Vol. 55 • No. 5
May 2012

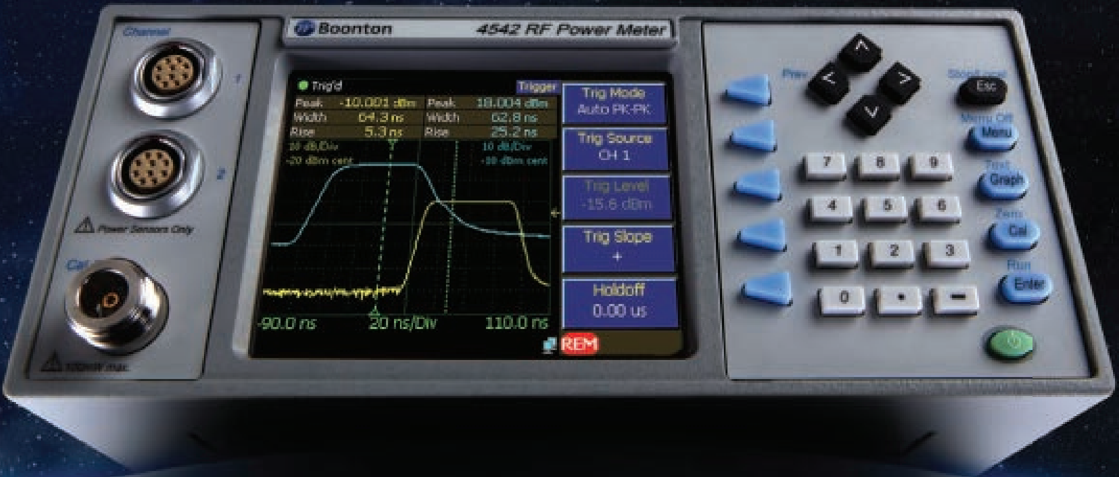
Microwave Journal

Montréal
Canada

MTT-S IMS
Show Issue

horizon house
Founded in 1958
mwjournal.com

Bigger where it counts...



in the Performance.

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

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

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

Boonton: Redefining How You Use Power Meters.

4530 RF Power Meter Series

4500B RF Peak Power Analyzer

4240 RF Power Meter

Scan QR Code

VISIT US AT THE
2012 IEEE MTT-S Show
BOOTH #1719 June 19-21

Wireless Telecom Group
Boonton Microlab Noisecom

Boonton

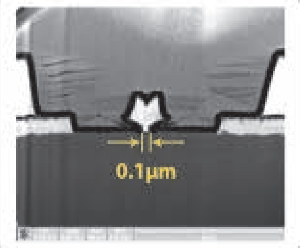
win
SEMICONDUCTORS

Leading Global Communications

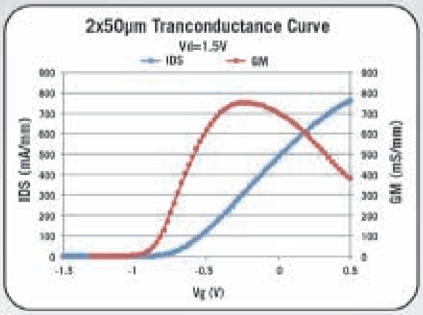
New 0.1μm pHEMT Technology

WIN is the world's largest and leading 6" GaAs foundry

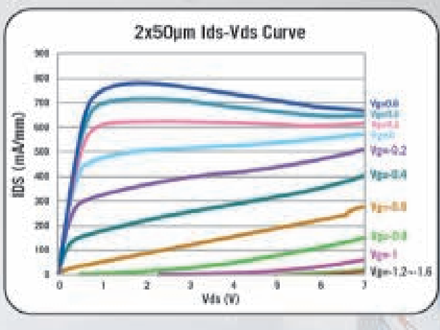
- 0.1μm gate length pHEMT technology
- 9V off-state breakdown voltage for power application
- Wafer thickness options of 50um (PP10-10) and 100um (PP10-11) available
- 860 mW/mm P_{sat} at 29GHz with Vd=4V
- 400 mF/mm^2 capacitor for design flexibility



PP10-10, 11 Tranconductance Curve



PP10-10, 11 I-V Curves



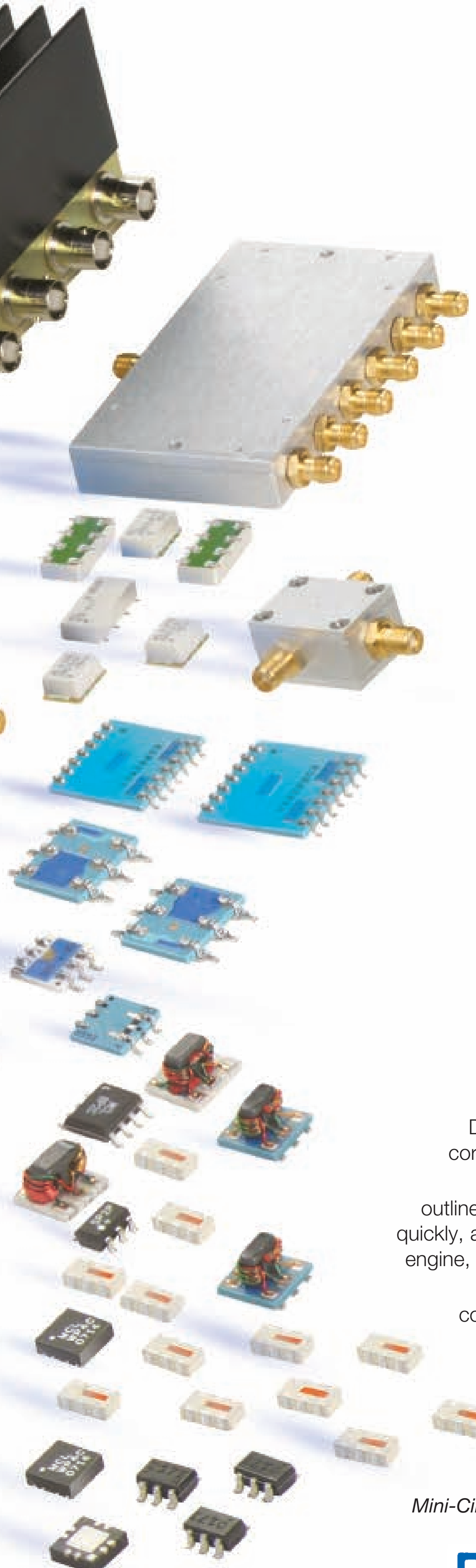
Comparison of WIN's millimeter wave pHEMT technologies

	PP25-21	PP15-50/51	PP10-10/11
Gate length	0.25μm	0.15μm	0.1μm
Operating Frequency	Up to 20GHz	Up to 30 GHz	Up to 90GHz
Max Drain Bias	8V	6V	4V
Max Id (Vg=0.5V)	490 mA/mm	630 mA/mm	760 mA/mm
IDSS (Vg=0V)	340 mA/mm	470 mA/mm	520 mA/mm
Max Gm	410 mS/mm	460 mS/mm	725 mS/mm
Vto	-1.15 V	-1.35 V	-0.95 V
Von (Diode turn on)	0.8 V	0.8 V	0.9 V
BVGD	20V (18V min)	16V (14V min)	9V (8V min)
f_T	65 GHz	90 GHz	130 GHz
f_{max}	190 GHz	185 GHz	180 GHz
Power Density (2x75μm)	1100 mW/mm @ 8V, 10GHz	870 mW/mm @ 6V, 29GHz	860 mW/mm @4V, 29GHz (2x50μm)

WIN SEMICONDUCTORS CORP. Tel:+886-3-397-5999 Fax:+886-3-397-5069 http://www.winfoundry.com

See us at IMS Booth 2816


MCL B 744
ADP-2-10
MCL B 744
ADP-2-10
MCL B 744
ADP-2-10



POWER SPLITTERS/ COMBINERS

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

The Industry's Largest Selection includes THOUSANDS of models, from 2 kHz to 18 GHz, at up to 300 watts power, and in coaxial, flat-pack, and surface-mount housings for 50 and 75 systems. ***From 2-way through 48-way designs, with 0°, 90°, or 180°*** phase configurations, Mini-Circuits power splitters/combiners offer outstanding performance for insertion loss, isolation, and VSWR. Decades of experience with multiple technologies make it all possible, from core & wire, microstrip, and stripline, to semiconductors and LTCC ceramics. ***Get easy-to-find, detailed data and performance curves, S-parameters,*** outline drawings, PCB layouts, and everything else you need to make a decision quickly, at minicircuits.com. Just enter your requirements, and our patented search engine, Yoni2, searches *actual test data* to find the models that meet your needs. ***All Mini-Circuits catalog models are in stock,*** continuously replenished, and backed by our 1-year guarantee. We even list *current stock quantities and real-time availability*, as well as pricing, to help our customers plan ahead and make quick decisions. So why wait? Take a look at minicircuits.com today!

RoHS Compliant
Product availability is listed on our website.

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

Mini-Circuits®
ISO 9001 ISO 14001 AS 9100
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

Yoni2® ***The Design Engineers Search Engine*** *finds the model you need, Instantly* • For detailed performance specs & shopping online see **minicircuits.com**

U.S. Patents
7739260, 7761442

IF/RF MICROWAVE COMPONENTS

448 rev H

RUGGED & RELIABLE

MADE IN THE USA FOR 50 YEARS!

M*E*C*A* – MICROWAVE ELECTRONIC COMPONENTS OF AMERICA

- Aviation
- Earth Station
- Instrumentation
- L, S, C, X, and Ku Bands
- Microwave Radio
- Mobile Satellite
- Radar
- Telemetry

MOST MODELS AVAILABLE FROM STOCK - 4 WEEKS ARO

POWER DIVIDERS/ COMBINERS

2-way through 16-way in N, SMA, BNC, TNC and 7/16 DIN connector styles from 0.4 to 18.0 GHz.

ATTENUATORS

Most available in 1 dB increments from 0 - 40dB. Power ratings from 2 to 150 Watts.

RF LOADS

Power ratings from 1 to 500 watts and frequency ranges up to 18 GHz.

DIRECTIONAL & HYBRID COUPLERS

Average power handling from 50W to 1kW. Standard coupling values of 3, 6, 10, 20, 30 and 40 dB.

DC BLOCKS

Available in N, BNC, TNC, SMA & 7/16 DIN configurations . Power ratings to 500 watts (2.5 kW peak).

INTEGRATED ASSEMBLIES

Let MECA create an integrated assembly with any of our standard RF/Microwave products on 19" panels, shelves or enclosures.

BIAS TEES

Covering bands from 0.5 – 2.5 GHz and 0.7 to 2.7 GHz in 7/16 DIN, SMA, N, BNC & TNC configurations with RF power ratings to 300 watts (3 kW peak).

CIRCULATORS & ISOLATORS

In both N & SMA-Female connectors with average power ratings from 2 to 250 watts. "Popular" frequency bands between 0.7 - 18.0 GHz.

MECA ELECTRONICS, INC.

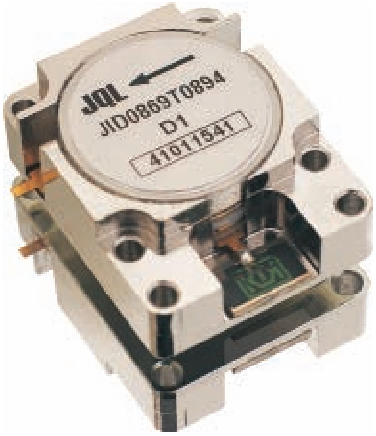
459 East Main Street Denville, NJ 07834

To learn more, please call 866-444-6322 or visit our website at www.e-MECA.com

See us at IMS Booth 2437

1961-2011

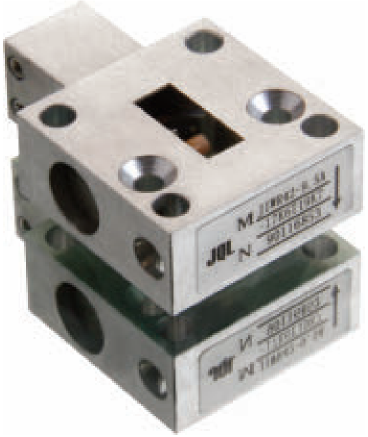
Technology On the Move™



Drop-in Isolators

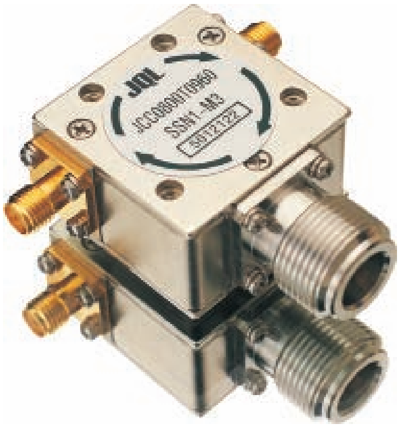
Cavity Filters

Surface Mount Circulators



Waveguide Isolators

Power Combiners



Coaxial Circulators

See us at IMS Booth 508

JQL

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

Ultra Low Phase Noise OCXO

Wireline | Wireless | Military & Space | Industrial

The OX-204 is an Ultra Low Noise OCXO designed for applications that have a need for uncompromised phase noise performance. The OX-204 achieves a noise floor of <-175dBc, without compromising the close-in phase noise at 1 and 10 Hz. The OX-204 is the latest addition to Vectron's family of low phase noise products.

Key Features

- -135 dBc / Hz at 10 Hz offset
- -175 dBc / Hz at 10 kHz offset
- 10 MHz standard, other frequencies available
- Compact 1" x 1" hermetic enclosure
- Low Power Consumption:
  4 Watts during warm-up
  1.5 Watts during steady state
- Temperature Stability:
  +/-10ppb at -20 to 70°C
  +/-20ppb at -40 to 85°C

75% reduction in area while maintaining Ultra Low Phase Performance

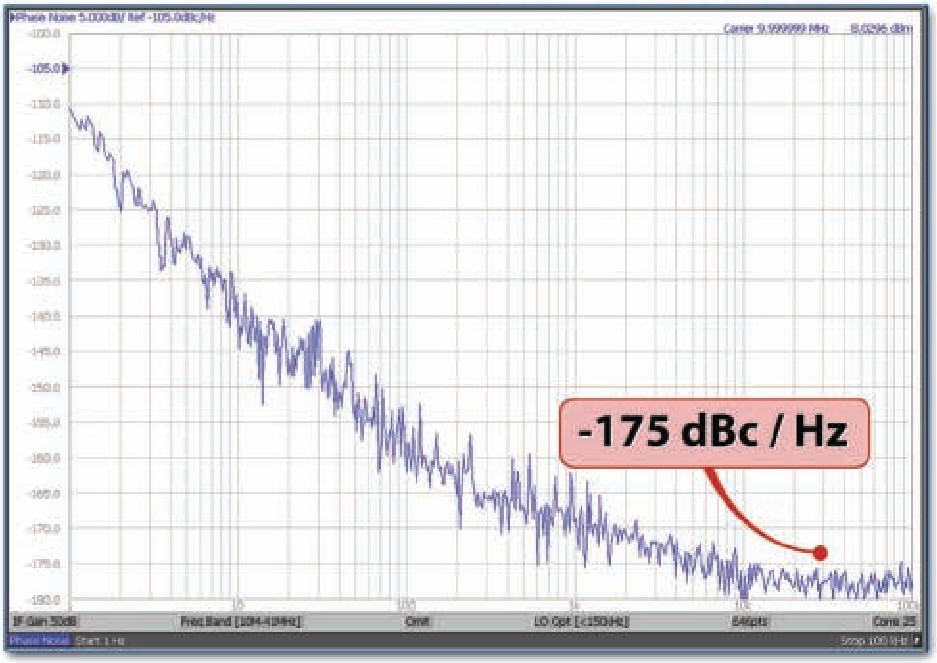
Applications

- Radar
- Satellite Communications
- Military Communications
- Test & Measurement Equipment
- DRO & Synthesizer references

International Microwave Symposium
IEEE 17-22 June 2012, Montreal, Canada MTT-S
http://ims2012.mtt.org/

Come Visit Us at our booth
#1300 during the MTTS show
in Montreal June 19 - 21

Phase Noise Performance



OCXO/EMXO | TCXO | VCSO | VCXO | Jitter Attenuation | SAW Filter | Clocks/XO | Crystals | Timing Solutions | High-Temp Electronics

For more information on these product visit www.vectron/products/ocxo/ox-204.htm or contact a customer service representative at 1-88-VECTRON-1

Select from **Our Precision Portfolio** that supports your performance requirements, ensuring **Stability , Synchronization and Timing**.

Helping Customers
Innovate, Improve & Grow

VECTRON
INTERNATIONAL
A DOVER COMPANY

Mars Rover Artwork Courtesy of NASA/JPL-Caltech

Supporting
Space Exploration
through the Development
of Innovative
Technology.

SPACE HERITAGE

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

Apollo 17

Mars Science Lab

Mars Opportunity Rover

Mars Spirit Rover

Iridium Satellite Constellation

CHIRP

GPS-3

GPS-R

V-Sensor

Thuraya

MSV

OCEANSAT 2

COSMO

SKYNET 5

K&L® MICROWAVE
A DOVER COMPANY
CMP

CERAMIC & MICROWAVE PRODUCTS
Electronic Components & Microwave Solutions
A DOVER COMPANY
CMP

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

www.klmicrowave.com

AS 9100
ISO 14001

See us at IMS Booth 1309

Your supplier of high performance, precise equipment for AWGN

NOISEWAVE
The new wave in NOISE

Ph. (973) 386-1119 • Fax (973) 386-1131 • info@noisewave.com • www.noisewave.com
See us at IMS Booth 3023

Under powered and over budget?
Problem solved.

AEROFLEX
METELICS

Eval Boards Available From Stock

Buy Online at Aeroflex.com/MSW

If you're in need of driving up the power handling and driving out cost in your next switch design, Aeroflex / Metelics' MSW series surface mount PIN diode switches and super-charged (+125V, -200V) MPD drivers are the perfect combination. It only takes a single driver to drive several of our high power (100 W C.W. or 500 W peak input power) switches—even symmetrical and asymmetrical T-R switches at the same time—saving you precious real estate and overhead. MPD drivers are TTL input compatible (single or double logic) and offer a typical switching speed of 2 µS. Covered with a high performance RF shield they're also worry free. Get your hands on an evaluation board today and put the perfect switch in your control.

Visit our website or call **888-641-7364**.

www.aeroflex.com/metelics

See us at IMS Booth 2305

PIN Diode Switch and Driver Combinations

Part Number	Configuration	Drive Voltage*	Recommended Switch Driver	Frequency Band (MHz)
MSW2000–200	T-R Switch, TX Left	+V Only	MPD2T28125-700	10 to 1,000
MSW2001–200	T-R Switch, TX Left	+V Only	MPD2T28125-700	400 to 4,000
MSW2002–200	T-R Switch, TX Left	+V Only	MPD2T28125-700	2,000 to 6,000
MSW2022-200	T-R Switch, TX Right	+V & -V	MPD2T5N200-702	2,000 to 6,000
MSW2050–205	T-R Switch, TX Left	+V Only	MPD2T28125-700	20 to1,000
MSW2051–205	T-R Switch, TX Left	+V Only	MPD2T28125-700	400 to 4,000
MSW2030–203	Symmetrical SP2T	+V Only	MPD2T28125-700	10 to 1,000
MSW2031–203	Symmetrical SP2T	+V Only	MPD2T28125-700	400 to 4,000
MSW2032–203	Symmetrical SP2T	+V Only	MPD2T28125-700	2,000 to 6,000
MSW2040–204	Symmetrical SP2T	+V Only	MPD2T28125-700	50 to 1,000
MSW2041–204	Symmetrical SP2T	+V Only	MPD2T28125-700	400 to 4,000
MSW2060-206	Symmetrical SP2T	+V & -V	MPD2T5N200-702	10 to 1,000
MSW2061-206	Symmetrical SP2T	+V & -V	MPD2T5N200-702	400 to 4,000
MSW2062-206	Symmetrical SP2T	+V & -V	MPD2T5N200-702	2,000 to 6,000
MSW3100–310	Symmetrical SP3T	+V Only	MPD3T28125-701	10 to 1,000
MSW3101–310	Symmetrical SP3T	+V Only	MPD3T28125-701	400 to 4,000
MSW3200-320	Symmetrical SP3T	+V & -V	MPD2T5N200-703	10 to 1,000
MSW3201-320	Symmetrical SP3T	+V & -V	MPD2T5N200-703	400 to 4,000

* +V Only = Up to +28V and +125V
+V & -V = Up to +5V and -200V

AEROFLEX
A passion for performance.

Microwave Journal

MAY 2012 VOL. 55 • NO. 5

Note from the Editor

IEEE MTT-S International Microwave Symposium & Exhibition

55 Years
of Publishing
Excellence

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

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

POSTMASTER: Send address corrections to *Microwave Journal*, PO Box 3256, Northbrook, IL 60065-3256 or e-mail mwj@omeda.com. Subscription information: (847) 291-5216. This journal is issued without charge upon written request to qualified persons working in the RF & microwave industry. Other subscriptions are: domestic, $120.00 per year, two-year subscriptions, $185.00; foreign, $200.00 per year, two-year subscriptions, $370.00; back issues (if available) and single copies, $10.00 domestic and $20.00 foreign. Claims for missing issues must be filed within 90 days of date of issue for complimentary replacement.

©2012 by Horizon House Publications Inc.

Posted under Canadian international publications mail agreement #PM40612608

© 2012 AWR Corporation. All rights reserved. AWR is a National Instruments Company.

The AWR mmWave design flow.

Often MMIC'd.

Never duplicated.

When you're racing toward important targets, design performance is paramount. Don't let yourself be duped. Nobody does more for mmWave MMIC design than AWR. You can do circuit, system, and EM simulations faster, easier, and more accurately. What's more, with schematic and layout in the same UI, you're more efficient and avoid the manual mistakes associated with running multiple tools. Tackle today's high-end, mission-critical mmWave MMIC designs with ease. Grab a test copy at www.awrcorp.com/mwo.

Stop waiting and start designing™

MICROWAVE OFFICE™

Microwave Journal

PERSPECTIVE

100 **Keep Assembly Closer to Home**
SemiGen Inc.
Jim Morgan, CEO of SemiGen Inc., discusses how RF/MW manufacturing presents its own set of unique circumstances and what to consider when deciding on outsourcing

SPECIAL REPORT

106 **Mobile World Congress Review**
Richard Mumford, Microwave Journal *International Editor*
Explores the recent Mobile World Congress 2012 show with special product highlights

TECHNICAL FEATURES

110 **Techniques for Improving Noise and Spurious in PLLs**
Eric Drucker, Agilent Technologies
Features techniques and how using the right design and modeling approaches creates multi-loop PLLs to efficiently deliver the performance needed for demanding applications

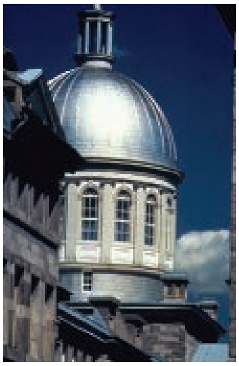
124 **Improved Linearity Doherty Amplifier Using Tunable Offset Line**
Shiwei Zhao, Zongxi Tang and Ping Su, University of Electronic Science and Technology of China
Introduction to tunable CRLH and coupled lines, using a variable capacitance diode in an offset line to improve linearity performance of a Doherty amplifier

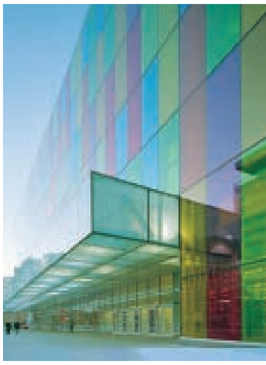
142 **Global Navigation Satellite Systems and Their Applications**
Rachid El Assir, Rohde & Schwarz
Provides an overview of the different navigation systems, explains the navigation channel and generic approach used by a commercial receiver to calculate a user position and describes channel acquisition and tracking

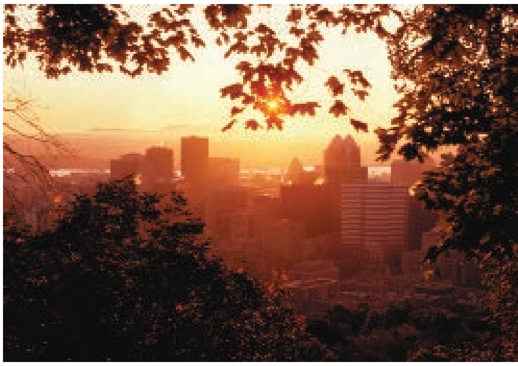
154 **Non-Uniform Defected Microstrip Structure Lowpass Filter**
Jian-Kang Xiao, Xidian University and State Key Laboratory of Millimeter Waves; Wen-Jun Zhu, Hohai University
Presents lowpass filters with ultra-wide stopband, using non-uniform DMS that is beneficial to higher order harmonic suppression

170 **Cost Effective High Power E- and W-Band Amplifier MMICs**
Jim Mayock, VIPER RF Ltd.
Describes the design and manufacture of a set of E- and W-Band MMIC power amplifiers based on six-inch 0.1 µm GaAs technology

184 **Compact UHF Fifth Order Bandpass Filter Using Cascaded Triplet CRLH-ZORs**
Boram Lee and Sungtek Kahng, University of Incheon
Presents a bandpass filter made very compact by implementing the CRLH ZORs and their coupling and forming a CT to have a steep skirt for high frequency selectivity







Photos courtesy of Tourisme Montréal

MILITARY, AEROSPACE & AVIONICS

Complete RF/Microwave Solutions

Carlisle's high performance connectors, cables and assemblies encompass a wide selection of sizes, materials and operating frequencies. Contact us for a comprehensive list of product offerings or custom solutions to meet YOUR unique application needs.

» Our **SMP and SSMP®** products provide superb isolation and performance and are excellent choices for high frequency, small form factor connectors and assemblies.

» **Phase Adjusters** - Our family of precision coaxial phase adjusters is ideally suited for Electronically Scanned Arrays (ESAs) and other military and space applications.

» **AccuPhase®** low loss phase stable flexible assemblies are optimal for any application where performance and stability at higher frequency ranges is critical.

For more information visit
www.CarlisleIT.com
866.282.4708

CARLISLE
INTERCONNECT TECHNOLOGIES

Microwave Journal

PRODUCT FEATURES

TECH BRIEFS

Departments

STAFF

Publisher: Carl Sheffres
Editor: David Vye
Managing Editor: Jennifer DiMarco
Technical Editor: Patrick Hindle
Associate Technical Editor: Dan Massé
Staff Editor: Laura Casasanto
Editorial Assistant: Barbara Walsh
Consulting Editor: Harlan Howe, Jr.
Consulting Editor: Frank Bashore
Consulting Editor: Peter Staecker
Consulting Editor: Dan Swanson
Web Editor: Chris Stanfa
Audience Development Manager:
Michelle Barry
Traffic Manager: Edward Kiessling
Marketing and Event Coordinator:
Kristen Anderson
Director of Production & Distribution:
Robert Bass
Art Director: Janice Levenson
Graphic Designer: Sachiko Stiglitz

EUROPE

International Editor: Richard Mumford
Office Manager: Nina Plesu

CORPORATE STAFF

CEO: William M. Bazzy
President: Ivar Bazzy
Vice President: Jared Bazzy

Editorial Review Board

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

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

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

www.mwjournal.com

Printed in the USA

TIP 1 For an inductor with the absolute maximum Q, pick one of these air core "Springs". They have flat tops for easy mounting and exceptional current ratings.

TIP 2 If you prefer conventional chip inductors, you'll get the highest Q with our new ceramic body 0402HP and 0603HP families. These tiny wirewound coils handle up to 2 times more current than the nearest competitor.


Coilcraft

Highest Q Finder

This new web tool finds inductors with the highest Q at your operating frequency

TIP 3 Need to find coils with the best Q at your L and frequency? Our **Highest Q Finder** web tool tells you in just seconds. Click again to plot the L, Q, Z and ESR of up to 4 parts simultaneously.

TIP 4 When it's time to build your prototypes, be sure to ask us for evaluation samples. They're always free and we can get them to you overnight. To get started, visit **www.coilcraft.com/Q**

Here are some high Q tips

Q-Tips® is a registered trademark of Chesebrough-Ponds, Inc.

Coilcraft®

WWW.COILCRAFT.COM

See us at IMS Booth 825

coilcraftdirect.com
No min order. Next day delivery.

Microwave Journal Online

Visit us @ mwjournal.com

Free Webinars

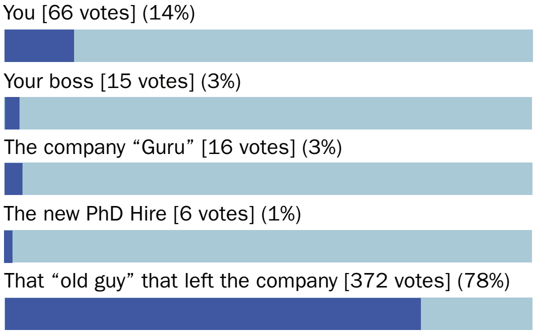
Innovations in EDA *by: Agilent Technologies* Comprehensive mm-Wave Design Solutions	Available On Demand
Improving GaN HEMT PA Design *Sponsored by: Cree/AWR*	Available On Demand
Agilent in Wireless Communications Next Generation 802.11ac WLAN MIMO Design & Test Challenges	5/10/12 at 1:00 PM ET
Agilent in Aerospace/Defense Mixed Signal Testing Challenges	5/17/12 at 1:00 PM ET
Besser Training Series - Mixers *Sponsored by: Mini-Circuits*	5/22/12 at 11:00 AM ET
Understanding Radio Channel: Part 2 *Sponsored by: EB (Elektrobit)*	5/23/12 at 12:00 PM ET
RF and Microwave Heating with COMSOL Multiphysics *Sponsored by: COMSOL*	5/24/12 at 2:00 PM ET
Innovations in LTE *by: Agilent Technologies* LTE Channel State Testing	5/31/12 at 1:00 PM ET

Web Survey

What do you like best about IMS?

Look for our multiple choice survey online at mwjournal.com

March Survey
"Who's the better engineer?"



Executive Interview

Janne Kolu, Vice President of Test Tools, EB (Elektrobit), explains the company's global reach, elaborates on the evolution of test systems in the wireless sector and discusses EB's latest product developments.

White Papers

Statistical Analysis of Modern Communication Signals
Bob Muro, Wireless Telecom Group

Redefining RF and Microwave Instrumentation Through Open Software and Modular Hardware
Tutorial, National Instruments

Selecting Ferrite Circulators for Radar Applications
Presented by: Richardson RFPD and Skyworks

Leverage Circuit-Envelope Simulation to Improve 4G PA Performance
Dr. John M. Dunn, AWR Corp.

LO Harmonic Effects on TRF3705 Sideband Suppression
Bill Wu and Russell Hoppenstein, Texas Instruments

IMS 2012 Show Coverage

Catch our exclusive conference information, news, social networking, photos, videos and more at MWJOURNAL.COM/IMS2012, proud sponsor of the IMS 2012 Cyber Café.

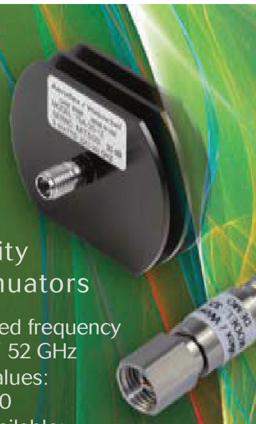
COM

Innovative Design Solutions for Performance-Driven Applications

AEROFLEX
WEINSCHEL

50 Watt Attenuators (Model 90) & Terminations (Model 1467)

- Standard dB values: 3, 6, 10, 20, 30
- dc-18 GHz frequency operation
- Choice of N or 3.5mm connectors



High Reliability Coaxial Attenuators

- New or extended frequency designs to 42 / 52 GHz
- Standard dB values: 3, 6, 10, 20, 30
- Connectors available: 3.5mm, 2.92mm or 2.4mm
- Custom dB values available
- MIL-DTL-3933 & Space Qualified

Model 251 High Power Coaxial Attenuator

- dc-6 GHz operation
- Convection Cooled, 200 Watts (Bi-directional)
- Standard dB values: 10, 20, 30 and 40 dB
- Type N connectors

Model 4202-63 Digital Attenuator

- 0.4-6 GHz frequency operation
- Attenuation Range: 0-63 / 1 dB steps
- Attenuation Accuracy: ±1 dB or 4%
- Switching Time: 300 nSec maximum
- Built-in TTL Interface
- Custom Configurations available

40 GHz Programmable Attenuators

- Available in 0-70 / 10 dB steps (Model 153-70) & 0-110 dB / 10 dB steps (Model 153-110)
- Low insertion loss & excellent repeatability
- Long-Life of 5 million operations
- 2.92mm connectors

3-Port Short/Open/Load Model 1591

- Specifically designed to simplify wireless test Setups
- dc to 2 GHz
- TNC female connectors
- VSWR 1:35 maximum

Aeroflex / Weinschel has been pioneering developments in microwave and RF technologies for more than 58 years. Today part of Aeroflex, we are continuing to set new standards in component and subsystem innovation with a wide variety of new products to fit the most demanding customer applications.

Our mission is to provide superior design capabilities, products of consistently high quality, and a high level of service to help our customers compete in today's demanding global markets.

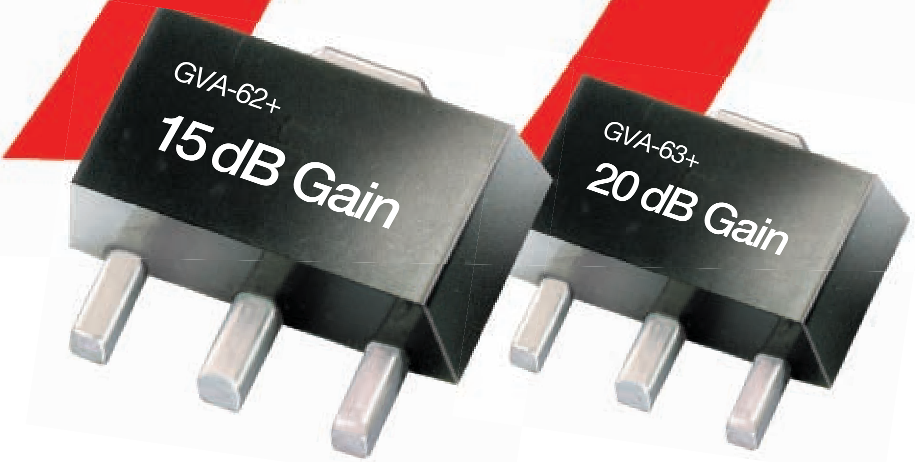
From broadband to base stations, defense subsystems to satellites, whatever your application, you can count on Aeroflex / Weinschel for innovative, high performance product solutions.

Call 800-638-2048
weinschel-sales@aeroflex.com
www.aeroflex.com/weinschel

See us at IMS Booth 2305

AEROFLEX
A passion for performance.

only **99¢** *ea.(qty. 20)*



FLAT GAIN WIDEBAND *amplifiers*

flatness from ±0.7dB across 0.1-6 GHz IP3 up to 39 dBm

Our new GVA-62+ and GVA-63+ amplifiers are spot-on for high performance base stations, portable wireless, LTE and cellular, CATV/DBS systems, MMDS, and wireless LANs. They make excellent gain blocks for almost any 50Ω circuit. DC power as low as 5V/69 mA delivers a typical output power of 18 dBm, unconditional stability, and built-in ESD protection, all with no external matching components required!

Just go to minicircuits.com for technical specifications, performance data, export info, pricing, ***real-time availability***, and everything else you need to make your selection today—for delivery as soon as tomorrow!

Model	Freq. Range (MHz)	Gain (dB)	P_{OUT} (dBm)	Price $ ea. (Qty. 20)
GVA-62+	10-6000	15	18	0.99
GVA-63+	10-6000	20	18	0.99

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

Mini-Circuits®
ISO 9001 ISO 14001 AS 9100
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

YONI2® ***The Design Engineers Search Engine*** *finds the model you need, Instantly* • For detailed performance specs & shopping online see **minicircuits.com**

U.S. Patents
7739260, 7761442

IF/RF MICROWAVE COMPONENTS

505 rev orig

Montréal Canada

JUNE 2012

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
27	28	29	30	31	1	2
3	4	5	6	7 **Webinar:** **Innovations in EDA** Sponsored by Agilent Technologies	8	9
10	11	12 **Webinar:** **Loadpull Measurement with PNA-X** Sponsored by Agilent Technologies ← **Joint Navigation Conference** Colorado Spring, CO → (12–15)	13	14	15	16
17 **IEEE MTT-S International Microwave Symposium** June 17–22, 2012 • Montréal, Canada **RFIC 2012** (17–19)	18	19 **MicroApps** (19–21)	20 **MicroApps Expert Forum** **MWJ/Strategy Analytics Forum @ IMS**	21 **Webinar:** **Simulating Power Transients and Noise** Sponsored by Agilent Technologies	22 **ARFTG 2012**	23
24	25	26	27	28 **Webinar:** **MSR Base Station Introduction and Measurement Challenges** Sponsored by Agilent Technologies	29	30

Go to: www.mwjournal.com/events

LOW LEAKAGE LEVEL LIMITERS

(Leakage Level as low as -10 dBm)
0.01 - 18 GHz

- **Maximum Input Power 1W CW, 100 W Peak**
- **Options for Leakage Levels**
  - **-10 dBm**
  - **- 5 dBm**
  - **0 dBm**
  - **+ 5 dBm**
- **Removable connectors for circuit board assembly**
- **Ideal for LNA Protection**

MODEL	FREQ. RANGE (GHz)	NOMINAL[2] LEAKAGE LEVEL (dBm)	TYPICAL[2] LEAKAGE LEVEL (dBm)	TYPICAL[3] THRESHOLD LEVEL (dBm)
LL00110-1	0.01 – 1.0	-10	-	-11
LL00110-2		- 5	-	- 6
LL00110-3		0	-	- 1
LL00110-4		+ 5	-	+ 4
LL0120-1	0.1 – 2.0	-10	-	-11
LL0120-2		- 5	-	- 6
LL0120-3		0	-	- 1
LL0120-4		+ 5	-	+ 4
LL2018-1	2 - 18	-	-10 TO -5	-10
LL2018-2		-	- 5 TO 0	- 5
LL2018-3		-	0 TO+5	0

Notes:
1. **DC Supply required: +5V, 5mA Typ.**
2. **Typical and nominal leakage levels for input up to 1W CW.**
3. **Threshold level is the input power level when output power is 1dB compressed.**

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

Please call for Detailed Brochures

Herotek

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

Coming Events

CALL FOR PAPERS

APMC 2012
Deadline: June 29, 2012
IEEE International Symposium on RF Integration Technology
Deadline: August 6, 2012

ONLINE: COMING SOON

For complete coverage of the IMS 2012 conference, event news, exhibitor product information and special reports from the editors of Microwave Journal, visit www.mwjournal.com/IMS2012.

www.mwjournal.com

JUNE

JNC 2012
Joint Navigation Conference
June 12–15, 2012 • Colorado Spring, CO
www.jointnavigation.org

RFIC 2012
IEEE Radio Frequency Integrated Circuits Symposium
June 17–19, 2012 • Montréal, Canada
www.rfic2012.org

IMS 2012
IEEE MTT-S International Microwave Symposium
June 17–22, 2012 • Montréal, Canada
www.ims2012.org

MicroApps 2012
The Microwave Application Seminars
June 19–21, 2012 • Montréal, Canada
http://ims2012.mtt.org/en/node/207

79th ARFTG Microwave Measurement Conference
June 22, 2012 • Montréal, Canada
www.arftg.org

JULY

2012 IEEE International Symposium on Antennas and Propagation and USNC-URSI National Radio Science Meeting
July 8–14, 2012 • Chicago, IL
www.2012apsursi.org

AUGUST

IEEE EMC 2012
August 5–10, 2012 • Pittsburgh, PA
http://2012emc.org

AUVSI Unmanned Systems N. America 2012
August 6–9, 2012 • Las Vegas, NV
www.auvsishow.org

SEPTEMBER

MMS 2012
12th Mediterranean Microwave Symposium
September 2–5, 2012 • Istanbul, Turkey
www.mms2102.org

ICUWB 2012
IEEE International Conference on Ultra-Wideband
September 17–20, 2012 • Syracuse, NY
www.icuwb2012.org

ION GNSS 2012
September 17–21, 2012 • Nashville, TN
www.ion.org

OCTOBER

COMSOL
8th Annual Multiphysics Conference
October 3–5, 2012 • Boston, MA
www.comsol.com/conference2012/usa/

Microwave Update 2012
October 18–21, 2012 • Santa Clara, CA
www.microwaveupdate.org

AMTA 2012
34th Annual Symposium of the Antenna Measurement Techniques Association
October 21–26, 2012 • Bellevue, WA
www.amta.org

RADAR 2012
International Conference on Radar
October 22–25, 2012 • Glasgow, UK
www.radar2012.org

EuMW 2012
European Microwave Week
October 28–November 2, 2012
Amsterdam, The Netherlands
www.eumweek.com

MILCOM 2012
Military Communications Conference
October 29–November 1, 2012 • Orlando, FL
www.milcom.org

4G World 2012
October 29–November 1, 2012 • Chicago, IL
www.4gworld.com

NOVEMBER

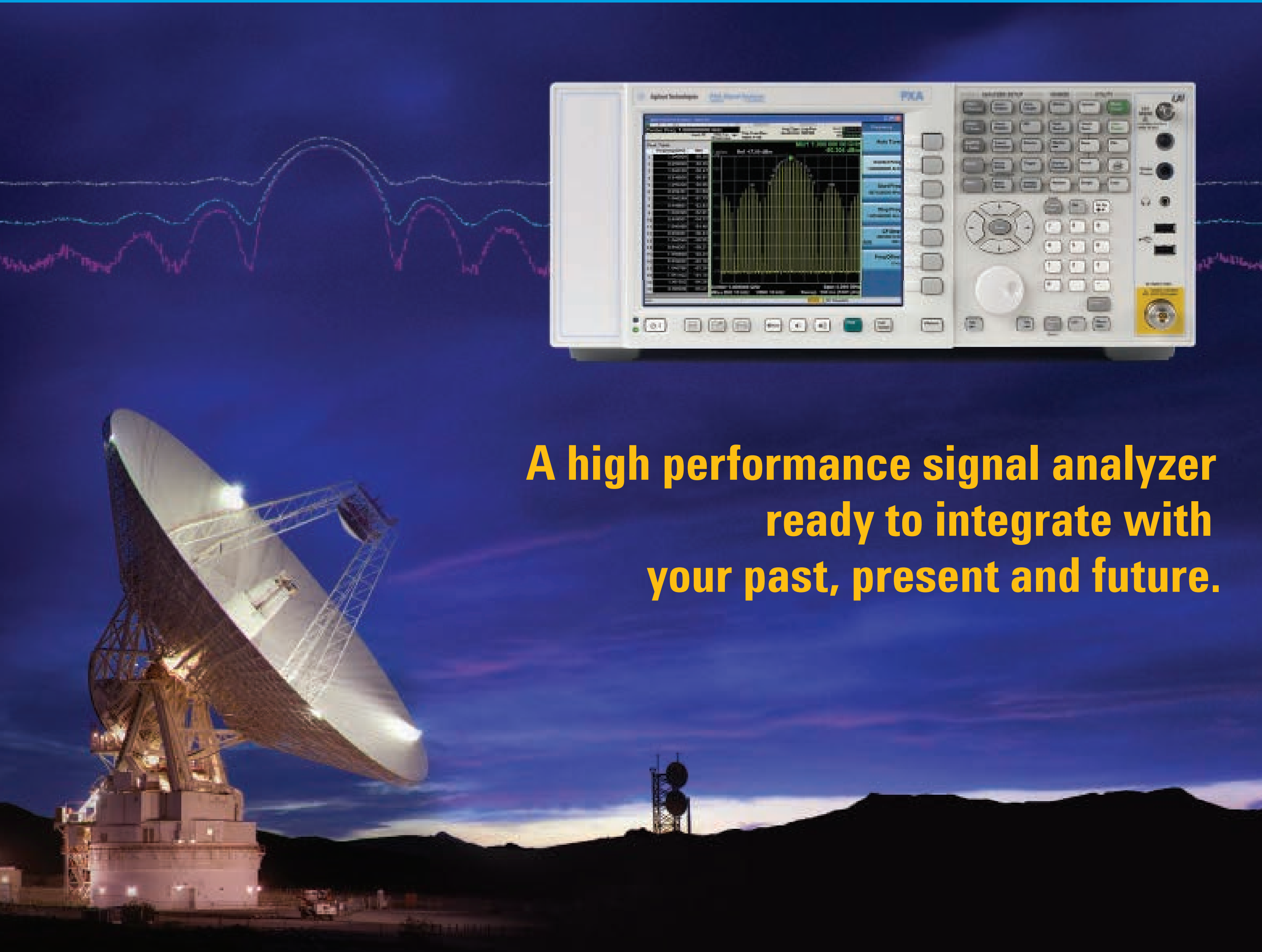
IME 2012
7th International Conference and Exhibition on Microwave and Antenna
November 5–7, 2012 • Shanghai, China
www.imwexpo.com

Electronica 2012
November 13–16, 2012 • Munich, Germany
www.electronica.de

DECEMBER

APMC 2012
Asia Pacific Microwave Conference
December 4–7, 2012 • Kaohsiung, Taiwan
www.apmc2012.com

See us at IMS Booth 3105



A high performance signal analyzer ready to integrate with your past, present and future.

The Agilent PXA signal analyzer delivers seamless integration now and can evolve over time to maximize longevity. With upgradable hardware including CPU, removable solid-state drive for enhanced security, I/O, and expansion slots, it's ready to drive your evolution today—and tomorrow.

That's thinking ahead. That's Agilent.

PXA Signal Analyzer (N9030A)
50 GHz in one box; 325 GHz with external mixing
160 MHz analysis bandwidth; 900 MHz wide IF output
-132 dBc/Hz phase noise, -172 dBm DANL, +22 dBm TOI
Phase noise, noise figure, pulse measurement applications
Code compatible with Agilent PSA, Agilent/HP 856x, HP 8566/58

Scan or visit http://goo.gl/Ta4cb for videos on optimized signal analysis

Get app notes, poster, CD and more about wideband-IF and millimeter-wave measurements, radar test, and technology refresh
www.agilent.com/find/PXA50

© 2012 Agilent Technologies, Inc.

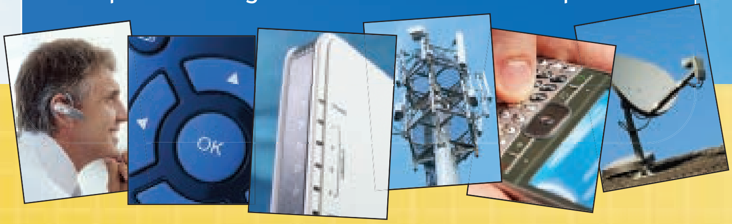
See us at IMS Booth 1015

u.s. 1-800-829-4444 canada 1-877-894-4414

Agilent Technologies

These *little* Xinger parts will make your low-power RF design *a lot* easier.

From countless wireless consumer electronics to today's ultra-compact base station and broadcasting infrastructure projects, insist on proven Xinger®-brand subminiature parts.



Anaren's newly expanded line-up of subminiature Xinger®-brand couplers, power dividers, baluns, and RF crossovers are the *reliable* solution for today's compact infrastructure equipment and point-of-use wireless devices.

From analog-to-digital conversion and pre-distortion receivers, transceivers, and low-power amplifiers – to handsets, handhelds, laptops, Bluetooth® devices, set-top boxes, and other broadcasting equipment – this family of parts offers:

> **Minimized footprints (0404, 0603, 0805)** leaving extra, valuable PCB space for additional functionality

> **Ultra-low profile** for a better fit inside today's compact devices and equipment

> **Low insertion loss** and excellent power handling for their size

> **Suitability for a wide range of bands and protocols,** including WiFi, WiMax, Bluetooth®,

802.1, ZigBee®, UWB, RFID, DECT, GSM, GPS, PCS, DCS, 3G, 4G, LTE, among others

> **RoHS compliance**

> **Competitive pricing**

> **And tape and reel packaging**

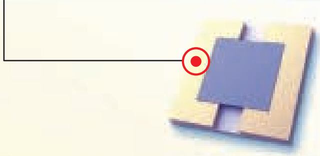
To learn more about Xinger-brand subminiature components – or obtain a sample kit from one of our authorized distributors for your qualified project, email sales@anaren.com or call our 800 number today.

See us at IMS Booth 709

Anaren®
What'll we think of next?®
www.anaren.com > 800-411-6596

Ask Anaren about:

New, high-frequency resistor family



Working on a high-frequency military or point-to-point radio? Our new, thick-film ceramic resistors fit the bill in terms of size and performance. 16 standard parts cover 6-20GHz. Footprints are tiny, as small as "0201" (0.509 x 0.254mm). And wire bondable and solderable parts are available. **Email ceramics@anaren.com to learn more, or visit www.RichardsonRFPD.com to obtain a sample kit.**

Anaren®
What'll we think of next?®

Military-grade resistive components

Broad offering of high-power handling, high-reliability resistors and attenuators. Product line covers DC to 6.0GHz; choose from Chip, SMT, Flangeless, and Flanged formats; BeO and AlN ceramic construction ensure high-power handling; proven product line and supplier; low, 50-piece minimum order quantity. **Email ceramics@anaren.com for more information, a quote, or free samples to qualified parties.**

Anaren®
What'll we think of next?®

'Lowest cost' resistive line family

Our new resistive components line offers an optimal balance of high performance in commercial bands, higher-power handling, and low cost. Constructed of RoHS-compliant Alumina or AlN ceramic, this family of SMT, chip, flanged, and flangeless terminations and attenuators covers DC to 6.0GHz. **Email resistives@anaren.com to learn more or obtain a sample kit.**

Anaren®
What'll we think of next?®

Microwave Journal China
微波杂志

May We Have Your Attention Please...

In March 2013, Microwave Journal and its parent company Horizon House will launch a new conference and trade show focused on high frequency electronic design. Electronic Design Innovation Conference (EDI Con) will be held March 12-14 in Beijing, complementing the introduction of our new print magazine, Microwave Journal China and companion website - microwavejournalchina.com. The event will be developed in collaboration with the companies that currently contribute to the Journal and operate in China. Our aim is to develop the premier communication channel for advancing microwave technology in this growing market through print, electronic media and a dedicated conference/ trade show.

At the Journal, we have been giving this project much thought and recognize this as an opportunity to design a different kind of program, albeit one that reflects the editorial focus of our magazine and the design community's needs. In its first year, EDI Con will be a two and a half day event with a technical program featuring the latest design techniques and technologies, workshops for advanced professional education and product training, business panels to discuss market trends and an exhibition of leading microwave companies.

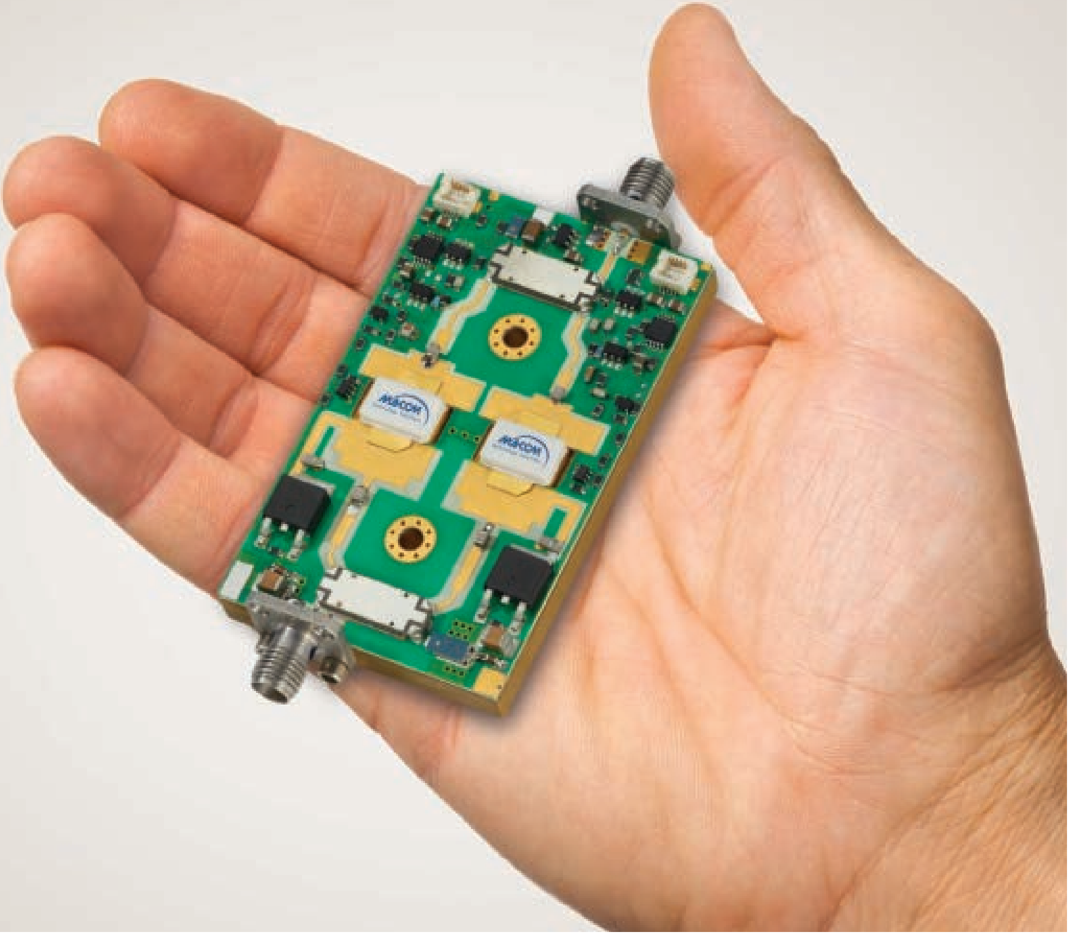
The technical program will be developed in partnership with industry and local academia with an emphasis on design trends and the needs of the industries we serve. Papers, workshops and tutorials will encompass all aspects of high frequency/ high speed design from new semiconductor processes and circuit architecture, to the advanced miniaturization and integration of microwave components and subassemblies necessary for tomorrow's communication systems. Topics will include advanced materials and semiconductors, simulation and EM modeling, as well as testing at the component and system levels.

The Journal often presents microwave technology in the context of business and industry. EDI Con will offer a similar balance with keynote talks and panel sessions featuring high-level executives from both industry and government. Designing a conference from the ground up provides the perfect opportunity to apply lessons learned from our involvement in a variety of other events and the freedom to innovate. By announcing this initiative now, we are reaching out to potential partners in this venture and we look forward to your feedback when we meet face to face in Montréal. We hope you participate. After all, there is no business like show business. And it all starts in Beijing, March 2013.

www.ediconchina.com

DAVID VYE
Microwave Journal *Editor*

POWER IN THE PALM OF YOUR HAND



Actual Size

M/A-COM Tech's Smart Pallet combines the power of GaN on SiC technology with intelligent bias circuitry in a small form factor that fits in the palm of your hand.

Learn why a leader in the US Defense industry chose M/A-COM Tech's Smart Pallet for their mortar locating radar systems at:

www.macomtech.com/GaN

M/A-COM
Technology Solutions
THE FIRST NAME IN MICROWAVE®

See us at IMS Booth 815

Montréal
Canada

Oh Canada!

Earlier this year, I participated in an industry focus group where we were asked the following question: "What is the number one opportunity for microwave technology and who is in the best position to capitalize on it?" My knee jerk response was to offer a short list of hot markets, including 4G, mobile internet, M2M, aerospace and defense, etc. In contrast, the technically-inclined members of the group saw opportunity from a completely different perspective. For them, opportunity was the chance to utilize spectrum more efficiently or to get more functionality into a smaller component.

It was an eye-opening moment for me, the realization that engineers view problems as opportunities. Besides being a great personality trait, it is a point of view that has widespread ramifications. While the promise of financial reward from future markets may fund R&D, it is technical advancement that creates markets and it is those who see problems as opportunities that lead the way. Rethinking the question, I now side with those who say the greatest opportunity in our field belongs to whoever can pack the most RF/microwave functionality into the smallest footprint (and I'll add "lowest cost" to the wish list). Miniaturization and integration have always been the leading technical goals for our industry and the International Microwave Symposium (IMS) is a great opportunity to assess where we are in that quest.

IMS has two major components, namely the technical conferences and the exhibition. In terms of size and quality, the technical program is unparalleled in its focus on microwave technology. How good are the technical papers presented at IMS? In our November 2011 cover story, the Journal reported on the industry's leading innovations. Our list of the top ten innovations of 2011 was compiled largely by cross-referencing three sources – twelve months of *Microwave Journal* editorial and the technical programs from IMS and European Microwave Week. If it is new and significant, it will be in the IMS technical program. Overviews of this year's technical programs are featured in this month's welcome messages from the IMS, RFIC and ARFTG chairs.

Of course the other component to IMS is the exhibition. This spring, many of you will be attending your share of industry-related trade shows or preparing new products to be introduced at these events. Some shows will be focused around a specific market/industry such as Mobile World Congress (see MWJ International Editor, Richard Mumford's show wrap-up in this issue, pg. 106) or CTIA Wireless. These are large events (40,000+ attendees) in which RF/microwave technology plays a small but critical part in the overall event eco-system. But the exhibition at IMS is all about our technology – the latest microwave components, subsystems, test solutions and software products.

For a preview of what will be on display, check out this issue's new IMS Product Showcase, pg. 250. This year, we are trying out a bold experiment to enhance the *Microwave Journal* user experience. Showing a bias to those folks that will be at the exhibition, we have organized products by their location on the exhibition floor rather than by product category. So when an attendee is standing in aisle 1500 for example, *Microwave Journal* will tell them what new products are nearby. The full exhibitor list with booth number (companies whose advertisements appear in this issue are in red) and the show floor map

(Continued on pg. 30)

David Vye
Microwave Journal *Editor*

High Performance RF and Microwave Filters

For mission-critical applications

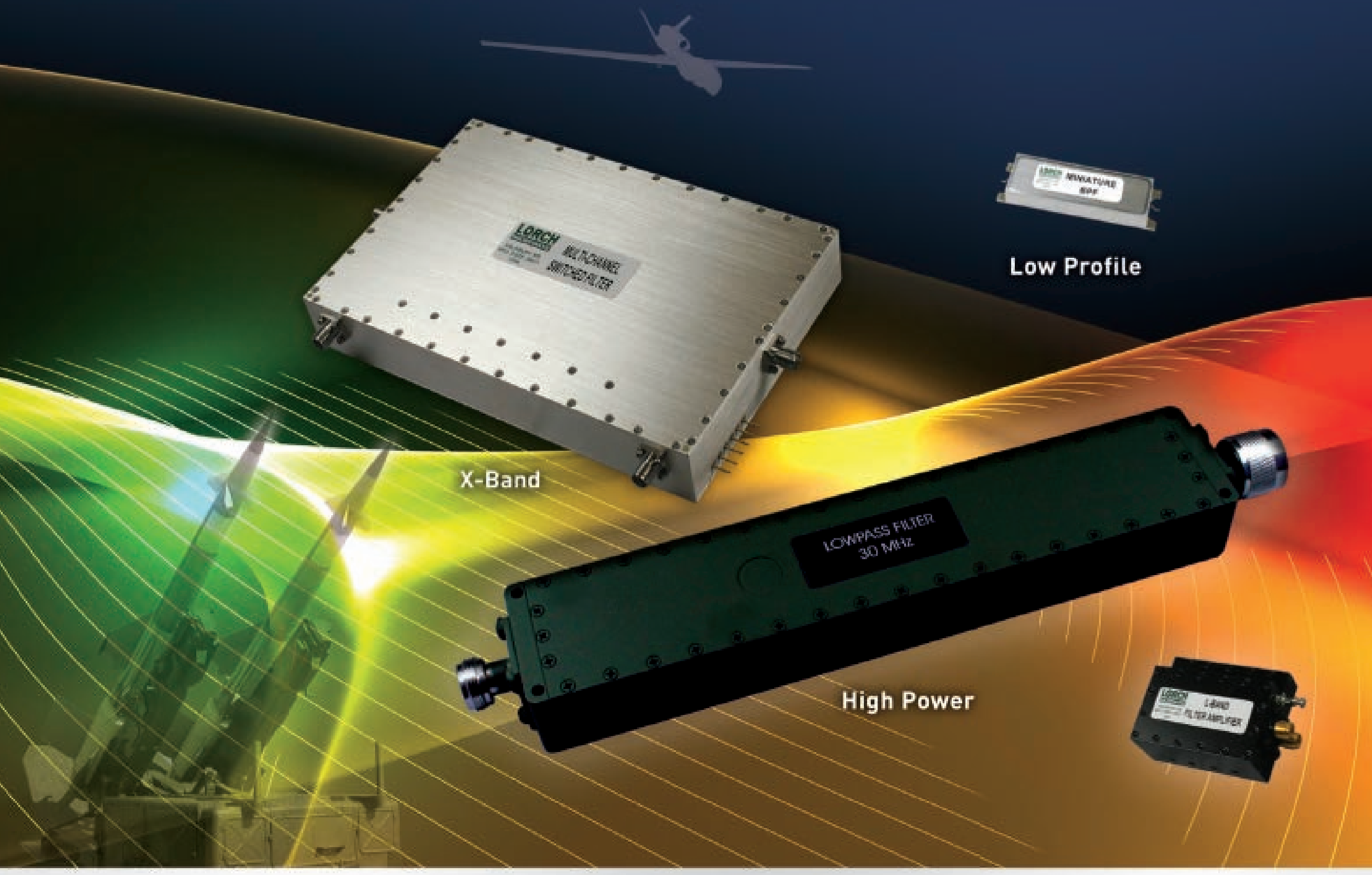
Precision

Speed

Execution

Integrated Assemblies
RF & Microwave Filters

When communications are critical and complex applications require engineering expertise, trust Lorch Microwave to deliver the highest quality products quickly and affordably while optimizing performance and value. We incorporate over four decades of innovative design and manufacturing technology with the flexibility to meet each customer's unique requirements, whether standard or custom, for military, industrial, and commercial markets globally.



