steeply as gain is reduced, has a more limited range of acceptable input power levels, i.e., for which the desired intermodulation performance is met.

The same applies to the P_{1dB} performance. The first F145x stage tolerates higher input power as a function of gain reduction before contributing to the overall compression performance of



▲ Fig. 2 Output IP3 vs. gain, showing the flatness of the K_{LIN} feature compared to a competing product.

the device. In contrast, the first stage amplifier of some competitive parts compresses early. With degrading P_{1dB} and OIP3 as a function of gain reduction, these competitive devices only allow a relatively small window of acceptable input power. ■

Integrated Device Technology Inc.
San Jose, Calif.
www.idt.com

IT DOES EXIST...



HA7062C REAL TIME PHASE NOISE ANALYZER

- >> 10MHz - >20GHz DUT Input Range
- >> 0.1Hz - 40MHz Measurement Offsets
- >> ANSI z540 NIST Traceable Data
- >> Absolute/Residual/Baseband/AM/Pulse
- >> 3 YEAR PRODUCT WARRANTY

ACCURATE PHASE NOISE MEASUREMENTS ARE NO LONGER A MYSTERY



Communications & Power Industries

beverly microwave division

CPI Beverly Microwave Division: Providing High Quality Weather Radar Products

***With our experience and product breadth,
we support new and existing
weather radar systems.***

Contact us about:

***Individual microwave components
or complete transmitters***

- Available in S, C and X band
- Peak power up to 1 MW
- Klystron, magnetron, or solid state



For More Details Visit : www.cpii.com/bmd

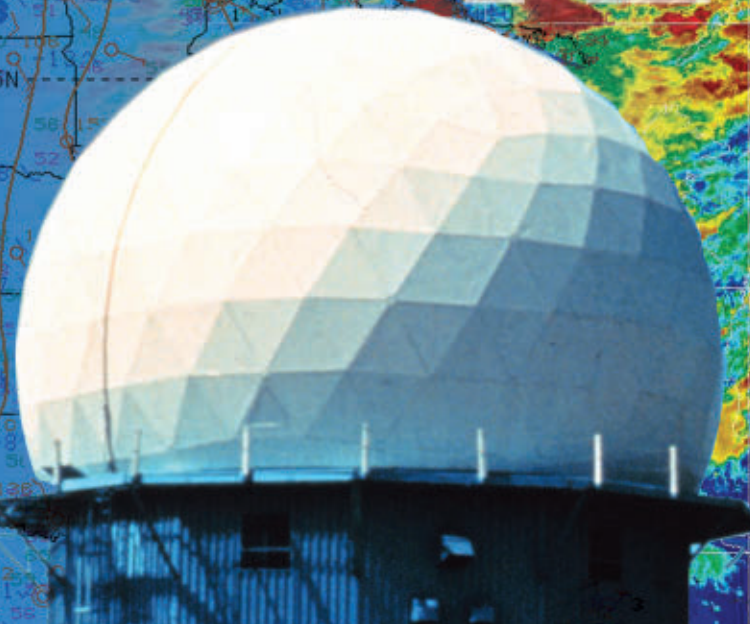
Transmitter / Receivers

Integrated Microwave Assemblies

Transmitters

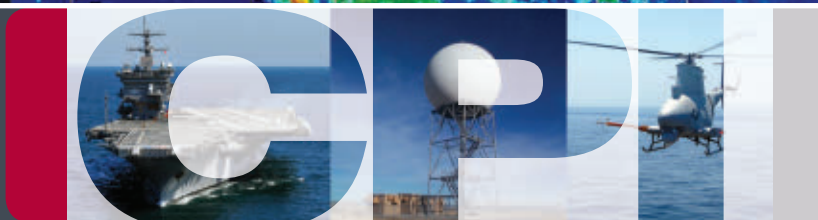
Receiver Protectors

WEATHER RADAR



Solid State Power Amplifiers
Integrated Microwave Assemblies
Control Components
Transmitters
Modulators

Receiver Protectors
Magnetrons
Crossed Field Amplifiers



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





Raytheon Developing Next-Gen Human/Machine Interface for Armored Ground Vehicles



Raytheon Co. is developing new technology to provide comprehensive situational awareness to troops inside windowless armored vehicles, as part of the Defense Advanced Research Projects Agency's (DARPA) Ground X-Vehicle Technologies (GXV-T) program.

The goal of GXV-T is to improve the mobility and survivability of armored vehicles without adding more armor and weight. DARPA is funding advanced technology development in four related areas: mobility enhancement, agility for survivability, crew augmentation and signature management. Raytheon BBN Technologies is developing crew-augmenting technologies.

"Our team is developing a virtual experience that gives the crews of armored military vehicles greater awareness of what's going on outside the vehicle, while also reducing their vulnerability to attack," said David Diller, GXV-T program manager for Raytheon BBN. "We're creating a three-dimensional model of the environment in real time that gives users views of their outside environment that would not normally be possible from inside the vehicle."

The Raytheon BBN technology uses lidar data to create a 3D model of the environment, employing high-definition video to produce a detailed, natural rendering of the surroundings. Additional sensors provide the precise location of any incoming hostile fire, while blue-force position updates locate friendly forces. Presenting all this sensor data in a natural, intuitive interface improves situational awareness while reducing the workload for the crew and allowing them to focus on the most relevant threats and challenges.



Source: DARPA Image

Advanced Space Surveillance Telescope Has Critical Military Applications



The most sophisticated space surveillance telescope ever developed is ready to begin tracking thousands of space objects as small as a softball. It's a boon to space surveillance and science and a new military capa-

bility important to the nation and the globe, an Air Force general says.

"It's not often we get an opportunity to witness the beginning of an entirely new military capability," Air Force Maj. Gen. Nina Armagno, director of strategic plans, programs, requirements and analysis for Air Force Space Command headquarters at Peterson Air Force Base in Colorado, said at the transfer event, "but that's exactly what we're doing here today."

The telescope, developed by the Defense Advanced Research Projects Agency, was turned over to the Air Force Oct. 18 at the Space Surveillance Telescope site atop North Oscura Peak on the northern part of the Army's 3,200 square mile White Sands Missile Range in New Mexico. The formal transition of the SST from a DARPA-led design and construction program to ownership by the Air Force begins the telescope's operational phase. The Air Force will move the SST to Harold E. Holt Naval Communication Station in Western Australia, operating and maintaining the telescope jointly with the Royal Australian Air Force. The SST also will be a dedicated sensor in the U.S. Space Surveillance Network, operated by the Air Force Space Command.

According to DARPA, SST represents breakthroughs in telescope design, camera technology and image analysis software, and allows much faster discovery and tracking of previously unseen or hard-to-find small space objects. SST has increased space situational awareness from a narrow view of a few large objects at a time to a widescreen view of 10,000 objects as small as softballs, DARPA says. The telescope also can search an area larger than the continental United States in seconds and survey the entire geosynchronous belt in its field of view—a quarter of the sky—multiple times in a night. "From a military perspective, any one of those objects could put satellites at risk," Armagno said. "That's why this capability is so important to us in Air Force Space Command."

The world and the threat have changed, she noted, adding, "We no longer have the luxury of assuming that we operate in a benign environment (or) that conflict will only be on land or at sea or in the air. Now we must concern ourselves with a conflict that may extend into space."

This calls for an in-depth understanding of what's go-



Source: DARPA Image

ing on in space, she added—what objects are there, what they are doing, what their intentions are and what they will do next. SST will provide such information to the United States and its allies, Armagno said, characterizing it as “the ability to better understand the space domain in order to identify and predict the actions of others. In turn this knowledge will help us deter others from reckless behavior, and [allow us] to posture ourselves to react if needed.”

Cognitive EW Development Contract

DARPA has awarded BAE Systems a \$13.3 million contract modification to extend its work on the Adaptive Radar Countermeasures (ARC) project.

Current EW systems are limited in their ability to quickly adapt to new and advanced threats because they rely on a database of known threats with predefined countermeasures. To ensure mission success in future anti-access/area denial environments, EW systems will need to isolate unknown hostile radar signals in dense electromagnetic environments, and then rapidly generate effective electronic countermeasures. The cognitive EW technologies developed for the ARC program employ advanced signal processing, intelligent algorithms and machine learning techniques.

Under the contract modification, for Phase 3 of the ARC program, BAE Systems will perform work that includes the

planned completion of algorithm development, advanced readiness testing, and key milestones for transitioning the ARC technologies to critical airborne warfare platforms, such as fifth-generation fighter jets.

“The Phase 3 award from DARPA recognizes the progress our team delivered at the end of Phase 2,” said Louis Trebaol, ARC program manager at BAE Systems. “In Phase 2, we successfully demonstrated the ability to characterize and adaptively counter advanced threats in a closed-loop test environment. We will now continue to mature the technology and test it against the most advanced radars in the U.S. inventory in order to successfully transition this important technology to the warfighter.”



Source: BAE Image

It's finally here...

The Signal Integrity Journal

Covering SI, PI, EMC/EMI



From the
Publishers of
Microwave Journal

www.signalintegrityjournal.com

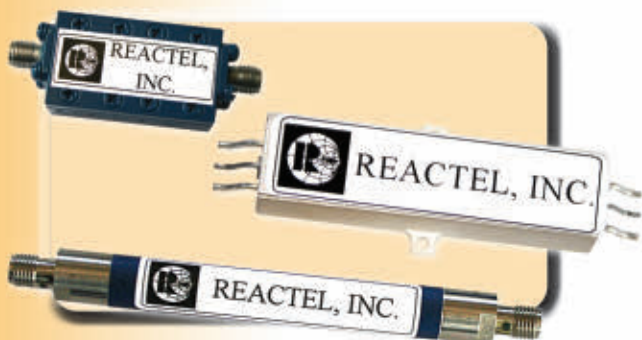
Reactel, Incorporated

Reacting First to All Your Filter Needs.

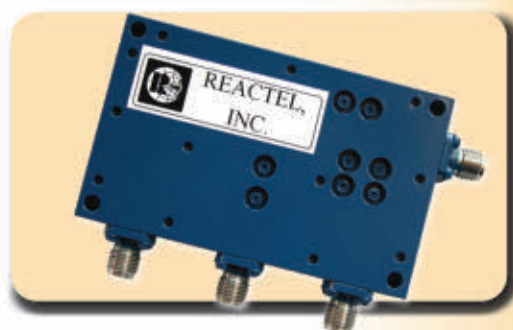


*When Being the First to React
Makes all the Difference in the World*

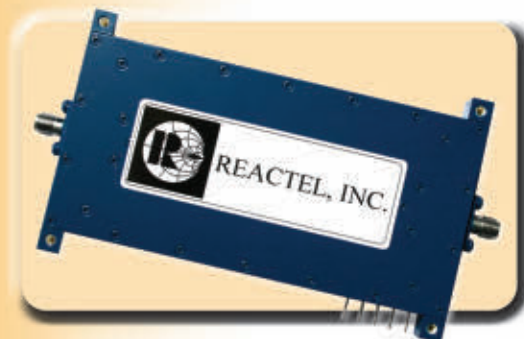
- **RF & Microwave Filters**



- **Diplexers & Multiplexers**



- **Multifunction Assemblies**



- **Ceramic Filters**



Reactel, Incorporated is your source for RF & Microwave Filters, Multiplexers and Multifunction Assemblies covering DC - 50 GHz.

Trust in Reactel's highly skilled engineers and technicians to quickly develop and produce the most reliable products for your filter requirements.

- 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
For general inquiries, please email reactel@reactel.com • <http://twitter.com/reacteljim>
Go online to www.reactel.com to download your Reactel catalog today.



ISO 9001:2008 Registered

@reacteljim

SIX DAYS

THREE CONFERENCES

ONE EXHIBITION

EUROPE'S PREMIER
MICROWAVE, RF,
WIRELESS AND
RADAR EVENT



**EUROPEAN
MICROWAVE WEEK**
NÜRNBERG CONVENTION CENTER
NÜRNBERG, GERMANY
8TH-13TH OCTOBER 2017
www.eumweek.com

SUBMIT YOUR PAPER ONLINE

EUROPEAN MICROWAVE WEEK 2017

**NÜRNBERG CONVENTION CENTER, NUREMBERG, GERMANY
8TH - 13TH OCTOBER 2017**

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 'Conferences' 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

© NürnbergMesse

EuMA
European Microwave Association

Official Publication:



Organised by:



Supported by:



Co-sponsored by:



Co-sponsored by:



The 12th European Microwave
Integrated Circuits Conference

Co-sponsored by:



The 47th European Microwave Conference

Co-sponsored by:



The 14th European Radar Conference

Co-sponsored by:



**SUBMIT SUMMARIES ONLINE BY 13TH FEBRUARY 2017 AT:
www.eumweek.com**



Newtec HTS Solution to Provide Connectivity to Sub-Saharan Africa

The Newtec Dialog® platform, including a Wi-Fi hotspot solution, has been selected by Avanti Communications Group as the High Throughput Satellite (HTS) ground segment technology platform for its ECO project. The project, which is a public-private partnership between the European Space Agency (ESA) and Avanti, will provide affordable and reliable satellite broadband connectivity in its first phase to 1,400 schools and community sites across Sub-Saharan Africa within the next two years.

Newtec's optimized ECO terminals will deliver the ECO satellite broadband services to all identified sites through

"...reduce the digital divide..."

Avanti and its service providers. These Wideband DVB-S2X 500 Mbaud terminals combine the satellite connectivity with a Wi-Fi hotspot, including optional solar panels,

and are part of the Newtec Dialog multiservice platform. The ECO service will initially be deployed in 32 Ka-Band spot beams out of multiple gateways in Europe and Africa.

"We are pleased to be able to use Newtec's technology on this vital project," said David Williams, CEO of Avanti. "The partnership is a significant step towards creating a solution for the endemic lack of affordable broadband connectivity across Sub-Saharan Africa."

The ECO satellite broadband services will benefit thousands of schools, communities and health centres, as well as Internet cafes and community area networks. The connectivity will also be used by local governments, telecom providers, mobile network operators and Internet service providers.

"One of Newtec's long-term objectives has been to reduce the digital divide and projects such as ECO are essential to this goal," said Didier Tymen, VP Sales EMEA of Newtec. "Our technology, including the Wi-Fi hotspot solution, delivers well against Avanti's network philosophy of Quality & Flexibility. It plays an important role in delivering the initiative's goals and makes reliable, but also affordable broadband a reality for millions across the region."

EU-US Agreement Offers New Opportunities for Research Cooperation

An agreement between the European Commission and the U.S. Government will enable European and American researchers to work together more closely on projects funded under Horizon 2020, the European Union's research and innovation programme.

Carlos Moedas, European Commissioner for Research, Science and Innovation, said, "Bright ideas should know no

boundaries, so European research and innovation is open to the world for collaboration. This agreement means that the best talent on both sides of the Atlantic will be able to work even closer together on tackling the global challenges that our societies are facing."

The agreement, known as the "Implementing Arrangement," facilitates cooperation between U.S. organizations and Horizon 2020 participants in cases where the U.S. organizations are funded by the U.S. and do not receive any funding from the Horizon 2020 programme. It simplifies cooperation between a selected Horizon 2020 project and a U.S. entity by enabling researchers to organise their cooperation outside the formal Horizon 2020 Grant Agreement signed for each project, in accordance with applicable laws, rules, policies and regulations of their respective funding programmes.

With a budget of €77 billion for 2014 to 2020, Horizon 2020 is one of the largest multinational programmes dedicated to research and innovation. Research and innovation cooperation between the EU and the U.S. is governed by the Agreement for Scientific and Technological Cooperation, which entered into force in 1998. On 18 June 2014 the EU-US S&T cooperation agreement was renewed for an additional five years with retroactive effect and is now valid until 14 October 2018.

"Bright ideas should know no boundaries..."

European Commission to Invest €9.1 Million in SMEs

Small and medium-sized enterprises (SME) from 24 countries have been selected for funding in the latest round of the Horizon 2020 SME Instrument. The funding is provided under Phase 1 of the instrument, which means that each project will receive €50,000 to finance feasibility studies for new products that can disrupt the market. The enterprises can also ask for up to three days of free business coaching.

The 189 SMEs that will receive funds proposed 182 projects in total (multiple SMEs can be involved in one project) and between them will receive €9.1 million in total. Italian SMEs were particularly successful with 34 companies accepted for funding, followed by firms from Spain (30) and the UK (18). Most of the projects funded (29) will be in the area of Information and Communications Technology (ICT), followed by transport and low-carbon energy systems (both 24).

"...new products than can disrupt the market..."

For More Information

Visit mwjournal.com for more international news

For the third cut-off of the SME Instrument Phase 1 this year, EASME received 1,938 project proposals from 40 countries. Since the launch of the programme on 1 January 2014, 1840 SMEs have been selected under Phase 1 of the SME Instrument.

WTSA-16 Gives ITU Impetus to Power Smart 5G Era

The World Telecommunication Standardization Assembly 2016 (WTSA-16) held in Hammamet, Tunisia from 25 October to 3 November, has given further impetus to the International Telecommunication Union (ITU) standardization work aimed at supporting government, industry and academia in achieving their priorities for year 2020 and beyond.

ITU membership has called for ITU's standardization arm to expand its study of the wireline networking innovations required to achieve the ambitious performance targets of smart 5G systems. This call has come in parallel with ITU members' reaffirmation of the importance of ITU's standardization work to drive the coordinated development of ultra-high-speed transport networks, the Internet of Things, future video technologies, and smart cities and communities.

The conference, which takes place every four years, gathered up to 1000 delegates from 92 countries to deliberate on a wide range of standardization topics critical to the next phase of innovation in ICT. The Assembly also reviews the structure and working methods of the ITU Telecommunication Standardization Sector (ITU-T) and elects the teams that will lead ITU-T's expert groups.

"WTSA-16 has achieved a range of victories for international collaboration," said Moktar Mnakri, Chairman of WTSA-16. "The diverse membership of ITU-T has reached a series of agreements to assist all regions of the world in their efforts to share in the social and economic benefits that will be accelerated by ICTs in coming years."

"The deliberations of WTSA-16 have demonstrated the great spirit of collaboration for which ITU membership is well known," said Chaesub Lee, director of the ITU Telecommunication Standardization Bureau. "Our members have worked tirelessly to reach agreement on the future shape of ITU-T, ensuring that it is fit for purpose to deliver standards capable of providing an equitable basis for ICT innovation worldwide."

"...a range
of victories for
international
collaboration..."



Frequency Matters.

www.mwjjournal.com/freqmatters

Filter Technology Trends in Mobile Wi-Fi Modules

Automotive Radar Sensors Address Interference Issues

Industry News and Events


Advances in RF Energy for Medical Applications

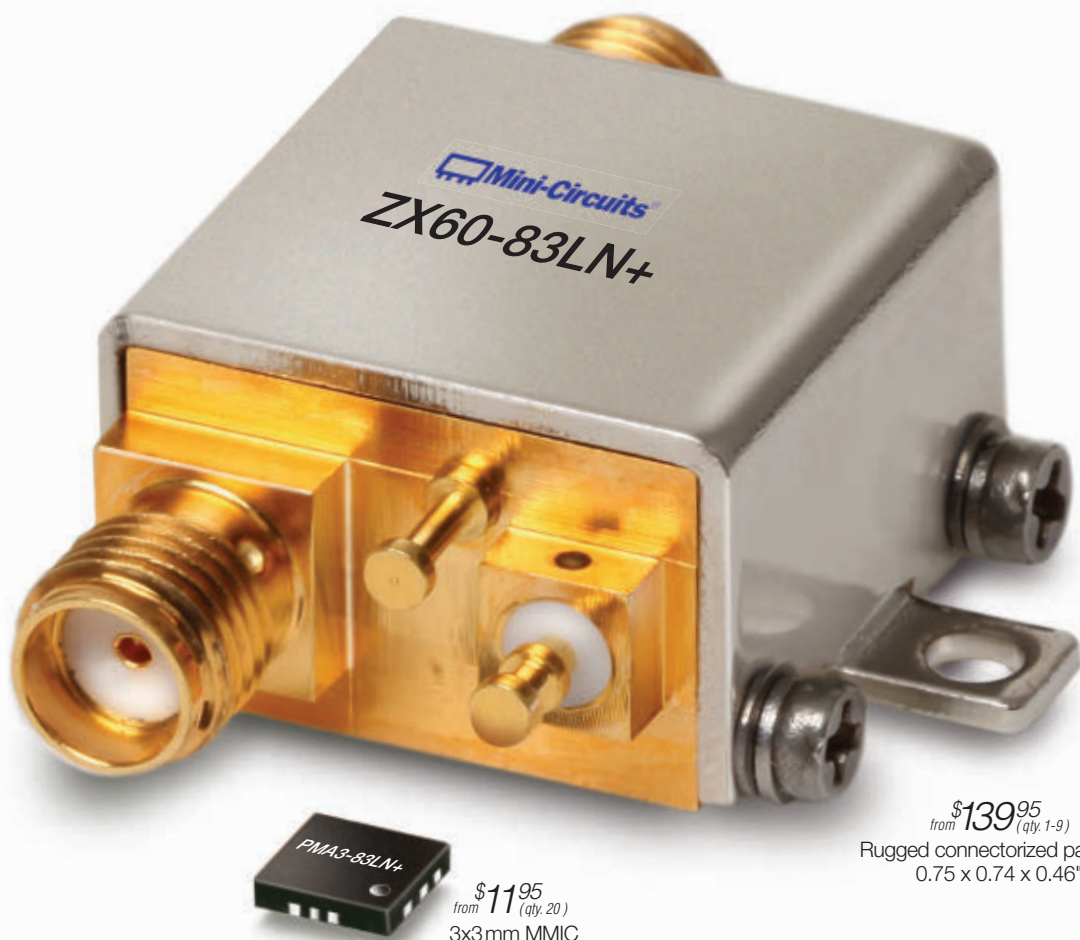


Catch up on the latest industry news with the bi-weekly video update **Frequency Matters** from Microwave Journal



Scan page using **layar** app

Sponsored By 



\$139⁹⁵
from (qty. 1-9)

Rugged connectorized package
0.75 x 0.74 x 0.46"

\$11⁹⁵
from (qty. 20)
3x3mm MMIC

0.5 to 8 GHz

LOW NOISE AMPLIFIERS

IN/OUT Termination Matched!

Low noise, high dynamic range, high output power, and flat gain from 0.5 to 8 GHz, all in a single amplifier! Mini-Circuits' popular ultra-wideband LNAs are now available in both a 3x3mm QFN for your PCB and a rugged connectorized package to facilitate your cable assemblies. Both models are matched over the 0.5 to 8 GHz range*, making them a snap to use for sensitive, high-dynamic-range receivers, instrumentation, defense systems, LTE, WiFi, S-Band and C-Band radar, SatCom and more! They're available off the shelf for a great value, so visit minicircuits.com and place your order today for delivery as soon as tomorrow!

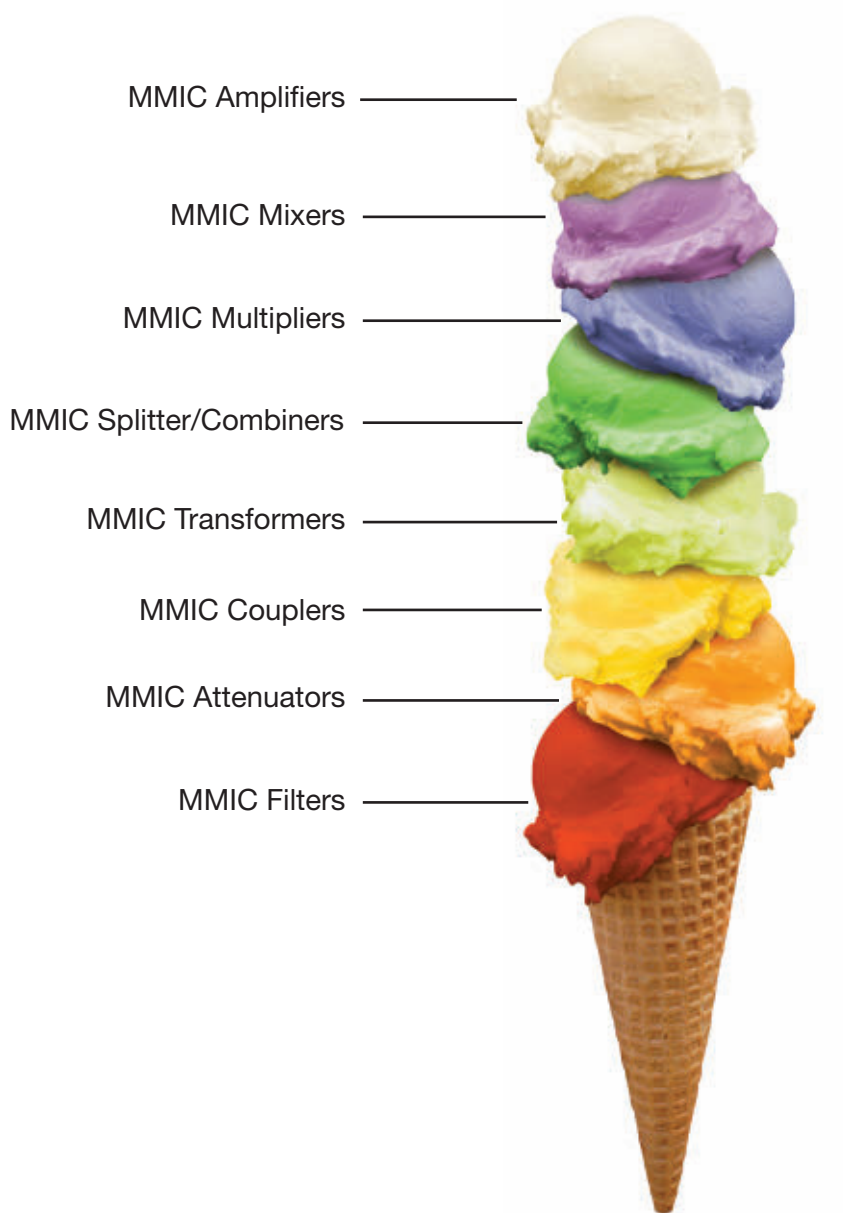
*See datasheet for suggested application circuit for PMA3-83LN+

†Flatness specified over 0.5 to 7 GHz

FEATURES:

- Low Noise Figure, 1.3 dB
- High Gain, 21 dB
- Excellent Gain Flatness, ± 0.7 dB[†]
- High IP3, +35 dBm
- High POUT, +23.2 dBm





Mini-Circuits



The other guy

Make the Smart Choice...

More than the Industry's Widest Variety of MMIC Components

Our promise to you goes beyond selection alone. Sure, Mini-Circuits MMIC products give you over 200 unique models from DC to 40 GHz to choose from, but when you choose Mini-Circuits, you're choosing more than the right component for your system. You're choosing all the advantages of 31 years of in-house, state-of-the-art design experience, absolute commitment to excellence in quality, reliable product supply through the lifetime of your system, and assurance of fast, easy, engineer-to-engineer application support whenever you need it. Our MMIC products don't just give you more choice.

They give you peace of mind that you're making the smart choice.

Make the smart choice. Visit minicircuits.com today.





UWB Indoor Location Technology is Finally Ready for Prime Time

Ultra-wideband (UWB) indoor location technology is on the cusp of substantial market growth. ABI Research forecasts that there is huge opportunity for the high-accuracy, low-cost ultra-wideband radio technology in industrial and IoT markets, with total RTLS/asset tracking revenues to reach \$15 billion by 2021.

“High-precision UWB technologies are nothing new, with companies like Time Domain, Ubisense and Zebra Technologies being long-established vendors in the RTLS/asset tracking market, says Patrick Connolly, principal analyst at ABI Research. “Though no one ever doubted UWB’s accuracy or ability to perform in challenging RF environments, the cost/accuracy trade-off previously limited this technology to very niche applications. But big change is now happening as start-ups invent ways to cost effectively implement the technology without compromising on performance.”

A number of companies are predicted to be very disruptive in this space. Decawave remains the biggest influencer, now shipping UWB ICs for less than \$15 at scale. This opened the floodgates for a host of start-ups working with the technology for the first time to contend in the market.

“...start-ups invent ways to cost effectively implement the technology without compromising on performance.”

Partners Decawave and Quantitec are making significant progress with the likes of Bosch; while Nanotron is a “20-year-old start-up” that offers a well-thought-out embedded location platform. UWINLOC is another new startup that created a semi-passive UWB solution that can ultimately compete on price with passive RFID, while also providing similar benefits

to active technology through energy harvesting.

Not only will UWB disrupt the existing market, it will also open up new opportunities around compliance, traceability, fleet management, pallet tracking, staff management, fulfillment and inventory management. The major competitive threat stems from Bluetooth; while it comes with a range of cost/accuracy trade-offs, its major advantage is its easy integration with smartphones and industrial wearables. Companies like Bluvision, Kontakt.io, MIST and Quuppa lead the way in this space.

“It is still very early,” concludes Connolly. “But the ability to deliver consistently on the impressive pricing, accuracy, and performance parameters that vendors are touting today will be what really differentiates Bluetooth and UWB technologies from one another.”

IoT Partner Programs Expand to Combat Ecosystem Complexity

In its recent analysis ranking more than 450 companies on their IoT service capabilities, ABI Research finds that IoT partner programs and their member companies are evolving their IoT offerings. IoT partner programs are ecosystems of companies focused on assembling end-to-end solutions around a supplier product portfolio. The programs streamline the IoT adoption process by enabling collaboration among hardware, software, and service providers across different technology sectors to deliver comprehensive IoT solutions for enterprises.