LORCH MICROWAVE

Salisbury, MD 21802 · USA · 800.780.2169 · 410.860.5100
Brackenholme Y08 6EL, UK · Tel/Fax +44 (0) 1757 633 755
www.lorch.com

See us at IMS Booth 1709

smiths
bringing technology to life

(pg. 248) directly precede the new products section to help readers locate specific companies without having to rifle through the entire magazine. And to add in a little fun, play this month's puzzler (pg. 282) – the new IMS Products Scavenger Hunt and bring the completed puzzle to our booth (#2018) to be entered into a daily prize drawing.

As an event that travels to different locations each year, IMS is also about its host city. And this year, the MTT-S is celebrating its 60th year by holding the symposium outside the U.S., truly living up to its "International" title. Montréal is a beautiful city, within driving range from many East Coast cities and hopefully a powerful draw for the international audience that the society is aiming to attract. The Journal celebrates this location with our latest graphic novel, "Montréal Road Trip 2012"– a salute to those of you pulling late hours to get new products ready in time for the event.

Also, this month's cover story pays tribute to the region's technical roots with a look at the rise and fall of former Canadian telecommunication giant, Nortel. This is a fascinating story of the vision and innovation that made this company a powerhouse during the dot com bubble and helped establish the Montréal-Ottawa-Toronto technology belt as world class.

Since the days when Ted Saad served as this magazine's first editor and was instrumental in creating the MTT-S, our two organizations have enjoyed a close and personal relationship. As an IMS media partner, it is a pleasure to support the event through our extended coverage and we thank the organizers for the opportunity to interact with attendees through the Cyber Café, the Device Characterization & Design Expert Panel at MicroApps and Strategy Analytics' "RF Market Opportunities for GaN" Panel. Congratulations to the MTT-S on turning 60 and we will see all of you problem solvers looking for opportunities in the Great White North. ■


ims

Attenuators
Resistors
Terminations
Broadband Splitters
Broadband Couplers
Thermal Management
Dividers
Filters

• Featured Products •

Temperature Variable Attenuators AV-0805
- Characterized to 5GHz
- 63mW Power Rating
- Values 0 - 10dB,
- Curves N1 - N9
- RoHS Compliant Solderable Terminals

Broadband 2, 3 & 4 Way SMT Splitters IPS Series
- Power Ratings to 3W
- Characterized to 20GHz
- 1.3:1 VSWR
- 50Ω or 75Ω Impedance
- Solder, Epoxy or Wirebond Terminals

Get Samples and See More at www.ims-resistors.com!
Come visit us in Montréal: Booth 2310!


FROM 500 MHZ TO 110 GHZ SIMPLE OR COMPLEX
WE MANUFACTURE THE COMPONENTS YOU NEED

NORDEN MILLIMETER

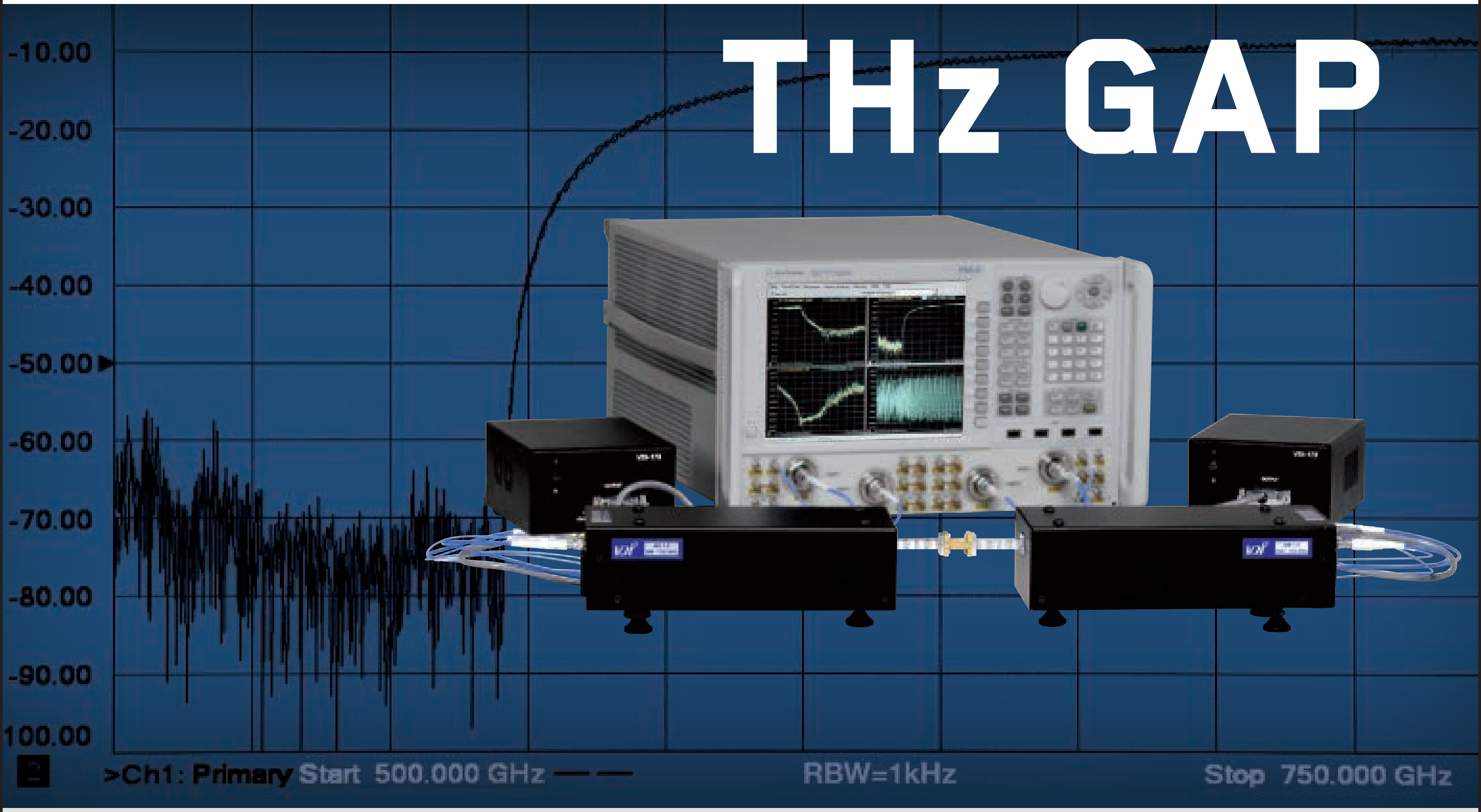
AMPLIFIERS
FREQUENCY MULTIPLIERS
TRANSCEIVERS & FREQUENCY CONVERTERS
CUSTOM ASSEMBLIES
OSCILLATORS

WWW.NORDENGROUP.COM
PHONE (530) 642-9123 FAX (530) 642-9420

See us at IMS Booth 3326

UNMATCHED DYNAMIC RANGE. **UNMATCHED PERFORMANCE.**

BRIDGE THE THz GAP



VDI'S VNA EXTENSION MODULES

provide high performance frequency extension of vector network analyzers into the THz range. Models are currently available that cover 50GHz to 1.1THz and combine high test-port power with superb dynamic range to offer unparalleled performance. VDI's VNA Extension Modules are compatible with all modern network analyzers. Contact VDI to discuss VNA and Extender configurations that will yield the best performance for your application.

Waveguide Band (GHz)	**WR15** 50-75	**WR10** 75-110	**WR8.0** 90-140	**WR6.5** 110-170	**WR5.1** 140-220	**WR3.4** 220-325	**WR2.2** 325-500	**WR1.5** 500-750	**WR1.0** 750-1,100
Dynamic Range (BW=10Hz,dB,typ)	120	120	120	120	120	110	100	**100**	60
Dynamic Range (BW=10Hz,dB,min)	100	100	90	90	90	90	80	**80**	40
Magnitude Stability (±dB)	0.15	0.15	0.15	0.25	0.25	0.3	0.5	**0.8**	1
Phase Stability (±deg)	2	2	2	4	4	6	8	**10**	15
Test Port Power (dBm)	3	3	0	0	-3	-9	-17	**-25**	-35

VIRGINIA DIODES, INC.

434.297.3257 | vadiodes.com

MITEQ® Your Amplifier **Source**

The largest and broadest Standard Amplifier product line available today!

Narrowband to Multi-Octave, ranging from 1 kHz to 65 GHz, with noise figures and power levels only dreamed about.

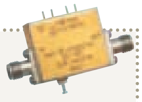
GaN

POWER Amplifiers

- **Frequencies in excess of 10 Octaves**
- Models from 30 MHz to 4 GHz
- **3 to 10 W**
- Single bias, 30V

High Power

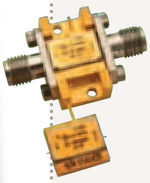
Amplifiers



- **Widest Bandwidths** available with standard frequencies from 2 - 40 GHz
- X- and Ka-Band SSPAs
- Over **250 standard models**
- Space and Airborne qualified

Broad and *Ultra-Broadband*

Amplifiers



- **0.1 - 40 GHz**
- Standard models covering all standard Communication, SATCOM and Military Bands
- Over **2,500 standard models**

SATCOM and *Radar*

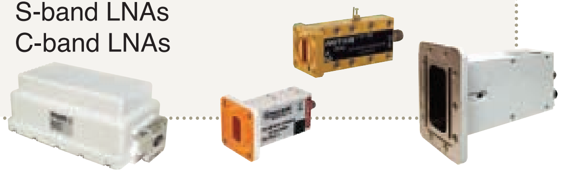
High-Performance Amplifiers

- SATCOM, Radar and Satellite Bands
- **Pulsed Power** Amplifiers
- Compact designs

Waveguide

Amplifiers

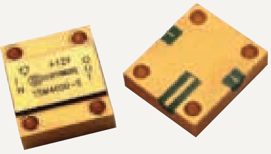
- **Noise Figures** as low as **28°K**
- Over **500 standard models** available
- Cooled **Ka-Band LNAs** down to **80°K**
- Rugged outdoor and airborne applications
- Waveguides with fiber optic interfaces
- S-band LNAs
- C-band LNAs

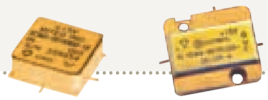


Surface Mount

Amplifiers

- **True Surface Mount** Amplifiers with frequencies **up to 40 GHz**
- Ultra High Frequencies
- Wideband
- Microwaveband
- Low-Noise



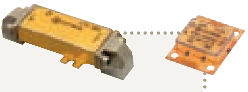


Quality RF/Microwave Prducts For Over 40 Years

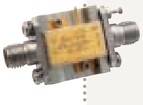
3 YEAR WARRANTY

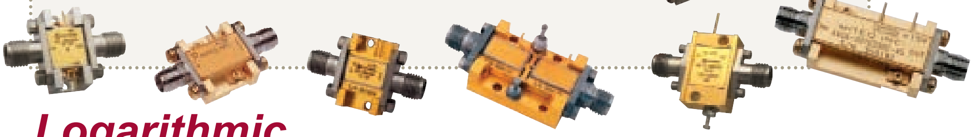
Low Noise

Amplifiers .001 MHz to 75 GHz



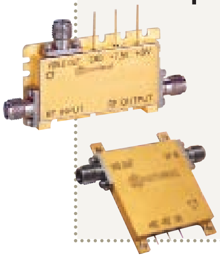
- **Lowest guaranteed noise figures** in the industry, ie: 0.3 dB in L-band and 2 dB in K-band
- Over **2,500 standard models** available
- Surface Mount, Connectorized, In-line



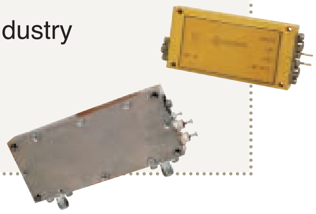


Logarithmic

Amplifiers available to 8 GHz



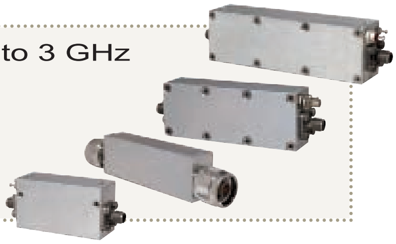
- **Fastest Rise time** in the industry, as low as **1 ns**
- -55 to +95°C temperature stability
- **Lowest Sensitivity levels** in the industry as low as -95 dBm
- Compact **Low Profile Housings**
- Space and Airborne qualified



Bipolar

Amplifiers available 1 KHz to 3 GHz

- Lowest noise figures available:
  1.1 dB @ 10 MHz
  1.4 dB @ 500 MHz
  1.7 dB @ 1 GHz

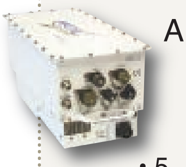


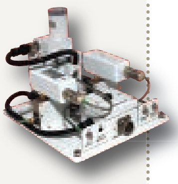
Complete Amplifier Assemblies and Sub-Assemblies

With over 40 years of RF/microwave component expertise. MITEQ designs and manufactures single or multifunction assemblies to customer specifications.

SATCOM

Amplifier **Systems and Equipment**





Amplifier Systems • Redundant LNAs • Fiber Optic LNAs
Amplifier Plate Assemblies

TWT Amplifiers • **Instrumentation Power** Amplifiers
• 5 - 51 GHz Coverage • Indoor and Outdoor Ruggedized Configurations

MITEQ can customize our standard designs to meet your specific requirements. For further information, please contact our Sales Department at (631) 439-9220 or e-mail components@miteq.com

ISO 9001 Registered ANAB AS9100 Registered

MITEQ®

100 Davids Drive, Hauppauge, NY 11788
TEL.: (631) 436-7400 • FAX: (631) 436-7430

See us at IMS Booth 1425

Other Amplifiers Available:

- *Built-In Test Detector*
- *Coaxial In-Line*
- *Cryogenic*
- *Desktop*
- *Detector Log Video*
- *Drop In*
- *Dual Output*
- *Fast Recovery (NMR/MRI)*
- *Gain Control*
- *IF Gain Control*
- *IF Auto Gain Control*
- *Limiting*
- *Low Current Consumption*
- *Low Frequency*
- *Low Phase Noise*
- *Medium Power*
- *Power Monitoring*
- *Pulse*
- *Pulse Modulated*
- *SATCOM*
- *Spaceborne*
- *Surface Mount*
- *Temperature Compensated*
- *Waveguide*
- *Multi-Octave*
- *75 Ohm*

MITEQ Components

- *Mixers*
- *Multipliers*
- *Fiber Optic Products*
- *Frequency Generation Products*
- *Microwave Control Products*
- *Passive Power Components*
- *IF Signal Processing*
- *Integrated Assemblies*

www.miteq.com

Goliath's Fall

The birthplace of the world's first smartphone is a one hour drive west from this year's IMS at the Palais des Congrès de Montréal. In 1998, ten years before Apple unleashed its iPhone or Research in Motion (RIM) of Waterloo, Ontario hit it big with the BlackBerry, a small group of engineers, industrial designers and psychologists at Nortel's Corporate Design Group in Ottawa developed the "Orbitor." This handheld device could transform into a pager, voice mailbox, fax machine or wireless phone with the simple touch of a finger or stylus. The company's R&D group had 80 finished units ready for market with service delivery trials set to begin with one of Europe's largest cell phone operators. Nortel had leveraged its joint venture in GSM with French company Matra (1992) and four years of internal development to produce a potential game-changing product. This level of market-leading innovation was not a fluke for Nortel's massive research center and the city known as Silicon Valley north.

Established in 1961, the epicenter of Nortel Networks' research and development was known as the Carling Campus. With a man-made lake and 11 glass and steel buildings totaling over 2 million square feet connected by underground tunnels, the campus was originally built to house 9000 workers. In addition to the 6700 employees engaged in advanced research and product development, the company employed nearly 2300 employees dedicated to manufacturing, marketing, operations and services. Less than a mile from the Carling site, Nortel's Technology Supply and Components organization operated its own 500,000 square foot Corkstown facility, home to Nortel Semiconductors, which designed and manufactured custom microchips and application-specific integrated circuits (ASIC); and Nortel Microwave Modules, which manufactured RF, wireless and transmission multi-chip modules.

In 2001 at the company's height, Nortel had 16,000 employees working in Ottawa with 12,000 of them in R&D. Researchers were working in all areas of hardware,

DAVID VYE
Microwave Journal *Editor*

RF & MICROWAVE FILTERS

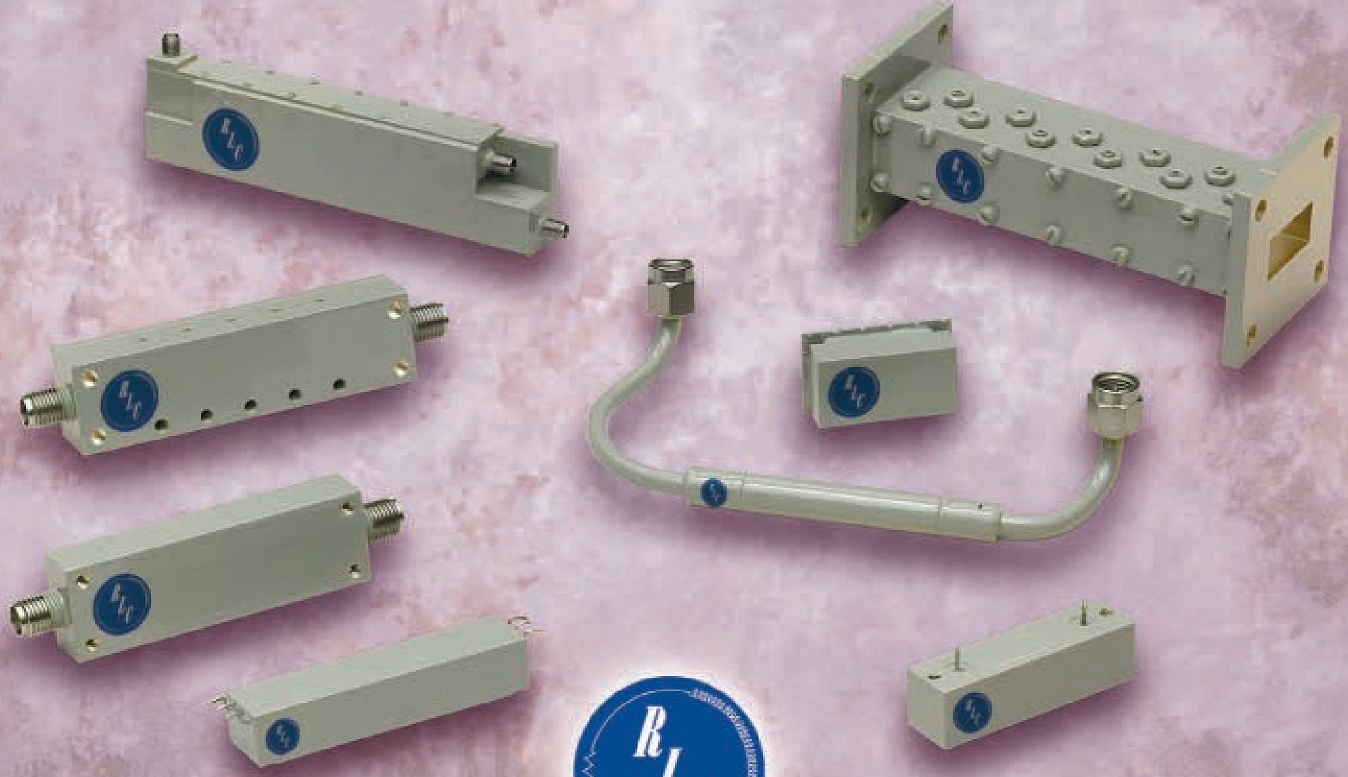
RLC has the customized filter solutions you need.

RLC manufactures a complete line of RF and Microwave filters covering nearly every application in the DC to 50 GHz frequency range. We offer different filter types, each covering a specific engineering need.

In addition, our large engineering staff and high volume production facility give RLC the ability to develop and deliver both standard and custom designed filters at competitive costs, within days or a few weeks of order placement.

- **Band Pass, Low Pass, High Pass & Band Reject**
- **Connectorized, Surface Mount, PCB Mount or Cable Filters**
- **Wave Guide Bandpass and Band Reject**
- **4th Order Bessel Filters**
- **Spurious Free, DC to 50 GHz, Low Loss, High Rejection**
- **Custom Designs**

*For more detailed information, or to access **RLC's exclusive Filter Selection Software**, visit our web site.*



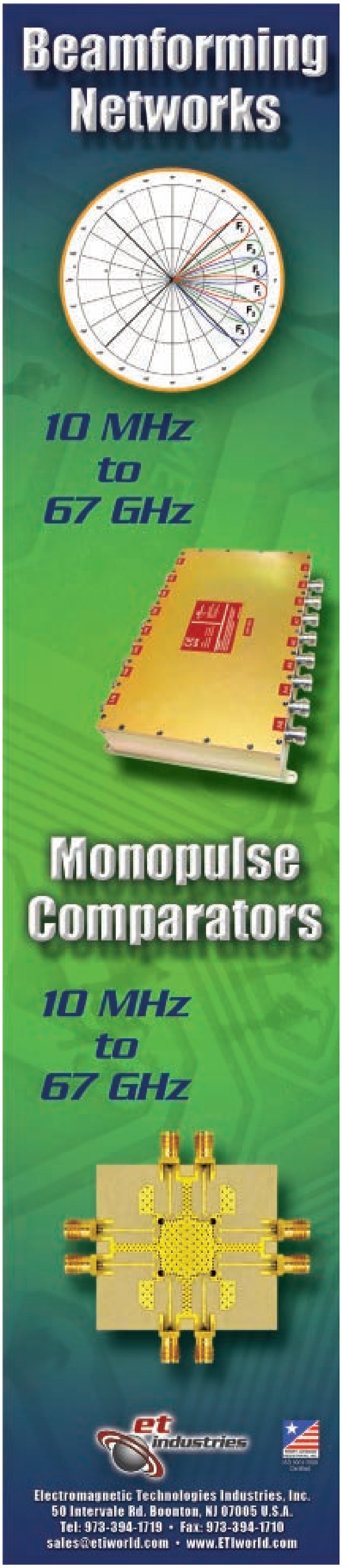
RLC ELECTRONICS, INC.

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

ISO 9001:2000 CERTIFIED

RLC is your complete microwave component source...
Switches, Filters, Power Dividers, Terminations, Attenuators, DC Blocks, Bias Tees & Detectors.

See us at IMS Booth 510



Beamforming Networks

10 MHz to 67 GHz

Monopulse Comparators

10 MHz to 67 GHz

et industries

Electromagnetic Technologies Industries, Inc.
50 Intervale Rd. Boonton, NJ 07005 U.S.A.
Tel: 973-394-1719 • Fax: 973-394-1710
sales@etiworld.com • www.ETIworld.com

software and semiconductor technology among multiple labs, including the Physical Design Integration Group, which focused on systems packaging and product integrity at the nearby Kanata complex. Ten years later, the nearly empty campus would be sold to the Public Works and Government Services Canada for a cash purchase price of CDN$ 208 million. The fall of Nortel marks a dark period in the long history of a vibrant and innovative Canadian-based telecommunications industry. Over 6000 patents, the intellectual output of this colossal R&D workforce, would be licensed to a consortium of foreign telecom OEMs for CDN$ 4.5 billion and the Orbitor would remain an obscure footnote in the development of mobile technology.

THE BIRTH OF BELL CANADA

Montréal lies at the eastern tip of Canada's Montréal-Ottawa-Toronto technology corridor and was home to the earliest manufacturing within the telecommunication sector. The industry got its start at the western tip, in the outskirts of Toronto in the town of Brantford, Ontario where Alexander Graham Bell first conceived the telephone in 1874. Bell's concept of transmitting speech electrically came into sharper focus in Boston where he created his "harmonic telegraph," along with his collaborator, Thomas Watson. Working in the transmitter room on June 2, 1875, Watson unintentionally produced and transmitted a twanging sound while trying to free a reed that had been too tightly wound to the pole of its electromagnet. Bell heard the sound from the receiving room and realized the complex overtones and timbre was similar to the human voice. Inspired by this accident, Bell raced to perfect his telephone while also writing up specifications to be filed with the United States Patent Office.

On February 14, 1876, Alexander Graham Bell's telephone patent application entitled "Improvement in Telegraphy" was filed by his attorney; just a few hours before the attorney for a Western Electric inventor named Elisha Gray filed a caveat for a telephone entitled "Transmitting Vocal Sounds Telegraphically." A patent caveat was a type of preliminary application for a patent that gave an inventor an additional ninety days grace to file a regular patent application. The caveat would prevent anyone else that filed an application on the same or similar invention from having their application processed for ninety days. Alexander Graham Bell was the fifth entry of that day, while Elisha Gray was 39th. Therefore on March 7, 1876, rather than honor Gray's caveat, Bell was awarded the first patent for a telephone - US Patent No. 174,465. Controversy persists to this day over the filing of these patents and the true ownership of the invention. Three days after being awarded the patent, Bell built and successfully tested Gray's liquid transmitter design, famously transmitting his "Mr. Watson, come here, I want to see you" message. On September 12, 1878, lengthy patent litigation involving the Bell Telephone Co. against Western Union Telegraph Co. and Elisha Gray began.

The Bell Telephone Co., was organized in Boston in 1877 by Bell's father-in-law Gardiner Greene Hubbard, and was started for the purpose of holding "potentially valuable patents," principally Bell's master telephone patent. The company subsequently merged with others (including Hubbard's National Bell Telephone Co.) to form the American Bell Telephone Co., which would later evolve into AT&T under the direction of Thomas Vail. Bell gave 75 percent of the Canadian patent rights to his father who served on the board of directors for Bell Telephone of Canada, incorporated in 1880. Bell Canada would operate telephone exchanges throughout Canada and manufacture telephones and associated equipment.

CST STUDIO SUITE 2012

Discover what happens...

Making Sense of the Real World – System Level EM Simulation

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 2012 helps optimize component as well as system performance.
Get the big picture of what’s really going on. Ensure your product and components perform in the toughest of environments.

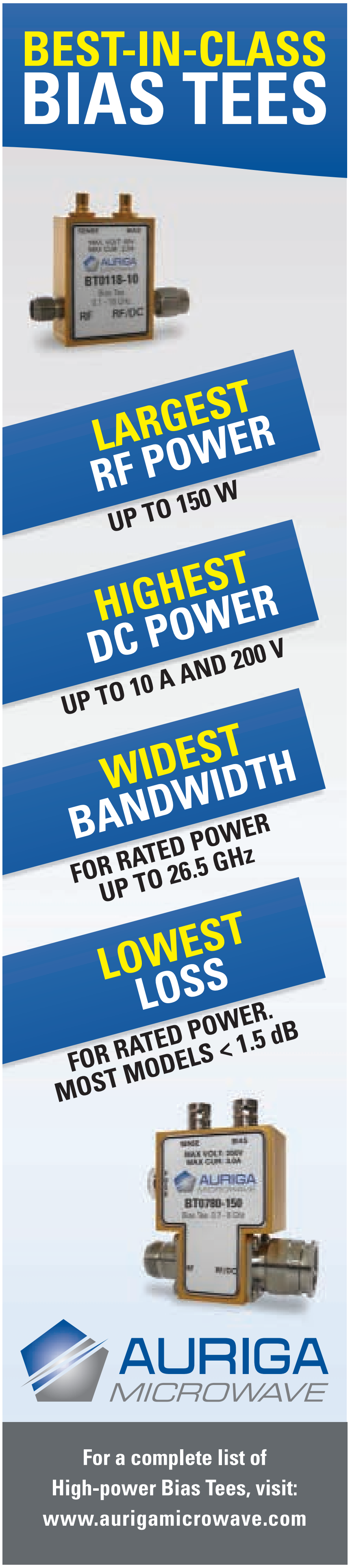
Choose CST STUDIO SUITE 2012 – complete technology for 3D EM.

See us at IMS Booth 1615

CST

CHANGING THE STANDARDS

CST of America®, Inc. | To request literature (508) 665 4400 | www.cst.com


BEST-IN-CLASS
BIAS TEES

LARGEST
RF POWER
UP TO 150 W

HIGHEST
DC POWER
UP TO 10 A AND 200 V

WIDEST
BANDWIDTH
FOR RATED POWER
UP TO 26.5 GHz

LOWEST
LOSS
FOR RATED POWER.
MOST MODELS < 1.5 dB

AURIGA
MICROWAVE

For a complete list of
High-power Bias Tees, visit:
www.aurigamicrowave.com

Montréal Canada

NORTHERN ELECTRIC IS CREATED

In 1881, a former New England sea captain named Charles Fleetford Sise unified all of the Canadian telephone networks under the aegis of Bell Telephone of Canada. He then began developing long-distance networks between cities. When the operator of the world's first telephone manufacturing plant died of tuberculosis, Sise lost his domestic supply of telephone equipment. Without an alternative Canadian supplier he would lose the Canadian patent rights. Had it not been for this law and his inability to find an alternative supplier, Sise may not have been pressured to start his own manufacturing plant and subsequent R&D labs.

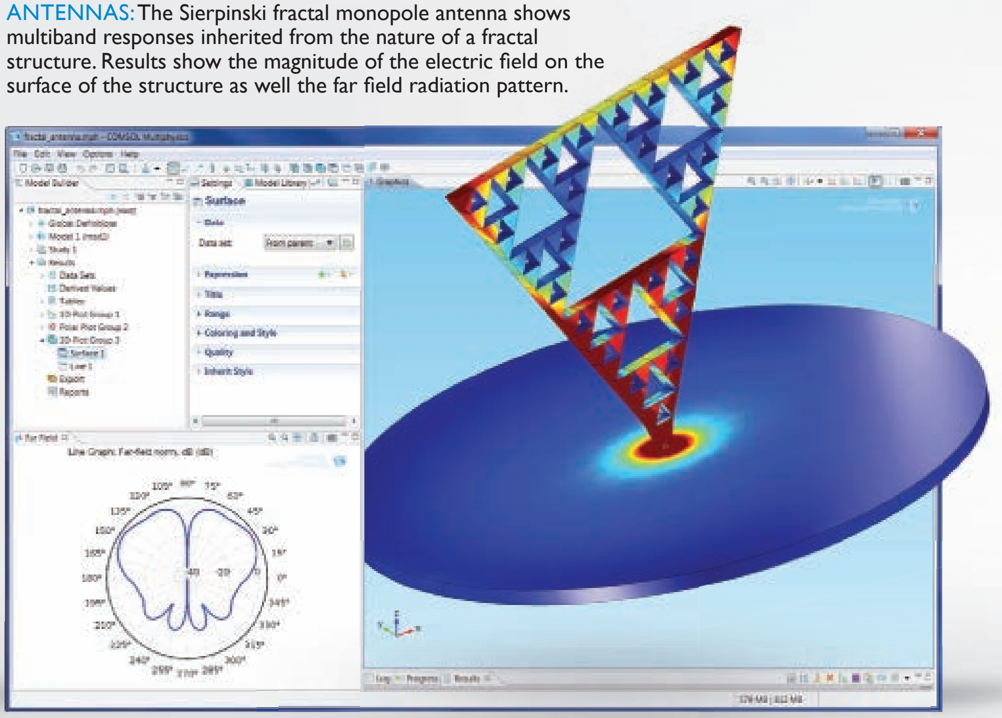
After consulting with Theodore Vail, president of the National Bell Telephone Co., a major shareholder in the Canadian telephone business and the man often credited with creating the nationwide AT&T network, Sise hired an experienced foreman from National Bell's Boston plant and rented two floors of a building in Montréal for manufacturing. The mechanical division of The Bell Telephone Co. of Canada began in 1882 with the arrival of Brown and the rental of those two floors. In addition to phones, the department would start manufacturing its first switchboard, a 50 line Standard Magneto Switchboard. The popularity of the telephone led to yearly growth and an expansion to 50 employees by 1888, transforming into a separate manufacturing branch with 200 employees and a new factory under construction by 1890.

Shortly, the production capacity outpaced demand for phones and the branch faced closure unless it could manufacture other products. In 1895, Bell Canada spun off its manufacturing arm to expand by building phones for other companies as well as other devices such as police and fire department call boxes. This new company was incorporated as Northern Electric and Manufacturing Co. Ltd.

By 1899, Bell Telephone of Canada purchased the Barrie and Johnson Wire and Cable company, which it had renamed the Imperial Wire and Cable Co. Northern Electric Co. amalgamated with Imperial in 1914 and moved to a new factory located at Shearer Street in Montréal. This facility would be the company's primary manufacturing center until the mid-1950s. In between that time, Northern Electric would grow alongside the technology that marked the first half of the twentieth century, developing a one-wire telegraphic switchboard for military service known as the portable commutator in WWI; in 1922, Northern developed the first Canadian vacuum tube – a $5 "Peanut" tube that was the smallest made, requiring only one-tenth of an amp, which was used on repeater apparatus for long-distance lines. The company also grew with the production of a large commercial grade radio system in 1923 and general use consumer radios in 1926.

With Canada pulled into WWII, the government froze development of non-military products in 1941, but placed orders for $40 million worth of military supplies. This represented 2.5 times the company's sales from 1939, leading to an expansion from 5000 to 8000 employees working around the clock to meet production demand and develop new technologies. Northern Electric supplied electrical equipment for Royal Canadian Navy Destroyers and produced a two-way wireless set for telephone communications between tanks and other military vehicles operated by Canadian, British and Russian armed forces. The company was also developing expertise in new technologies such as radar and microwaves, delivering 19,000 magnetron tubes for radar. This expertise would serve the company well after the war in its development of Canada's first microwave relay long-distance telephone and television systems.

ANTENNAS: The Sierpinski fractal monopole antenna shows multiband responses inherited from the nature of a fractal structure. Results show the magnitude of the electric field on the surface of the structure as well the far field radiation pattern.



Verify and optimize your designs with COMSOL Multiphysics®

Multiphysics tools let you build simulations that accurately replicate the important characteristics of your designs. The key is the ability to include all physical effects that exist in the real world. Order a free CD containing 700 multiphysics presentations at **www.comsol.com/confcd**

Product Suite

COMSOL Multiphysics

FLUID
CFD Module
Microfluidics Module
Subsurface Flow Module

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

MECHANICAL
Heat Transfer Module
Structural Mechanics Module
Geomechanics Module
Acoustics Module

ELECTRICAL
AC/DC Module
RF Module
MEMS Module
Plasma Module

MULTIPURPOSE
Optimization Module
Material Library
Particle Tracing Module

INTERFACING
CAD Import Module
File Import for CATIA® V5
LiveLink™ for SolidWorks®
LiveLink™ for SpaceClaim®

LiveLink™ for Pro/ENGINEER®
LiveLink™ for Creo™ Parametric
LiveLink™ for Inventor®
LiveLink™ for AutoCAD®
LiveLink™ for MATLAB®

COMSOL

©2012 COMSOL. COMSOL, COMSOL Multiphysics and LiveLink are either registered trademarks or trademarks of COMSOL AB. AutoCAD and Inventor are registered trademarks of Autodesk, Inc., in the USA and other countries. LiveLink for AutoCAD and LiveLink for Inventor are not affiliated with, endorsed by, sponsored by, or supported by Autodesk, Inc., and/or its affiliates and/or subsidiaries. MATLAB is a registered trademark of The Mathworks, Inc. Pro/ENGINEER and Creo are trademarks or registered trademarks of Parametric Technology Corporation or its subsidiaries in the U.S. and in other countries. SolidWorks is a registered trademark of Dassault Systèmes SolidWorks Corp. CATIA is a registered trademark of Dassault Systémes. SpaceClaim is a registered trademark of SpaceClaim Corporation.

Universal Microwave Components Corporation UMCC

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

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

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

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

www.umcc111.com

CUTTING THE CORD WITH BELL LABS

Before Bell came along, Western Electric was the principal manufacturer for Western Union, the telegraph company. In 1882 Western Electric joined the Bell System (Bell purchased a controlling interest in its stock) and subsequently the company manufactured in every country with significant telephone systems. Bell's subsequent acquisition of Western Electric was crucial in the establishment of a nationwide phone system, a system characterized by its early, primary emphasis on the production and distribution of hardware. Western Electric owned 44 percent of Northern Electric, the rest was owned by Bell of Canada. For the first fifty years of the company's existence, Northern Electric essentially manufactured equipment based on designs and processes licensed from Western Electric.

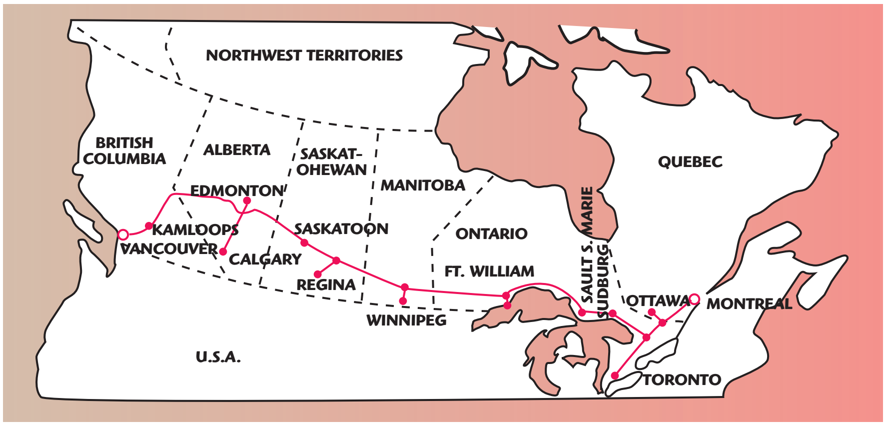
In 1949, the Department of Justice sought the separation of Western Electric (manufacturing) from AT&T (service). As a consequence of this antitrust case, AT&T was ordered to divest all of its non-telephone activities, except those involving national defense. The 1956 consent decree also called for Western Electric to relinquish its 40 percent interest in Northern Electric of Canada, the last vestige of its international operations. Under the decree, Western Electric terminated its patent and licensing relationship with Northern Electric.

Cut off from its major technology wellsprings, Northern would either have to license technologies from others in the Canadian market or create its own technologies to compete in world markets. Choosing the latter, Northern Electric began to achieve technical independence in 1957 by creating its own research and development facilities in Belleville, and, in 1959, established Northern Electric Research and Development Laboratories in Ottawa, Ontario. At the same time, Bell Canada began stepping up its own development activities.

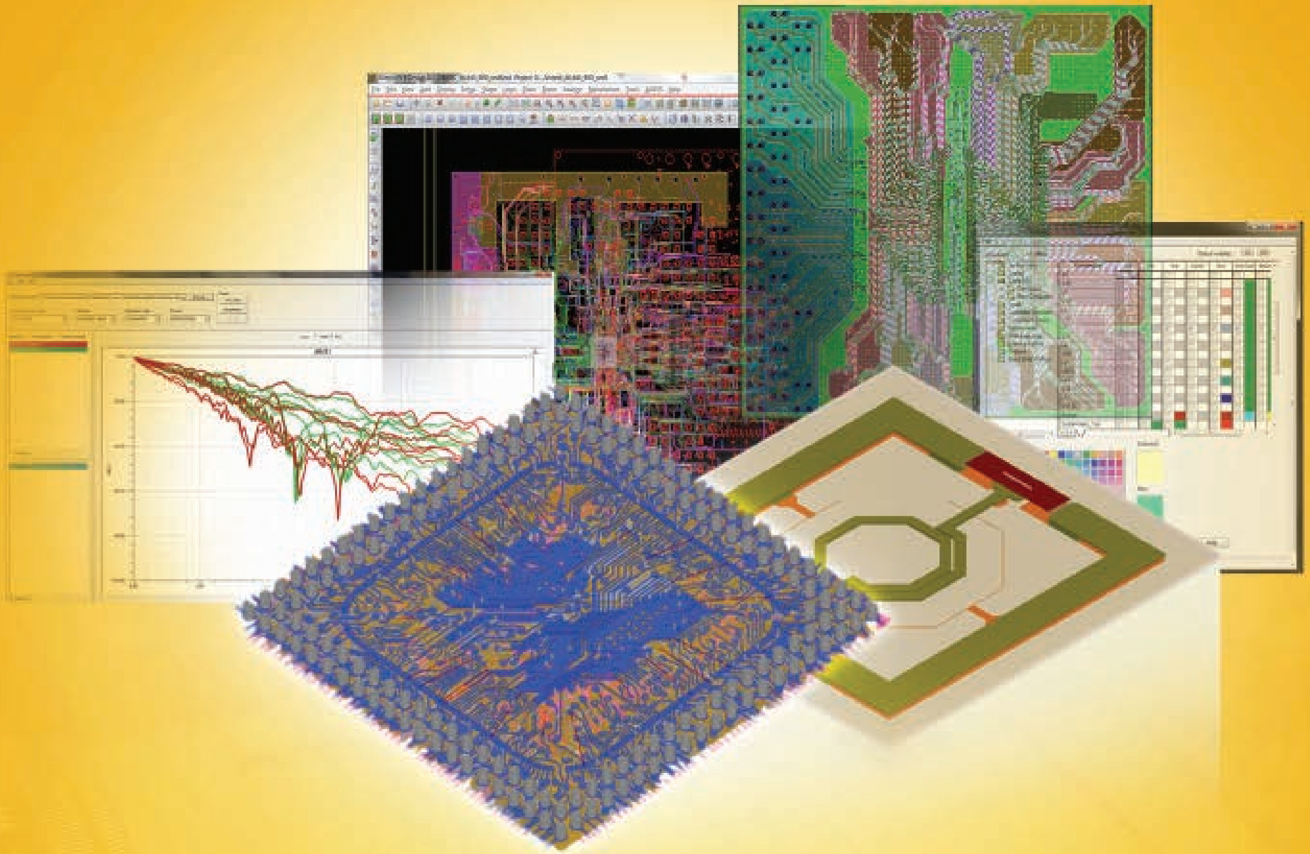
NORTHERN DEVELOPS TRANS-CANADA SKYWAY

In 1958, Northern built the equipment for the Trans-Canada Skyway, the world's longest microwave transmission network spanning over 6275 km at a cost of $50 million ($375 million in 2012 dollars). The system was implemented under Bell Canada president Thomas Eadie as an all-Canadian microwave network for transporting telephone conversations, teletype messages and television signals. This microwave-relay used 139 line-of-sight repeater stations spaced at approximately 25 mile intervals, to make a connection from Sydney, Nova Scotia to Victoria, British Columbia. The system allowed a microwave signal to travel from one coast to the other in just one-fiftieth of a second.

The towers ranged from nine meters high to over 100 meters high in northern Ontario (see ***Fig-***



▲ *Fig. 1 Route of the Trans-Canada Skyway microwave system.*



HFSS™ for full custom IC, package and PCB design

ANSYS HFSS, the industry standard for 3D full wave electromagnetic field simulation, can now be operated directly from within your chosen custom IC, package and PCB layout environment. Automatically extract reliable and accurate s-parameter models using the power of HFSS without ever leaving your design environment.

Realize Your Product Promise™

ANSYS®

For more information, visit www.ansys.com/HFSS

Or call us at 866 267 9724

See us at IMS Booth 907

ure 1). The 10 or 12 foot diameter parabolic antennas were fed by rectangular waveguide with ferrite isolators and circulators enabling two transmitters and two receivers to be connected to one dish, providing two separate message channels through the repeater in each direction. In the interest of providing greater isolation, the received signal was re-transmitted 252 MHz above or below the received frequency. The systems used eight such frequencies ranging from 5.974 to 6.404 GHz with 118 MHz spacing between two channels over the same path in the same direction. Each received carrier, at a level of approximately 1 micro watt, together with the local oscillator output, entered a balanced crystal mixer pre-amp whose 70 MHz output was pre-amplified to 0.09 V rms.

narda today

The Engineer's **Choice** for **Attenuators**

"Our Narda 794FM 4-8 Ghz variable attenuator was obtained in the 1980s, and it's still going strong."

Narda's offers a robust selection of fixed, variable, and step attenuators.

- Frequencies Range from DC to 40 GHz
- High Power Handling to 150 Watts
- Attenuation Range from 0 to 69 dB
- Connectors Include SMA, 2.92 mm, and Type N

Scan using your Smart Phone or Tablet to learn more!

Visit us at **IMS 2012** Booths 2916 & 2917

narda

Engineering, without compromise since 1954.

an L3 communications company

www.nardamicrowave.com • 631.231.1700

A NEW EMPHASIS ON R&D

Chief executive Cy Peachey joined the company in the 1920s and was instrumental in establishing the company's ethos of internal research and development. When Northern Electric was deprived of its links to Western Electric after the U.S. antitrust action, Peachey declared, "We know how to do it. We've got good engineers and we're going to build our research and development organization and we're all going to be pretty proud of it." As a major force at the company until the 1960s, he helped establish research labs in Belleville, Ontario (1957) and two years later in Ottawa, which started out with 42 engineers but grew to 800 people within five years. The lab was responsible for developing a growing list of successful products such as the very modern Contempra telephone (see ***Figure 2***) featuring the first dial-in-hand design. This product sold into 3.4 million homes and was put on display at New York's Museum of Modern Art.

On the technology side, the R&D labs developed the SA-1 community dial office (CDO), a small Class 5 Crossbar for local switching used in telephone exchanges in rural areas. Rural communities represented a sizable portion of Canada's sparse population and provided a good market niche for Northern to capitalize on while serving the unique communication needs of its customers. Freedom from AT&T allowed local engineers to pursue their own so-

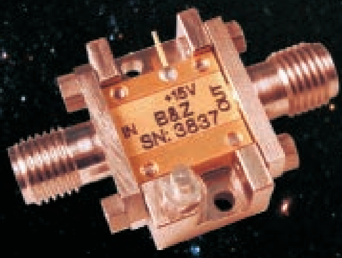
▲ *Fig. 2 Northern Electric's Contempra phone, the first dial-in-hand design.*

AMPLIFIERS

HIGH PERFORMANCE
100 kHz to 50 GHz

- To Your Specification
- Reasonable Prices

Most can be delivered in one week!



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

Visit us in Montreal at IMS 2012
Booth 1927

B&Z TECHNOLOGIES
INNOVATING TO EXCEL

Ph: +1 (631) 444-8827
Fax: +1 (631) 444-8825
E-Mail: info@bnztech.com
Web: www.bnztech.com
Made in USA

Year 3 Warranty

lutions for a market with different needs than those of its southern neighbors.

Communications for rural living provided an opportunity in the SATCOM business in the 1960s. When the Canadian Parliament decided to establish a domestic communications satellite network called Telesat Canada, Northern played a key technical role. As a prime subcontractor for Hughes Aircraft, Northern developed the satellite electronics and antenna equipment. The Anik A satellite system, which cost $90 million at the time, made Canada the first country to utilize synchronous satellite for domestic communication purposes. A contract for three satellites to operate in the 6/4 GHz range was awarded to Hughes Aircraft, with the participation of Northern Electric and Spar Aerospace (another Canadian company). Each satellite provided twelve high-capacity microwave channels for color television or as many as 960 one-way telephone calls. Of the thirty-seven ground stations built, twenty-four were equipped with receive only capability to provide live television programming to isolated Northern communities. This reduced the cost of the ground stations to $150,000 each from one- to two-million dollars for units capable of carrying radio, television and two-way voice.

See us at IMS Booth 1315

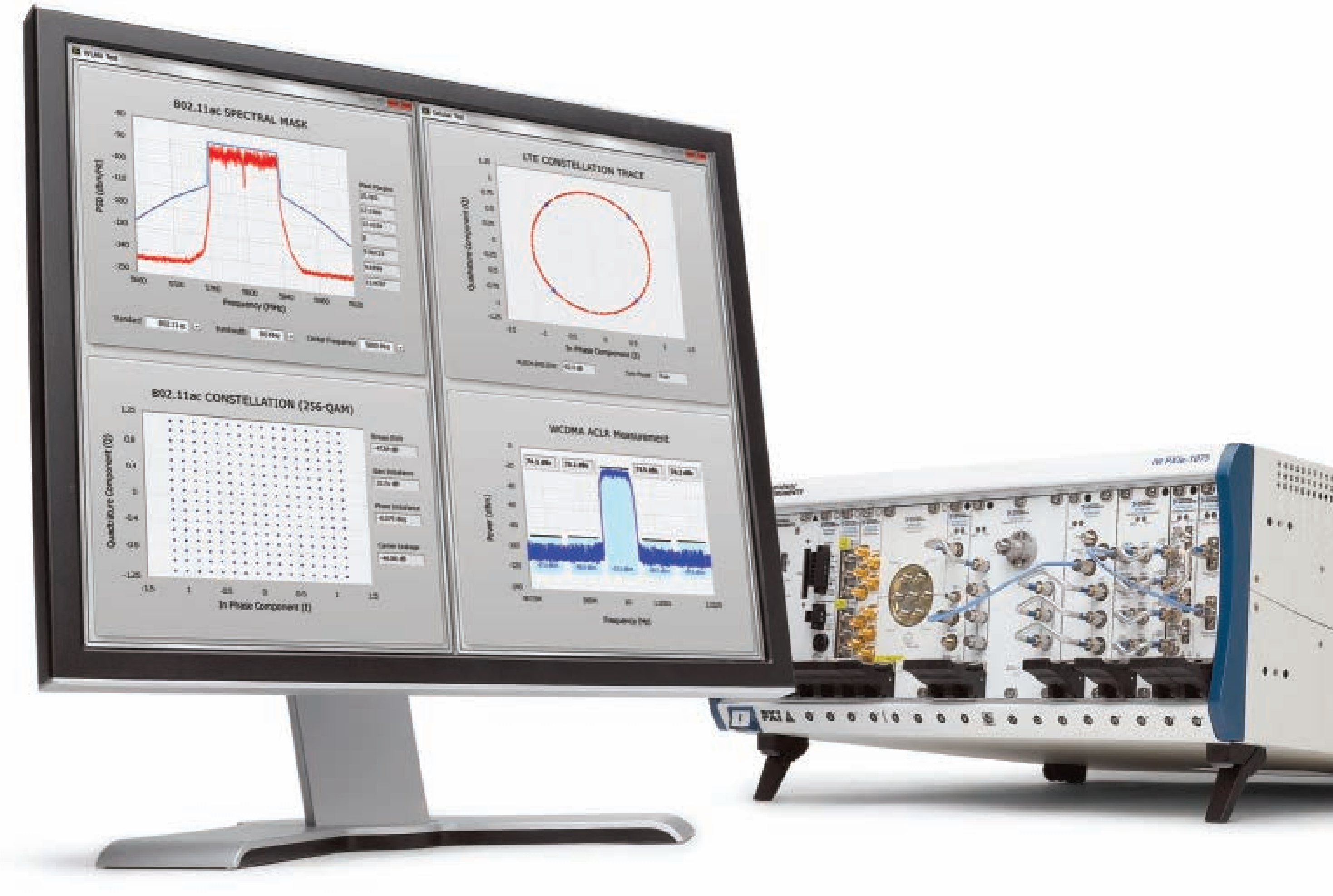
THE DIGITAL COMMUNICATION REVOLUTION BEGINS

In September of 1969, under the direction of a young Bell Canada engineer named R. Charles Terreault, Northern Electric set out to create a twenty-year plan for developing a telecommunications network. Terreault assembled the twenty-person team that produced a monumental twelve-volume Long Term Network Evolution Study, drawing upon the latest developments in microelectronics. The plan forecast the total digitization of the network up to the point of ISDN then called Multiple-Use Selective Routing. Everything was planned for, from decentralization of switching toward the user to an orientation toward broadband switching (for video). The cornerstone of Terreault's plan was the introduction of a complete line of digital switches by the late 1970s and early 1980s.

When Bell Labs put its first digital transmission system, the T-1, into service in 1965, Terreault realized that the digitization trend was irreversible, not only in transmission but in switching. In 1971, Bell Canada and Northern Electric followed the U.S. by deploying their own hybrid system switch, the SP-1 – representing the first major technological achievement in the modern history of Canadian telecommunications. The small switch

Redefining RF and Microwave Instrumentation

with open software and modular hardware



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

WIRELESS TECHNOLOGIES

National Instruments supports a broad range of wireless standards including:

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

>> Learn more at ni.com/redefine

800 813 5078

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

NATIONAL INSTRUMENTS™

See us at IMS Booth 1315

was ideal for rural independent operating companies and the $60 million dollar R&D investment was a great success, helping Northern establish a U.S. market.

Terreault symbolized the new generation of Canadian researchers who had emerged since the split with Western Electric and Bell Labs. His Digital World team members were ready to pioneer the digital revolution in Canada and the global market, but he had to convince Bell Canada's senior management in the investment. The challenges were technological, organizational and economical. In 1971, Bell Canada and Northern Electric launched a joint venture Bell-Northern Research (BNR) and the new-to-market SP-1 hybrid switch was just beginning to pay off its investment. There was internal resistance to undertake a new technical direction so quickly. When Terreault performed a series of impact studies on a five years status quo, all indicators showed that a rapid transition to fully digital switching would be profitable for the carrier.

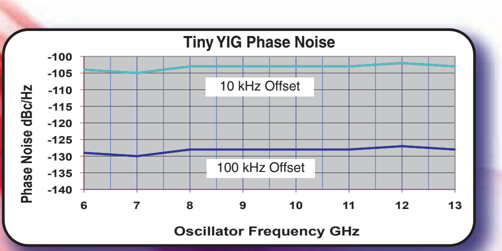
While many company executives agreed with the conclusions of the Long Term Network Evolution Study, they were skeptical about the pace of the transition to the digitalization world. Ultimately, Terreault's long-term plan was accepted and in 1972, Bell, Northern and BNR undertook a joint brainstorming session on digital switching that resulted in the definition of three essential elements: a private branch exchange (PBX), a low-capacity public switch, and a high-capacity public switch.

By late 1972, Northern Electric released its first electronic switch, the SG-1 also known as PULSE PBX. Within three years, the company had sold 6000 units. In 1973, the engineers squeezed a translation coder-decoder (CODEC) unit onto a single integrated circuit, making it cost effective to convert between analog and digital and serve each telephone line with its own CODEC. This technical achievement was to be the key to all digital-switch programs and allowed Northern's first completely digital product, the SL-1 PBX with the capability to serve organizations with up to 7600 inside lines. Years ahead of any competition, the success of the SL-1 led the company to extend its digital technology to the telephone central office switch. Thus, BNR developed the Digital Multiplex System (DMS-10) for small central offices and the DMS-100, a full-featured, local/toll digital switch with support for 100,000 lines two years later.

Rapid growth in the United States became a model for further expansion in the Caribbean, Europe and the Pacific Rim. In Japan, the DMS-

Tiny YIG TO-8 Oscillators with Superior Phase Noise

Teledyne Microwave Solutions YIG oscillators exploit the principle of magnetic resonance to generate a clean low phase noise microwave signal over broad tuning ranges.



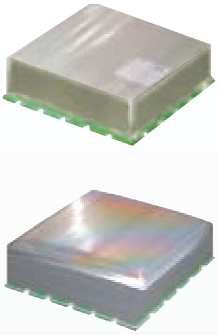
- Excellent Phase Noise
- Up to 16 GHz: 3 to 8 and 8 to 16 GHz
- Permanent Magnet (PM)
- Surface Mount or PCB
- Low Power Consumption (single bias optional)
- Available for Commercial applications: Synthesizers, Spectrum Analyzers, PXI Instrumentation, Bit Error Rate Testers, Signal Generators

OSCOR Green by REI

TELEDYNE
MICROWAVE SOLUTIONS
Everywhereyoulook™

650-691-9800 • Fax 650-962-6845 • www.teledynemicrowave.com
email: microwave@teledynemicrowave.com

See us at IMS Booth 2115



APA Wireless
TECHNOLOGIES

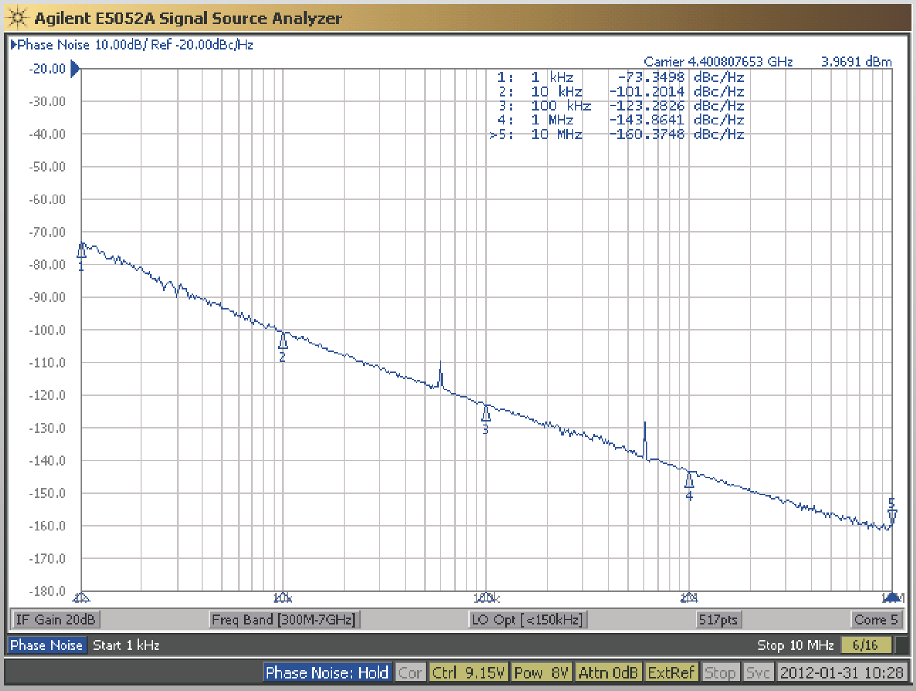
Need to cover hundreds of MHz without phase hits or microphonics?

Features:

Superb phase noise
Wide band
Rugged design
Ideal for ODU/Base station applications

4200 to 4600MHz of Screaming Hot Bandwidth in a half-inch package

Running 128QAM and starving for bits? You need the phase noise that only APA's **Physics Based Technology** can provide. Fundamental Mode operation, 400MHz of continuous bandwidth, best-in-class phase noise within the 4 to 5 GHz band AND linear tuning that won't wreck your loop dynamics. Fully characterized over the industrial temperature range, phase hit free and 100% factory tested ensures every bit you send is "in the clear".



Agilent E5052A Signal Source Analyzer

Phase Noise 10.00dB/ Ref -20.00dBc/Hz

Carrier 4.400807653 GHz 3.9691 dBm

```
 1:  1 kHz    -73.3498 dBc/Hz
 2:  10 kHz  -101.2014 dBc/Hz
 3:  100 kHz -123.2826 dBc/Hz
 4:  1 MHz   -143.8641 dBc/Hz
>5:  10 MHz  -160.3748 dBc/Hz
```

IF Gain 20dB | Freq Band [300M-7GHz] | LO Opt [<150kHz] | 517pts | Corr 5

Phase Noise Start 1 kHz Stop 10 MHz 6/16

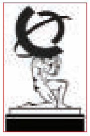
Phase Noise: Hold Cor Ctrl 9.15V Pow 8V Attn 0dB ExtRef Stop Svc 2012-01-31 10:28

See us at IMS Booth 112

VISIT US AT APAWireless.com

10 allowed Northern to become the first non-Japanese supplier to Nippon Telegraph and Telephone, and opened markets in China and Eastern Europe. Because of an existing U.S. appliance maker called Northern Electric, the company renamed itself as Northern Telecom in 1976 and restructured its international subsidiaries under one corporate umbrella.

NORTHERN TELECOM ENTERS THE WIRELESS MARKET



Northern Telecom was part of the wireless revolution from the earliest days of cellular. In 1982, Northern Telecom and General Electric announced plans to develop, build and market cellular mobile communication systems based on switching provided by the DMS-100 and radio equipment from GE. That same year, AT&T was forced to spin off its Bell companies under pressure from the U.S. government, opening up the U.S. switching market to competition. As the second largest supplier of telecommunications equipment in North America, Northern Telecom was looking at a U.S. switching business worth $320 billion a year.

The chief executive through this period of growth was John Roth. Roth was instrumental in establishing Northern Telecom's wireless business. Joining the company in 1969 as a design engineer, he was named COO in 1995 and then president in February 1997. Under his leadership, the R & D budget was bolstered to nearly 15 percent of revenue, which amounted to US$ 1.58 billion in 1995. As the digital switching market matured, much of the research dollars went into new specialized areas and parallel restructuring of the company into four separate businesses. The first business was Northern's traditional switching operations that served old-line phone companies; one unit focused on broadband networks serving cable companies and the upstart long-distance companies created by the AT&T break-up; one specialized in enterprise networking serving large organizations – including corporations and government departments – using internal communications networks; and one concentrating on wireless networks, which mainly served the rapidly expanding cellular telephone firms.

Roth wasted no time in mapping out the next step in the evolution of Northern Telecom, betting the company's future on the Internet. Roth saw that networks were going to migrate from telephone-based to Internet-based. He wanted Northern Telecom to be at the center of this build up of the Internet into a technology as reliable and accessible as the telephone. Needing to move quickly to beat

Greenray TCXOs offer a wide frequency range and are optimized for long-term Vibration, Shock, and Acceleration Sensitivity perfomance for the most demanding Communications, Military, and Aerospace applications.

T1215
Frequency 10 - 800 MHz
Attributes Hermetic Pkg.
Best Stability ±0.3 ppm
Output CMOS, Sine wave LVPECL
Size 9.0 x 7.0 x 2.8
0.35 x 28 x 0.11 in., SMT

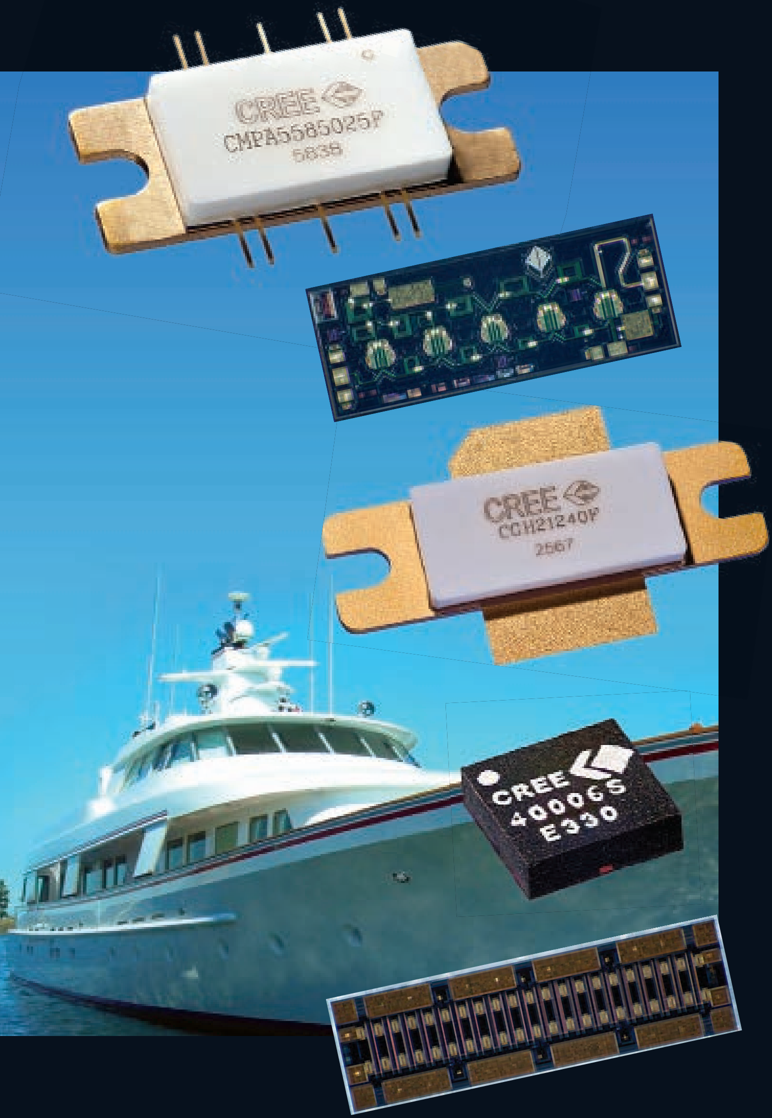
T53
Frequency 10 - 50 MHz
Attributes Tight Stability High Shock & Vibration
Best Stability ±0.3 ppm
Output CMOS, Sine wave
Size 5.0 x 3.0 x 2.2
0.20 x 0.12 x 0.09 in., SMT

T72 New Product
Frequency 10 - 50 MHz
Attributes Ultra-tight Stability High Shock & Vibration
Best Stability ±0.2 ppm
Output Clipped Sine wave
Size 7.0 x 5.0 x 2.5
0.28 x 0.20 x 0.10 in., SMT

Visit Us At MTT-S
Booth #3206

GREENRAY frequency control solutions
Made in the USA

TEL 717-766-0223 www.greenrayindustries.com sales@greenrayindustries.com



CREE RF PRODUCTS

Cree RF products lead the industry in performance and reliability. Our portfolio of commercially available GaN-on-SiC HEMTs and MMICs are competitively priced and enable innovative architectures.

- AMPS FOR CELLULAR BASE STATIONS
- PHASED ARRAY RADAR
- PLEASURE CRAFT MARINE RADAR
- WEATHER RADAR
- AIR TRAFFIC CONTROL
- MARITIME VESSEL TRAFFIC CONTROL
- DEFENSE TRACKING
- SATELLITE RADIO
- MOBILE TV
- TACTICAL RADIOS
- EMC AMPS
- C-IED

CREE GaN-on-SiC DEVICES DELIVER INDUSTRY-LEADING PERFORMANCE

Cree is the world's largest provider of GaN-on-SiC products and services for the RF/wireless industry. Whether you need foundry services, chips or packaged product, Cree has the capacity and commercial availability you need to elevate your design's performance with the highest reliability.

Broadband CW Power Applications	
20 MHz – 1000 MHz	2.0 GHz – 6.0 GHz
20 MHz – 6000 MHz	2.5 GHz – 6.0 GHz
0.5 GHz – 2.5 GHz	6.0 GHz – 18.0 GHz

Telecom	Radar	Satcom
4G LTE	L-Band	C-Band
Small Cell	S-Band	X-Band
Multi-band	X-Band	Ku-Band

Visit cree.com/rf to sign up for the RF enewsletter and request samples, or call us at +1 866 924 3645

CREE®

See us at IMS Booth 2125

You're Invited!
IMS2012
Booth #1818

Richardson RFPD will be hosting 15-minute presentations in our booth, followed by Q&A with the leading innovators and suppliers of RF, Wireless & Energy Technologies.

Join us in Booth #1818 to learn the latest on the products, solutions, and technologies everyone will be talking about at IMS2012.

GET THE COMPLETE SCHEDULE OF TOPICS AND PRESENTERS FOR DAY 1 & DAY 2

RichardsonRFPD
An Arrow Company

©2012 Richardson RFPD

out the competition, Roth turned largely to acquisitions rather than relying solely on in-house R&D efforts. The company's soaring stock facilitated the completion of stock-swap acquisitions.

Four major acquisitions were completed in 1998, including Winnipeg-based Broadband Networks Inc., a designer and manufacturer of broadband wireless communications networks (purchased for US$ 593 million); Chelmsford, Massachusetts-based Aptis Communications Inc., a start-up firm that concentrated on remote-access data networking (US$ 290 million); and Kanata, Ontario-based Cambrian Systems Corp., maker of an innovative technology to speed up Internet traffic (US$ 300 million). These purchases were dwarfed, however, by the US$ 9.1 billion stock-swap for California-based Bay Networks Inc. Bay Networks, the third largest maker of products linking computers to the Internet, served the corporate market with a host of data networking products and services that meshed well with Northern Telecom's existing corporate operations. The addition of Bay provided Northern with the ability to offer corporate customers integrated networks for sending voice, video and data over the Internet. With the company focusing increasingly on networking, Northern Telecom was renamed Nortel Networks Corp. in April 1999.

By the fall of 2000, Nortel Networks' market capitalization hit US$ 240 billion, a six-fold increase since Roth had taken over as CEO. Roth planned to continue the breathtaking acquisition pace, vowing to spend ten percent of the company's market cap each year to purchase the new technology it would need to keep pace with the other heavyweights of networking, most notably Cisco Systems Inc., Ericsson and Lucent Technologies Inc. Nortel's emphasis on new technology was demonstrated by its generating 60 percent of its revenues from products less than 18 months old. The company had a clear focus on optical technology for many years. In 1966, researchers at BNR published the first paper considering the possibility of using glass fibers to carry information. By 1989, Nortel became the first telecom supplier to announce a complete family of SONET-standard fiber optic products. By 2000, Nortel was working to establish a more significance presence in the undersea-fiber business while gaining a reputation as a leader in the area of wireless Internet technologies.

THE DOWNFALL

Nortel once accounted for over a third of the value of the entire Canadian Stock Exchange, now known as the S&P/TSX Composite Index. It became a giant through the surge in Internet demand in the latter half of the 1990s. That growth was also leveraged by the company's ambitious strategy of acquiring smaller companies to help it meet that demand. Nortel's reputation as a market heavyweight derived from its influence on the TSE 300 Composite Index. Unlike the Dow Jones, which is a price-weighted average of 30 stocks, the TSE 300 and the S&P/TSX Composite are float-weighted indices, which take into account the number of shares available, as well as the company's share price. So Nortel, which used to have 3.8 billion shares outstanding, wielded an enormous amount of influence.

The higher Nortel's share price went, the greater its weight in the index and the more the TSE 300 Composite Index rose. In 1999, the TSE 300 Composite Index rose by almost 30 percent, compared to the Dow's 25 percent rise. Without Nortel and BCE, the TSE 298 was up only 6.5 percent. The "Nortel effect" made it virtually impossible for investors or the manager of a diversified Canadian equity mutual fund to outperform an index that had a huge exposure to a stock that was doing so well. On the flip side, when Nortel's stock falls, so does the index, which is what happened on October 25, 2000. Company CEO, John Roth

Let us help turn your vision into reality

Richardson RFPD is a specialized electronic component distributor providing design engineers with deep technical expertise and localized global design support for the latest new products from the world's leading suppliers of RF, Wireless and Energy Technologies.

Deep Technical Expertise

Our specialized knowledge in RF, Wireless and Energy Management engineering can help you accelerate time-to-market, find complete solutions, save development costs and, ultimately, turn your vision into reality.

We employ over 150 local field technical resources throughout the world, working side-by-side with design engineers to provide one-on-one support for new designs in many of the most popular applications.

The Latest New Products from the World's Leading Suppliers

Our best-in-class New Product Introduction (NPI) program provides our supplier partners with maximum exposure to design engineers developing the next generation of products for applications in aerospace and defense, broadcast transmission, machine-to-machine (M2M), renewable energy, and wireless infrastructure.

Design Support from Prototype to Production

Richardson RFPD is the leader in helping customers design-in the latest products and most innovative technology from the market leaders on our line card. We have relationships and programs with the most technically advanced suppliers of:

- Semiconductors
- Passive RF and Microwave Components
- Connectors and Cable Assemblies
- Relays and Switches
- M2M/Embedded Solutions
- Power and Control Devices
- Passive Power Components – including Power Film/ Electrolytic Capacitors
- Thermal Management

Contact your local Richardson RFPD field sales engineer with your next product design challenge.

Featured Suppliers

ANADIGICS
We Have A Chip For That

ANALOG DEVICES

Anaren®

american technical ceramics

freescale™

GORE
Creative Technologies Worldwide

M/A-COM Technology Solutions
THE FIRST NAME IN MICROWAVE

Maxwell® TECHNOLOGIES
Enabling Energy's Future™

Microsemi

Peregrine Semiconductor

SIERRA WIRELESS™

SKYWORKS®
BREAKTHROUGH SIMPLICITY

TriQuint® SEMICONDUCTOR

WAKEFIELD SOLUTIONS

Your Global Source for
RF, Wireless & Energy Technologies

RichardsonRFPD
An Arrow Company

www.richardsonrfpd.com I 800.737.6937 I 630.208.2700

©2012 Richardson RFPD. All rights reserved. All brands and trademarks are property of their respective owners. Specifications subject to change without notice. MK120144/April, 2012. Printed in the USA.

Our Suppliers

Supplier Line Card

The Richardson RFPD model is designed to be the best in the world at bringing our suppliers' products to market on a global basis. We maintain strong relationships with the leading technology manufacturers and work closely with them to supply our customers with world-class products and services.

A

Abracon
Aeroflex / Inmet
Aeroflex / KDI
Amphenol Connex
Amphenol RF
ANADIGICS
Analog Devices, Inc. (ADI) *
Anaren
ATC (American Technical Ceramics)

B

Bomar Interconnect
Bonitron

C

Carlisle Interconnect Technologies
Cornell Dubilier
Crystek
CT-Concept Technologie AG
CTS Electronic Components

D

Dynex

E

Electronic Devices, Inc. (EDI)
Emerson Network Power
Empower RF Systems, Inc.

F

Fractus
Freescale Semiconductor

G

General Electric
Genteq
Gore

H

Honeywell Semiconductor
HUBER+SUHNER *

I

Illinois Capacitor, Inc.
IQD Frequency Products

J

Janus Remote Communications *
Johanson Manufacturing

K

KEMET
Kendeil

L

Laird Technologies
LS Research

M

M/A-COM Technology Solutions
Maestro Wireless Solutions
Maxwell Technologies
Micronetics
Microsemi
Mitsubishi *

N

NDK America *
Nitronex *
Nujira

O

Ohmite

P

PCTEL
Peregrine Semiconductor
Polyphaser
Powerex *

R

Radiall
Radiall - AEP
Raltron
RECOM Power, Inc.
Renesas *
(formerly NEC Semiconductor)
RES-INGENIUM
RF Industries
Roving Networks

S

Sarantel
Scintera
SDT Technology
Semikron *
Sierra Wireless *
Skyworks Solutions, Inc. *
Spectrum Advanced
Specialty Products
STMicroelectronics *
SV Microwave

T

Tamura
Teledyne Coax
Teledyne Relays
TriQuint Semiconductor
TRU Corporation
TT electronics Semelab
Tyco Electronics

U

United Chemi-Con
United Monolithic Semiconductors
(UMS)

V

Valpey Fisher (CTS)
Vincotech

W

Wakefield
WanTcom
Westcode

Y

Y-Lynx

**All of our supplier agreements are global except those indicated with an asterisk.*

Your Global Source for
RF, Wireless & Energy Technologies

RichardsonRFPD
An Arrow Company

www.richardsonrfpd.com I 800.737.6937 I 630.208.2700

©2012 Richardson RFPD. All rights reserved. All brands and trademarks are property of their respective owners. Specifications subject to change without notice. MK120144/April, 2012. Printed in the USA.

REALIZE YOUR VISION

FROM PROTOTYPE TO PRODUCTION

Our global team of over 150 local technical resources are ready to work with you one-on-one at every step of your design journey to accelerate time-to-market, find complete solutions, save development costs and, ultimately, turn your vision into reality.

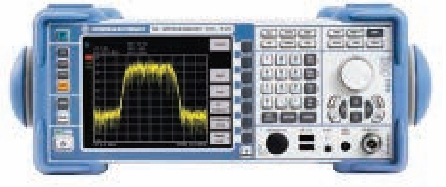
Contact your local Richardson RFPD field sales engineer with your next RF, Wireless or Energy Technology product design.

www.richardsonrfpd.com

RichardsonRFPD
An Arrow Company

©2012 Richardson RFPD. All rights reserved. All brands and trademarks are property of their respective owners. MK120003

RENT.
MICROWAVE.



SHIP TODAY.

TWT Amplifiers · Probes · Antennas
HF Communication Test Systems
Network Analyzers · Synthesizers
Signal Generators · and more

TEST TOMORROW.

- Solutions that fit your budget and schedule
- Invaluable expertise and technical support
- On-site lab with ASQ Certified technicians
- Same day shipping on most items
- HUBZone & ISO 9001 Certified

Call us today (888) 544-ATEC
Visit us on the web
www.ATECorp.com/mj

ATEC®
30th Anniversary
Advanced Test Equipment Rentals
The Knowledge. The Equipment. The Solution.

Follow Us!

See us at IMS Booth 3220

issued the first in a long series of sales warnings and the stock fell from $96 to $71 and the TSE 300 plunged 840 points in one day.

Throughout 2001, with its sales steadily collapsing, Nortel issued a stream of revenue and profit warnings and began a series of sweeping layoffs, cutting its 90,000-strong workforce by more than half. By the end of the year, the stock went from $46 to under $12. A continued sales slump and a downgrade of its long-term debt to "junk" status knocked the stock price down to 69 cents by October – less than 1 percent of where it had been just two years earlier and facing delisting from the New York Stock Exchange. The company that was once Canada's biggest now held the 46th spot and had a weighting in the S&P/TSX Composite Index of less than one percent.

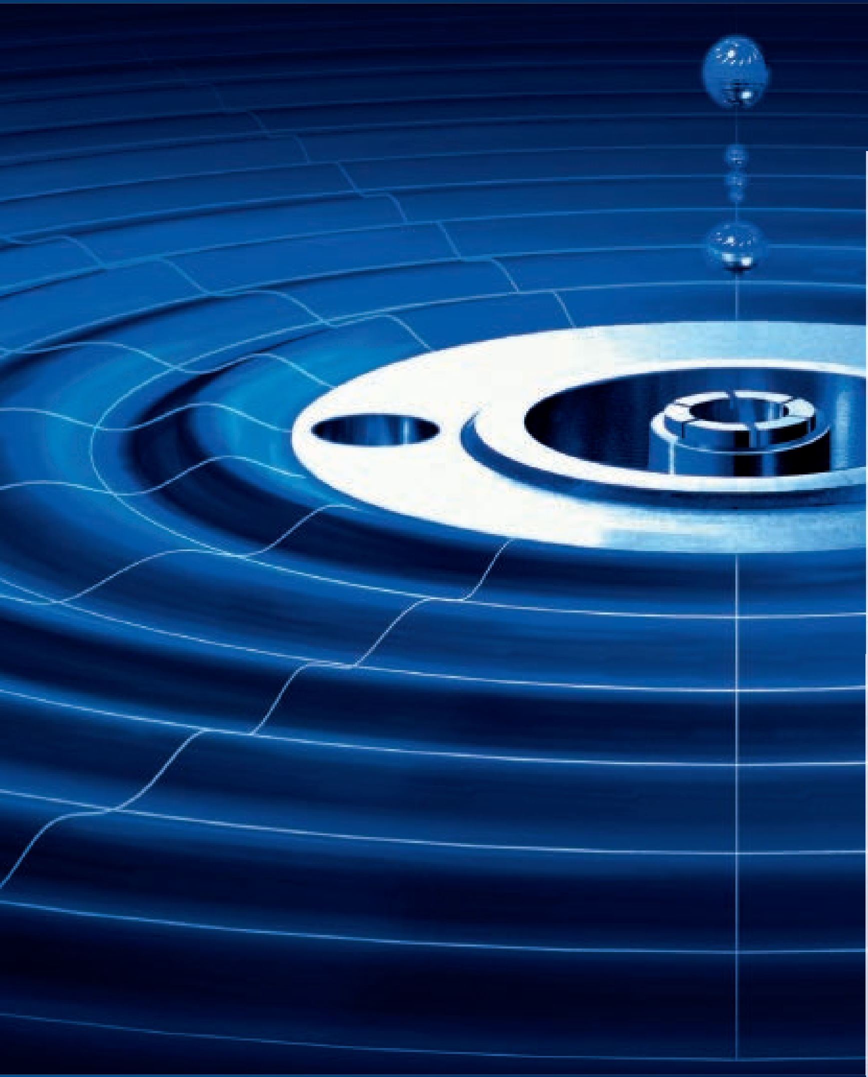
Job cuts that brought the workforce down to 35,000 employees started to pay off on the bottom line by the spring of 2003. In April, the company reported its first quarterly profit in three years. Technology companies began buying equipment again and Nortel landed several high-profile billion-dollar contracts.

But just as Nortel's stock was recovering, the company announced that an accounting review had turned up "irregularities" and it would have to restate its finances back to 2000. In March 2004, two senior finance executives were put on leave and then fired the following month along with CEO Frank Dunn after Nortel revealed that its 2003 profit would be slashed in half. As regulators began investigating, the company cut another 3250 jobs. In May of 2005, after Nortel finally reported its 2003 and 2004 financial results, it was clear that the company was facing only modest revenue growth and Nortel's management was facing an increasingly competitive marketplace. The shares slipped to $3 – their lowest point in more than two years.

Nortel paid out US$ 575 million and 629 million common shares in 2006 to settle a class-action lawsuit that accused the company of misleading investors about the health of the company. On December 1, 2006, Nortel went ahead with the stock consolidation it had planned but never implemented back in 2002. It chopped the number of shares by 90 percent — a move that boosted its stock price 10-fold to the $24 range. In February, 2007, Nortel announced its plans to reduce its workforce by 2000 employees, and to transfer an additional 1000 jobs to lower-cost job sites.

The Securities and Exchange Commission filed civil fraud charges against Nortel for accounting fraud from 2000 to 2003 to close gaps between its true performance, its internal targets and Wall Street expectations. Nortel settled the case, paying $35 million. By February 2008, the stock was back below $10 ($1 on a pre-consolidation basis) as losses grew and sales fell. By March, the stock had hit an all-time low. In late 2005, the company tried to engineer a turnaround. Mike Zafirovski, a former president and COO of Motorola took over as president after Nortel paid Motorola $11.5 million to release him from his non-compete agreement. John Roese was brought in to help correct many years of neglect in R&D. Constant retrenchment at Nortel had left the fabled BNR legacy in tatters. Three years of painful rebuilding had given the company a growing financial safety margin, though only marginal profits, to start behaving like a contender again. In August of 2008, Nortel Networks announced it was buying Novera Optics and three other small companies, the first significant acquisitions in years. The price was modest, less than $33 million, but it was the strongest signal that Nortel believed it was finally turning the corner and could compete for promising startups with Cisco Systems, where several of the company's newest executives had formerly worked.

But several failed business decisions and the freezing of global credit would thwart this turn around. On Roese's watch, Nortel sold promising but profitless



Rosenberger

Test, Measurement & Calibration

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

- **RF high precision connectors**, adaptors and devices, e.g. connector heads, opens, shorts or loads of all popular connector series such as RPC-N, -7.00, -3.50, -2.92, 2.40, -1.85 or -1.00 mm
- **Calibration and verification kits** for a number of coaxial standard test interfaces
- **Test cables & test devices**, e.g. VNA microwave test cables, high performance cable assemblies, airlines, interchangeable port connector system, T-calibration adaptors and many more
- **Automated Test Equipment (ATE) products -** multiport Mini-Coax connectors – with 2, 4, 6, 8 channels – for semiconductor test equipment applications

New:

- RPC-N revolving calibration adaptor

Rosenberger – more than 50 years experience in high frequency technology

Exploring new directions

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

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

See us at IMS Booth 2015

wireless equipment to Alcatel just as older generations of the same gear suddenly found big markets in emerging economies. Nortel had pulled out of India in the face of mounting losses, just as the market opportunity exploded, forcing the company to overhaul aging gear to generate some sales. And then the global financial crisis hit and the recession compounded Nortel's financial challenges and directly impacted its ability to recover. In 2008, despite winning a contract from China Telecom for advanced wireless gear in seven provinces, the company had trouble financing the deal before it would start generating revenues sometime in the following year. During its reporting of third quarter 2008 results, Nortel announced it would restructure into three vertically-integrated business units: Enterprise, Carrier Networks and Metro Ethernet Networks, this last entity had been put up for sale the previous month. The company, whose name had long been synonymous with optical networking gear, was selling off its Metro Ethernet Networks (optical and 40G) business to shore up the rest of the company and focus on 4G and related technologies. As part of the decentralization of the organization, four executive positions were eliminated including Roese. The company was in a death spiral.

In January 2009, Nortel Networks filed for creditor protection. The company reached this point after multiple management regimes had failed to remake the company after the telecom bubble burst. The company's demise was gradual but steady. The final phase in the Nortel saga was the pre-announced 3Q08 earnings (guiding down expectations), the sale of its Metro Ethernet Networks (MEN) division, and the latest reorganization. The announcement followed numerous incremental divestitures and shutdowns of specific businesses and product lines (for example, broadband access and the UMTS and WiMAX RAN segments) in an attempt to focus and differentiate while cutting costs.

Nortel hoped that by filing with a cash reserve of $2.6 billion, the company would re-emerge as a leaner version of its former self in the future. Nortel's mobile infrastructure business was now solely focused on Long Term Evolution/System Architecture evolution LTE/SAE using scarce product development dollars to fund another promising technology that North American phone companies wanted to support iPhones and other future devices capable of handling video and huge files. Nortel was also working hard to develop a strong LTE/SAE ecosystem including LG Electronics, LG Nortel and other partners, doing its best to demonstrate capabilities through trials with Verizon and T-Mobile Germany and hoping for


TRAK
UAV
MISSION CRITICAL SOLUTIONS

EW/ELINT SYNTHESIZER
- L-Band Multi-Output Reference Generator
- Phase Locked Multi-Frequency
- Ultra-Low Phase Noise Low g-Sensitivity 125 MHz Reference
- Enhanced Counter Measure; Military Airborne Operating Environment

RADAR EXCITER UPCONVERTER
- Multi-Frequency, Low Phase Noise Synthesized Up-Converter with X-Band BIT Detector
- <50 nSec Switching Speed Between IF Output & Multiplied X-Band Output
- Low Profile Hermetically Sealed Package
- Military Airborne Operating Environment

GPS SYNCHRONIZED STANDARD
- Direction Finding (TOA/AOA) or SatCom Precise Reference OTM
- Low Phase Noise Low g-Sensitivity 10 MHz Reference
- Synchronized From Internal C/A Code GPS or External SAASM GPS 1 PPS
- MIL Ground Mobile and Airborne Operating Environments

smiths
bringing technology to life
www.trak.com
813-901-7200
TRAK

See us at IMS Booth 1709

The Leader in Switching Solutions

The global provider of ultraminiature, hermetically sealed and solid state switching products for over 40 years.

Our products meet a wide range of applications in the aerospace, commercial, defense, industrial, RF, Space and Test & Measurement markets.

MICROWAVE COAXIAL SWITCHES

- SPDT, Transfer, Multi-Throw Switches and Switch Matrices
- 5 million cycles characteristic life
- DC to 40 GHz
- Custom products
- 3-State attenuated switch

ELECTROMECHANICAL RELAYS

- New LoopBack Relay
- Signal integrity up to 12 Gbps
- DC-10 GHz

INDUSTRIAL/COMMERCIAL SOLID-STATE RELAYS

- Single, Dual and 3-Phase products
- Soft start motor controllers
- High current, high voltage

MILITARY & COTS SOLID-STATE RELAYS

- Robust design, wide temperature range
- AC, DC and Bidirectional
- Short circuit protection

Scan here to learn more!

Please Visit us:
Booth #2115
MTT-S • June 19-21

TELEDYNE
COAX SWITCHES

TELEDYNE RELAYS
A Teledyne Technologies Company

800-596-3855 • www.teledynerelays.com
800-351-7368 • www.teledynecoax.com

RoHS or Non-RoHS:
Your Choice!

some commercial launches within the year.

But the bankruptcy filing was easily exploited by competitors who reminded customers that Nortel could no longer give assurances of continued development of any specific products and used the filing as a chance to reshuffle the supplier landscape to their benefit. After repeated restructuring, a shaky immediate financial outlook, shrinking market share, tight public credit markets and cautious investors, the cards were stacked against any such comeback.

THE SELL-OFF

Two and a half years after filing for bankruptcy protection, Nortel threw in the towel, announcing that a consortium of six different companies had won the rights to its 6000 patents in a July 2011 auction. The list of winners included Apple, EMC, Ericsson, Microsoft, RIM and Sony. Not among the winners were Google, which placed the initial $900 million stalking horse bid, and Intel. According to Nortel, the patents won a total of $4.5 billion from the six companies involved. RIM indicated that it spent $770 million in the auction, while Ericsson said it paid $340 million. The other companies involved did not share the dollar value of their bids. The 6000 patents pertained to wireless technology, LTE 4G, data networking, voice technologies, and more. The auction was one of the final steps in Nortel's dissolution following bankruptcy. The proceeds will go to paying back Nortel's creditors.

THE AFTERMATH

In writing this article, I was in contact with an engineer who had been at BNR and Nortel for 7½ years in the microwave division, followed by the TDMA base station group and finally, the OC-192 fiber optic group before being laid off like everyone else. At the very end, he was a technical advisor. During the boom period ending around 2001, he estimates that there were between 50 and 100 RF/microwave designers doing hardcore design in Ottawa covering all aspects of RF circuit design. This design work would range from wireless CDMA, TDMA and GSM base station circuits all the way to fiber optics OC-3 up to OC-768 circuit packs and everything in between. In 1994, he was working on the LNA for a 512 QAM 6 GHz radio. At one point, he recalled hearing Nortel was Agilent's second biggest test equipment customer in the world. "Seeing all the equipment we had in the huge labs here, it didn't surprise me." What was surprising to everyone was just how far this Goliath would fall. ■


Microwave components from

Your time-trusted source

Mil Spec Compliant RF/Microwave Control Components since 1960

I-Q Vector Modulators
- 500 MHz to 24 GHz in four bands
- Broadband 2 to 18 GHz model
- Simultaneous Phase & Amplitude Control
- High Modulation Rate – >50 MHz
- High Resolution & Accuracy
- Guaranteed Monotonic

Phase Shifters/ Frequency Translators
- 500 MHz to 18 GHz
- Full 360 Degrees Phase Control
- Translation Rates—Up to 500 kHz
- Digital & Analog Control
- Guaranteed Monotonic

Attenuators
- 200 MHz to 40 GHz
- Up to 80 dB Attenuation
- Digital and Analog Control
- Guaranteed Monotonic

To learn more or get a catalog please visit www.herley.com and click on General Product Catalog.

Switches
- 200 MHz to 40 GHz
- SPST to SP16T
- Non-Reflective & Reflective
- High Speed—Rise/Fall <10 nanoseconds
- Phase & Amplitude Matched models
- Low Cost Hermetic models

HERLEY

Proven Microwave Performance

www.herley.com

227A Michael Drive, Syosset, NY 11791
Tel: 516-802-0900 • FAX: 516-802-0897 • sales.newyork@herley.com

A KRATOS Company

See us at IMS Booth 1607

We've Pushed The Technology Envelope.

Our New Hybrid Power Modules Now Provide High Output Power Levels Across An Instantaneous BW From 4-18 GHz.

AR's new line of Hybrid Power Modules (HPM's) are small, compact and lightweight, but they're big on power and performance. Our standard products deliver up to 5 watts of output power with excellent linearity, gain flatness and the ability to withstand infinite output mismatches.

Ultra Wide Bandwidth and High Power – A Great Combination

Our rugged modular products utilize the latest microelectronic technologies to achieve outstanding performance and small size for demanding applications. Thin film processes using chip and wire devices are used for the higher frequency 4-18 GHz frequency bands, whereas thick film lower cost custom design approaches using chip or packaged transistors can be used in the lower frequency regions.

Regardless of the techniques used, we can supply our HPM's in true hermetic housings to meet both fine and gross leak testing to military specifications.

AR Has The Capabilities To Produce Cost-Effective, Custom-Designed HPM's To Your Specs

Both military and commercial solutions can be provided to meet your specific need for high performance in a compact size. Connectorized or pallet type custom designs, which can be integrated into higher order assemblies, can also be provided, giving you alternate solutions for even your most demanding applications. These modular amplifiers can also be supplied as a complete self contained air cooled assembly including power supplies, a digital control panel, gain control and input overdrive protection.

Applications For Our HPM's Are Limited Only By Your Imagination but a small sampling are:
Jammers, Radars, ECM, ECCM, Data links, TWTA replacements and drivers, and Communications.
To learn more, call AR RF/Microwave Instrumentation at 215-723-8181.

www.arworld.us/hpm

Come See Us at IMS 2012, The Palais des congres, Montreal, Canada
June 19-21, 2012, Booth 1201

RoHS

ISO 9001:2008
Certified

rf/microwave instrumentation

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

USA 215-723-8181. For an applications engineer, call 800-933-8181.
In Europe, call ar United Kingdom 441-908-282766 • ar France 33-1-47-91-75-30 • emv GmbH 89-614-1710 • ar Benelux 31-172-423-000

www.arworld.us

Copyright © 2012 AR. The orange stripe on AR products is Reg. U.S. Pat. & TM. Off.

Maury Microwave – bringing all of the pieces together.

Whether its interconnecting with adapters or cable assemblies, or turning your instruments into calibrated measurement and modeling solutions, Maury Microwave completes the puzzle.

Your Calibration, Measurement & Modeling Solutions Partner!

Maury Microwave Corporation • 2900 Inland Empire Blvd., Ontario, California 91764
Tel: 909-987-4715 • Fax: 909-987-1112 • Email: maury@maurymw.com

www.maurymw.com

Visit Maury Microwave at
IMS2012, Booth #1215

Measurement & Modeling Device Characterization

Maury Microwave offers Measurement and Modeling Device Characterization Systems and Services including nonlinear passive, active and hybrid-active fundamental and harmonic load pull, non-50Ω X-Parameter modeling, pulsed IV, pulsed S-Parameters and compact transistor modeling, and patent-pending ultra-fast/accurate noise parameters. Maury's solutions are the ideal choice for transistor and amplifier designers, for research and development and for production and stability testing.

VNA Calibration Kits & Metrology Adapters

Maury Microwave offers the widest range of SOLT and TRL network analyzer calibration kits for all Agilent, Rohde Schwarz and Anritsu VNAs, calibration standards, metrology in-series and between-series coaxial and waveguide adapters, connector gage kits and test-port cable assemblies.

Test Essentials™

Maury's Test Essentials™ line includes color-coded precision adapters for perfect matings every time, in-series and between-series test essential adapters, torque wrenches, cable assemblies and accessories for everyday use. Test Essentials™ are carried in-stock and available for sale on Maury's e-Store and through our extensive network of local sales representatives and distributors.

Test Essentials™
Maury Microwave

Stability™ Microwave/RF Cable Assemblies

Maury Microwave's Stability™ series sets the standard for high-performance ruggedized microwave/RF cable assemblies. Designed specifically for phase-stable and amplitude-stable applications, Stability™ offers excellent measurement repeatability even after cable flexure. With a ruggedized, durable construction, Stability™ will outlast and outperform other assemblies resulting in a reduced total cost-of-test. Stability's™ light weight, superior flexibility and small form factor make it ideal for daily use with VNA's, test instruments, bench-top testing and ATE systems. Stability™, the phase stable cable of choice.

Stability™
Maury Microwave

Maury Microwave

Strategic Partners Agilent Technologies — Global Solutions Partner · AMCAD Engineering — Advanced Modeling for Computer-Aided Design · Anteverta microwave

Bienvenue – Welcome to IMS 2012

Ke Wu

IMS 2012 General Chairman

I am very excited about this much discussed and anticipated year of 2012, which promises to be a special year for all of us. We certainly have a multitude of world events this year, and not just in sports, or in movies, or in economics, or in politics. For us, as microwave engineers, the most important event plays out right here in Montréal this summer: our IMS 2012 and Microwave Week! What could be more exciting than this?

On behalf of the entire IMS 2012 Steering Committee and the City of Montréal, I feel privileged and honored to invite you and your family to take part in this historic and unparalleled event this June.

It has been a long and eventful journey that started in the early 1950s in New York City with the formation of the IEEE MTT-S. This journey has seen the creation and subsequent growth of IMS, the MTT-S flagship event and the largest gathering in the entire microwave community. This year, IMS finally comes to Montréal, Canada, a truly international destination. Not only is this the second time that IMS will be held outside the U.S., it also coincides with the 60th anniversary of MTT-S, which makes this a truly unique event to be remembered in the future.

During Microwave Week, June 17 – 23, you will be able to register for and participate in various technical programs in connection with three events, namely the Radio Frequency Integrated Circuits (RFIC) Symposium (www.rfic2012.org), IMS (www.ims2012.org), and the 79th Automatic Radio Frequency Techniques Group (ARFTG) Conference (www.arftg.org).

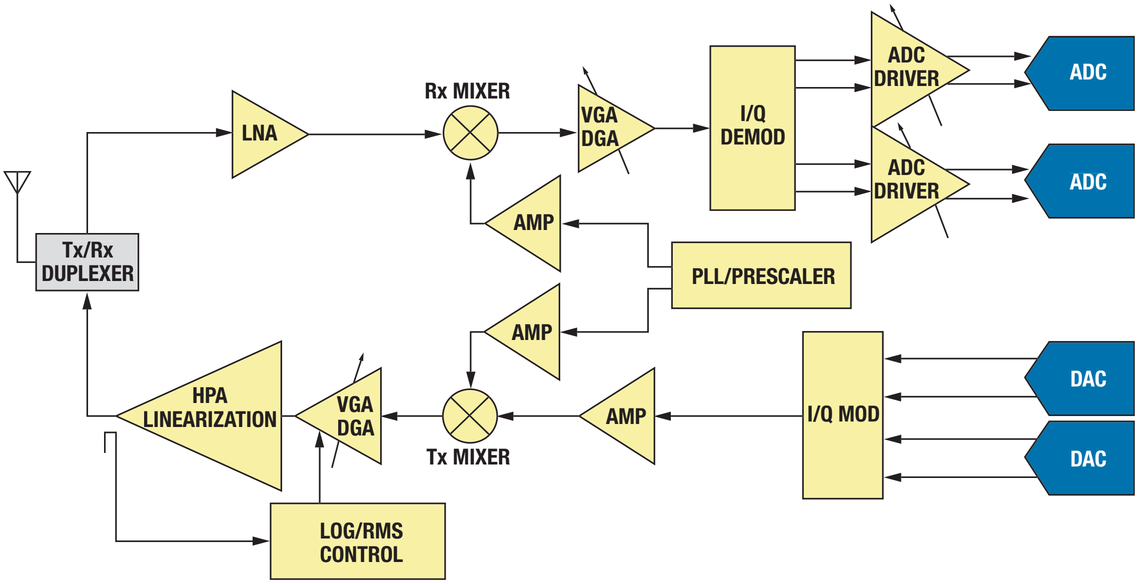
In spite of the current uncertain economic situation and financial worldwide turmoil, we are expecting to have about 10,000 attendees and 600 exhibitors with over 900 booths joining us. This high expectation is encouraged by early indications that point to a very successful symposium. We have already broken historic IMS records including an all-time record number of technical paper submissions from 49 different countries and regions, an all-time record number of MicroApps presentation proposals, and never before have there been so many commercial exhibit booth reservations early on. We are building not just a larger IMS, but also a

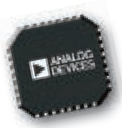
Unequaled RF performance, selection, and integration. ADI delivers.

1000+ RF ICs, industry-leading tools, and reference circuits optimize radio designs.

No one is delivering more ways to meet RF design challenges than Analog Devices. We provide 1000+ high performance ICs for every part of the RF signal chain. From high performance discrete building blocks to integrated subsystems on a chip, ADI offers solutions for every RF challenge. Complete reference circuits, best-in-class online design tools, webinars, evaluation boards, and technical support forums further assure optimum design success. Explore our innovative products and design resources at **analog.com/RF**.

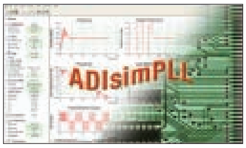
High performance ICs for every part of the RF signal chain





Integrated functions for multiple frequencies

- ADF435x: Wideband PLL, VCO
- ADRF660x: Mixer, PLL, VCO
- ADRF670x: Modulator, PLL, VCO
- ADRF680x: Demodulator, PLL, VCO
- ADRF6510/ADRF6516: Dual VGAs, filters
- ADRF6850: Demodulator, PLL, VCO, VGA



Design resources

- RF Tools: ADIsimPLL,™ ADIsimRF,™ ADIsimSRD,™ ADIsimCLK™
- Circuits From the Lab™: dozens of RF reference circuits
- EngineerZone™: online support community

See us at IMS Booth 1725

analog.com/RF

ANALOG DEVICES

better one, starting right here in Montréal!

Founded in 1642, Montréal is one of the most romantic, welcoming, artistic, innovative and diversified cultural cities in the world. It is often called the "Paris" of North America, because of its French heritage and flair. The city offers everything to everyone with easy access to everywhere.

IMS 2012 will be held in the colorful Palais de Congrès de Montréal, which is located in the heart of this vibrant city and surrounded by the old world charm of this historic town and the modern cosmopolitan dynamics of the new city. Everything is within a short walking distance. The area is accessible by subway, bus and car from other parts of the city.

Montréal downtown is a very animated place full of people of all ages. This is also one of the safest metropolitan areas in the world. Most of the 3.5 million local residents are multilingual with multiple cultural backgrounds. To facilitate and enrich your stay in Montréal, we have prepared a set of local tours and guest programs for all interested parties and family members during Microwave Week. You will also find that your presence at Microwave Week will add a special international flavour to Montréal's beautiful summer decorated by its well-known festivities.

IMS 2012 will present an outstanding technical program and plenary keynote addresses, in conjunction with workshops, short courses and special sessions including two special memorial sessions. Student Paper Competitions, Student Design Competitions and the Graduate Design Challenge are organized to highlight the outstanding contributions of the new generation of researchers from our academic communities. These activities have always attracted large crowds in the technical sessions, interactive forums and special presentations. Awardees will be announced during the Awards Banquet on Wednesday.

In conjunction with the excellent technical programs and abundant social activities, you have the opportunity to attend and explore the world's largest exhibition dedicated to the RF and microwave industry. This exhibition will also feature university and academic laboratory booths. We will see a strong presence of international companies. Therefore, we expect to have more business interactions and exchanges among our well established exhibitors, new exhibitors and attendees. In addition, the regular historical exhibit, showing how far our technical community has come, will be

High Kv VCSO

VCS573

5x7mm VCSO for
Datacom, Telecom, and
DAC clock applications

- High Tuning Gain Transfer, Typical Kv=350ppm/V
- 600 to 1000MHz Output
- High Tuning Gain Transfer, Kv
- +3.3 Vdc Supply Voltage
- -40°C to 85°C Temp. Range
- LVPECL differential outputs
- ± 50ppm APR
- Output Enable/Disable Function
- SAW filter design
- Extremely Low Jitter

A World of Solutions

Compact
4-Way Power Dividers

VFPD400 Series

3x3mm QFN for
Wireless communications,
Point to Point, WLAN/WiMax,
SAT Radio, ISM band equipment

- Highly repeatable monolithic design
- Low insertion loss: 0.8dB
- Excellent phase balance: ±1.0°
- Amplitude balance: ±0.20 dB
- 600MHz to 4.0GHz

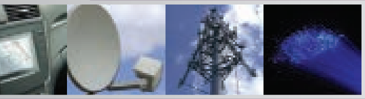
http://delivr.com/1fpmu

CTS Valpey Corporation
www.ctsvalpey.com

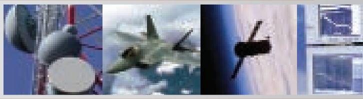
IMS2012
MONTRÉAL
Come visit us at
Booth #1728

60 GHz TRANSCEIVERS

New Highly Integrated IC Radio Solution for Low Cost 60 GHz Applications!



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

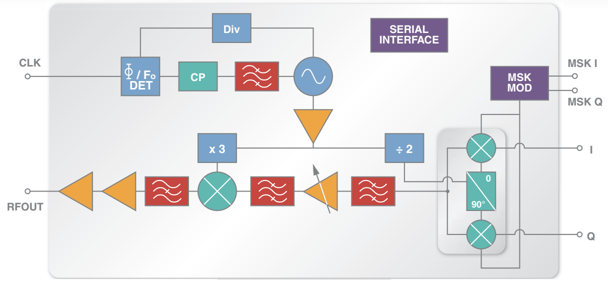


HMC6000 & HMC6001

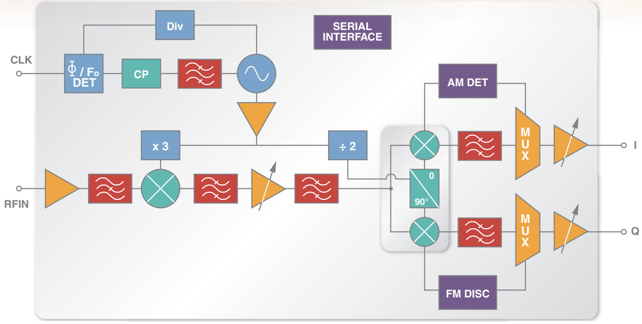
Supports WiGig & IEEE 802.11ad Multi-Gbps Solutions!

- *High Output Power Silicon Germanium*
- *Covers 57 - 64 GHz Frequency Band*
- *Complete Analog Baseband to RF Solution*
- *Integrated Frequency Synthesizer*
- *Universal Analog I/Q Baseband Interface*
- *Up to 1.8 GHz RF Bandwidth*

HMC6000 Transmitter



HMC6001 Receiver



Frequency (GHz)	Function	P1dB (dBm) NF (dB)	Max Gain (dB)	Gain Control Range (dB)	Phase Noise @ 1 MHz Offset (dBc/Hz)	Power Dissipation (W)	Part Number
57 - 64	60 GHz Integrated Transmitter	12 dBm	38	17	-86	0.8	**HMC6000**
57 - 64	60 GHz Integrated Receiver	6 dB	67	65 @ 1 dB Step	-86	0.61	**HMC6001**

Hittite Microwave's Application Group Supports Customers Through All Phases of Product Development!

Hittite
MICROWAVE CORPORATION

Contact Us: txrx@hittite.com

2 Elizabeth Drive • Chelmsford, MA 01824
978-250-3343 tel • 978-250-3373 fax • txrx@hittite.com

More Information at: www.hittite.com
Receive the latest product releases - click on "My Subscription"

See us at IMS Booth 1701

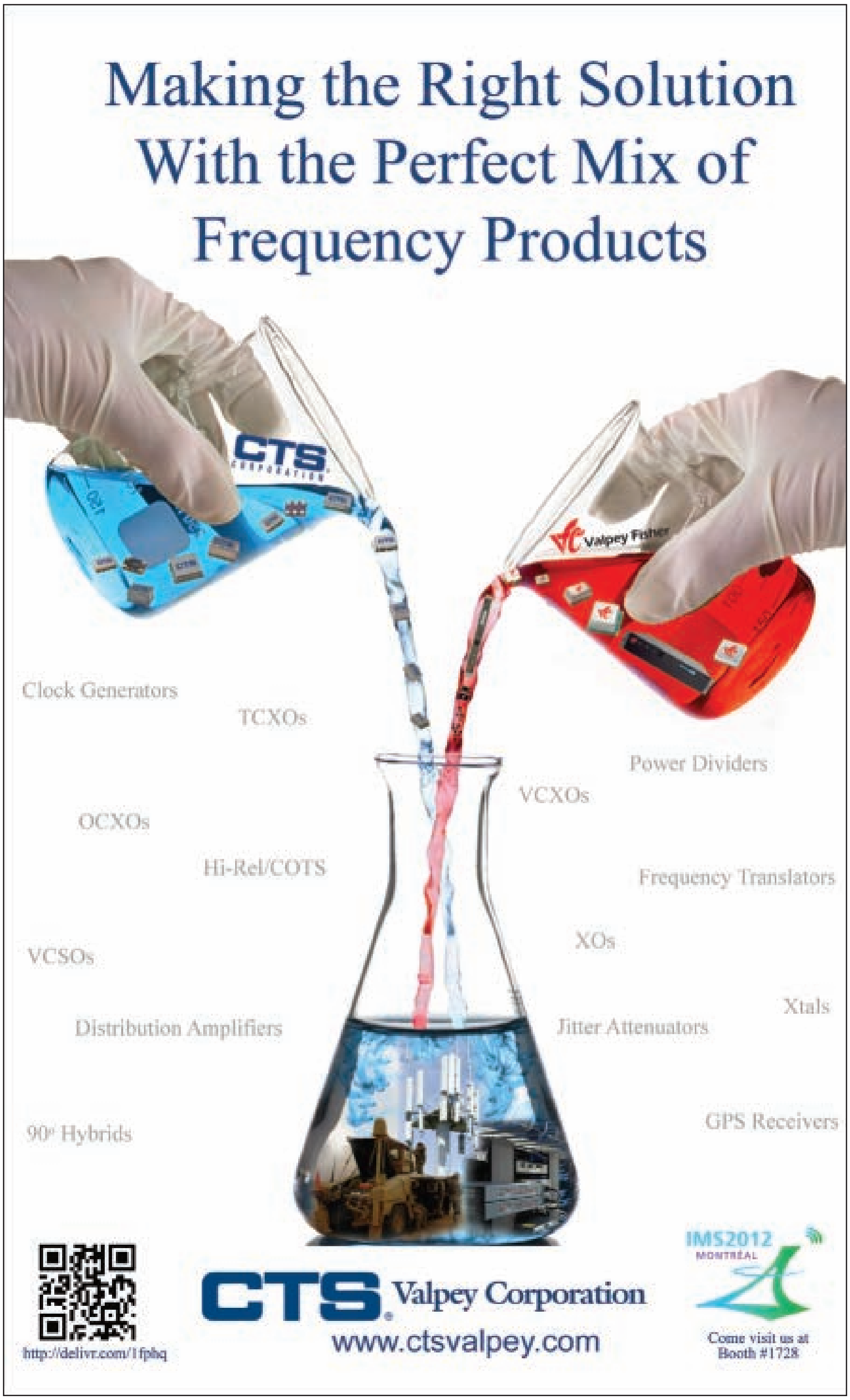
enhanced by a healthy addition of Canadian historical components. Another noteworthy highlight is the much-anticipated MicroApps presentations during the commercial exhibition.

Please make sure that you don't miss your opportunity to visit these booths during the three day exhibition. Exhibition hours are Tuesday, June 19th, 9:00 AM to 5:00 PM, Wednesday, June 20th, 9:00 AM to 6:00 PM, and Thursday, June 21st, 9:00 AM to 3:00 PM. On Wednesday, we will also have the traditional Industry-Hosted Cocktail Reception held on the exhibition floor starting at 5:00 PM. You should not miss this opportunity to interact with exhibitors while enjoying complimentary refreshments and snacks.

This year's motto "Microwaves without Borders" or "Micro-ondes sans Frontières" not only reflects our unique French heritage and culture in North America but also the international cooperation and spirit of our community. The successful organization of such a Microwave Week requires a huge effort and the selfless dedication of many volunteers. I would like to thank those who have already and will continue to contribute including the Steering Committee, our TPRC, our exhibit manager MP Associates, our IEEE meeting planner, our sponsors, our media partners, and of course the MTT-S AdCom. I would like to particularly express my appreciation to *Microwave Journal* and its staff for the help they have provided.

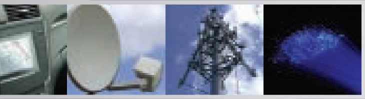
Again, I warmly welcome you and your family to this historic and unparalleled event and hope that you will find time to explore the friendly atmosphere of Montréal with its myriad of attractions, wealth of activities, exquisite cuisines and excitement of life, while also enjoying our popular professional meetings and social gatherings. You can find useful information on the city of Montréal at www.tourism-montreal.org. In addition, there are many famous festivals and international happenings like the world famous Formula 1 Grand Prix and the Jazz Festival, for your enjoyment right before and after Microwave Week.

This is a very rare opportunity for all of us to celebrate this historic event in Montréal, which you cannot afford to miss. Please go to http://ims2012.mtt.org for more information and the latest news for your attendance at IMS 2012 and Microwave Week. I do hope that you have received or downloaded your copy of the Program Book for detailed information. A bientôt! See you soon! ■



Clocks & Timing ICs

New Clock Generators with Programmable Frequencies!



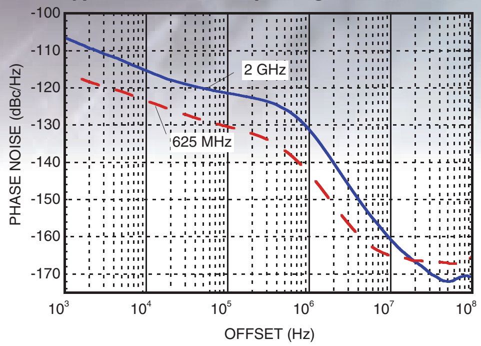
Analog, Digital & Mixed-Signal
ICs, Modules, Subsystems & Instrumentation

HMC1032LP6GE & HMC1034LP6GE
125 MHz to 3 GHz!

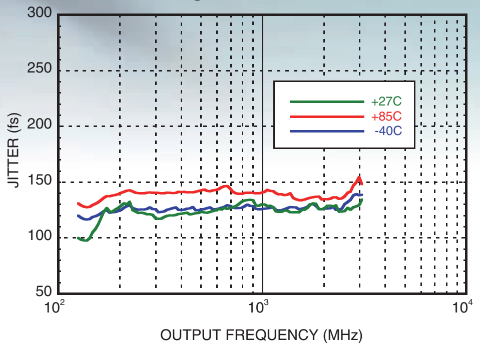
Surpasses G.8251 & GR-253-CORE Jitter Specifications!

- ***Best-in-Class Jitter Performance:*** ***78 fs_{RMS} Typical at f = 800 MHz***
- ***Programmable Frequencies from 0.125 to 3 GHz*** ***"Exact Frequency Mode" Achieves 0 Hz Frequency Error***
- ***Fractional-N Mode of Operation for Any Frequency Setting***
- ***Industry-leading Phase Noise Floor*** ***<-165 dBc/Hz Noise Floor Improves Data Converter SNR Performance***

Typical Closed Loop Integer Phase Noise



Integrated RMS Jitter



	Maximum Frequency (MHz)	Function	Phase Jitter (Frac/Int) (fs RMS)	Phase Noise Floor (dBc/Hz)	Maximum Reference Freq. (MHz)	Typical Power Consumption (W)	Figure of Merit (Frac/Int) (dBc/Hz)	Part Number
NEW!	350	Clock Generator with Fractional-N PLL+VCO	116 / 75	-165	350	0.86	-227 / -230	**HMC1032LP6GE**
NEW!	500	Integer Mode PLL (x1, x5, x10)	Defined by VCXO	Defined by VCXO	140	0.005	-208	**HMC1031MS8E**
NEW!	3000	Clock Generator with Fractional-N PLL+VCO	118 / 78	-165	350	0.86	-227 / -230	**HMC1034LP6GE**

	Max. Clock Rate (GHz)	Function	Input	Output	Phase Jitter (12 k to 20 MHz)	Rise / Fall Time (ps)	Disable Mode	Power Supply (V)	Part Number
	8	1:9 Fanout Buffer	LVPECL, LVDS, CML, CMOS	LVPECL	8 fs RMS	65	Yes	3.3	**HMC987LP5E**
NEW!	4	Clock Divider & Delay Management	LVPECL, LVDS, CML, CMOS	LVPECL	13 fs RMS	90	Yes	5 or 3.3	**HMC988LP3E**

Ideal for Low Noise / Low Jitter Clock Multiplication & Clock Generation for ADC, DAC, DSP, FPGA & PHY Devices!

Hittite
MICROWAVE CORPORATION

Contact Us: timing@hittite.com

2 Elizabeth Drive • Chelmsford, MA 01824
978-250-3343 tel • 978-250-3373 fax • timing@hittite.com
See us at IMS Booth 1701

Order On-Line at: www.hittite.com
Receive the latest product releases - click on "My Subscription"

RFIC 2012 General Chair's Message

Welcome to the 2012 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium, which will take place in Montréal, Canada (www.RFIC2012.org) on June 17-19, 2012. Our symposium, held in conjunction with the IEEE MTT-S International Microwave Symposium, opens Microwave Week 2012 with three days focused exclusively on RFIC technology and innovation.

This year's venue is the Palais des Congrès de Montréal. Montréal, a 3.6 million metropolis, is the second largest French-speaking city in the world – located on an island at the junction of the St. Lawrence and Ottawa rivers. Montréal is a very walkable, dense city with a well-preserved historic center besides a modern downtown, plenty of public spaces and parks, a quick and clean transit system, beautiful architecture and neighborhoods, and of course lots of sidewalk cafés for people watching. We hope that you take full advantage of these opportunities on your visit.

Some of the prevalent themes in this year's conference include the emergence of Terahertz technology and applications, and the continuing expansion of smartphones, multi-band and re-configurable RF, and silicon millimeter-wave design. As usual, the latest advances in RFIC design from the device level to the system level will be covered in various formats including a complete workshop program taught by RFIC experts, panel sessions featuring respected industrial and academic voices in the RFIC community, and an exciting two-day technical program.

The 2012 RFIC Symposium will kick-off on Sunday, June 17 with a full lineup of half-day and full-day workshops covering a wide array of topics. Workshop topics will include mm-Wave Silicon PAs, Fast-Settling RF Frequency Synthesis, RF at the Nanoscale, RF Spectrum Sensing and Signal Detection, ICs for Biomedical Applications, Digital Transmitters, Short-Range Near-Field Communications, RF Front-End and Transceiver Techniques, Multi-Standard Radio Coexistence, 3D Integrated Circuits, recent developments in active/passive mixer design and high-speed wireline transceivers, and advances in noise analysis of RF circuits and front-end modules for mobile applications.

The Plenary Session will then be held on Sunday evening with keynote addresses given by two renowned industry leaders. They will share their views and insights on the direction and challenges that the RFIC design community is facing. The first speaker is Professor Thomas Lee of Stanford University, one of the pioneers of CMOS RF research for wireless communications. He will present a talk titled "Terahertz Electronics: The Last Frontier." The second speaker is Robert Gilmore, VP of Engineering at Qualcomm. He will bring perspective and knowledge from one of the leading wireless suppliers in the industry. The title of his talk will be "Towards the 5G Smartphone: Greater System Capacity, More Bands, Faster Data Rates, Advanced Applications and Longer Battery Life."

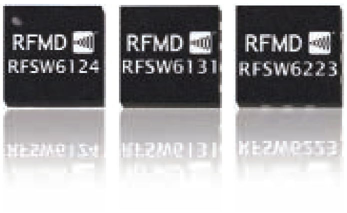
Immediately following the Plenary Session, conference attendees can gather at the RFIC Reception, to be held outdoors this year, which provides a relaxing time for all to mingle with old friends and catch up on the latest news.

The technical program will then commence on Monday and Tuesday with 23 technical sessions featuring a total of 126 papers. The RFIC technical sub-committees were re-organized this year to align with the growing trends in industry and academia. Sub-committees were formed in the areas of low-power transceivers (RFID, NFC, ZigBee, Sensor Nodes, WPAN, WBAN, and biomedical) and reconfigurable front-ends (SDR/Cognitive radio, Wideband/Multi-band Front-ends, Digital RF circuits/architectures). Technical sessions will feature papers on advances in LNA design and SDR front-end techniques, millimeter-

Albert Jerng
RFIC 2012 General Chairman

RFMD.

High-Performance Symmetric Switches for Communications Systems



RFMD offers a wide selection of broadband high-performance symmetric switches suitable for applications in the cellular, 3G, LTE, and other high-performance communications systems. Covering single-pole double-throw (SPDT), double-pole double-throw (DPDT), and single-pole triple-throw (SP3T), these products are ideal for use in high-performance and space-constrained applications. Each switch is 3V and 5V positive logic compatible.

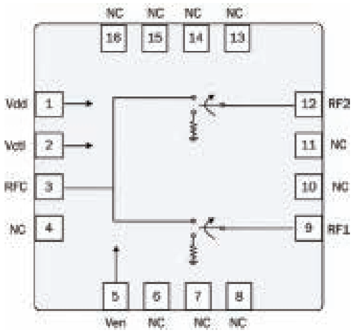
SPECIFICATIONS

Switch Type	*Freq Range (MHz)*	*Insertion Loss (dB)*	*Isolation (dB)*	*Input P1dB (dBm)*	*Control Voltage (V)*	*Package (mm)*	*Part Number*
SPDT	LF to 6000	0.75	65.0	35.5	5	4 x 4 QFN	RFSW6124
SP3T	LF to 6000	0.5	27.0	33.0	5	1.5 x 1.5 DFN	RFSW6131
DPDT	LF to 6000	0.65	33.0	35.5	5	3 x 3 QFN	RFSW6223

FEATURES

RFSW6124

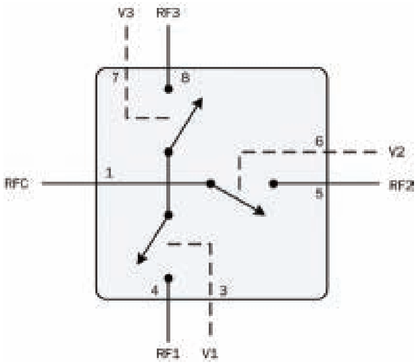
- LF to 6000MHz operation
- Symmetric SPDT
- Insertion Loss: 0.75dB (2GHz)
- Isolation: 65dB (2GHz)
- IIP3: 47dBm
- P1dB: 35.5 at 5V



FEATURES

RFSW6131

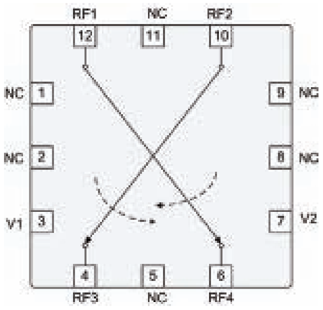
- LF to 6000MHz operation
- Symmetric SP3T
- Insertion loss: 0.5dB (2GHz)
- Isolation: 27dB (2GHz)
- IIP3: 56dBm
- P1dB: 33dBm at 5V



FEATURES

RFSW6223

- LF to 6000MHz operation
- Symmetric DPDT
- Insertion loss: 0.65dB (2GHz)
- Isolation: 35dB (2GHz)
- IIP3: 56dBm
- P1dB: 35.5dBm at 5V



RFMD® is a trademark of RFMD, LLC. ©2012 RFMD.

RFMD®

Mobility. Connectivity. Energy.