“IoT partner programs are critical, as supplier diversity and offer complexity is not lessening and no one company can deliver a complete end-to-end IoT solution,” says Ryan Harbison, research analyst at ABI Research. “Over the past year, companies like Dell and Intel continued to grow their programs to target additional verticals like manufacturing and energy. IoT partner programs ‘un-fragment’ the market for end-users and drive awareness to hardware, software and service providers that combined can deliver an end-to-end IoT solution.”

Dell is expanding its partner program ecosystem with its series of IoT gateways, relying on partners like Action Point and Datatrend Technologies. Through a portal, Dell customers can search for the partners that will best fit their needs, based on a variety of metrics like vertical offerings and location. The initial program success is so strong that Dell aims to double its program members by the end of 2016.

Similarly, Intel’s IoT Solution Alliance continues to create interoperable, secure solutions to drive efficiencies and deliver device system performance insights. Program members like Advantech and relayr help Intel differentiate its devices and the value they provide to end users.

Partner programs drive value for parent organizations, like Dell and Intel, by expanding their ecosystem user base through their member company connections. The programs, in turn, drive value for member companies through incremental business opportunities. Finally, enterprises acquiring IoT capabilities enjoy faster time to market and potentially a more integrated solution.

“Today’s successful partner programs are the ones striking the right balance between their number of partners and the overall product offering,” concludes Harbison. “It is not about having the biggest partner program; it

“...successful partner programs are the ones striking the right balance between their number of partners and the overall product offering..”

CommercialMarket

is about working to forge new alliances with like-minded partners across multiple sectors and consistently delivering valuable IoT services to a broad range of customers. It is about learning how to adapt in the expanding IoT universe.”

IoT Gateway Shipments to Exceed 64 Million Units in 2021

IoT gateways, which manage and control complex connected environments by aggregating and transmitting sensor data, as well as translating communication protocols, are on the rise. ABI Research forecasts IoT gateway shipments will grow to exceed 64 million units in 2021. While home automation and security market components will account for well over 50 percent of all IoT gateway shipments over the next five years, it will be the mobility and transportation segments, as well as industrial and infrastructure, which generate the most revenue.

“The home automation and security market relies on gateways for aggregating and orchestrating communications between an increasing variety of home sensors and cloud services,” says Dan Shey, managing director and vice president at ABI Research. “However, this segment will only represent around 30 percent of the market’s five-year

value. This is because gateways in the home do not have the same requirements for ruggedness, antenna design and processor requirements as gateways used in industrial and commercial settings.”

The higher priced, albeit lower volume, sectors are mobility and transportation, as well as industrial and infrastructure. IoT gateway opportunities in fleet management are small, but growing. Companies such as Omnitrac, PeopleNet and Sierra Wireless are offering gateways for multi-application communications in fleet vehicles, such as critical event reporting, fault monitoring, and navigation. The industrial and infrastructure market segment, meanwhile, relies on many traditional markets like smart grid and video surveillance. Looking ahead, this segment will also benefit from new higher growth markets through applications in the smart cities and manufacturing/process industries.

“There are many traditional names that have been serving the M2M/IoT gateway market for years, such as CalAmp, Cisco, Cradlepoint, Digi International, Eurotech and Sierra Wireless,” concludes Shey. “But these big name players are just a small share of the total supplier base, which includes both branded and white label vendors. In this growing IoT market, consolidation is not expected anytime soon and suppliers are increasingly turning to software and services to differentiate.”

Microwave & RF

6th
edition

**The trade show of Radiofrequencies, Microwaves,
Wireless, EMC and Optical Fiber.**

22 & 23 March 2017
Paris Expo
Porte de Versailles

EXHIBITION - CONFERENCES - ANIMATIONS



www.microwave-rf.com

@Microwave_RF

The World's Most Advanced Portfolio of Active Antenna IC Solutions for 5G, RADAR, and SATCOM

| Market | Product Family | Part Number | Description |
|--|---|---|---|
| 5G Communications Antenna Arrays | Ka-Band Silicon Core IC Solutions | AWMF-0108 AWMF-0113 | Quad Core Tx/Rx IC Eight Channel Tx IC |
| RADAR and Communications Active Antennas | X-Band Silicon Core IC and ASIC Solutions | AWS-0101 AWS-0103 AWS-0104 AWS-0105 AWMF-0106 | Dual Beam Low NF Quad Core IC Dual Beam High IIP3 Quad Core IC Single Beam Low NF Quad Core IC Single Beam High IIP3 Quad Core IC Medium Power Front End ASIC |
| SATCOM and Stratellite Active Antennas | K and Ka-Band Silicon Core IC Solutions | AWS-0102 AWMF-0109 AWMF-0112 AWMF-0113 | 4-element Rx Quad Core IC (K-Band) 4-element Tx Quad Core IC (Ka-Band) 8-element Rx Octal Core IC (K-Band) 8-element Tx Octal Core IC (Ka-Band) |

A uniquely positioned product portfolio for 5G, RADAR, and SATCOM markets

Commercial Active Antenna Core ICs covering X to Ka-band

Custom Active Antenna and mmW Si Core ICs covering L to W-band

Expert systems level understanding and optimal technology selection

mmW Si
Core ICs

Active Antenna
ASICs

mmW
Front End ICs



Around the Circuit

Barbara Walsh, Multimedia Staff Editor

MERGERS & ACQUISITIONS

Qualcomm Inc. and **NXP Semiconductors N.V.** announced a definitive agreement under which Qualcomm will acquire NXP. Pursuant to the agreement, a subsidiary of Qualcomm will commence a tender offer to acquire all of the issued and outstanding common shares of NXP for \$110 per share in cash, representing a total enterprise value of approximately \$47 billion. NXP is a leader in high-performance, mixed-signal semiconductor electronics, with innovative products and solutions and leadership positions in automotive, broad-based microcontrollers, secure identification, network processing and RF power. As a leading semiconductor solutions supplier to the automotive industry, NXP also has leading positions in automotive infotainment, networking and safety systems.

Analog Devices Inc. announced the acquisition of **Innovasic Inc.**, a leading provider of deterministic Ethernet semiconductor and software solutions. The acquisition adds a suite of multiprotocol industrial Ethernet solutions and key enabling technologies to ADI's Smart Automation Solutions portfolio for industrial automation and Industrial Internet of Things (IoT). With the industrial automation market already transitioning from serial fieldbus to Ethernet connectivity, and with the simultaneous push toward a ubiquitous Industrial IoT, there is a clear need for highly reliable, real-time Ethernet connectivity for sensitive industrial automation applications. The acquisition of Innovasic will give ADI customers immediate access to a set of innovative solutions for today's Industrial Ethernet applications.

Linear Technology has announced that, based on a preliminary vote at their Annual Stockholders Meeting, the merger agreement under which **Analog Devices**, will acquire Linear Technology, has been approved. Stockholders also approved the election of the seven Linear Technology directors that were nominated for election and other proposals relating to the transaction. Approximately 99 percent of voting LLTC stockholders cast their votes in favor of the proposal to approve the merger agreement, representing approximately 79 percent of LLTC's outstanding common stock as of the record date for the Annual Meeting of Stockholders. The final vote results will be reported on a Current Report on Form 8-K that Linear Technology will file with the Securities and Exchange Commission.

Altamira Technologies Corp., a provider of technology solutions to the U.S. Intelligence and Defense Communities, announced its acquisition of **APG Technologies**, a Northern Virginia-based advanced engineering company supporting various customers in the United States DoD, Space, and Intelligence Community (IC). APG supports the DoD, Space and Intelligence Communities in overcoming the complex challenges of today's mission critical information systems and responding to the ever-increasing velocity, variety and volume of data while maintaining focus on the continually expanding complexity of missions. APG transforms data into clear information that enables U.S. national security leaders to act with confidence.

COLLABORATIONS

NI announced a collaboration with **DARPA** to supply core infrastructure for a path-breaking channel emulation testbed, called Colosseum, which will play a central role in the DARPA Spectrum Collaboration Challenge. NI will provide USRP software defined radios (SDR) that support a wide variety of open source and proprietary tool flows including GNU Radio, RFNoC and LabVIEW system design software. The Colosseum channel emulation testbed supports up to 256×256-channel, real-time channel emulation, calculating more than 65,000 channel interactions at up to 80 MHz of real-time bandwidth per channel.

Airbus Defence and Space and **Orbital ATK** have been selected by Eutelsat to partner to build the company's latest video satellite, EUTELSAT 5 West B. According to the terms of the contract signed between the three companies, Airbus Defence and Space will lead the team and be co-prime contractor with Orbital ATK for the development and construction of EUTELSAT 5 West B. Airbus Defence and Space will provide the communications payload operating in Ku-Band and the satellite will be based on Orbital ATK's GEOSTAR platform. Scheduled for launch in 2018, EUTELSAT 5 West B will have a launch mass of around three tonnes and 5 kW of power.

Analog Devices Inc. and **Dell EMC** unveiled a proof of concept (POC) for an Internet of Things (IoT) solution that tracks the health and location of first responders. The POC IoT solution is designed to improve the safety and effectiveness of first responders when involved in an emergency situation, especially those in harsh environments. According to the National Fire Protection Association, more than 60,000 fire fighter injuries in North America alone are reported annually, of which 25 percent are as a result of overexertion or strain. The POC IoT solution tracks the location and vital signs of first responders at all times in or outside of buildings.

ACHIEVEMENTS

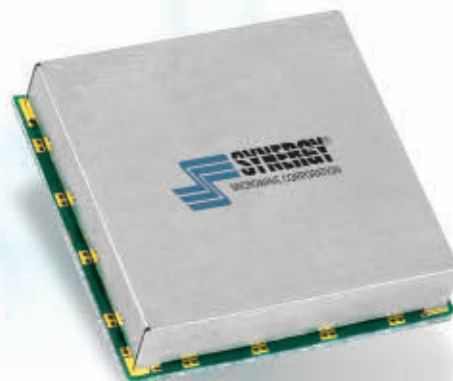
Anritsu Co. announced it has earned the 2016 Global Product Line Strategy Award—Manufacturing Test Software for IoT from Frost & Sullivan. In making the announcement, Frost & Sullivan stated that newly released software packages from Anritsu uniquely position the company's Universal Wireless Test Set MT8870A as an all-in-one instrument with unmatched solutions that support a wide range of wireless technologies to conduct high-volume production tests on IoT devices. In its report, Frost & Sullivan stated that Anritsu enjoys a prominent position in the global wireless manufacturing test and measurement equipment market, capitalizing on its extensive breadth of software packages supporting manufacturing tests for IoT devices.

The National Science Foundation (NSF) has announced 11 awards, worth a total of \$12 million, to support activities aimed at enhancing the public's access to the radio frequency spectrum i.e., the part of the electromagnetic spectrum used

Amazingly Low Phase Noise SAW VCO's

Features:

| Very Low Post Thermal Drift
| Small Size Surface Mount *



| Model | Frequency [MHz] | Tuning Voltage [VDC] | DC Bias VDC @ I [Max.] | Phase Noise @ 10 kHz (dBc/Hz) [Typ.] |
|--------------|-----------------|----------------------|------------------------|--------------------------------------|
| HFSO600-5 | 600 | 0.5 - 15 | +5 VDC @ 35 mA | -146 |
| HFSO640-5 | 640 | 0.5 - 12 | +5 VDC @ 35 mA | -151 |
| HFSO745R84-5 | 745.84 | 0.5 - 12 | +5 VDC @ 35 mA | -147 |
| HFSO776R82-5 | 776.82 | 0.5 - 12 | +5 VDC @ 35 mA | -146 |
| HFSO800-5 | 800 | 0.5 - 12 | +5 VDC @ 20 mA | -146 |
| HFSO800-5H | 800 | 0.5 - 12 | +5 VDC @ 20 mA | -144 |
| HFSO800-5L | 800 | 0.5 - 12 | +5 VDC @ 20 mA | -142 |
| HFSO914R8-5 | 914.8 | 0.5 - 12 | +5 VDC @ 35 mA | -139 |
| HFSO1000-5 | 1000 | 0.5 - 12 | +5 VDC @ 35 mA | -141 |
| HFSO1000-5L | 1000 | 0.5 - 12 | +5 VDC @ 35 mA | -138 |
| HFSO1600-5 | 1600 | 0.5 - 12 | +5 VDC @ 100 mA | -137 |
| HFSO1600-5L | 1600 | 0.5 - 12 | +5 VDC @ 100 mA | -133 |
| HFSO2000-5 | 2000 | 0.5 - 12 | +5 VDC @ 100 mA | -137 |

** Package dimension varies by model (0.5" x 0.5" or 0.75" x 0.75").*

Talk To Us About Your Custom Requirements.



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

Around the Circuit

to facilitate telecommunications and modern information systems essential for public safety, transportation and national defense. The research activities supported by these awards represent bold new approaches with the potential to contribute to improvements in the efficiency of radio spectrum utilization while protecting passive sensing services, and allowing traditionally underserved Americans to benefit from current and future wireless-enabled goods and services.

Doodle Labs announced global regulatory approvals of its embedded Industrial Wi-Fi product portfolio. The transceivers have been certified as fully compliant for the U.S. (FCC), Canada (IC) and Europe (ETSI) as DFS Master and Client devices. While Doodle Labs' technology is known for its flexibility and customizability, these certifications provide customers with a streamlined path to release and deploy standardized, government-approved products. Doodle Labs' Industrial Wi-Fi product portfolio has been designed to provide customers with the industry's best-in-class performance, particularly those addressing challenging applications.

Fractal Antenna Systems has been issued a patent for a fundamentally new approach to power gathering and transport, as well as heat transfer, with the innovation of metamaterials based on fractal geometry. They were issued U.S. patent 9,482,474, entitled "Radiative Transfer and Power Control with Fractal Metamaterial and Plasmonics." Fractal metamaterials are collections of detached resonators, themselves intricate structures made from repeated and scaled designs. Each fractal resonator lies close to another, collecting and transferring its energy along with adjacent ones, without actual physical connection. The process happens at the speed of light and is a man-made form of 'radiative transfer'.

CONTRACTS

CACI International Inc. announced it has been awarded a prime position on a five-year, multiple-award, indefinite delivery/indefinite quantity contract with a \$900 million ceiling value to continue providing services in program management, engineering and technical support, and professional services for the **U.S. Special Operations Command** (SOCOM) on the SOCOM-Wide Mission Support (SWMS) program. The contract spans several CACI market areas, enabling the company to provide a wide range of mission-essential solutions and services to Special Operations Forces (SOF). SOCOM synchronizes the planning of special operations and provides SOF to support persistent, networked and distributed Global Combatant Command operations in order to protect and advance our nation's interests.

The Naval Sea Systems Command awarded **Science Applications International Corp.** a contract to manufacture MK 48 Mod 7 heavyweight torpedo afterbody/tailcone sections. The work to be performed will increase the quantity of the MK 48 Mod 7 heavyweight torpedoes for operational use. The contract has a 27-month base period of performance from award to final acceptance and includes options for the procurement of spares, production support material, engineering services, test equipment

design and manufacturing, and hardware repair services. If all options are exercised, the total contract value will be more than \$383 million with an expected completion date of January 2020. Work will be performed in Bedford, Ind.; Marion, Mass.; Middletown, R.I. and Indianapolis, Ind.

BAE Systems has been awarded a **U.S. Army** contract modification valued at \$146.5 million to construct and commission a new facility that will increase the capacity for producing insensitive munitions at the Holston Army Ammunition Plant in Kingsport, Tenn. The project to build the Insensitive Munitions Weak Nitric Acid Recovery Facility is a major part of a multi-year effort to increase the production capacity of Insensitive Munition eXplosives (IMX), which are designed to be robust but more stable and safer to handle than conventional munitions. The plant, operated by BAE Systems, produces a wide range of explosive formulations for multiple applications to support the military, as well as commercial mining and oil operations.

Engility Holdings Inc. announced it was awarded a \$71 million contract by the **Naval Air Warfare Center Aircraft Division** (NAWCAD) to deliver systems engineering on U.S. naval aircraft and weapons systems. NAWCAD is responsible for advancing research and development, engineering, and test and evaluation of all Navy and Marine Corps air vehicle systems. As part of the contract, Engility will assess the technical performance, suitability and risks of aircraft, weapon and integrated systems. The team will perform systems engineering, analysis, development, integration and testing for the introduction of warfare systems into naval aircraft.

Harris Corp. has received a four-year, \$55 million contract to perform sustainment work on the electronic warfare system used by the **U.S. Air Force** to protect B-52s and C-130s from radar-guided threats. The contract was received during the first quarter of Harris' fiscal 2017. Harris will redesign one of the ALQ-172's Line Replaceable Units (LRU-1) as part of wider efforts to increase the electronic warfare suite's reliability and supportability. In addition to a new LRU design, Harris will develop software, support customer testing and other solutions for the U.S. Air Force.

The **U.S. Air Force Research Laboratory** and the **Office of the Secretary of Defense** have awarded **Raytheon** a \$14.9 million contract to further enhance its process for producing gallium nitride-based semiconductors. The new agreement follows a previous GaN Title III contract, completed in 2013, and aims to increase the performance, yield and reliability of Raytheon GaN-based, wideband, monolithic, microwave-integrated circuits and circulator components. Gallium Nitride (GaN) is a semiconductor material that can efficiently amplify high power RF signals at microwave frequencies thereby enhancing a system's range, while reducing size, weight, power consumption and cost.

Mercury Systems Inc. announced it received a \$6.3 million follow-on order from a leading defense prime contractor for microwave transceivers for a precision guided munitions application. The order was booked in the company's fiscal 2017 first quarter and is expected to be shipped over the next several quarters.

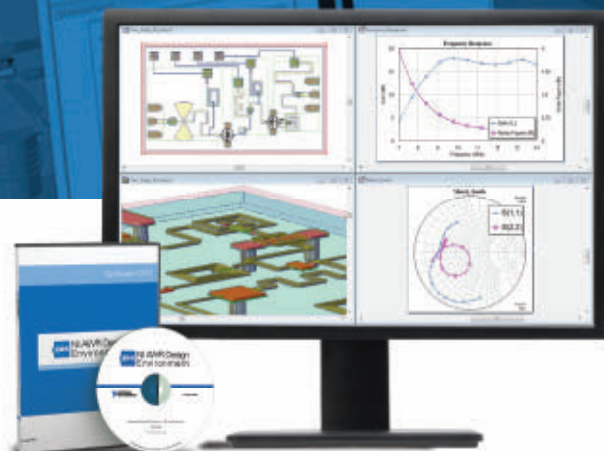
ONE PLATFORM, ZERO BARRIERS

SIMPLY SMARTER

NI AWR DESIGN ENVIRONMENT

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

Learn more at ni.com/awr



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



High Performance PLO Solutions

RFS Series Fixed Frequency PLLs | 1 GHz - 6 GHz

Reference Signal Included • No External Programming • Fixed Frequency

| Part Number | Freq (MHz) | Output Power (dBm) (typ) | Spurs (dBc) | PN @1kHz (dBc/Hz) (typ) | PN @10kHz (dBc/Hz) (typ) |
|-------------|------------|--------------------------|-------------|-------------------------|--------------------------|
| RFS4500A-LF | 4500 | 2 | -65 | -85 | -86 |
| RFS5600A-LF | 5600 | 2 | -65 | -80 | -86 |

SFS Series Fixed Frequency PLLs | 500 MHz - 15 GHz

No External Programming • Ultra-Low Noise • Small Size

| Part Number | Freq (MHz) | Output Power (dBm) (typ) | Spurs (dBc) | PN @1kHz (dBc/Hz) (typ) | PN @10kHz (dBc/Hz) (typ) |
|--------------|------------|--------------------------|-------------|-------------------------|--------------------------|
| SFS12000H-LF | 12000 | 0 | -65 | -97 | -103 |
| SFS14000H-LF | 14000 | 0 | -65 | -96 | -102 |

DRO Series Dielectric Resonator VCOs | 7 GHz - 14 GHz

Exceptional Spectral Purity • Low Power Consumption • Precision Tuning

| Part Number | Freq (MHz) | Vtune (Vdc) | PN @10kHz (dBc/Hz) (typ) | Output Power (dBm) (typ) | VCC / ICC (Vdc/ma) |
|-------------|------------|-------------|--------------------------|--------------------------|--------------------|
| DRO8800A | 8800 | 0 - 12 | -104 | 2 | 5 / 20 |
| DRO12000A | 12000 | 0 - 12 | -106 | 0 | 5 / 23 |

WWW.ZCOMM.COM

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

ISO 9001:2008



Around the Circuit

PAR Technology Corp. announced that its subsidiary, **Rome Research Corp.** (RRC), has been awarded a \$5.2 million subcontract from **Delta Solutions & Strategies LLC** of Colorado Springs, Colo. to provide operation and maintenance of the USAF Air Combat Command (ACC) High Frequency Global Communication System – Puerto Rico Station (HFGCS-PRS). HFGCS-PRS is one of 13 worldwide high powered, high frequency stations that make up the USAF's Command and Control (C2) network.

Comtech Telecommunications Corp. announced that its Tempe, Ariz.-based subsidiary, **Comtech EF Data Corp.**, which is part of Comtech's Commercial Solutions segment, received a \$1.2 million equipment order from **General Dynamics Mission Systems—Canada** in support of the Canadian Armed Forces (CAF) Mercury Global project. This is the initial order of Comtech EF Data's DMD2050E WGS-certified Universal Satellite Modem to support General Dynamics Mission Systems—Canada's implementation and In-Service Support of the Mercury Global Anchor Segment. The DMD2050E complies with MIL-STD-188-165A and NATO standard STANAG-4486, Edition 3 Super High Frequency (SHF) Military Satellite Communications (MILSATCOM) Frequency Division Multiple Access (FDMA) Modem.

Thales Alenia Space has signed a contract with the **Korea Aerospace Research Institute (KARI)** to supply a satellite navigation system known as the Korea Augmentation Satellite System (KASS). KARI, on behalf of the South Korean Ministry of Land, Infrastructure and Transport (MO-LIT), will receive the KASS System relying on the European Geostationary Navigation Overlay System (EGNOS) developed by Thales Alenia Space as prime contractor for the European Commission, with ESA as the contracting authority. The EGNOS system has been operating in Europe since 2009 for Safety of Life (SoL) services.

The Royal Malaysian Navy (RMN) has selected the **Terma SCANTER 6000** radar as the combined navigation and helicopter control radar for its two Lekiu-class frigates mid-life modernization and service life extension. The SCANTER 6000 is a coherent X-Band 2D solid state radar that has been specifically designed as an affordable all-weather sensor solution to plug the gap between standard marine navigation radars and more expensive military surveillance radar systems. It is very versatile, and has the capability to control aircraft and increase tactical options and safety.

PEOPLE



▲ Vincent E. Pelliccia

Anokiwave Inc., an innovative company providing highly integrated IC solutions for mmWave markets and active antenna based solutions, announced the appointment of **Vincent E. Pelliccia** as vice president, business development. This appointment comes at a strategic time for Anokiwave with tremendous opportunities to grow its business into the rapidly developing mmWave 5G, radar, sat-

FEATURED

WHITE PAPERS

The information you need, from industry experts

Understanding the Basics of MIMO Communication Technology

Check out these new online Technical Papers featured at **MWJournal.com**

Microwave Journal

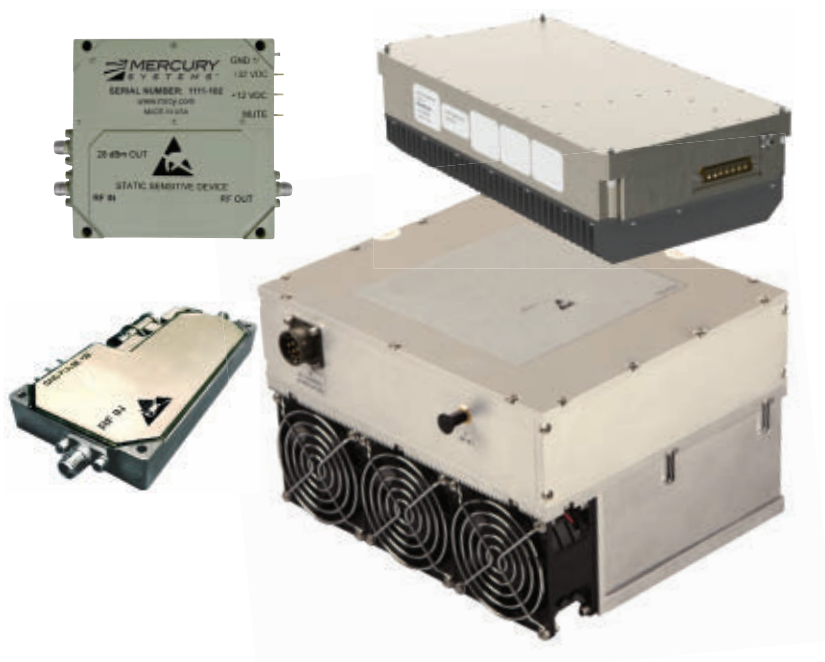
Frequency Matters.

Innovation Amplified.

MERCURY SYSTEMS OFFERS GALLIUM NITRIDE (GAN) POWER AMPLIFIERS FROM 100 MHz TO 40 GHz WITH POWER TO 4 kW.

Key Features:

- Compact, lightweight and high output power for improved SWaP metrics
- High-power broadband CW transmitters for ECM and threat simulation
- High-power narrowband pulsed transmitters for military/commercial radar systems
- High-power linear amplifiers for communication systems
- All of our amplifiers are designed and manufactured in the USA



INNOVATION THAT MATTERS™



Learn more and download our amplifier brochure at mrcy.com/amplifier





ProtoTx

Everything you need to
upconvert I/Q or IF signals to RF

4 Programmable Operating Modes:

- I/Q upconverter
- RF = LO - IF upconverter
- RF = LO + IF upconverter
- Synthesizer

 **Polyphase**
Microwave
A Technology Service Corporation Company

812-323-8708 • sales@polyphasemicrowave.com
polyphasemicrowave.com/mj

INTRODUCING Microwave Journal's New Video Library



Applications

Products

Events

Companies

Visit and bookmark
videos.microwavejournal.com

Sponsored video programs
are available



Frequency Matters.

Around the Circuit

com and satelllite markets. Pelliccia joined Anokiwave in March 2016, and brings 30 years of industry experience starting with E-Systems designing Null Steered Phased Arrays and then at M/A-COM working on Ku-Band VSAT and LMDS systems.

The board of **Resonant Inc.** appointed **Jeff Killian** as chief financial officer (CFO), effective October 24, 2016. Killian will succeed Ross Goolsby, who has been serving as the interim CFO of the filter start-up. Killian has almost 30 years of relevant financial, filter and semiconductor industry experience. He was CFO at Cascade Microtech since 2010. During his eight years at Cascade, company revenue grew from \$77 million to \$144 million, with an attendant market cap from \$25 million to \$258 million. Cascade was acquired by FormFactor in 2016. Prior to Cascade, Killian was at TriQuint Semiconductor, where he held several roles over 11 years, including director of financial planning and analysis.



▲ **Rainer Lörger and Oliver Herzberger**

Quintech Electronics & Communications Inc. and **DEV Systemtechnik** announced the promotions of **Rainer Lörger** and **Oliver Herzberger** each to the position of co-managing director for DEV Systemtechnik. Together, they will guide the company, with Lörger focusing on administrative and sales functions, while Herzberger will head up the engineering and technology responsibilities. Herzberger has been with DEV since 1998 and Lörger joined in 2009. The co-managing directors possess a familiar and focused understanding of the goals and direction of the company and will provide the leadership necessary to serve and grow the satellite and telecommunications industry businesses of DEV Systemtechnik.



▲ **Jingya Huang**

Indium Corp. announced that **Jingya Huang** has joined the company as marketing communications assistant manager. Huang is responsible for creating and managing promotional and branding activities that support the company's worldwide sales and marketing programs. She manages Indium Corp.'s global trade show program, internal communications, social media and the expansion of its web presence. Huang has several years of experience in advertising, marketing and communications. In her last position, she focused on digital marketing for Chinese markets. Huang has also worked as an account planner at a full-service advertising agency, where she performed strategic planning, market research, project management and sales support.

REP APPOINTMENTS

Agile Microwave Technology Inc., a product innovator in RF and microwave component and sub-system market announced the appointment of **TriLight MICROWAVE AB** as its sales representative in the UK and Russia. TriLight MICROWAVE is a sales representative and distribution company focused on RF components for radar,

10 MHz Rubidium Frequency Standard

- **5 MHz and 10 MHz outputs**
- **Ultra-low phase noise**
(< -130 dBc/Hz at 10 Hz)
- **0.005 ppm aging over 20 years**
- **Built-in distribution amplifier**
(up to 22 outputs)
- **1 pps input and output**

The FS725 Benchtop Rubidium Frequency Standard is ideal for metrology labs, R&D facilities, or anywhere a precision frequency standard is required.

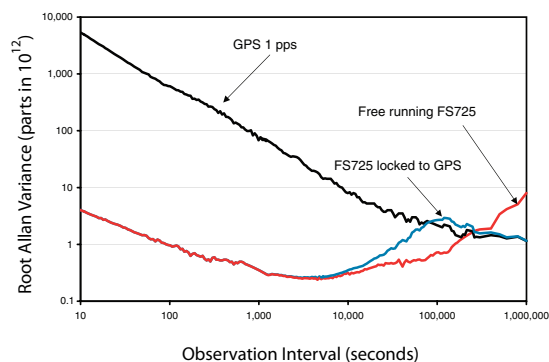
It has excellent aging characteristics, extremely low phase noise, and outstanding reliability. A 1 pps input is provided for phase-locking to GPS, providing Stratum 1 performance.