Visit RFMD at IEEE IMS 2012, Booth 1210


DO NOT CONFORM

Custom MMIC

Let Performance Drive

www.CustomMMIC.com

See us at IMS Booth 3210


Covering Your Spectrum

- Fixed Attenuators
- Terminations
- Variable Attenuators
- Power Dividers/Splitters
- RF Adapters
- DC Blocks
- RF Tuners
- DC to 50 GHz
- 1 watt to 1000 watts
- Custom Solutions

A Tradition of Quality

A Commitment to Customer Service

WA Weinschel Associates

Broadband RF/Microwave Solutions

19212 Orbit Drive
Gaithersburg, MD 20879
Voice: 877.948.8342
Fax: 301.963.8640
RF@WeinschelAssociates.com

www.WeinschelAssociates.com

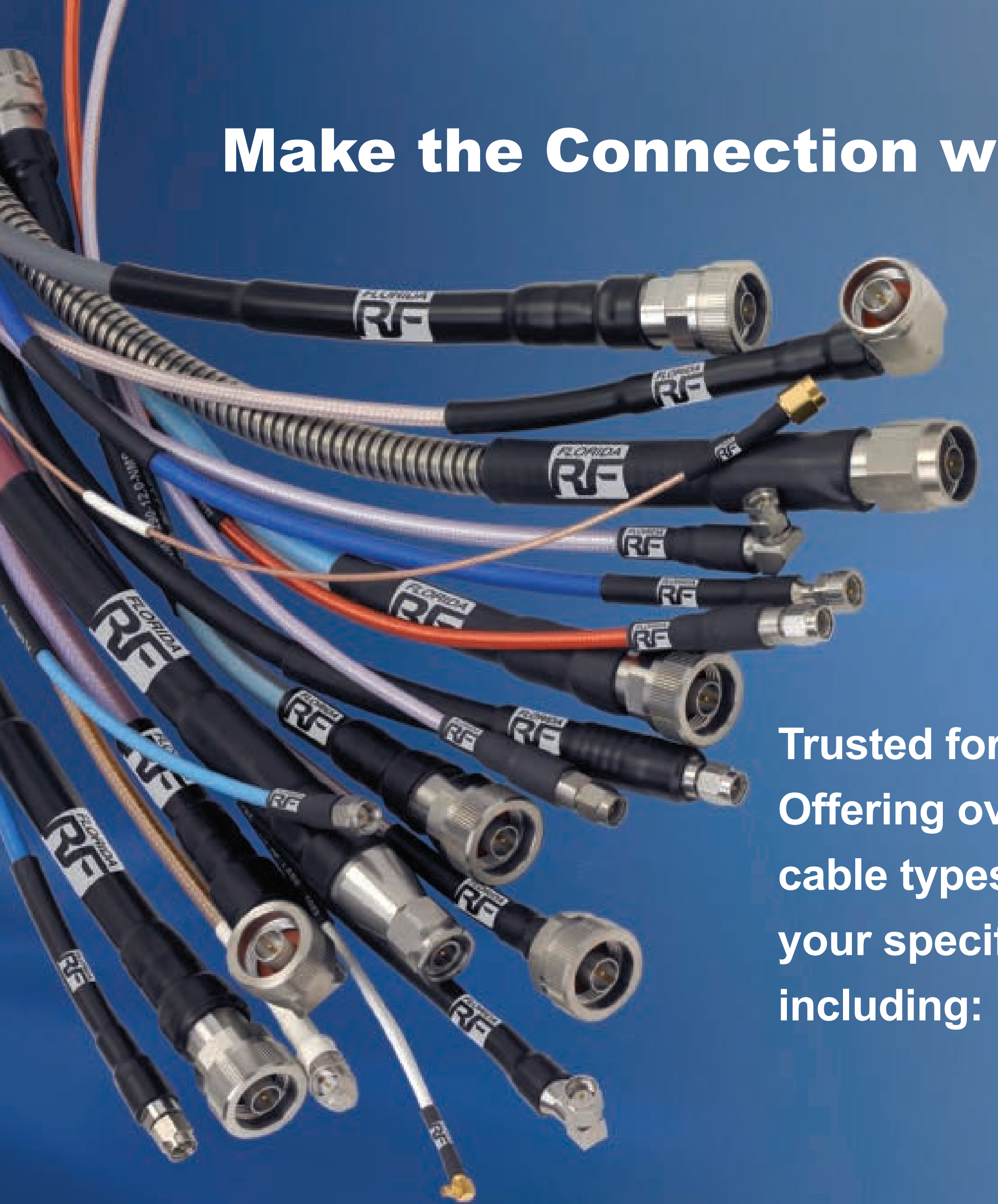
See us at IMS Booth 2616

wave power amplifiers and phase noise reduction techniques, advanced transmitters including multi-band reconfigurable power amplifiers, terahertz technology, low-power circuits, advanced frequency synthesis, baseband circuits and modulators for wideband transceivers, 60 GHz transceiver circuits, and advanced mobile and wireless transceivers and SoCs.

The technical program features a strong set of industry papers from leading wireless RFIC companies such as Mediatek, Skyworks, NXP, ST Micro, Infineon, IBM, Broadcom, Anadigics, Marvell, Renesas and Analog Devices. There will also be an invited paper from Qualcomm titled “The Path Towards Gb/s Wireless LANs.” On Tuesday afternoon, the technical program will conclude with the Interactive Forum which features 24 poster presentations. The poster session gives attendees the chance to speak directly with authors regarding their work in an informal setting.

The conference will also hold lunch-time panel sessions on Monday and Tuesday on several interesting topics relevant to the present and future of RFIC development. The Monday panel session is entitled “THz Integrated Circuits: Do Future Markets Support Highly Integrated Silicon-based IC Development?” and will explore the applications and markets that may drive the development of terahertz technology in silicon. The Tuesday panel session is entitled “RF Scaling: Can It Keep Up With Digital CMOS? Should It?” and will see panelists debate the pros and cons of scaling RF circuits in deep sub-micron CMOS technology. Be sure to attend these lively and entertaining events.

On behalf of the RFIC Steering Committee, I would like to extend a warm welcome to attend this year’s 2012 RFIC Symposium. We are looking forward to an exciting program and seeing all of you this June in Montréal! ■



Make the Connection with FLORIDA RF Labs

Trusted for over 25 years. Offering over 100 different cable types to best suit your specific application including:

- **Lab-Flex®** – Low-loss up to 50 GHz
- **Lab-Flex® S** – Low-loss, stranded center conductor up to 65 GHz (NEW)
- **ASR** – Precision test port assemblies (NEW)
- **Semi-Rigid** – In both solid and microporous dielectrics
- **Semi-Flexible** – Hand-Formable
- **Various Flexibles** – M17 and custom cable types up to 50 GHz

and an endless array of connector interfaces and configurations

The assemblies you need, *when* you need them!

smiths interconnect
bringing technology to life

8851 SW Old Kansas Ave, Stuart, FL 34997 USA
Phone: +1 772-286-9300 or 800-544-5594 | www.rflabs-emc.com

See us at IMS Booth 1704

79th ARFTG Microwave Measurement Conference

Welcome to the 79th Automatic RF Techniques Group (ARFTG) Microwave Measurement Conference being held at the Palais des Congrès de Montréal, on Friday, June 22, 2012. The conference will include technical presentations, an interactive forum and an exhibition; all to give you ample opportunity to interact with your colleagues in the RF and microwave test and measurement community.

The conference theme is "Nonlinear Measurement Systems" and we are looking forward to the invited talks of Dr. Jacques Sombrin on "Future Test Benches for the Optimization of Spectrum and Energy Efficiency in Telecom Nonlinear RF Components and Amplifiers" and Dr. Thibault Reveyrand on "New Sampling Paradigm Dedicated to RF Ultra-Wideband Receivers." The contributed conference papers focus on nonlinear measurement systems, calibration issues, on-wafer measurements, uncertainty, broadband and millimeter-wave measurements, and other areas of RF and microwave measurement.

Also, be sure to check out the joint ARFTG/IMS workshops on "Overview of Advanced Dielectric Measurement Techniques" and "Device model extraction based on Vectorial Large-Signal Measurements" on Monday, as well as the NVNA Users' Forum on Thursday afternoon. The NVNA Users' Forum is an informal discussion group devoted to sharing information and issues related to instrumentation utilized in vector large-signal analysis of microwave circuits and systems that contain nonlinear elements. This event is open to all ARFTG, IMS and RFIC attendees.

An important part of any ARFTG Conference is the opportunity to interact one-on-one with colleagues, experts and vendors in the RF and microwave test and measurement community. Whether your interests include high-throughput production or one-of-a-kind metrology measurements, complex systems or simple circuit modeling, small to large signal measurements, phase noise or noise figure or DC to lightwave, you will find similarly interested technologists. Starting with breakfast, continuing through two exhibition/interactive forum sessions and the luncheon, there will be ample opportunity for discussion with others facing similar challenges. Attendees find that these interactions are often the best source of ideas and information for their current projects, so come and join us.

Full details of the technical program and conference are available at: www.arftg.org.

ARFTG Conference registration is available through the IMS website at: www.ims2012.org.

Dominique Schreurs
ARFTG Conference Chair

Aerospace • Marine • Medical • Military • Satellite • Test

The Most Comprehensive Line of High Performance Connectors, Low Loss Cable & Cable Assemblies

REQUEST A COPY OF OUR NEW 2012 CATALOG

IMS 2012
June 17-22
Visit Us At Booth
2431

Dynawave has earned respect over the past 25 years by solving the most challenging interconnect problems where size, weight, power, loss, phase stability, flexure and other design concerns are critical.

Together, with the expanded talent, experience and capabilities of Dynawave Cable in the design & manufacturing of low loss, RF/MW cable, we can address a broader range of interconnect needs in an extremely cost effective manner.

RF MICROWAVE CONNECTORS

SMP - 40GHz
SMPM - 50GHz
SMPSM - 60GHz
SMA - 26.5GHz
SSMA - 46GHz
BMA - 26.5GHZ
BMAM - 38GHz
2.92mm - 40GHz
2.4mm - 50GHz
1.85mm - 65GHz
Type N - 18GHz
TNC - 18GHz
In Series Adapters - 50GHz
Between Series Adapters - 40GHz

LOW LOSS CABLE

DynaFlex® Series:

Series DF 100
"Best All Around Performance"

Series DF 200
"Best Phase/Loss Performance"

Series DF 300
"Best Weight Performance"

Series DF 400
"Best Flexure Performance"

D-Flex® - 18GHz
D-Flex® Microporous - 40GHz
Cable Assemblies - 65GHz
Semi-rigid Cable Assemblies - 65GHz

Please contact us with your application, and allow us to provide you a precise solution:

WWW.DYNAWAVE.COM
978 469-0555
dynawave® INCORPORATED

WWW.DYNAWAVECABLE.COM
978 469-9448
dynawave® CABLE INCORPORATED

Dynawave Incorporated | 135 Ward Hill Avenue | P.O. Box 8224, Haverhill, MA 01835 | Tel (978) 469-0555 | Fax (978) 521-4589 | sales@dynawave.com
ISO 9001 : 2008. Certificate No. 10002306 QM08

IMS 2012 MicroApps

The Microwave Application Seminars (MicroApps) – scheduled for the Palais des congrès de Montréal (Montréal Convention Center), June 19-21, 2012, as part of IMS 2012 – is a series of concise application note technical presentations given by exhibitors that are distinct and separate from yet complementary to the IEEE technical sessions. MicroApps are engineering topics of interest to the microwave community and cover new products, noteworthy state-of-the-art materials, components and measurement tools, and novel manufacturing and design techniques that incorporate the exhibitor's products and technologies in an application-centric setting.

This year's program is the most successful yet, offering more than 79 presentations on a diverse range of topics that include hardware, software and test. There will be 76 application notes, two keynote addresses and one panel session.

This year, Wednesday admission to the exhibit floor and also to the MicroApps Symposium is free. This means even more can take advantage of the special talks that day, which include a keynote presentation, "James Clerk Maxwell Part II" by Dr. James Rautio and the *Microwave Journal* Panel Session, "Device Characterization Methods and Advanced RF/Microwave Design." This special panel session takes place in the MicroApps theatre from 12:00 to 1:30 PM on Wednesday. This session will have leading companies in the field make presentations on the latest technology and techniques available followed by a question and answer period with the presenters. Attendees can also grab a whiskey shot Wednesday evening at the industry-hosted reception in honor of Maxwell and his Scotland heritage (sponsored by Sonnet).

GaN PANEL SESSION

Where Are the Emerging RF Market Opportunities for GaN?

Join Strategy Analytics and *Microwave Journal* for a special panel of industry leaders to explore the business opportunities for GaN. Each industry expert will make a brief presentation followed by a question and answer session with the panel. Complimentary breakfast will be served.

Wednesday, June 20th
8:00-10:00 AM
Palais des Congrès,
Room 516

MicroApps sessions are open to everyone, thanks to sponsorship by Agilent Technologies. The MicroApps theatre is conveniently located in the midst of the exhibits. The complete and up-to-date MicroApps Symposium schedule can be found in the IMS Program Book or online at http://ims2012.mtt.org. A MicroApps CD of all the presentations will be available for free to all, and those who are unable to attend in person will be able to order the CD from Agilent, watch the *Microwave Journal* webcast of the Panel Session and view the virtual presentations online at the IEEE.tv website.

Come to MicroApps, learn and enjoy. We look forward to seeing you in Montréal, Canada.

James Weiler
IMS MicroApps 2012 Chair

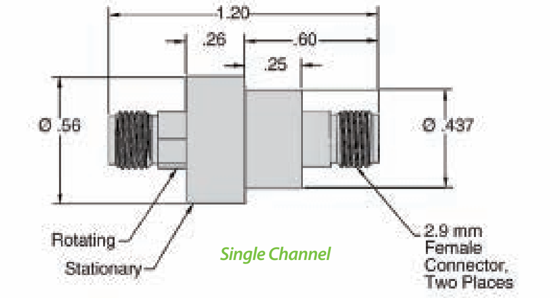
PERFECTION

When you need perfection in satellite high frequency communication.

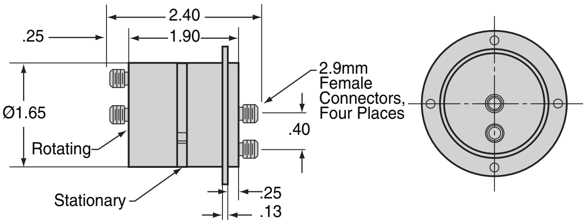
Family of Broadband High Frequency Coaxial Rotary Joints

Single Channel & Dual Channel Rotary Joints — Frequency DC to 40.0 GHZ
MDL's short low torque, high performance coaxial rotary joints as well as our extensive line of waveguide rotary joints have set the standards of the industry .

You've never been in better hands.
Quality from CAD to crate, quick turnaround, and tight economy is what we're all about. Call an MDL specialist today at 800-383-8057 or visit us at mdllab.com. You'll find that we specialize in perfection.



Single Channel



Dual Channel

SINGLE CHANNEL SPECIFICATIONS:

ELECTRICAL		
FREQUENCY	DC - 40 GHz	
VSWR	DC - 10 GHz	1.20 : 1 MAX.
	10 - 26 GHz	1.35 : 1 MAX.
	26 - 40 GHz	1.75 : 1 MAX.
WOW	1.05 MAX.	
INSERTION LOSS	DC - 10 GHz	0.2 dB MAX.
	10 - 26 GHz	0.4 dB MAX.
	26 - 40 GHz	0.6 dB MAX.
PEAK POWER	Equal to connector rating	

DUAL CHANNEL SPECIFICATIONS:

ELECTRICAL	Channel 1	Channel 2
FREQUENCY	7.0 - 22.0 GHz	29.0 - 31.0 GHz
VSWR	1.50:1 MAX.	1.70:1 MAX.
WOW	0.15	0.25
INSERTION LOSS	0.5 dB MAX.	1.0 dB MAX.
ISOLATION	Channel to Channel	50.0 dB MIN.

MDL

Scan here to visit our website

Microwave Development Laboratories, 135 Crescent Road, Needham Heights, MA 02494
V: 781-292-6680/6684 • F: 781-453-8629 • E-mail: mdlsales@mdllab.com • www.mdllab.com

Visit MDL in Montréal at IMS 2012 • Booth#723

IMS 2012 Social Media Scene

Last year, in preparation for MTT-S IMS, I wrote about Twitter (and related apps) starting to be used by RF/microwave companies. At that time, social media had not really caught on in our industry. What a difference a year makes as many companies and individuals are now using social media as one of their conduits for marketing efforts. Numerous companies and individuals now have hundreds or even thousands of Twitter followers and Facebook fans. While the use of social media in our industry is still not widespread, more and more companies are getting involved on a daily basis.

Twitter continues to be a powerful and popular social media tool. As you plan and execute your marketing programs for IMS 2012, don't forget to use the hashtag #IMS2012 in your Tweets. Spread the word about activities that you are planning, events you are attending, talks you are giving and keep everyone abreast of the best places to visit while in Montréal. *Microwave Journal* will be displaying a Twitter feed on our Online Show Daily microsite that is the official landing page of the Cyber Café at IMS 2012. Follow us and others involved in the show so you can keep up to date in real-time about what is going on at the conference and exhibition.

A couple of creative social media supporters are teaming up this year to run the Passport to IMS 2012 Montréal program. Every participant will receive a passport with 12 exhibitors listed on it and will visit the booths to get their passport stamped. After the passport is completed, participants can turn them in to the *Microwave Journal* booth #2018 to be entered into several prize drawings. The unique part of the program is that it integrates the use of social media by having participants post photos on Facebook and Tweet about products and giveaways at the booths (visit www.landingportal.com/IMSpassport for more details).

Turning to new trends on the social media scene, Pinterest has been growing rapidly in popularity even though it has been around for a few years. Pinterest is a virtual bulletin board site where people can put together boards of their favorite photos that link back to the web pages where they appear. Businesses are just starting to find uses for Pinterest, kind of in the state where Twitter was a few years ago. Consumers first jump in and as the user base grows, businesses start to find ways in which they can generate traffic to their content.

Microwave Journal is one of the first in this industry to use Pinterest and will be creating boards using products from our IMS 2012 Product Showcase (existing boards can be viewed at www.pinterest.com/pathindle). For IMS 2012, we will develop Pinterest boards by product category (Software/EDA, Test/Measurements, Components, etc.) using pictures of products that will be featured at the exhibition. The pictures will link to descriptions of what the company is featuring at the show including the specific product "pinned" on the board. These will be available on our Online Show Daily microsite.

Over the past year, the biggest rise in popularity for a social media site that we have seen has been on LinkedIn. As an example, *Microwave Journal* started the RF and Microwave Community group a few years ago with some limited success over the first couple of years. Now the group has close to 12,000 members and is still growing. There are daily posts for various discussion topics, technical questions, promotional items and of course, an active job opportunity section. *Microwave Journal* strives to be at the forefront of social media marketing and will continue to innovate in this area as we do in print, online and at events as a full service media partner.

When creating or growing your social media presence, remember that social media is just one component of an integrated marketing plan that should utilize many channels in order to promote a brand or product. ■

PATRICK HINDLE
Microwave Journal *Technical Editor*

Visit Rogers' Booth #2902 at IMS 2012

Find out whose designs win the ROG Award Contest

Winners will be announced at the
ROGERS' CUSTOMER APPRECIATION EVENT

Decades of Growth for Both High Reliability and Commercial Applications

1950 1970 1990 2000 2012 FUTURE

RT/duroid® 5000
TMM®
RO3000®
Theta® Circuit Materials
RO4000®
RO4730™ LoPro™
ULTRALAM® 2000
RT/duroid 5880LZ
RT/duroid 6000

Attend Our MicroApps Sessions

Tuesday
June 19th
11:05 am
John Coonrod
"Bonding Materials used in Multilayer Microwave PCB Applications"

Tuesday
June 19th
3:05 pm
Al Horn
"Reducing Active Device Temperature Rise and RF Heating Effects with High Thermal Conductivity Low Loss Circuit Laminates"

Learn more about our Technology Support Hub
rogerscorp.com/acm/technology

ROGERS CORPORATION
Advanced Circuit Materials Division

USA: +1 480-961-1382 Europe: +32 9 235 3611 www.rogerscorp.com/acm

Reactel, Incorporated

Reacting First to All Your Filter Needs.

Enter to win an iPad2 at MTT! Booth #2210

WE'RE AT YOUR FINGERTIPS!

Submitting a request for immediate attention will never be easier.

Reactel is happy to introduce our Filter RFQ App available for Apple and Android devices.

Reactel's product line includes RF & Microwave Filters, Multiplexers and Multifunction Assemblies covering the frequency range of DC to 50 GHz.

Google play

Available on the App Store

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.

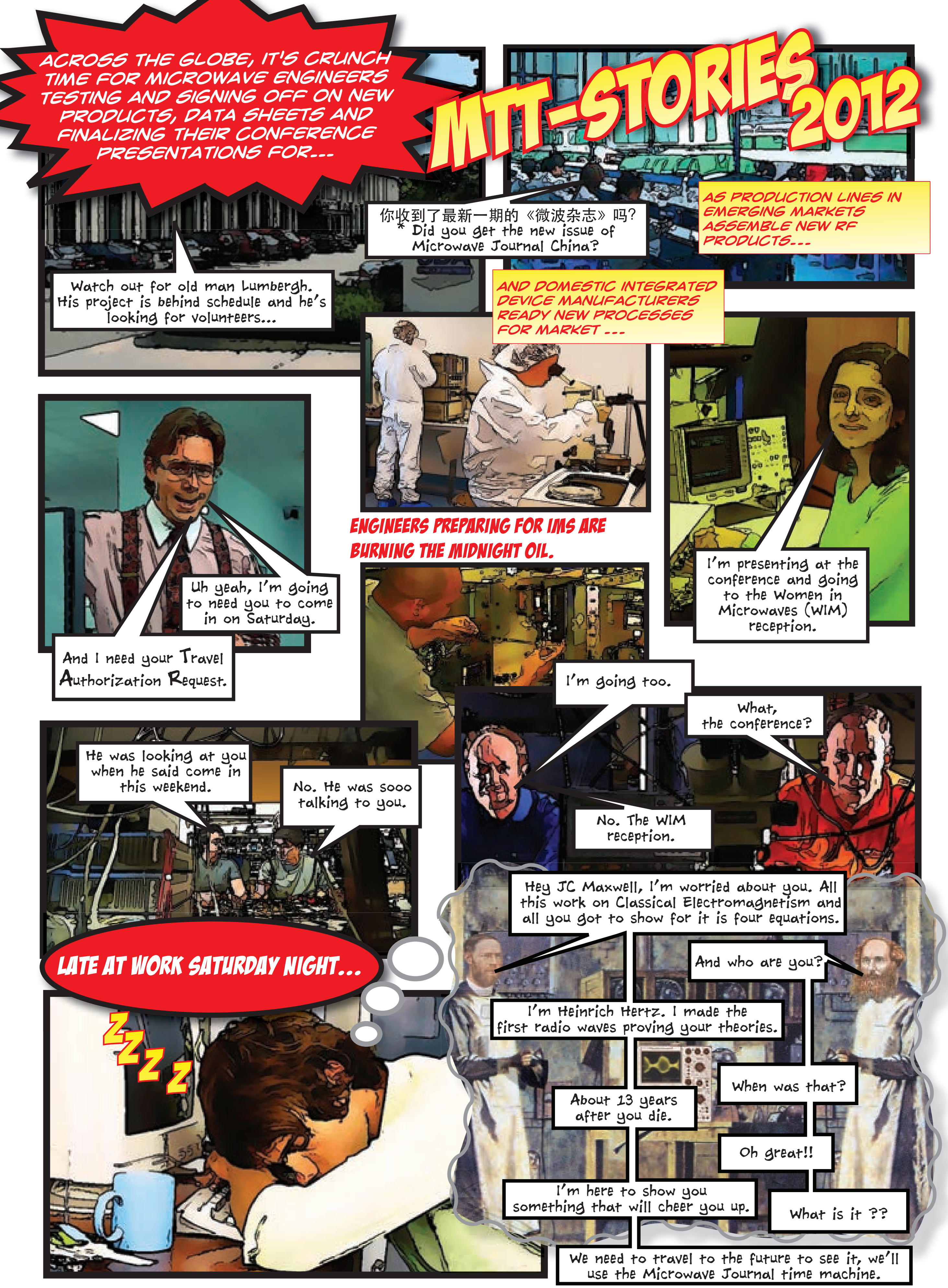
Passport to IMS2012 MONTRÉAL SPONSOR

@reacteljim

RoHS Compliant

FM Approvals

Montréal® Journal


ACROSS THE GLOBE, IT'S CRUNCH TIME FOR MICROWAVE ENGINEERS TESTING AND SIGNING OFF ON NEW PRODUCTS, DATA SHEETS AND FINALIZING THEIR CONFERENCE PRESENTATIONS FOR...
MTT-STORIES 2012
你收到了最新一期的《微波杂志》吗?
* Did you get the new issue of Microwave Journal China?
AS PRODUCTION LINES IN EMERGING MARKETS ASSEMBLE NEW RF PRODUCTS...
Watch out for old man Lumbergh. His project is behind schedule and he's looking for volunteers...
AND DOMESTIC INTEGRATED DEVICE MANUFACTURERS READY NEW PROCESSES FOR MARKET ...
Uh yeah, I'm going to need you to come in on Saturday.
And I need your Travel Authorization Request.
ENGINEERS PREPARING FOR IMS ARE BURNING THE MIDNIGHT OIL.
I'm presenting at the conference and going to the Women in Microwaves (WIM) reception.
I'm going too.
What, the conference?
No. The WIM reception.
He was looking at you when he said come in this weekend.
No. He was sooo talking to you.
LATE AT WORK SATURDAY NIGHT...
Z Z Z Z
Hey JC Maxwell, I'm worried about you. All this work on Classical Electromagnetism and all you got to show for it is four equations.
And who are you?
I'm Heinrich Hertz. I made the first radio waves proving your theories.
When was that?
About 13 years after you die.
Oh great!!
I'm here to show you something that will cheer you up.
What is it ??
We need to travel to the future to see it, we'll use the Microwave Journal time machine.


What is a Microwave Journal? Is this horseless carriage really a time machine?
They call it a Woodie and Microwave Journal chronicles the industry created through your work, JC.
Mr. Peabody and I use the way-back machine.
We travel by Phone Booth Dudes!!!
What industry?
JC, your theories launched a whole microwave industry and every year they gather at an event called IMS. It's like Christmas for engineers.
I have been told that I look like a young Santa Claus.
IMS is in Montréal this year, second time outside the United States.
LEAVING THE UNITED STATES
...ARTANCE DES ÉTATS-UNIS
Very international.
You do have your passport?
And this year they celebrate the 60th year of that Microwave Society.
Crazy dream, Must... Wake... Up...
JC, I'm like your biggest fan.
And you say engineers can solve my equations on a ... Computer?
THE NEXT MORNING...
!!
What's your business in Canada?
We're attending a microwave conference.
Like the oven?
Whoa, its working. You saved Lumbergh's skin.
Just in time to get it in the Microwave Journal Show Issue.
We've got to move these microwave products.
I want my...
I want my...
I want my...
MTT
Have a great show everyone!
Don't forget your passport!

Conference Hotel Locations

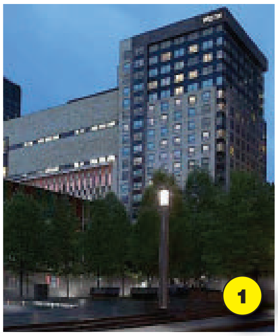
① **Le Westin Montréal**
– Co-Headquarters
② **Hyatt Regency Montréal**
– Co-Headquarters
③ **Fairmont The Queen Elizabeth**
④ **Le Centre Sheraton Montréal Hotel**
⑤ **Holiday Inn Select Montréal Centre-Ville**
⑥ **Embassy Suites Montréal by Hilton**
⑦ **Hilton Montréal Bonaventure**
⑧ **Montréal Marriott Château Champlain**
⑨ **Holiday Inn Montréal Midtown**
⑩ **InterContinental Montréal**
⑪ **Delta Centre-Ville**
⑫ **Hôtel Gouverneur Place Dupuis**
⑬ **Hôtel Le Dauphin Montréal Downtown**

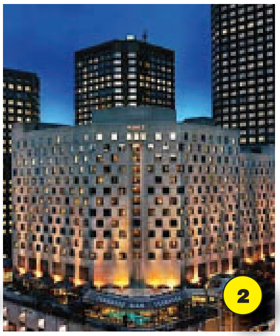
Métro Access
- GREEN LINE
- ORANGE LINE
- YELLOW LINE

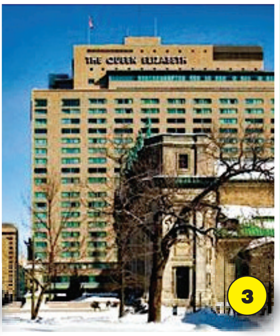
Scale (Approx.): Meters
0 50 100 150 200 250 = 0.5 miles
0 1min 2min
Est. Walking Time

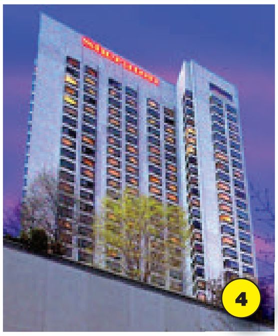
MICROWAVES WITHOUT BORDERS
MICRO-ONDES SANS FRONTIÈRES

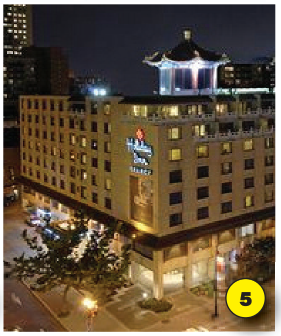
International Microwave Symposium
IEEE June 17-22, 2012, Montréal, Canada MTT-S
http://ims2012.mtt.org/

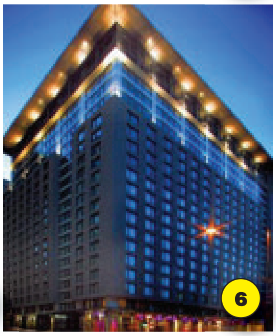


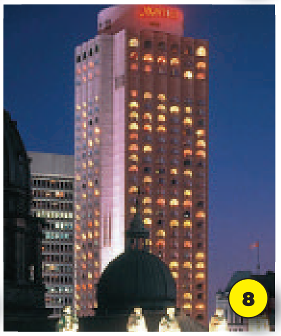


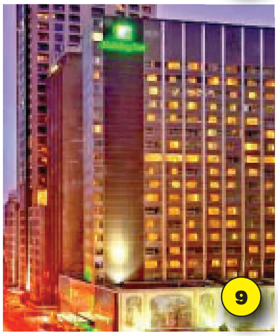


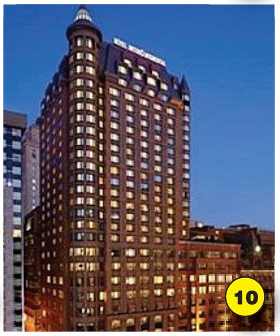


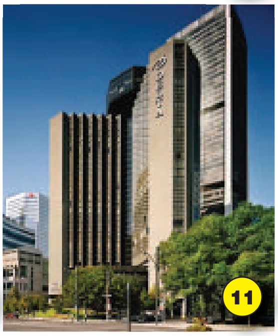


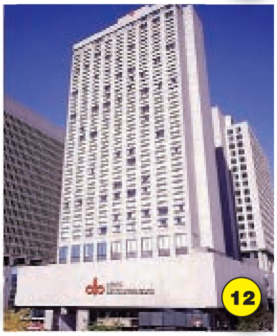


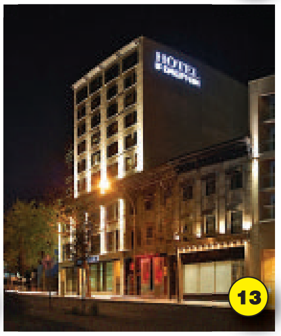












Map of Downtown Montréal area provided courtesy of CTT, Inc. Stop by CTT's Booth 2414

The next generation air and missile defense radars demand effectiveness, reliability, power efficiency and affordability. You can count on CTT's twenty-five years of experience in microwave amplification and subsystem integration to meet these demands.

CTT offers not only form, fit, function of microwave amplifier replacements for many mature systems, but also incorporates leading-edge technology components such as GaN and GaAs.

CTT has delivered production quantities of amplifiers with power levels of 10, 20, 40, 80, and 100 Watts – and higher – for a variety of radar applications.

CTT is well positioned to offer engineering and production technology solutions – including high-rel manufacturing – to infuse new technology into legacy systems for improved reliability and life cycle costs.

- AMDR-X Radar
- VLO/FLO Threats
- Shipboard Radar
- New Land Radar

More than twenty-five years ago CTT, Inc. made a strong commitment to serve the defense electronics market with a simple goal: quality, performance, reliability, service and on-time delivery of our products.

Give us a call to find out how our commitment can support your success. **It's that simple.**

Microwave Technology Leadership

- ❖ **Power Amplifiers**
  - **NEW GaN and GaAs Models**
  - Radar Bands up to 400W
  - Pulse and CW
  - **NEW** Rack-Mount Configurations
- ❖ **Low-Noise Amplifiers**
- ❖ **Up and Downconverters**
- ❖ **Subsystems**
- ❖ **Contract Manufacturing**
- ❖ **Custom Engineered Options**

nsai
ISO 9001:2000 QUALITY

USA-based thin-film microwave production facility

241 East Java Drive • Sunnyvale • California 94089
Phone: 408-541-0596 • Fax: 408-541-0741
www.cttinc.com • E-mail: sales@cttinc.com

CTT INC.

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

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
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

Ciao Wireless, Inc. 4000 Via Pescador, Camarillo, CA 93012
Tel (805) 389-3224 Fax (805) 389-3629 sales@ciaowireless.com
See us at IMS Booth 2606

Raytheon to Help U.S. Army Better Detect Rocket, Artillery and Mortar Threats

Raytheon Co. has been awarded a $45.5 million contract for the prototype build of the Ku-Band Multi-Function RF System (MFRFS) Sense and Warn (S&W) radars for the U.S. Army. The contract is a follow-on to an ongoing effort being performed by Raytheon to improve the performance of the Counter Rocket Artillery and Mortar (C-RAM) S&W systems currently fielded at forward operating bases in theater of operations.

Under the contract, Raytheon will procure long-lead material and subsystems for Ku-Band MFRFS prototype systems to be built in 2012. The work is in support of Program Directorate C-RAM under PEO Missiles and Space in Huntsville, Ala. The development of the Ku-Band MFRFS system heavily leverages technology developed by Raytheon on the Army's Future Combat Systems (FCS) program.

As a precursor to the Ku-Band MFRFS variant, Raytheon developed, tested and deployed a Low Quadrant Elevation (QE) MFRFS C-RAM S&W system in 14 months, utilizing residual assets from the FCS program. Eighteen additional Low QE systems, for C-RAM applications, will be deployed during the first half of 2012 using FCS assets. Both the Low QE MFRFS and the Ku-Band MFRFS systems provide improved S&W times, virtually eliminate false alarms and improve coverage of currently fielded C-RAM systems. The Ku-Band system will further improve performance and reduce logistics costs.

"The MFRFS C-RAM mission is extremely important in that it provides a life-saving capability to our men and women in uniform," said Glynn Raymer, vice president of Combat and Sensing Systems for Raytheon's Network Centric Systems business. "By reliably providing them with additional warning of incoming threats, we dramatically improve their survivability. And, by reusing existing technology, we are able to minimize the cost and risk of rapidly fielding improved C-RAM systems," Raymer added.

> *"The MFRFS C-RAM mission is extremely important in that it provides a life-saving capability to our men and women in uniform."*

U.S. Army Awards Contract for AN/TPQ-53 Firefinder Radar

The U.S. Army Product Manager for Radars (PdM Radars) awarded a contract recently to Lockheed Martin for the AN/TPQ-53 Firefinder Radar. The award is a Firm Fixed Price contract for $881 million with the base year and two option years, which could yield up to 51 systems. The base year is $166 million that will produce 12 systems. All training and testing support to include a Limited User Test as well as Initial Operational Test and Evaluation is covered by the contract.

Source: U.S. Army

The AN/TPQ-53 (formerly referred to as the EQ 36) provides improved operational and physical functionality over existing AN/TPQ 36 radars systems. The radar detects in-flight projectiles at greater rangers and determines and communicates the firing point locations with a high degree of accuracy. It does this with a low false alarm rate and with an improved coverage pattern. This capability allows for more effective detection and counter-battery actions.

"The AN/TPQ-53 will bolster the level of protection for Soldiers in the field, by expanding basic counterfire radar capabilities in both 90 and 360 degree modes," said Lt. Col. Robert Thomas, PdM Radars. "This is a great example of the Army and industry coming together to ultimately deliver a system that will greatly enhance situational awareness by providing the precise location of hostile indirect fire weapons."

Harris Introduces Ultra-Light, High-Frequency Spaceborne Antenna Reflector

Harris Corp., an international communications and information technology company, has introduced the first-ever fixed-mesh antenna reflector that supports emerging requirements for high-throughput, high-reliability Ka-Band and higher frequency satellites. The solution is ideal for satellite Internet, HDTV and cellular backhaul providers, and businesses that transfer large amounts of data between remote locations, such as oil and gas companies and maritime users. The fixed-mesh reflector design significantly lowers the antenna's mass for a given aperture size as compared to traditional solid reflectors. The lower mass is made possible by incorporating a flight-proven mesh surface instead of a traditional solid reflector membrane surface. Other benefits and features include:

- The new design is not sensitive to acoustic loading during launch, which reduces the overall structure and mass of the satellite.
- The reflector greatly increases the gain and potential

Go to www.mwjournal.com for more defense news items

spot beams available to satellite manufacturers and service providers. The increased frequency reuse provided by additional spot beams enables higher data rates required by providers of bandwidth-hungry services.

- The reflector features flight-proven design elements refined during development and production for U.S. government and commercial programs, including the application of reflective mesh; unique, high-accuracy surface-shaping technology; and thermally stable materials. The highly reflective mesh surface provides excellent RF reflectivity without exotic surface treatments required for high-frequency solid reflectors.
- The antenna reflector's projected aperture ranges from 2.6 to 3.5 meters in diameter, with a compact stowed configuration suitable for most launch vehicles. Its mass is half that of conventional solid reflector technology, which greatly increases potential mission performance compared to currently employed technologies.

"This new fixed-mesh antenna reflector is a natural extension of our existing offerings and addresses the emerging need for larger apertures at a fraction of the mass and weight of conventional solid reflectors," said Sheldon Fox, group president, Harris Government Communications Systems. "Harris has a 35-year legacy of providing high-performance antenna solutions with unmatched performance, and this solution supports the ever-increasing global demand for higher bandwidth capacity."

With more than 50 antenna reflectors in orbit, Harris is the leading supplier of large reflector apertures and unfurlable mesh reflector antenna systems for all orbital regimes. The company's offerings span UHF band through Ka-Band, in sizes ranging from 2.6 meters to the world's largest commercially available 22-meter reflector. Harris reflector products have the highest surface accuracy design in the industry, while substantially exceeding the specified mean mission duration of the spacecraft and payload.

> *"This new fixed-mesh antenna reflector is a natural extension of our existing offerings and addresses the emerging need for larger apertures at a fraction of the mass and weight of conventional solid reflectors."*

Enhance your system performance with Mercury's Microwave and Digital Solutions

formerly LNX Corp.

Our EW, ECM, C-IED, SIGINT and COMINT subsystem designs mitigate your risk and help you meet shorter program timelines.

Digital Receiver & IFM Solutions
- Wideband tuning receivers >1 GHz
- Wideband and direct digitization

DRFM Solutions
- ASIC and assemblies 1.2 GHz IBW

Microwave Components & Integrated Microwave Assemblies
- Custom and standard products

mc.com/mwj

Copyright © 2012 Mercury Computer Systems, Inc.

MERCURY COMPUTER SYSTEMS™

Best-of-breed provider of open, commercially developed, application ready and multi-INT subsystems for the ISR market

See us at IMS Booth 618

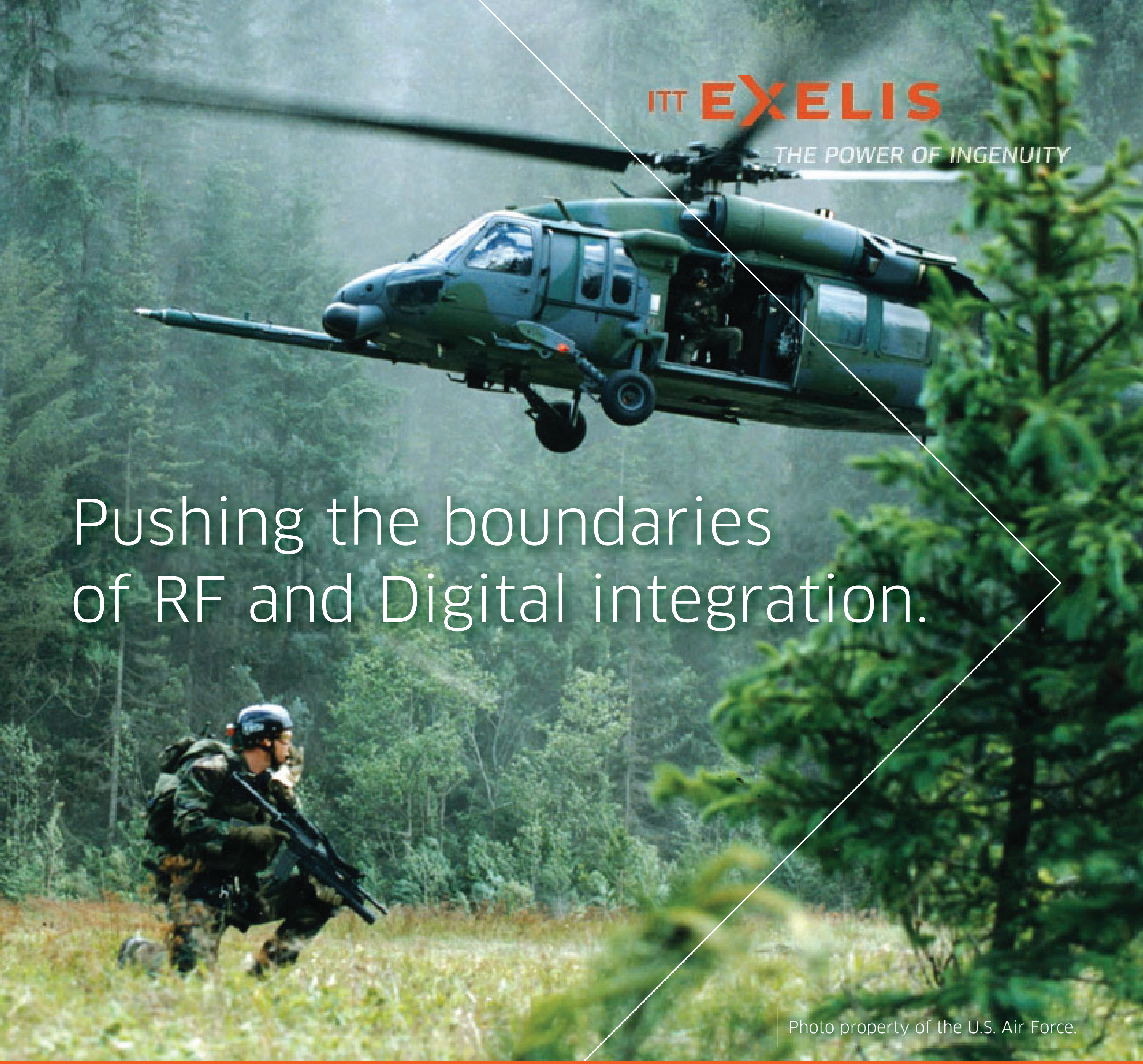


Photo property of the U.S. Air Force.

The ITT Exelis microwave systems business has been designing and manufacturing high performance direct, digital-based (DDS) synthesizers and radio frequency (RF) waveform generators for more than twenty years. If your radar, identification of friend or foe (IFF), electronic warfare (EW) or signals intelligence systems (SIGINT) requires fast switching and clean signals, trust the expertise of Exelis for the most sophisticated solutions today. Our expertise is in low spurious, wideband solutions from DC to 26 GHz.

www.exelisinc.com/microwavesystems

Exelis and “The Power of Ingenuity” are trademarks of Exelis Inc. ITT is a trademark of ITT Manufacturing Enterprises, LLC., and is used under license. Copyright © 2012 Exelis Inc. All rights reserved.

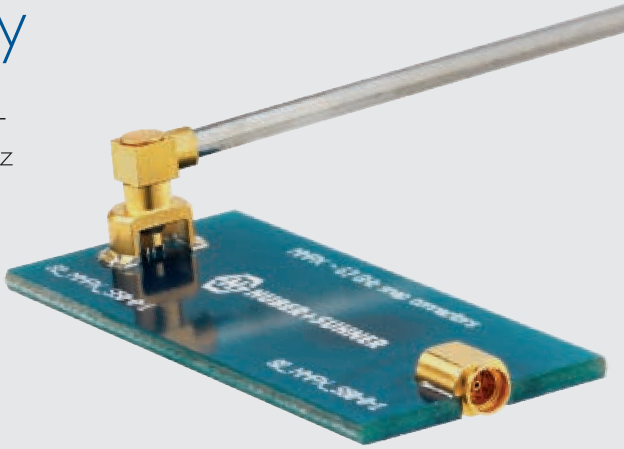
See us at IMS Booth 1814

HUBER+SUHNER
Excellence in Connectivity Solutions

MMPX –
leading edge RF technology

The snap-on connector family MMPX is the most ideal coaxial-to-PCB system solution for operating frequencies up to 67 GHz and data rates up to 80 Gbps.

- Broadband characteristics from DC to 67 GHz
- Mechanically superior design
- Extensive technical support:
  3D-files, modelling data and customised footprints included



HUBER+SUHNER AG
9100 Herisau/Switzerland, info@hubersuhner.com, hubersuhner.com

International Report
Richard Mumford, International Editor

Indian Operators Prime Networks for Mobile Broadband Uptake

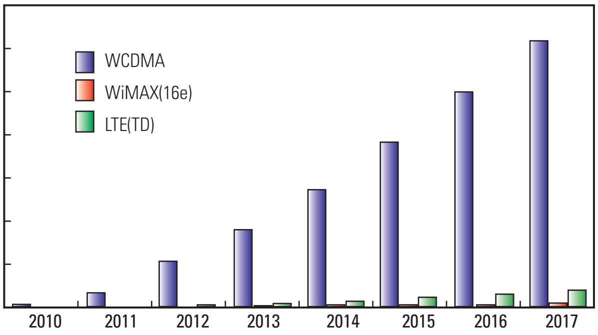
“The Indian mobile subscriber market has demonstrated strong growth in the past decade or so, but when it comes to the adoption of mobile data services, the results are more mixed,” commented Jake Saunders, vice president of forecasting at ABI Research, following the company’s new study – Indian Mobile Broadband Market. He continued, “Yes, total wireless data subscribers stood at more than 370 million at the end of 2011, but only 17 million had access to WCDMA services; the rest are being served by GPRS/EDGE.”

The report highlights the constraints behind the Indian mobile broadband sector and complications of the current regulatory scene, as well as market drivers for future growth. It indicates that the Indian market is full of potential. At the end of 2011, there were 900 million mobile subscribers. However, a note of caution is merited. The market is heavily fragmented, with more than 70 3G licensed circles. Considerable expectations were placed on 4G WiMAX, which failed to materialize. WCDMA and TD-LTE subscriber adoption will eclipse 90 million and 5 million respectively, by 2013.

There are a number of challenges to kick-starting the Indian mobile broadband market. The large landmass and population are two substantial reasons, but India’s low average monthly revenue per user ($3 to $5) also constrains cash flow to fund infrastructure investments.

Addressing potential developments Philip Solis, ABI Research’s research director, mobile devices, stated, “While 3G services are only now establishing a toehold in the Indian market, operators such as Aircel, Augure, and Infotel are turning to TD-LTE, a 4G technology of the time division variant, to help address the market potential for mobile data services. LTE offers the potential to change the cost equation of delivering mobile data services through increased spectral efficiency – not just in dense, urban communities but also rural towns and villages.”

Mobile Broadband Subscribers by Technology
India, Forecast: 2010 – 2017



Source: ABI Research

COST Receives Additional €10 Million from European Commission

The European Commission Directorate-General for Research & Innovation has informed COST and the European Science Foundation (ESF) of its decision to allocate an additional €10 million to COST. This latest allocation raises the total budget for COST to €250 million, which was the maximum initially envisaged by the EU Seventh Framework Programme (FP7) subject to a mid-term evaluation.

COST is an intergovernmental framework for European Cooperation in Science and Technology, which implements networking activities for researchers, contributing to the European Research Area (ERA) goals and participating in the delivery of the Europe 2020 agenda.

“This further increase in the COST budget reveals the European Commission’s trust in our intergovernmental framework’s ability to build excellence-driven networks by connecting high-quality scientific communities through a bottom-up inclusive approach throughout Europe and worldwide. With these additional funds, COST will continue to invest in science and technology activities, thus reinforcing COST’s contribution to Europe’s research and innovation capacities by favouring trans-domain multidisciplinary networks and integrating the talent of the next generations,” commented Dr. Ángeles Rodríguez-Peña, president of the COST Committee of Senior Officials (CSO).

> *“...COST will continue to invest in science and technology activities...”*

“The ESF, as implementing agent for COST and the beneficiary of the COST II grant agreement with the European Commission, has indeed been asked to consider the additional annual financing of €13.4 million when submitting the annual Work Programme from now on. We are already preparing the respective annual Amendment 2012 for a total of €43.3 million in cooperation with the CSO and aim for a smooth approval process in June 2012,” added Martin Hynes, chief executive of ESF.

HELIOS Makes Silicon Breakthrough

Researchers in Europe have succeeded in presenting an integrated tuneable transmitter on silicon, for the very first time. The breakthrough is the result of the HELIOS (Photonics electronics functional integration on complementary metal oxide-semiconductor, CMOS) Project, which is backed under the Information and Communication Technologies (ICT) Theme of the EU’s Seventh Framework Programme (FP7) to the tune of €8.5 million.

Experts from the Electronics and Information Technol-

Go to www.mwjournal.com for more international news items

ogy Laboratory of the French Atomic Energy Commission (CEA-Leti) and III-V lab, a joint lab of Alcatel-Lucent Bell Labs France, in cooperation with Thales Research and Technology in the UK, believe the tuneable laser source integrated on silicon to be a groundbreaking achievement in efforts to secure fully integrated transceivers. Researchers at Ghent University and the Interuniversity Microelectronics Centre (IMEC) in Belgium, and the University of Surrey, UK, who designed the modulator, supported the research.

The group from CEA-Leti and III-V lab also demonstrated single wavelength tuneable lasers, with a 21 mA threshold at 20°C, a 45 nm tuning range and a side mode suppression ratio larger than 40 dB over the tuning range.

Commenting on the results, CEA-Leti France photonics program manager, Laurent Fulbert, said: "We are proud to jointly present with III-V lab the results of the integrated silicon photonics transmitter and the tuneable laser. The ability to integrate a tuneable laser, a modulator and passive waveguides on silicon paves the way of further developments on integrated transceivers that can address several application needs in metropolitan and access networks, servers, data centres, high-performance computers as well as optical interconnects at rack-level and board-level.

> *"Experts...believe the tuneable laser source integrated on silicon to be a groundbreaking achievement..."*

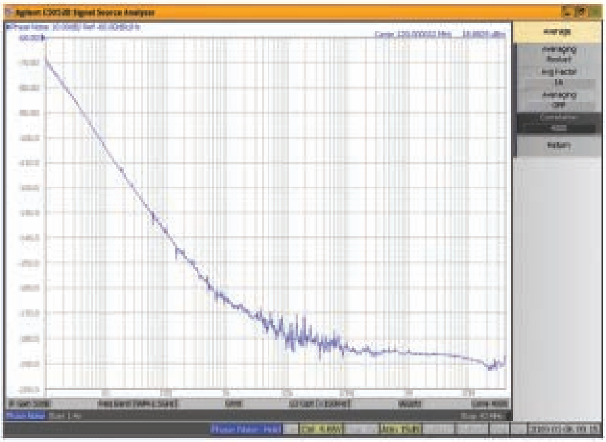
EC Launches New Cluster Initiatives

The European Commission has announced new and updated initiatives to assist small and medium-sized enterprises (SME) to go international. New projects will be launched to support clusters of SMEs so that they can benefit from the growth in Asia, Latin America, North America and Russia.

A new pilot action aims to upgrade the profile of 25 experts working in clusters to act as 'multipliers' and train other cluster managers to support SMEs in trading globally. Some 30 cluster benchmarking evaluators will be trained and 80 cluster organisations are expected to be benchmarked against clusters that are performing elsewhere so they can all learn from each other and perform more effectively. These cluster organisations will also sign up to the European Cluster Collaboration Platform, which will help them gain greater international exposure and ultimately new business and export opportunities for their SMEs.

The projects involve 20 organisations in Greece, Ireland, Hungary and Turkey encompassing further partners from Bulgaria, the Czech Republic, Croatia, Iceland, Poland, Portugal, Romania, Serbia, Slovakia and Spain. The overall EC contribution amounts to over €1.5 million.

Keep the noise down!



OCXOF Series Phase noise for 100MHz unit

Min guaranteed performance	10Hz	100Hz	1kHz	10kHz	100kHz offsets
level 1	-100	-135	-162	-176	-182 dBc/Hz
level E	-102	-137	-164	-178	-182 dBc/Hz

Samples available upon request

Pascall
thinking inside the box

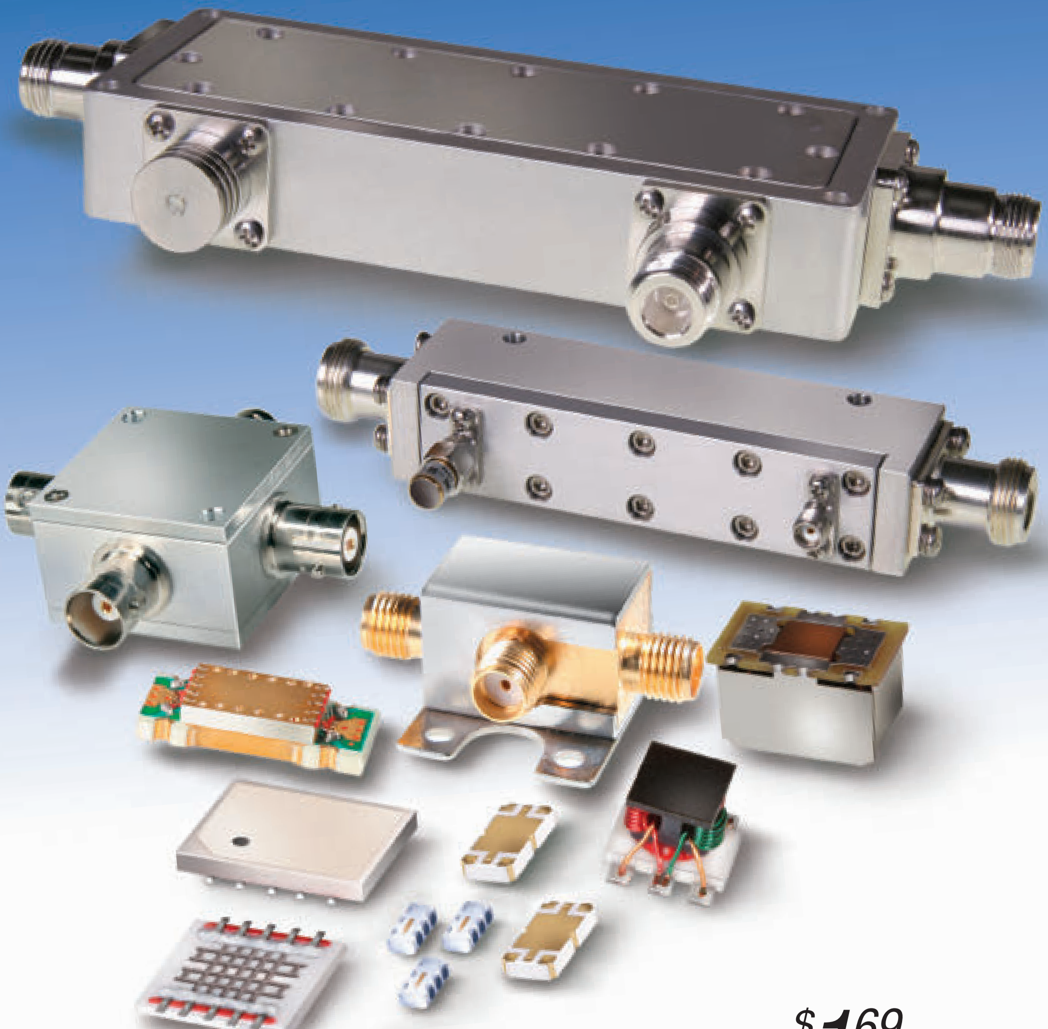
Tel +44(0) 1983 817300
Fax +44(0)1983 564708
e-mail mjenquiries@pascall.co.uk
www.pascall.co.uk

A subsidiary of Emrise Electronics

See us at IMS Booth 3413

Directional / Bi-Directional

COUPLERS



5 kHz to 12 GHz up to 250 W from $ 1 69 ea. (qty.1000)

Looking for couplers or power taps? Mini-Circuits has 236 models in stock, and we're adding even more! Our versatile, low-cost solutions include surface-mount models down to 1 MHz, and highly evolved LTCC designs as small as 0.12 x 0.06", with minimal insertion loss and high directivity. Other SMT models are designed for up to 100W RF power, and selected core-and-wire models feature our exclusive Top Hat™, for faster pick-and-place throughput.

At the other end of the scale, our new connectorized air-line couplers can handle up to 250W and frequencies as high as 12 GHz, with low insertion loss (0.2 dB @ 9 GHz, 1 dB @ 12 GHz) and exceptional coupling flatness! All of our couplers are RoHS compliant. So if you need a 50 or 75 Ω, directional or bi-directional, DC pass or DC block coupler, for military, industrial, or commercial applications, you can probably find it at minicircuits.com, and have it shipped today!

See minicircuits.com for specifications, performance data, and surprisingly low prices!
Mini-Circuits...we're redefining what VALUE is all about!

Mini-Circuits®
ISO 9001 ISO 14001 AS 9100
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

YONI®2 ***The Design Engineers Search Engine*** *finds the model you need, Instantly* • For detailed performance specs & shopping online see **minicircuits.com**
U.S. Patents
7739260, 7761442

IF/RF MICROWAVE COMPONENTS

495 rev org

SUPER ULTRA WIDEBAND

AMPLIFIERS

+24 dBm output... 0.7 to 21 GHz from $845 ea.

Calling these amplifiers "**wideband**" doesn't begin to describe them. Consider that both the ZVA-183X and ZVA-213X amplifiers are unconditionally stable and deliver typical +24 dBm output power at 1dB compression, 26 dB gain with +/- 1 dB flatness, noise figure of 3 dB and IP3 +33 dBm. What's more, they are so rugged they can even withstand full reflective output power when the output load is open or short. In addition to broadband military and commercial applications, these super wideband amplifiers are ideal as workhorses for a wide number of narrow band applications in your lab or in a production environment.

Visit our website for comprehensive performance data and specifications for our ZVAs or any of our over 10,000 catalog items. You can even order on-line for next day shipment.

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

TYPICAL SPECIFICATIONS

	MODEL	FREQ. (GHz)	GAIN (dB)	POUT (dBm) @ 1 dB Comp.	NOISE FIG. (dB)	PRICE (1-9)
	ZVA-183X+	0.7-18	26	+24	3.0	845.00
	ZVA-213X+	0.8-21	26	+24	3.0	945.00
	ZVA-183+	0.7-18	26	+24	3.0	895.00
	ZVA-213+	0.8-21	26	+24	3.0	995.00

Note: Alternative heat-sink must be provided to limit maximum base plate temperature.

All models IN STOCK!

RoHS compliant

Mini-Circuits®

ISO 9001 ISO 14001 AS 9100

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

YONI2® ***The Design Engineers Search Engine*** *finds the model you need, Instantly* • For detailed performance specs & shopping online see **minicircuits.com**

U.S. Patents
7739260, 7761442

IF/RF MICROWAVE COMPONENTS

440 rev H

Commercial Market

Dan Massé, Associate Technical Editor

LTE Small Cell Shipments Will Surpass LTE Macro Base Station Shipments in 2014

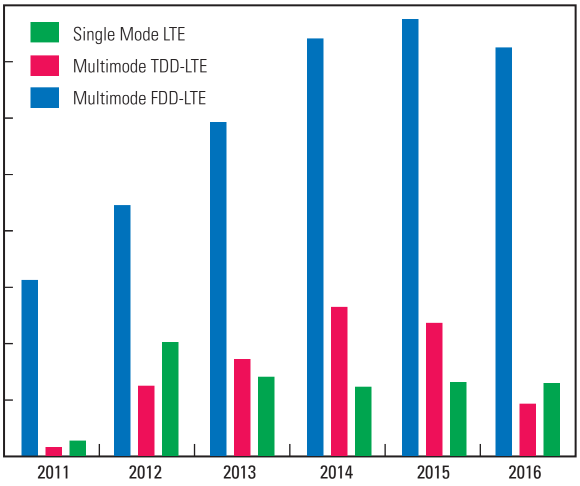
Changing cellular network paradigms are driving a shift in the architecture of base stations from traditional macrocells to distributed base stations and toward the growing use of small cell base stations. The primary drivers for this transition are the increasing data traffic demand and the OPEX and CAPEX cost savings inherent in deploying small cell equipment.

Operators will initially deploy small cell equipment as in fills on the pico and microcell layers, but will quickly transition to deploying them as a fundamental part of a network rollout. In fact, the number of LTE small cells sold (127,000) will surpass the number of LTE macrocells, forecast at 113,000, as early as 2014. However, LTE base station revenues will continue to be dominated by macro base station revenue with small cell revenue of $1.09 billion representing only 5.2 percent of the total revenue of $20.86 billion in 2014 and growing to $4.44 billion or 23.9 percent of the total $18.60 billion LTE base station market by 2016.

Equipment manufacturers have been quick to respond to this shift in RAN architecture. Ericsson acquired BelAir networks as part of its "HetNet" initiative, Nokia Siemens Networks announced Flexi Zone, Alcatel-Lucent continues to expand its lightRadio™ portfolio and Huawei has announced its AtomCell products.

Nick Marshall, principal analyst, networks, comments, "This mobile broadband-driven data storm is stretching traditional macrocell network capacity to the limit and driving the move to heterogeneous networks." Likewise, semiconductor suppliers are also positioning themselves to participate in this market with TI, Freescale, Cavium, Mindspeed, and DesignArt among the manufacturers offering new "base station-on-a-chip" SoCs. "These base station baseband SoCs are among the most complex ICs on the market today and raise the bar in terms of complexity," says Marshall. ABI Research's new report, "The LTE Base Station Market," examines the ecosystem and outlook for LTE base stations. The report looks at base station topology and the uptake of small cells and remote radio heads (RRH) as elements of the distributed base station. The report also examines the merchant semiconductor baseband processor suppliers for these base stations.