With a built-in 5 MHz and 10 MHz distribution amplifier, the FS725 is the ultimate laboratory frequency standard.

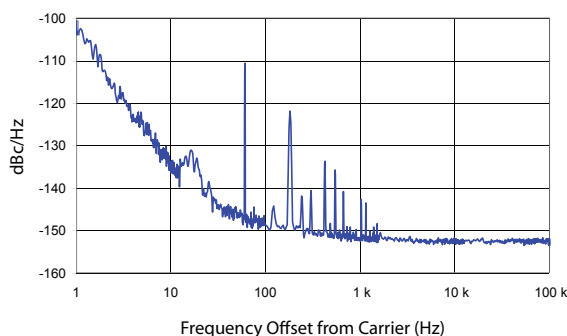
FS725 ... \$2695 (U.S. list)



Allan Variance vs. Time



FS725 Single Sideband Phase Noise



FS725 rear panel



IEEE Wireless and Microwave Technology Conference

WAMICON 2017

Hilton Cocoa Beach

Cocoa Beach, Florida

April 24-25, 2017

JOIN US

The 18th annual IEEE Wireless and Microwave Technology Conference (WAMICON 2017) will be held in Cocoa Beach, Florida on April 24-25, 2017. The conference will address up-to-date multidisciplinary research needs and interdisciplinary aspects of wireless and RF technology. The program includes both oral and poster presentations as well as tutorials and special sessions. The conference also features an active vendor exhibition area and an array of networking opportunities.

CALL FOR PAPERS

The technical program is focused on Emerging Technologies for 5G Systems including active and passive components and systems as well as wireless communications. Prospective authors are invited to submit original and high-quality work for presentation at WAMICON 2017 and publication in IEEE Xplore.

Topics of interest include:

- 5G Power Amplifiers, Beamforming, mmWave and Antennas
- Internet of Things (IoT)
- Active Components and Systems
- Passive Components and Antennas
- Microwave Applications

Visit www.wamicon.org for complete submission details.

Important Dates

Papers Due: January 4, 2017

Author Notification: January 25, 2017

Final Papers Due: February 8, 2017



www.wamicon.org

Exhibit/Sponsor Opportunities Available!

**Email: jassurian@reactel.com
dzavac@tte.com**

Around the Circuit

avionics, EW, military defense, space and oil exploration markets. Teamed with Agile MWT factory sales engineers, TriLight MICROWAVE AB will provide sales and technical support to RF and microwave product designers and manufacturers.

Bliley Technologies has signed a distribution agreement with **Avnet**. Effective immediately, Avnet will offer a broad lineup of standard and custom crystal oscillators, precision AT, SC, IT and FC cut crystals, piezoelectric transducers and GPS disciplined modules from Bliley Technologies to customers in the Americas through its broadline components Electronics Marketing group and Avnet USI, Avnet's defense/aerospace specialty distribution business unit. Bliley Technologies provides quality frequency generation solutions for SATCOM/space, defense/aerospace electronics, wired and wireless communication, industrial and medical instrumentation and consumer electronics. The company is among a select few vertically integrated manufacturers in the U.S. designing and manufacturing both crystals and oscillators in a single facility.

Richardson RFPD will distribute **Tagore Technology Inc.'s** portfolio of high-power RF switches to customers worldwide. Tagore Technology has developed innovative switch products using proprietary technology that significantly reduces total board area. These switches handle 1 W to 50+ W CW input RF power and operate from 10 MHz to 6 GHz. They are available in SPDT, SP3T and SP4T configurations. Compared to traditional PIN diode solutions, Tagore's switches offer lower power consumption, with current draw in microamps instead of milliamps. These fully-integrated switches operate from 2.7 V and do not require external negative voltages or external passive components.

PLACES

Ampleon announced the opening of its RF Energy Competence Center in Hefei, PRC. The company is recognized as a leader in the RF Energy market and continues to invest in the emerging use of this technology. While RF energy covers a broad range of applications (domestic and professional cooking, heating and drying, ignition and lighting), the new competence center's current focus is on solid-state cooking. Key to the success of solid-state cooking in both consumer and professional applications is providing white goods manufacturers with local integration and application support. Ampleon closely works with leading companies in this market, having their design and production sites in China.

EnSilica has further expanded its network of specialist design centers with the establishment of a new facility near Oxford, UK, focusing on RF and low power sensing applications. The new design centre will be headed by Alan Wong, formerly the IC design director at Frontier Microsystems, who joins EnSilica with immediate effect as director of RF IC Design. Wong brings with him a design team whose pioneering experience in ultra-low power RF and sensor interfaces significantly extends EnSilica's skills-base in addressing the needs of wireless connected IoT and wearable products.

Ultra-Wideband
10 MHz to 13 GHz



Power Handling
up to 2W

Now!
4-Channels
in 1 Compact
Device

Programmable ATTENUATORS

0 to 120 dB 0.25 dB Step 1 MHz to 13 GHz* from **\$395**

Features

- Models with attenuation range up to 30, 60, 63, 90, 95, 110 or 120 dB
- Choose from USB, Ethernet, RS232 and SPI control options
- Use our software or yours! User-friendly GUI and DLLs included[†]
- Sweep or hop attenuation levels
- Save and recall customized attenuation patterns
- Pocket-sized package, as small as 3.0 x 2.0 x 0.6"
- **Now** 16 unique models in stock, ready to ship!

* Specs may vary by model. See data sheets for specific model information.

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

Perfect for...

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

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



www.minicircuits.com/products/programmable_attenuators.shtml



Advances in RF Energy for Medical Applications

Franck Nicholls and Jose Fernandez Villaseñor, M.D.
NXP Semiconductors, Chandler, Ariz.

The benefits of electromagnetic energy for treating medical conditions have been recognized since the late 19th century. Today, although probably only magnetic resonance imaging (MRI) is familiar to most people, many other medical applications exploit its unique abilities. They include reducing the size of tumors, aiding cardiac surgery, rejuvenating skin and treating muscular conditions. Medical systems based on RF energy are continually advancing, thanks in large measure to the transition from vacuum tubes to solid-state. Semiconductor devices such as LDMOS bring flexibility, enable advanced modes of operation and offer advantages at microwave frequencies.

SPARK OF INSPIRATION

The benefits of RF energy in almost all medical applications are gained from heat generated by some form of RF generator. Although the first recorded evidence of heat from any source used for medical purposes dates to prehistoric times, when heated rocks were used to reduce or stop blood flow (hemostasis), it was the prodigious inventor and scientist Nicola Tesla who first proposed, in 1891, that the application of electricity could produce heat in a human body. This was dangerous territory, as electricity caused electric shock. Shortly after Tesla's results were presented, French physician and biophysicist Jacques Arsene d'Arsonval discov-

ered that when the frequency of this energy was above 10 kHz, rather than shocking the patient, it caused the skin to heat. He proposed ways of applying this "high frequency" current to the body using contact electrodes, capacitive plates and inductive coils.

The use of RF energy to heat deep tissue was first suggested by Austrian chemist R. von Zaynek, who noted that production of heat in tissue was a function of both frequency and current density. In 1908, German physicist Karl Franz Nagelschmidt coined the name "diathermy" for this, during what were the first extensive experiments on humans. Nagelschmidt is considered to be the pioneer in the field, writing the first textbook on the subject in 1913. Important developments in later years included those of Harvey Cushing and William T. Bovie, in which an electrosurgical device developed by Bovie was used to cause homeostasis during the resection of a vascular brain tumor.

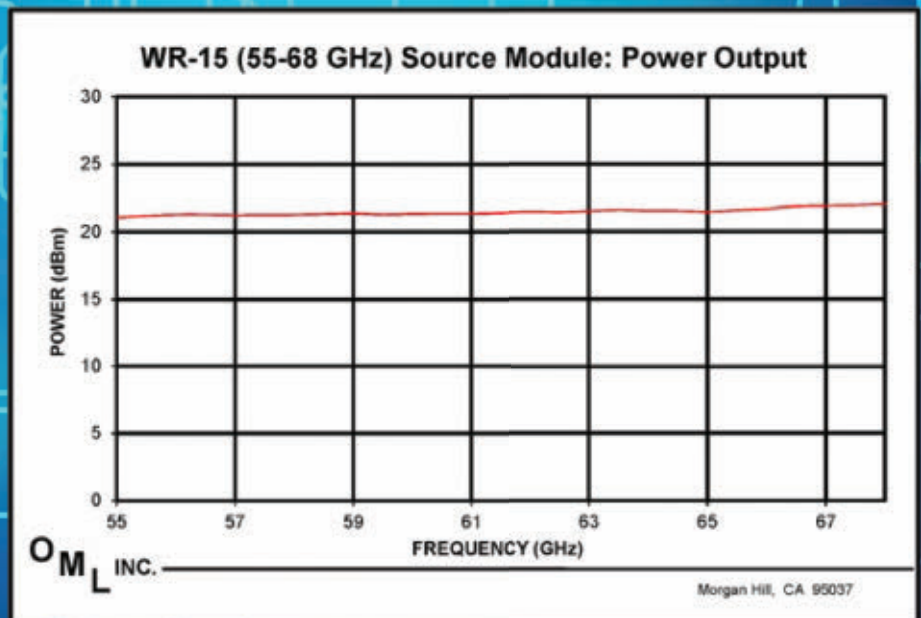
The initial use of RF energy for diathermy was impeded by the lack of devices to generate it, as spark-discharge Tesla coil machines could reach frequencies of only 2 MHz. This type of diathermy was called longwave diathermy, because of the long wavelengths at these frequencies. The invention that broke this logjam was the vacuum tube, revealed in 1904 by John Ambrose Fleming, which ultimately increased the frequency to about 300 MHz (see **Figure 1**).

Making the Connection and Extending Your Capabilities in 5G & WiGig (802.11ad)



**High Power
Source Module
50-75 GHz**

Power > 20 dBm



High Power Source for IMD Testing

Innovation in Millimeter Wave Solutions
www.omlinc.com
(408) 779-2698



CERNEX, Inc.

RF, MICROWAVE & MILLIMETER-WAVE
COMPONENTS AND SUB-SYSTEMS
UP TO 325GHz

AMPLIFIERS UP TO 110GHz
FREQUENCY MULTIPLIERS/DIVIDERS
(UP TO 160GHz)

CONVERTERS UP TO 110GHz
ANTENNAS UP TO 220GHz

COUPLERS UP TO 220GHz
FERRITE PRODUCTS
(ISOLATORS/CIRCULATORS)
UP TO 160GHz

FILTERS/DIPLEXERS
SOURCES UP TO 160GHz

SWITCHES UP TO 160GHz
PHASESHIFTERS UP TO 160GHz

TRANSITIONS/ADAPTERS (UP TO 325GHz)
WAVEGUIDE PRODUCTS UP TO 325GHz

TERMINATIONS/LOADS UP TO 160GHz
MIXERS (UP TO 110GHz)

ATTENUATORS (UP TO 160GHz)
DETECTORS (UP TO 160GHz)

LIMITERS (UP TO 160GHz)
BLAS TEE (UP TO 100GHz)

POWER COMBINERS/DIVIDERS EQUALIZERS

CABLES
ASSEMBLIES/CONNECTORS (UP TO 100GHz)
SUB-SYSTEMS (UP TO 100GHz)

Cernex, Inc.
1710 Zanker Road, Suite 103
San Jose, CA 95112
Tel: (408) 541-9226
Fax: (408) 541-9229

www.cernex.com
cernex@cernex.com

Technical Feature



▲ Fig. 1 A Fischer diathermy machine, circa 1920.

| TABLE 1 | |
|--|--|
| ADVANTAGES OF LDMOS FOR MEDICAL | |
| LDMOS vs. Vacuum Tubes | LDMOS vs. BJT and VMOS |
| <ul style="list-style-type: none"> Flexibility: greater control of power, frequency and phase because of low voltage power supply Consistency: small part-to-part variation Reliability: greater lifetime with no performance degradation over time | <ul style="list-style-type: none"> Performance above 100 MHz Extremely rugged No carcinogenic BeO in packages |

Diathermy machines operating at this frequency were called shortwave diathermy. Like many RF and microwave technologies, the advancement of vacuum tube technology dramatically accelerated during the world wars, and new types of vacuum electron devices were created. The most noteworthy was the magnetron, which made it possible for emerging radar systems to generate high power at higher frequencies. One of the beneficiaries of the magnetron has been the medical profession, and many of the initial applications are still in use today and still use magnetrons for generating RF energy.

Like vacuum tubes before them, transistors further extended the reach of RF energy medicine. The earliest examples of transistor-based power generation appeared in the 1950s, although these devices generated minimal power and were extremely fragile. As their limitations were mitigated in subsequent years, semiconductor technologies such as the bipolar junction transistor (BJT) and vertical metal oxide semiconductor (VMOS) transistor were adopted for medical devices. Today, laterally-diffused met-

al oxide semiconductor (LDMOS) power transistors are proving to be the preferred solid-state technology, producing power levels up to 1500 W. LDMOS transistors have advantages that make them well suited to be the alternative to their vacuum tube and transistor predecessors (see Table 1).

The primary benefit transistors have over vacuum tubes for medical applications is flexibility. The output power can be tightly controlled over their full dynamic range, which enables heat transferred to human tissues to be reduced when required. They support sweeping frequencies within an

ISM band (from 902 to 928 MHz, for example), which helps to maximize the energy transferred to the body. For advanced systems that use multiple probes to combine wave fronts, the phase can be controlled to move the areas that must be targeted. While vacuum tubes require potentially dangerous high voltages, generated by large and heavy power supplies, transistors operate at 32 to 50 V_{DC}. The biggest advantages of LDMOS transistors over previous semiconductor technologies are their ability to operate at higher frequency, such as 915 and 2450 MHz, and ruggedness. LDMOS power transistors will survive when almost all the transmitted energy is reflected back, because of an impedance mismatch such as a short or open circuit. This is important in medical applications because human tissue can present a variable load to the probe.

Originally, the capabilities of available RF power sources determined the frequencies where electromagnetic energy-based systems were used. The first operating frequencies were very low, with both frequency and

HIGH POWER

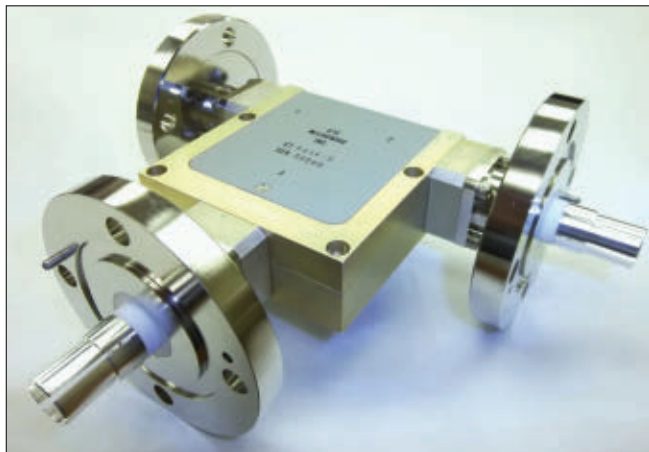
100 MHz
to 20 GHz



**For Military / Radar
Applications.**

Isolators/Circulators

325 MHz NEW HIGH POWER Circulator for Radar & UHF Frequencies



Model CT-1864-S is rated at 60kW peak and 600W average power at 325 MHz. The unit provides 20 dB minimum isolation, 0.2 dB insertion loss and 1.20:1 maximum VSWR. Its extremely compact design has flange to flange insertion length of only 6-3/4" and a height of 5-1/4". For use in radar applications, it has 1-5/8" EIA connectors. It is also available at other UHF frequencies and connector types.

The following models are examples of our High Power units

| Model No. | Power | Connectors | Freq. Range |
|-----------|--------------------|------------|-----------------|
| CT-1542-D | 10 Kw Pk 1 Kw Av | DIN 7/16 | 420-470 MHz |
| CT-2608-S | 3 Kw Pk 300 W Av | "Drop-in" | 1.2-1.4 GHz |
| CT-3877-S | 2.5 Kw Pk 250 W Av | "Drop-in" | 2.7-3.1 GHz |
| CT-3838-N | 5 Kw Pk 500 W Av | N Conn. | 2.7-3.1 GHz |
| CT-1645-N | 250 W Satcom | N Conn. | 240-320 MHz |
| CT-1739-D | 20 Kw Pk 1 Kw Av | DIN 7/16 | 128 MHz Medical |

Broadband Units • Common Band Devices • High Isolation Units • Multiport Devices • Drop-In Devices • Wireless/PCN Devices • High-Power Industrial/Medical Iso Adaptors Waveguide Junctions • High-Power TV Units • VHF and UHF Devices

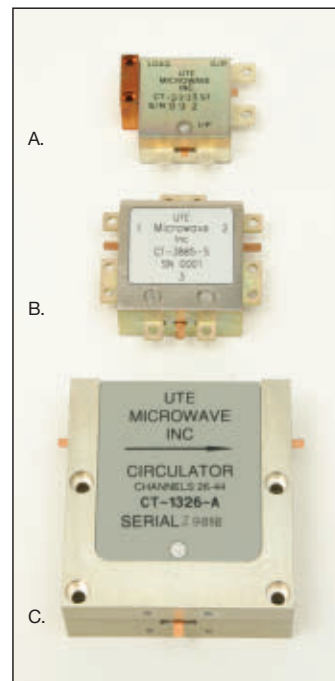
sales@utemicrowave.com

HIGH POWER Drop-in Series

A broad line of low loss HIGH POWER Drop-in circulators are available from VHF to Ku band including Kilowatt average power levels at VHF thru S band. L and S band radar are a specialty. A few of these are shown here.

- A) 2.7-3.1 GHz 1 kW pk, 100 W av
- B) 1.2-1.4 GHz 3 kW pk, 300 W av
- C) UHF TV Band 5 kW pk, 500 W av

**Our "POWER-LINE"
serves the
COMMUNICATIONS,
TELECOM,
MEDICAL, SCIENTIFIC,
TV, PCS and
INDUSTRIAL
markets.**



FEATURES:

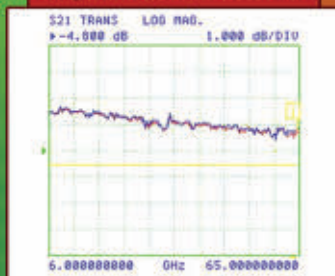
- Power levels to 5 KW CW, 75 KW PK.
- Low Intermod Units
- Low Loss Options
- Extended Octave Bandwidths
- Power Monitors and DC Blocks
- Iso Filter-Monitor Assemblies



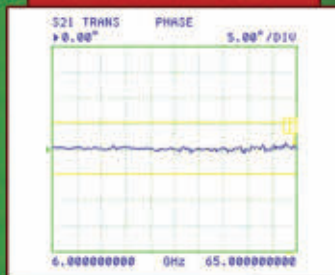
3500 Sunset Ave., Asbury Park, NJ 07712
Tel: 732-922-1009 Fax: 732-922-1848
E-mail: info@utemicrowave.com

6 - 65 GHz Power Dividers

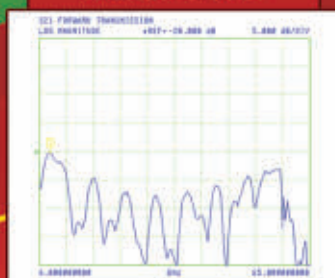
Amplitude Balance <.3dB



Phase Variation <1°



Isolation >20dB



VSWR <1.6:1

For hot air, ask our competitors.
For advanced microwave
products, call ETI.



Tel: 973-394-1719
Fax: 973-394-1710

Electromagnetic Technologies Industries, Inc.
50 Intervale Rd. Boonton, NJ 07005 U.S.A.
sales@etiworld.com • www.ETIworld.com



ISO 9001

TechnicalFeature

TABLE 2

ISM FREQUENCIES FOR MEDICAL APPLICATIONS

| | ISM Band (MHz) | | | | |
|-------------------|---------------------|-------|-------|-----------|----------|
| | 13.56 | 27.12 | 40.68 | 915 | 2450 |
| | High Frequency (HF) | | | Microwave | |
| Diathermy | X | X | X | X | X |
| Skin Rejuvenation | X | X | X | | Emerging |
| Ablation | X | | | X | X |

output power increasing over time. However, as medical, scientific and industrial systems began to proliferate, it became necessary to specify areas of the electromagnetic spectrum for operation. These industrial, scientific and medical (ISM) bands for the U.S. are shown in **Table 2**, and are widely accepted throughout the world. Some countries use additional frequencies. Many other systems operate in these same bands, including Wi-Fi, Bluetooth, microwave ovens and RF-based industrial equipment. With ISM bands unregulated, equipment must prevent or tolerate interference generated by nearby applications.

RF HEATING OF TISSUE

With the exception of MRI—which uses an intense electromagnetic field for imaging, not heating—all medical applications use RF to create heat. The electromagnetic field applied at high frequencies forces the water dipole to move with every cycle, creating friction between the molecules and generating heat. The frequencies at which this heat is generated and the hardware used to apply the heat largely determine the utility for specific medical uses. Generalizing about the use of electromagnetic energy for medical applications:

- Changes in tissue occurring at the molecular level differ with frequency
- Lower frequencies penetrate deeper into the skin than higher frequencies
- Lower frequencies penetrate fewer types of tissue than microwave frequencies
- Systems operating at microwave frequencies can more precisely direct energy to specific areas
- Medical systems operating at lower frequencies have been in use far longer than microwave-based systems that operate above 900 MHz

- The advantages of systems operating at microwave frequencies are gaining importance and becoming more thoroughly understood.

After the early efforts by Tesla and others suggested an interaction between radiated electromagnetic energy and the human body, the mechanism was further clarified and extended to all non-conducting materials. It was shown that the depth of penetration is determined by the frequency of the radiation and the insulating properties of the material. When microwave generators became available, it was demonstrated that because of their short wavelengths, specific areas could be targeted precisely. Greater penetration at lower frequencies (to about 2 inches) makes lower frequencies desirable for applications such as diathermy, in which the goal is often to soothe aching muscles. Microwave frequencies offer benefits such as faster heat delivery, more precise targeting of specific areas (a tumor, for example) and more accurate control.

At low frequencies, the electromagnetic field is generated between two or more electrodes, the shape dictating the characteristics of the field. The most common types of electrodes are rods and plates, between which the target material is placed. With increasing electrode distance, the voltage to maintain the electric field strength also increases, and the maximum distance between the electrodes and, thus, the maximum thickness of the target material is determined. When microwave frequencies are used, the energy is launched from a small emitter and guided through space to the target; a set of plates, used with lower frequency applications, is not required.

Arguably, there are dozens of medical applications that use RF energy, either alone or in combination with light or a laser at various wavelengths.

SWITCH-N-SAVE

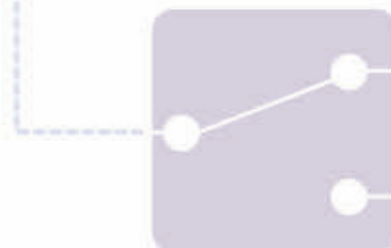
NEW!

RF Switches

by

CEL

SWAP THEM WITH OTHER
SUPPLIER SWITCHES FOR
BIG SAVINGS



LOWER COST SOLUTIONS

Cost Savings for New and Existing Customers













HIGHER RF PERFORMANCE

Better RF Performance than other RF Switches



HIGH JAPANESE QUALITY

Manufactured in Japan with High Quality, Packaging and Testing

| CEL Part Numbers | Switch Type | MAX Freq. (GHz) | Insertion Loss (dB) | | Isolation (dB) | | Compression point @ 3V (dBm) | | Package Type (mm) |
|------------------|-----------------|-----------------|---------------------|---------|----------------|---------|------------------------------|----------------|--|
| | | | 2.5 GHz | 6.0 GHz | 2.5 GHz | 6.0 GHz | 2.5 GHz | 6.0 GHz | |
| CG2163X3 | SPDT | 6.0 | 0.40 | 0.50 | 40 | 31 | +33 @ P1.0dB | +32 @ P1.0dB |  (1.5 x 1.5 x 0.37) |
| CG2164X3 | DPDT | 6.0 | 0.50 | 0.65 | 25 | 17 | +32 @ P0.5dB | +30 @ P0.5dB |  (1.5 x 1.5 x 0.37) |
| CG2176X3 | Absorptive SPDT | 6.0 | 0.45 | 0.55 | 30 | 22 | +37.5 @ P0.5dB | +37.5 @ P0.5dB |  (1.5 x 1.5 x 0.37) |
| CG2179M2 | SPDT | 3.0 | 0.45 | N/A | 26 | N/A | +30 @ P0.1dB | NA |  (1.25 x 2.0 x 0.9) |
| CG2185X2 | SPDT | 6.0 | 0.35 | 0.40 | 28 | 26 | +29 @ P0.1dB | +29 @ P0.1dB |  (1.0 x 1.0 x 0.37) |
| CG2214M6 | SPDT | 3.0 | 0.35 | N/A | 25 | N/A | +30 @ P0.1dB | NA |  (1.1 x 1.5 x 0.55) |
| CG2409M2 | SPDT | 3.8 | 0.45 | N/A | 27 | N/A | +37.5 @ P0.1dB | NA |  (1.25 x 2.0 x 0.9) |
| CG2409X3 | SPDT | 6.0 | 0.40 | N/A | 26 | N/A | +37.5 @ P0.1dB | |  (1.5 x 1.5 x 0.37) |
| CG2415M6 | SPDT | 6.0 | 0.35 | 0.45 | 32 | 26 | +31 @ P0.1dB | +31 @ P0.1dB |  (1.1 x 1.5 x 0.55) |
| CG2430X1 | SP3T | 6.0 | 0.50 | 0.60 | 28 | 25 | +28 @ P0.1dB | +28 @ P0.1dB |  (1.5 x 1.5 x 0.37) |

CEL

WWW.CEL.COM/SWITCHES

Broadest Selection of In-Stock RF Switches



PIN Diode



Waveguide



USB Controlled



Electromechanical



Surface Mount

- Coaxial, Waveguide and Surface Mount options available
- SPST thru SP12T and Transfer configurations
- Frequencies from 10 MHz to 110 GHz
- All in-stock and ship same-day



Fairview Microwave
RF COMPONENTS ON DEMAND. *Done!*

Technical Feature

However, they generally fall into the following categories: MRI, diathermy, ablation and skin rejuvenation. MRI will not be discussed, because its benefits are not derived from heat.

DIATHERMY

As the first treatment to use electromagnetic energy, diathermy has a long-established track record of effectiveness, and its use has expanded dramatically over the years. Today, diathermy either applies heat directly to the skin (shortwave diathermy) or heats it using a probe situated a short distance from the body that directs energy to the skin (microwave diathermy). Shortwave diathermy operates at 13, 27 or 40 MHz, and microwave diathermy operates at either 915 or 2450 MHz. Although vacuum tubes have long been used as the RF power source for both shortwave and microwave diathermy, LDMOS power transistors are replacing them, due to their longevity; precise control of power level, frequency and phase; simpler control mechanisms; smaller amplifier size and lower operating voltage (see Table 1).

Shortwave diathermy employs either two plates, placed on either side of the area of the body to be treated, or induction coils, molded to fit the body or wrapped around a limb. As the high frequency waves travel through the body tissues between the plates or coils, they generate heat. The degree of heat and depth of penetration partially depend on the absorptive and resistance properties of the tissues that the waves encounter. Shortwave diathermy is most effective for treating pain caused by sinusitis, kidney stones and pelvic infections, as well as conditions that cause muscle spasms.

Microwave diathermy is very effective for evenly warming tissues without heating the skin. Unlike shortwave diathermy, microwave diathermy does not apply heat directly to the body, rather beams RF energy into it from a probe to generate heat within the targeted tissues (see **Figure 2**). As it cannot penetrate deep into muscles,



▲ Fig. 2 Microwave diathermy treatment.

the primary applications are for areas closer to the skin, such as shoulders. The probe focuses the RF energy field directly on the targeted tissue in a more concentrated area than shortwave diathermy. Absorption of the energy causes heating in the tissues, deeper than infrared treatments but not as deep as shortwave diathermy.

As heat increases, so does blood flow, which can improve flexibility in joints and connective tissue. As pain and inflammation are reduced, arthritis sufferers can increase the range of motion. Other applications include treatment of sprains, strains, lesions, degenerative joint disease, rheumatoid arthritis, stiffness in the joints, hematoma, bursitis, synovitis, infected surgical incisions, carbuncles and abscesses. Diathermy can be used for surgical procedures, where a probe is applied to a blood vessel to cause the blood to coagulate, cauterizing the area. It is also effective in removing tumors in cases where traditional surgical techniques are impractical, such as the prostate, bladder, cervix, brain, ovaries, bowels and tonsils.

ABLATION

Ablation, in medical terms, applies to any technique (including surgery) that destroys tissue for a specific beneficial purpose. Two types of ablation systems use RF energy: RF ablation typically operates between 450 and 500 kHz and microwave ablation operates at either 915 or 2450 MHz. RF and microwave ablation are principally employed for heart surgery and tumor reduction and removal. Increasingly, they are considered a first-line treatment. RF ablation is the most widely used technique, while microwave ablation treatment is growing as studies

The Right RF Parts. Right Away.



We're RF On Demand, with over one million RF and microwave components in stock and ready to ship. You can count on us to stock the RF parts you need and reliably ship them when you need them. Add Fairview Microwave to your team and consider it done.

fairviewmicrowave.com
1.800.715.4396

Fairview Microwave
RF COMPONENTS ON DEMAND. *Done!*

show where its operating frequency provides unique benefits. The ablation procedure is typically guided by images generated by MRI, computed tomography (CT) or ultrasound, enabling the surgeon to precisely address a specific location with the ablation electrode. The electric current produced by the RF power source causes tissue heating around the probe at temperatures high enough to cause tissue death.

There are two types of RF ablation: monopolar and bipolar. In monopolar RF ablation, a single group of electrodes delivers energy at the tumor site using a ground pad to complete the circuit through the body. The pad, which acts as a return path for the RF current, is generally located on the patient's thighs or back. Bipolar RF ablation allows current to flow between multiple groups of electrodes and does not require the use of grounding pads.

The procedure is performed by inserting the probe into the target tissue to be destroyed. Tissue is heated by applying current between the probe and the ground pad or other electrodes. To ensure that tissue heating occurs only where desired, some parts of the probe may be insulated. Cell death depends on temperature and application time, ranging from a few minutes to kill cells at 50°C and just a few seconds at higher temperatures.

In many cases, microwave ablation has advantages over its low frequency counterpart. Molecules continuously realign as the microwave energy field oscillates, which increases kinetic energy and tissue temperature. Because of its small wavelength, the amount of energy delivered around the probe is denser and makes the procedure faster. Unlike lower frequency currents, energy at microwave frequencies can permeate all biological tissues, including bone and lungs that resist electric current. Consequently, microwave ablation generates a greater volume of energy around the probe, expanding the ablation zone and potentially reducing the number of required applications. The design of the microwave probe is a major determinant of the shape and size of the ablation zone. Researchers have produced many types of probes with varying degrees of effectiveness at controlling the transfer of RF energy. More than one probe can be used to create a larger ablation zone that precisely conforms to the target area. The phase of the signal at each probe can be varied to create zones of constructive and destructive wave interaction, yielding a positive effect on the results.

The benefits of microwave ablation versus RF include reduced application time (as little as a few minutes), higher temperatures, reduced sensitivity to various types of tissue, reduced need to reposition the probe and the ability to treat tumor types where RF ablation cannot be used.

Another use of ablation is renal denervation (see **Figure 3**), the subject of research for its potential to treat hypertension in patients for whom medication and other traditional remedies are not effective. It is a minimally-invasive procedure that reduces blood pressure by ablating the renal nerves. A small catheter is placed in the femoral artery, which provides ac-

Digital Attenuators & Phase Shifters

Up to 18 GHz



| Freq. Range (GHz) | Insertion Loss (dB) max. | VSWR (dB) max. | Least Significant Bit | Operating Power (max) | Model Number |
|---|--------------------------|----------------|-----------------------|-----------------------|--------------|
| Digitally Controlled Analog Attenuators, 64 dB, 8 Bits | | | | | |
| 4.00-8.00 | 6.0 | 2.00:1 | 0.25 | <= 0 dBm | DAT-19 |
| 8.0-12.40 | 6.0 | 2.00:1 | 0.25 | <= 0 dBm | DAT-21 |
| 6.0-16.00 | 6.0 | 2.00:1 | 0.25 | <= 0 dBm | DAT-23 |
| 6.0-18.00 | 6.5 | 2.00:1 | 0.25 | <= 0 dBm | DAT-25 |
| Linear Voltage Controlled Analog Attenuators, 64 dB | | | | | |
| 4.0-8.0 | 5.0 | 1.9 | -- | <= 0 dBm | AAT-25 |
| 8.0-12.4 | 5.0 | 2.0 | -- | <= 0 dBm | AAT-27 |
| 6.0-16.0 | 5.0 | 2.0 | -- | <= 0 dBm | AAT-29 |
| Switched Bit Digital Attenuators, 64 dB, 8 Bits | | | | | |
| 0.50-1.00 | 3.7 | 2.00:1 | 0.25 | + 20 dBm | DAT-16 |
| 1.00-2.00 | 4.0 | 2.00:1 | 0.25 | + 20 dBm | DAT-17 |
| 2.00-4.00 | 6.5 | 2.00:1 | 0.25 | + 20 dBm | DAT-18 |
| Switched Bit Digital Phase Shifters, 360°, 8 bits | | | | | |
| 0.50-1.00 | 4.5 | 1.80:1 | 1.40 | + 20 dBm | DST-11 |
| 1.00-2.00 | 4.5 | 1.80:1 | 1.40 | + 20 dBm | DST-12 |
| 2.00-4.00 | 6.0 | 1.80:1 | 1.40 | + 20 dBm | DST-13 |

See website for complete list of 32 dB and 64 dB attenuators and phase shifters.

PULSAR
MICROWAVE CORPORATION

 www.pulsarmicrowave.com

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

When it comes to power inductors,
we're spreading things a little thin



(actual height)

In fact, with hundreds of options under 1.2 mm high,
finding the perfect low-profile power inductor is no tall order!

Let's face it, thin is in. From smart phones and wearables to all types of portable devices, you face constant pressure to pack more performance into thinner packages.

To help, we continue to expand our line of mini, low-profile power inductors with footprints as small as 1.14 x 0.635 mm and maximum heights as low as 0.50 mm!

Select inductance values from 0.018 to

3300 μ H and current ratings up to 20 Amps.

Get the skinny on all our low-profile power inductors, including the new ultra-low loss XEL4012 Series with inductance values that have been fully optimized for high frequency applications over 5 MHz. Visit coilcraft.com/lowprofile today!



WWW.COILCRAFT.COM



cess to the nerves serving the renal artery. The nerves are ablated by passing electromagnetic energy into the artery through the catheter tip placed in the kidneys. The energy is transmitted through the vessel wall to damage the renal nerves.

SKIN REJUVENATION

Many techniques that fall within the broad term of cosmetic therapy (also called esthetic therapy) employ

RF energy, either alone or in combination with a laser or other source of light (see **Figure 4**). Optical energy has been used for many years for treating dermatologic problems, sometimes combining lasers and intense pulse light (IPL) for epilation, removal of vascular and pigmented lesions, reduction of fine wrinkles and acne treatment. In most cases, the laser's power is generated by an RF source; power levels of several kilo-

watts at a frequency of 100 MHz create a plasma in a chamber, from which the laser light is extracted.

The limitations of optical techniques caused researchers to investigate the use of RF energy, which has become very popular. RF treatments rely on the tissue's electrical properties rather than on the concentration of molecules in the skin for thermal destruction. RF technology transfers energy to the skin at relatively low

FASTER, QUIETER, SMALLER SIGNAL SOURCES QUICKSYN SYNTHESIZERS

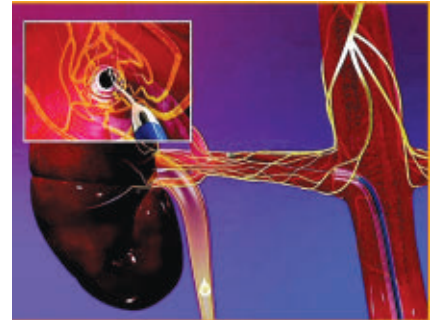
Design smaller and more efficiently with National Instruments QuickSyn synthesizers. The revolutionary phase-refining technology used in QuickSyn synthesizers enables blazing fast switching speeds, very low spurious and phase noise performance, wide frequency range, and small footprint.

ni-microwavecomponents.com/quicksyn



QuickSyn Lite Synthesizer

© 2016 National Instruments. All rights reserved.



▲ Fig. 3 Microwave ablation used for renal denervation.



▲ Fig. 4 Before (a) and after (b) skin rejuvenation using RF energy.

ATC's 400 Series SMT Capacitors for Precision Tuning Solutions

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

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

Typical Applications:

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



Features:

- Capacitance: 0.1 pF to 68 pF
- Tightest Tolerance to ± 0.01 pF
- EIA 01005, 0201, 0402 and 0603 Case Sizes
- Voltage Rating: up to 200 WVDC
- Stable NPO Dielectric
- Unit-to-Unit Performance Repeatability
- RoHS Compliant / Lead-Free



AMERICAN
ATC North America
sales@atceramics.com

TECHNICAL
ATC Europe
saleseur@atceramics.com

CERAMICS
ATC Asia
sales@atceramics-asia.com

THE ENGINEERS' CHOICE®
ISO 9001 REGISTERED COMPANY

THE ENGINEERS' CHOICE®

www.atceramics.com

temperatures, so it is well suited for acting on dermal collagen without affecting the epidermis, which enables more effective wound healing and provides effective skin rejuvenation in a short time (see **Figure 5**). As it does not affect epidermal melanin, patients of all skin types can be treated, including those with darker skin and those prone to developing post-inflammatory hyperpigmentation.

There are several approaches to

RF-based treatments: Monopolar RF applies a single electrode tip to the target area, and another plate serves as a ground pad. Bipolar RF targets tissue using two points on the tip of a single probe, and tripolar RF employs multiple electrodes to heat both shallow and deep layers of the skin at the same time. A relatively new technique, called fractional RF, uses a very thin, needle-type electrode that can service multiple zones of tissue with-

out affecting the epidermis and adnexa, which results in faster healing. Another approach, called unipolar RF, works without delivering current to the skin. Rather, it uses energy to induce rotational oscillations in water molecules, targeting the reticular dermis and subcutaneous junction, in contrast to the bipolar technique that affects the papillary and mid-level dermis.

One skin rejuvenation application can reduce or eliminate telangiectasia (commonly called varicose veins), a skin condition that can be benign or a symptom of underlying and sometimes serious illness. Often referred to as spider veins owing to its web-like appearance, it is recognized by tiny blood vessels that cause a threadlike appearance on the skin and can form in clusters. Studies show that RF and possibly microwave ablation can reduce the plaques typical of this disease, using lower temperatures and with fewer side effects. The technique called VNUS Closure, introduced by VNUS Medical Technologies in 1998, is a similar approach that uses an injected saline solution to numb the leg, squeeze blood from the vein and protect surrounding tissue. After the procedure, blood is naturally rerouted through other healthier veins.

A cosmetic procedure called body contouring allows reshaping of the body without surgery and has resulted in numerous noninvasive and often proprietary techniques. RF energy is used to deliver current deep into areas of fat cells to destroy them. Connective tissue and fat both contribute to the development of cellulite, for which RF energy has proven to be effective in minimizing. The heat produced causes collagen proteins in connective tissue to change and tighten. Studies have shown that it may also increase blood flow and fat metabolism at the treatment site. RF energy also affords its noninvasive capabilities for liposuction. Radio frequency assisted liposuction (RFAL), a technique developed by one manufacturer, uses RF energy to produce heat using two electrodes, one external and one internal and connected to a handheld controller.

Electro-optical synergy (ELOS), also called E-light technology, combines bipolar RF and optical energy to reduce the intensity and potential side effects of optical energy. Studies

Complete Connections for Your 5G Applications!



1.0mm Series



Test Cables



Multi Coax & Phase Matched Cables

Visit us @ Booth **Hall A1. 152**,
Electronica 2016 Messe Munich, Germany,
Nov. 8~11, 2016



Frontlynk Technologies Inc.
Tel: +886-6-356-2626 Fax: +886-356-6268
www.frontlynk.com
E-mail: info@frontlynk.com

RF-LAMBDA

THE LEADER OF RF BROADBAND SOLUTIONS

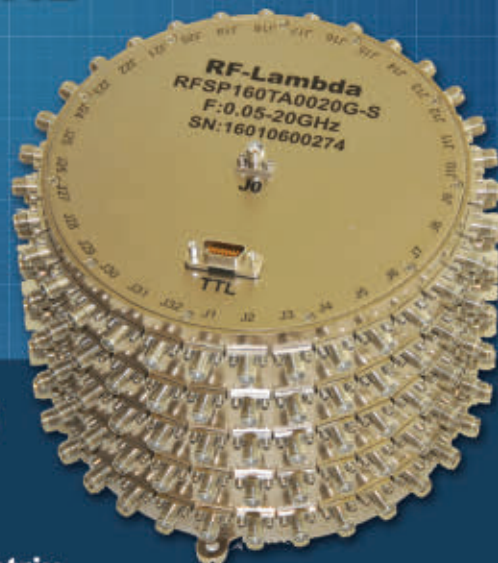
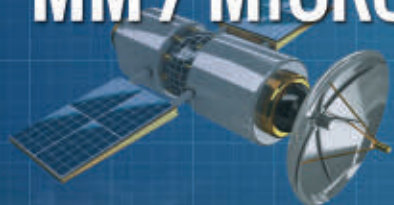
WWW.RFLAMBDA.COM

ITAR & ISO9000
Registered Manufacture



Thousand
in stock

RF SWITCHES MM / MICROWAVE DC-50GHz



160 CHANNELS
mm/Microwave

0.05-20GHz

Filter Bank Switch Matrix

For Phase Array Radar Application Satellite communication.



PN: RFSP32TA5M43G

SP32T SWITCH 0.5-43.5GHz

PN: RFSP16TA5M43G

SP16T SWITCH 0.5-43.5GHz

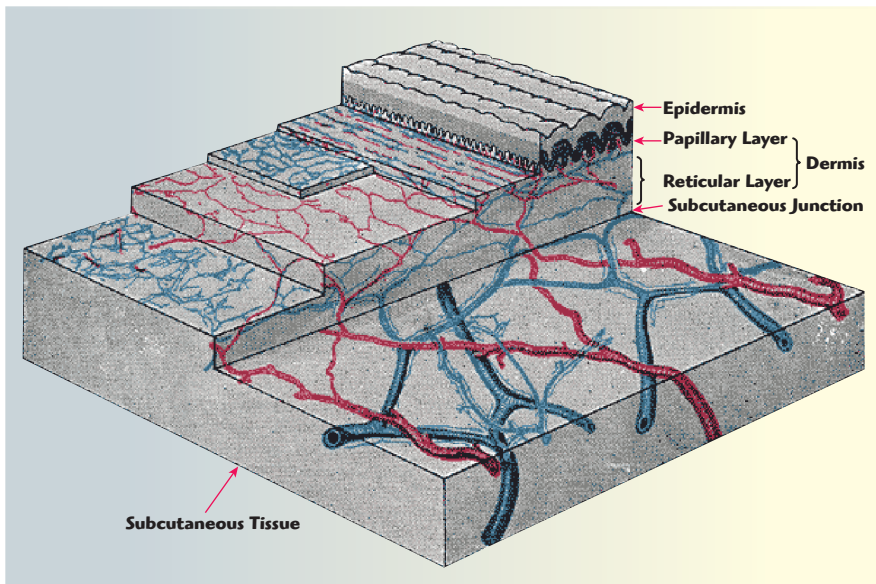


www.rflambda.com
sales@rflambda.com

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

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





▲ Fig. 5 Cross section of human skin. Source: Henry Gray, "Anatomy of the Human Body," 1918.

have shown that it can be used with all hair types and is effective in removing white hair.

EMERGING APPLICATIONS

RF technology is being used to treat other pathologies, and many rely on

RF ablation. It is being used to treat various heart conduction disorders, of which there are many. The procedure has been demonstrated to be safe, with a mortality rate of less than one per 2,000 procedures. RF ablation is also being used to treat hepatocellular car-

cinoma, the most common type of liver cancer. Electrodes are inserted into the liver tumor using percutaneous, laparoscopic or open surgery with guidance from ultrasound imaging. As it is a local treatment with minimal effects on normal healthy tissue, it can be repeated multiple times. The technique has proven to have four-year survival rates like those of surgical resection. Barrett's esophagus, a serious complication of gastroesophageal reflux disease, is also being treated using RF ablation. The RF energy is delivered through an endoscope inserted into the esophagus that allows abnormal cells to be destroyed while protecting the healthy cells underneath.

CONCLUSION

The use of RF energy in medicine has a long history and has proven its effectiveness, either alone or used with a laser for diathermy, ablation and skin treatment. Advances in solid-state device technology enable better control and flexibility, especially LDMOS RF power transistors that extend treatment options to microwave frequencies. ■



TELECOMENGINE

Insights to give you to the competitive advantage






ICT Market Research & Forecasts

- 5G Infrastructure
- Internet of Things
- Big Data & Analytics
- Content Delivery Networks
- Location Based Services
- Mobile Payments
- Telecom APIs
- OSS/BSS

visit <http://store.telecomengine.com>

All Reports in PDF Download Format
Ask Us About Corporate Licenses and Company-Wide Subscriptions



Secure, Mobile-Friendly Online Ordering
Invoice and Bank Transfer Options Available



TELECOMENGINE

Order online or call for assistance US Toll Free: 800.966.6326 ext 1969 | International: +1.781.619.1969

UP TO 100 Watt AMPLIFIERS

NOW! 100 kHz to 26.5 GHz



\$995
from ea. qty. (1-9)

High-powered performance across wide frequency ranges. Mini-Circuits' class A/AB linear amplifiers have set a standard for wideband high-power performance throughout the RF and microwave industry. Rugged and reliable, they feature over-voltage and over-temperature protections and can withstand opens and shorts at the output! Available with or without heat sinks, they're perfect for demanding test lab environments and for integrating directly into customer assemblies. With standard models covering frequencies from 100 kHz up to 26.5 GHz, chances are we have a solution for your needs in stock. Place your order on minicircuits.com today for delivery as soon as tomorrow! Need a custom model? Give us a call and talk to our engineers about your special requirements!

| Model | Frequency (MHz) | Gain (dB) | Pout @ Comp. | | \$ Price* (Qty. 1-9) |
|---------------------------|--------------------|--------------|--------------|-------------|-------------------------|
| | | | 1 dB (W) | 3 dB (W) | |
| ZVM-273HP+ | 13000-26500 | 14.5 | 0.5 | 0.5 | 2195 |
| ZVE-3W-83+ | 2000-8000 | 35 | 2 | 3 | 1295 |
| ZVE-3W-183+ | 5900-18000 | 35 | 2 | 3 | 1295 |
| ZHL-4W-422+ | 500-4200 | 25 | 3 | 4 | 1160 |
| ZHL-5W-422+ | 500-4200 | 25 | 3 | 5 | 1670 |
| ZHL-5W-2G+ | 800-2000 | 45 | 5 | 5 | 995 |
| ZHL-10W-2G+ | 800-2000 | 43 | 10 | 12 | 1295 |
| • ZHL-16W-43+ | 1800-4000 | 45 | 12 | 16 | 1595 |
| • ZHL-20W-13+ | 20-1000 | 50 | 13 | 20 | 1395 |
| • ZHL-20W-13SW+ | 20-1000 | 50 | 13 | 20 | 1445 |
| LZY-22+ | 0.1-200 | 43 | 16 | 30 | 1495 |
| ZHL-30W-262+ | 2300-2550 | 50 | 20 | 32 | 1995 |
| ZHL-30W-252+ | 700-2500 | 50 | 25 | 40 | 2995 |
| LZY-2+ | 500-1000 | 47 | 32 | 38 | 2195 |
| LZY-1+ | 20-512 | 42 | 50 | 50 | 1995 |
| • ZHL-50W-52+ | 50-500 | 50 | 63 | 63 | 1395 |
| • ZHL-100W-52+ | 50-500 | 50 | 63 | 79 | 1995 |
| • ZHL-100W-GAN+ | 20-500 | 42 | 79 | 100 | 2395 |
| NEW! ZHL-100W-272+ | 700-2700 | 48 | 79 | 100 | 7995 |
| ZHL-100W-13+ | 800-1000 | 50 | 79 | 100 | 2195 |
| ZHL-100W-352+ | 3000-3500 | 50 | 100 | 100 | 3595 |
| ZHL-100W-43+ | 3500-4000 | 50 | 100 | 100 | 3595 |

Listed performance data typical, see minicircuits.com for more details.

• Protected under U.S. Patent 7,348,854

*Price Includes Heatsink



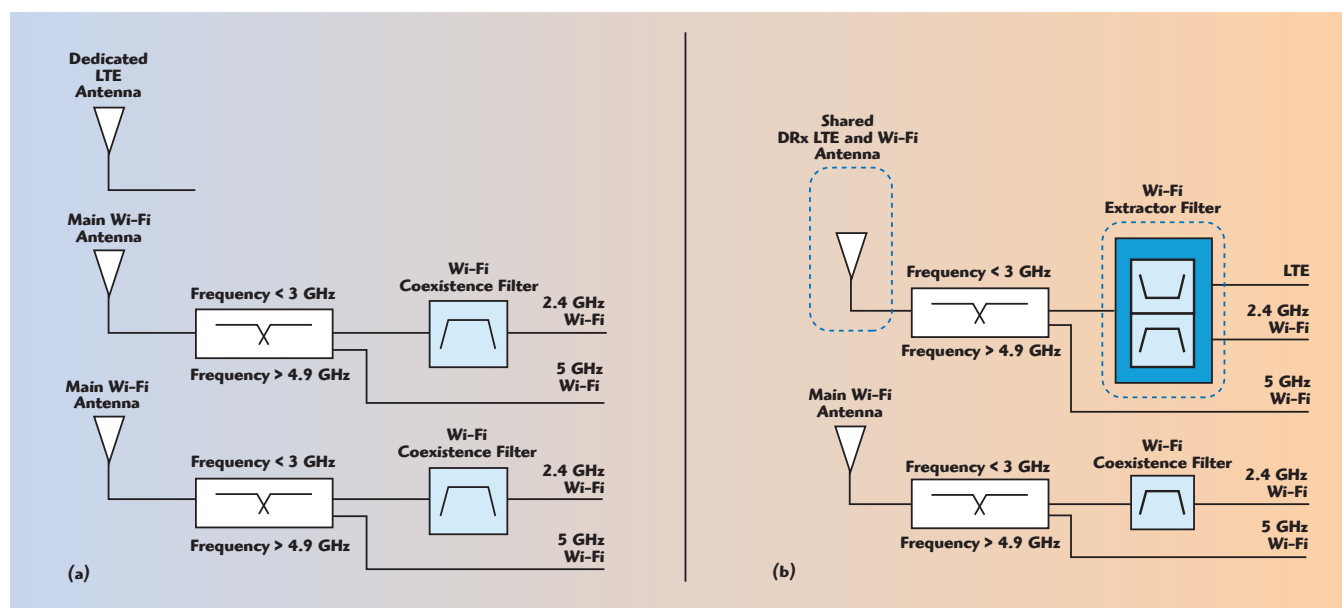
Filter Technology Trends in Mobile Wi-Fi Modules

Kevin Gallagher
Qorvo, Chelmsford, Mass.

In smartphones, high performance Wi-Fi is key to satisfying the ever-growing demand for mobile data, because Wi-Fi offloads traffic from operators' LTE networks. Trends in 2017 will include the growing prevalence of 2×2 multiple-input-multiple-output (MIMO) in handsets, which enables dual simultaneous data streams. IEEE 802.11ac, which utilizes the 5 GHz band and offers greater throughput than its predecessors, will continue to proliferate, while the industry prepares for the next

standard, 802.11ax, which will further improve performance.

The drive to continually increase Wi-Fi performance creates design engineering challenges requiring the use of advanced RF filters, typically incorporated into integrated modules to maximize performance, simplify design and save space. One of these challenges is antenna sharing, which facilitates the addition of 2×2 MIMO Wi-Fi alongside increasingly complex LTE functionality in the limited space available



▲ Fig. 1 Simplified smartphone architecture with 2×2 MIMO Wi-Fi and separate LTE antenna (a) and shared Wi-Fi/LTE antenna (b).



Established technologies for Small Cell/DAS networks

HUBER+SUHNER supports indoor and outdoor networks with dedicated solutions for Small cell and DAS connectivity. All relevant application imply different technologies as radio frequency and fiber optics, including solutions for daisy chaining and multiplexing with network cubes. HUBER+SUHNER copes with these technologies and has for each application the suitable solution at hand. One stop shop reduces complexity for the purchaser and opens up additional economic potential.

› wirelessinfrastructure.hubersuhner.com

HUBER+SUHNER AG 9100 Herisau/Switzerland
HUBER+SUHNER INC. Charlotte NC 28273/USA

within the handset. Other challenges: Designs must avoid interference with neighboring LTE bands, including bands that use the new Class 2 standard for higher output power, and support simultaneous dual-band Wi-Fi operation.

ANTENNA SHARING

The number of antennas in smartphones has grown to support faster data services as well as a growing range of RF technologies. Today's handsets may require as many as six or seven antennas for primary cellular and diversity receive (DRx), Wi-Fi, near-field communications (NFC) and other technologies. It becomes increasingly difficult to squeeze still more antennas into the limited physical space available within a typical high performance smartphone. Antenna sharing alleviates this problem (see **Figure 1**), as it allows handsets to accommodate 2x2 MIMO Wi-Fi by sharing the cellular DRx antenna between Wi-Fi and LTE.

Antenna sharing requires two advanced filters to avoid interference between 2.4 GHz Wi-Fi and adjacent LTE bands (7, 38, 40 and 41), while duplexing the LTE and Wi-Fi paths to a single antenna port. A 2.4 GHz notch filter is used to remove the Wi-Fi signal from the LTE path, while a 2.4 GHz bandpass filter removes LTE interference from the Wi-Fi path. The

use of temperature-compensated bulk acoustic wave (BAW) filters enables designs to minimize insertion loss, meet attenuation requirements for Wi-Fi and LTE, use the full Wi-Fi spectrum and operate across temperature.

One example of a commercial product is Qorvo's 885060 Wi-Fi extractor filter module (see **Figure 2**), which combines the notch and bandpass filter into a single module and reduces the need for external matching. The BAW bandpass filter provides high performance Wi-Fi and meets out-of-band attenuation requirements (see **Figure 3**). The notch filter meets the Wi-Fi attenuation requirements and achieves low insertion loss for the adjacent LTE bands (see **Figure 4**).

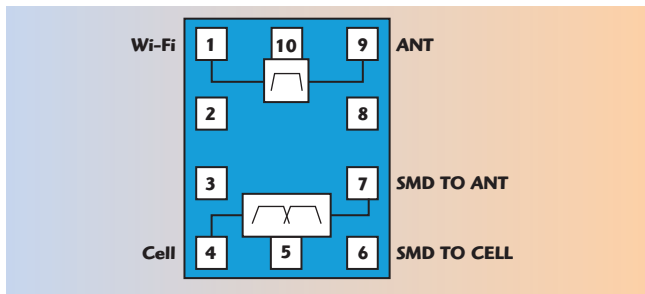
LTE POWER STANDARD

Whether or not the handset uses antenna sharing, all handsets require filters to ensure coexistence between 2.4 GHz Wi-Fi and the adjacent LTE bands. A new coexistence challenge is presented by Power Class 2, an emerging standard for higher output power in TD-LTE band 41 (2.5 GHz) and potentially other high frequency bands. Band 41 is increasingly being used in the United States, China and other countries. Power Class 2 increases handset output power to 26 dBm, double the previous 23 dBm maximum defined by power class 3. The goal of increased output power is to compensate for greater propagation losses at higher frequencies. Raising handset output power enables carriers to maintain cell coverage without adding expensive infrastructure.

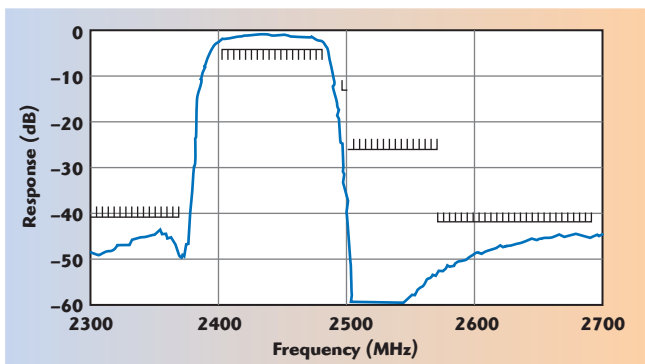
The filtering challenge is to attenuate these higher power LTE signals sufficiently to protect the neighboring 2.4 GHz Wi-Fi spectrum. The Wi-Fi filter that is required will depend on the filter that the handset manufacturer chooses for band 41. If a high performance filter is used for band 41, the Wi-Fi attenuation requirements will be less stringent; however, if a lower performance filter is used, greater attenuation will be required to avoid interference, meaning a higher performance Wi-Fi filter will be needed.

CONCURRENT DUAL-BAND OPERATION

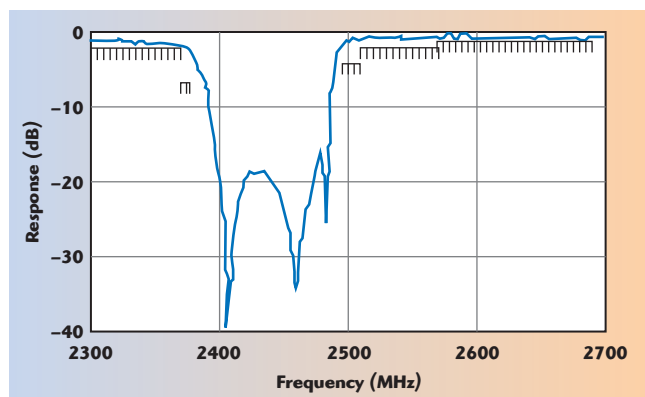
Another emerging Wi-Fi filtering challenge is presented by the trend toward concurrent dual-band



▲ Fig. 2 A diplexer module enables Wi-Fi and LTE to share a common antenna (e.g., Qorvo's 885060).



▲ Fig. 3 Response of the Wi-Fi bandpass filter in the diplexer module.