LTE Macro Base Stations by Technology World Market, Forecast: 2011–2016



Source: ABI Research

Maritime Satellite Communications Market Tops 5.5 Percent in Terminal Growth, $1.4 B in Revenues

Euroconsult, the leading international consulting and analysis firm specializing in the satellite and space sectors, recently forecast that the number of satellite communications terminals in the global maritime market will nearly double over the next decade, with a compound annual growth rate (CAGR) of 7 percent over the 10-year period. While MSS terminals are still expected to account for the majority of terminals deployed over the decade, VSAT service providers should gain significant market share in terms of revenue in the coming 10 years.

> *"Onboard bandwidth requirements keep growing, driving the maritime market in a direction quite beneficial to satellite communications."*

In the second edition of the report "Maritime Telecom Solutions by Satellite, Global Market Analysis & Forecasts," Euroconsult provides an in-depth view of the dynamics determining growth in the maritime satcom sector, along with analysis and forecasts for the different levels of the value chain. The report offers a detailed review of the merchant shipping, fishing, passenger ship, leisure vessel, offshore and government segments. The breakdown between MSS applications and VSAT frequency bands is explored through each of these sections.

"Onboard bandwidth requirements keep growing, driving the maritime market in a direction quite beneficial to satellite communications," said Wei Li, senior consultant at Euroconsult. "Fully integrated IP applications providing Internet access, audio and video streaming, and the integration of ships into corporate networks generate significant capacity demand at sea."

Euroconsult said the number of terminals used for global maritime satellite communications grew at around 6 percent in 2011, while revenues at the satellite operator level increased by over 7 percent. The total size of the market reached about 317,000 active terminals in 2011 that gen-

Go to www.mwjournal.com for more commercial market news items

erated more than $1.4 billion in revenues at the service provider level. Established MSS services and especially the emerging VSAT business contributed to the overall growth of the maritime satellite communications market.

The report also suggests that the proliferation of new Ka-Band based services, which allow much faster upload and download speed than either traditional VSAT or MSS, could expand the maritime market further. Inmarsat, the largest MSS operator, continues to ready its constellation of three Ka-Band satellites planned to be operational by 2014/2015. Euroconsult projects that by 2021, the VSAT market will account for the majority of satellite-based maritime communications revenues. Overall, Euroconsult predicts that the maritime satcom market will grow at a healthy rate over the next decade, but not as rapidly as in recent years. The expected slowdown of revenue growth is mainly due to decreasing airtime unit and equipment prices with the overall improvement of technology.

Smartphone Shipments Will Eclipse All Other Handset Shipments Combined

Global handset shipments will increase 29 percent from 1.7 billion in 2012 to 2.2 billion in 2016. The key driver of this growth will come from the smartphone segment, which is forecast to become larger than the ultra-low cost, low-cost, and feature phone segments combined by 2016. The total shipments of non-smartphones will grow 1.08 billion in 2012 to 1.09 billion in 2016 while smartphone shipments will grow from 643 million to 1.1 billion over the same period.

OEMs that have had historic success addressing the low-cost handset segments will be under tremendous pressure to shift their portfolio to smartphones. Considering that they currently serve consumers with low disposable incomes, these OEMs will need to deliver smartphones that are price competitive to low-cost handsets. "This emerging scenario could become a very dangerous situation for Nokia's handset business as the smartphone and feature phone segments will not be able to support each other in trying times," says Kevin Burden, vice president and practice director, mobile devices.

Low-cost OEMs that are shifting to smartphones, such as Huawei and ZTE, will be a key driving factor for the growth and innovation in the sub-$150 smartphone segment. Low-cost smartphones are forecast to grow from 45 million shipments in 2012 to 170 million in 2016. "The writing is on the wall: either you have a successful smartphone strategy or you will have to steal market share to grow," says Michael Morgan, senior analyst, mobile devices.

SP12T RF SWITCHES
Non-Terminated & Terminated

OUTSTANDING PERFORMANCE

MADE IN THE USA

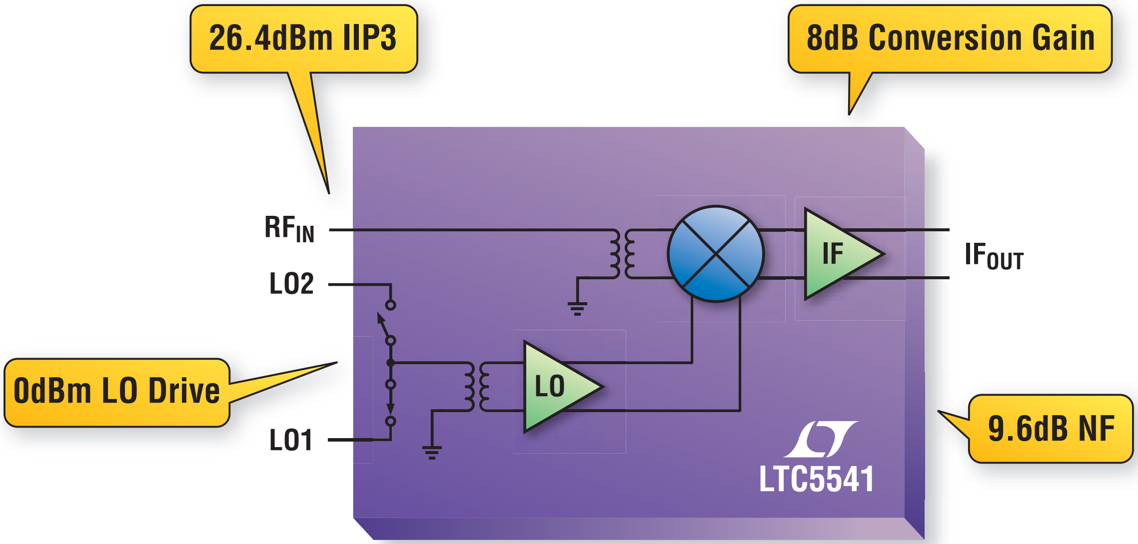
Visit Us At the IMS 2012 Booth #3217

ULTRA LOW PASSIVE INTERMODULATION (PIM)

SPDT, Transfer, and Multi-Throw coaxial switches in SMA, Type N, TNC, SC, and custom configurations. Over 3,000 high quality switch combinations. The leader in High Power and Low Intermodulation switches.

CHARTER ENGINEERING, INC.
www.ceiswitches.com
Tel: (727) 525-1025
6729 55th Street North
Fax: (727) 525-1050
Pinellas Park, FL 33781
www.ceiswitches.com
sales@ceiswitches.com

Highest Dynamic Range Mixers—Only 660mW



3.3V Optimized Passive Mixers with +8dB Gain—No Compromise

The pin-compatible LTC®5540 mixer family delivers outstanding linearity and noise figure, even in the presence of blocking signals. These new 3.3V low power mixers provide the most robust receiver performance for all 4G, 3G and 2.5G cellular and broadband wireless basestation standards, including LTE, WiMAX and other high performance infrastructure radios.

3.3V Passive Mixer Family

Parameters	**LTC5540**	**LTC5541**	**LTC5542**	**LTC5543**
Operating Frequency	600MHz to 1.3GHz	1.3GHz to 2.3GHz	1.6GHz to 2.7GHz	2.3GHz to 4.0GHz
Input IP3	26dBm	26.4dBm	26.4dBm	24.5dBm
Conversion Gain	8dB	8dB	8dB	8dB
Noise Figure (NF)	9.9dB	9.6dB	9.9dB	10.2dB
NF @ 5dBm Blocking	16.2dB	16.0dB	17.3dB	17.5dB
Power Consumption	0.66W	0.63W	0.65W	0.66W

Info & Free Samples

www.linear.com/554X

1-800-4-LINEAR

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

LINEAR TECHNOLOGY

Around the Circuit

Laura Casasanto, Staff Editor

INDUSTRY NEWS

Analog Devices Inc. (ADI) has acquired **Multigig Inc.**, a small, privately-held San Jose, Calif. company specializing in highly innovative high-performance clocking technology. The acquisition will enhance ADI's clocking capabilities in stand-alone and embedded applications, and will strengthen ADI's position in delivering high-speed data converters and signal processing solutions for their customers. Analog Devices acquired Multigig Inc. in a cash transaction completed on March 30, 2012. The engineers will become part of ADI's existing clock design team and will move to ADI's San Jose, CA facility.

M/A-COM Technology Solutions Holdings sold 6 million shares at $19 apiece in its initial public offering. The company, which raised $114 million from the offering, had expected to sell 5.6 million shares at $17 to $19 a share. At the IPO price, the company is valued at around $860 million. The chipmaker, which plans to use part of the IPO proceeds to pay holders of its Class B convertible preferred stock, posted a net income of $22 million in the three months ended December 30, 2011 on revenue of $73 million. The company is backed by its chairman John Ocampo, who will hold about 57 percent stake in it after the offering.

TriQuint Semiconductor Inc. officially opened **TriQuint International Pte Ltd.**, its new international headquarters in Singapore. The facility will be the focal point for most international customers, suppliers and manufacturing partners and is located at the Changi Business Park, close to Singapore's Changi International Airport. This new office will offer dedicated resources in a wide variety of areas ranging from customer service to supply chain management.

Anritsu Co. announced that its VectorStar Broadband ME7838A vector network analyzer (VNA) system was used by **Modelithics Inc.** to validate the performance of its nonlinear diode models for W-Band Single Anode and W-Band ZBD flip chip Schottky diodes from **Virginia Diodes Inc.** Two-port series S-parameter measurements were made using the ME7838A and on-board probing with calibration reference at the component pad-stacks to validate the model's performance from DC to 125 GHz.

AWR Corp. has been issued a U.S. Patent by the United States Patent and Trademark Office for a "block-specific harmonic balance analysis system." Originally filed on December 3, 2008, U.S. Patent No. 8,131,521 addresses circuit simulation using multi-rate harmonic balancing. Specifically, the invention – known as MRHB™ and first available within AWR's 2009 product release – speeds the design of complex circuits by enabling the effective reduction of analysis dimensions (e.g., frequency or time). AWR was also recently awarded U.S. Patent No. 7,346,480, entitled "Impedance Mismatch Modeling in a Data Flow or Discrete Time Based System Simulation."

Digilent Inc. and **Analog Devices Inc.** (ADI) unveiled two all-in-one analog design kits. The kits include access to downloadable teaching materials, online support, textbook, reference designs and lab projects to design and implement analog circuits as a supplement to their core engineering curriculum. The Digilent Analog Discovery Design Kit ($99 USD) and the more advanced Digilent Analog Explorer Design Kit ($199 USD) allow students to build and test a wide range of analog and digital circuits using their own PC without the need for any other equipment.

Delta Electronics Manufacturing announced its certification to AS9100:2009 (Rev C) Quality Management System (QMS) for Aviation, Space and Defense organizations. The AS9100 quality standard is based on ISO 9001 guidelines, as well as additional stringent requirements specific to the Aviation, Space and Defense industries. Among other changes, revision C brings the standard in line with ISO9001:2008 and expands the scope of coverage to include land and sea based systems for Defense applications.

NuWaves Engineering has been selected to join the University of Dayton Research Institute's **Center for Unmanned Aerial System Exploitation** (CUE) consortium. CUE was established in 2009 under a grant from the Ohio Third Frontier program to meet increasing demand for sensor and payload integration, systems analysis, and flight demonstration and test of unmanned aerial systems. NuWaves is pledging a minimum of $50,000 of Independent R&D funds to advance the UAS electronic technologies.

CONTRACTS

Rohde & Schwarz teamed up with **7Layers**, an international group of engineering and test centers, to complete RF and protocol conformance testing on an LTE device developed for the United States 700 MHz (3GPP Frequency Band 14) Public Safety Broadband Network. Since public safety communications equipment requirements differ from the requirements of a commercial network device, public safety equipment needs to be thoroughly tested for LTE RF and protocol conformance as well as for specific user applications. By using the Rohde & Schwarz R&S TS8980 LTE RF conformance test system, 7Layers is working on device validation and certification of an LTE device for public safety, functional in 3GPP Frequency Band 14.

Texas Instruments Inc. (TI) and **6WIND** announced support within the 6WINDGate™ software solution for TI's new scalable 28-nm multicore processors based on its recently announced KeyStone II multicore architecture. The 6WINDGate software provides a proven solution to the challenges of performance, scalability, software compatibility and time-to-market faced by developers of high-end

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

HIGH POWER

PRODUCTS

POWER DIVIDERS

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

◊ In excess of theoretical split loss of 3.0 dB

∞ With matched operating conditions

HYBRIDS

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

◊ In excess of theoretical coupling loss of 3.0 dB

COUPLERS

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

* Add suffix - LF to the part number for RoHS compliant version.

∞ With matched operating conditions

Unless noted, products are RoHS compliant.

SYNERGY®
MICROWAVE CORPORATION

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

See us at IMS Booth 1600

networking equipment. 6WINDGate includes a full set of control plane modules, a high performance networking stack and a wide range of data plane protocols that have been specifically optimized to deliver maximum performance on TI's KeyStone II-based multicore processors.

RF Micro Devices Inc. announced **LG** has selected RFMD to supply multiple components in support of the LG Optimus 4× HD and the Optimus 3D Max smartphones. RFMD components enabling LG's flagship smartphones include RFMD's PowerSmart® power platform, and RFMD's RF5501 802.11b/g/n Wi-Fi front end module. RFMD's PowerSmart features an RF Configurable Power Core™ that delivers multiband, multi-mode coverage of all cellular communications modulation schemes, including 4G, up to LTE 64QAM.

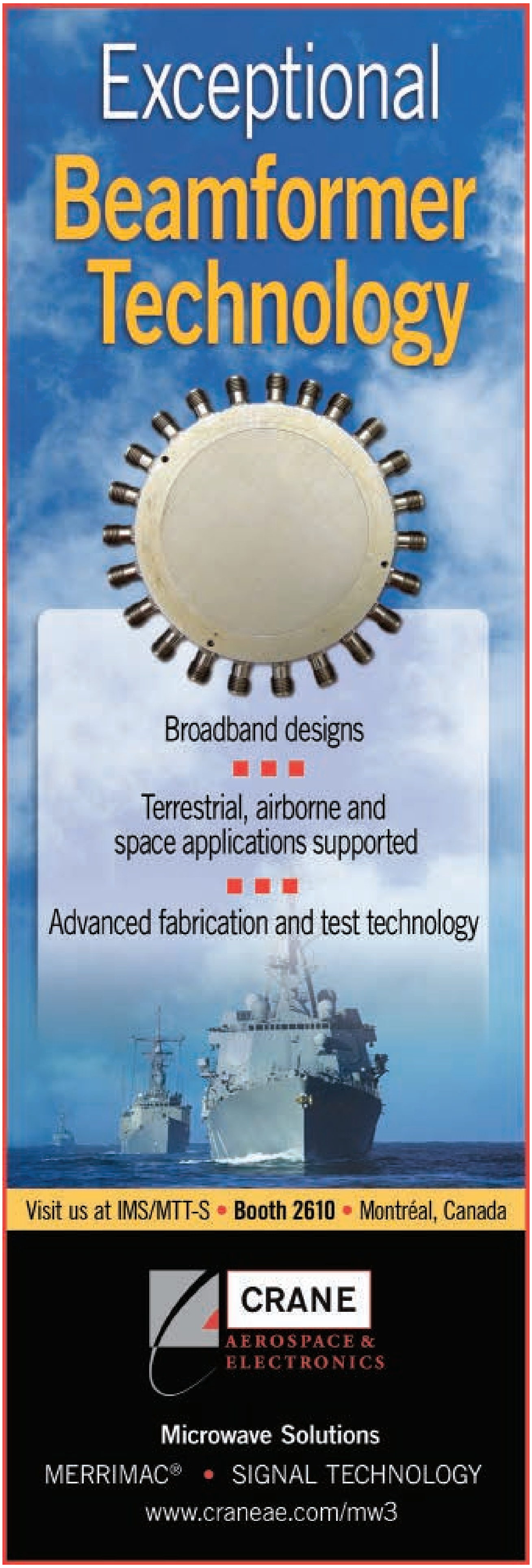
NEW MARKET ENTRY

Constant Wave Inc. has launched a suite of consulting services to support the needs of RF design and test engineers. Their consulting services include: design or test process development and optimization; measurement, analysis and application assistance; and live product training. The services are customized to specific customer needs – whether engineers need help developing or improving a test process, or solving a measurement challenge.

PERSONNEL

Crane Co. has announced the appointment of **Robert Tavares** as president of the Electronics Group of Crane Aerospace & Electronics, and **David Bender** as president of the Aerospace Group of Crane Aerospace & Electronics. As president of the Electronics Group, Tavares' responsibilities will include operations of Electronics Group locations and product solutions, including power, microwave and microelectronics. As president of the Aerospace Group, Bender is responsible for Aerospace Group site operations and product solutions, which include Fluid Management, landing systems, cabin systems and sensing & utility systems.

Laser Services Inc. has announced the hiring of several new team members in response to over a 15 percent growth in 2011. In the sales department, **Phil Kendall** has joined Laser Services as a sales representative bringing 20 years of sales, product, and operations management experience in the medical device and technical ceramics markets. **Jamese Rivera**, sales representative, comes to Laser Services with over 10 years of customer service experience in various manufacturing environments. **Susan Sullivan** has joined their administrative staff in the role of human resources representative and purchasing coordinator. Rounding out the new hires is **Decio Ferreria** in the Marketing Department, **Jose Colon** in Administration and Reception, and **Jonah Morton** in the Processing Department. Two Co-op students from Greater Lowell Technical High School, **Iziah Martinez** and **Michael Chhun**, are also onboard as active members of the Laser Services team.



Aethercomm®
We make hardware that saves lives.™

IMS 2012
MONTRÉAL
IEEE
Visit our booth 2237.

HIGH POWER RF SWITCHES

Aethercomm has been designing and manufacturing solid state high power RF switches for over 12 years for our own high power systems. We are now offering them to the industry as stand alone modules.

Custom Modules Available:

- Different Frequency Ranges
- Smaller Volumes
- Higher Isolation
- Higher Power Levels
- Faster Switching Speeds
- Lower Insertion Loss

Standard Product Offerings Available:

Model Number	Frequency Range	CW Power Rates	Peak Power Handling	Insertion Loss	Isolation	VSWR	Switching Speed	Size
SSHPS 0.96-1.22-3000	960-1220 MHz	250 Watts	3000 Watts	0.8 dB	60 dB	2.0:1	4 μsec	4.5 x 3.5 x 1.0 inches
SSHPS 1.2-1.4-4000	1200-1400 MHz	200 Watts	4000 Watts	0.7 dB	60 dB	1.6:1	4 μsec	4.5 x 3.5 x 1.0 inches
SSHPS 2.7-2.9-1000	2.7-2.9 GHz	100 Watts	1000 Watts	0.8 dB	40 dB	1.7:1	4 μsec	3.5 x 3.5 x 1.0 inches
SSHPS 2.9-3.1-1000	2.9-3.1 GHz	100 Watts	1000 Watts	0.8 dB	40 dB	1.8:1	4 μsec	3.5 x 3.5 x 1.0 inches
SSHPS 2.7-3.5-1000	2.7-3.5 Ghz	50 Watts	1000 Watts	0.9 dB	40 dB	2.0:1	4 μsec	3.5 x 3.5 x 1.0 inches
SSHPS 0.020-1.000-200	20-1000 MHz	200 Watts	1500 Watts	0.7 dB	25 dB	2.0:1	5 μsec	3.0 x 3.0 x 1.0 inches
SSHPS 0.225-0.450-400	225-450 MHz	400 Watts	2000 Watts	0.7 dB	40 dB	2.0:1	5 μsec	3.0 x 3.0 x 1.0 inches
SSHPS 1.0-2.5-200	1000-2500 MHz	200 Watts	1000 Watts	0.9 dB	25 dB	1.5:1	4 μsec	4.0 x 6.0 x 1.3 inches

SSHPS 1.03-1.09-5000 Typical Data

- Operation from 1030-1090 MHz
- Peak Power Handling of 5000 Watts
- Insertion Loss = 0.4 dB nominal
- Isolation = 58 dB typical
- Operation into an Infinite VSWR
- -40C to +70C Operation
- Internal BIT
- < 5μSec Switching Speed
- Return Loss, All Ports = -14 dB nominal
- 4.5" wide x 3.5" long x 1.0" high
- All switches High Power Tested & ESS Screened

SSHPS
1.03-1.09-5000

☎Tel 760.208.6002
sales@aethercomm.com

BSI REGISTERED
ISO 9001:2008
FM 89366

BSI
AS 9100
FM 551035

12 YEARS IN BUSINESS 12 1999-2011

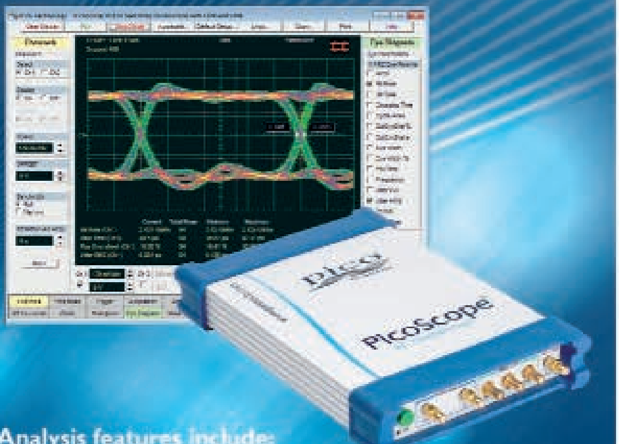
www.aethercomm.com

THE PICOSCOPE 9200A SERIES

12 GHz SAMPLING OSCILLOSCOPES FOR YOUR PC

All-in-one 12 GHz bandwidth sampling oscilloscopes for:

- Serial and telecoms signal analysis
- Built-in 100ps step generator for TDR/TDT analysis
- Signal path characterization of cables, components and boards
- Pre-compliance and verification testing of communication standards
- 8 GHz optical model also available



Analysis features include:

- Eye diagram analysis, including 40 measurements for NRZ, RZ eye diagrams
- 48 measurements for electrical signal characterization
- Histogram analysis for accurately measuring noise and jitter
- Mast testing with 44 standard masks built-in
- Pattern mask sync trigger
- FFT analysis

PicoScope model	9201A	9211A	9221A	9231A
12 GHz Sampling Oscilloscope	●	●	●	●
8 GHz optical-electrical converter			●	●
USB port	●	●	●	●
LAN port		●		●
Mask testing	●	●	●	●
Histogram analysis	●	●	●	●
Clock recovery trigger		●	●	●
Pattern sync trigger		●		●
Dual signal generator outputs		●		●
Electrical TDR/TDT analysis		●		●

www.picotech.com/RF914

pico®
Technology

Around the Circuit

REP APPOINTMENTS

LadyBug Technologies announced two new sales reps. **Sea-Port Technical Sales** of Bellevue, Wash., is the company's new authorized distributors covering the Pacific Northwest for their entire range of USB Power Sensors. **Partner Electronic** of İzmir, Turkey is the new authorized distributors in Turkey for the company's entire range of fast, compact USB RF/µWave Power Sensors. Partner Electronic offers a wide range of products and services based on its extensive knowledge of RF, EMC, and test and measurement solutions and will be responsible for marketing and promoting Ladybug products in Turkey.

RFMW Ltd. and **MAST Technologies** announced a worldwide distribution agreement. MAST Technologies is a leading designer and manufacturer of RF absorbing materials. RFMW Ltd. is a specialized distributor providing customers and suppliers with focused distribution of RF and microwave components as well as specialized component-engineering support. According to the agreement, RFMW will distribute MAST Technologies broad portfolio of RF absorber material including cavity resonance and EMI absorbing elastomers, lossy and reticulated foam absorbers, as well as conductive and absorptive caulks and coatings that reduce EMI/EMC and RFI emissions.

Building on its successful model of local distribution centers in the U.S., UK, and Taiwan, **Mini-Circuits** announced that it is expanding its global network with **TejasRF.com**. Now customers all over India can enjoy the advantages of nominal factory prices in local currency, as well as local service and support, local freight, quicker response and faster delivery times than ever before possible, even for small quantity orders. TejasRF.com builds on the company's long-established presence and local sales support in India by offering online access to the entire Mini-Circuits catalog of over 6800 RF/IF and microwave products. With just a few clicks, Mini-Circuits' customers in India will get what they need, when they need it, as quickly and efficiently as possible.

Richardson RFPD Inc. has completed a global distribution agreement with **TRU Corp.**, a leader in the design, development and manufacture of custom, high performance RF/microwave interconnect solutions. TRU's high power cable assemblies provide power handling capabilities up to six times better than traditional RF assemblies. In addition to their distinctive high power cable assembly capabilities, TRU offers a wide range of standard and unique RF connectors. Richardson RFPD's worldwide field sales engineering teams are now assisting design engineers in integrating TRU connectors and cable assemblies into high power designs.

Vaunix Technology Corp. has announced the hiring of a new sales representative, **Premier Measurement Solutions**, to handle customer relationships in India. Premier Measurement Solutions Private Ltd. was formed by an expert team that has been in the test and measurement industry for close to two decades. They offer expertise in test automation for the wireless market, wafer level characterization, and CW signal generators and digital attenuators.

WORLD'S WIDEST SELECTION

VCOs

RoHS COMPLIANT

RoHS models available, consult factory.

12 to 6840 MHz from $11.95 ea. (qty. 5)

Want a miniature surface mount, shielded plug-in, or rugged coaxial voltage controlled oscillator with the right stuff for your project? Go to minicircuits.com! You'll find over 800 standard catalog models, ***always in stock***. They're optimized to meet specific requirements, from narrow, broad, or octave bandwidths to linear tuning, low phase noise, dual output, 5V PLL/synthesizer implementation, or size, as small as 0.30 x 0.30 x 0.07". Selection is a snap, even with so many models to choose from! Just enter your requirements, and our patented search engine, Yoni2, searches *actual test data* to find the models that meet your needs. And if you need a custom design, challenge us with a phone call or email! We constantly design new models to meet new needs—so you'll get a quick response, fast turnaround times, and all at a surprisingly low price. Give your competition *real competition*...specify a Mini-Circuits VCO!

All SMT components are glued, as well as soldered, in place for long-term, reliable performance even after multiple reflow operations.

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

Mini-Circuits®
ISO 9001 ISO 14001 AS9100
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

Yoni2® ***The Design Engineers Search Engine*** *finds the model you need, Instantly* • For detailed performance specs & shopping online see **minicircuits.com**
U.S. Patents 7739260, 7761442

IF/RF MICROWAVE COMPONENTS

359 rev T

Keep Assembly Closer to Home

Jim Morgan
SemiGen Inc., Manchester, NH

Outsourcing of manufacturing occurs across a broad spectrum of industries, and the philosophy of employing it is changing rapidly as companies are increasingly positioning themselves as brands as opposed to manufacturers. The outsourcing decision for RF/microwave (RF/MW) companies, however, has a unique set of circumstances as compared to conventional digital electronics. The straight-forwardness of digital electronics is conducive to high levels of automation and the employment of relatively unskilled workers. Quality and compliance in the digital world can also be determined through the use of functional test equipment working on the basis of logic one and zero levels whose repeatability, accuracy and calibration are relatively clear-cut. Moving these types of manufacturing and test procedures overseas thus becomes a relatively simple decision.

RF/MW manufacturing and test, on the other hand, often relies upon much more precisely defined, and sometimes difficult to define, procedures. In fact, RF/MW manufacturing is to a large degree an artisan-based process that is learned by being immersed in the business and is often passed along through ties of family or friendship. RF/MW testing also requires more complex tools such as spectrum analyzers and frequency counters whose accuracy, repeatability and calibration have large variables. As a result, test specifications and methods are more critical and once again, rely more heavily on the knowledge and experience of operators and engineers.

These challenges have become even greater in the last decade or so. Product lifecycles have been compressed, increasing the pressure to get new products to market fast and putting pressure on manufacturing costs. Future sales of new products have become harder to predict so OEMs are understandably wary of investing in new manufacturing equipment. Meanwhile, performance expectations and multi-function requirements are increasing and the quest for reduction in footprints is omnipresent. Each of these issues leads to tighter manufacturing specifications and the risk of variables in the manufacturing process causing problems.

VALUE OF OUTSOURCING RF/MW MANUFACTURING

A considerable number of RF/MW OEMs are addressing these challenges by taking a close look at outsourcing some or all of their manufacturing. One key advantage of outsourcing is that the OEM can focus on its core competency – which typically involves research and development, engineering, and sales and marketing – while the contract manufacturer in turn focuses on its core competency. In many cases, greater concentration on engineering and marketing makes it possible for OEMs to improve their position in the marketplace.

Additionally, outsourcing to the right contract manufacturer often makes it possible to improve manufacturing and quality control. Contract manufacturers utilize leading-edge automated equipment and highly experienced staff members for multiple OEMs' products. This means the contract manufacturer can afford to maintain a higher level of manufacturing technology and expertise than a typical RF/MW OEM with less than $100 million in sales. The right contract manufacturer will already have all or most of the equipment required to bring the product to market so the OEM's required capital investment will be eliminated or greatly reduced.

Outsourcing RF/MW manufacturing to a contract manufacturer also can eliminate or reduce many costs that are less obvious and therefore sometimes not considered in the decision of whether or not to outsource. For example, by reducing the OEM's manufacturing headcount, outsourcing reduces the OEM's exposure to employment-related expenses and risks such as benefit costs, workers' compensation insurance, liability for accidents occurring on the

Introducing ATC's Family of Ultra-Broadband SMT Products

Ultra-Broadband Inductors

Delivering the Highest Performance in the Industry

ATC's new 506WLC Series is ideal for ultra-broadband DC decoupling networks and bias tee applications in optical communications systems utilizing high-speed digital logic.

Attributes:

- Ultra-Broadband Performance
- Ultra-Low Insertion Loss
- Flat Frequency Response
- Excellent Return Loss Through 40 GHz
- Operating Temperature Range: -55°C to +125°C
- Unit-to-Unit Performance Repeatability
- Rugged Powdered Iron Core
- Gold Plated Leads

Ultra-Broadband Capacitors

Providing the Lowest Insertion Loss

550Z Series

- Case Size: 0201
- Operating Frequency: 160 KHz (-3 dB roll-off) to 40+ GHz*
- Capacitance: 10 nF

550L Series

- Case Size: 0402
- Operating Frequency: 16 KHz (-3 dB roll-off) to 40+ GHz*
- Capacitance: 100 nF

Features:

- EIA Case Sizes 0201 and 0402
- Orientation Insensitive
- One Piece Construction
- Insertion Loss: <0.5 dB typical
- Operating Temperature: (-55°C to +125°C)
- RoHS Compliant Terminations

Applications:

- High Speed Data
- Transimpedance amplifiers
- Broadband Test Equipment
- Broadband Microwave/ millimeter-wave
- ROSA/TOSA†
- SONET††

RoHS Compliant

* 25 °C, no bias applied
† Receive and Transmit Optical Sub-Assembly
†† Synchronous Optical Network

AMERICAN TECHNICAL CERAMICS

ATC North America
631-622-4700
sales@atceramics.com

ATC Europe
+46 8 6800410
sales@atceramics-europe.com

ATC Asia
+86-755-2396-8759
sales@atceramics-asia.com

THE ENGINEERS' CHOICE®

www.atceramics.com

See us at IMS Booth 3027

job and other potential legal liabilities, etc. Outsourcing manufacturing can also reduce or eliminate the need for administrative infrastructure required to support the manufacturing operation such as human resources, purchasing and accounting.

VALUE OF ONSHORE MANUFACTURING

Countries such as China, Singapore, Thailand and Malaysia are often considered the obvious locations for RF/MW OEMs considering outsourcing to a contract manufacturer. Offering the advantages of low-cost labor and a rapidly developing manufacturing infrastructure, these and other developing countries have become the default location for companies wishing to outsource production in order to lower costs.

However, a combination of economic forces is eroding the cost advantages of developing countries while at the same time the United States is becoming a more attractive place to build electronics products. A recent study from the Boston Consulting Group stated that: “Our analysis concludes that, within five years, the total cost of production for many products will be only about 10 to 15 percent less in Chinese coastal cities than in some parts of the U.S. where factories are likely to be built. Factor in shipping, inventory costs, and other considerations and – for many goods destined for the North American market – the cost gap between sourcing in China and manufacturing in the U.S. will be minimal.”

But onshore outsourcing has advantages for RF/MW manufacturers that go beyond the general improvement in the U.S. competitive position. The highly complex nature of RF/MW manufacturing means that it is often difficult to completely document every aspect of what is required to produce a quality product and in some cases the requirements of the product are not even fully known. This leads to complexities in transferring a manufacturing process to a contract manufacturer. These complexities can be overcome; however, the unique nature of RF manufacturing can make it challenging to transfer an RF/MW process to an overseas contract manufacturer. Language difficulties may make it difficult to communicate the myriad of details needed to maintain the OEM’s high quality standards.

The large physical distance between an overseas contract manufacturer and a U.S.-based OEM exacerbates these difficulties. It typically costs $4,000 in travel expenses to send an employee to Asia for a short visit to a contract manufacturer. These costs do not include the costs of the employee’s time. It takes a minimum of a week for an employee to fly to Asia, spend a day or two at the contract manufacturer, fly back and acclimate to the time zone changes, and resume his or her previous level of productivity. The time expended on such a trip by an engineer with a fully loaded cost of $100,000 per year adds another $2,000 to the cost. At a total cost of $6,000 per visit, the OEM faces the difficult tradeoff between the need for close communications with the overseas contract manufacturer versus limiting trips to keep costs under control.


Coaxial Solutions:
Test and Measurement
Accessories

Look to Aeroflex / Inmet for coaxial components to meet all of your test and measurement applications. Backed by over 35 years of innovative component solutions for military, wireless, optical and test and measurement, you will find hundreds of quality components ready for same-day shipment. Included are in series and between series adapters, attenuators, Bias Tees, DC Blocks, Terminations, power dividers and iCALIBER test cables.

Quality products, ROHS compliant, ready for you. To learn more, or to order, call 1-888-244-6638 or visit us on the web: www.aeroflex.com/inmet

Aeroflex / Inmet
Ann Arbor, Michigan

Coaxial Adapters
Frequency ranges to 65 GHz

Fixed Attenuators
Attenuation values 0 to 60 dB, frequency ranges DC to 50 GHz

iCALIBER® Test Cables
3.5mm, Type N, SMA connectors

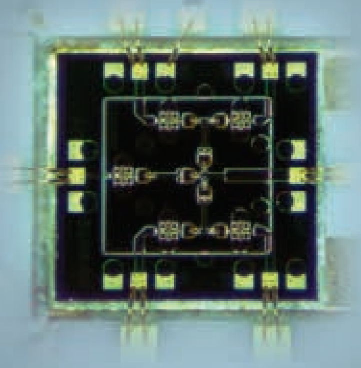
Power Dividers
Broadband resistive to 26.5 GHz, Wilikinson up to 18 GHz.

AEROFLEX
INMET
An ISO 9001 Certified Company

AEROFLEX
A passion for performance.

See us at IMS Booth 2305

LOOPS MATTER



We've lived wire bond loop heights and loop lengths for over 30 years.

Whether it's wire or ribbon, we make them the way you want them. Our fully automated Hesse and Knipps bonders and veteran manual assemblers provide consistent results time after time.

IKE Micro

Build to Print Microelectronics and RF/Microwave Manufacturing.
Complete module assembly, MCMs, packaging.

ISO 9001:2008 Certified ITAR Registered
www.ikemicro.com

See us at IMS Booth 501

When working with an overseas RF/MW contract manufacturer, it is also often necessary to ship U.S.-made equipment such as bonders and test equipment overseas. Shipping delicate equipment into developing countries is expensive, risks damage to the equipment and often takes months which can delay the product introduction.

Outsourcing RF/MW manufacturing to an onshore contract manufacturer also avoids other concerns and risks involved in working with an offshore source. The limited intellectual property protection in developing countries creates the risk that proprietary information provided by the OEM to an offshore contract manufacturer will later end up in the hands of a competitor. Working with an onshore contract manufacturer provides much greater protection of intellectual property rights and also makes it much easier to comply with any related regulations.

Model BME25869-35
2500-6000MHz
35 Watt Power Amplifier System

Comtech, the industry's leader for solid state, broadband, high power amplifier systems, offers a new line of compact integrated systems *for frequencies up to 6 GHz and beyond.* These systems combine RF and microwave components, such as LNAs, High Power Switches, Limiters, Directional Couplers, and Detectors, into a highly compact package. These units can be configured to your exact needs and are ideally suited for many defense applications. **Contact us today with your requirements and specs...we'll meet your needs and exceed your expectations.**

Comtech...Simply More.

COMTECH PST™

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

WHAT TO LOOK FOR IN A CONTRACT MANUFACTURER

Whether you are looking onshore or offshore, any credible RF/MW contract manufacturer should be able to provide complete fabrication and test capabilities including singulation, assembly, wire bond, test, repair, kitting and stocking of components. A quality system should be in place that assures the integrity of every product manufactured, such as compliance with ISO9001-2008, MIL-STD and J-STD requirements. Full RF test capabilities through 40 GHz and ITAR registration should be final tick boxes that will give you confidence there will be no bumps in the road to delivery. In the RF/MW field, a contract manufacturing company should also be able to demonstrate an ability to attract, retain and enhance the capabilities of a skilled staff such as wire bonders and die attach workers.

BIG OR SMALL? WHAT'S RIGHT FOR YOU?

Bigger firms with large assembly lines are the obvious choice when high volumes and automation concerns are driving decisions. But even if these needs are the norm, the advantages of identifying at least one small local supplier cannot be overlooked. Their overhead expenses are lower so it does not require a specified minimum number of pieces per month. They generally work with OEMs on projects ranging from prototype builds to thousands of pieces per month and can scale up or down quickly to handle increasing volumes. They can easily switch gears and take on repair work or even a complete product line.

CONCLUSION

RF/MW manufacturing is considerably more difficult than conventional electronics manufacturing, so it requires skilled artisans with many years of experience to do it right. Many RF/MW OEMs are finding it difficult to maintain these resources internally or are finding their high cost makes it difficult to stay competitive. Onshore outsourcing makes sense for RF/MW products because it eliminates hidden costs and the time zone, language and cultural barriers that often make it difficult to transfer a process overseas. ■

Dependable
RF Solutions

jfw

- ITAR Registered!!
- Custom designs with NO NRE Charges!!
- JFW Products Include:
  - RF Switches
  - RF Matrix Switches
  - Programmable Attenuation Systems
  - Fixed Attenuators & Terminations
  - Programmable Attenuators
  - RF Test Accessories
  - Rotary Attenuators
  - RF Power Dividers

JFW Industries, Inc.
5134 Commerce Square Drive Indianapolis, IN 46237
Toll Free 877-887-4JFW (4539) Call 317-887-1340
Email-sales@jfwindustries.com Web-www.jfwindustries.com

See us at IMS Booth 2019

Mobile World Congress Review

Mobile communication impacts the daily lives of hundreds of millions, drives commerce and shapes economies. The 2012 Mobile World Congress (MWC), which took place at the Fira de Barcelona Conference and Exhibition Centre between February 27 and March 1, has become an established global showcase for the industry and an important platform for the technology that is being developed today that will shape the future.

The GSMA reported that over the four days, a record number of more than 67,000 visitors (the number of individual attendees, including delegates, exhibitors, contractors and media) from 205 countries attended the Congress, with more than 1500 exhibiting companies occupying 70,500 net square metres of exhibition and business meeting space.

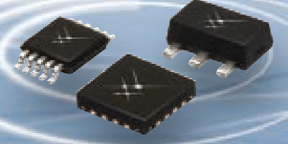
With such a worldwide audience, broad global issues other than the usual commercial proliferation of networks and services were addressed during the conferences, forums, seminars and GTI summit. For instance, recognizing that in emerging and developing regions, mobile communications technology has the capacity to provide lifelines, educate and be a tool for development, a number of seminars covered pertinent issues ranging from: green power for mobile and community power from mobile, disaster response and agricultural value added services in emerging markets.

Of course, at a premier event that attracts global media attention and the participation of high profile movers and shakers, the major focus is on the need and desire to sate the developed world's rapacious appetite for mobile content and meet the challenge to develop applicable technology at a pace that will satisfy that demand.

The continuing evolution and promotion of the smartphone and now the 'superphone,' the mushrooming development of Apps for every purpose, the insatiable demand to download games, movies and live content and access the Internet, and even make the occasional old fashioned 'phone call' are putting an ever increasing strain on the networks. Capacity, or the lack of it, has been a major concern for some time. In recent years, considerable progress has been made, particularly at the 'core,' but the danger is that the problems have been moved to the fringes and, in this case, out of sight can mean out of range!

Only a few years ago, the new buzz at the Mobile World Congress was LTE, which, along

Richard Mumford
Microwave Journal ***International Editor***



SKYWORKS®

Discrete and Integrated RF Solutions

See Our New Products Supporting Diverse Applications at IEEE MTT-S IMS2012 • Booth 1507 • Montreal, Canada • June 19–21!

Handsets and Mobile Devices

Part Number	Description	Frequency (GHz)	Package (mm)
SKY65534	WLAN / Bluetooth® Front-End Module with Integrated PA, Filter, LNA, and T/R Switch	2.4	QFN 20L 2.5 x 2.5 x 0.45
SKY65535	WLAN Front-End Module with Integrated PA with Filter, LNA, and SPDT Switch	5.0	QFN 16L 2.5 x 2.5 x 0.45
SKY77701-16	High PAE Power Amplifier Module for CDMA / WCDMA / HSPA+ / LTE – Band I	1.92–1.98	10-pin MCM 3 x 3 x 0.9

WiFi Connectivity

SE5516A	802.11ac Dual-Band Front-End Module with PA, LNA, and SP2T Switch	2.4, 5.0	LGA 4 x 4 x 1
SE5003L1	802.11ac Matched Power Amplifier with Harmonic Filter	5.0	QFN 20L 4 x 4 x 0.9
TT20P6-0709P0-1825E	High Power Infrastructure Filter can be Configured in a Pass Band Design	0.7–2.1	5" x 1.9" x 1"

Wireless Infrastructure

SKY12210-478LF	High Power (100 W) T/R SPDT Switch, 44 dB Isolation @ 2.6 GHz	0.9–4.0	QFN 16L 4 x 4 x 1.5
SKY13419-365LF	CMOS DBS Switch Matrix with Tone/Voltage Detector High Isolation 40 dB @ 900 MHz	0.25–2.15	QFN 20L 4 x 4 x 0.9
SKY65185	Dual-Channel Variable Gain Amplifier Front-End Module with 31.5 dB Control Range	1.7–2.7	32-pin MCM 7 x 7 x 1.35
SKY65373-11	Variable Gain Low Noise Amplifier with High Linearity @ 35 dB and Low NF @ 1 dB	1.7	16-pin MCM 8 x 8 x 1.3
SKY67130-396LF	High Linearity Amplifier Driver with +16 dBm $OP_{1\ dB}$ and 39.5 dBm OIP3 @ 22 mA	0.7–2.7	DFN 8L 2 x 2 x 0.75
SKY73208	Wideband Rx Mixer with Integrated Integer-N PLL and VCO	0.35–5.0	36-pin MCM 6 x 6 x 1.35
SKYFR-000782	Single Junction Circulator with Very Low Insertion Loss of 0.08 dB Typical	2.11–2.17	Drop-in 19 mm
SKYFR-000827	Single Junction Circulator with Very Low Insertion Loss of 0.12 dB Typical	2.3–2.4	SMT – Robust Lead, 23 mm

Smart Energy—Connected Home and Automation 802.15.4, ISM, and ZigBee®

SE2435L	High Power RF Front-End Module, 1 W High Efficiency with Integrated PA, LNA, and Diversity Switch	0.86–0.93	QFN 24L 4 x 4 x 0.9
SE2436L	High Power 0.5 W Front-End Module for ISM band applications, with PA, LNA, Bypass and Antenna Diversity	2.4	QFN 24L 4 x 4 x 0.9
SE2438T	Ultra Low Power ZigBee® Front-End IC with PA, LNA, Tx/Rx Bypass	2.4	QFN 20L 3 x 3 x 0.5
SKY65367-11	High Power / High Efficiency Tx/Rx Front-End Module with Integrated PA and Bypass	0.17	16-pin MCM 4 x 4 x 0.9
SKY67012-396LF	Low Noise Amplifier with < 0.85 dB NF and < 5 mA Current @ 3.3 V	0.3–0.6	DFN 8L 2 x 2 x 0.75

Receive Skyworks Product News

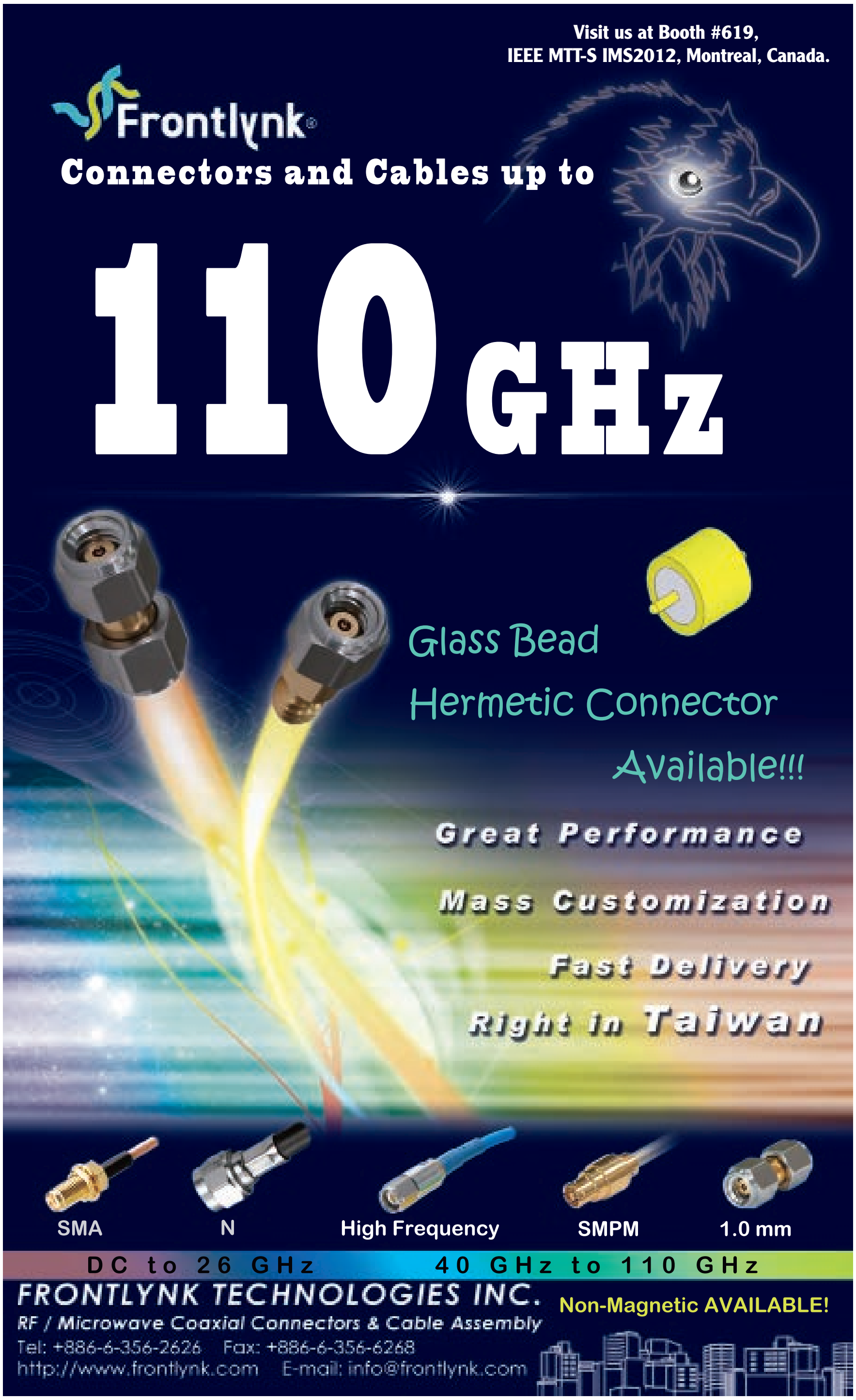
New products (indicated in blue, bold) are continually being introduced at Skyworks. Join our customer email program today via ***www.skyworksinc.com*** to start receiving information on new product releases, literature, upcoming tradeshow events, and more!

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

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

with its siblings LTE-Advanced and TD-LTE, has developed at pace with rollouts having commenced. In particular, there have been significant deployments in Asia, particularly South Korea, while in North America, the spread has generally been confined to large cities with high density.

It also looks like LTE could finally find its voice. Major efforts are being made to provide Voice over LTE (VoLTE) – two years on from the GSMA announcing their backing of the 'One Voice' solution to VoLTE at the 2010 Mobile World Congress. Having been conceived as an IP cellular system solely for carrying data with voice carried either by VoIP or by 2G or 3G, operators have realised that the omission of voice from LTE, allied to the lack of SMS, needed to be addressed. Standardisation is now a key issue, with voice quality being a particular concern.


Visit us at Booth #619,
IEEE MTT-S IMS2012, Montreal, Canada.

Frontlynk®
Connectors and Cables up to
110 GHz

Glass Bead
Hermetic Connector
Available!!!

Great Performance
Mass Customization
Fast Delivery
Right in Taiwan

SMA | N | High Frequency | SMPM | 1.0 mm
DC to 26 GHz | 40 GHz to 110 GHz

FRONTLYNK TECHNOLOGIES INC.
RF / Microwave Coaxial Connectors & Cable Assembly
Tel: +886-6-356-2626 Fax: +886-6-356-6268
http://www.frontlynk.com E-mail: info@frontlynk.com
Non-Magnetic AVAILABLE!

Further along the developmental spectrum is 4G LTE-Advanced, a key feature of which is Carrier Aggregation, which is being standardized in 3GPP as part of LTE Release 10. Basically, carrier aggregation enables expansion of effective bandwidth delivered to a user terminal through concurrent utilization of radio resources across multiple component carriers that are 'aggregated' to form a larger overall transmission bandwidth. Work is ongoing but at MWC 2012, Cognovo demonstrated carrier aggregation communications in real-time on an LTE Advanced baseband, and a number of carriers have announced deployment as early as 2013.

Another approach to addressing the capacity question is the deployment of small cells to bridge the gaps and expand coverage. Some of the largest operators have made small cell deployments. 2012 has seen the world's first LTE femtocell deployment by SK Telecom and the marrying of small cell technology with Wi-Fi is a hot topic. Small cell developers stated that the current aim is to take advantage of chipset development and low cost components while employing advanced RF and network management.

As well as network capacity, another contagion of the smartphone revolution is the drain on handset batteries with the potential for 4G handsets requiring charging two or even three times a day. A specific answer to this problem is to address PA efficiency through the development and deployment of Envelope Tracking. This is a standard PA architecture providing power optimization technology which delivers high efficiency over the entire spectrum used for 3G and 4G standards. At MWC 2012, Nujira showcased its first commercial chip for mobile handsets.

With an event as vast and far reaching as MWC, it is impossible to cover all of the key issues and innovations and this article has attempted to highlight a few of the more significant areas of R&D. Many of these technological developments are in the RF and microwave sector with test and measurement, semiconductor and chipset, near-field communication, small cells and mobile backhaul companies demonstrating their latest offerings on the exhibition floor. **For the full MWC wrap-up, visit www.mwjournal.com/MWC2012review.** ■

Smart now.
Smart later.

VectorStar® Network Analyzers are technologically and economically smart.

Anritsu's industry-leading technology delivers performance where it really matters. The VectorStar 70 kHz to 125 GHz flagship broadband system provides industry-best performance in all three critical performance areas: broadband frequency coverage, dynamic range, and measurement stability. Whatever your starting requirement, feel safe in the knowledge that Anritsu VectorStar offers the expandability you need in the future. As your needs grow, so can your VectorStar, with:

- 20, 40, 50, and 70 GHz models and the flagship 70 kHz to 125 GHz broadband system
- Industry-leading combination of frequency coverage, dynamic range, and stability
- Two-port, four-port, and multiport (4-12) variants
- Nonlinear measurement systems

For applications ranging from microwave component testing to on-wafer device characterization, when you want best-in-class performance and industry-leading technology, you know the answer—Anritsu.

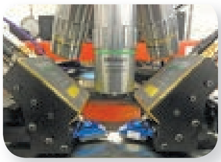
To learn more and download an application note from our library, visit us at:

www.anritsu-offer.com/vna-mwj/

Scan code
for library:

See us at IMS Booth #807

Microwave Bench Portfolio



40 kHz to 125 GHz VNA
- On-wafer and bench top
- Extensions to 750 GHz

Two-Port and Multiport VNA Solutions
- 20, 40, 50, and 70 GHz

Signal Generators
- 0.1 Hz to 70 GHz
- Extensions to 325 GHz
- Low phase noise

Power Meters
- 10 MHz to 50 GHz

USB Power Sensors
- 10 MHz to 26 GHz

Sales Offices: USA and Canada 1-800-ANRITSU, Europe 44 (0) 1552-433433, Japan 81 (45) 223-1111, Asia-Pacific (852) 2301-4980, South America 55 (21) 2527-8922, www.anritsu.com, ©2012 Anritsu Company

Techniques for Improving Noise and Spurious in PLLs

A phase-locked loop (PLL) can be used for a range of purposes, including frequency synthesis. However, successful design of a synthesizer depends heavily on the choices the engineer makes, such as whether to employ a single or multiple loop approach, and on important design considerations like noise and spurious.

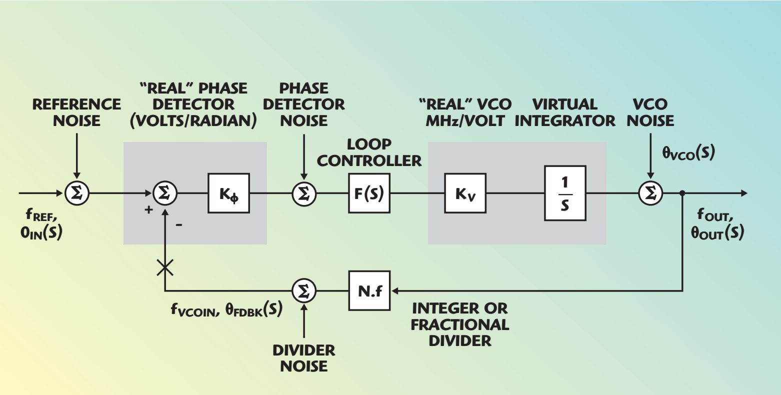


Fig. 1 A basic PLL block diagram is illustrated here with the various noise sources.

UNDERSTANDING PLL BASICS

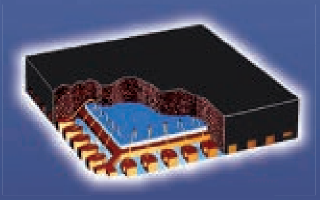
In order to fully understand the choices and design considerations that come into play with the PLL, it is critical to first have an understanding of PLL basics. In the steady-state, a PLL is a linear control system where the variable of interest is phase. Laplace s-domain analysis is used to predict the stability and phase noise performance of the loop.

A basic block diagram of a PLL is shown in ***Figure 1***. The "input" to the PLL is the reference frequency and the output frequency is $f_{OUT} = N.f \cdot f_{IN}$. With an integer divider, the output frequency steps are the same as the reference. With a fractional divider, the output step size can be much less than the reference. However, fractional dividers have serious spur issues and the phase noise is typically not as good as integer dividers.

The open loop transfer function is the gain around the loop, GH(s). Analyzing GH(s) gives

Eric Drucker
Agilent Technologies, Santa Clara, CA

UMS 6-BIT PHASE SHIFTERS



A comprehensive family of 6-bit phase shifters from L to X-band:

- Outstanding accuracy & speed
- Bare die and SMT hermetic & plastic package
- Class S for Space applications

L-BAND BARE DIE / SMT PLASTIC PACKAGE

Part Number	Freq. (GHz)	Insertion Loss (dB)	Peak Phase Error (°C)	RMS phase Error (°)	Input Power @1dB Comp
CHP3010-99F	1.2 - 1.4	7	-1 / +3	1.5	24
CHP3010-QFG	1.2 - 1.4	7	-1 / +3	1.5	24

S-BAND BARE DIE / SMT PLASTIC PACKAGE

Part Number	Freq. (GHz)	Insertion Loss (dB)	Peak Phase Error (°C)	RMS phase Error (°)	Input Power @1dB Comp
CHP4012a98F	2.7 - 3.5	6	-2 / +4	1	24
CHP4012-QEG	2.7 - 3.5	6	-2 / +4	1	24

C-BAND BARE DIE / SMT PLASTIC PACKAGE

Part Number	Freq. (GHz)	Insertion Loss (dB)	Peak Phase Error (°C)	RMS phase Error (°)	Input Power @1dB Comp
CHP4014-98F	5 - 6	6	-4 / +4	1	26
CHP4014-QEG	5 - 6	6	-4 / +4	1	26

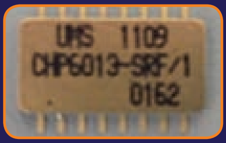
X-BAND BARE DIE / SMT PLASTIC PACKAGE

Part Number	Freq. (GHz)	Insertion Loss (dB)	Peak Phase Error (°C)	RMS phase Error (°)	Input Power @1dB Comp
CHP3015-99F	8.5 - 11.5	7	-3 / +5	2	24
CHP3015-QDG	8.5 - 11.5	7	-	-	24

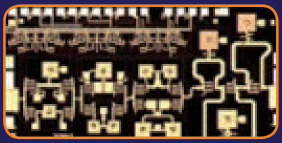
CMOS/TTL compatibility: 0 / 3.3 & 0 / 5.0 (V) - Switching time: <30ns
(soon available in hermetic package)

L-BAND HERMETIC PACKAGE

Part Number	Freq. (GHz)	Insertion Loss (dB)	Peak Phase Error (°C)	RMS phase Error (°)	Control Voltage (V)
CHP6013-SRF	1.2 - 1.4	8.5	-5 / +5	2	-5 / 0



Space evaluated process (EPPL)



Contact us: **www.ums-gaas.com**

UMS SAS - Europe,
Ph: +33 1 69 86 32 00
e-mail: mktsales@ums-gaas.com

UMS USA, Inc. - America,
Ph: +1 978 905 3162
e-mail: philippe.labasse@us.ums-gaas.com

UMS - Asia,
Ph: +86 21 6103 1703
e-mail: xavier.taltasse@ums-gaas.com

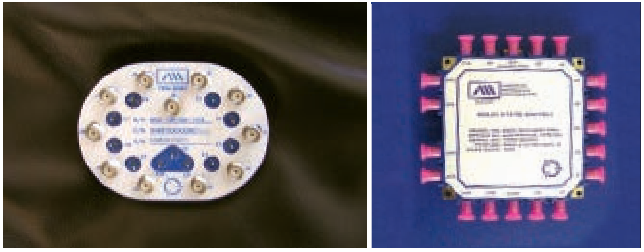
Worlwide distributor: Richardson RFPD, Inc – www.richardsonrfpd.com

united monolithic semiconductors

See us at IMS Booth 1616

American Microwave Corporation

NEW! High Power Solid State Switches 5 - 100 watts, 50 MHz to 18 GHz



AMERICAN MICROWAVE CORPORATION IS A LEADER IN THE DESIGN & MANUFACTURE OF DC TO 40 GHZ SOLID STATE CONTROL COMPONENTS.

WWW.AMERICANMIC.COM

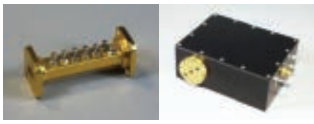
See us at IMS Booth 1829

MESA MICROWAVE CORPORATION

YOUR RELIABLE RF & MW SOURCE

Here at Mesa Microwave the customer is our top priority. We view reliability, efficiency, and quality as the three most important factors contributing to our ongoing business success.

In addition to our high performance RF connectors and cable assemblies we are able to supply a variety of electronic components to meet your unique applications.