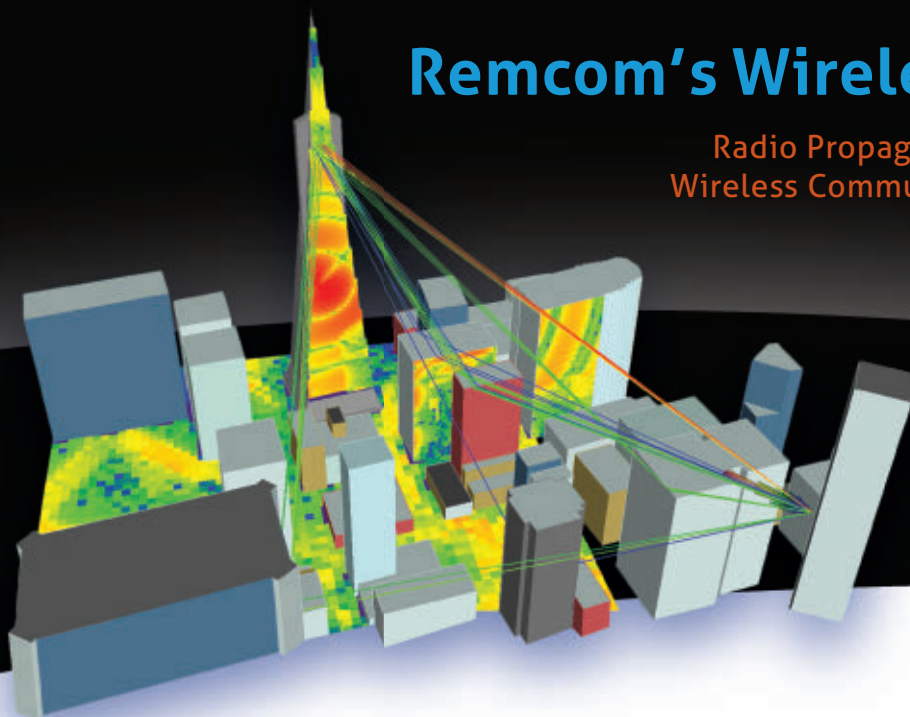
▲ Fig. 4 Response of the Wi-Fi notch filter, including the adjacent LTE bands.

| 2009 | 2013 | 2017+ |
|--|---|--|
| 802.11n | 802.11ac | 802.11ax |
| <ul style="list-style-type: none"> • MIMO antennas to enable range, capacity and performance • Introduced dual band operation (2.4 GHz, 5 GHz) for higher throughput • Up to 600 Mbit/s data rate | <ul style="list-style-type: none"> • Wider channels in 5 GHz band increasing total throughput • Beamforming for signals • Higher data rate | <ul style="list-style-type: none"> • Higher order modulation for faster throughput • Greater network capacity, specifically for dense environments |

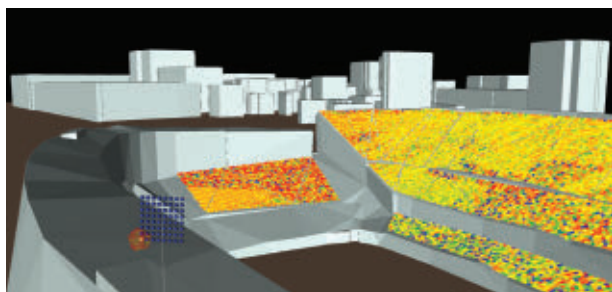
▲ Fig. 5 Evolving Wi-Fi standards.

Remcom's Wireless InSite®

Radio Propagation Software for
Wireless Communication Planning



Wireless InSite is a suite of ray-tracing models for simulating wireless propagation and communication channel characteristics in complex urban, indoor, rural and mixed environments.



MIMO capability predicts received power and complex channel matrix throughout Soldier Field stadium

Predictive Simulation for Telecommunications and Wireless Networks:

- 5G MIMO simulation
- Macrocell and small cell coverage
- Urban multipath and shadowing
- Indoor WiFi
- Wireless backhaul
- LTE and WiMAX throughput analysis
- Ad hoc networks and D2D communication

See all the latest
enhancements at

www.remcom.com/wireless-insite-features >>>

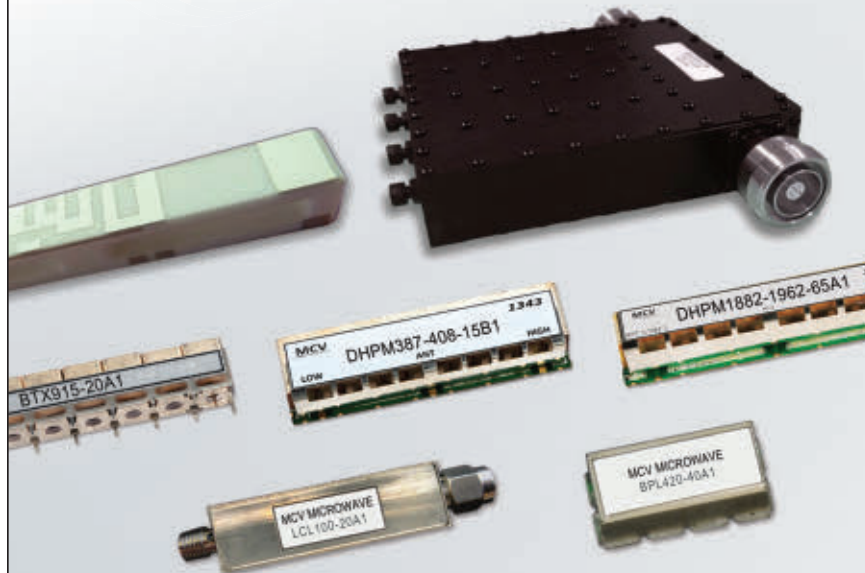
REMCOM®



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



MCV
MICROWAVE



QUICK-TURN

CUSTOM PROTOTYPE RF/MICROWAVE FILTERS & ANTENNAS

WIRELESS INFRASTRUCTURE

PUBLIC SAFETY

MILITARY & SPACE

SATELLITE RECEIVER

PRODUCTS

LTE DAS and In-Building Network Filter Solutions

High Power/Low PIM Filters and Duplexers

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

Ultra-high Q Dielectric Resonators and Meta Materials

Narrow Band and Broad Band Antennas

Call for a FREE Consultation

858.450.0468

mcv-microwave.com

SpecialReport

operation. Today's handsets support both 802.11ac (5 GHz) and the older Wi-Fi standards that use 2.4 GHz (802.11n, b and g). As Wi-Fi becomes more prevalent and is incorporated into more households, wearables and other devices, it will be valuable for a handset to simultaneously communicate on both Wi-Fi bands. The 5 GHz band provides the highest performance, so it may be used for internet access via a local, high bandwidth access point. The 2.4 GHz band will be used because it provides greater range and enables communication with devices that support only the 2.4 GHz band. Wi-Fi filters need to support this concurrent usage, ensuring adequate attenuation of 2.4 GHz signals in the 5 GHz band and vice versa.

Wi-Fi filters are being incorporated into integrated front-end modules (iFEM) with other components in the Wi-Fi transmission chain, such as power amplifiers and switches. Modules provide better performance, reducing matching losses, simplify design complexity, save space, limit the number of discrete components and reduce time to market for the handset manufacturers.

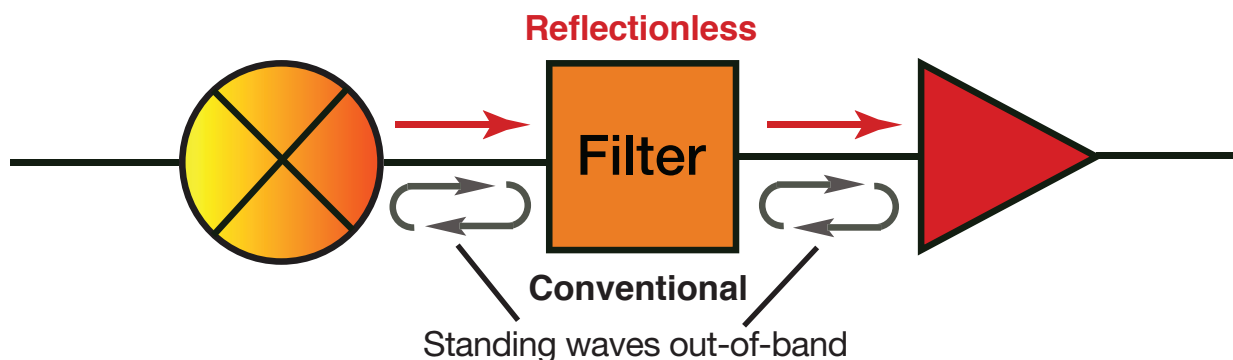
CONCLUSION

Advanced filters and iFEMS are essential components, needed to enable future Wi-Fi performance improvements. 2x2 MIMO in handsets will increase during 2017, particularly among the fast-growing manufacturers in China. This will drive adoption of iFEMs and antenna sharing, as manufacturers seek to add a second Wi-Fi RF chain within the limited space available in increasingly complex handsets.

The upcoming 802.11ax standard will further improve throughput, especially in dense user environments such as stadiums and airports (see **Figure 5**). Performance improvements will be achieved, in part, by using more complex modulation coding (i.e., 1024-QAM compared with the 256-QAM maximum in 802.11ac), which will tighten the error vector magnitude (EVM) specification from 1 percent to 0.5 percent. To support 802.11ax, Wi-Fi iFEMs will need to improve linearity without sacrificing filter performance. ■

NOW! Revolutionary **ABSORPTIVE/REFLECTIONLESS** **FILTERS**

DC to 21 GHz!



Stop Signal Reflections Dead in Their Tracks!

\$6⁹⁵
ea. (qty. 1000)

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

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



X-Series

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

 **Tiny 3x3mm QFN**

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

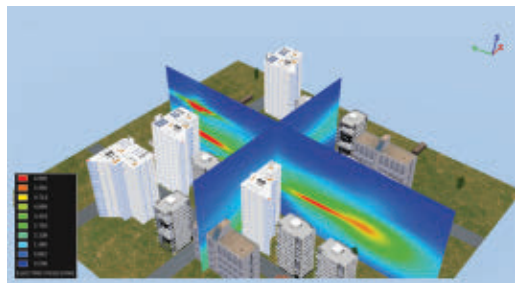
² See application note AN-75-007 on our website

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

⁴ Defined to 3 dB cutoff point

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





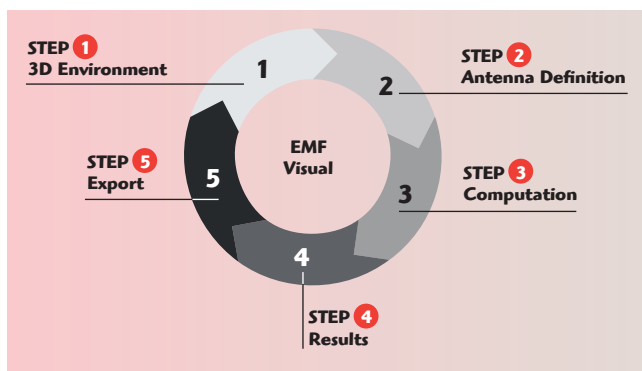
Electromagnetic Exposure Simulation Software

Microwave Vision Group (MVG)
Paris, France

Across the globe, telecommunication regulatory bodies are paying more and more attention to human exposure to RF emissions, with the result that nowadays gaining authorization for installing new antennas is often dependent upon proof of compli-

ance with local reference levels. Compliance becomes dependent on accurate simulation of human exposure to electromagnetic fields, which is the only way to calculate and assess the cumulated level of exposure generated by new antennas in their future installation sites together with all those already in place that are used for cellular networks or radio services.

To address this issue a new version of the EMF Visual software has been developed. The existing version offers reliable and fast calculations and enables the visualization of electromagnetic fields in a determined zone (near-field/far-field), taking into account the multiple emitters and their interaction with surrounding buildings. The simulation results can be compared directly with reference levels given by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), Safety Code 6, FCC. Therefore, providing clear and



▲ Fig. 1 Process utilized by EMF Visual.

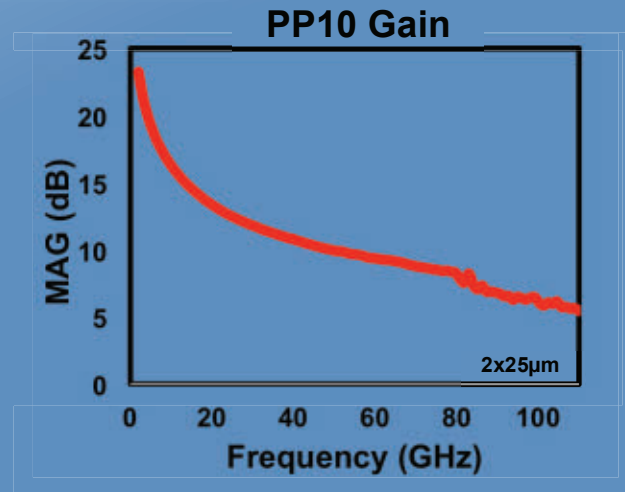
Technology And Manufacturing Solutions For Demanding Applications

PP10

The technology of choice for E-band power

0.1 μ m High Performance pHEMT

- 130GHz f_t , 4V operation
- MAG>8dB at 80GHz
- 0.8W/mm P1dB @ 29GHz
- 1.2 dB Fmin at 40 GHz
- 50 μ m and 100 μ m wafer thickness



Now With Monolithic PN Diodes for ESD Protection Circuits

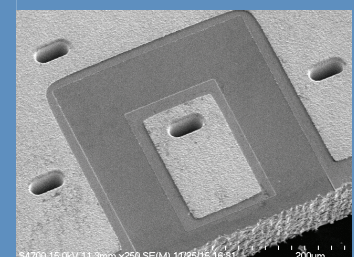
- Enables ESD protection from 250V to 2KV
- Low capacitance
- Compact layout



Compact ESD Protection

Advanced Options For Improved Performance

- RF isolated through-wafer vias \rightarrow low inductance RF transitions
- Capacitors with direct ground connection
- Enhanced Moisture Protection
- Low-k Dielectric Overcoat



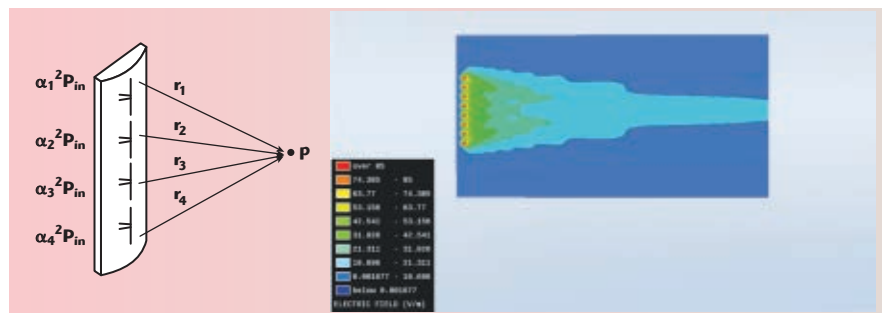
RF Isolated Back Via



SEMICONDUCTORS

Compound Semiconductor Solutions
from RF to Lightwave

www.winfoundry.com/contactus



▲ Fig. 2 The E-field calculated at each point in the mesh is the superposition of the fields emitted by each sub-antenna of the radiating element.

easy-to-understand evaluations of the compliance of a site.

The new version of EMF Visual is even more powerful thanks to advanced features. It now uses GPU resources, which provide coverage of larger areas for exposure evaluation and enables the use of the Geographical Information System (GIS) database or 3D objects conversion for direct loading of virtual 3D scenes, while interfacing with SketchUp software. In addition, the new version allows users to assign material properties to the entire surrounding 3D environment in order to take into account their impact on exposure levels, while still making fast calculations.

The simulation tool is based on a five step process as shown in **Figure 1**. The first is the definition of the complete 3D scenario. In this phase, the user can define or build a complete 3D scenario based on existing components provided with the software (buildings, ground profiles, etc.) There is a wide range of choice included in the software representing different types of buildings, roads, masts, towers, houses and indoor objects and the user can select different electromagnetic properties for the materials.

Once the scenario is defined, the second step is the antenna selection and installation within the specific scenario. EMF Visual provides a wide database of generic antennas which can be used. In addition, the BSA synthesis module can be used to add custom antennas based on user defined specifications such as: frequency, beamwidth, tilt, input power, gain, etc. The user defined antennas can be exported to the EMF Visual database for use in different scenarios.

The third step is the definition of the computation volume inside the area of interest. Once this is identified the calculation is launched, taking into account the surrounding environment and the interaction with other radiation elements present. The computation is based on ray tracing techniques. The user can select the mesh size of the computation volume and use a non-uniform grid in order to improve the resolution around the antennas and save computation time.



FLAT, STABLE GAIN



SINGLE POSITIVE SUPPLY



LOW NOISE FIGURE



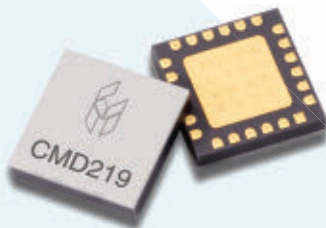
HIGH POWER HANDLING



LOW POWER CONSUMPTION



SMALLEST FORM FACTOR



Low Noise Amplifiers

- Frequencies from 2 to 45 GHz
- Noise figures as low as 1 dB
- Gain from 15 to 30 dB
- +20 dBm Input Power Handling
- Stable from -55 to +85°C

Think of what you'll save with an LNA you can design *with* instead of design around.

Given everything we've built into our LNAs, you'll be wondering what to do with the extra power and board space. Not to mention the time and money.

Download fully characterized datasheets and S-parameters, and start engineering your next receiver today.

CustomMMIC.com

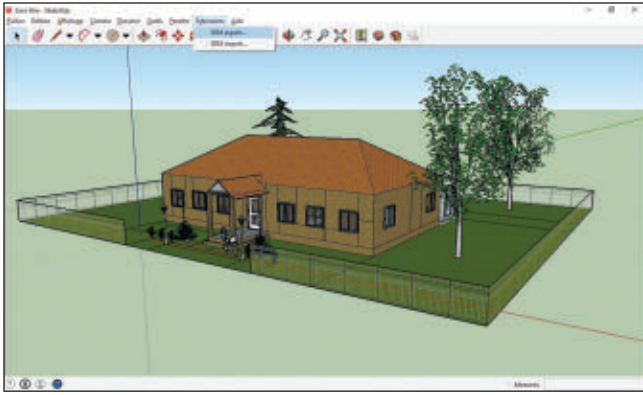


Fig. 3 SketchUp import example.

The E-field calculated at each point in the mesh is the superposition of the fields emitted by each sub-antenna of the radiating element (see **Figure 2**). Once, the input

power (P_{in}) and phase (α) of each sub-element is known, the total E-field can be calculated at any point (p) in the 3D space as the sum of the individual contributions.

Once the simulation of the scenario is complete, the next step is to visualize the results. The user can define surface or cut-planes to visualize the E-field levels inside the scenario contained within the user defined computation volume. In addition to E-field, the software can display H-field, power density, percentage of power or percentage of field for multi-frequency sources. The software can also automatically determine the safe distance from the radiating element based on the standards/recommendations defined by the European Union, ICNIRP or other regulatory and governing bodies. The user can also change the color and transparency of the results for an optimal view.

The scenario definition setup in the software package provides several possibilities. It contains the standard EMF Visual tool with CPU or advanced GPU option. For a precise and rapid creation of a 3D environment, several options are available. The user can use the internal generic database, which is quite comprehensive and provides a wide range of buildings, ground floors, towers, masts, indoor objects, etc.

The user can also opt for a plug-in for SketchUP using the SE-SKP-EMF option whereby the user can import custom structures into the EMF Visual software using the SDM format as shown in **Figure 3**. Another option is the 3D creation tool (SE-AGETIM-Light-EMF) that generates a complex 3D terrain using the GIS user interface. The detail of the final output depends on the quality of input data.

The third option is the 3D conversion tool (SE-FFT-EMF) that can be used to convert files from VRML, TDF, OpenInventor and OpenFlight formats to the SDM format, which is used by the EMF Visual. This tool is a package of several tools each used to convert to a specific file format.

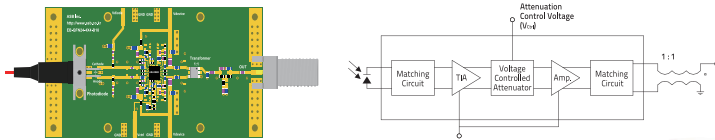
Microwave Vision Group (MVG)
Paris, France
www.mvg-world.com



Brilliance in RF Microwave
Wireless / Broadcast / Automotive / Satellite / Military

Optical Trans-Impedance Amplifiers, 50 ~ 1200 MHz

AGC included

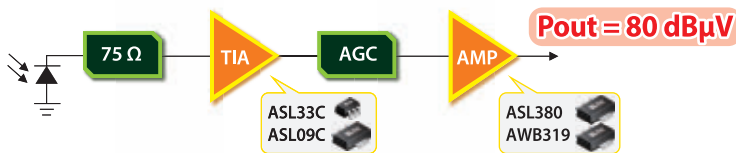


@ $V_d = 5V$, $I_d = 290\text{ mA}$

| Part No. | Gain @ V_c (dB) | GF (+/-) (dB) | S22 (dB) | EIN (pA/rHz) | Output Power (dBμV) | CSO (dBc) | CTB (dBc) | Package |
|----------|---------------------|---------------|----------|--------------|---------------------|-----------|-----------|---------|
| ASA306B | 38 ~ 18 @ 0 ~ 4.3 V | 1.0 | -15 | 3.1 | 86 ⁽¹⁾ | 57 | 53 | QFN24 |
| | 33 ~ 13 @ 0 ~ 4.3 V | 1.3 | -13 | 3.3 | 81 ⁽¹⁾ | > 60 | > 60 | |

(1) OMI = 3.5 %, 541.25 MHz of NTSC 79 channels in the optical input range of -7 ~ +1 dBm.

FTTH (fiber-to-the-home) Solution, 50 ~ 1000 MHz



| Part No. | V_d (V) | I_d (mA) | Gain (dB) | NF (dB) |
|----------|-----------|------------|-----------|---------|
| ASL33C | 3.0 | 45 | 23.0 | 0.85 |
| ASL09C | 3.3 | 35 | 22.5 | 0.85 |
| ASL380 | 5.0 | 80 | 17.2 | 1.70 |
| AWB319 | 5.0 | 80 | 21.0 | 2.00 |

2-Bit Digital Attenuator, DC~2700 MHz, AAT2075B2

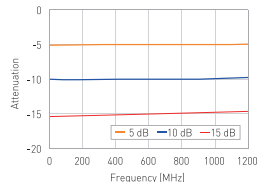
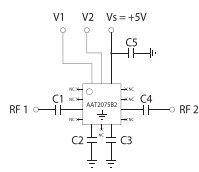
75Ω Impedance

Attenuation : 15 dB with 5 dB LSB

Attenuation Accuracy :

± (0.15dB + 3%) @ DC ~ 1200 MHz

QFN14 (2 x 2 mm²)



Waveguide Components

**RF Solutions
From RF Engineers**

RF Solutions From RF Engineers

866.727.8376
visit pasternack.com today!

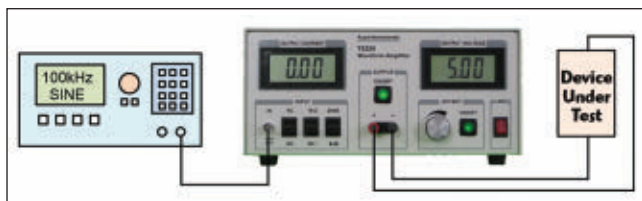




High Voltage and High Current Waveform Amplifier

Accel Instruments
Irvine, Calif.

Many test and measurement applications require a driver amplifier that provides high voltage, high current or any combination. Typical benchtop signal sources — function generators, arbitrary waveform generators, signal generators and data acquisition systems — are unable to provide high voltage or current. The output of most benchtop generators is limited to about ± 5 V into 50 Ω and 100 mA drive current. With a typical output resistance matched to 50 Ω , they can't drive low resistance loads that draw high current. To address these needs, Accel Instruments developed the benchtop TS250 high voltage and high current waveform amplifier for general laboratory and test and measurement applications. The TS250 will provide an output voltage to 65 V and can drive more than 6 A. The TS250 is used to amplify function generators and other weak signal sources (see **Figure 1**), extending the function generator's capabilities.



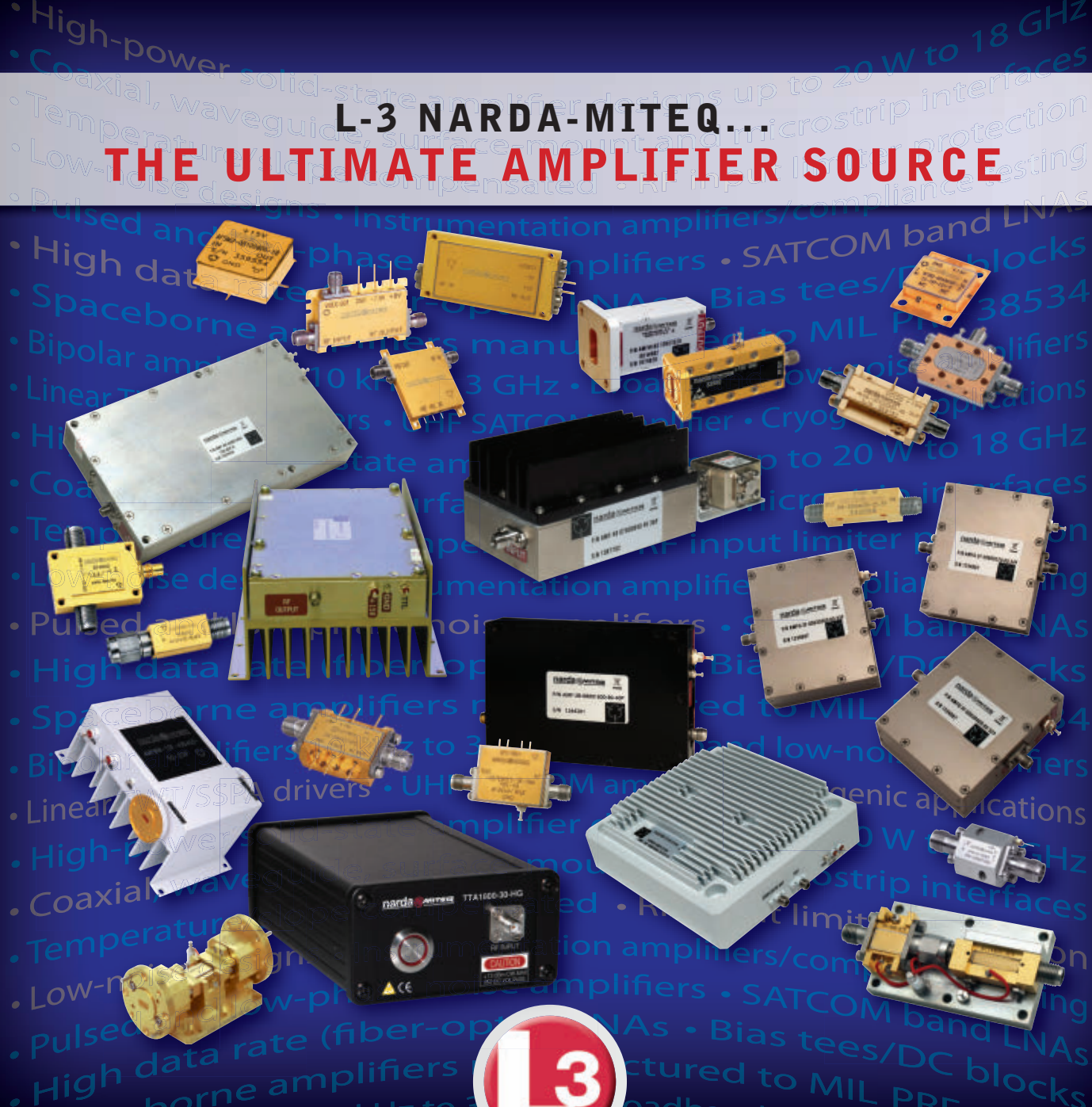
▲ Fig. 1 Typical use of a waveform amplifier.

The TS250 power amplifier (see **Figure 2**) has a selectable voltage gain of 0 or 20 dB. 20 dB is normally used for applications that require high voltage, while 0 dB supports high current applications. The input impedance of the TS250 can be set to either 50 or 1 k Ω . The TS250 amplifier has very low output impedance (approximately 50 m Ω) to maintain signal integrity without distortion. A DC offset voltage can be added to the output signal, similar to the DC offset feature with most function generators. It can generate an AC signal on the DC voltage, which is useful for power supply ripple or ripple rejection tests.

WAVEFORM DISTORTION

Using a signal generator to drive a non-50 Ω load can attenuate and distort the desired waveform. When driving low resistance loads, the signal will be attenuated by the voltage division from the higher source impedance, as shown in **Figure 3a**. A square wave from a function generator may be distorted by capacitive or inductive loads (see **Figures 3b** and **3c**). With a capacitive load, the source generator output resistance and load capacitance form a lowpass filter. With an inductive load, such as a relay or a magnetic coil, the generator output resistance and load form a highpass filter. Driving

L-3 NARDA-MITEQ... THE ULTIMATE AMPLIFIER SOURCE





narda  **MITEQ**

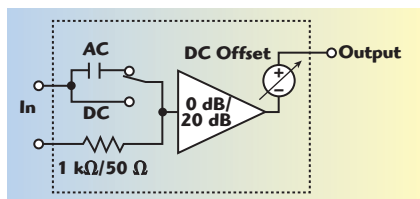
The Largest and Broadest Amplifier Selection

L-3 Narda-MITEQ offers more amplifier solutions than any other company. With over 60 years of experience and an extensive, diversified amplifier design library, we can meet or exceed your specific requirements quickly. We are the proven source for standard and customized amplifier solutions, offering more than 10,000 catalog products. Providing everything from design to production, we are ready to meet your most complex challenges. When your next project demands an amplifier with a proven track record, count on L-3 Narda-MITEQ – *your best resource for amplifier solutions.*

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

Narda-MITEQ

  L3com.com

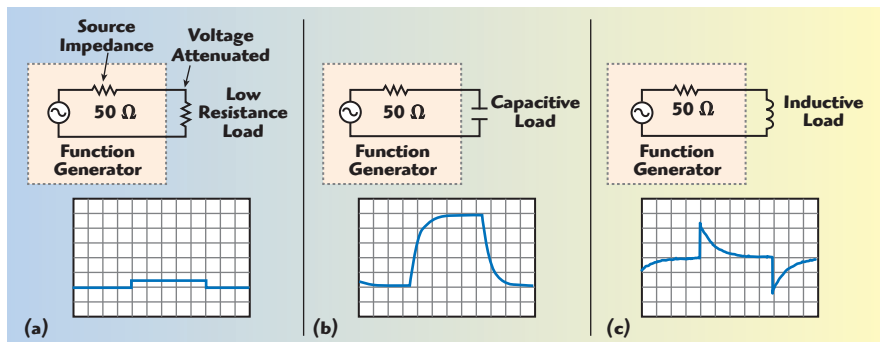


▲ Fig. 2 Functional block diagram of the TS250 waveform amplifier.

such loads from the TS250 waveform amplifier will not distort the waveform because of the TS250's low source resistance and high current capacity.

APPLICATIONS

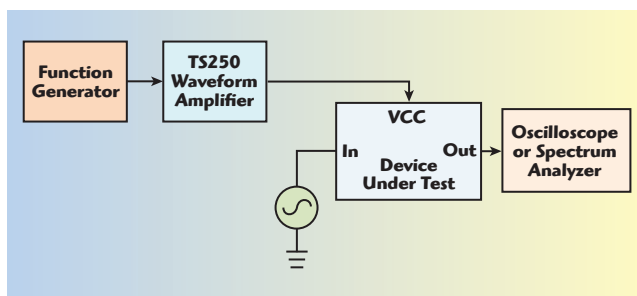
Piezoelectric transducers, electro-mechanical relays and power supplies are three applications that require higher voltage than is available from most function generators, i.e., from 10 to 65 V. Other applications present low impedance loads and require high current, such as generating a high magnetic field in a coil. Yet other cases — voltage transient and pulsed thermal transient testing — require both high current and high voltage. Some signal sources are weak and require amplification, such as data acquisition systems (DAQ).



▲ Fig. 3 Examples of waveform distortion when a 50 Ω function generator drives low resistance (a) capacitive (b) and inductive (c) loads.

The output impedance of a DAQ is low, 1 Ω or so, with a limited current drive of 1 mA. DAQ analog outputs are designed to see a load of 1 kΩ or greater. In all of these applications, a waveform amplifier is needed.

A common product development test is power supply ripple injection and rejection, to identify amplifier spurs or phase and am-



▲ Fig. 4 Test setup for power supply ripple rejection.

plitude noise caused by noise from the power supply. This requires generating an AC ripple voltage on top of the DC supply voltage and sweeping the ripple frequency from near DC to 1 MHz. The AC ripple is usually a sine wave, although it can be any waveform, such as a square or triangle wave or random noise. The test is particularly difficult when the device being tested draws high DC current. **Figure 4** shows how the TS250 waveform amplifier is used for ripple injection testing. Using a network analyzer in place of the function generator and oscilloscope or spectrum analyzer enables measurement of the power supply ripple rejection ratio (PSRR).

Helmholtz coils are commonly used to generate uniform magnetic fields; however, producing high frequency and high magnetic fields is challenging, requiring high current drive. Using a series capacitor to tune the Helmholtz coils to resonance cancels the coils' reactance, reducing the coils' impedance from 10 kΩ to less than 1 Ω, or just the parasitic resistance of the coils. The TS250 amplifier can drive up to 6 A through the coils to produce high magnetic fields at high frequencies.

Accel Instruments
Irvine, Calif.
www.accelinstruments.com

Covering Your Spectrum

- Fixed Attenuators
- Variable Attenuators
- Terminations
- Power Dividers/Splitters
- RF Adapters
- DC Blocks
- RF Tuners
- DC to 50 GHz
- 1 Watt to 2000 Watts
- Custom Solutions

*Providing the highest quality and cost-competitive
Broadband RF and Microwave Products
in the Industry since 1989.*

Visit our new website with interactive catalog and online RFQ!

www.WeinschelAssociates.com

19212 Orbit Drive
Gaithersburg, MD 20879
Voice: 301.963.4630
Fax: 301.963.8640
RF@WeinschelAssociates.com





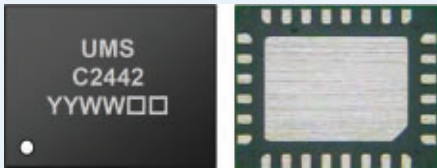
www.rosenberger.com/aerospace

Aerospace Products

Whether aviation or spaceflight applications – Rosenberger is a qualified and trusted supplier of connectors and cable assemblies to the aerospace industry. Our aerospace products are designed and manufactured in accordance with ESCC, MIL-PRF 39012, or DIN EN 9100.

PRODUCT RANGE

- Cable assemblies
- Board-to-Board connections
- Board-to-Cable connections
- SMD types
- PCB connectors



24 GHz Transceiver for Industrial Sensors and Automotive Radar

United Monolithic Semiconductors has utilized its expertise on the design, manufacture and marketing of leading edge RF and millimeter wave components and solutions to develop the newly introduced CHC2442-QPG, a state-of-the-art, fully integrated 24 GHz transceiver solution for industrial sensor and automotive radar applications. Designed specifically to address sensor applications in the 24 GHz ISM band, the transceiver provides a fully integrated front-end. It offers a high level of flexibility, which can make it the basis for a wide range of industrial sensors, from short range car applications to robotic and peripheral security systems.

LEADING EDGE PERFORMANCE

The CHC2442-QPG includes a signal generation Tx and a dual reception Rx in a single component. This solution is claimed to offer leading edge performance due to a low phase noise voltage controlled oscillator (VCO), a high transmit power level, dual Rx with very low noise figures, all combined with a high level of isolation between Tx and Rx channels. The versatile transceiver also includes power and temperature monitors and a programmable pre-scaler.

The CHC2442-QPG is fully compatible with standard digital interfaces through a serial interface (SPI) with data read and write capabilities. It is available in a surface-mount 28L-QFN4X5 SMD plastic package,

is qualified to AEC-Q100 and is also available in high production volumes.

INTEGRATION

A high level of integration and state-of-the-art performance make the CHC2442-QPG a more than suitable solution for industrial sensor and automotive applications. Operating in the -40° to $+125^{\circ}\text{C}$ temperature range, features include maximum Tx power of >13 dBm with a Tx power control range of 12 dB, Rx gain of 37 dB and an Rx gain control range of 24 dB.

United Monolithic Semiconductors (UMS)
Paris, France
www.ums-gaas.com



6.5 to 40 GHz Microwave Power Modules

The M1245 MPM provides 200 W minimum output power across 6.5 to 18 GHz, with spurs no greater than -50 dBc and a maximum noise power density of -35 dBm/MHz. The power amplifier's small-signal gain is 60 dB minimum. The RF input connector is SMA female, and the output interface is WRD-650 double-ridged waveguide. The MPM operates from a $+270$ VDC supply, per MIL-STD-704E, and has 900 W maximum power dissipation. The housing size is $8.5" \times 9.75" \times 1.5"$.

The M2842 MPM is designed to provide 60 W minimum output power from 18 to 40 GHz and 100 W minimum from 20 to 36 GHz. Spurs are no greater than -45 dBc, the maximum

noise power density is -30 dBm/MHz and the minimum small-signal gain is 40 dB. The RF input connector is a 2.9 mm female, and the output interface is WRD-180 double-ridged waveguide. This MPM operates from a $+28$ VDC supply and dissipates a maximum of 400 W. The housing size is $8.5" \times 9.75" \times 1.75"$.

Both MPMs have individual on/off controls for supply voltage and RF, with visual indicators for warm-up, high voltage and a fault condition. The units are cooled by conduction and can operate from -40° to $+85^{\circ}\text{C}$.

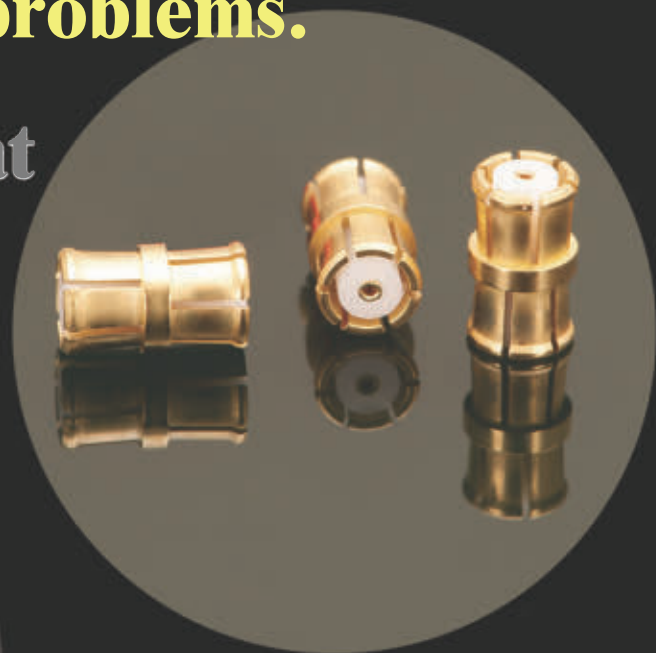
L-3 Electron Devices
San Carlos, Calif.
www.L-3com.com/edd

For defense and communications applications that require high power, L-3 Electron Devices offers two microwave power modules (MPM) that lead in size, weight and power (SWaP). Integrating a solid-state driver, TWT and power supply, each MPM is housed in a compact package designed for rugged military environments.



We design and manufacture the products to help solving your problems.

We don't just do what everyone else does.



www.spectrum-et.com

Email: sales@spectrum-et.com



Tunable Frequency and Bandwidth Filter

K&L is shipping a digitally-controlled bandpass filtering system that tunes anywhere from 700 MHz to 6 GHz and has continuously adjustable bandwidth. The system simplifies LTE and Wi-Fi testing by eliminating the large number of fixed filters required to cover all the bands. This single filter can be tuned to any of the cellular and Wi-Fi bands between 700 MHz and 6 GHz and the filter bandwidth set to the appropriate

channel bandwidth. For a center frequency between 700 MHz and 2 GHz, the 1 dB bandwidth can be set from 5 to 40 MHz. For a center frequency between 2 and 5 GHz, the 1 dB bandwidth can be from 10 to 40 MHz, and between 5 and 6 GHz, the bandwidth can range from 12 to 40 MHz. The filter's harmonic rejection is 60 dBc from DC to 13 GHz.

The filter system has Ethernet, GPIB, USB and RS-232 interfaces

with compatible software for automated testing. The user interface works with smartphones, tablets and traditional PCs. The filter system measures 27" x 31" x 22" and weighs approximately 200 lbs.

K&L Microwave
Salisbury, Md.
www.klmicrowave.com

Find Reps, Engineers and Used Equipment.

Post your listing on the new MWJ classified section.



Frequency Matters.

classified

Help Wanted

www.mwjjournal.com/classifieds

HIGH PERFORMANCE PASSIVE FREQUENCY DOUBLERS

Up to
**15.0
GHz**



Features

- | Low Conversion Loss
- | Good Harmonic & Sub-Harmonic Rejection
- | Small Size

Talk To Us About Your Custom Requirements.



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

EDI CON

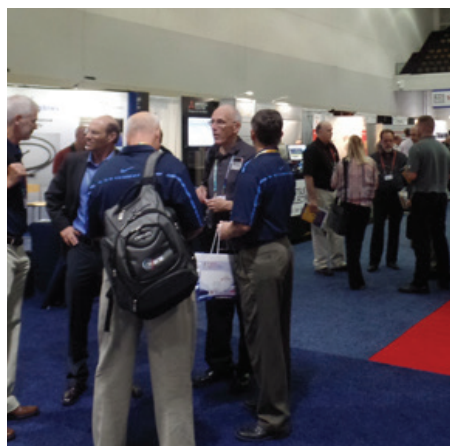
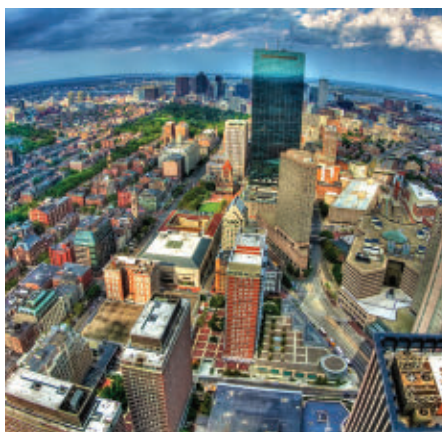
BOSTON

2017

September 11-13
Hynes
Convention Center

Save the date!

- Only industry event for RF & microwave engineers in the continental US in 2017
- Biggest high-speed design conference on the East Coast



Plan a fall getaway to New England, attend EDI CON USA!

Bring your team: Alumni and Group discounts

Bring your family: Partner Programs: see the best of Boston

Spend the day: Daily round trip private busing from Boston suburbs for local attendees

Attend the conference: Influence tomorrow's engineers and designs, learn something new

Attend the exhibit: Network with industry experts, see the latest products and services



EDI CON is where high-frequency meets high speed: what's similar, what's different, and how we can learn from each other. See you in Boston!

Scan page
using [layar](#) app

www.EDICONUSA.com

component and system simulation ■ materials/PCB boards ■ devices and foundry services ■ components
cables and connectors ■ test and measurement ■ verification ■ RF and microwave ■ 5G ■ IoT
autonomous cars ■ radar ■ signal integrity ■ power integrity ■ EMC/EMI

EDI CON China
comes to Shanghai!



2017

Electronic Design **Innovation** Conference

电子设计**创新**大会

Reserve your booth now to reach engineers in China working on
RF, microwave, and high-speed digital designs

April 25-27, 2017

Shanghai Convention & Exhibition
Center of International Sourcing

Scan page
using **layar** app

Shanghai, China



Conference includes: technical sessions, workshops, panels, short courses, poster sessions, and plenary keynotes.

Partnerships:

China Electrotechnical Society's (CES) Electromagnetic Technology Conference & Exhibition (EMC China)
China Radar Industry Association (CRIA) conference

Sponsorships: Gold, silver, bronze, and exhibit sponsorships now available.



Fifth year for the conference

**EDI CON China 2016 saw
35% increase in unique attendees**

**Exhibition of more
than 100 companies**

Sign up now to choose your booth! **EDICONCHINA.com**

Host Sponsor:



Diamond Sponsor:



Corporate Sponsor:



Organized by:



EDI CON China returns to Beijing, April 17-19, 2018.

Benchtop Power Amplifier

VENDORVIEW

The 350S1G6 provides wide-band high linear output power over a frequency band of 0.7 to 6 GHz. Over 350 W of output power is achieved with only 1 mW of input power. This amplifier is designed using "Hybrid Microelectronics Technology" resulting in an amplifier with greater power density, smaller size and lower production cost than previously possible. For a full product demo, visit www.arworld.us/html/video-AR350S1G6%20Amplifier.asp.

AR RF/Microwave Instrumentation
www.arworld.us



Build Your Own Bandpass Filter

VENDORVIEW

AtlanTecRF launched its second 'build your own' web tool, specifically designed for people looking to customize bandpass filters. Every web tool is designed by engineers with the aim of simplifying the product specification process by guiding each user through a range of simple questions. Once completed, the form provides the AtlanTecRF customer services team with the information needed to deliver a customized quote that matches each customer's bandpass filter specifications.

AtlanTecRF
www.atlantecrf.com



Improved Navigation and Support

K&L Microwave's website provides information and tools, such as the Filter Wizard® web application, to speed the identification of custom design solutions from a full range of company products. The latest web update features a new look, mobile device support, social media links and improved LTE band navigation to test set components for broadband emission monitoring. Customers can also research capabilities, access datasheets, submit quote requests and download catalog sections.

K&L Microwave
www.klmicrowave.com

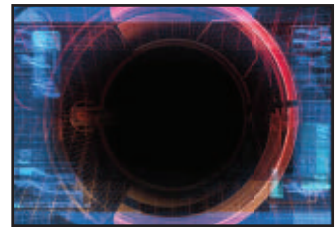


Unlocking Millimeter Wave Insights

VENDORVIEW

Sit down with Keysight millimeter wave experts in a new video, "Unlocking Millimeter Wave Insights," as they discuss the challenges and the commercialization of tools for millimeter wave design, simulation, measurement and analysis. As you reach up to millimeter wave, it's easy to underestimate the complexities at these frequencies. See how Keysight is taking the mystique out of millimeter waves and unlocking new insights in this short video. Visit <https://youtu.be/mVJCZ5wAU0Y> to learn more.

Keysight Technologies Inc.
www.keysight.com



New Look and Content

Kuhne electronic's new website features a new look and new content that is clear, modern, informative and responsive. Simply download the datasheets of the company's modules with just one mouse click, or browse various applications to find a solution for your project. Using dedicated specification filters allows customers to immediately locate the respective module. Also, take a look at the new products including bidirectional amplifiers, signal generators for RF heating and plasma applications, linearized amplifiers and much more.

Kuhne electronic GmbH
www.kuhne-electronic.de



Added Functionality and Value Features

Microwave Marketing's new website has been designed to offer greater functionality and access to manufacturer/product information. It now offers more product and market focus, enabling customers to view synergistic products across multiple brands, either within the same application set or product group. Added value features help customers find solutions to fit their requirements for multiple building blocks within the same system. Further features that will be launched soon include technical and applications support via live chat, and a web store for direct purchases.

Microwave Marketing
www.microwavemarketing.com



RF-LAMBDA

THE LEADER OF RF BROADBAND SOLUTIONS

ITAR & ISO9000
Registered Manufacture



PIN DIODE, GaAs AND GaN CONTROL PRODUCTS

SWITCH IN PIN DIODE, GaAs AND GaN TECHNOLOGY UP TO 67GHz



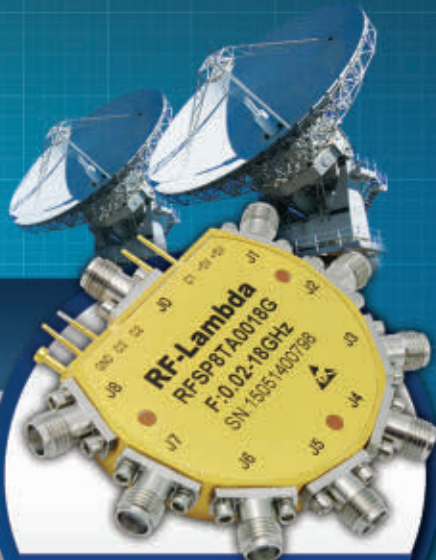
PN: RFSP4TA5M43G
FULL BAND 0.05-43.5GHz SP4T
SWITCH 50NS SPEED



PN: RFSP2TRDC18G
HIGH POWER 10W DC-18GHz HOT
SWITCHABLE SP2T SWITCH



PN: RFSP2TR5M06G
HIGH POWER 100W DC-6GHz HOT
SWITCHABLE SP2T SWITCH



PN: RFSP8TA0018G
HIGH IP3 500DBM 0.02-18GHz
SP8T PIN DIODE SWITCH



PN: RFPST1826N6
DIGITAL CONTROL PHASE SHIFTER 360
DEGREE 64 STEP 18-26GHz

DIGITAL AND VOLTAGE CONTROL PHASE SHIFTER UP TO 40GHz



PN: RFPST0618N6
DIGITAL CONTROL PHASE SHIFTER
360 DEGREE 64 STEP 6-18GHz



PN: RVPT0818GBC
VOLTAGE CONTROL PHASE
SHIFTER 360 DEGREE 8-18GHz



PN: RVPT0408GBC
VOLTAGE CONTROL PHASE
SHIFTER 360 DEGREE 4-8GHz

DIGITAL AND VOLTAGE CONTROL ATTENUATOR UP TO 50GHz



PN: RFDAT0040G5A
DIGITAL STEP ATTENUATOR
0.1-40GHz 5 BITS 31dB



PN: RFVAT0218A30
VOLTAGE CONTROL ATTENUATOR
2-18GHz 30dB IP3 500DBM



PN: RFVAT0050A17V
VOLTAGE CONTROL ATTENUATOR
0.01-50GHz 17dB



PN: RFDAT0018G8A
DIGITAL STEP ATTENUATOR 0.1-18GHz
8 BITS 128dB IP3 500DBM

www.rflambda.com
sales@rflambda.com

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

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



New Cable Design Tool

VENDORVIEW

Pickering Interfaces' new graphics-based Cable Design Tool allows users to create customized cable assemblies using detailed design characteristics that include a selection of connector types, wire type, pin definitions, pin and cable labeling, cable bundling, length selection, sleeving comments and more. It also features a built-in library of standard cable sets for customization, or cables can be designed from scratch. The tool runs on all modern browsers and is fully supported on all major tablet operating systems.

Pickering Interfaces Ltd.
www.pickeringtest.com



Field Replaceable Connectors

Signal Microwave has updated their website. Recently added is a new line of 2.92 mm field replaceable connectors with typical VSWR under 1.10:1. These are available in standard 2 and 4 hole flange sizes. Test board offerings now include 40 and 70 GHz boards for VNA calibration verification. These boards can be used as a measurement verification tool. The basic version consists of a 50 Ω through line, a 25 Ω "Beatty" line and a 100 Ω differential pair line.

Signal Microwave
www.signalmicrowave.com



Smart Front-End Module

VENDORVIEW

Skyworks introduced a highly integrated 470 to 510 MHz front-end module (FEM) that is ideal for smart energy, smart metering (electric, gas, water, heat), security, RFID, industrial and other Internet of Things (IoT) applications. The SKY66115-11 FEM operates over a wide variety of supply voltages at low power consumption and comes in a small 4 mm \times 4 mm \times 0.9 mm, 16-pin multichip module solution. Its extended range more than doubles when compared to a stand-alone system-on-chip solution. Visit www.skyworksinc.com/Product/3138/SKY66115-11.

Skyworks Solutions Inc.
www.skyworksinc.com



Connector Installation Videos

VENDORVIEW

The SPINNER MultiFit™ and SPINNER Cut And Fit (CAF®) monobloc connectors have been a big hit with installers. Their easy handling, fast, reliable installation and excellent technical values put them in a class of their own. And now SPINNER has released installation videos to supplement the written instructions. The installation videos show the connectors for the following cable types and sizes: SF 3/8", SF 1/2", LF 1/2", LF 7/8", LF 1 1/4" and LF 1 5/8".

SPINNER GmbH
www.youtube.com/spinnergmbh



Website Launch

VENDORVIEW

Smiths Microwave Subsystems announced that TRAK Microwave has launched a new website. The site has been designed to allow easy navigation through a library of time and frequency systems, integrated microwave assemblies and high performance ferrite components. Users can download datasheets, request pricing with attachments, check out the factory, find a local sales representative, submit questions and view all new items posted on the site in the updates section—including product releases, tech briefs, company news, events and insightful blogs.

TRAK Microwave Corp.
www.trak.com



Ferrite Bead Impedance Calculator

Vishay Intertechnology Inc. has introduced the industry's first online ferrite bead impedance calculator. Available at www.vishay.com/inductors/ferrite-bead-calculator/, the time-saving online tool makes it simple to find the impedance of Vishay's most popular surface-mount ferrite beads at any given frequency and calculate the effective impedance at the stated frequency with DC bias applied. The new calculator eliminates the need to determine impedance information from the Z vs. frequency graph in product datasheets, plus it also removes the guesswork in determining how much impedance is reduced.

Vishay Intertechnology Inc.
www.vishay.com



December Short Course Webinars

Technical Education Training

PAM4 Demands Accurate S-Parameters

Sponsored by: Anritsu
Live webcast: 12/1/16

CST Webinar

Simulating Electromagnetic Shielding in Electronics and Transportation Applications

Live webcast: 12/1/16

RF/Microwave Training

MMIC Design Overview

Sponsored by: National Instruments
Live webcast: 12/6/16

Technical Education Training

Designing Antennas Using COMSOL Multiphysics®

Sponsored by: COMSOL
Live webcast: 12/8/16

CST Webinar

Accurate Simulations of Multistage Axial VIRCATORS Operating in S-Band Using CST PARTICLE STUDIO

Live webcast: 12/8/16

CST Webinar

Radome Simulation

Live webcast: 12/15/16

Technical Education Training

Demystifying 5G and the Evolution to Massive MIMO for Increased Capacity and Profit

Sponsored by: Rohde & Schwarz
Live webcast: 12/15/16

CST Webinar

Coreless Packaging Technology for Compact, High-Performance Mobile Devices

Live webcast: 12/20/16

Register to attend at mwjournal.com/webinars

Scan page
using  app

Past Webinars On Demand

Technical Education Training Series

- Ampleon Brings RF Power Innovations Towards Industrial Heating Market
- Tackling the Test Challenges of Next Generation ADAS Vehicle Architectures
- Performing On-Wafer VNA Measurements from 70 kHz to 110 and 145 GHz
- Design of an 800 W GaN Power Amplifier Stage for Pulsed L-Band Applications Using Simulated Load-Pull
- Preparing for the Autonomous Car: Developing a 5G Network and Integrating Sensors
- Innovative Passives and Substrates Enable RF Power Amplifier Designs for Cooking Applications
- VCO Fundamentals
- On the Road to 5G, Advances in Enabling Technology: A Materials Perspective
- Vector Network Analyzers as a Tool for Signal Integrity in High Speed Digital Systems
- SiGe and RF SOI for Sub-6 GHz LNA Applications
- The Promise and Perils of mmWave
- Specifying Flexible Building Blocks for Automated Production Test Systems
- Improving Base Station Design -- RF Innovations

RF/Microwave Training Series

Presented by: Besser Associates

- Passive Components: Dividers, Couplers, Combiners
- Introduction to Radar
- Mixers and Frequency Conversion

CST Webinars

- Antenna Analysis and Design with Characteristic Mode Analysis
- Transformer Simulation
- EMC Simulation for Space Applications with CST STUDIO SUITE
- Analyzing HF & LF RadHaz Scenarios with 3D EM Simulation

Innovations in EDA

Presented by: Keysight Technologies

- How to Design Phased Arrays for 5G, Radar and Satellite
- Advances in High Power RF Design

Keysight Wireless Communications and Connectivity Series

- Unlocking Wideband 5G & mmWave Insights to 110 GHz

Keysight in Aerospace/Defense

- Real-Time Recordings and Post-Processing of Wide Bandwidth EW Signals

CELEBRATING 40 YEARS!

Make Connections. Make a Difference.



**INTERNATIONAL WIRELESS
COMMUNICATIONS EXPO**

Conference: March 27-31, 2017

Exhibits: March 29-30, 2017

Las Vegas Convention Center

IWCEexpo.com

Integrating Technology & Education

IWCE 2017 is a venue where people can make the human connections they need to be successful, whether it is connecting to a future client, boss, employee or business partner. It's also where people can find information about a technology or policy that is crucial to success. See innovation at its best and join us for the premier event for communications technology.

REGISTER TODAY!

Use promo code SVE3 for 20% off IWCE conference and free exhibit hall admission.

Co-located with:



In partnership with IWCE's **URGENT** COMMUNICATIONS

Inspiration for Your Next Innovation

Be a part of the next chip, board, and
systems design revolution.

JANUARY 31 – FEBRUARY 2

Santa Clara Convention Center | Santa Clara, CA

REGISTER AT designcon.com

Use promo code “inspire” for
FREE expo admission

Host Sponsor



Unlocking Measurement Insights for 75 Years

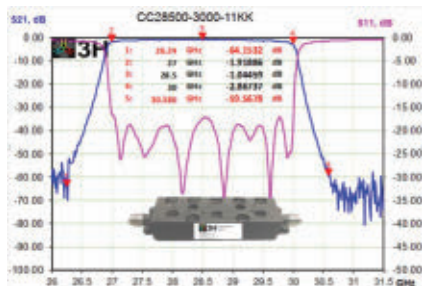


NEW PRODUCTS

FOR MORE NEW PRODUCTS, VISIT WWW.MWJOURNAL.COM/BUYERSGUIDE
FEATURING **VENDORVIEW** STOREFRONTS

COMPONENTS

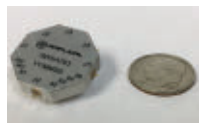
Bandpass Filter



3H's Ka-Band, bandpass filter has a center frequency of 28.5 GHz with a 3 dB bandwidth of 3 GHz. Insertion loss at Fo is >1.5 dB with a VSWR of 1.5:1 while offering >50 dB selectivity. This filter is capable of handling 50 W CW within a package size of 1.65" x 0.63" x 0.50". Please contact 3H Communication Systems at (949) 529-1583 or send an email to sales@3hcomm.com.