1425 W. Elliot Road Ste. 206
Gilbert, AZ. 85233
T: (480) 890-1612
F: (480) 890-2150
Email: sales@mesamw.com
Web: www.mesamw.com

Our Product Line

- ATTENUATORS (fixed & variable up to 40 GHz)
- AMPLIFIERS (LNA, Power, DC to 65 GHz)
- TWTA's (DC-40 GHz, High Power, Pulse)
- HORNS (DC-170 GHz)
- DRO (Up to 65 GHz)
- BENDS (E&H)
- TERMINATIONS
- CRYSTALS (multi/single layer)
- CONNECTORS (up to 110 GHz)
- COAXIAL ADAPTERS (up to 110 GHz)
- CABLE ASSEMBLIES (up to 110 GHz)

CAGE CODE: 6LBG8

the stability information about the loop expressed as phase margin. The reference, phase detector and N divider noise obeys a lowpass transfer function where the loop rejects the noise beyond the loop bandwidth (BW). The voltage-controlled oscillator (VCO) noise obeys a highpass transfer function where the VCO noise is rejected inside the loop BW. The loop controller F(s) is typically an integrator with a zero, although more complicated networks can be used.

$$T_{REF}(s)=\frac{\theta_{OUT}(s)}{\theta_{IN}(s)}=\frac{Forward\_Gain}{1+Loop\_Gain}=$$
$$\frac{G(s)}{1+GH(s)}$$
$$GH(s)=\frac{\theta_{FDBK}(s)}{\theta_{IN}(s)}=K_{\phi}\cdot F(s)\cdot\frac{K_V}{S}\cdot\frac{1}{N}$$
$$LP(s)=T_{REF}(s)=N\frac{GH(s)}{1+GH(s)}$$
$$HP(s)=T_{VCO}(s)=\frac{1}{1+GH(s)} \qquad (1)$$

To model the noise associated with the various PLL components, the following equations can be used:

$$\pounds(f)=(k_0+\frac{k_1}{f}+\frac{k_2}{f^2}+\frac{k_3}{f^3})$$
$$S_{\phi}(f)=2\cdot L(f)=2\cdot(k_0+\frac{k_1}{f}+\frac{k_2}{f^2}+\frac{k_3}{f^3}) \qquad (2)$$

Here, L(f) is the single-sideband (SSB) phase noise at a given offset from the carrier and $S_{\phi}(f)$ is the double-sideband phase noise or power spectral density. The coefficients (k_0, k_1, k_2, k_3) represent the noise floor 10 dB/decade, 20 dB/decade and 30 dB/decade regions. Lesson's model predicts that RF and µW oscillators have flat, $1/f^2$ and $1/f^3$ regions, while high Q oscillators (crystal and SAW) have flat, 1/f and $1/f^3$ regions. Dividers and phase detectors have a flat and 1/f or flicker region. For example, for a µW VCO, knowing the floor, a point in the $1/f^2$ region (dB_{f2_VCO}, f2_VCO) and a point in the $1/f^3$ region (dB_{f3_VCO}, f3_VCO), the noise equation is obtained.

$$k_{0\_VCO}=10^{\frac{dB_{floor\_VCO}}{10}};k_{2\_VCO}=10^{\frac{dB_{f2\_VCO}}{10}}\cdot(f2\_VCO)^2;$$
$$k_{3\_VCO}=10^{\frac{dB_{f3\_VCO}}{10}}\cdot(f3\_VCO)^3$$
$$S_{\phi\_VCO}(f)=2\cdot(k_{0\_VCO}+\frac{k_{2\_VCO}}{f^2}+\frac{k_{3\_VCO}}{f^3})$$
$$S_{\phi\_Input\_Noise}(f)=S_{\phi\_REF}(f)+S_{\phi\_N\_Divider}(f)+S_{\phi\_PD}(f)$$
$$S_{\phi\_Input\_Noise\_Pedestal}(f)=N^2\cdot S_{\phi\_Input\_Noise}(f)$$
$$S_{\phi\_Input\_Noise\_Pedestal\_Loop}(f)=S_{\phi\_Input\_Noise\_Pedestal}(f)\cdot\left|LP(jf)\right|^2$$
$$S_{\phi\_VCO\_Loop}(f)=S_{\phi\_VCO}(f)\cdot\left|HP(jf)\right|^2$$
$$S_{\phi\_Output}(f)=S_{\phi\_VCO\_Loop}(f)+S_{\phi\_Input\_Noise\_Pedestal\_Loop}(f) \qquad (3)$$

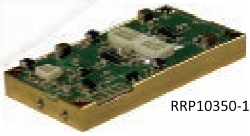
Advance Your System
With Our Affordable & Smart GaN Solutions

- PHASED ARRAY RADAR
- MARINE RADAR
- AIR TRAFFIC CONTROL RADAR
- IFF RADAR
- TACTICAL RADIOS
- WEATHER RADAR

Pallet Amplifier

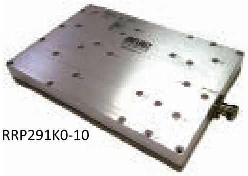
Part Number	Frequency (MHz)	Gain (dB)	Pout (W)	Eff. (%)	Pulse Droop (dB)	Duty (%)	Pulse Width (µs)	VDD (V)	Dimension (mm)
RRP03250-10	135 ~ 460	31	300	45	0.5	10	200	50	114.3 x 25.4 x 28
RRP10350-10	1030 ~ 1090	28	350	50	0.5	5	200	50	53.2 x 28 x 8
RRP13330-10	1200 ~ 1400	14	330	65	0.5	20	500	50	85 x 40 x 10
RRP29280-10	2700 ~ 3100	9	280	50	0.5	20	500	50	86 x 39 x 10


RRP03250-10


RRP10350-10

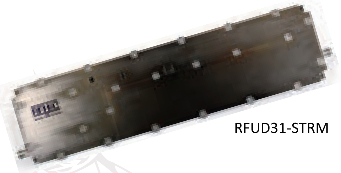
kW SSPA

Part Number	Frequency (MHz)	Gain (dB)	Pout (W)	Eff. (%)	Pulse Droop (dB)	Duty (%)	Pulse Width (µs)	VDD (V)	Dimension (mm)
RRP131K0-10	1200 ~ 1400	53	1000	40	0.5	20	500	50	250 x 150 x 28
RRP291K0-10	2700 ~ 3100	60	1000	30	0.5	20	500	50	220 x 145 x 27


RRP291K0-10

T/R Module

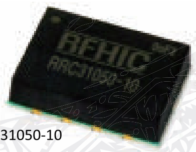
Part Number	Frequency (GHz)	Tx Pout (W)	Rx NF (dB)	Rx Gain (dB)	Tx Gain (dB)	Duty Cycle (%)	Pulse Width (µs)	Attenuator	Phase Shifter
RFUD95-X15-200	9.3 ~ 9.5	15	3.5	30	32	10	100	6 Bit, 31.5dB	N/A
RFUD31-STRM	2.7 ~ 3.5	200	3.5	25	53	20	500	6 Bit, 31.5dB	6 Bit, 360deg
RFUD13-LTRM	1.2 ~ 1.4	250	3.5	35	54	20	500	6 Bit, 31.5dB	6 Bit, 360deg


RFUD31-STRM

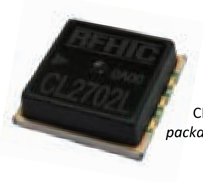
GaN Hybrid Amplifier

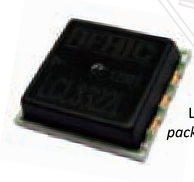
Part Number	Frequency (MHz)	Gain (dB)	Pout (W)	Eff. (%)	Pulse Droop (dB)	Duty (%)	Pulse Width (µs)	VDD (V)	Dimension (mm)
RRC13050-10	1200 ~ 1400	36	50	65	0.5	10	100	50	20.5 x 15 x 4.8
RRC29050-10	2700 ~ 3100	20	50	55	0.5	10	100	50	20.5 x 15 x 4.8
RRC31050-10	2700 ~ 3500	24	50	50	0.5	20	1000	50	20.5 x 15 x 4.8
RRY56025-10	5400 ~ 5900	20	25	42	0.5	10	50	50	20.5 x 15 x 4.8
RRC94030-10	9300 ~ 9500	17	25	40	0.5	10	100	50	20.5 x 15 x 4.8
RNP04006-A1	400 ~ 450	33	4	72	0.5	10	100	24	20.5 x 15 x 4.8


RFUD13-LTRM


RRC31050-10

Radar LNA


CL2702-L
package : CP-16A


LCL3322-L
package : CP-16B

√ Please contact us for your customized solution.

RF & MW is our business & passion

USA Office
Tel : 919-677-8780 / E-mail : sales@rfhicusa.com

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

Come & enjoy RFHIC **Booth #2508** at **IEEE MTT-S IMS 2012**

RFHIC
www.rfhic.com

HIGH POWER RF AMPLIFIERS

310. 306. 5556 www.ophirrf.com

OPHIR RF
THE ART OF WIRELESS™

Military Applications • Scientific Labs • EMC Testing

Model	Frequency	Power	Size (H x W x L)
5304024	100-1000MHz	200W	1.5" x 3.0" x 12.0"
5304025	800-3000MHz	200W	1.5" x 3.0" x 12.0"
5304043	2500-6000MHz	50W	1.1" x 5.0" x 7.0"
5303084	500-3000MHz	50W	6.0" x 5.0" x 1.1"
5303129	700-4000MHz	8W	9" x 5.2" x 1.8"

Model	Frequency	Power	Size (RU)
5227	80-1000MHz	500W	5U
5228	80-1000MHz	1000W	11U
5136A	800-2000MHz	500W	6U
5194	2000-6000MHz	100W	5U

IMS2012 MONTRÉAL

Come and visit us at IEEE IMS 2012
Montreal, Canada, June 17-22, Booth # 2602

.WANTED.

WE'RE LOOKING FOR INTERNATIONAL DISTRIBUTORS / REPRESENTATIVES

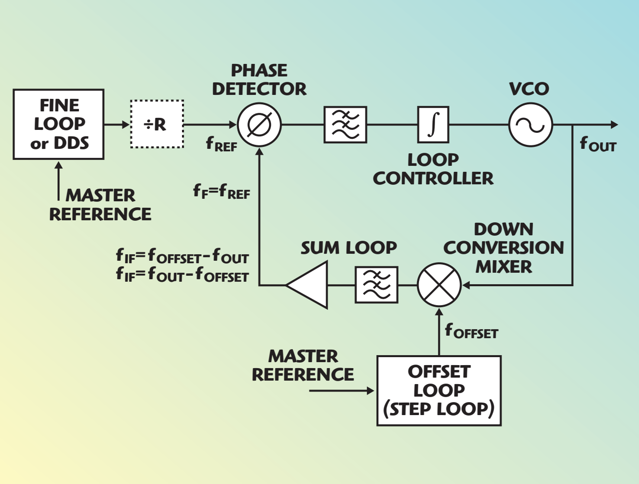
• UP TO 40 GHz FREQUENCY
HIGH PERFORMANCE
Coaxial Cables & Cable Assemblies

*VSWR
<1.30
*MECH. PHASE STABILITY
<+/- 7°
*MECH. AMPLITUDE STABILITY
<+/- 0.12 dB.

AMT *Connect to Excellence...*

You're welcome to visit our booth "no. 3306" in 2012 MTT-S International Microwave Symposium...

Feel free to contact us : yunusek@advancedmicrowave.net
www.advancedmicrowave.net



▲ *Fig. 2 Shown here is a common multiple-loop synthesizer configuration. Note that the loop to generate the master reference is not shown.*

The input noise sources are then multiplied by N to produce what is commonly known as the pedestal. The optimum loop BW is where the pedestal crosses the VCO noise. The total noise is the sum of the loop modified pedestal noise (low passed) and VCO noise (high passed). Taking 10 log of the output noise, less 3 dB, gives the final SSB noise.

THE SINGLE-LOOP APPROACH

Single-loop phase-locked loops can be economical and efficient synthesizer solutions, offering a combination of moderate performance, compact size and low-power operation. Using commercial components such as fractional-N ASICs and careful modeling, they can be optimized to provide signals with reasonable phase noise, spurious performance and fine frequency resolution.

THE MULTI-LOOP APPROACH

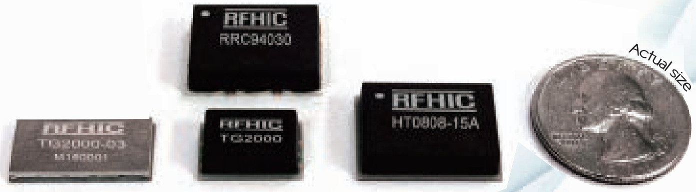
The single-loop approach, however well optimized, has its limits. For higher performance synthesizers, multiple PLLs are used because they provide much better phase noise and spurs compared to simple, single-loop fractional N (FN) synthesizers. There are many configurations of multiple-loop synthesizers, one of which is depicted in ***Figure 2***. It consists of a sum loop, fine loop and step loop.

The offset or step loop generates coarse frequency steps, while the fine loop (or DDS) generates a low-frequency, octave-wide signal with fine resolution that fills in between the coarse steps. The sum loop adds these two signals together. In general, the noise of the offset loop and master reference sets the "close-in" performance and the sum loop VCO sets the "far-out" performance. The fine loop should be a second-order contributor. Since the sum loop has a mixer, care must be taken with the frequency plan to avoid any spurs crossing within the loop BW.

This triple-loop approach is used in the Agilent N5181B/N5182B X-Series Signal Generator (see ***Figure 3***). The fractional N loop generates 62.5 to 125 MHz. The 3 to 6 GHz output of the offset loop (125 MHz steps) is mixed with the sum loop VCO output frequency to produce an in-

RFHIC means Affordable GaN

Less is More

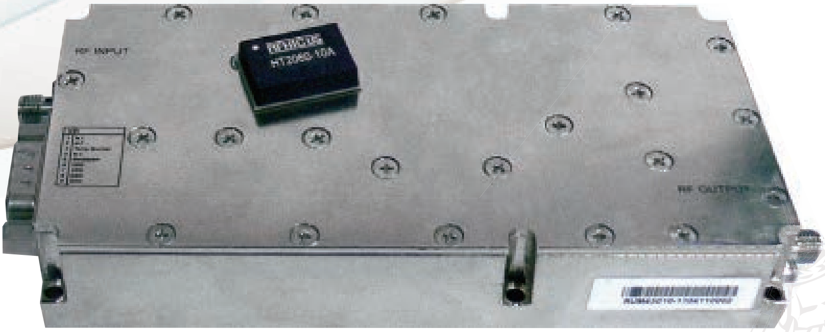


Go ahead and measure it; this is the actual size GaN Technology

&

You Get More for Less

2-6GHz 10W Wideband Amp Comparison



RUM43010-10 *5.12 x 2.52 x .84 (Inch)*

Both of these parts cover the same 2-6GHz and generate the same 10W of power.

RFHIC's Line of Hybrid amplifiers maximize the benefits of a decade-long leadership in GaN technology. GaN hybrids have a power density that is unrivaled, small enough to fit in any application. Using our expertise, we have developed hybrids that may be used in Radar or Broadband applications, optimum for either wide frequency range or high power situations. RFHIC Hybrids are guaranteed to be less expensive than our competition. All of our Hybrids have SMT packaging, for easy drop-in manufacturing. Small Size, Low Cost, High Power, Versatile, Cutting Edge, Easy to Manufacture.

Radar Application

Part Number	Frequency (MHz)	Power (W)	Gain (dB)	PAE (%)
RRC13050-10	1200 ~ 1400	50	36	65
RRC31050-10	2700 ~ 3500	50	24	50
RRC29050-10	2700 ~ 3100	50	20	55
RRC94030-10	9300 ~ 9500	25	17	40
RRY56025-L1	5400 ~ 5900	25	20	42

Wideband Application

Part Number	Frequency (MHz)	Power (W)	Gain (dB)	PAE (%)
HM0005-10A	20 ~ 520	10	30	50
HM0525-10A	500 ~ 2500	10	20	35
TG2000-10	20 ~ 2000	10	14	45
TG2000-03	200 ~ 2000	3	33	45
TG2000-05	200 ~ 2000	5	33	38

Telecom Application

Part Number	Frequency (MHz)	Power (W)	Gain (dB)	PAE (%)
HT0808-15A	869 ~ 894	10	35	55
HT2008-15A	2065 ~ 2080	10	33	55
HT0808-30A	869 ~ 894	25	28	45
HT1919-30A	1930 ~ 1995	25	32	45
HT2121-30A	2110 ~ 2170	25	33	45

√ Please contact us for your customized solution.

RF & MW is our business & passion

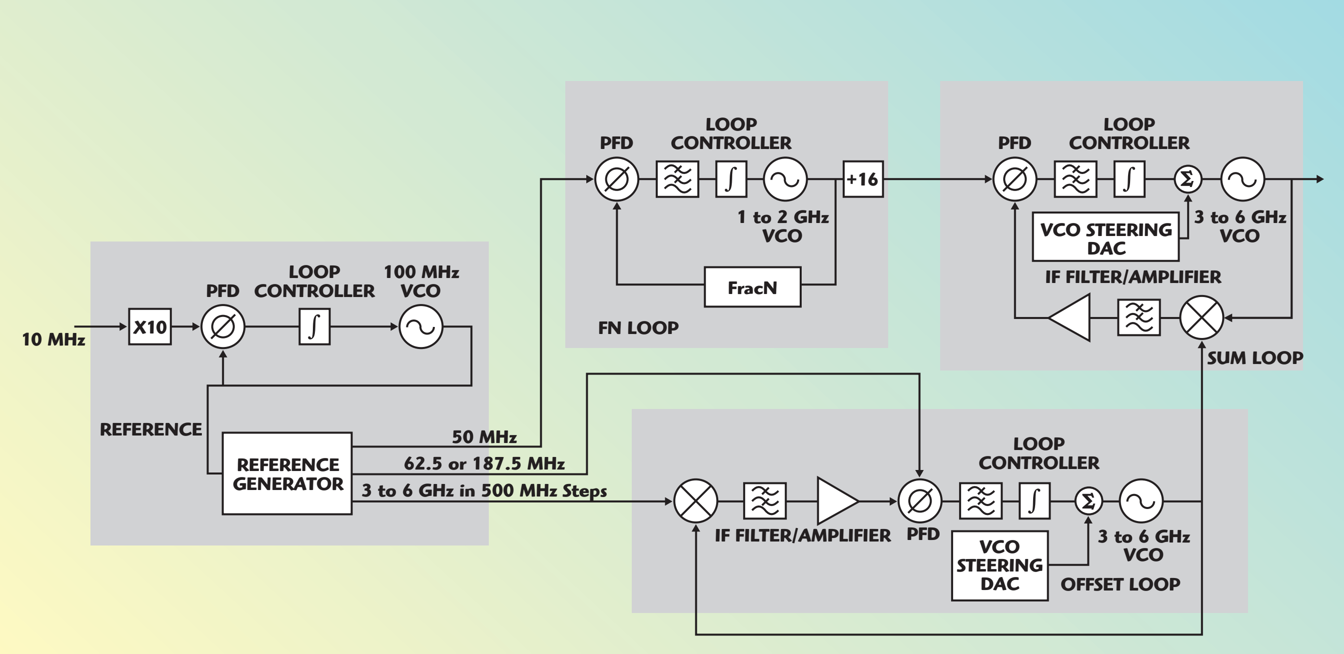
USA Office
Tel : 919-677-8780 / E-mail : sales@rfhicusa.com
Worldwide
Tel : 82-31-250-5078 / E-mail : rfsales@rfhic.com

Come & enjoy RFHIC **Booth #2508** at **IEEE MTT-S IMS 2012**

RFHIC
www.rfhic.com

termediate frequency (IF) that is the same as the FN loop generated reference. By using upper and lower sideband mixing, full coverage is obtained.

The reference block generates a very low noise 100 MHz that is locked to a high quality 10 MHz reference. From this 100 MHz, the 50 MHz reference for the FN loop is generated. For the offset loop, a series of frequencies from 3 to 6 GHz is generated in 500 MHz steps. Two additional reference frequencies of 62.5 and 187.5 MHz are generated for the offset loop.



▲ *Fig. 3 This block diagram graphically depicts the triple-loop approach employed in the N5181B and N5182B X-Series signal generators.*

The Best Performance in Convertibility……….. WEST·BOND's 747677E Wedge & Ball Bonder

Our exclusive X-Y-Z controlled manual Ultrasonic Wire bonding Machine:
The 747677E Wedge-Wedge and Ball-Wedge Wire bonding machine, with convertibility for either 45° or 90° feed, and Ball Bonding, all in one machine.

- 45° and 90° Wire Feed Convertibility
- Wire or Ribbon Bonding
- Ball-Wedge Bonding
- Throatless Chassis
- ESD Protection
- Adjustable Work Platform
- Orthogonal X, Y, and Z Axes

See the West·Bond Model 747677E and other fine West·Bond equipment at
IMS MTTS Show in Montreal, Canada at The Palais des Congres June 19-21, 2012 (booth #1901)

WEST·BOND, INC.
1551 S. Harris Court Anaheim, CA 92806

www.westbond.com
Ph. (714) 978-1551 Fax (714) 978-0431
e-mail: sales@westbond.com

Industry's Leading Digital and Analog Phase Shifter's

Offering a complete line of Digital and Analog Phase Shifters to 40GHz

Amplifiers

Attenuators - Variable

DLVA & ERDLVA & SDLVA's

DTO's

Filters

Form, Fit & Function Products

Hybrids, Dividers & Couplers

IFM's & Frequency Discriminators

Integrated MIC/MMIC Modules

I/Q Vector Modulators

Limiters & Detectors

Log Amplifiers

Pulse & Bi-Phase Modulators

Phase Shifters

Rack & Chassis Mount Products

Receiver Front Ends

Single Sideband Modulators

SMT & QFN Products

Solid-State Switches

Switch Matrices

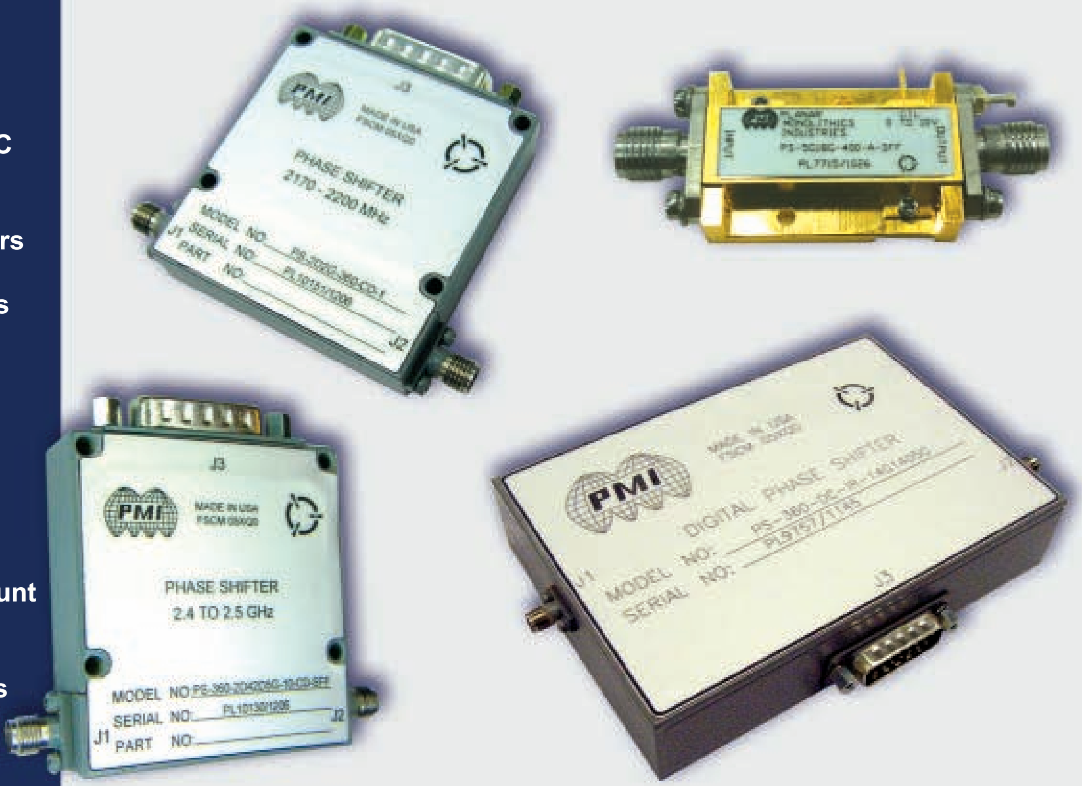
Switch Filter Banks

Threshold Detectors

USB Products

High Quality Phase Shifter's and Bi-Phase Modulators for Commercial and Military applications.

- Frequency Bands covering 10MHz to 40GHz
- Digital and Analog Controlled Models
- 0 to 360 Degrees of Phase Shift
- Low Insertion Loss
- Up to 12-BIT Resolution Available
- Ultra-High Phase Accuracy
- High Speed
- Small Size, Light Weight for Airborne and UAV Applications
- Single Supply and Ultra-Low Power Consumption Available



Join us at IEEE MTT-S June 19-21 in Montreal - Booth # 403

PMI

PLANAR MONOLITHICS INDUSTRIES, INC.

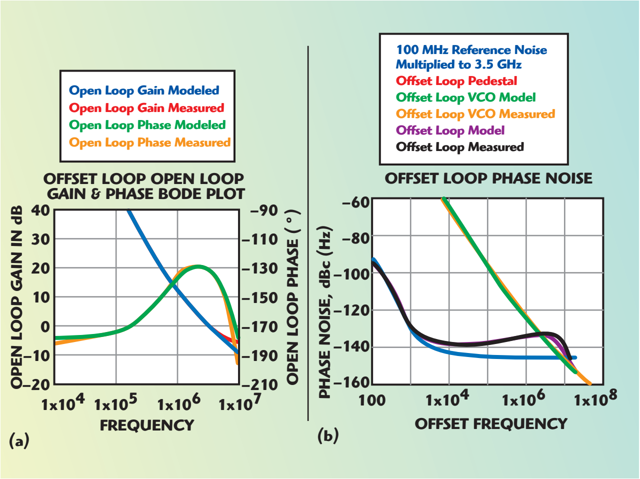
7311-F Grove Road, Frederick, Maryland 21704 USA
Tel: 301-662-5019 | Fax: 301-662-1731
Email: sales@pmi-rf.com | www.pmi-rf.com

ISO9001:2008 Certified

OFFSET LOOP

The frequencies in the offset loop are all integrally related to n *500 MHz. Therefore, even though there is a mixer in the loop, there are no crossing spurs and the closest spur to the carrier is 62.5 MHz. VCO steering is necessary so the loop locks on the appropriate sideband.

The close-in phase noise of the offset loop is the sum of the n*500 MHz noise, 62.5 or 187.5 MHz reference noise, and phase frequency detector noise. This assumes perfect multiplication of the 100 MHz VCXO signal to 500 MHz and then up to the various harmonics. A fudge factor is added to take into account any extra noise sources.



▲ *Fig. 4 The Bode and noise plots show excellent agreement between the model and measured results. The phase margin is ~48°.*

$$S_{\phi\_Input\_Noise\_offset}(f) = n_{harm^2} \cdot S_{\phi\_500\_MHz}(f) + S_{\phi\_PD\_offset}(f) + S_{\phi\_62.5\_MHz\_Ref\_offset}(f) + S_{\phi\_fudge\_offset}(f) \qquad (4)$$

The 3 to 6 GHz VCO has rather poor phase noise. Consequently, the offset loop needs a wide-loop bandwidth to reject or track out the noise of the VCO. The offset loop controller consists of a differential lowpass filter, a low-noise differential to single-ended instrumentation amplifier, step attenuators to control the loop gain with changing K_V. Each of these blocks, including the VCO tune port, adds phase shift in the loop that can adversely affect the phase margin and hence, the stability of the loop.

The differential lowpass filter rejects the 62.5 MHz energy from the phase detector so sidebands are not produced on the offset loop carrier. These sidebands can interact in the sum loop to produce a close-in spur on the final output. The trade off in designing this filter is to maximize the attenuation at 62.5 MHz while keeping the phase shift low at gain crossover. Within the passband of the filter, the phase shift can be approximated by a constant time delay.

Components and Integrated Assemblies up to 140 GHz

Industries served - Avionics, Defense, Telecommunication, Space, Broadcasting, VSAT, Industrial, 4G/LTE, Medical, Homeland Security, and more.

Ferrite Product Group
(Isolators and Circulators)
Provides Coaxial, Drop-in, Strip-line, Micro-strip, Surface Mount and Waveguide configurations. We specialize in broad-band width, miniature, magnetically shielded, higher-power, lower inter-modulation distortion (IMD), and lower insertion loss ferrite devices. We deliver standard products from stock to 6 weeks.

Base Station Product Group
(Telecommunication products)
Provides Receiver Multicouplers, High Power Transmitter Combiners, Multiband Combiners, Power Dividers, Power Combiners, Duplexers, Triplexers, Couplers, LNAs, Rack Mount Systems, 60 GHz Wireless Radio Links, E-Band Wireless Radio Links and more.

Switch Product Group
Provides Electromechanical Switches, Custom Broadband Digital Switches, and Switch Matrices, with higher MTBF. Renaissance is the first in the industry to produce a truly Hermetic Electromechanical space qualified SPDT switch.

Millimeter Wave Product Group
Provides ultra high speed data transmission Radio Links, Wireless Video distribution systems with HD capabilities, Power Amplifiers, Various Radar solutions, Sensors, Detection and Imaging systems, Transceivers, LNA's, PIN Switches, VCO's, Gunn Oscillators, Multipliers, Combiners, Mixers, Attenuators, FPGA and more.

Come visit us at IMS MTT-S 2012 show in June at booth # 500.

RENAISSANCE ELECTRONICS CORPORATION
hxi

AS9100 Certified
ISO 9001:2008

We Have the Solutions! Contact Us Today! Made in the U.S.A.
978-772-7774 fax 978-772-7775 www.rec-usa.com www.hxi.com

USB Style RF & Microwave Control Components and LNA's to 40GHz

- **Amplifiers**
- **Attenuators - Variable**
- **DLVA & ERDLVA & SDLVA's**
- **DTO's**
- **Filters**
- **Form, Fit & Function Products**
- **Hybrids, Dividers & Couplers**
- **IFM's & Frequency Discriminators**
- **Integrated MIC/MMIC Modules**
- **I/Q Vector Modulators**
- **Limiters & Detectors**
- **Log Amplifiers**
- **Pulse & Bi-Phase Modulators**
- **Phase Shifters**
- **Rack & Chassis Mount Products**
- **Receiver Front Ends**
- **Single Sideband Modulators**
- **SMT & QFN Products**
- **Solid-State Switches**
- **Switch Matrices**
- **Switch Filter Banks**
- **Threshold Detectors**
- **USB Products**

RF & Microwave USB Style Components & LNA's featuring:

- 50MHz - 40GHz Low Noise Amplifier
- 500MHz - 40GHz SPDT Absorptive Switch
- 100MHz - 40GHz Variable Attenuator
- Other models available - Contact PMI for details

All units are PC Software Supported

Amplifier Model AMP-12-50M40G-USB		Switch Model P2T-500M40G-USB		Attenuator Model ATN-30-100M40G-USB	
Frequency:	0.050 - 40.0GHz	Frequency:	0.5 - 40.0GHz	Frequency:	0.1 - 40.0GHz
Gain:	12dB Typ.	Switch Type:	SPDT, Absorptive	Attenuation Range:	30dB
Gain Flatness:	±2.5dB Typ.	Insertion Loss:	6.0dB Max.	Insertion Loss:	5dB Typ. (To 20GHz) 8dB Typ. (To 40GHz)
VSWR In/Out:	2.3:1	VSWR In/Out:	2.1:1 Typ.	VSWR In/Out:	2.5:1 Typ.
Noise Figure:	4.5dB Typ. To 20GHz 5.5dB Typ. To 40GHz	Isolation:	60dB Min.	Accuracy:	±2.5dB Typ.
OP1dB:	10dBm Typ.	Input Power:	+20dBm CW Max.	Attenuation Step:	1.0dB
Custom PMI Graphic User Interface for Control via PC					

Join us at IEEE MTT-S June 19-21 in Montreal - Booth # 403

PMI

PLANAR MONOLITHICS INDUSTRIES, INC.

7311-F Grove Road, Frederick, Maryland 21704 USA
Tel: 301-662-5019 | Fax: 301-662-1731
Email: sales@pmi-rf.com | www.pmi-rf.com

ISO9001:2008 Certified

The op-amp and VCO blocks are modeled with a simple time delay, T. The “lead lag” summing network was specifically designed to have flat attenuation with frequency. The gain crossover and open loop transfer function, assuming a delay of 24 nS, is shown in ***Figure 4*** and given by:

$$f_{x\_offset} = K_{V\_offset} \cdot K_{\phi\_offset} \cdot A_{PD\_offset} \cdot$$

$$A_{atten\_offset} \cdot A_{int\_offset} \cdot A_{ld\,lg\_offset} = 3.2 \text{ MHz}$$

$$T_{int\_offset}(s) = \frac{s + f_{z\_int\_offset}}{s} \; f_{z\_int\_offset} = 80 \text{ kHz}$$

$$\text{Open Loop Gain } (T_{offset} = 24 \text{ nS})$$

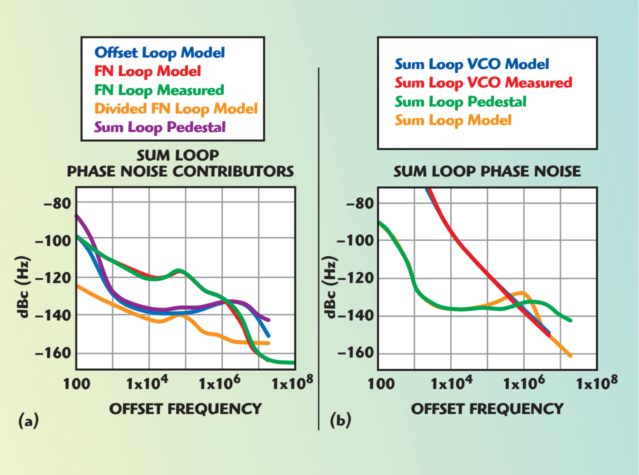
$$GH_{offset}(s) = \frac{f_{x\_offset}}{s} T_{int\_offset}(s) \cdot e^{-2\pi \cdot s \cdot T_{offset}};$$

$$LP_{offset}(s) = \frac{GH_{offset}(s)}{1 + GH_{offset}(s)}; HP_{offset}(s) = \frac{1}{1 + GH_{offset}(s)} \qquad (5)$$

Using the lowpass and highpass loop transfer functions, and the various noise source equations, the offset loop noise can be calculated using:

$$S_{\phi\_output\_offset}(f) = S_{\phi\_pedestal\_offset}(f) \cdot$$

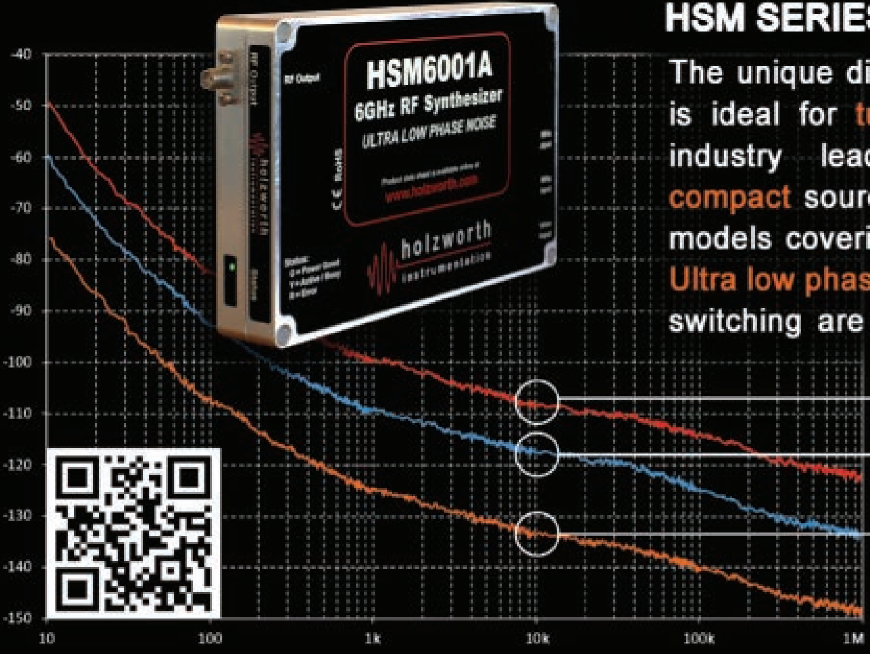
$$\left|LP_{offset}(jf)\right|^2 + S_{\phi\_VCO\_offset}(f) \cdot \left|HP_{offset}(jf)\right|^2 \qquad (6)$$



▲ *Fig. 5 The plotted results of the sum loop noise contributors and final output noise.*

The phase detector, reference and other noise sources in the loop degrade the multiplied reference noise by about 5 dB, total. The loop bandwidth is set at ~3.2 MHz. This causes a large phase noise peak, which is attenuated by the sum loop. The offset loop noise is shown in Figure 4.

AGILE LOCAL OSCILLATORS



HSM SERIES: NON-PLL SYNTHESIZERS

The unique digital to direct-analog architecture is ideal for tunable LO generation, providing industry leading stability. These rugged, compact sources are available in 6 broadband models covering a range of 250kHz to 20GHz. Ultra low phase noise, spectral purity, and fast [1] switching are just a few of many advantages.

[1] FAST: < 200ns SWITCHING SPEEDS. See it at IMS booth 2926

holzworth
instrumentation

phone: +1.303.325.3473
www.holzworth.com

Phase Critical PERFORMANCE

Phase Optimized Interconnects from TIMES Microwave Systems

- **Leading Edge Phase Performance**
- **Eliminate Phase/Temperature "PTFE knee"**
- **Absolute Phase and Tracking Applications**
- **Wide Temperature Range**
- **Range of Styles and Sizes**

Phasetrack™ Flexible Cable Assemblies

- PT130, PT180, PT210, PT318
- Proven, Rugged Flexible Construction
- TF4 Dielectric Phase Performance
- Triple Shielding Technology
- -55C to +150C Temperature Range

Phasetrack PFlex™ Cable Assemblies

- PF130, PF402
- Flexible "In-the-Box" Cable Assemblies
- TF4 for Absolute and Tracking Phase Applications
- Easy Installation, Proven Reliability
- -55C to +125C Temperature Range

Phasetrack™ Low Smoke Cable Assemblies

- PT400-LS, PT600-LS
- Support Low Smoke Applications
- Absolute and Tracking Phase Applications
- Sized for Rugged, Low Loss Performance
- -40C to +85C Temperature Range

PhaseTrack™ Semi-Rigid Cable Assemblies

- PT110-SR, PT141-SR
- Classic Semi-Rigid Style now with TF4
- New Designs or Drop-In Replacements
- -55C to +125C Temperature Range

SiO2 (Silicon Dioxide) Cable Assemblies

- SiO2-090, SiO2-141, SiO2-200, SiO2-270
- Semi-Rigid Style Assemblies
- Ultimate Phase Tracking Performance
- Extreme Temperatures, Severe Environments
- -273C to +600C Temperature Range

For Performance, Quality and Reliability you can count on, count on Times Microwave Systems - The Leader

TIMES MICROWAVE SYSTEMS
An Amphenol Company

AS9100 / ISO 9001:2008 Registered

World Headquarters: 358 Hall Avenue, Wallingford, CT 06492 • Tel: 203-949-8400, 1-800-867-2629 Fax: 203-949-8423
International Sales: 4 School Brae, Dysart, Kirkcaldy, Fife, Scotland KY1 2XB UK • Tel: +44(0)1592655428
China Sales: No. 318 Yuan Shan Road • Shanghai, China 201108 • Tel: 86-21-51761234 Fax: 86-21-64424098
www.timesmicrowave.com

See us at IMS Booth 514

FRACTIONAL N AND SUM LOOP

The FN loop generates a 1 to 2 GHz output that is divided by 16 to produce the 62.5 to 125 MHz reference input to the sum loop. The FN loop uses an Agilent proprietary chip set with a 50 MHz reference, making the noise and spurious performance much better than commercially available parts. Because of the division, the noise and spurs in the FN loop are reduced by 24 dB before the sum loop. The same methodology is used to analyze this loop. The 1 to 2 GHz output is divided by 16 to produce the 62.5 to 125 MHz before the input to the sum loop. The divided fractional spurs are less than –90 dBc.

The sum loop uses a low-noise 0.75 to 1.5 GHz VCO that is multiplied to 3 to 6 GHz. The reference input to the sum loop is the divided fractional N loop. The offset loop is summed using a mixer in the feedback path. Since the IF frequency of the sum loop (mixer output) is much less than the offset loop (mixer input), the mixer crossing spurs are high order and hence, at a very low level. The noise of the sum loop, as shown in ***Figure 5***, is given by:

$$
\begin{aligned}
&S_{\phi\_\mathrm{pedestal}\_\mathrm{sum}}(f) = S_{\phi\_\mathrm{output}\_\mathrm{offset}}(f) + S_{\phi\_\mathrm{divided}\_\mathrm{FN}\_\mathrm{output}}(f) + \\
&S_{\phi\_\mathrm{PD}\_\mathrm{sum}}(f) + S_{\phi\_\mathrm{fudge}\_\mathrm{sum}}(f) \\
&S_{\phi\_\mathrm{output}\_\mathrm{sum}}(f) = S_{\phi\_\mathrm{pedestal}\_\mathrm{sum}}(f) \cdot \left|LP_{\mathrm{sum}}(jf)\right|^2 + \\
&S_{\phi\_\mathrm{VCO}\_\mathrm{sum}}(f) \cdot \left|HP_{\mathrm{sum}}(jf)\right|^2 \qquad (7)
\end{aligned}
$$

Using this mathematical software, it is easy to adjust the various loop parameters, such as gain crossover, pole and zero locations, and the various noise sources in the loop to optimize performance by performing “what if” scenarios. Once this is done, the component values can be calculated and a circuit simulator used, like Agilent’s Advanced Design System or SPICE, to verify each loop’s performance with the component values in place.

CONCLUSION

Regardless of how well optimized a single-loop PLL is, there are still limitations. Multiple-loop solutions can substantially improve performance in terms of close-in and wide offset noise, along with spurious. Using the right design and modeling approaches, multi-loop PLLs can efficiently deliver the performance needed for demanding applications. ■

Eric Drucker *is a senior engineer with Agilent’s Technology Leadership Organization, a central resource for advancing measurement technology. He has been with Agilent for 12 years, working on PLL synthesizers for RF and microwave products and has taught numerous courses/workshops on PLL design. Prior to joining HP/Agilent, he spent the first half of his career with Fluke Corp. and several start-ups in the Seattle, Wash. area. He received his MSEE from Stanford in 1974.*

IEEE MTT-S IMS 2012
MicroApps Expert Forum

Device Characterization Methods
& Advanced RF/Microwave Design
Montreal, Canada: June 20, 12:00 – 1:30 PM

PRECISION CNC ROBOTIC MACHINING
Multi Axis Turn / Mill
MILLING up to 5 Axis
“LIGHTS OUT” PRODUCTION 24/7

Amplifier housings for the military and commercial segments of the microwave industry.

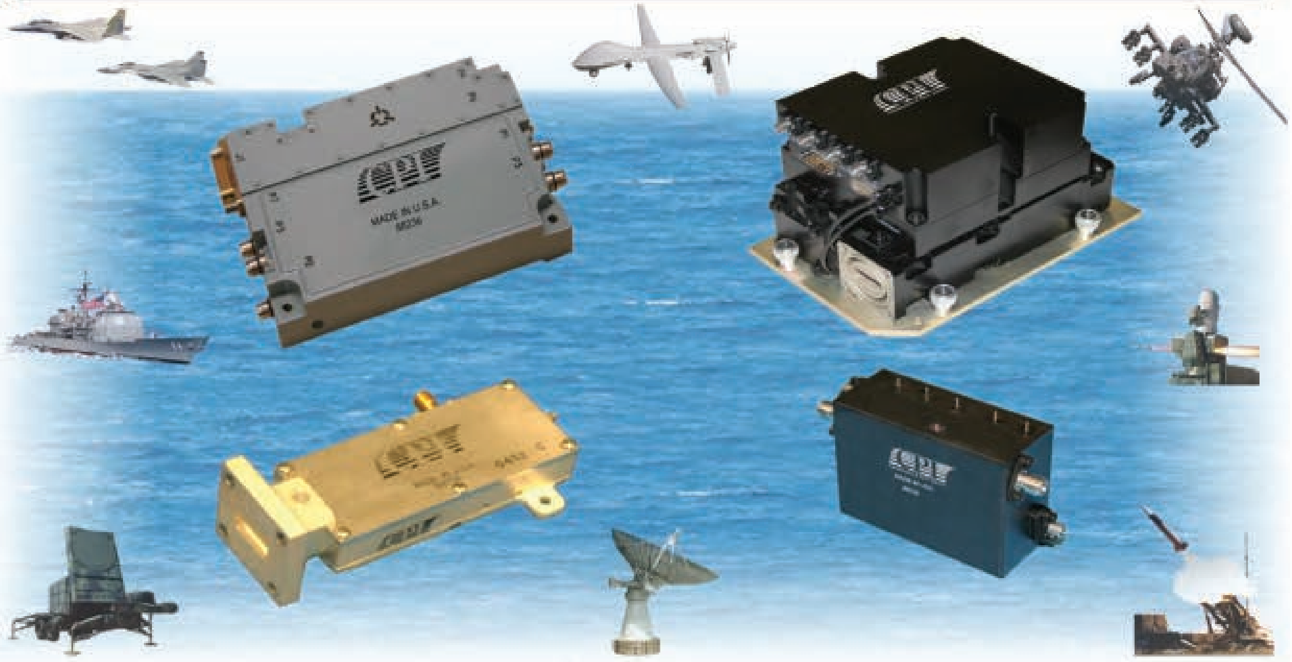
Medical device component parts

Fiber optic connector housings

DYNAMAC INC.
Precision CNC Machining
ISO9001:2008 Certified

630.543.0033
Fax 630.543.0055
sales@dynamac-usa.com
www.dynamac-usa.com

Integrated Microwave Assemblies



Advanced Technology - Extensive Experience - Superior Performance

CPI
Communications & Power Industries

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

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

Communications & Power Industries
Beverly Microwave Division

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

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

See us at IMS Booth 2438

Improved Linearity Doherty Amplifier Using Tunable Offset Line

A Doherty power amplifier using a tunable offset line is proposed for linearity improvement. The conventional offset line is substituted with coupled lines and composite right/left-handed transmission lines (CRLH), incorporating a variable capacitance diode to adjust the phase at the output of the main amplifier, so the phase distortion of the peak amplifier at a high power level can be corrected by tuning the voltage of a variable capacitance diode in the proposed offset line. The performance of the proposed DPA is studied, using numerical simulations, in the frequency range from 2 to 2.5 GHz. The analysis indicates that the proposed DPA, with a tunable offset line, can show an improved linearity at a high input power. The measured results show an excellent IMD3, which agrees with the simulated results. Furthermore, compared to a conventional Doherty PA, the PAE of the proposed amplifier is improved by 5 to 7 percent, while the IMD3 is reduced by approximately 25 dB.

Modern wireless communication systems, such as CDMA and W-CDMA, have critical system requirements for high linearity. Therefore, many power amplifiers are operated to deliver a significantly backed-off average output power. These methods result in low efficiency, due to the over 10 dB back-off. It is difficult to obtain optimum efficiency and high linearity performance in the same Doherty amplifier. The main linearity deterioration of Doherty amplifier occurs in the peaking amplifier, due to the peaking amplifier operating in Class C, which generates high order intermodulation distortion (IMD) products. Many traditional linearization techniques, such as pre-distortion and feed-forward, could be adopted, but these methods require the use of external control circuits and signal processing, resulting in an increased level of design complexity and its linear performance improvement is still limited. In addition, an N-way Doherty amplifier has also been reported for high efficiency and linearity; however, its size and performances have limitations for W-CDMA base station applications.

Composite right/left-handed transmission lines (CRLH) and capacitor-loaded coupled lines can suppress the second and higher order harmonics of the output[1,2,3] and at the same time, the structure exhibits either a negative or a positive phase, as well as a 0 phase, according to the design needs.[4] Due to its compact and

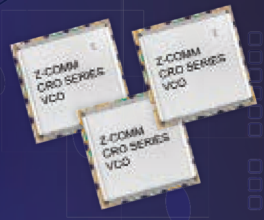
Shiwei Zhao, Zongxi Tang and Ping Su
University of Electronic Science and Technology of China, Chengdu, China

Z~Communications, Inc.
ISO 9001:2008 Certified

The World Leader
in
VCOs & PLLs

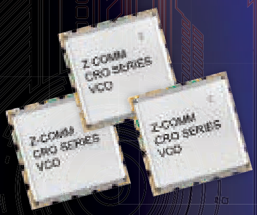
Your Trusted Source for High Quality Products, Performance and Delivery

- Highly stable, robust solutions up to 4 GHz
- Superior phase noise performance
- Low tuning sensitivity and low frequency drift
- Quick turnaround on custom solutions
- Unmatched pricing with fast delivery



CRO Series VCOs 400 MHz - 4000 MHz

VCO Part No.	Low Freq. (MHz)	High Freq. (MHz)	Tuning Voltage (Vdc)	10 kHz PN (dBc/Hz)	Power Output (dBm,typ.)	Supply Voltage (Vdc)
CRO0410A-LF	390	430	0.5-4.5	-117	-4	5
CRO1000A-LF	1000	1000	0-3.3	-121	3	5
CRO1507A-LF	1504	1511	0.5-4.5	-117	2.5	5
CRO1940A-LF	1910	1970	0.5-4.5	-112	3.5	5
CRO2275A-LF	2250	2300	0.5-4.5	-113	1.5	5
CRO2343A-LF	2310	2376	0.5-4.5	-109	0	5
CRO2477A-LF	2440	2540	0.5-4.5	-108	3.5	5
CRO2537A-LF	2530	2545	0.5-4.5	-115	3	5
CRO2885A-LF	2880	2890	0.5-4.5	-115	7	5
CRO3069A-LF	3064	3074	0.5-4.5	-116	2.5	5
CRO3200A-LF	3200	3200	0.5-4.5	-116	11	5
CRO3662A-LF	3657	3667	0.5-4.5	-113	1.5	5
CRO3850B-LF	3850	3850	0.5-4.5	-109	2.75	5



For additional parts and ordering information
visit www.zcomm.com

RoHS Compliant

14118 Stowe Drive, Suite B • Poway, CA 92064
Tel: (858) 621-2700 • Fax: (858) 486-1927 • sales@zcomm.com

See us at IMS Booth 2528

ANGLES
"UNLIMITED"
Right Angles
Bulkhead Cable Jacks
(1=2)

	N Right Angle Jack	N rev Pol Angle Jack	TNC Right Angle Jack	TNC rev Pol Agle Jack	N Right Angle SS 18GHz
RG 55	#	#	#	#	–
RG 58	#	#	#	#	–
RG 141	#	#	#	#	–
RG 142	#	#	#	#	–
RG 223	#	#	#	#	–
Sig 195*	#	#	#	#	–
Sig 240*	Δ	Δ	Δ	Δ	–
LMR 195*	#	#	#	#	–
LMR 240*	Δ	Δ	Δ	Δ	–
HP 450	–	–	–	–	#
HP 500	–	–	–	–	#
LA 190	–	–	–	–	Δ
LA 290	–	–	–	–	Δ
RFD 190	–	–	–	–	Δ
RFD 191	–	–	–	–	Δ
RFD 290	–	–	–	–	Δ

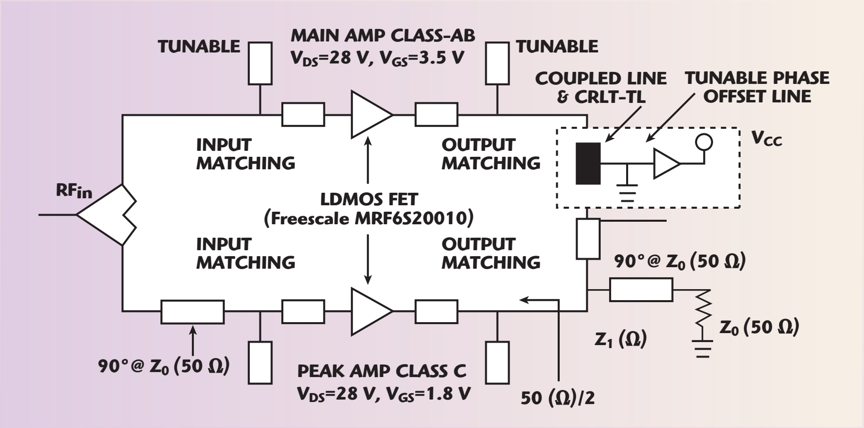
#, in stock or in production
Δ, in current development

45 deg Angle

SMA JxSMA (ss)
RFD 3186-3536 (Stock)

*Registered trademarks of respective owners

RF Depot.com Inc.
7850 Browning Road • Pennsauken NJ 08109
Tel. 856-488-2000
Toll Free 877-RF Depot



▲ *Fig. 1 Proposed architecture of a DPA using a tunable offset line.*

flexible design, the structure lends itself easily to integration with other microwave components and devices. Recently, some works were reported to improve the linearity of Doherty amplifiers by composite right/left-handed transmission lines and defected ground structure (DGS).[5,6] Because harmonic components play a positive role in improving PAE and linearity, the CRLH and DGS are used to suppress second and other order harmonics of the main amplifier output. However, at a high power level, the phase distortion of the peaking amplifier still cannot be solved, so the linear improvement is also limited. The inherent linearity deterioration of a Doherty amplifier sets a threshold for achievable performance.

In this article, tunable CRLH and coupled lines, using a variable capacitance diode in an offset line to improve linearity performance of a Doherty amplifier, is introduced. The tuning voltage of a variable capacitance diode,[7] the tunable CRLH and coupled lines, can be adjusted to adopt any phase and this makes the design more flexible and usable. The proposed structure is shorter by 7 to 12 mm in length than the offset line of a conventional one. The proposed structure suppresses the second and higher order harmonics of the main amplifier output and, at the same time, the phase distortion of the peaking amplifier at a high power level can be corrected by tuning the voltage of a variable capacitance diode in CRLH and coupled lines. The proposed tunable offset line method not only fulfills the phase delay and phase correction, but also results in some other improvements, such as higher PAE and improved linearity.

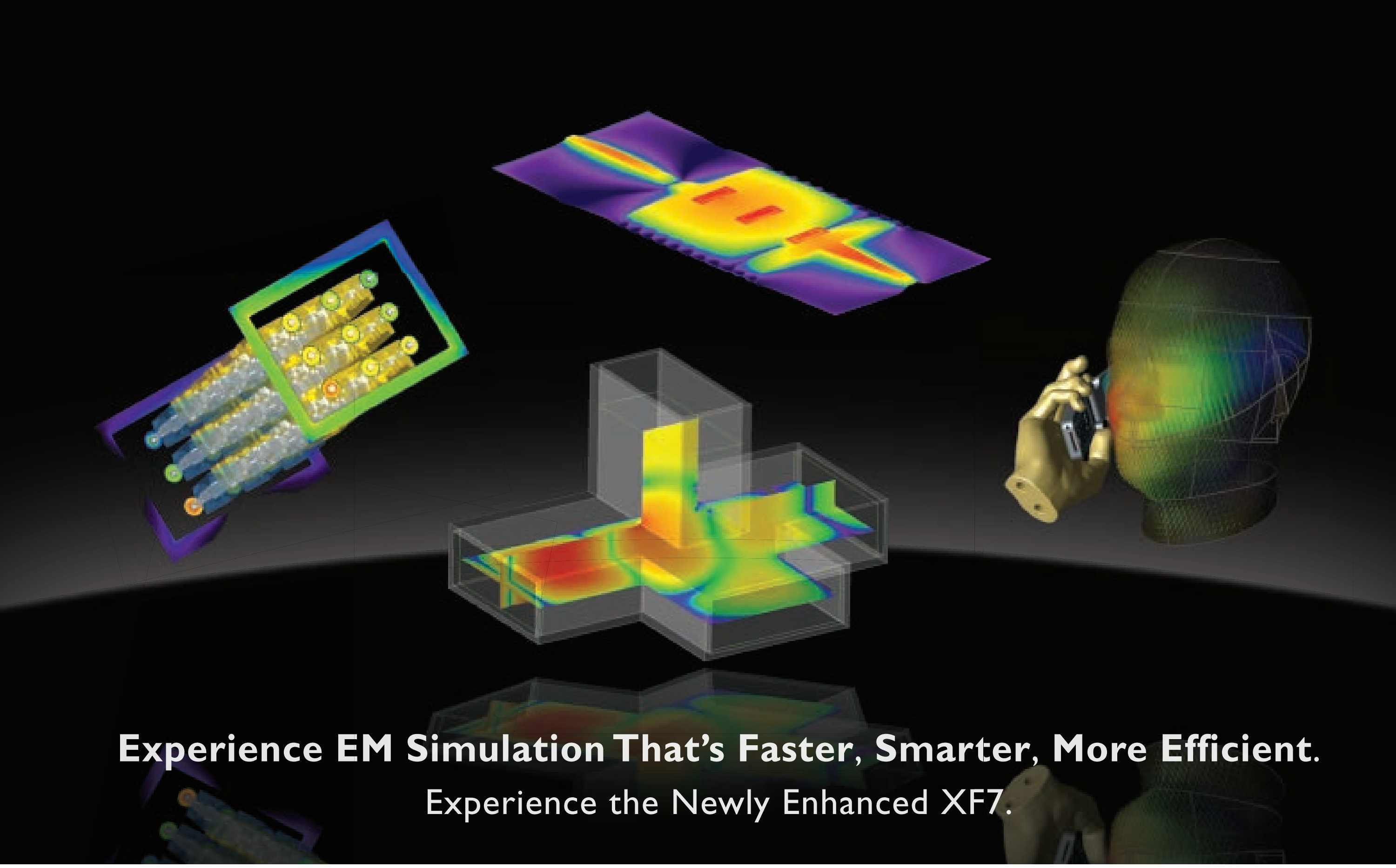
FUNDAMENTAL THEORY

Circuit Description

In the proposed tunable Doherty amplifier, the conventional offset line is replaced with a variable capacitance diode loaded CRLH and coupled lines to suppress the harmonics and adjust the phase with the variable capacitance diode. The proposed structure makes the design more flexible and makes many other improvements in the Doherty amplifier. The topology of the circuit is shown in ***Figure 1***. The main amplifier (Class AB) signal, passing through a tunable offset line and a λ/4 transmission line, is combined with the peak power amplifier (Class C) signal at the output. Due to the Class AB of the main amplifier, the linearity of the entire Doherty amplifier is ensured and, at the same time, with the peak amplifier operating in Class C, the efficiency of the entire Doherty amplifier also is improved. The tunable offset line consists of variable capacitance diode-loaded coupled lines or variable capacitance diode-loaded CRLH. The R_{opt} and Z_0 are used for the load impedances of the main and peak amplifiers, respectively. The R_{opt} is selected as $2Z_0$ for matching and decreasing power leakage to the peak amplifier when the peak amplifier is turned off, and when it is turned on, Z_0 is 50 Ω and Z_1 is

$$\sqrt{Z_0 \frac{Z_0}{2}}\Omega$$

Figure 2 shows a tunable offset line using variable capacitance diode-loaded coupled lines. The structure consists of a variable capacitance diode load and a pair of the symmetrical parallel coupled-lines. The harmonic suppression and variable phase are



Experience EM Simulation That's Faster, Smarter, More Efficient.

Experience the Newly Enhanced XF7.

Remcom's XF7 is continually evolving to stay ahead of the curve. We push beyond standard updates, adding important functionality and streamlining usability in direct response to our customers' needs. Our goal is to exceed expectations and provide a truly unique experience with each new version.

Join us at **IMS, booth #2430** to see the latest advancements in XF7.

New features for 2012 include:

- Waveguide ports
- Stretch, twist, bend, and wrap geometry
- XStream® GPU Acceleration for Time-dependent Materials, Magnetized Ferrite, Debye/Drude Dispersive Materials, and more
- Materials database
- ODB++ PCB import within CAD Merge, allowing retention of previous modifications to the PCB
- Time Domain Reflectometry (TDR) and Time Domain Transmission (TDT) output types
- Ability to combine SAR from multiple sources

REMCOM®

Electromagnetic Simulation Solutions

Visit **www.remcom.com/xf7** to learn more.

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

Hand image reprinted with permission from CTIA – The Wireless Association®. All rights reserved.

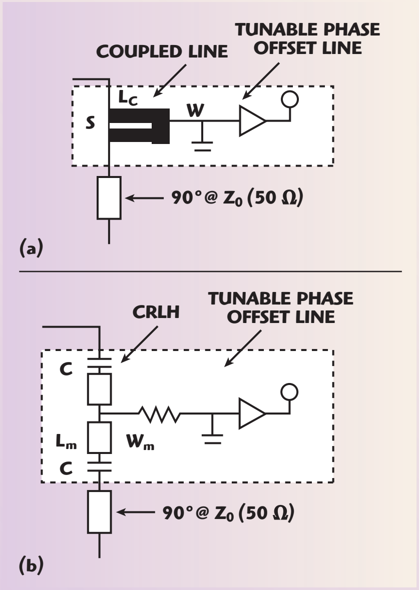
Ultra Low Loss Coaxial Cable

18 GHZ TNC
27 GHZ SMA
40 GHZ 2.9
50 GHZ 2.4

290	190	1501	160
2 Shield	3 Shield	2 Shield	3 Shield
19G Fco	27G Fco	45G Fco	52G Fco
0.301 dia	0.205 dia	0.150 dia	0.140 dia
0.2db 18 GHZ	0.42db 27 GHZ	0.77db 40 GHZ	0.97db 50 GHZ
① \$281.00	② \$328.00	② \$332.00	③ \$367.00

① 3 FT SMA Plug
② 3 FT 2.9 Plug
③ 3 FT 2.4 Plug

RF Depot.com Inc.
7850 Browning Road • Pennsauken NJ 08109
Tel. 856-488-2000
Toll Free 877-RF Depot



▲ *Fig. 2 Proposed offset line using variable capacitance diode-loaded coupled lines (a) and using variable capacitance diode-loaded CRLH (b).*

achieved by the variable capacitance diode loaded coupled lines. The impedance of the tunable offset line is 50 Ω, and the phase of the offset line can be modified through changing the voltage of the variable capacitance diode. The modifying phase of the main power amplifier will be more flexible, so that the phase distortion of the peaking amplifier at high-power level will be cancelled. Therefore, the performance of the proposed Doherty power amplifier (DPA) can be improved much more than with a DPA using a conventional offset line. The other tunable offset line is a variable capacitance diode loaded CRLH. The variable capacitance diode-loaded CRLH replaces the conventional offset line, where the right-handed transmission line (RHTL) and the left-handed transmission line (LHTL), are composed of capacitors and inductors. When the series and shunt resonances are equal, the structure is said to be balanced. According to the desired phases for two different frequencies, the phase response of CRLH-TL will be –π/2 at f_1 (fundamental frequency) and –2π at f_2 (second harmonic). Therefore, a large portion of the second harmonics generated from the main and peaking amplifiers will be cancelled at the summing load. Furthermore, at high-power level, the phase distortion of the peaking amplifier will be corrected through the tuning voltage of the variable capacitance diode.