3H Communication Systems
www.3hcommunicationsystems.com

SP5T Absorptive Switch, Drop-In



Amplical's SW5A203 SP5T miniature broadband coaxial absorptive PIN diode switch features low insertion loss, low VSWR, high

isolation and fast switching speed. J1, J2, J3, J4 and J5 ports are terminated in 50 (when switched in the isolation (off) state). All RF ports incorporate DC blocks. An on-board TTL-compatible driver provides convenient logic control. The switch operates from +5 V DC and a negative DC supply ranging from -12 to -20 V. The ultra-compact package is designed for drop-in microstrip or strip line applications.

Amplical
www.amplical.com

PIN Diode SP8T Switch Reflective



Ducommun's 18 to 40 GHz PIN diode SP8T switch reflective, Model CP8-29225040-01, features low insertion loss/high isolation, fast switching and

complete solid-state solutions. The specifications are frequency: 18 to 40 GHz, insertion loss: 3 dB (goal), 5 dB (max) 18 to 30 GHz, 4 dB, (goal), 6 dB (max) 30 to 40 GHz, isolation: 40 dB (min) and return loss: 10 dB (min).

Ducommun
www.ducommun.com

Electromechanical Relay Transfer Switches



Fairview Microwave introduced a line of 43 electromechanical transfer switches that cover frequency bands from DC to 40 GHz.

These products can be used as "drop-out switches" for signal reversal or to bypass a component under test. Superior performance includes insertion loss as low as 0.2 dB and isolation greater than 80 dB.

Some models feature power handling capability up to 700 W (CW) at 1 GHz. These transfer switches are in-stock and ship same-day.

Fairview Microwave
www.fairviewmicrowave.com

mmWave Power Dividers



MECA's 2-way and 4-way, 30 W Wilkinson power dividers operate across microwave and mmWave bands covering 6 to 40 GHz with

2.92 mm connectors. The 2-way has typical numbers of 1.3:1 input and 1.17:1 output VSWRs and isolation of 22 dB Typ. The 4-way also has excellent typical specs of 1.2:1 VSWRs and isolation of 19 dB typ. Made in the U.S. and 36-month warranty.

MECA Electronics Inc.
www.e-MECA.com

ISM Band Bandpass Filter



This TX/RX filter dramatically reduces adjacent and out-of-band interference to the ISM Band (902 to 928 MHz), allowing higher data rates and im-

proved range. It features high Q, low loss and extremely sharp lowside cutoff limits 800 MHz cellular-band noise and interference. Available with SMA adapter board or stand-alone, it is designed for infrastructure ISM-Band users. It features automated data collection, dedicated monitoring and data links.

Integrated Microwave Corp.
www.imcsd.com

YIG-Tuned Band Reject Filters



Micro Lambda Wireless Inc. announced the production release of YIG-tuned band reject filters with 50 dB notch depths at 500 MHz and 60 dB notch depths starting at 2 GHz. Standard models cover the 500 MHz to

2 GHz, 2 to 6 GHz, 6 to 18 GHz and 2 to 18 GHz. The standard model operates over the 0 to +65°C temperature range, but Military versions covering -40° to +85°C are available on special order.

Micro Lambda Wireless
www.microlambdawireless.com

Power Splitter/Combiner



Mini-Circuits' ZN2PD2-14W+ is a 2-way 0° high-power splitter/combiner providing up to 35 W power handling as a splitter (1 W as a

combiner) and low insertion loss across the entire 500 to 10500 MHz frequency range. Its outstanding combination of high power handling and low loss

minimize power dissipation and provide excellent signal power transmission from input to output. The ZN2PD2-14W+ comes housed in a rugged aluminum alloy case measuring 4.5" x 2.5" x 0.67" with SMA connectors.

Mini-Circuits
www.minicircuits.com

18 to 40 GHz Down-Converter



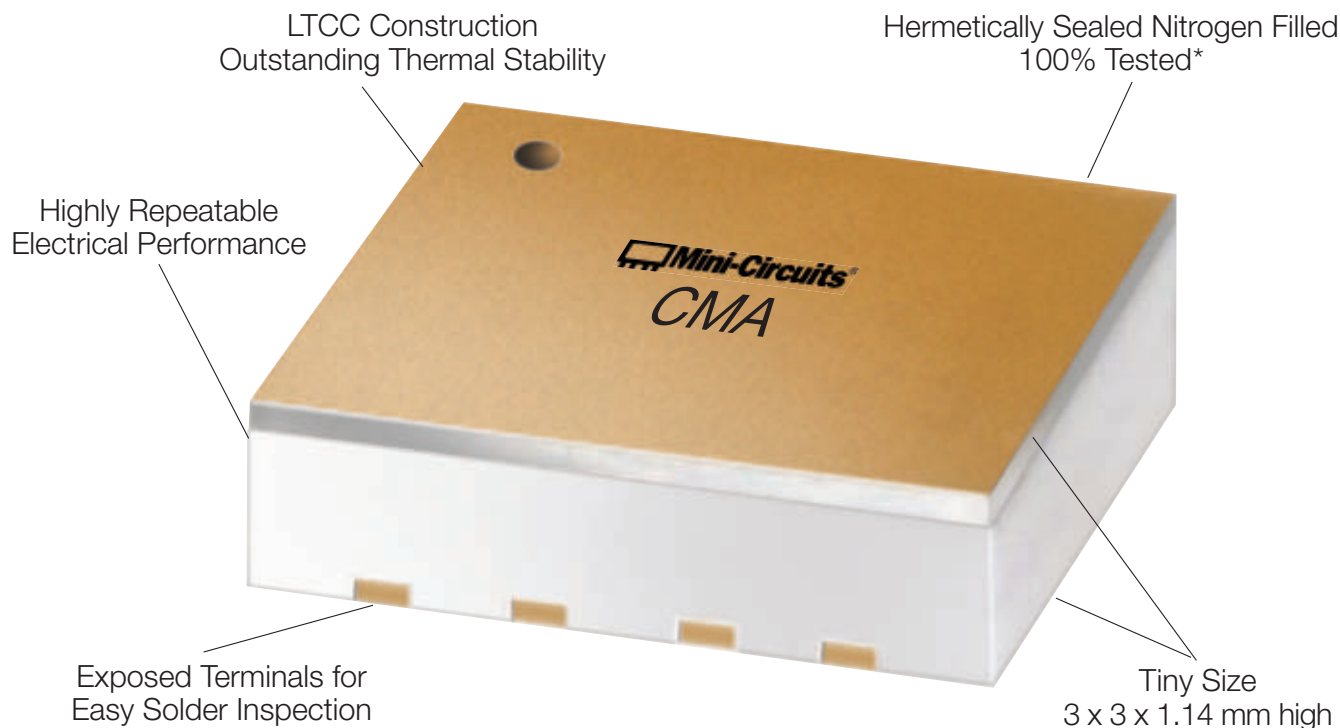
Model N15-5356 is a millimeter wave frequency converter with a single RF input and two IF outputs at 4 to 18 GHz. The unit has integrated LO sources and down-converts 18

to 26.5 GHz and 26.5 to 40 GHz simultaneously. A positively sloping gain across the frequency range compensates for other system losses.

Norden Millimeter
www.nordengroup.com

ULTRA-REL™ CERAMIC MMIC AMPLIFIERS

10 MHz to 7 GHz



Low NF from 0.5 dB High IP3 up to +42 dBm Low DC current 65 mA **\$745** from ea. (qty 20)

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

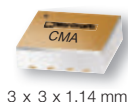
Qualified for: (see website for complete list and details)

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

*Gross leak only

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

Electrical Specifications (-55 to +105°C)



3 x 3 x 1.14 mm

| Model | Freq. (GHz) | Gain (dB) | P _{OUT} (dBm) | IP3 (dBm) | NF (dB) | DC (V) | Price \$ea. (qty 20) |
|------------|-------------|-----------|------------------------|-----------|---------|--------|----------------------|
| CMA-81+ | DC-6 | 10 | 19.5 | 38 | 7.5 | 5 | 8.95 |
| CMA-82+ | DC-7 | 15 | 20 | 42 | 6.8 | 5 | 8.95 |
| CMA-84+ | DC-7 | 24 | 21 | 38 | 5.5 | 5 | 8.95 |
| CMA-62+ | 0.01-6 | 15 | 19 | 33 | 5 | 5 | 7.45 |
| CMA-63+ | 0.01-6 | 20 | 18 | 32 | 4 | 5 | 7.45 |
| CMA-545+ | 0.05-6 | 15 | 20 | 37 | 1 | 3 | 7.45 |
| CMA-5043+ | 0.05-4 | 18 | 20 | 33 | 0.8 | 5 | 7.45 |
| CMA-545G1+ | 0.4-2.2 | 32 | 23 | 36 | 0.9 | 5 | 7.95 |
| CMA-162LN+ | 0.7-1.6 | 23 | 19 | 30 | 0.5 | 4 | 7.45 |
| CMA-252LN+ | 1.5-2.5 | 17 | 18 | 30 | 1 | 4 | 7.45 |

RoHS compliant



NewProducts

Active Frequency Multipliers



Pasternack, a leading provider of RF, microwave and millimeter wave products, has released a new series of active frequency multipliers that simplify system designs by offering

high output power levels. These active frequency multipliers are important building block components used in local oscillator (LO) chains for radar, communication receivers and frequency sources to extend frequencies and achieve optimal performance. They support multiple markets and applications including electronic warfare, electronic countermeasures, point-to-point radio, VSAT radio, test instrumentation and telecom infrastructure.

Pasternack

www.pasternack.com

Transfer Switch



PMI model no. PXS-1G2G-80-T-SFF is an absorptive, high speed, two pole transfer switch

capable of switching within 100 ns max. The frequency range is 1 to 2 GHz. This switch has > 80 dB isolation. Features include SMA female connectors. Unit

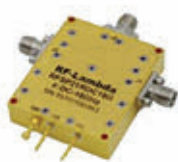


size is 1.2" x 1.2" x 0.5" with painted blue finish.

Planar Monolithics Industries Inc.

www.pmi-rf.com

Reflective DC to 18 GHz Coaxial SP2T Switch



RF Lambda's reflective DC to 18 GHz coaxial SP2T switch features wide band operation DC to 18 GHz with TTL compatible driver included. Fast switching speed 50 ns, low insertion loss and

high isolation, temperature ranges from -45° to +85°C. Customization is available upon request. Hermetically sealed packages up to 60,000 ft are available. Primary applications are military, airborne, wireless infrastructure, satellite communications and medical applications.

RF Lambda

www.rflambda.com

300 W Bidirectional Coupler



Richardson RFPD Inc. announced the availability and full design support capabilities for a new bidirectional surface-mount coupler from Innovative Power Products Inc. The IPP-8036 is one of the fea-

tured surface-mount products from IPP's full line of dual directional couplers. It is a 300 W,

50 dB dual directional coupler that operates from 20 to 1000 MHz. IPP has leveraged soft-board laminate technology and embedded internal terminations in order to offer the IPP-8036 in a surface mount package.

Richardson RFPD Inc.

www.richardsonrfpd.com

High Power Cavity Filters



RLC Electronics is currently manufacturing high power cavity filters for military and commercial applications. Filters can accommodate any high power connector desired, including but not limited to N, SC, HN or 7/16. The benefits of this type of filter include sharp attenuation, low loss and consistent performance unit-to-unit. The unit pictured above is a 1280 MHz bandpass filter with 65 dB rejection at 1000 MHz and 1800 MHz. The filter is rated for 400 W avg and 2000 W cW (20% duty cycle) and exhibits low loss (0.3 dB).

RLC Electronics Inc.

www.rlcelectronics.com

E-Band Waveguide Diplexer



Model SWY-74384355-12-11 is an E-Band waveguide diplexer with a low passband of 71 to 76 GHz and a high passband of 81 to 86 GHz. The nominal insertion loss of the diplexer is 0.5 dB and the minimum isolation is 55 dB. Since both low and high passband frequencies can be changed by modifying the design, custom designs are available under different model numbers.

SAGE Millimeter

www.sagemillimeter.com

Wide Bandwidth Triple-Balanced Mixer



Synergy introduced its "Spur Tamer" series of mixers with the release of the first model in this series. The STM-6000 is a broadband triple balanced mixer covering the LO and RF

frequency band from 1 to 6000 MHz and the IF port bandwidth is from 1 to 4000 MHz. The even mode spurious rejection are significantly improved over conventional triple balanced mixers, making this product ideal for applications in high performance frequency converters where low spurious and high LO rejection are desirable.

Synergy Microwave Corp.

www.synergymw.com

BLUE TOPS RF MODULES

LOW NOISE AMPLIFIERS
FREQUENCY MULTIPLIERS
FREQUENCY DIVIDERS
AND MORE!

- Inputs: 5 MHz to 8 GHz, fixed
- Outputs: to 16 GHz
- Machined Aluminum Case
- Integral Filters and Amps
- Low Intrinsic Phase Noise
- Low Conversion Loss
- Low Cost / Fast Delivery

"Quietly the Best"

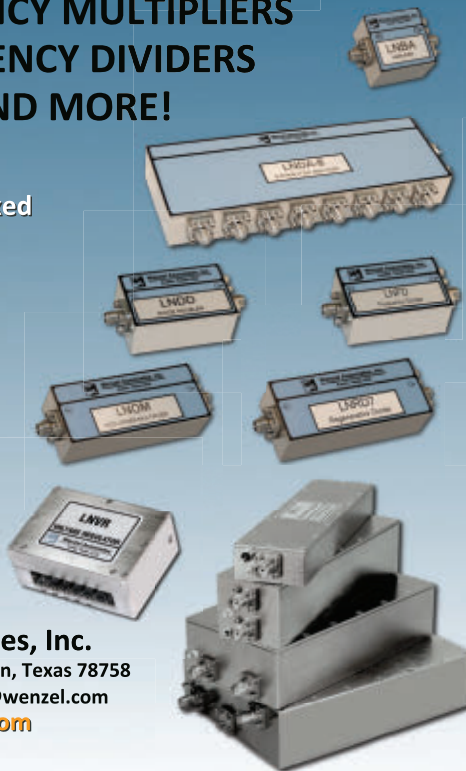


Wenzel Associates, Inc.

2215 Kramer Lane, Austin, Texas 78758

512-835-2038 • sales@wenzel.com

www.wenzel.com



SIX DAYS



THREE CONFERENCES



ONE EXHIBITION

EUROPEAN MICROWAVE WEEK 2017
NÜRNBERG CONVENTION CENTER,
NUREMBERG, GERMANY
8TH - 13TH OCTOBER 2017



**EUROPEAN
MICROWAVE** WEEK
NÜRNBERG CONVENTION CENTER
NUREMBERG, GERMANY
8TH-13TH OCTOBER 2017
www.eumweek.com

EUROPE'S PREMIER MICROWAVE, RF, WIRELESS AND RADAR EVENT

THE EUROPEAN MICROWAVE EXHIBITION (10TH - 12TH OCTOBER 2017)

- 8,000 sqm of gross exhibition space
 - 4,000 Attendees
- 1,700 - 2,000 Conference delegates
- In excess of 300 international exhibitors (including asia and us as well as europe)

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

**EuMIC
2017**
The 12th European Microwave
Integrated Circuits Conference
Co-sponsored by:



47TH EUROPEAN MICROWAVE CONFERENCE 2017
The 47th European Microwave Conference
Co-sponsored by:



**EURAD
2017**
The 14th European Radar Conference
Co-sponsored by:



INTERESTED IN EXHIBITING?

For International Sales:

Richard Vaughan, International Sales Manager
E: rvaughan@horizonhouse.co.uk
Tel: +44 20 7596 8742

For US Sales:

Alyssa Connell, Event Coordinator
E: aconnell@mwjournal.com
Tel: +1 781 619 1930

OR VISIT: www.eumweek.com



Changzhou ZhongYing SCI&TEC Co., Ltd.

The Manufacturer of PTFE Laminate



Our New Product High Frequncy Plastic

Product Features

- Dk: 2.40, 2.55, 2.65, 3.00, 3.35, 3.55, 4.00, 4.50, 6.00
- Low Df: 0.0006~0.0012
- Stable Dielectric properties under different frequencies
- Excellent thermal-mechanical properties and stabilities
- ROHS compatible
- Applicable to injection molding and extrusion
- Weatherability: good
- Lasting operation temperature: 160 °C
- Reasonable commercial cost structure and fast bulk delivery

Applications

- Military radars, missile guidance systems
- Base station antennas, digital broadcasting antennas
- Phase shifter
- Filters, couplers and low-noise amplifiers
- Radio frequency connector

Add: No.28, Feilong West Road,
Zhonglou District, Changzhou
City, Jiangsu Province, China
Tel: +86-519-83253355
Fax: +86-519-83253350
Email: sd15@czzyst.cn;
pcb@czzyst.cn

NewProducts

CABLES & CONNECTORS

VNA Test Port Extension Cables



These phase stable alternatives to over-priced OEM test cables provide the utmost precision in vector measurements in the lab and during calibrations. The cable is constructed with an armor assembly to protect the cable and connectors, ensuring consistent performance in VNA, PNA and scalar test calibrations. Fewer calibrations means less downtime, resulting in the MegaPhase promise of lowest cost per measurement. Cable assemblies are available in any user-defined length up to 25 feet.

MegaPhase
www.megaphase.com/tm/vna

AMPLIFIERS

Wideband Medium Power Amplifier



Covering a frequency range of 0.1 to 20 GHz and more than 1 W output, Advanced Microwave's wideband medium PA comes with universal AC input, 95 to 250 V AC. This model is super linear and is ideal for multi-tone, radar and fiber-optic applications. It accepts narrow pulses less than 1 nano-sec.

Advanced Microwave Inc.
www.advmic.com

1 to 6 GHz, 350 W Benchtop PA



AR's 350S1G6 provides wideband high linear output power over 0.7 to 6 GHz. Over 350 W of output power is achieved with only 1 mW of input power. This amplifier is designed using "Hybrid Microelectronics Technology," resulting in an amplifier with greater power density, smaller size and lower production cost than previously possible.

AR RF/Microwave Instrumentation
www.arworld.us

GaAs Low Noise FETs



CEL is offering new GaAs low noise FETs to replace the discontinued Renesas Electronics FET devices. These new drop-in replacements support frequencies of 12, 20 and 24 GHz (K- and Ku-Bands). They are ideal for low noise blocks (LNB) for communications satellites including Direct Broadcast Satellites (DBS), VSAT systems and others.

CEL
www.cel.com/RF

1 to 40 GHz AMP with Detected Output



Ciao Wireless Inc. introduced an ultra-broadband amplifier which features an integrated wideband detector for communication applications. This amp comes with two min gain options of 30 dB min (35 dB TYP) and 15 dB min (20 dB TYP). The gain flatness is ± 3.25 maximum. The typical output power is +13 dBm across 1 to 28 GHz. The input and output VSWR is 2.3 or better. The typical noise figure is 6 across the full band (1 to 40 GHz).

Ciao Wireless Inc.
www.ciaowireless.com

C-Band RF Power Modules



High efficiency, high power and compact with proven GaN technology, the VSC3645 can be easily combined to create high power C-Band radar transmitters. CPI

BMD's solid-state power amplifiers are reliable, highly-efficient and easy to maintain. The VSC3645 solid-state power amplifiers are designed for use in maritime surveillance and weather radar transmitters covering 5.2 to 5.9 GHz. GaN transistors are combined into a 4.2 kW output and are air cooled.

Communications & Power Industries, Beverly Microwave Division
www.cpii.com/BMD

SSPA Module



Exodus introduced the ultra-wide band AMP1074 compact SSPA covering the full 2 to 20 GHz frequency band at 10 W min. The AMP1074 uses C&W

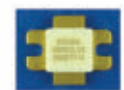
hybrid GaN devices, and operates from a 32 VDC supply at 4.5 A with gain flatness of 5 dB max peak-to-peak. Covering multiple bands, this SSPA is suitable for use with all modulation standards and features a small form factor, lightweight construction and high reliability. Typical applications include EMI/RFI testing, EW and communications systems.

Exodus Advanced Communications
www.exoduscomm.com

GaN-on-SiC HEMT Transistors

Integra Technologies' models IGN0912L45 and IGN0912L125 are designed for L-Band avionics applications. These high-power GaN-on-SiC HEMT transistors supply > 45 W and > 125 W of output power at 50 V drain bias, with up to 20 dB of gain and 57% of efficiency at 444 × (7 μs on, 6 μs off), 22.7% pulse conditions.

Integra Technologies Inc.
www.integrattech.com



2017 INTERNATIONAL MICROWAVE SYMPOSIUM

4 – 9 JUNE 2017 HONOLULU, HAWAII

CALL FOR PAPERS

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

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

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

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

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

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

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

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

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



Symposium Chairs

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

Technical Program

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

Electronic Paper Management

J. Hacker, M. DeLisio, S. Owens

Workshops and Short Courses

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

Panel, Rump, Focus, and Special Sessions

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

Interactive Forum

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

Plenary Session and 5G Summit

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

Technical Program Competitions

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

TPC At Large

J. Lin, H. Okazaki

Publicity, Promotions, and Publications

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

Website and Program Book

C. Brough, D. Goshi, M. Moorefield

Social Media

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

Microwave Magazine

I. Mostafanezhad, A. Singh

Local Arrangements / Operations

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

Finance and Registration

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

Student Volunteer Coordination

A. Morishita, J. Dang, T. Chun

Focus Groups

R. Pang, R. Iwami, B. Lei

Young Professionals

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

Women in Microwaves

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

STEM and Project Connect

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

MicroApps and Exhibitor Workshops

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

Historical and University Exhibits

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

Global Ambassadors

K. Wu, D. Zimmerman

Conference and Exhibition Management

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

Senior Advisors

T. Weller, S. Kanamalluru

Seals of Approval

NQA Registered ISO 9001:2008 & AS9100C

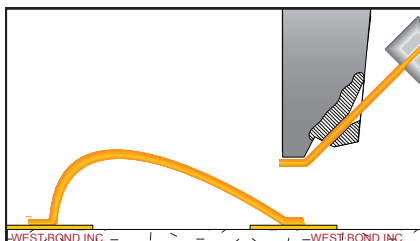
**Guaranteed Highest Possible
Hermeticity with Kovar®**



Metal Processing Co., Inc.
Specializing in Glass-to-Metal Seals

Kovar Feedthrus • Housings • Shrouds • Connectors

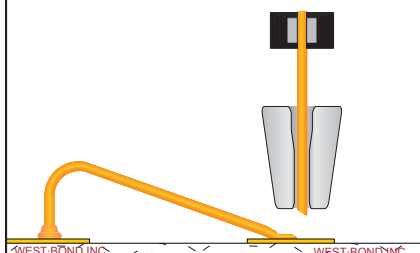
sales@metproco.com
www.metproco.com
978-649-1289



BOND

WIRE BOND

WEST BOND



www.westbond.com

NewProducts

SYSTEMS

Digital Receiver



The K707 digital receiver supports two FMC 310 plug-in modules providing up to 6 antenna inputs, 128 independent channels of DDC, and one spectrum analyzer embedded in a Xilinx Kintex-7 FPGA. It supports monitoring and/or recording of wide- or narrow-band spectra or channelized IF Band data. The receiver supports contiguous recording at 1,300 MByte/s to four SSDs until running out of disk space. Aggressively priced, this receiver combines an embedded PC running 6 4-bit Linux with an internal FPGA.

Innovative Integration
www.innovative-dsp.com

SOURCES

OEM Signal Generator Platform



Berkeley Nucleonics (BNC) released a user-customizable OEM signal generator platform for RF/microwave systems requiring brand singularity or

system integration. The platform leverages proven designs at 20 and 26.5 GHz, low phase noise, phase coherence and robust modulation features. Fast frequency switching speeds ensure a broad range of applications can be addressed. The Fast Switching (FS) option allows for extremely fast digital sweeps at a minimum rate of 10 μ s.

Berkeley Nucleonics
www.berkeleynucleonics.com

Wideband Microwave Signal Source



DS Instruments introduced a redesigned version of its highest-

end microwave signal generator with output past 22 GHz. Phase noise has been driven below -90 dBc at 10 KHz offset. New internal variable attenuators complement the standard stepped power output level settings. Active harmonic filtering to -30 dBc typical and dual-control put this device in a league with equipment priced thousands more.

DS Instruments
www.ds instruments.com

Low Phase Noise OCO



Morion has released the improved MV269, low noise OCO in a small DIL14 package, measuring just 21 mm \times 13 mm \times 9.5 mm. Available at 60 to 120 MHz, the MV269 has phase noise of -153 dBc/Hz @ 1 kHz offset



and < -170 dBc/10 kHz; sine wave or HCMOS. It works at 5 or 3.3 V. Temperature stability is at < 5E-8 from 0 to 60°C; frequency adjustment for external synchronization provided,

but due to excellent < 1E-7/year aging unit may work as a stand-alone unit; Ideal as a reference oscillator in synthesizer and PLL circuits.

Morion
www.morion-us.com

Compact Active Multiplier



QuinStar's model QMM-753012040 is a compact active (x4) multiplier designed for E-Band RF front-ends, driving LO ports of E-Band mixers and up-converters with 13 dBm typical power from 60 to 87 GHz. It is featured with a 2.9 mm coaxial connector at input, WR-12 output embedded with a waveguide window, and two side slots for mounting screw access. The multiplier has in-band harmonics rejection at 30 dBc or better and spurious signal rejection 60 dBc or better.

QuinStar Technology Inc.
www.quinstar.com

Voltage Controlled Oscillator



The DRO series voltage controlled oscillator is a fundamental, narrowband signal source utilizing a high-Q dielectric resonator for optimal phase noise performance. The DRO VCO solution is currently

being offered for frequencies operating within 7 to 14 GHz. This customizable, ultra-low noise oscillator series is available with both electrical tuning and mechanical tuning for fine frequency precision.

Z-Communications
www.zcomm.com

ANTENNAS

Filtered Omni-Directional Antennas



Southwest Antennas' new filtered omni-directional antennas with integrated goose-necks give users an easy plug-and-play solution for enhanced radio performance without complicating their radio setup. This can be particularly useful for handheld or

body worn tactical radio systems, which are often deployed in areas with crowded RF environments and powerful co-located transmitters. These antennas feature custom electronics inside of the antenna to ensure the filter performs optimally across the antenna's entire operating frequency range, and are available with several RF connector options.

Southwest Antennas
www.southwestantennas.com

MICRO-ADS

Advanced Switch Technology
Switches for the Telecom Industry



AST'S OUTDOOR SWITCHES
For all outdoor & severe weather applications
754 Fortune Crescent, Kingston, ON, K7P 2T3, Canada
Tel: 613 384 3939 - e-mail: info@astswitch.com
www.astswitch.com

VISA MASTERCARD DISCOVER

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:

AVOZ-D2-B: for production testing attenuators
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
AVRQ-5-B: for optocoupler CMTI tests

Avtech Electrosystems Ltd.
<http://www.avtechpulse.com/>



Coatings for EMI/RFI Shielding

X5 Series Electrically Conductive Elastomeric Systems

X5SC

Silver filled
Shielding effectiveness:
90-110 dB

X5N

Nickel filled
Shielding effectiveness:
40-60 dB

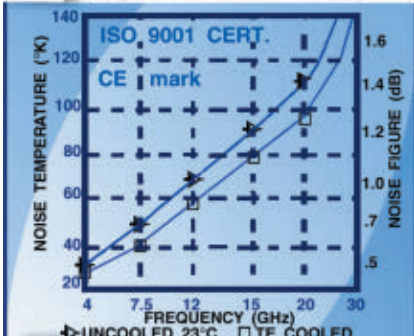
X5G

Graphite filled
Shielding effectiveness:
40-50 dB

MASTERBOND 40 YEAR ANNIVERSARY

+1.201.343.8983 • main@masterbond.com
www.masterbond.com

LOW NOISE AMPLIFIERS
www.SATELLINK.com



SATELLINK, INC.
3525 MILLER PARK DR.
GARLAND, TX 75042
CALL (972) 487-1434
FAX (972) 487-1204

34th

REVOLUTIONARY HERMETIC SMP CONNECTORS

These SMPs meet the requirements of MIL-STD-348, but utilize unique housing interface features, which significantly improves reliability and production assembly yields. Proprietary techniques are used to independently control plating thickness on pin and housing.



For use with Aluminum, Kovar and other package materials



SPECIAL HERMETIC PRODUCTS, INC.

PO BOX 269 - WILTON - NH - 03086
(603) 654-2002 - Fax (603) 654-2533
E-mail: sales@shp-seals.com
Web: www.shp-seals.com

TECHPLUS MICROWAVE Inc.

HIGHEST QUALITY FILTERS
FOR ANY
APPLICATION OR ENVIRONMENT

COMMERCIAL * MILITARY *
SPACE * PUBLIC SAFETY

WWW.TECHPLUSMICROWAVE.COM
916-672-6356

The best Solution for RF Technology!

LOWEST PRICE & HIGHEST QUALITY

SRTechnology Corporate

TERMINATION
N_{max} 2WATT
18GHz
VSWR 1.18:1

TERMINATIONS
ATTENUATORS
CONNECTORS
CABLE ASSEMBLIES
ADAPTORS

- Frequency Range : DC-18GHz
- Impedance : 50 Ohm
- Power Rating : 2 Watt
- V.S.W.R.
- DC-4GHz : 1.05:1
- 4-8GHz : 1.10:1
- 8-18GHz : 1.18:1

Warranty 3 years
Payment Term within 30 days from IN date

sales@srtechnology.com +82-2-908-9003
srtechnology.com

SECTOR MICROWAVE SWITCHES



MILITARY HI-REL COMMERCIAL

(631) 242-2300 PHONE (631) 242-8158 FAX
WWW.SECTORMICROWAVE.COM

RF Amplifiers, Isolators and Circulators from 20MHz to 40GHz

- Super low noise RF amplifiers
- Broadband low noise amplifiers
- Input PIN diode protected low noise amplifiers
- General purpose gain block amplifiers
- High power RF amplifiers and broadband power amplifiers



- RF isolators and circulators
- High power coaxial and waveguide terminations
- High power coaxial attenuators
- PIN diode power limiters
- Active up and down converters

Wenteq Microwave Corporation
138 W Pomona Ave, Monrovia, CA 91016
Phone: (626) 305-6666, Fax: (626) 602-3101
Email: sales@wenteq.com, Website: www.wenteq.com



Call for Papers

COMCAS 2017 continues the tradition of providing an international, multidisciplinary forum for the exchange of ideas, research results, and industry experience in the areas of microwave/RF/mm-wave engineering, communications, antennas, solid state circuits, electronic devices, engineering in medicine, radar, sonar and electronic systems.

The technical program includes invited talks by international experts and contributed papers and will be complemented by a large industrial exhibition.

Important Deadlines

Summary Submission:
April 20, 2017

Acceptance Notification:
July 3, 2017

Full Paper Submission:
September 4, 2017

For more information visit:

www.comcas.org

Email: comcas@ieee.org

Organizing Committee

Conference Chair:
Shmuel Auster
Elta Systems Ltd, Israel.
IEEE AP/MTT Chapter Chair

Technical Program Chair:
Amir Boag
Tel Aviv University, Israel

Technical Program Co-Chairs:
Stephen B. Weinstein
CTTC, USA

Caleb Fulton
Univ. of Oklahoma, USA

Oren Eliezer
Phazr, Texas, USA

Lance M. Kaplan
US Army ARL, USA

Aleksey Dyskin
Technion, Israel

Reuven Shavit
Ben-Gurion University, Israel

Ofar Barnea
Tel Aviv University, Israel

Publications Chair:
Benjamin Epstein
ECS Inc., USA

Global Administration:
James Rautio
Sonnet Software USA

Exhibition Chair
Oren Hagai
Intelligent, Israel

Students and Young Professionals:
Aleksey Dyskin
Technion, Israel
Yiftach Richter
Bar Ilan University, Israel

Treasurer:
Robert C. Shapiro
IEEE ComSoc

Electronic Submissions Chair and Co-chair:
Benjamin Epstein
ECS Inc., USA
Matthias Rudolph
BTU Cottbus, Germany

Local Arrangements Chair:
Itai Voller
AEAI, Israel

Tali Pe'er
Analog Devices, Israel

Publicity Chair and Co-Chairs
Carl Shreffers
Microwave Journal, USA

Pat Hindle
Microwave Journal, USA

Gary Lerude
Microwave Journal, USA

Sherry Hess
NII/AFR, USA

Antti Lautanen
NII/AFR, Finland

Tushar Sharma
University of Calgary, Canada

Members at Large:
Barry S. Perlman
MTT Society

Douglas N. Zuckerman
IEEE Communications Society

Advisor:
Paz Itzhaki-Weinberger
IWC Ltd, Israel

Secretariat:



Ortra Ltd.
1 Nirim Street, P. O. Box 9352
Tel-Aviv 6109202, Israel
Tel: +972-3-6384444 Fax: +972-3-6384455
Email: comcas@ieee.org

Papers are solicited in a wide range of topics:

Communications and Sensors

Long Range Low Power Networks
5G Mobile Communication
Cognitive Radio & Spectral Sharing
Software-Defined Radio & Multiple Access
Micro/Pico/Femtocell Devices and Systems
MIMO Antenna Systems for Communications
Modulation & Signal Processing Technologies
Spatial Coding
First Responder/Military Communications
Optical/Wireless Convergence and Integration
Radio over Fiber
Sensor Networks and Technologies
On-Body and Short Range Communications

Antennas, Propagation, and Scattering

Smart Antennas, Beamforming and MIMO
Wave Propagation and Channel Modeling
Wave Scattering and RCS
NanoEM, Plasmonics, and Applications
Metamaterials, FSS and EBG
EM Field Theory and Numerical Techniques
EM Interference & Compatibility, SI
Spectrum Management and Monitoring
ELF, RF, μ Wave, mmW and THz Measurements

Signal Processing (SP) and Imaging

Microwave Imaging and Tomography
Acoustic/Sonar Imaging and Techniques
Radar SP and Imaging, SAR, ATR
MIMO SP for Radar
Ground and Foliage Penetration Systems
Signal Acquisition and Sensor Management
DF, Emitter Location, Elint, Array Processing
Target Detection, Identification and Tracking
Data Fusion
Time Domain and UWB SP

RF/MW Devices and Circuits, RFICs

Solid-State Devices, RFICs
 μ Wave, mmW and Sub-mmW Circuits/Technologies
Nano and THz Devices/Technologies
Microwave Photonics
Passive Components and Circuits
Filters and Multiplexers
Ferroelectrics, RF MEMS, MOEMS, and NEMS
Active Devices and Circuits
RF Power Amplifiers and Devices
Tunable and Reconfigurable Circuits/Systems
Analog/Digital/Mixed RF Circuits
Circuit Theory, Modeling and Applications
Interconnects, Packaging and MCM
CAD Techniques for Devices and Circuits
Emerging Technologies
Thermal Management for Devices
Internet of Things

Microwave Systems, Radar, Acoustics

Aeronautical and Space Applications
RFID Devices/Systems/Applications
Automotive/Transportation Radar & Communications
Environmentally Sensitive ("Green") Design
UWB and Multispectral Technologies & Systems
Emerging System Architectures
Modelling Techniques for RF Systems
Radar Techniques, Systems and Applications
Sonar Systems and Applications
Wireless Power Transfer & Energy Harvesting
Terahertz Systems

Biomedical Engineering

Advances in MRI: Technology, Systems and Applications
Medical RF, MW & MMW Applications and Devices
Medical Imaging and Image Processing

General and Other Topics

Regular verbal presentations will be 20 min. in length; there will also be Poster sessions.

All submitted papers will be peer reviewed. Accepted papers will be published in the COMCAS 2017 Proceedings, which will be submitted for inclusion to IEEE Xplore® after the conference.

For author's instructions and further information, see www.comcas.org.



Join Us for Week Long Wireless Event
at the Hyatt Regency in Phoenix, Arizona

<http://www.radiowirelessweek.org/>

Program Highlights

KEYNOTE SPEAKER

Tuesday, 17 January 2017

"5G on the Road to WRC-19"

Jayne Stancavage, Senior Manager-Spectrum Policy (ITU-R), Intel Corporation

Abstract: Significant progress is being made on the road to 5G via research and development, the creation of new standards, network trials, and product designs. Two major efforts are currently underway in the International Telecommunication Union – Radiocommunication Sector (ITU-R). First, ITU-R Working Party 5D is undertaking a wide range of tasks culminating in the development of the specification(s) for IMT-2020. The second major effort revolves around spectrum access. Demand for mobile broadband spectrum continues to grow due to an increasing number of users (~3.6 billion mobile broadband subscriptions in 2016) and more bandwidth-intensive traffic such as video. Join us for a discussion on key milestones on the 5G road to WRC-19.

WORKSHOPS

Sunday, 15 January 2017 and Monday, 16 January 2017

Inkjet and 3D printed electronics for the Internet of Things and 5G communication systems

Chairs: Apostolos Georgiadis, Heriot-Watt University and Manos Tentzeris, Georgia Institute of Technology

Techniques for High Efficiency Linear Power Amplification of 5G Signals

Chair: Roman Maršálek, Brno University of Technology

High speed Optical Communications and Opto-electrical Component Technologies for 400 Gbit/s and Beyond

Chairs: Koichi Murata, GigPeak Inc. and Noriaki Kaneda, Nokia Bell Labs

Shaping the Career with Next Generation RF Technologies

Chairs: Tushar Sharma, University of Calgary and Ibrahim Khalil, NXP Semiconductors

PANEL SESSION

Monday, 16 January 2017

Linearization of Power Amplifiers in 5G

Chair: Neil Braithwaite, Consultant

MTT-S DISTINGUISHED LECTURER TALKS

Monday, 16 January 2017

Design of millimetre-wave multifunction integrated circuits for data communication and remote sensing applications

H. Zirath, Chalmers University

Millimeter-wave and Terahertz Applications Enabled by Photonics

T. Nagatsuma, Osaka University

Gallium Nitride Power MMICs – Fact and Fiction

C. Campbell, Qorvo

IEEE Topical Workshop on the Internet of Space

Tuesday, 17 January 2017 and Wednesday, 18 January

Introducing a new co-located conference at RWW, that will feature keynote talks "The Challenges of Space" and "Creating Iridium" as well as several presentations from industry and academic leaders in this booming field.

EXHIBITS AND DEMO SESSIONS

Monday, 16 January 2017 and Tuesday, 17 January



<http://www.radiowirelessweek.org/>



Telecommunication Networks for the Smart Grid

Alberto Sendin, Miguel Sanchez-Fornie,
Iñigo Berganza, Javier Simon
and Iker Urrutia

Telecommunication networks enable the so-called smart grid to be smart, relaying usage data to the utility and, when required and enabled, controlling usage to prevent demand from exceeding generation capacity. "Telecommunication Networks for the Smart Grid" was written to help the electric power industry understand the telecommunications technologies and services that underpin the smart grid. It

is equally useful for telecommunications professionals called to deploy or support smart grid networks.

Since readers won't likely have a full understanding of the topic, the first three chapters provide a foundation. The authors begin by defining the smart grid concept, identifying the standards for smart grids and discussing the requirements for the attendant networks. The second chapter provides a tutorial on telecommunications networks for power systems engineers who are not familiar with networking. For telecommunications engineers not familiar with power systems, the third chapter offers a similar tutorial.

The remainder of the book (chapters 4 through 9) covers smart grid applications and requirements, typical telecommunications technologies used, a networking architecture for meeting smart grid requirements and power line communications (PLC) and wireless approaches for relaying data. The final chapter has guidelines for

implementing a "pragmatic" smart grid project, including the end-to-end process, system design and requirements (e.g., EMC and environmental). The authors conclude with a smart grid example, beginning with the network design and showing the actual data traffic at key points in the network.

Collectively, the authors bring extensive experience in the power industry, telecommunications and smart grids. They all work for Iberdrola, a global electric utility based in Spain, with operations in Brazil, Scotland and the U.S.

To order this book, contact:

Artech House
www.artechhouse.com
ISBN-13: 978-1-63081-046-7
353 pages
\$169

Available in hardcover and eBook formats

THE LATEST "WORDS" IN MICROWAVE DESIGN...



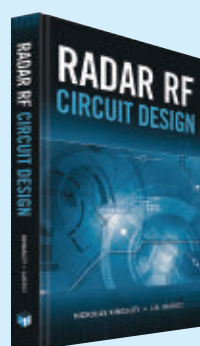
On-Wafer Microwave Measurements and De-embedding

Errikos Lourandakis
Hardcover • 280 pp. • 2016
ISBN: 978-1-63081-056-6
\$169 / £125



Modern RF Microwave Filter Design

Prakash Bhartia and Protap Pramanick
Hardcover • 412 pp. • 2016
ISBN: 978-1-63081-157-0
\$179 / £133



Radar RF Circuit Design

Nickolas Kingsley and Joseph R. Guerri
Hardcover • 316 pp. • 2016
ISBN: 978-1-60807-970-4
\$169 / £128

US: Call 1-800-225-9977 (in the U.S. or Canada),
or 1-781-769-9750, ext. 4030

Fax 1-781-769-6334

E-mail to: artech@ArtechHouse.com

UK: Call +44 (0)20 7596 8750

Fax +44 (0)20 7630-0166

E-mail artech-uk@ArtechHouse.com

For complete descriptions and to order, visit

ArtechHouse.com

All orders plus shipping/handling and applicable taxes.



ARTECH HOUSE
BOSTON | LONDON

685 Canton Street, Norwood, MA 02062 USA
16 Sussex Street, London SW1V 4RW UK

BE SEEN IN



Frequency Matters.

2017 Microwave Journal Editorial Calendar

| | EDITORIAL THEME | BONUS DISTRIBUTION |
|-------------------------------------|--|--|
| JAN | Radar and Antennas | DesignCon Military Radar Summit EMV |
| FEB | Satellite and Radio Communications | Mobile World Congress Satellite GOMACTech |
| MAR & SUPPLEMENT | Test and Measurement | Microwave & RF EDI CON China Expo Electronica |
| | Cables and Connectors | IWCE IEEE MTT-S IMS |
| APR | Amplifiers and Oscillators | WAMICON AUVSI Xponential |
| MAY | IEEE MTT-S IMS Show Issue | IEEE MTT-S IMS Space Tech Expo Aerospace Electrical Systems Expo |
| JUN & SUPPLEMENT | Semiconductors/MMICs/RFICs | Sensors Expo |
| | Aerospace & Defense Electronics | Sensors Expo EDI CON USA |
| JUL | RF & Microwave Software and Design | IEEE EMC & Signal/Power Integrity |
| AUG | High Frequency Components and PCBs + EDI CON Show Issue | IEEE Autotestcon EDI CON USA |
| SEP & SUPPLEMENT | European Microwave Week Show Issue | EuMW IEEE CSICS |
| | Military Microwaves | EuMW MILCOM |
| OCT | Passive and Control Components | AMTA COMCAS Asia Pacific Microwave Conference |
| NOV | Government and Military Electronics | |
| DEC | 5G and IoT New: Company Profile | IEEE MTT-S Radio and Wireless Symposium Mobile World Congress |

For more information, visit mwjournal.com/advertising

| ADVERTISER | PAGE No. | ADVERTISER | PAGE No. | ADVERTISER | PAGE No. |
|---|------------|--|---|--|-------------|
| Aaronia AG..... | 18 | IEEE Comcas 2017 | 116 | R&D Interconnect Solutions | 24 |
| Advanced Switch Technology | 115 | IEEE MTT-S International Microwave Symposium 2017 | 113 | Reactel, Incorporated | 45 |
| American Technical Ceramics..... | 75 | IEEE Radio & Wireless Week 2017 | 117 | Remcom..... | 83 |
| Anaren Microwave..... | 39 | IEEE WAMICON 2017..... | 62 | RF-Lambda | 35, 77, 103 |
| Anokiwave..... | 53 | IWCE 2017..... | 106 | RFMW, Ltd. | 13 |
| AR RF/Microwave Instrumentation | 29 | JQL Electronics Inc..... | 6 | Richardson RFPD | 19 |
| Artech House..... | 118 | K&L Microwave, Inc..... | 7 | Rogers Corporation..... | 31 |
| ASB, Inc..... | 90 | Keysight Technologies | 21 | Rohde & Schwarz GmbH | COV 3 |
| Avtech Electrosystems | 115 | L-3 Narda-MITEQ | 27, 93 | Rosenberger | 95 |
| B&Z Technologies, LLC | 15 | Linear Technology Corporation | 11 | Sage Millimeter, Inc..... | 9 |
| Berkeley Nucleonics Corp..... | 30 | Master Bond Inc. | 115 | Satellink, Inc. | 115 |
| California Eastern Labs..... | 69 | MCV Microwave | 84 | Sector Microwave Industries, Inc. | 115 |
| Cernex, Inc..... | 66 | MECA Electronics, Inc. | COV 2 | Signal Integrity Journal..... | 44 |
| Changzhou Zhongying SCI & TEC Co., Ltd. . | 112 | Mercury Systems, Inc. | 59 | Skyworks Solutions, Inc..... | 33 |
| Ciao Wireless, Inc..... | 42 | Metal Processing Co., Inc. | 114 | Special Hermetic Products, Inc..... | 115 |
| Coilcraft | 73 | MiCIAN GmbH | 88 | Spectrum Elektrotechnik GmbH | 97 |
| CPI Beverly Microwave Division..... | 41 | Microwave & RF 2017..... | 52 | SRTechnology Corporation..... | 115 |
| CST of America, Inc..... | 23 | Microwave Journal | 48, 58, 60, 98, 105, 119 | Stanford Research Systems..... | 61 |
| Custom MMIC | 89 | Mini-Circuits | 4-5, 16, 37, 49, 50, 63, 79, 85, 109, 121 | Synergy Microwave Corporation | 55, 99 |
| DesignCon 2017 | 107 | Modelithics, Inc..... | 26 | TechPlus Microwave, Inc..... | 115 |
| Eclipse Microwave | 34 | National Instruments..... | 25, 57 | Telecom Engine | 78 |
| EDI CON China 2017 | 101 | NI Microwave Components | 74 | Teledyne Microwave Solutions | 8 |
| EDI CON USA 2017 | 100 | Norden Millimeter Inc..... | 32 | UTE Microwave Inc..... | 67 |
| ET Industries | 68 | OML Inc. | 65 | Weinschel Associates | 94 |
| EuMW 2017 | 46, 111 | Pasternack | 91 | Wenteq Microwave Corporation..... | 115 |
| Fairview Microwave | 70, 71 | Polyphase Microwave, Inc..... | 60 | Wenzel Associates, Inc. | 110 |
| Frontlynk Technologies Inc. | 76 | Pulsar Microwave Corporation | 72 | Werlatone, Inc..... | COV 4 |
| GGB Industries, Inc..... | 3 | QuinStar Technology, Inc..... | 36 | West Bond Inc..... | 114 |
| Herotek, Inc..... | 28 | | | WIN Semiconductors Corp. | 87 |
| Holzworth Instrumentation..... | 40 | | | Z-Communications, Inc. | 58 |
| Huber + Suhner AG..... | 81 | | | | |

Sales Representatives



Frequency Matters.

Eastern and Central Time Zones

Chuck Boyd
Northeast Reg. Sales Mgr.
(New England, New York,
Eastern Canada)
685 Canton Street
Norwood, MA 02062
Tel: (781) 619-1942
FAX: (781) 769-5037
cboyd@mwjournal.com

Michael Hallman
Eastern Reg. Sales Mgr.
(NJ, Mid-Atlantic, Southeast,
Midwest, TX)
4 Valley View Court
Middletown, MD 21769
Tel: (301) 371-8830
FAX: (301) 371-8832
mhallman@mwjournal.com

Pacific and Mountain Time Zones

Brian Landy
Western Reg. Sales Mgr.
(CA, AZ, OR, WA, ID, NV, UT,
NM, CO, WY, MT, ND, SD, NE &
Western Canada)
144 Segre Place
Santa Cruz, CA 95060
Tel: (831) 426-4143
FAX: (831) 515-5444
blandy@mwjournal.com

International Sales

Richard Vaughan
International Sales Manager
16 Sussex Street
London SW1V 4RW, England
Tel: +44 207 596 8742
FAX: +44 207 596 8749
rvaughan@horizonhouse.co.uk

Germany, Austria, and Switzerland

(German-speaking)
WMS Werbe- und Media Service
Brigitte Beranek
Gerhart-Hauptmann-Street 33,
D-72574 Bad Urach
Germany
Tel: +49 7125 407 31 18
FAX: +49 7125 407 31 08
bberanek@horizonhouse.com

Korea

Young-Seoh Chinn
JES Media International
2nd Floor, ANA Bldg.
257-1, Myungil-Dong
Kangdong-Gu
Seoul, 134-070 Korea
Tel: +82 2 481-3411
FAX: +82 2 481-3414
yschinn@horizonhouse.com

China

Shenzhen
Michael Tsui
ACT International
Tel: 86-755-25988571
FAX: 86-10-58607751
michaelt@actintl.com.hk

Shanghai

Linda Li
ACT International
Tel: 86-21-62511200
lindal@actintl.com.hk

Beijing

Cecily Bian
ACT International
Tel: +86 135 5262 1310
cecilyb@actintl.com.hk

Hong Kong, Taiwan, Singapore

Mark Mak
ACT International
Tel: 852-28386298
markm@actintl.com.hk

Japan

Katsuhiko Ishii
Ace Media Service Inc.
12-6, 4-Chome,
Nishiiko, Adachi-Ku
Tokyo 121-0824, Japan
Tel: +81 3 5691 3335
FAX: +81 3 5691 3336
amskatsu@dream.com



VCO's and Synthesizers

You Define It. We'll Design It.

Replacement Solutions for End-of-Life Parts. Custom Designs as Easy as 1-2-3.

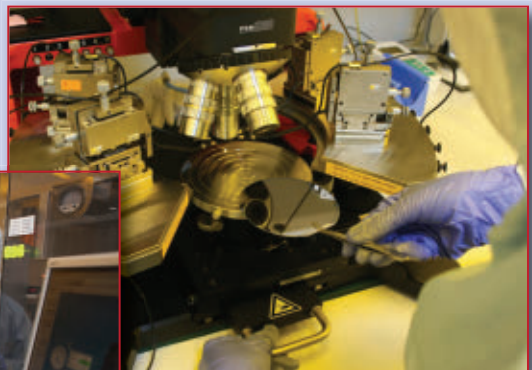
Whether you need replacement parts or you have a new requirement for VCOs or synthesizers, Mini-Circuits is here to support you. Our engineers will work with you to find a solution from our extensive library of existing designs or develop a custom design to meet your needs, as easy as 1-2-3! Reach out to apps@minicircuits.com today, and see why so many customers trust Mini-Circuits as the industry's solid source.

- VCOs from 3 to 7000 MHz
- Synthesizers from 56 to 7800 MHz
- Thousands of Models in Stock
- Industry-leading design capability
- Reliable supply through the life of your system!



FAB\$ and LAB\$

From Russia with Love and Expertise



Exhibiting passion and professionalism like James Bond, Micran has grown a hundredfold from its origins in 1991 as a private firm of eight people into a modern innovative company with a strong team of specialists, utilizing their expertise in the fields of microwave electronics, communications, radio location, test and measurement equipment, and information security.

Now one of Russia's leading manufacturers of solid-state EHF and SHF electronics, the company grew out of the Tomsk State University of Control Systems and Radioelectronics (TUSUR) lab. The links between the two remain strong. In cooperation with the University, Micran has created a Telecommunications Scientific-Research Institute, Nanoelectronics Educational Research Center and Siberian Solid-State SHF Electronics Competence Center.

From 2013 to 2015, Micran and TUSUR developed and organized high-tech production of solid-state millimeter wave radar using electronic components of its own design, which laid the groundwork for the development of an interconnected surveillance system for selected areas.

In addition to its links with academic and commercial research bodies, Micran's key strengths are the full cycle of its in-house research and development. All of the company's products are developed and manufactured in compliance with international standards and recommendations, including ETSI, IEC, IEEE, DIN, ITU, ANSI, EIA and ETS, which are covered by the corresponding patents. The company's flexible manufacturing facility is geared up for both low-volume and high-volume production, meeting all the needs of the market.

Micran's MMIC Design Center began its activity in

2008. Since that time the team has gained substantial experience through joint activity with the company's Internal III-V Foundry and successful projects with popular foundries in Europe and Asia. Subsequently, MMICs can be manufactured using proven foundry processes from OMMIC, United Monolithic Semiconductors (UMS) and WIN Semiconductors.

Micran's MMIC Design Center, working in cooperation with the company's Internal III-V Foundry, has the capability to design and fabricate a variety of III-V microwave devices, producing both off-the-shelf products or custom designed MMICs. Micran can offer competitive vertical diode processes, which are claimed to offer superior performance and extended functionality. The offering includes the QZBD process that is based on a vertical GaAs zero bias diode. This process is suited primarily for ultra-wideband, wide dynamic range power detectors with no DC bias required.

Another is the QSBD process, which has at its core a vertical GaAs Schottky barrier diode with high reliability and excellent performance. Various types of passive microwave devices can be designed based on the QSBD process, including limiters, mixers, multipliers and detectors.

The QPIN process is based on a vertical GaAs PIN diode that simplifies the design of different passive microwave devices such as switches, limiters, attenuators and phase shifters.

Micran uses proven microwave design software from leading companies and focuses on quality control for the manufacturing of quality products. On-wafer device characterization can be carried out using the company's test and measurement capabilities, including the measurement of S-parameters, power, noise figure and load-pull.

www.micran.com

Get there faster, with automotive T&M solutions from Rohde & Schwarz.

Signal analysis and target simulation accelerate
the development of automotive radar sensors.
With the R&S®FSW and the ARTS ITS 9510, we
have the perfect package to speed you on your way.

www.rohde-schwarz.com/ad/automotive-fsw



ROHDE & SCHWARZ



WERLATONE®

WE ARE HIGH POWER

Test & Measurement Directional Couplers

Up to 1000:1 Bandwidth • Low Insertion Loss • Covering DC-6.5 GHz!



Directional Couplers

| Model | Type | Frequency (MHz) | Power (W CW) | Coupling (dB) | Insertion Loss (dB) | VSWR (ML) | Flatness (± dB) | Size (Inches) |
|--------|------|-----------------|--------------|---------------|---------------------|-----------|-----------------|--------------------|
| C6021 | Dual | 0.01-1000 | 500 | 40 | 0.45 | 1.30:1 | 0.5 | 6.7 x 2.27 x 1.69 |
| C5725 | Dual | 0.1-1000 | 500 | 40 | 0.5 | 1.25:1 | 0.5 | 5.2 x 2.67 x 1.69 |
| C9688 | Dual | 1-1000 | 800 | 40 | 0.5 | 1.20:1 | 1.0 | 6 x 2.2 x 2.2 |
| C7734 | Dual | 30-2500 | 100 | 43 | 0.35 | 1.25:1 | 1.5 | 3.5 x 2.6 x 0.7 |
| C8188 | Uni | 30-3000 | 20 | 20 | 2.4 | 1.35:1 | 1.0 | 6 x 1.5 x 1.1 |
| C3910 | Dual | 80-1000 | 200 | 40 | 0.2 | 1.20:1 | 0.3 | 3 x 3 x 1.09 |
| C8373 | Bi | 100-2500 | 200 | 20 | 0.8 | 1.25:1 | 1.75 | 9.58 x 1.48 x 0.88 |
| C7711 | Dual | 100-3000 | 100 | 40 | 0.35 | 1.25:1 | 1.0 | 3 x 2.2 x 0.7 |
| C7058 | Bi | 200-2000 | 200 | 10 | 0.3 | 1.25:1 | 1.0 | 6.4 x 1.6 x 0.72 |
| C8060 | Bi | 200-6000 | 200 | 20 | 1.1 | 1.40:1 | 2.25 | 4.8 x 0.88 x 0.5 |
| C7248 | Bi | 300-3000 | 100 | 6 | 0.35 | 1.25:1 | 1.0 | 6 x 2 x 0.85 |
| C8000 | Bi | 600-6000 | 100 | 30 | 0.4 | 1.25:1 | 1.0 | 1.8 x 1 x 0.56 |
| C8214 | Bi | 700-2500 | 100 | 6 | 0.35 | 1.25:1 | 1.0 | 6 x 2 x 0.85 |
| C10462 | Dual | 700-4200 | 250 | 40 | 0.2 | 1.30:1 | 1.0 | 2 x 2 x 1.06 |
| C10525 | Dual | 700-4200 | 700 | 50 | 0.2 | 1.35:1 | 1.0 | 2.15 x 2 x 1.36 |
| C10537 | Dual | 700-4200 | 700 | 60 | 0.2 | 1.35:1 | 1.0 | 2.15 x 2 x 1.36 |
| C10536 | Dual | 700-4200 | 1000 | 50 | 0.2 | 1.35:1 | 1.0 | 2.15 x 2 x 1.36 |
| C10751 | Dual | 700-4200 | 1000 | 60 | 0.2 | 1.35:1 | 1.0 | 2.15 x 2 x 1.36 |
| C10006 | Dual | 700-4200 | 2000 | 50 | 0.2 | 1.35:1 | 1.0 | 3 x 3 x 1.59 |
| C10117 | Dual | 700-6000 | 250 | 40 | 0.2 | 1.30:1 | 1.0 | 2 x 2 x 1.06 |
| C10364 | Dual | 700-6000 | 500 | 50 | 0.2 | 1.35:1 | 1.0 | 2.15 x 2 x 1.36 |
| C10762 | Dual | 1000-6000 | 300 | 40 | 0.2 | 1.30:1 | 0.5 | 2 x 2 x 1.06 |
| C10958 | Dual | 1000-6000 | 400 | 40 | 0.2 | 1.35:1 | 0.5 | 2 x 2 x 1.06 |
| C10761 | Dual | 1000-6000 | 600 | 40 | 0.2 | 1.35:1 | 0.5 | 2.15 x 2 x 1.36 |
| C8644 | Bi | 1800-6100 | 60 | 20 | 0.4 | 1.25:1 | 1.0 | 1.1 x 0.75 x 0.48 |
| C10743 | Dual | 2000-6000 | 500 | 40 | 0.2 | 1.30:1 | 0.5 | 2.15 x 2 x 1.36 |
| C10746 | Dual | 2000-6500 | 500 | 50 | 0.2 | 1.35:1 | 1.0 | 2.15 x 2 x 1.36 |
| C10748 | Dual | 2000-6500 | 500 | 60 | 0.2 | 1.35:1 | 1.0 | 2.15 x 2 x 1.36 |

Werlatone, Inc.

17 Jon Barrett Road
Patterson, NY 12563

T 845 278 2220

F 845 278 3440

sales@werlatone.com

www.werlatone.com