Linearity Analysis

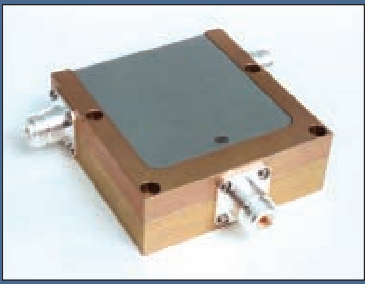
At low-power level, the IMD3 of the entire DPA is only provided by the main amplifier, while the peak amplifier is turned off, due to the suppression of harmonics at the output of the main amplifier in the proposed DPA. Compared to the conventional offset line structure, the second and higher order harmonics of the main amplifier are effectively suppressed from 3.5 to 7 GHz by the proposed structure. The AM-AM distortions of the proposed DPA are lower than that of a conventional DPA.

At high-power level, while the peak amplifier is turned on, IMD3 is a composite of contributions from both the main and peak amplifiers, the output phase distortion of the Doherty amplifier comes mainly from the peak amplifier, while the carrier amplifier is biased at Class AB operation. In this case, the nonlinear output current of the active devices can be approximately expressed by a Taylor series expansion:

$$I_{out} = gm_1 v_i + gm_2 v_i^2 + gm_3 v_i^3 + \ldots \qquad (1)$$

where v_i is an input voltage and gm_x is the xth-order expansion coefficients of the nonlinear transconductance. The third-order intermodulation distortion (IMD3) current is mainly generated by the $gm_3 v_i^3$ term of Equation 1. Assuming that the load modulation does not seriously affect linearity and that the main amplifier is biased as Class AB to have a gm_3 of –a, the bias of the peaking amplifier for the two-way Doherty amplifier should be adjusted to have a gm_3 of a to perfectly cancel the IMD3 current generated by the main amplifier. However, the bias point of the peaking amplifier for a perfect IMD3 cancellation may approach closely to a Class B bias. Furthermore, a Class C biased peak amplifier brings a lot of AM-AM and AM-PM distortion at high power. The AM-AM and AM-PM distortions of the peak amplifier can result in IMD3 deterioration. However, in the proposed DPA, the phase distortion of the peak amplifier can be corrected by tuning the phase of the main amplifier, so that the phase distortion and gm_3 of the proposed entire DPA can be decreased. Therefore, the IMD3 of the entire DPA is improved. In

HIGH POWER
100 MHz to 20 GHz

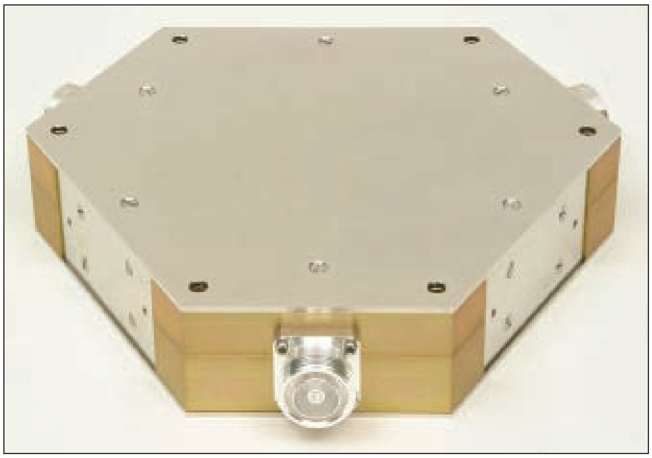


As one of the leading suppliers of ferrite components in the industry, UTE Microwave has pioneered innovative designs, quality craftsmanship and exceptionally high quality products. Custom designs, standards...many of them off-the-shelf, are the result of over 35 years of experience in the industry.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

For Military / Radar Applications.

Isolators/Circulators

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



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

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

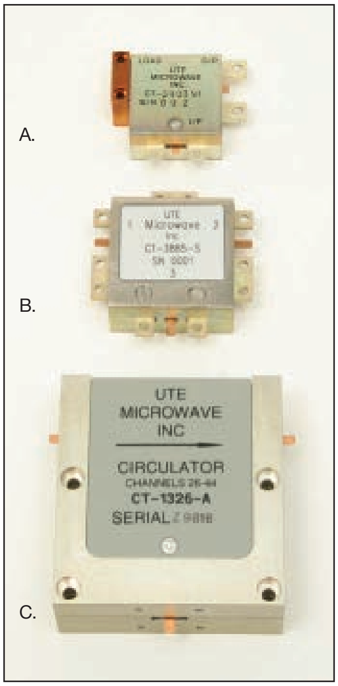
HIGH POWER Drop-in Series

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.

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

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**

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

UTE
MICROWAVE INC.

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

See us at IMS Booth 2321

Contact us for more information on our extensive product line and current catalog. We accept Visa, MC, Amex

TECDIA

THIN FILM CERAMIC TECHNOLOGY

Science, Engineering, Tradition spawn today's solutions and tomorrow's innovation for Micro & Light waves.

Single Layer Capacitors & Resistors

Dense, fine grain ceramics

GBBL designs for Hi-K

ALTAS®

Multiple pattern options

Unbeatable quality and reliability

IRC™

WWW.TECDIA.COM

the proposed DPA, tuning the variable capacitance diode-loaded coupled lines or the variable capacitance diode-loaded CRLH at the output of the main amplifier can correct the phase distortion of the peak amplifier. At the same time, the second and higher order harmonics of the main amplifier output are largely suppressed, so the linearity of the proposed DPA is improved.

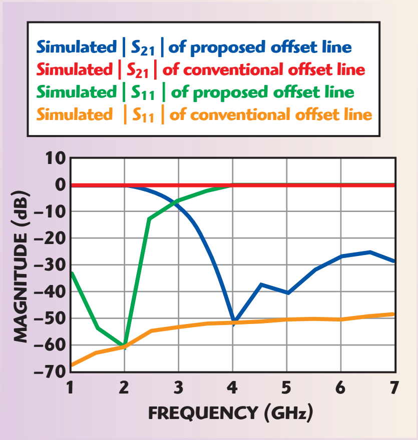
TABLE I
REACTANCE AND PHASE OF THE PROPOSED STRUCTURE

Reverse Voltage (V)	*C_s (PF)*	*Reactance*	*Phase*
1.8	10.0	49.9 ∠0.03	–21.4°
1.0	12.0	49.9 ∠0.01	–23.1°
0.6	15.0	50.1 ∠0.03	–25.6°

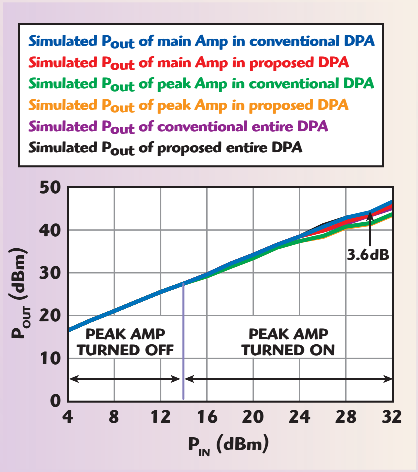
REALIZATION OF THE LINEAR AMPLIFIER BASED ON A TUNABLE OFFSET LINE

Tunable Varactor Diode-loaded Coupled Lines for Offset Line

The schematic diagram of a tunable offset line, using varactor diode-loaded coupled lines, was shown previously. The tunable offset line consists of a variable capacitance diode load and a pair of symmetrical parallel coupled-lines with a length L_c, a width W and a slot S between the lines. The phase of the offset line varies according to changes in capacitance of the diode, which are obtained by tuning the reversed voltage of the diode. The reactance and variable phase of the proposed structure are shown in ***Table 1*** for the frequency range from 2010 to 2100 MHz, where, L_c, S and W are 4, 0.2 and 0.5 mm, respectively. C_s is the equivalent value of the varactor diode. In addition, a 50 Ω tunable offset line is chosen to match the $\lambda/4$ transmission line. The simulated S-parameters of the varactor diode-loaded coupled lines and the conventional offset line are shown in ***Figure 3***, compared to a conventional offset line. The second and higher order harmonics in the varactor diode-loaded coupled lines is largely suppressed. The rejection band is extended from 3.5 to 7 GHz with a rejection ratio more than 20 dB. In the total process of DPA operation (low and high power level), the linearity of the main amplifier, and also of the overall Doherty amplifier improved, due to the suppression of the second and higher harmonics at the main amplifier output in the proposed structure. The optimized performances are shown on the basis of a 23.2° offset line.



▲ *Fig. 3 Simulated S-parameters of the varactor diode-loaded coupled lines and conventional offset line.*



▲ *Fig. 4 Simulated AM-AM distortions in DPA using a tunable coupled line and a conventional DPA.*

Figures 4 and ***5*** show the simulated AM-AM and AM-PM distortions of the proposed and conventional DPAs. At low-power level, the IMD3 of the entire DPA is only provided by the main amplifier, while the peak amplifier is turned off. The phase distortion in the conventional DPA is almost the same as that of the proposed DPA. Due to the suppression of harmonics in the output of the main amplifier in the proposed DPA, the AM-AM distortions in the proposed DPA is lower than that of a conventional DPA. At high-power level, while the peak amplifier is turned on, IMD3 is

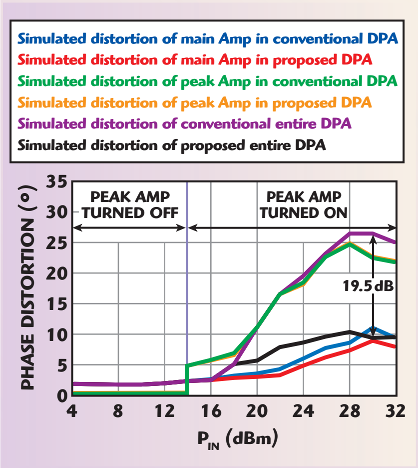
Exorcise phantom PIM signals

PIM. It's far from passive. Phantom signals caused from PIM can haunt you and your operators for eternity. But with San-tron's PIM cable assemblies on your side, you can sleep easy. These assemblies offer PIM figures as low as -181 dBc (-163 dBc typical). They're a perfect combination of specially plated, non-paramagnetic, high-performance eSeries connectors and the best flexible cable. The interfaces of these connectors have been perfectly matched and an extended ferrule provides support at the crucial solder-wick line to allow for repeated flexure. Stop the phantom calls and put an end to the PIM nightmare by requesting a quote today at **Santron.com**.

San·tron

Always Thinking

See us at IMS Booth 2219



▲ *Fig. 5 Simulated AM-PM distortion in DPA using a tunable coupled line and a conventional DPA.*

a composite of the contributions from both the main amplifier and peak amplifier. The harmonics of the main amplifier are suppressed by the proposed coupled line. While P_{in} is 30 dBm, the P_{out} distortion of the proposed DPA is improved by as much as 3.6 dB over that of the conventional DPA. Furthermore, at high-power level, the phase distortion of the peak amplifier (Class C) is large, which will result in the deterioration of IMD3. However, the gm_3 parameters of the FETs are opposite in the peak and main amplifiers of the proposed DPA. The phase distortion of the peak amplifier can be corrected by tuning the phase of main amplifier, so that the phase distortion and gm_3 of the proposed entire DPA can be decreased. Therefore, the IMD3 of the entire DPA is improved. In the proposed DPA, tuning the reversed voltage of the varactor diode-loaded coupled lines at the output of the main amplifier can correct the phase distortion of the peak amplifier. As shown, the simulated AM-PM distortion is improved in the proposed DPA, especially, when P_{in} is 30 dBm, the phase distortion of the proposed DPA is improved by 19.5° over that of a conventional DPA.

Tunable Varactor Diode-loaded CRLH for Offset Line

To achieve the tunable offset line, a variable capacitance diode-loaded CRLH can also be adopted. The configuration of the proposed offset line was shown previously. The proposed structure is composed of a varactor diode and CRLH. The CRLH is realized by loading a conventional transmission line (TL) with lumped element series capacitors (C) and shunt inductor (L) where the length and width of the right-handed transmission line in CRLH are l_m and w_m, respectively. When the series and shunt resonances are equal, the structure is said to be balanced, Z_{OR}, Z_{OL} and Z_o^{CRLH} are fixed as Z_{offset}. The characteristic impedance of the tunable offset line and the λ/4 transmission line can be obtained by a load modulation technique. The CRLH can be designed using P and Q, where P and Q are

$$2\pi\sqrt{L_R C_R} \quad \text{and} \quad \frac{N}{2\pi\sqrt{L_C C_C}},$$

respectively. The RH TL has a negative phase response (phase lag) proportional to $\sqrt{L_R C_R}$, whereas the LH TL has a positive phase response (phase lead) proportional to $1/\sqrt{L_C C_C}$. P, Q, Z_{OR} and Z_{OL} are altogether used to determine C, L and the


Break on Through With G.T. Microwave

Frequency Translators
BPSK Modulators
Phase Shifters
Attenuators
Switches
QPSK Modulators
Custom-Sub Assemblies
I & Q Vector Modulators

For Leading Edge Ultra-Broadband or Optimized Narrow Band Technology from 20 MHz to 32 GHz Call...

Check out our new website today...
www.gtmicrowave.com

G.T. Microwave Inc.

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

PCI Precision Connector, Inc.

Precision Cable Connectors

Our Specialty

When off-the-shelf cable connectors aren't good enough for your application, just call "Your Connector Experts" at PCI.

If we don't already have a solution

we'll create one

Whether it's the need for low VSWR, low insertion loss, high power handling or robust captivation... the Engineering team at PCI can meet the need and make your transition from cable to connector smooth and seamless.

Precision Connector Standard Series	
1.0mm	(DC to 110 GHz)
1.85mm	(DC to 65 GHz)
2.4mm	(DC to 50 GHz)
2.92mm	(DC to 45 GHz)
3.5mm	(DC to 34 GHz)
SSMA	(DC to 35 GHz) (DC to 40 GHz)
SMA	(DC to 24 GHz) (DC to 26.5 GHz)
TNC	(DC to 12.4 GHz) (DC to 18 GHz)
N	(DC to 11 GHz) (DC to 18 GHz)
Addt'l Series:	BMA, SMP, SMPM, SC

PCI

Precision Connector, Inc.

"Your Connector Experts"

Precision Connector, Inc.
700 International Drive
Franklin, IN 46131
Phone: 317-346-0029
Fax: 317-346-0039
www.precisionconnector.com
sales@precisionconnector.com

See us at IMS Booth 3303

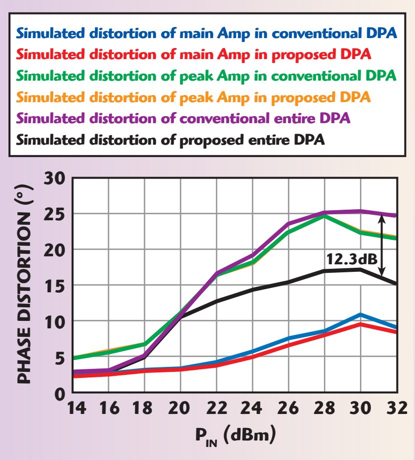
unmatched customer service unequaled engineering expertise unparalleled manufacturing capability

physical length of RH-TL. When C and L are 10 pF and 42 nH, and l_m and w_m are 4 mm and 1 mm, respectively, the reactance and variable phase of the proposed structure is shown in ***Table 2***, in the frequency range from 2010 to 2100 MHz. Because the second harmonics generated in the main and peaking amplifiers will be cancelled at the summing load, while the peak amplifier is turned off, harmonics cannot be suppressed, so the linearity is not improved. At high-power level, the peak amplifier is turned on when the main amplifier reaches saturation, tuning the reversed voltage of varactor diodes in CRLH, the phase distortion of the peak amplifier at high-power level can be corrected. As shown in ***Figure 6***, at high-power level, compared to a conventional Doherty PA, the simulated AM-PM distortion of the proposed Doherty PA is reduced by 12.3 dB (P_{in} is 31 dBm).

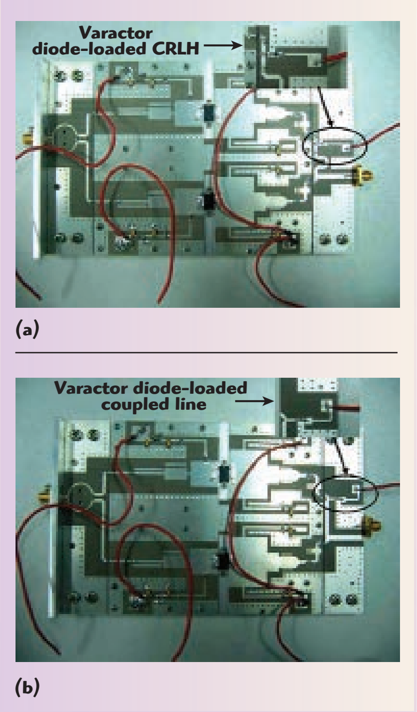
TABLE II

COMPONENT VALUES OF THE CAPACITANCE DIODE-LOADED CRLH

Reverse Voltage (V)	C_s (PF)	Reactance	Phase
20.1	0.3	49.9 ∠0.03	–27.4°
19.3	0.2	49.9 ∠0.06	–21.2°
18.5	0.1	50.1 ∠0.01	–23.2°



▲ *Fig. 6 Simulated AM-PM distortion in DPA using tunable CRLH and a conventional DPA.*



▲ *Fig. 7 Photographs of DPAs using a varactor diode-loaded CRLH (a) and coupled lines (b).*


The difference: apples and oranges? You decide.

MegaPhase - Simply Better

Unmatched service before and after our unmatched delivery time, backed by our industry-leading 12 month warranty. MegaPhase cables are still the "Lowest Cost per Measurement" and always phase stable. Best overall value - period.

VNA Test Port Extension Cable	Alternative OEM	MegaPhase
3.5mm connectors, 26.5 GHz, 38 inches	$3,505	$800
2.4mm connectors, 50 GHz, 38 inches	$6,033	$1,256
1.85mm connectors, 67 GHz, 38 inches	$8,021	$1,770

Very typical Test cable comparison.

IMS2012 | Visit us at the IEEE MTT-S International Microwave Symposium Montreal, Quebec, Canada, June 17-22, 2012 - **Booth #2721**

Excellence in RF Interconnects

MEGAPHASE

2098 West Main Street, Stroudsburg, PA 18360
Tel: 1-888-261-6225
Fax: 1-877-MegaFax / 570-424-6031
Email: fastquote@megaphase.com / Web: www.megaphase.com/mwj

EQA ISO 9001 Registered Firm UKAS QUALITY MANAGEMENT 047

Generates complex conditions.
And extreme confidence.

The Agilent MXG X-Series signal generator lets you simulate complex signal technologies and extreme conditions with unmatched performance. Like the cost-effective EXG, it features industry-leading ACPR, EVM and output power. So you can be sure that the products you're developing are perfectly ready for real-world performance.

MXG X-Series Signal Generators
Analog and vector; 9 kHz up to 6 GHz
Lowest phase noise in the industry: -146 dBc @ 1 GHz
160 MHz bandwidth; ± 0.2 dB flatness
Real-time 4G, video, GNSS with Signal Studio software

See how the innovations in the X-Series benefit you. Watch the video at http://goo.gl/74MSw

Trade in your current signal generator today and receive up to 50% off your upgrade
www.agilent.com/find/MXGwireless

© Agilent Technologies, Inc. 2012

See us at IMS Booth 1015

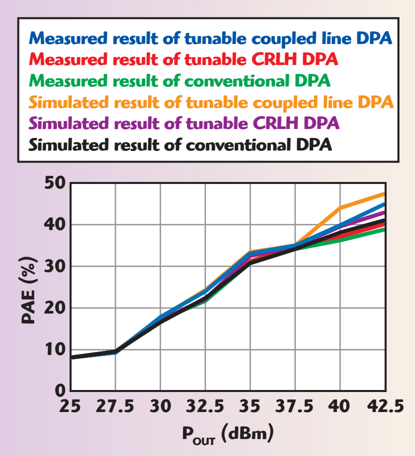
u.s. 1-800-829-4444 canada: 1-877-894-4414

Anticipate __Accelerate __Achieve

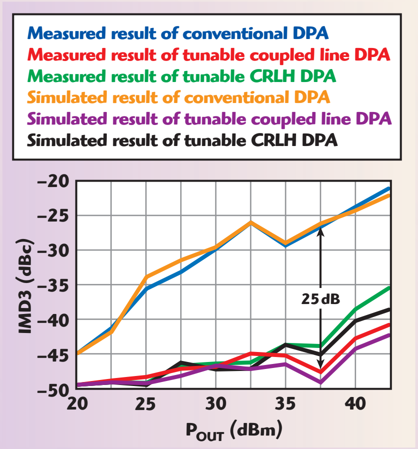
Agilent Technologies

SIMULATED AND MEASURED RESULTS

The proposed Doherty power amplifier was simulated using Agilent ADS from 2 to 2.5 GHz. ***Figure 7*** shows the photographs of the fabricated proposed Doherty amplifiers (varactor diode-loaded CRLH and varactor diode-loaded coupled line), where a Taconic RF35 substrate (ε_r = 3.5 tan δ = 0.001) was used. The Microsemi's KV2111 and Philips's BB181 varactor diodes are chosen for the tunable coupled line and tunable CRLH, respectively. The phase of the offset line is tuned at –21°, –23° and –27° by adjusting the voltage of the varactor diode manually. The optimized PAE and linearity is achieved with a –23° phase offset line. The PAE of the DPA is simulated by using load/source pull and harmonic balance methods. The PAE is measured by calculating P_{ac}/P_{dc}, where P_{ac} is the difference between P_{out} and P_{in}. P_{dc} is calculated from the voltage and current of the power supply. At high-power level, a better match at the output of the main amplifier is achieved and at the same time, the parameter γ is optimized using the tunable offset line, so the total efficiency of the Doherty amplifier system is improved. The measured and simulated PAEs of the proposed DPA and conventional PDA are shown in ***Figure 8***. At low-power level (P_{out} under 29 dBm), the peak amplifier is turned off and the PAE of the proposed DPA is the same as that of the conventional DPA. For P_{out} above 29 dBm, the peak amplifier is turned on and the voltage of varactor diode is adjusted to optimize the match and compensating phase. Consequently, the PAE of the proposed DPA is improved. The measured and simulated PAE of the proposed DPA is greater (5 to 7 percent) than that of the conventional DPA. The maximum measured PAE of the proposed DPA is 45.2 percent at 2.01 GHz.



▲ *Fig. 8 Measured and simulated results (PAE) of the proposed DPA and conventional DPA.*



▲ *Fig. 9 Measured and simulated IMD3 of the proposed DPA and conventional DPA.*


Powerful Multipath/Link Emulator

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

250 MHz bandwidth

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

Software showing mobile link setup

dBm

RF Test Equipment for Wireless Communications

dBmCorp, Inc
32A Spruce Street ◆ Oakland, NJ 07436
Tel (201) 677-0008 ◆ Fax (201) 677-9444
www.dbmcorp.com

See us at IMS Booth 2336

It works accurately with tight tolerances and tight budgets.

The Agilent EXG X-Series signal generator lets you simulate multiple signal technologies, efficiently and affordably. Like the pure and precise MXG, it features industry-leading ACPR, EVM and output power. So you can feel confident that the devices you're manufacturing are ready for real-world performance.

EXG X-Series Signal Generators

- Analog and vector; 9 kHz up to 6 GHz
- Fast switching speed (<900 μs)
- Simplified signal creation with Signal Studio software
- High reliability, easy self-maintenance

See how the innovations in the X-Series benefit you. Watch the video at http://goo.gl/rhyds

Trade in your current signal generator today and receive up to 50% off your upgrade
www.agilent.com/find/Agilent_EXG

© Agilent Technologies, Inc. 2012

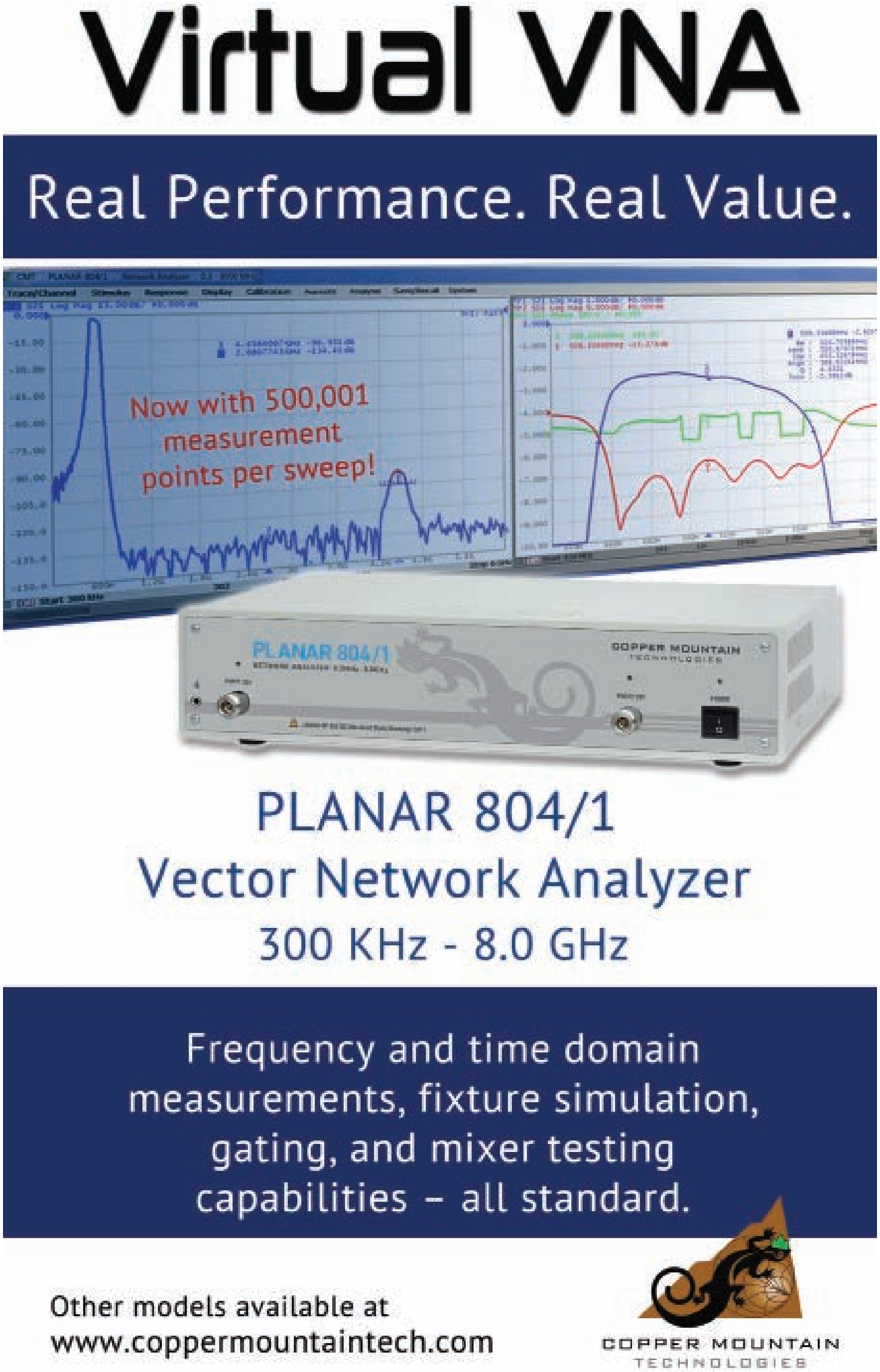
See us at IMS Booth 1015

u.s. 1-800-829-4444 canada: 1-877-894-4414

Anticipate __Accelerate __Achieve

Agilent Technologies

Figure 9 shows the measured and simulated IMD3 performance of the proposed DPA using two-tone signals at 2015.5 and 2020.5 MHz (the tone spacing is 5 MHz). In the proposed DPA, the harmonic of the amplifier is suppressed. At the same time, the phase distortion of the peak amplifier and gm$_3$ of the proposed entire DPA can be decreased by tuning the proposed offset line, so the IMD3 of the two proposed DPAs were considerably improved compared to that of the conventional DPA. The IMD3 of the DPA using the tunable CRLH is not as good as that of the DPA using a tunable coupled line, mainly because the harmonic of the DPA cannot be suppressed while the peak amplifier is turned off and the phase of the second harmonic deviates a little from -2π, while tuning the tunable offset line at high-power level. At low-power level (P_{out} under 29 dBm), the peak amplifier is turned off and the harmonic of the main amplifier is suppressed by the proposed structure. IMD3 is improved over that of the conventional one. At high-power level (P_{out} above 29 dBm), the peak amplifier is turned on, the phase of main amplifier and gm$_3$ are modified by tuning the voltage of the varactor diode and the distortion of the peak amplifier output is corrected. The IMD3 is improved by approximately 25 dB better than that of a conventional one. The data shows the improvement in linearity due to lower harmonics and the decrease of the phase distortion and gm$_3$.



Virtual VNA

Real Performance. Real Value.

PLANAR 804/1
Vector Network Analyzer
300 KHz - 8.0 GHz

Frequency and time domain measurements, fixture simulation, gating, and mixer testing capabilities – all standard.

Other models available at
www.coppermountaintech.com

COPPER MOUNTAIN TECHNOLOGIES

CONCLUSION

A Doherty power amplifier, using a tunable offset line, is proposed to improve linearity and PAE. The tunable offset line is achieved by two structures, one is a varactor diode loaded coupled line, the other is a varactor diode-loaded CRLH. The proposed structure is utilized to suppress second and higher order harmonics and, at the same time, it can correct the phase distortion of the peak amplifier and decrease the gm$_3$ of the entire DPA by tuning the voltage of the varactor diode at high-power level. In addition, tuning the phase in a DPA becomes more flexible with the proposed structure. Testing results show that the linearity of the proposed DPA has been improved by 25 dB over the conventional DPA, which verifies the advantages of the proposed structures. ■

References

1. M.A. Antoniades and G.V. Eleftheriades, “Compact Linear Lead/lag Metamaterial Phase Shifters for Broadband Applications,” *IEEE Antennas and Wireless Propagation Letters*, Vol. 2, No. 7, July 2003, pp. 103-106.
2. S.H. Ji, S.K. Eun, C.S. Cho, J.W. Lee and J. Kim, “Linearity Improved Doherty Power Amplifier Using Composite Right/Left-Handed Transmission Lines,” *IEEE Microwaves and Wireless Components Letters*, Vol. 18, No. 8, December 2008, pp. 533-535.
3. Y.C. Jeong, S.G. Jeong, J.S. Lim and S. Nam, “A New Method to Suppress Harmonics Using λ/4 Bias Line Combined by Defected Ground Structure in Power Amplifiers,” *IEEE Microwaves and Wireless Components Letters*, Vol. 13, No. 12, December 2003, pp. 538-540.
4. Y. Yu, Y. Liu, S. Li and S. Li, “A Novel High-power Amplifier Using a Generalized Coupled-line Transformer with Inherent DC-block Function,” *Progress in Electromagnetics Research*, Vol. 119, 2011. pp. 171-190.
5. Y. Yang, J. Yi, Y.Y. Woo and B. Kim, “Optimum Design for Linearity and Efficiency of a Microwave Doherty Amplifier Using a New Load Matching Technique,” *Microwave Journal*, Vol. 44, No. 12, December 2001, pp. 20-36.
6. Y. Zhao, A.G. Metzger, P.J. Zampardi, M. Iwamoto and P.M. Asbeck, “Linearity Improvement of HBT-based Doherty Power Amplifiers Based on a Simple Analytical Model,” *IEEE Transactions on Microwave Theory and Techniques*, Vol. 54, No. 12, December 2006, pp. 4479-4488.
7. I. Lin, M. Devincentis, C. Caloz and T. Itoh, “Arbitrary Dual-band Components Using Composite Right/Left-Handed Transmission Lines,” *IEEE Transactions on Microwave Theory and Techniques*, Vol. 50, No. 4, April 2004, pp. 1142-1149.

See us at IMS Booth 317

TRUflex™ PWR Series

High Power RF Cable Assemblies

- Broad range of connector and cable combinations
- kW power handling capabilities
- Quick Connect/Disconnect interface technology
- Test and adapter solutions available
- Experience in high power design and safety innovations

Power to the People

TRU Corporation offers an extensive line of flexible RF cable assembly and connector solutions for applications that require high power/voltage capability as well as reliable, high quality performance. Our long heritage in high power design has made us a premier supplier in high power markets including critical applications in the industrial equipment segment.

TRU offers a broad selection of straight and right angle connector interface options as well as the extensive range of cable choices. Our cables are specifically designed for their power capability and reliability. Our innovative Quick Connect/Disconnect interfaces: TRU-SQS®, TRU-QRM™ and TRU-QDS®, provide highly efficient and repeatable high power solutions without the need for added hand tools to securely mate.

To learn more about the TRUflex™ PWR Series, visit our website:
trucorporation.com

Visit us at MTT-S 2012 • Booth 924

TRU Corporation | Peabody, MA 01960 USA
1 800 262-9878 (1 800 COAX-TRU) | 978 532-0775
To request TRUflex™ PWR Series literature: marketing@trucorporation.com
trucorporation.com

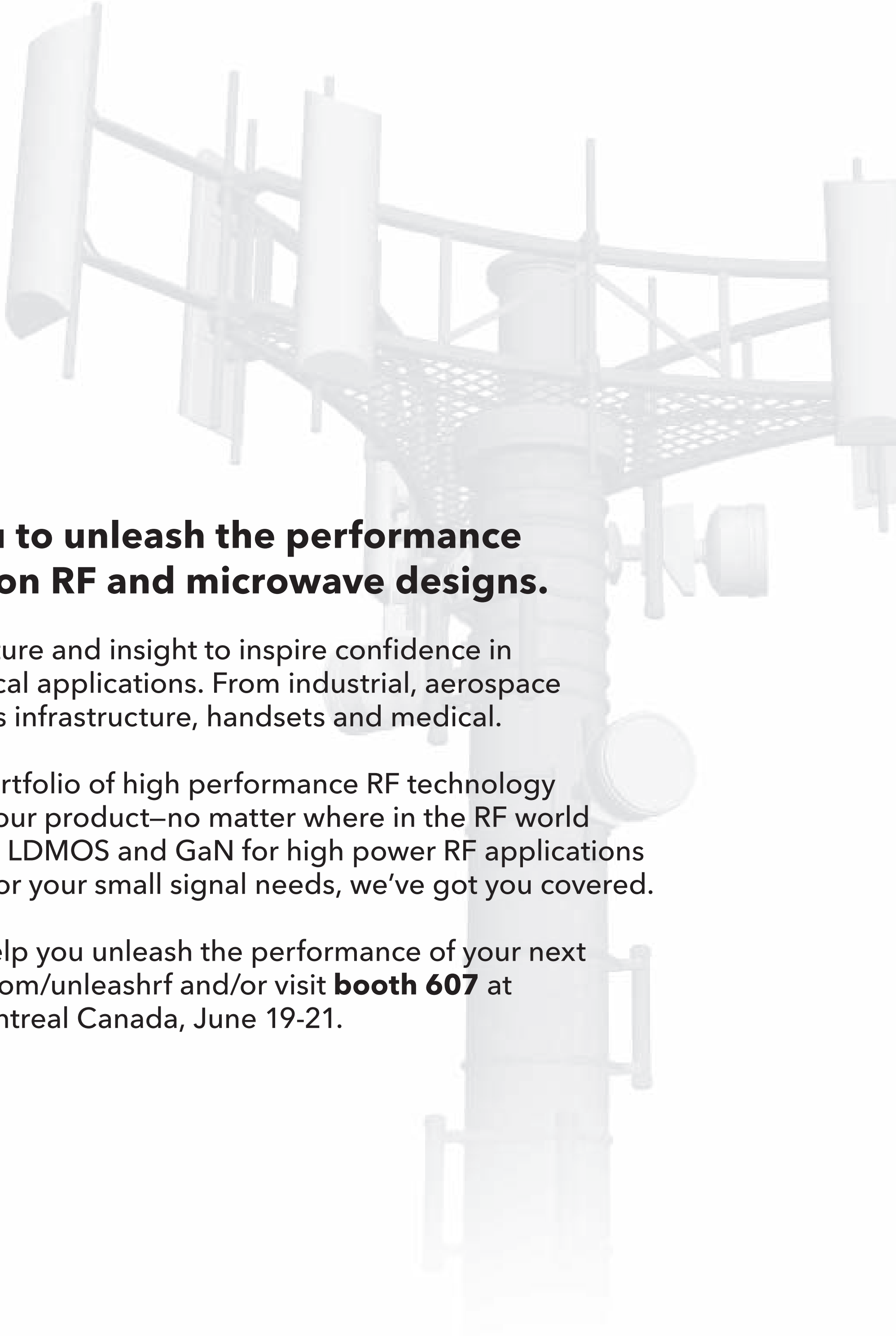
TRU®

EXPERIENCE. TRU INNOVATION.

©2012 TRU Corporation

UNLEASH RF

www.nxp.com/unleashrf



NXP enables you to unleash the performance of next-generation RF and microwave designs.

We have the infrastructure and insight to inspire confidence in your performance-critical applications. From industrial, aerospace and defense to wireless infrastructure, handsets and medical.

Only NXP delivers a portfolio of high performance RF technology that can differentiate your product—no matter where in the RF world you play... Whether it's LDMOS and GaN for high power RF applications or SiGe and BiCMOS for your small signal needs, we've got you covered.

To see how NXP can help you unleash the performance of your next design visit www.nxp.com/unleashrf and/or visit **booth 607** at IMS/MTT-S 2012 in Montreal Canada, June 19-21.

NXP

Global Navigation Satellite Systems and Their Applications

The Global Positioning System (GPS) was once the only operational global navigation satellite system (GNSS) and it was used all over the world to access location-based services (LBS). With the Russian GLONASS navigation system and the future deployment of China's Compass and Europe's Galileo navigation, there will be increased focus on the capabilities and applications of such systems. This article gives an overview of the different navigation systems, explains the navigation channel and generic approach used by a commercial standard receiver to calculate a user position and generally describes channel acquisition and tracking. GNSS applications such as differential GNSS (D GNSS) and multiple frequency-band navigation, their complexity and benefits are also presented.

Global navigation satellite systems are made up of satellites spanning the globe in a set of defined orbits and aim to provide accurate, uninterrupted and global three-dimensional (3D) position and velocity information to users equipped with appropriate receiving equipment. GPS has been operational for some time and GLONASS has just become operational, whereas Galileo and Compass navigation systems will be deployed gradually in the next ten years and may be used in addition to GPS to improve location-based services.

A GNSS network is composed of satellite space vehicles (SV), user equipment (UE) and control stations (CS). Satellite transmissions are referenced to highly accurate atomic clocks onboard the satellites that are synchronous to the GNSS system time base.

The worldwide control network monitors the health and status of the satellites and uploads the satellite navigation data, which is composed of immediate 'ephemeris' navigation data and non-immediate 'almanac' navigation data from different CSs. This data, along with the ranging information tracked at the UE

Rachid El Assir
Rohde & Schwarz, Munich, Germany

Connect Here.

For complete

Vertical Integration

2D/3D Design Tools
ANSYS HFSS™
Electrical Simulation Modeling

At Delta Electronics Manufacturing, we control every aspect of every process, from product inception through final inspection. The result, is a RF/microwave or millimeter wave interconnect solution that meets your expectations, first time, every time.

CNC Turning Centers

In house state-of-the-art automated electroplating

Now AS9100 Registered

Precision assembly, test and inspection

With over eighty standard connector lines and value-added products such as cable assemblies, all you need to do is ...

Connect Here.

DELTA
ELECTRONICS MFG. CORP.
Connect Here.

Delta Electronics Mfg. Corp.
Tel: (978) 927-1060 • Fax: (978) 922-6430
P.O. Box 53 • 416 Cabot St.
Beverly, MA 01915 USA

DeltaRF.com

AS9100/ISO 9001 REGISTERED
RoHS COMPLIANT
SOMWBA Woman-Owned CERTIFIED

Come see us at IMS 2012 in Montreal, Booth #1825

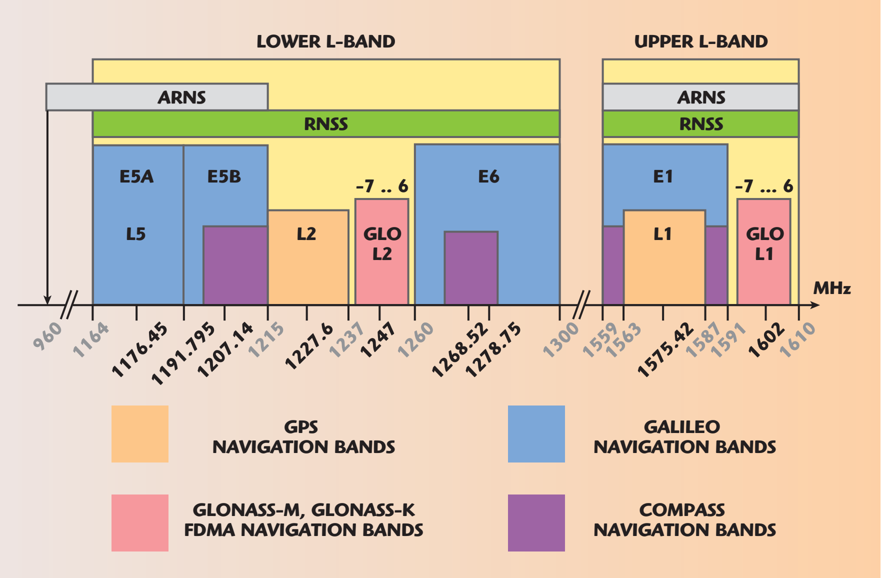

When
it matters...

GORE® Electronic Materials

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

gore.com/emi

EMI GASKETS AND GROUNDING PADS



▲ *Fig. 1 GNSS navigation RF bands.*

from at least four satellites, enables the receiver module to calculate the satellites' positions and subsequently the 3D position of the UE.

GPS

The nominal GPS satellite constellation consists of 24 middle earth orbit (MEO) satellites arranged in six orbital planes with four satellites per plane. The satellites broadcast ranging codes and navigation data on three frequencies – L1 (1,575.42 MHz), L2 (1,227.6 MHz) and L5 (1,176.45 MHz) – using code division multiple access (CDMA), as can be seen in ***Figure 1***. Each satellite transmits on these bands, but with different ranging codes than those employed by other satellites. These codes were selected because they have low cross-correlation properties, thereby minimizing the interchannel interference.

GLONASS

GLONASS is a frequency division multiple access (FDMA)-based GNSS. A subcarrier is allocated but not reserved to a specific satellite. GLONASS became fully operational at the end of 2011, when the three nominal orbital planes were completely filled by eight satellites each. All satellites additionally share one spreading code that is optimized for noise suppression. Two satellites can share the same frequency number if they are located at diametrically opposite antipodal points on the same orbit, and therefore cannot be seen by a user on the Earth at the same time. Subcarriers are allocated to GLONASS in the upper and lower bands.

The modernization of GLONASS as part of the GLONASS-K program will be continued. In the future, Russian satellites are to broadcast optimized CDMA signals in the GPS and Galileo L1/E1 bands as well as in other bands, in order to harmonize the GLONASS system with GPS and Galileo.

GALILEO

Galileo is an independent European GNSS. It is expected to be partially operational with 18 satellites in 2015 and fully operational with 30 satellites in 2020. One of the benefits of Galileo is that it can complement GPS to provide better navigation performance mainly in urban areas. The system uses CDMA to modulate the satellite signals and thus employs a dedicated spreading code for each space vehicle.

In addition, GPS and Galileo are supposed to share the same frequencies in the upper GNSS band (also called L1/E1) and minimize inter-/intrasystem interference by selecting orthogonal pseudo random noise (PRN) and applying binary offset carrier (BOC) modulation, as shown in ***Figure 2***.

COMPASS

Compass is a global navigation system that will not be fully operational before 2020. Because the Galileo proj-

Your question:
What's important about differential probes?

Our answer: High signal fidelity and smart features.
With an input resistance of 1 MΩ and an input capacitance of 0.6 pF, the R&S®RT-ZD probes put a minimum load on a signal source's operating point. The micro button at the probe tip for instrument control and the R&S®ProbeMeter for differential and common mode DC measurements offer new capabilities. Extensive standard accessories provide high flexibility for test point contacting.

For more information, visit:
www.scope-of-the-art.com/ad/faq-dp
See us at IMS Booth 2415

ROHDE&SCHWARZ

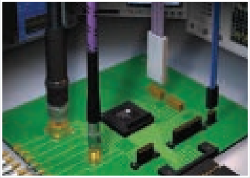
When failure is not an option...

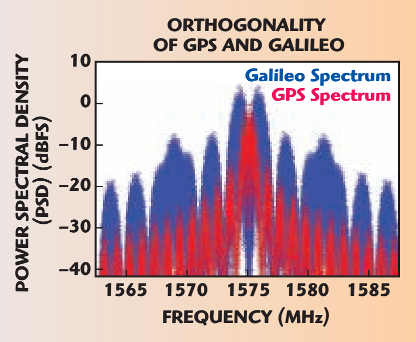
GORE® Wire and Cable

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

gore.com/electronics

WIRE AND CABLE





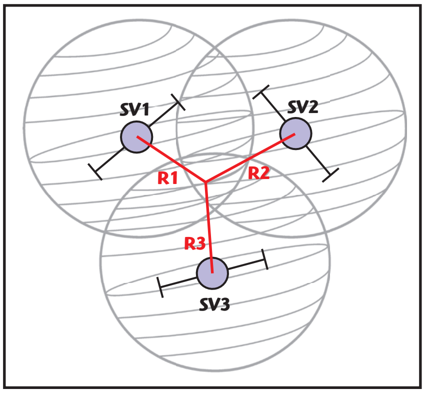
▲ *Fig. 2 Power spectral density of GPS L1 C/A and Galileo E1.*

ect has been delayed, China's regional Compass satellite system Beidou-2, designed to cover large parts of Asia, is scheduled to become operational in 2012 and broadcast on the same bands pre-allocated to Galileo (see Figure 1). These bands can then be acquired solely by the Chinese Compass/Beidou-2 navigation program.

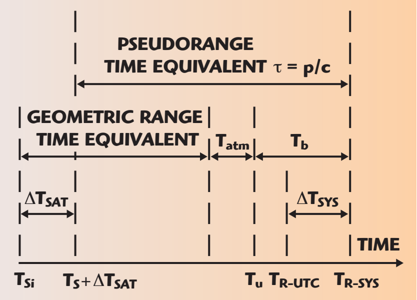
LOCALIZATION SYSTEM MODEL

Navigation employs ranging to determine a user's position. Therefore, taking ranging measurements from different satellites (which may belong to different navigation satellite systems) makes 3D positioning possible. The geometric range, R_i, is defined as the line of sight (LOS) distance from the satellite to the user. Knowing the position of three satellites and the absolute geometric range at a given UE location from each satellite allows users to locate their position at the intersection of three spheres centered around the satellites, each having a radius, R_i. This basic trilateration approach is illustrated in ***Figure 3***.

The geometric range R_i (equivalent to LOS propagation) is not actually available at the UE, since the satellite signal propagation time gets distorted due to different factors such as refraction in the ionosphere and the troposphere, multipath propagation and satellite clock ambiguities. The distorted version of the geometric range is the pseudorange p_i, which is the distance crossed by the ranging signal of a specific satellite to reach a user on the Earth. If t_i is defined to be the propagation time of the GNSS signal from sv_i to the UE, then $p_i = t_i c$, where c is the speed of light. The ranging observation t_i and consequently p_i can be directly calculated from the tracked code and carrier phase of the corresponding tracking channel at the UE. The navigation solution based on the aforementioned trilateration concept requires resolving the ambiguity in the pseudorange of every tracked satellite and thereby calculating R_i using the indirectly measured p_i and the GNSS satellite-UE channel model that relates R_i to p_i.



▲ *Fig. 3 Illustration of localization using ranging signals from three satellites.*



▲ *Fig. 4 Illustration of satellite-UE channel model.*

GNSS SATELLITE-UE CHANNEL MODEL

As shown in ***Figure 4***, the generic channel model that can be used to relate the geometric range to the pseudorange SV_i of space vehicle can be expressed as:

$$p_i = \tau_i c = R_i + (T_{atm_i} + T_b - \Delta T_{SAT_i})c \qquad (1)$$

where T_b corresponds to the receiver time bias, T_{atm} to the atmospheric ambiguities and ΔT_{SATi} to the satellite clock errors. The geometric range R_i of a satellite (the radius of the trilateration sphere) can be calculated from the observed t_i using Equation 1. The UE location is determined by calculating the geometric range of at least four satellites and the corresponding satellite coordinates (x_i, y_i, z_i), which are the centers of the trilateration spheres at T_{si}, where

See us at IMS Booth 2324

Your question:
Can the R&S®RTO also perform logic analysis?

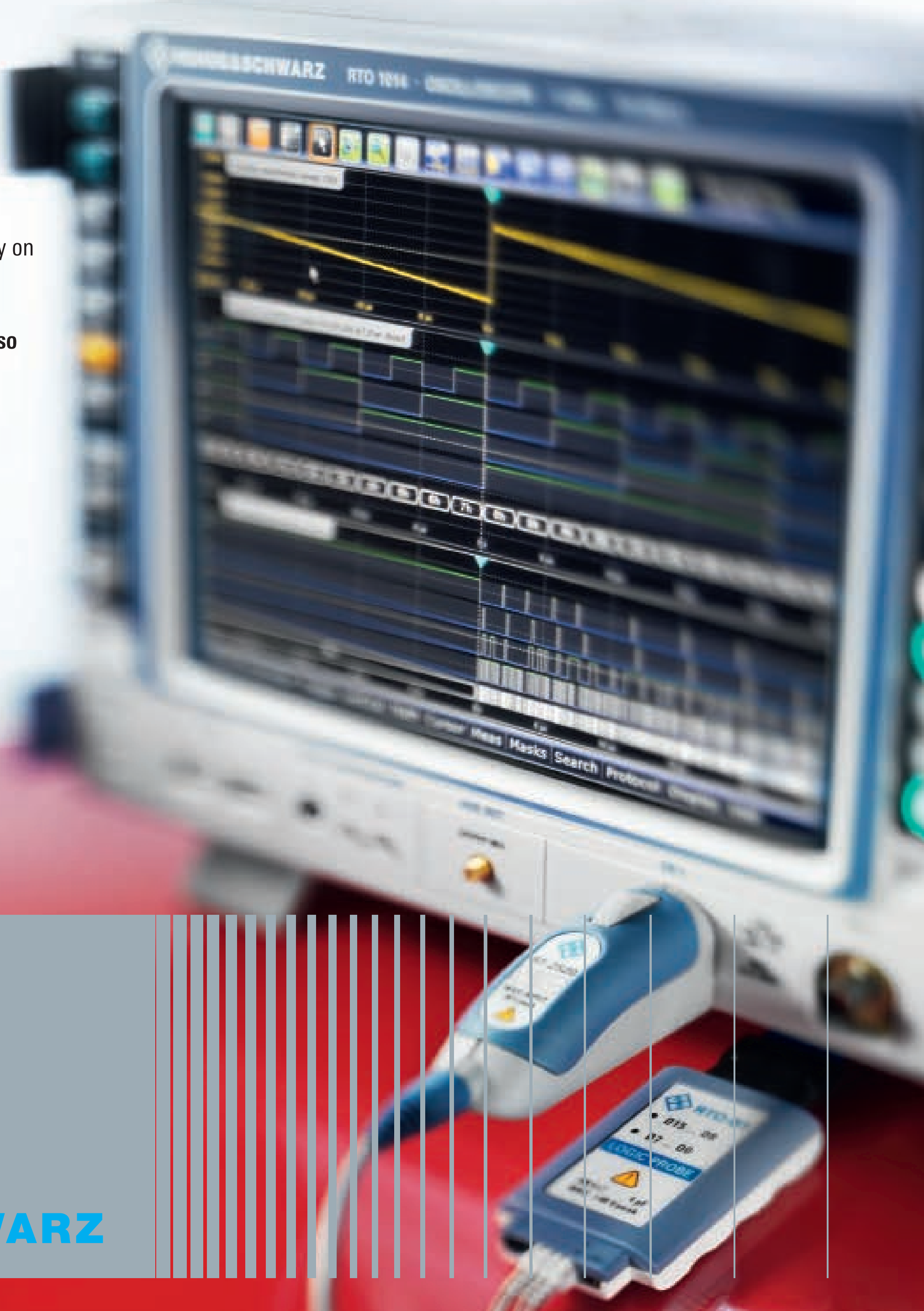
Our answer:
Yes! Test embedded designs quickly and accurately with the MSO option.
A new hardware option turns the R&S®RTO into an MSO. It provides 16 additional digital channels with an input frequency of up to 400 MHz.
The advantages at a glance:

- 5 Gsample/s sampling rate for detailed signal analysis across the entire 200 Msample memory depth
- Extremely high acquisition rate of 200 000 waveforms/second for accelerated debugging
- Hardware-implemented trigger and numerous trigger types for pinpointing faults
- The ease of use you have come to rely on

For more information, visit:
www.scope-of-the-art.com/ad/faq-mso

See us at IMS Booth 2415

ROHDE&SCHWARZ

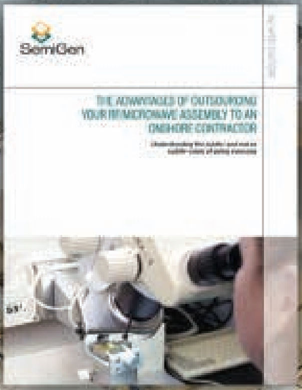


Assembly and Test Services for RF/Microwave Products

THINK QUALITY. THINK ONSHORE.

SemiGen
Get the Edge

Download Our FREE White Paper



RF Supply Center

Shop our RF supply center for bonding supplies & devices, too!

SemiGen.net

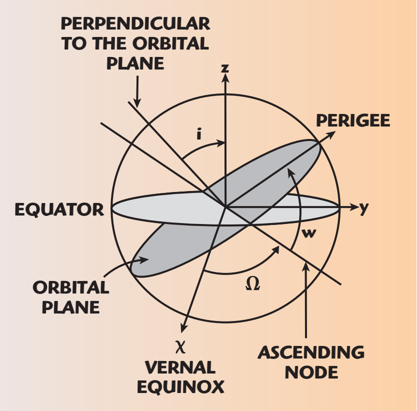


Fig. 5 Satellite's position in ECI.

$$T_{Si} = T_{R-UTC} + \Delta T_{SYS} - \tau_i - \Delta T_{SAT_i} \qquad (2)$$

T_{SYS} is the time difference between a specific GNSS system time base and a common system time base for the Universal Time Coordinate (UTC) to be calculated and $T_{R\text{-}UTC}$ corresponds to the receiver time in UTC.

Least square algorithms are usually used for UE location and time calculation. Other weighted least square algorithms with weights assigned proportionally to the measured carrier-to-noise ratio (C/N) of every tracked satellite are also very widely used in commercial receivers. T_b, T_{atmi} and ΔT_{SAT_i} are the distortion parameters that differentiate the geometric range from the pseudo range and will be described in the following subsections.

SATELLITE POSITION CALCULATION

To determine the location of the UE, first the position of all satellites must be determined. According to Newton's laws, the gravitational force exerted by the Earth's mass M on a satellite of mass m located at a distance r is:

$$F = m\mathbf{a} = -G\frac{mM}{r^3}\mathbf{r} \qquad (3)$$

G is the universal gravitational constant; r is the distance between the center of gravity of the Earth and the satellite in an Earth-centered inertial (ECI) orthonormal xyz coordinate system whose x and y axes do not rotate with the Earth. In Equation 3, $r = \|\mathbf{r}\|$. The transformation from the differential equation's ECI coordinate system to the UE coordinate system, which rotates with the Earth and is also called an Earth-centered, Earth-fixed (ECEF) system, is merely a rotation.

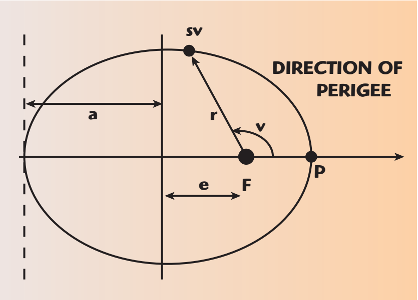


Fig. 6 GNSS orbital parameters.

Equation 3 should be rotated from ECI to ECEF to obtain a differential equation that can be used to calculate the satellite coordinates in the same UE's ECEF coordinate system. Only then can the trilateration generic concept work properly.

ECI VS. ECEF

The ECI coordinate system is centered at the Earth's center of gravity. The xy plane is taken to coincide with the Earth's equatorial plane. As described in Kaplan[1] (section 6), GPS ECI uses the orientation of the equatorial plane at 12:00 UTC on January 1, 2000. The x-axis is fixed in the direction of the vernal equinox (see ***Figure 5***). The z-axis is normal to the xy plane.

ECEF, on the other hand, is the coordinate system used to calculate the position of UE, since it rotates with the Earth. The x-axis points in the direction of 0° longitude. Therefore, the transformation between ECI and ECEF is a rotation of the xy plane. The angle of rotation is derived from the Earth's sidereal time at any given moment.

MOTION EQUATION

The acceleration vector **a** in Equation 3 is the second derivative of **r**. Consequently, the two-body mass differential equation of motion in ECI is:

$$\frac{d^2\mathbf{r}}{dt^2} = -\frac{GM}{r^3}\mathbf{r} \qquad (4)$$

where d^2/dt^2 is the second derivative operator. The solution to Equation 4 can be shown as an ellipse with its focal point located at the center of gravity of the Earth (see ***Figure 6***). The

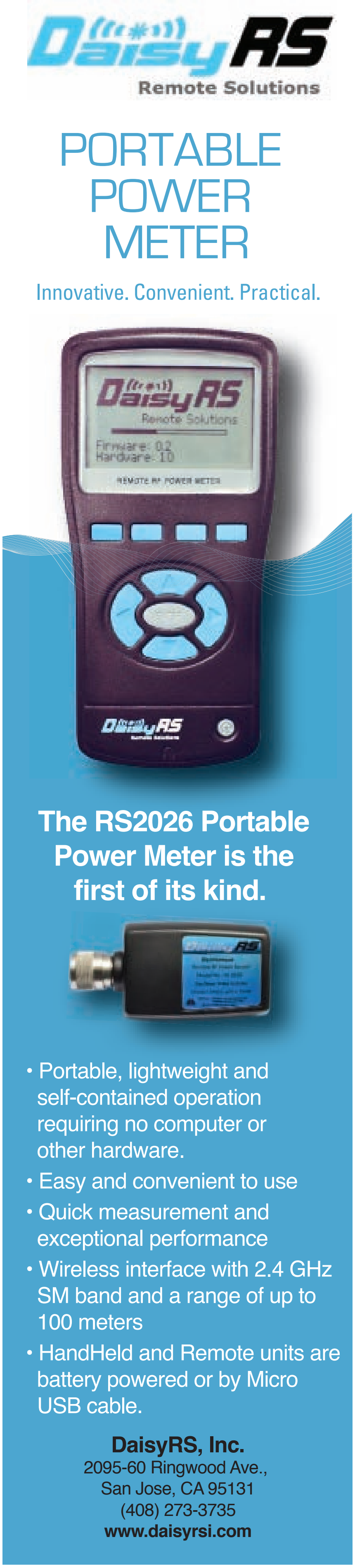
Your question:
What does the R&S®RTO have to offer at 4 GHz bandwidth?

Our answer: The best precision and acquisition rate in its class.
The new R&S®RTO model is a powerful solution for developing digital, analog and RF designs. The extremely low-noise frontend offers the full measurement bandwidth of 4 GHz even at the smallest scaling (1 mV/div). The dynamic range (ENOB > 7 bit) is outstanding, as is the acquisition rate of 1 million waveforms per second. Fast FFT analysis, high dynamic range and a maximum bandwidth of 4 GHz also make the new R&S®RTO ideal for frequency domain measurement.

For more information, visit www.scope-of-the-art.com/ad/faq-rto4

See us at IMS Booth 2415

ROHDE&SCHWARZ


DaisyRS
Remote Solutions

PORTABLE
POWER
METER

Innovative. Convenient. Practical.

The RS2026 Portable
Power Meter is the
first of its kind.

- Portable, lightweight and self-contained operation requiring no computer or other hardware.
- Easy and convenient to use
- Quick measurement and exceptional performance
- Wireless interface with 2.4 GHz SM band and a range of up to 100 meters
- HandHeld and Remote units are battery powered or by Micro USB cable.

DaisyRS, Inc.
2095-60 Ringwood Ave.,
San Jose, CA 95131
(408) 273-3735
www.daisyrsi.com

true anomaly v represents the angle of the satellite in its orbit referenced to the perigee, the orbital point at the shortest distance to the Earth. The semi-major axis of the orbit a and the eccentricity e define the shape of the elliptical orbit and are determined by the location of and the direction in which the satellite is released from its space shuttle.

However, Equation 3 does not describe the motion of the satellite precisely, since ambiguities are caused by the solar and lunar gravitational forces and by the fact that the Earth is not perfectly spherical. This is the reason why GPS and Galileo control stations upload an up-to-date version of the satellite's Keplerian orbit parameters, e.g., a and e, usually every two hours.

After locating the satellite in its orbit, the argument of the perigee w, the longitude of the ascending node Ω and the inclination of the orbit i are used to transform the position of the satellite to ECI using a set of rotations as shown in Figure 6. These parameters are transmitted by GPS and Galileo satellites as part of the ephemeris message.

GLONASS satellites, on the other hand, do not transmit any Keplerian parameters in the ephemeris of the navigation message. They simply transmit the location and the velocity of the satellite at a specific epoch in ECEF.

Rotating the differential Equation 4 from ECI to ECEF and updating it to take into account the spherical harmonics and the gravitational forces of the sun and the moon would allow the UE to estimate the position of the satellite in a time span of 30 minutes around the reference epoch. Fourth-order Runge-Kutta numerical methods are usually used by GLONASS receivers to determine the position of the satellite in a span of 30 minutes based on the motion differential equation and the location and velocity of the satellite in ECEF at the reference epoch. The solar/lunar gravitational accelerations in ECEF are also transmitted as part of the ephemeris of GLONASS satellites.

APPLICATIONS

Different types of GNSS receivers are used, depending on the precision required by the specific application. To understand these applications, it is important first to understand the generic functionality of the different hardware and software modules of a GNSS receiver. The three basic functionalities of a GNSS receiver are described below.

Acquisition: The receiver uses open loop circuits to search for the Doppler frequency and the approximate code phase for every visible satellite if enough acquisition channels are available in the device. The code phase search window for GPS is 1023 chips, for GLONASS 511 chips and for Galileo 4092 chips. These are the lengths of the corresponding spreading code of the respective GNSS. The search resolution is usually ½-chip, which maps to around 150 m in GPS, since the chip rate of the coarse acquisition (CA) civilian signal is 1.023 MHz.

The search window for the Doppler usually has a resolution of 50 Hz. Signals are acquired on a per-channel basis, and the up to ½-chip phase-ambiguous signal is passed to the code and carrier tracking loops to achieve perfect signal locking, thereby removing code-phase and frequency ambiguities.

Tracking: The code phase acquired from an acquisition channel has a maximum error of ½-chip (150 m in GPS). The code phase is tracked in a delay locked loop (DLL), which utilizes the special correlation properties of GNSS signals to track and lock the code phase. Locking the carrier phase usually happens in a phase locked loop (PLL). The two tracking circuits are interconnected, since the DLL requires that the PLL eliminate the Doppler shift, while the PLL requires that the DLL provide perfect correlation. Like acquisition, signals are also tracked on a per-channel basis. It would not be possible to track a signal without an acquisition stage that initializes the DLL and PLL, thereby allowing them to converge when tracking the GNSS signal of a specific satellite.

Navigation: The navigation algorithm makes use of all the CDMA code-phase and carrier-phase readings (depending on the application) to calculate the position of UE.

STANDARD GNSS

Standard GNSS receivers usually operate on one frequency band, the

TINY TOUGHEST MIXERS UNDER THE SUN

0.2" x 0.18"

Rugged, tiny ceramic SIM mixers *from* $4.95 *ea. qty. 1000* offer unprecedented wide band, high frequency performance while maintaining low conversion loss, high isolation, and high IP3.

Over 21 models IN STOCK are available to operate from an LO level of your choice, +7, +10, +13, and +17 dBm. So regardless of the specific frequency band of your applications, narrow or wide band, there is a tiny SIM *RoHS* compliant mixer to select from 100 kHz to 20 GHz. Built to operate in tough environments, including high ESD levels, the SIM mixers are competitively priced for military, industrial, and commercial applications. Visit our website to view comprehensive performance data, performance curves, data sheets, pcb layouts, and environmental specifications. And, you can even order direct from our web store and have it in your hands as early as tomorrow!

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

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

Mini-Circuits®
ISO 9001 ISO 14001 AS9100
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

YONI2® ***The Design Engineers Search Engine*** *finds the model you need, Instantly* • For detailed performance specs & shopping online see **minicircuits.com**
U.S. Patents
7739260, 7761442

IF/RF MICROWAVE COMPONENTS

428 rev H

Dare to Compare!

QUIET!

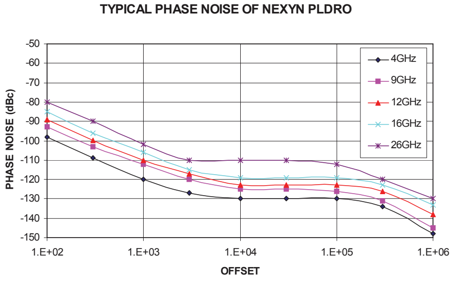
Now Delivering

and PRECISE

OCXO, PLXO

Phase Locked & FR DROs

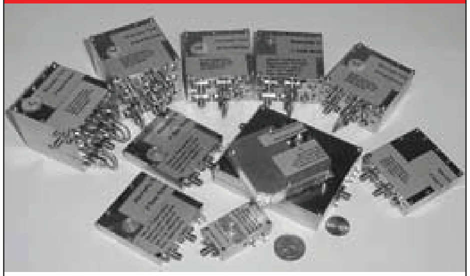
New Products! *Details on website*



Typical Phase Noise at 14 GHz

100 Hz	- 88 dBc/Hz
1 KHz	-109 dBc/Hz
10 KHz	-119 dBc/Hz
100 KHz	-120 dBc/Hz
1 MHz	-135 dBc/Hz

- Reliable and Rugged Design
- Extremely Low Microphonics
- 5-500 MHz External Reference
- Frequency: **3 to 30 GHz**
- Power output: +15 dBm
- Spurious: < -80 dBc
- -55 to +85 C (temp range)
- **Int. Ref. Stability to +/- 0.05 ppm**
- Now offering PLO .3 to 3 GHz
- Low Noise crystal reference
- **Dual Loop Output Frequency to nearest KHz w/ Ext. 10 MHz Ref**



We have moved!

Nexyn

Nexyn Corporation
1287 Forgewood Ave.
Sunnyvale, CA 94089

Tel: (408) 962-0895
Fax: (408) 743-5354
Visit our website at **www.nexyn.com**

Excellent Technical Support
Guaranteed Performance and
Competitive Pricing

L1/E1 band. GLONASS enhances GPS receivers by increasing the probability to find at least four satellites at a LOS. The precision of standard GNSS receivers is around 10 m.

A-GNSS

The calculation of a satellite position requires decoding the navigation message. It takes 30 s in GPS to decode one frame containing an ephemeris set, and the receiver cannot get a position fix before decoding the first three subframes (18 s) of a GPS page. As a result, it takes a long time to get a location fix when booting a GNSS receiver. Using A-GNSS, a mobile communications downlink such as CDMA2000 transmits the ephemeris navigation information to the UE, thereby minimizing the time needed by the UE to get a fix to around 1 s.

Additionally, in the UE-assisted mode of A-GNSS, the mobile phone works as a sensor and thus only acquires and tracks code and carrier phases. An assisted server is responsible for locating the UE on the basis of the reported tracking observations from the UE to a base station (BS). The BS, e.g. LTE BS, transmits some acquisition assistant data to the UE prior to the measurement. This data is used by the UE to reduce its code and carrier phase search windows, thereby minimizing the acquisition effort and consequently accelerating the acquisition process of the GNSS sensor.

The acquisition assistant data is simply the acquired code phase and carrier phase or frequency read from a GNSS receiver located at the BS tower. The UE initializes its acquisition code and frequency search windows around the values transmitted by the BS and in this way reduces the size of the acquisition search windows depending on the maximum BS coverage radius.

DIFFERENTIAL GNSS

As expressed in the generic channel Equation 3, two of the most significant factors affecting the accuracy of determining the position of a satellite are the ionosphere and satellite clock correction ambiguities. The vector (baseline) from a static reference point – which is at a close proximity to the user – to the UE can be determined by simply processing the tracking readings or the ionosphere delay as well as the satellite clock error of the static reference point at the UE. This makes it possible to eliminate the similar ambiguities in the ionosphere and satellite clock and thus improve the performance of GNSS to 1 m. The transmitted correction data is called differential data. GNSS performance can increase even more if carrier phase readings are additionally used.

Differential corrections are usually transmitted using regional navigation satellite systems, which are also called satellite-based augmentation systems (SBAS). The best known SBAS is the American WAAS providing D-GPS service to North America.

MULTIPLE FREQUENCY GNSS

Satellites sometimes transmit the same signal on different bands, e.g., GPS on L1 and L2. By combining tracking readings from L1 and L2, it is possible to remove the ionosphere ambiguities. This is because the ionosphere deflection from the LOS is inversely proportional to the square of the carrier frequency. As a result, GNSS performance can be improved to the range of 5 m.

CONCLUSION

Although many advanced applications such as multiple frequency GNSS and differential GNSS can improve the performance of GNSS receivers significantly, the commercial solutions are still heavily limited to standard GNSS and A-GNSS because they are easy to implement. In the future, the market trend will continue to move toward combining GNSS signals on common bands such as L1/E1 to increase satellite availability in urban areas. ■

Reference

1. E. Kaplan and C. Hegarty, *Understanding GPS: Principles and Applications*, Artech House, 2006.

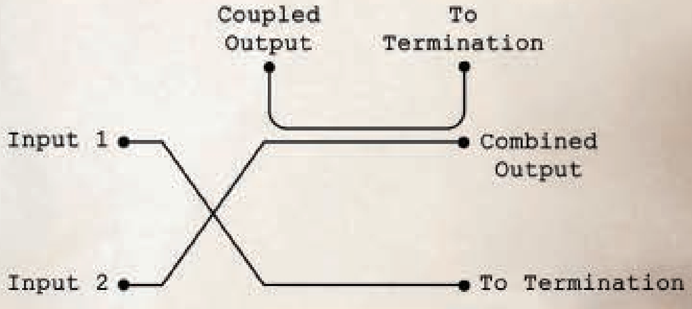
Rachid El Assir *received his bachelor's degree in electrical engineering from the American University of Beirut in 2003 and his master's of science degree in communications engineering from Munich Institute of Technology in 2005. Since then he has been working on the baseband development of Rohde & Schwarz state of the art signal generators. El Assir currently leads the development of the global navigation satellite systems (GNSS) program on vector signal generators.*

Coupling Redefined

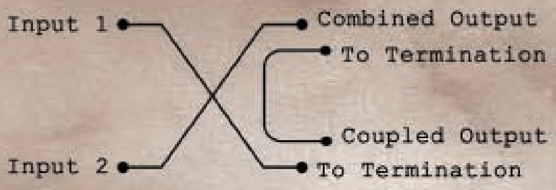
Doupler™ (dŭ'-pler)

Noun:

(Engineering / Electrical Engineering) a device that combines amplifier outputs and samples power, single device with one half typical insertion loss and smaller footprint.

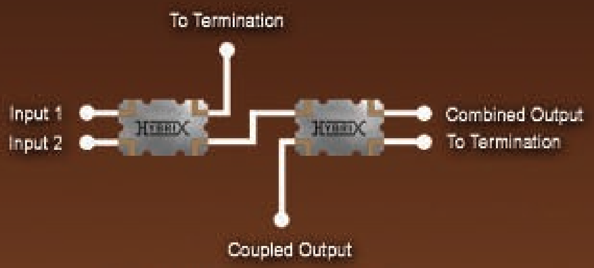


Previous Implementation



Doupler™ Implementation

Doupler ™ Part Number	Frequency	Architecture Power Combining	Power Monitoring	Launch Date
DHDL20F	2110 - 2170 MHz	3-dB Hybrid	20-dB Directional	Available Now
DHDK20F	1930 - 1990 MHz	3-dB Hybrid	20-dB Directional	Available Now
DHDL20F	1805 - 1880 MHz	3-dB Hybrid	20-dB Directional	Available Now
DDDP30F	2500 - 2700 MHz	Doherty Combiner	30-dB Directional	April 2012
DDDL30F	2110 - 2170 MHz	Doherty Combiner	30-dB Directional	April 2012
DDDP20F	2500 - 2700 MHz	Doherty Combiner	20-dB Directional	May 2012
DDDL20F	1805 - 1880 MHz	Doherty Combiner	20-dB Directional	May 2012
DDDV30F	700 - 800 MHz	Doherty Combiner	30-dB Directional	May 2012
DHDD30F	925 - 960 MHz	3-dB Hybrid	30-dB Directional	June 2012
DHDT30F	869 - 894 MHz	3-dB Hybrid	30-dB Directional	June 2012
DHDV30F	700 - 800 MHz	3-dB Hybrid	30-dB Directional	June 2012



Previous Implementation

Doupler™ Implementation

FLORIDA RF Labs

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

See us at IMS Booth 1704

MICROWAVE JOURNAL REVIEWED EDITORIAL BOARD

Non-Uniform Defected Microstrip Structure Lowpass Filter

A defected microstrip structure (DMS) has properties similar to a defected ground structure (DGS), but without any leakage through the ground plane. In this article, new lowpass filters with ultra-wide stopband, using non-uniform DMS that is beneficial to higher order harmonic suppression, are presented. A comparison is made to lowpass filters using standard 50 Ω microstrip lines and stepped-impedance microstrip lines. The proposed lowpass filters have the advantages of good frequency selectivity, ultra-wide stopband and simple circuit topology and it shows that the proposed filter, with stepped impedance microstrip line, has better out of band suppression and enhanced return losses than that with a uniform microstrip line and, simultaneously, the DMS units are smaller, which decrease the circuit size. The validity of the design is demonstrated by experiment.

Currently, the defected ground structure (DGS)[1-4] has been widely employed for RF circuit design and improving RF components performance. DGS increases the effective capacitance and inductance of a microstrip line. It is more efficient for harmonic suppression, especially when using periodical DGSs,[4] which results in a greatly improved stopband, because the EM field is highly concentrated under the microstrip line (ML). However, DGS introduces wave leakage through the ground plane, which brings difficulties with encapsulation.

Compared with DGS circuit, the defected microstrip structure (DMS)[5-7] has no enclosure problems, because there is no leakage through the ground plane. DMS is easier to integrate with other microwave circuits and has an effectively reduced circuit size compared with DGS. Simultaneously, DMS exhibits the properties of slow-wave, rejecting microwaves at certain frequencies and has an increasing electrical length for certain circuits, which are similar to DGS, but without any manipulation of the ground plane. The defection in the microstrip line creates resonance characteristics in the frequency response.

Lowpass filters reject the higher harmonics and spurious responses of circuits, which plays a very important role in RF circuits and systems. The conventional implementation of a lowpass filter (LPF) involves the use of open stubs or stepped impedance microstrip lines. However,

Jian-Kang Xiao
Xidian University, Xi'an, China
State Key Laboratory of Millimeter Waves, Nanjing, China
Wen-Jun Zhu
Hohai University, Changzhou, China

EWT

Where Performance Counts

Bandpass • Bandreject • Highpass • Lowpass • Transmit • Receive • Duplexers • Multiplexers

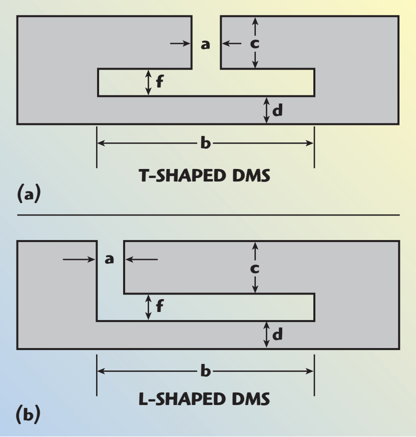
Military • Commercial
Wireless • Space

Eastern Wireless TeleComm understands just how much is on the line with each and every product we make. We continually provide the highest quality filter products, design support, and service to our customers each and every time. Where Performance Counts, Count on EWT.

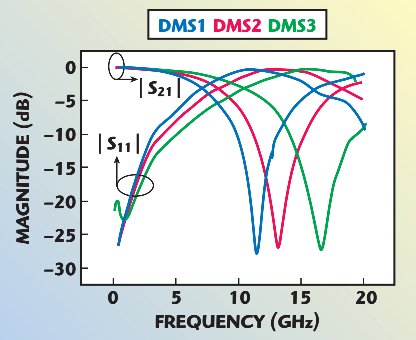
Specializing in custom design and manufacturing of RF and Microwave filters and filter based products to 50 GHz.

www.ewtfilters.com

Eastern Wireless TeleComm, Inc.
Tel: 410.749.3800 Fax: 410.749.4852
sales@ewtfilters.com



▲ *Fig. 1 Defected microstrip structures.*



▲ *Fig. 2 Simulated S-parameter of a 50 Ω microstrip line with a T shaped DMS unit.*

TABLE I

STOP BAND CHARACTERISTICS OF T-SHAPED DMS IN A 50 Ω MICROSTRIP LINE (ε_r=2.2, H=0.8 mm)

	DMS1	DMS2	DMS3
DMS Dimension (mm)	a=f=0.4, b=8	a=f=0.4, b=6	a=f=0.4, b=4
	d=0.93	d=0.93	d=0.93
Cut-off Frequency (GHz)	6.83	8.25	10.4
Attenuation Pole (GHz)	11.2	13.1	16.3

these structures have a gradual cut-off response. The filter rejection characteristic can only be improved by increasing the number of sections, and this method increases the passband insertion loss and the filter's physical size. In the past few years, some new methods, such as complementary split ring resonators (CSRR),[8] and DGS, especially the periodical DGSs,[4] have been applied to LPF design.

In this article, a new technique for developing DMS assisted lowpass filters with ultra-wideband is presented. The conductor plane of a standard 50 Ω transmission line and a stepped-impedance transmission line are perturbed by non-uniform DMS to generate an ultra-wide rejection band that is beneficial to higher order harmonics suppression. New lowpass filters, with good performances of transmission zero and ultra-wide stopband, are designed and a kind of lowpass filter with DMS cells reduction is fabricated and measured. The experimental results demonstrate the validity of the new design.

DEFECTED MICROSTRIP STRUCTURE

A conventional DMS consists of a horizontal rectangular slot and a vertical rectangular slot in the middle of a conductor strip, as shown in ***Figure 1***. The figure also shows an L-shaped DMS, which is also called a spurline. Similar to the DGS, DMS increases the electrical length of the microstrip line and disturbs its current distribution. As a result, the effective capacitance and inductance of the microstrip line increase. Accordingly, the DMS has slow-wave and stopband characteristics, as the simulation shown in ***Figure 2*** demonstrates, and the dimensions as well as the performance of the DMS are shown in ***Table 1***. It shows that the cut-off frequency of the DMS increases, as the dimension b decreases, so new lowpass filters with ultra-wide stopband can be designed by using these characteristics, because non-uniform DMSs extend the stopband greatly. Here, the simulated results are obtained by using a 50 Ω microstrip line with a substrate relative permittivity of 2.2 and a thickness of 0.8 mm. The DMS may have more obvious stopband performance by using a substrate with higher permittivity. The electrical performances of stopband for DMS can be simulated by a parallel LC resonant circuit,[9] and the equivalent circuit of a DMS matches the response of the 1st Butterworth lowpass prototype, as ***Figure 3*** shows. Where:

$$C = \frac{\omega_c}{Z_0 g_1} \cdot \frac{1}{\omega_0^2 - \omega_c^2},$$

$$L = \frac{1}{4\pi^2 f_0^2 C} \qquad (1)$$


SAW Modules

SAW for Defense & Space

Integrated Microwave Assemblies for IF signal processing with SAW's exceptional performance:
- state-of-the-art design
- high freq selectivity
- high dynamic range
- MIL & space qual
- minimal SWaP

Radar
Space
Communications
Electronic Warfare

PHONON CORPORATION

90 Wolcott Rd. Simsbury, CT 06070 (860) 651-0211 www.phonon.com/mod

Ultra Low Noise OCXO Solutions

for the Most Demanding Applications

ONYX IV Series Crystal Oscillators

Small lightweight ruggedized OCXO features low phase noise, good temperature stability and low g-sensitivity. Designed for PCB mount applications for excellent phase noise performance during vibration.

- **5 MHz to 130 MHz (fixed frequency)**
- **Ruggedized/Low Cost/High Performance**
- **Low Phase Noise Floor to -176 dBc/Hz**
- **G-Sensitivity to 2E-10/g per axis**
- **Light Weight < 30 grams**
- **PCB Mount Package: 1” x 1” x 0.5”**

Citrine Series Crystal Oscillators

This ruggedized OCXO can be configured to meet most demanding static and dynamic environment applications for frequencies up to 650 MHz. Both Standard and Ultra Low Noise phase noise options are available.

- **5 MHz to 650 MHz (fixed frequency)**
- **Low Phase Noise Floor to -190 dBc/Hz**
- **G-Sensitivity to 2E-10/g per axis**
- **Vibration Isolated Option**
- **Dual Output or High Output Level to +21 dBm**
- **Phase Lock Option**
- **Machined Aluminum Housings from 2” x 2” x 0.7”**

MXO - Multiplied Crystal Oscillators

One or more low noise multiplier stages are combined with Wenzel’s industry leading ULN crystal oscillator. This Integrated Microwave Assembly (IMA) can be configured to any fixed frequency between 200 MHz and 12 GHz. Base oscillator frequency output, multiple outputs along the multiplier string and phase locking capability are some common options.

- **200 MHz to 12 GHz (fixed frequency)**
- **Exceptional Phase Noise**
- **Excellent Spectral Purity**
- **Phase Lock Option**
- **High Output Power Level Option**
- **Base Oscillator and Multiple Output Options**
- **Machined Aluminum Housings from 2.5” x 4” x 1”**

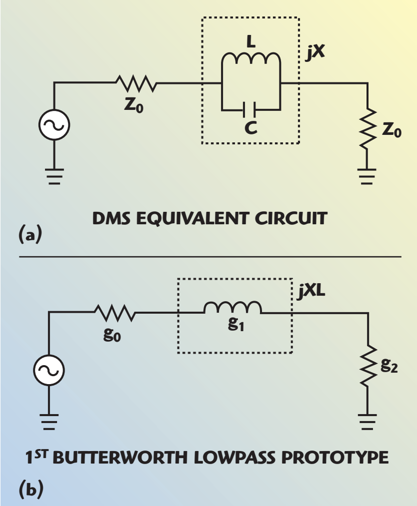
Come Visit Us at The IMS / MTT-S Show, Montreal, Canada - **Booth #3112**

Wenzel Associates, Inc.
2215 Kramer Lane - Austin, Texas
512-835-2038 - sales@wenzel.com
www.wenzel.com

CROVEN CRYSTALS
Wenzel International, Inc.
500 Beech Street - Whitby, Ontario, Canada
905-668-3324 - crovensales@crovencrystals.com
www.crovencrystals.com

Here, ω_0 and ω_c denote the resonant frequency and cut-off frequency of the parallel LC resonator, respectively, Z_0 is the characteristic impedance, and g_1 is the normalized parameter of the first Butterworth lowpass prototype.

Calculated variation curves of the external quality factor Q_e, versus DMS parameters a, c and f are shown in ***Figures 4*** to ***6***, respectively. It shows that for a T-shaped DMS, Q_e has no obvious variation with parameters a increasing, while Q_e increases greatly with parameter a increasing. For L-shaped DMS, Q_e increases with parameter a increasing, while it decreases with parameter a increasing. Both have adequate Q values.

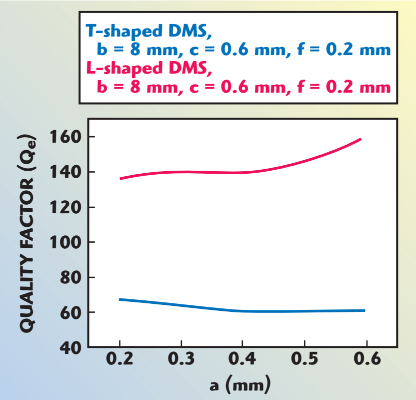


▲ *Fig. 3 Equivalent circuit of the DMS and Butterworth lowpass prototype.*

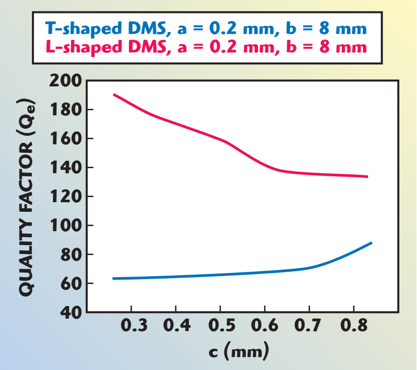
NON-UNIFORM DMS LOWPASS FILTERS

Lowpass filter with L-shaped DMS

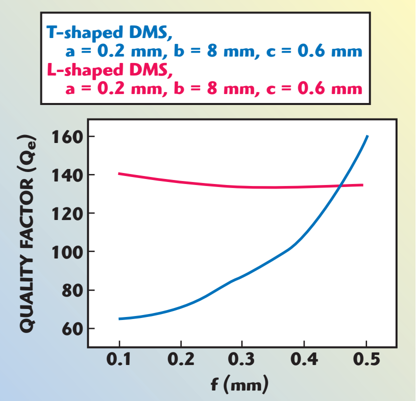
In order to demonstrate a lowpass filter with ultra-wide stopband imple-



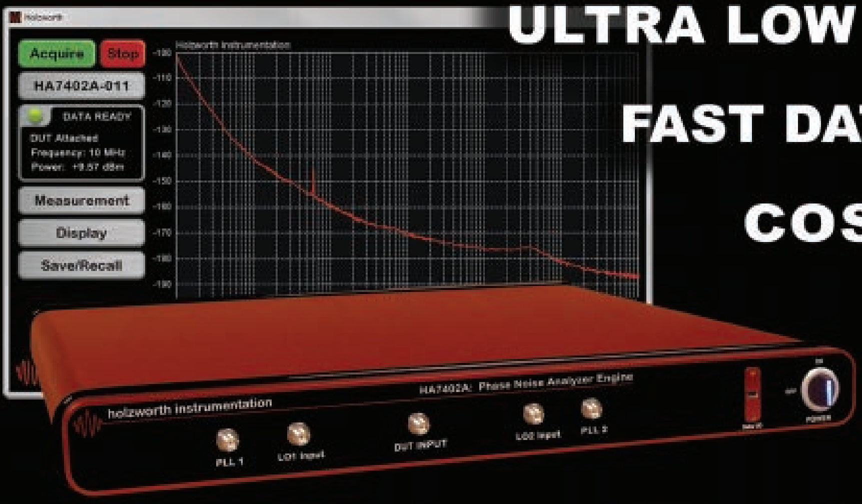
▲ *Fig. 4 Q_e vs. parameter a for T-shaped and L-shaped DMS.*



▲ *Fig. 5 Q_e vs. parameter c for T-shaped and L-shaped DMS.*



▲ *Fig. 6 Q_e vs. parameter f for T-shaped and L-shaped DMS.*



DECISIONS, DECISIONS...

Holzworth PHASE NOISE ANALYZERS make it easy.

ULTRA LOW NOISE FLOORS

FAST DATA ACQUISTION

COST EFFECTIVE

INTUITIVE GUI

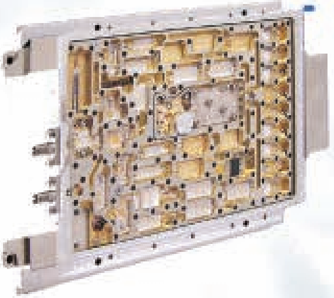
RELIABLE

Experience a live demo at IMS booth 2926. Bring your DUT!

holzworth
instrumentation

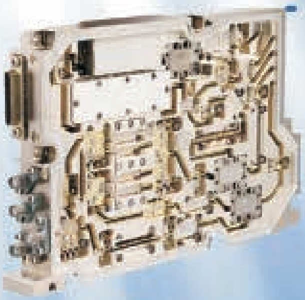
phone: +1.303.325.3473
www.holzworth.com

RF AND MICROWAVE HIGH DENSITY SUBSYSTEMS AND SYSTEMS



CUSTOMIZED MICROWAVE MODULES 0.5-50 GHz

- RF Multilayer Technology
- 20-30 Layers, each with a Different ε_r
- Dual Side RF Board
- Mixed RF, IF and Digital Functions and Integration



SUPER HETERODYNE RECEIVER (S.H.R)

- RF Input: 0.5-18 GHz
- Triple Down Conversion
- Phase Tracking (Pairs): ±4°
- Spurious Free Dynamic Range: -45 dBc

MILLIMETER-WAVE DUAL INPUT DOWN CONVERTER

- Wide Band Coverage: 18-40 GHz
- IF Frequency Range: 2-16.5 GHz
- High Input Dynamic Range
- High Input Power Protection
- Internal mmW BIT Generators
- Two Receiving Antennas Support

HIGH POWER AMPLIFIERS

- Solid State Architectures (GaN etc.)
- 1 MHz - 3000 MHz Up to 2000 W
- Amplifiers & OPUs
- Digital Full Status Monitoring

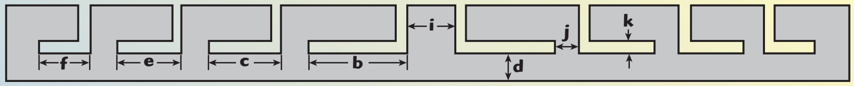
Elisra Microwave has over 45 years of proven experience in supplying best of class components and Multi-function integrated assemblies for a wide variety of RF and microwave applications up to 50 GHz

- Customized Multi-function Integrated Assemblies up to 50 GHz
- Solid State Amplifiers LNA & HP up to 18GHz
- PIN Diode Control Devices
- Frequency Synthesizers 0.5-18GHz

See us at IMS Booth 519

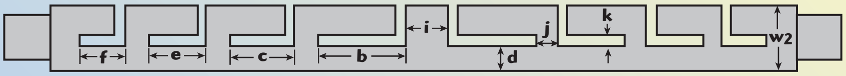
Elbit Systems
EW and SIGINT - Elisra
Operations and MW Business Line
(Formerly elisra)

48 Mivtza Kadesh St. Bene Beraq, 51203 Israel. Tel. 972(3)617-5655, Fax. 972(3)617-5299, Email: tim1@elisra.com, www.mw-elisra.com



With 50 Ω uniform microstrip line, b = 5 mm, c = 4 mm, d = 1.03 mm, e = 3 mm, f = 2 mm, i = 7 mm, j = 0.5 mm, k = 0.4 mm

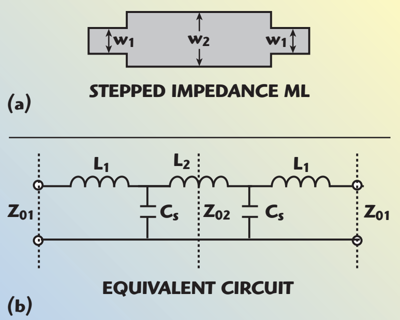
(a)



With stepped impedance microstrip line, b = 5 mm, c = 4 mm, d = 0.8 mm, e = 3 mm, f = 2 mm, i = 7 mm, j = 0.5 mm, k = 0.4 mm, w_2 = 3 mm

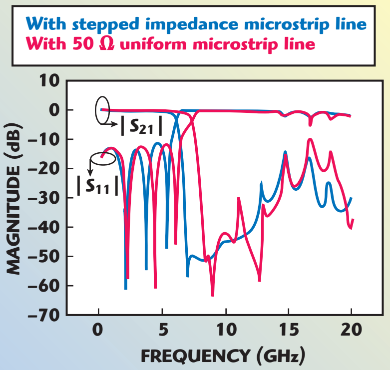
(b)

▲ *Fig. 7 L-shaped DMS lowpass filters.*

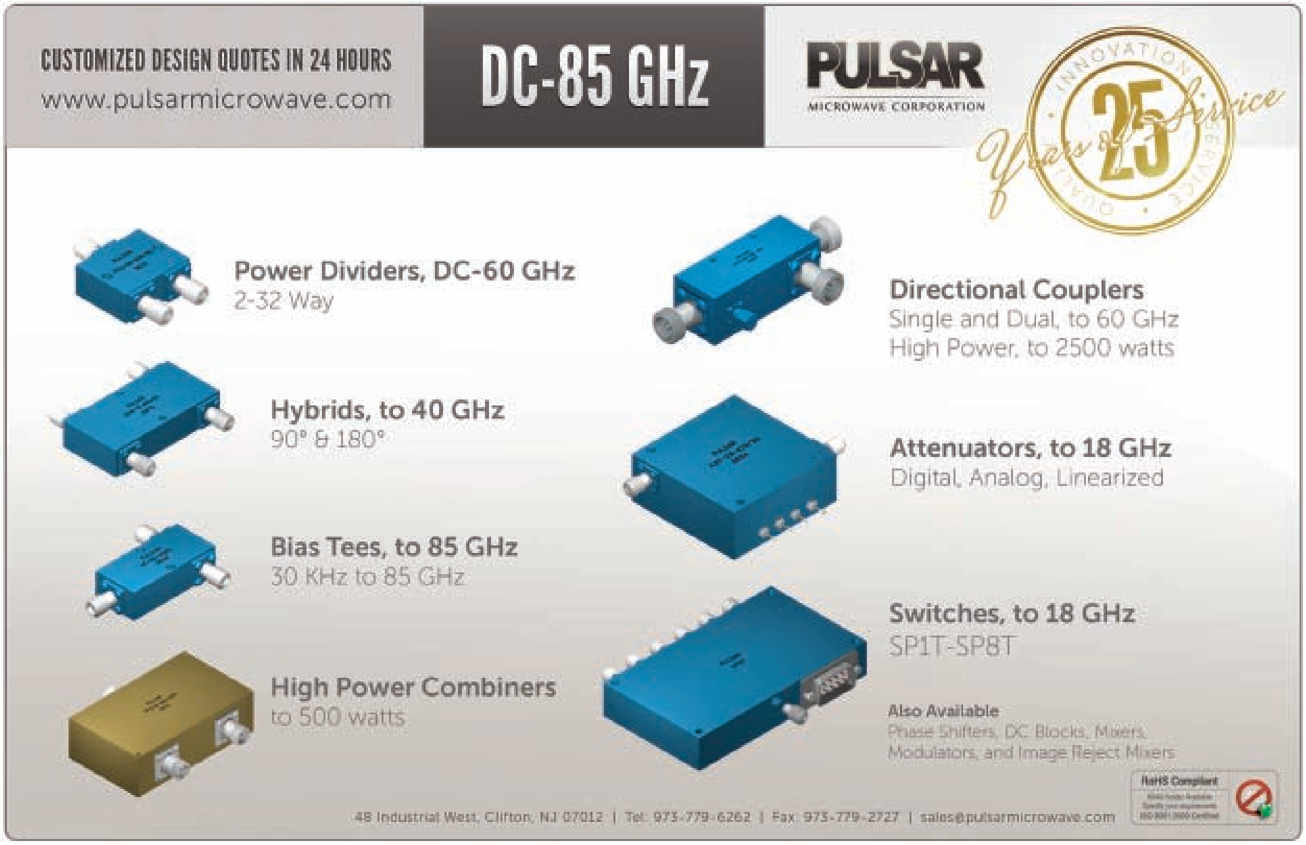


▲ *Fig. 8 Stepped impedance ML and equivalent circuit.*

mentation, L-shaped and T-shaped DMS lowpass filters with non-uniform cells are proposed and are designed on Duroid substrates with a relative permittivity of 2.2 and a thickness of 0.8 mm. All the filters are symmetrical structures. The L-shaped DMS lowpass filters with 50 Ω microstrip line (ML) and stepped impedance microstrip line are shown in **Figure 7(a)** and **(b)**, respectively, and the equivalent circuit model of the stepped impedance ML is shown in **Figure 8**, where Z_{01} and Z_{02} can be calculated as 50 Ω and 43.73 Ω, respectively. **Figure 9** shows the simulated frequency responses of the lowpass filter. It can be seen that with a 50 Ω uniform ML, the filter has a cut-off frequency of 7.3 GHz, while the filter has a lowered cut-off frequency of 6.12 GHz with the stepped impedance ML. Both have good frequency selectivity and ultra-wide stopband of more than 12.7 GHz, which is 1.6 times the cut-off frequency. Calculated variation curves of the cut-off frequency versus the filter parameter d are shown in **Figure 10**. It shows that the cut-off frequency increases with d increasing



▲ *Fig. 9 Simulated frequency responses of the lowpass filter with eight L-shaped DMS cells.*


CUSTOMIZED DESIGN QUOTES IN 24 HOURS
www.pulsarmicrowave.com
DC-85 GHz
PULSAR MICROWAVE CORPORATION
25 Years of Service
Power Dividers, DC-60 GHz
2-32 Way
Directional Couplers
Single and Dual, to 60 GHz
High Power, to 2500 watts
Hybrids, to 40 GHz
90° & 180°
Attenuators, to 18 GHz
Digital, Analog, Linearized
Bias Tees, to 85 GHz
30 KHz to 85 GHz
Switches, to 18 GHz
SP1T-SP8T
High Power Combiners
to 500 watts
Also Available
Phase Shifters, DC Blocks, Mixers, Modulators, and Image Reject Mixers
RoHS Compliant
48 Industrial West, Clifton, NJ 07012 | Tel: 973-779-6262 | Fax: 973-779-2727 | sales@pulsarmicrowave.com

Microsemi

Our Gallium Nitride (GaN) amplifier products employ the latest semiconductor technologies and present the very best performance to our customers. Gallium Nitride (GaN) technology, coupled with our chip and wire die level expertise maximize power added efficiency and high power density characteristics of GaN in small convenient packages. Multi-octave amplifiers and application specific narrow band amplifiers cover frequencies to 18 GHz. GaN amplifiers operate with voltages between +28VDC to +50VDC (design dependent). Catalog designs offer power levels up to 100 Watts; custom designs to 200 Watts are available.

GaN Power Amplifiers

Model Number	Frequency (GHz)	Gain (dB min)	Psat (dBm min)	Psat (dBm typ)	Psat (Watts typ)	Voltage (V) Current (A)	PAE	ECCN
AML056P4013	0.5 - 6.0	40	35	36	4	28V, 0.75A	22%	EAR99
AML056P4014	0.5 - 6.0	40	37	38	6	28V, 1.0A	20%	EAR99
AML056P4511	0.5 - 6.0	45	39	40	10	28V, 1.3A	25%	EAR99
AML056P4512	0.5 - 6.0	45	43	44	25	40V, 2.7A	23%	EAR99
AML13P5013	1.0 - 3.0	50	46	47	50	28V, 4.8A	25%	EAR99
AML26P4011	2.0 - 6.0	40	40	41	12	28V, 1.5A	30%	EAR99
AML26P4012	2.0 - 6.0	45	43	44	25	28V, 3.0A	30%	EAR99
AML26P4013	2.0 - 6.0	50	46	47	50	28V, 6.0A	30%	EAR99
AML59P4512	5.5 - 9.0	45	45	46	40	28V, 4.0A	35%	3A001.b.4.b
AML59P4513	5.5 - 9.0	45	48	49	80	28V, 8.0A	35%	3A001.b.4.b
AML910P4213	9.9 - 10.7	43	37	38	6	32V, 0.5A	30%	EAR99
AML910P4214	9.9 - 10.7	43	39	40	10	32V, 0.8A	30%	EAR99
AML910P4215	9.9 - 10.7	46	41.5	42	15	32V, 1.3A	30%	EAR99
AML910P4216	9.9 - 10.7	46	42	43	20	32V, 1.3A	30%	3A001.b.4.b
AML811P5011	7.8 - 11.0	45	43	44	25	28V, 2.8A	30%	3A001.b.4.b
AML811P5012	7.8 - 11.0	50	46	47	50	28V, 5.5A	30%	3A001.b.4.b
AML811P5013	7.8 - 11.0	50	48	49	80	28V, 11.5A	25%	3A001.b.4.b
AML1416P4511	14.0 - 16.0	45	42	43	20	35V, 3.2A	18%	ITAR
AML1416P4512	14.0 - 16.0	45	45	46	40	35V, 6.2A	18%	ITAR
AML618P4014	6.0 - 18.0	40	39	40	10	32V, 2.8A	12%	ITAR
AML618P4015	6.0 - 18.0	40	42	43	20	32V, 4.9A	12%	ITAR
AML218P4012	2.0 - 18.0	35	37	38	6	32V, 1.5A	13%	ITAR
AML218P4011	2.0 - 18.0	40	39	40	10	32V, 2.8A	12%	ITAR
AML218P4013	2.0 - 18.0	38	42	43	20	32V, 4.9A	12%	ITAR

Features: Fast TTL On/Off (Rise/Fall < 100ns);
Wide operating temperature range: -54° to +85°C (hermetically sealed)

Microsemi Corporation | 1000 Avenida Acaso | Camarillo, CA 93012
Tel: 805-388-1345 | Fax: 805-484-2191 | Email: sales@amlj.com | www.amlj.com

See us at IMS Booth 1424

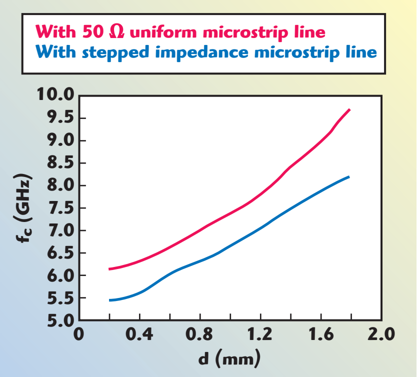


Fig. 10 *Variation of the cut-off frequency vs. parameter d.*

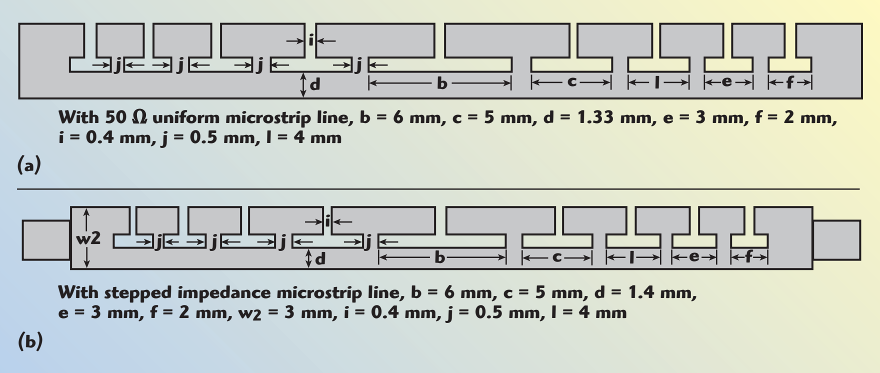


Fig. 11 *T-shaped DMS lowpass filters.*

and the cut-off frequency of the filter with a 50 Ω ML always has a larger value than that with a stepped impedance ML, when they have the same parameter d.

Lowpass filter with T-shaped DMS

Proposed lowpass filters with ultra-wide stopband by using non-uniform T-shaped DMS are shown in ***Figure 11***. Their operation principle is the same as that of the L-shaped DMS filter. The simulated frequency responses of the lowpass filter with 50 Ω microstrip line by using nine T-shaped DMS non-uniform cells are shown in ***Figure 12***. It can be seen that the lowpass filter has transmission zeros, good out of band suppression and an ultra-wide stopband of more than 10 GHz. The filter cut-off frequency decreases with the parameter d decreasing. ***Figure 13*** shows the simulated frequency responses of the lowpass filter with different DMS cells. It can be seen that the lowpass filter with nine DMS cells and seven DMS cells nearly have the same cut-off frequency of approximately 9.45

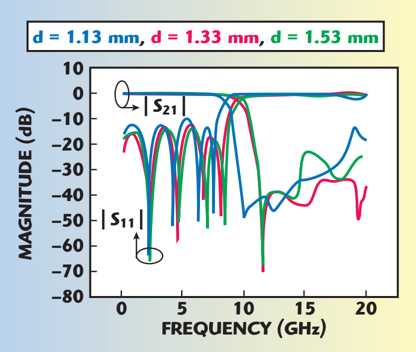


Fig. 12 *Simulated frequency responses of the lowpass filter with 50 Ω microstrip line and nine T-shaped DMS cells.*


One Stop Shop
Integrated Front End Assemblies
- Simplified Contracting
  - One PO
  - One Spec
- Consolidated Supply Chain
- Eliminate System Integration Problems
  - Mechanical Interface
  - RF Interaction
- Optimized Performance
  - Lowest Loss
  - Flattest Phase and Amplitude
  - Minimum VSWR

CMC
Coleman Microwave Company
1-800-563-3449
www.colemanmw.com

See us at IMS Booth 2442

SIZE MATTERS

NEXT GENERATION

POWER AMPLIFIERS

*COTS modules * rack mount amplifiers * multi-function PA solutions*

1163	20-520 MHz, 125 Watt
1189	500-2500 MHz, 100 Watt
1178	2000-6000 MHz, 35 Watt

Certified to ISO 9001:2008
TÜVRheinland
Precisely Right.

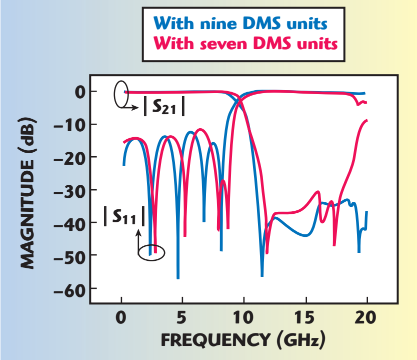
www.EmpowerRF.com

EMPOWER
RF SYSTEMS, INC.

IMS2012
MONTRÉAL

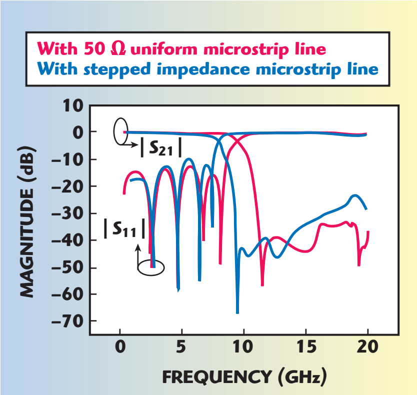
Booth 2203

316 West Florence Ave., Inglewood, CA 90301 USA, Phone: +1(310)412-8100, Fax: +1(310)412-9232



▲ *Fig. 13 Frequency responses of the lowpass filter with seven and nine DMS cells, using a 50 Ω microstrip line.*

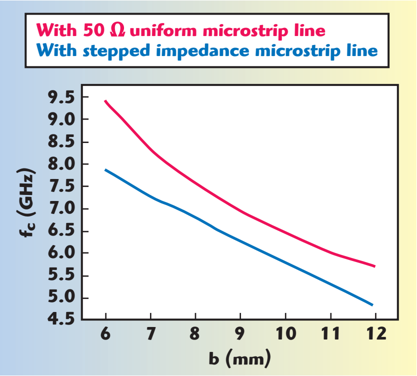
GHz. However, the former has a wider stopband than the later because more non-uniform DMS cells bring a larger reject band range. ***Figure 14*** shows the frequency responses of the lowpass filter with nine DMS cells, using uniform microstrip line and stepped impedance microstrip line. ***Figure 15*** shows the variation curves of cut-off frequency versus the filter physical parameter b. It can be seen that the lowpass filter with stepped impedance ML shows a lower cut-off frequency, which correspondingly introduces a



▲ *Fig. 14 Frequency responses of the lowpass filter with nine DMS cells, using 50 Ω microstrip line and stepped impedance microstrip line.*

wider stopband than that with a 50 Ω uniform ML. It also can be seen that the filter cut-off frequency decreases with the parameter b increasing.

It is known that the stopband is related to the number of DMS cells, and a wider stopband always leads to a larger circuit size. Here, lowpass filters with five T-shaped DMS cells are also designed, in order to reduce the circuit size, as ***Figure 16*** shows. The simulated frequency responses are shown



▲ *Fig. 15 Cut-off frequency vs. parameter b for the lowpass filter with nine DMS cells.*

in ***Figure 17***. It shows that the filter has an ultra-wide stopband of approximately 2.45 times the cut-off frequency of 5.8 GHz and the stepped impedance ML introduces a better out of band suppression and a better passband return loss than the uniform ML. Variation curves of cut-off frequency versus parameters b and d for the lowpass filter with reduced DMS cells are shown in ***Figures 18*** and ***19***, respectively. They show that the cut-off frequency decreases with b increasing, while it increases with d increasing, and a larger

ROCK SOLID

LAB BRICKS

Tower-tested, bench-approved, programmable USB test devices

Signal Generators, Digital Attenuators, Solid State Switches & Hubs to 20 GHz

vaunix

www.vaunix.com

Shop online.

VISA MasterCard AMERICAN EXPRESS

See us at IMS Booth 1129

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

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

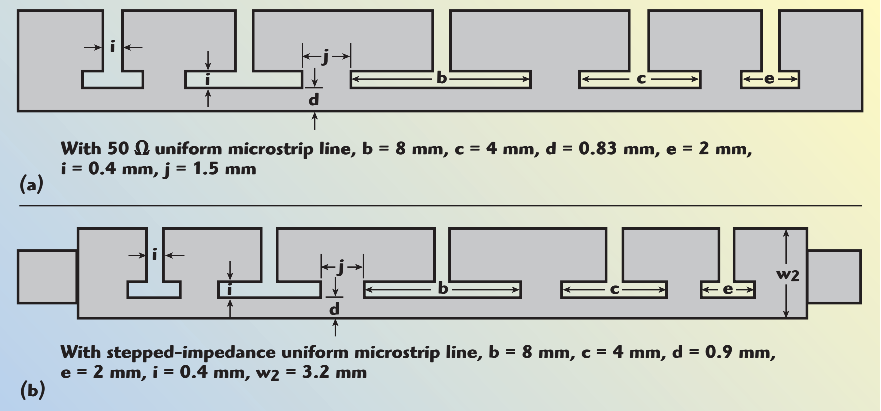
www.rohde-schwarz.com/ad/raptor-spa

See us at IMS Booth 2415

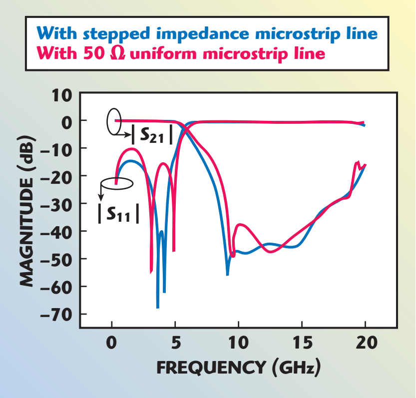
Technological highlights: spectrum analysis

- The only instrument up to 67 GHz (R&S®FSU67)
- Wideband signal analysis with up to 120 MHz bandwidth and deep capture memory
- General-purpose OFDM analyzer
- One-box testing including phase noise and residual phase noise measurements with crosscorrelation up to 50 GHz

ROHDE & SCHWARZ



▲ *Fig. 16 T-shaped DMS lowpass filter with reduced cells.*



▲ *Fig. 17 Frequency responses of the lowpass filter with reduced DMS cells, using 50 Ω and step impedance microstrip lines.*

d introduces a larger difference on filter cut-off frequency between uniform and stepped impedance MLs.

In order to verify the design, a lowpass filter, as shown in Figure 16(b), was fabricated and measured and the hardware, which has a circuit size of no more than 40×3.2 mm is shown in ***Figure 20***. The figure also shows the measured performances, taken with an Agilent E5071C vector network analyzer. The measured results are similar to the simulation. The measured discrepancies are mainly due to the simulation precision and fabrication uncertainty.

CONCLUSION

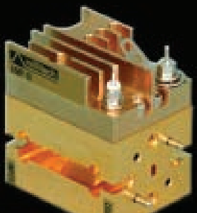
New microstrip lowpass filters, with ultra-wide stopband by using periodical non-uniform DMS, are designed and a comparison between lowpass filters with uniform 50 Ω and stepped-impedance microstrip lines is made. It shows that, with stepped-impedance microstrip line, the filter has enhanced return losses and better out of band suppression. The new design is demonstrated by measurement. Compared with DGS assisted lowpass filter, the DMS lowpass filter has a simpler topology and is easier to fabricate. Most importantly, it has no enclosure problem, because there is no leakage from the ground plane. ■

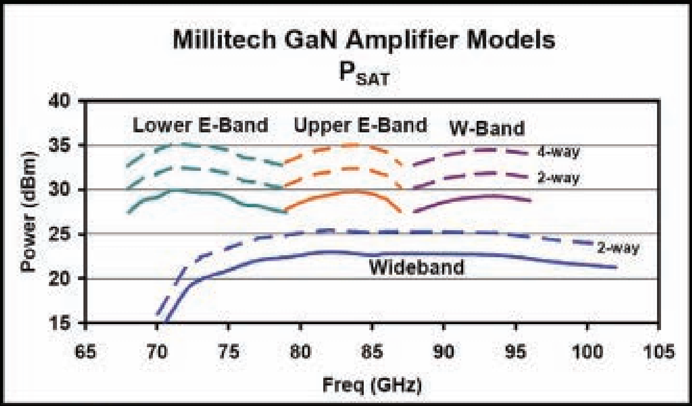
ACKNOWLEDGMENT

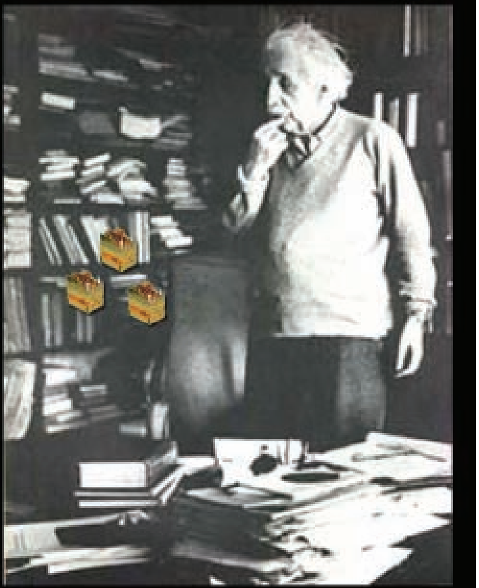
This work was supported in part by the Open Research Fund of China State Key Laboratory of Millimeter Waves (K201107).

A Quantum Leap in Power

Millimeter-Wave GaN
Standard Models up to 3 Watts
Higher Powers available







www.millitech.com

millitech®
Millimeter Wave Technology & Design

See us at IMS Booth 1809

Do you need to replace discontinued instrumentation?

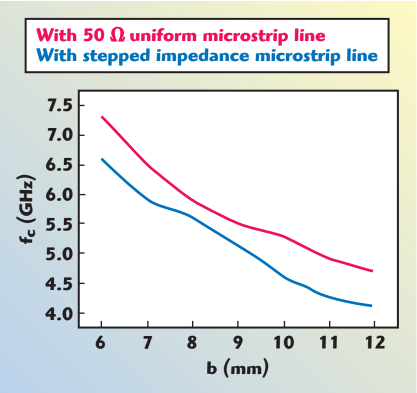
Rohde & Schwarz offers signal generators as well as spectrum and network analyzers that understand the existing code written for your test system.

- Retain your current test system software
- Benefit from our experience in code emulation
- Rely on our long-term support

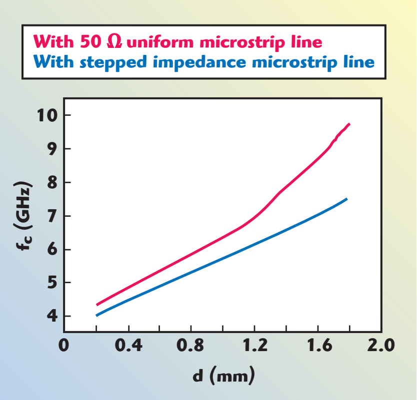
www.rohde-schwarz.com/ad/legacypro

See us at IMS Booth 2415

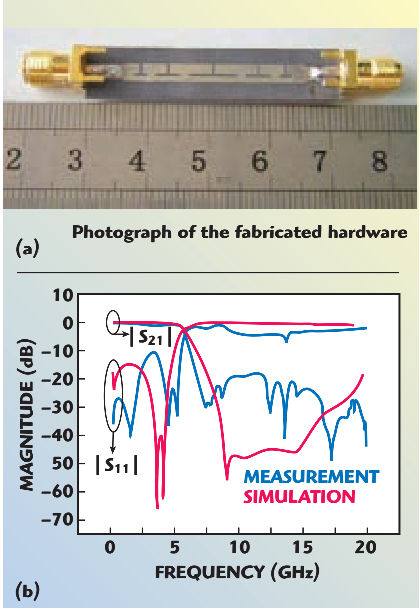
ROHDE&SCHWARZ



▲ *Fig. 18 Cut-off frequency vs. parameter b for the lowpass filter with reduced DMS cells.*



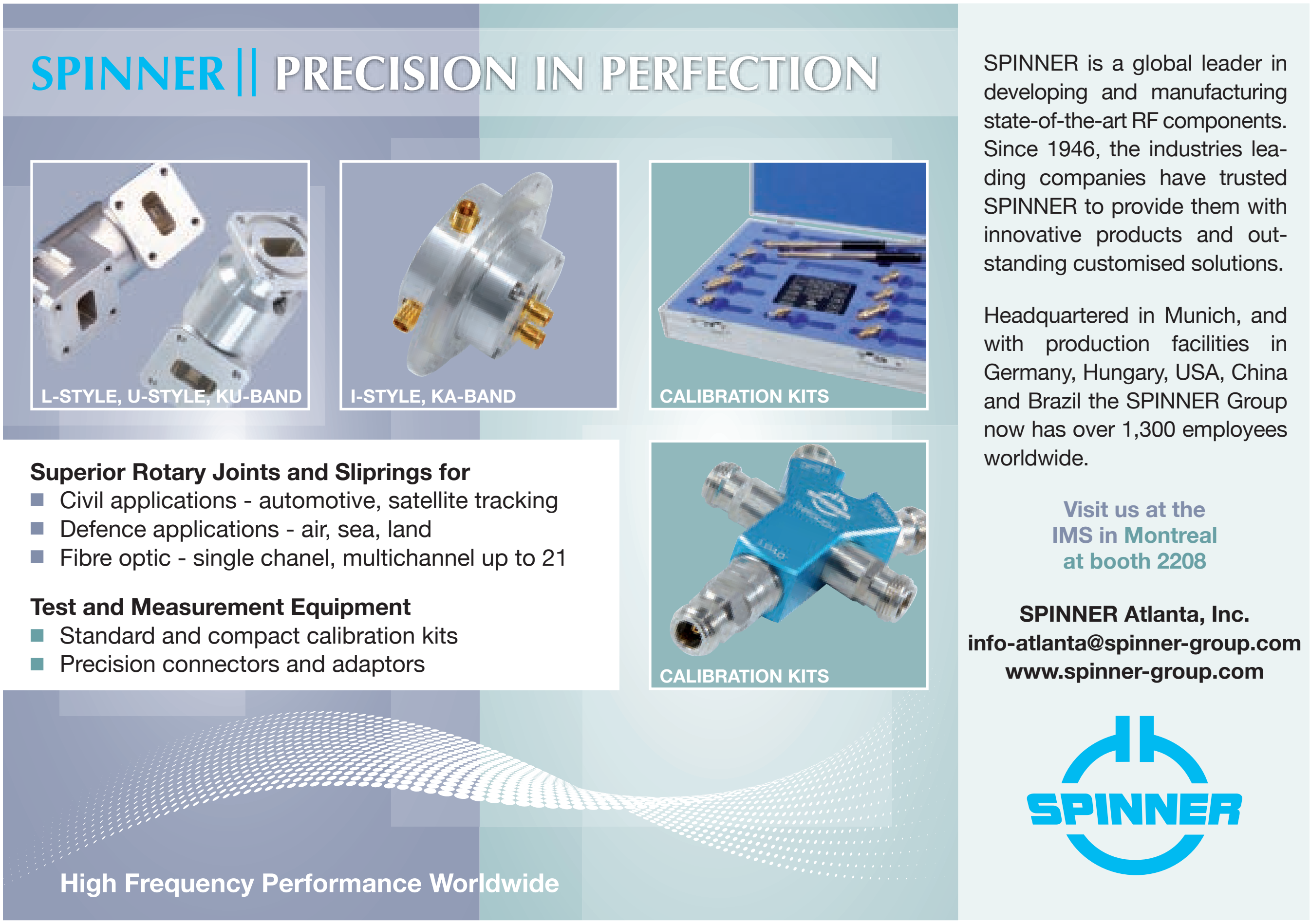
▲ *Fig. 19 Cut-off frequency vs. parameter d for the lowpass filter with reduced DMS cells.*



▲ *Fig. 20 The fabricated filter (a) and its performance (b).*

References

1. C.S. Kim, J.S. Park, D. Ahn and J.B. Lim, "A Novel 1D Periodic Defected Ground Structure for Planar Circuits," *IEEE Microwave Guided Wave Letters*, Vol. 10, No. 4, April 2000, pp. 131-133.
2. D. Ahn, J.S. Park, C.S. Kim, Y. Qian, and T. Itoh, "A Design of the Low-pass Filter Using the Novel Microstrip Defected Ground Structure," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 49, No. 1, January 2001, pp. 86-93.
3. J.S. Lim, C.H. Kim, D. Ahn, Y.C. Jeong and S. Nam, "Design of Low-pass Filters Using Defected Grounded Structure," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 53, No. 8, August 2005, pp. 2539-2545.
4. J.K. Xiao, Y.F. Zhu and J. Fu, "DGS Lowpass Filters Extend Wide Stopbands," *Microwaves & RF*, Vol. 50, No. 3, March 2011, pp. 66-76.
5. S. Zhang, J.K. Xiao, Z.H. Wang and Y. Li, "Novel Low-pass Filters Using Defected Microstrip Structure," *Microwave Journal*, Vol. 49, No. 9, September 2006, pp. 118-128.
6. J.A. Tirado-Mendez and H. Jardon-Aguilar, "Comparison of Defected Ground Structure (DGS) and Defected Microstrip Structure (DMS) Behavior at High Frequencies," *2004 International Conference on Electrical and Electronics Engineering (ICEEE) Digest*, pp. 7-10.
7. J.A. Tirado-Mendez, H. Jardon-Aguilar and F. Iturbide-Sanchez et al, "A Proposed Defected Microstrip Structure (DMS) Behavior for Reducing Rectangular Patch Antenna Size," *Microwave and Optical Technology Letters*, Vol. 43, No. 6, October 2006, pp. 481-484.
8. M.K. Mandal, P. Mondal and S. Sanyal et al, "Low Insertion Loss, Sharp-rejection and Compact Microstrip Low-pass Filters," *IEEE Microwave and Wireless Components Letters*, Vol. 16, No. 11, November 2006, pp. 600-602.
9. J.K. Xiao and W.J. Zhu, "New Bandstop Filter Using Simple Defected Microstrip Structure," *Microwave Journal*, Vol. 54, No. 9, September 2011, pp. 134-144.


SPINNER || PRECISION IN PERFECTION

L-STYLE, U-STYLE, KU-BAND
I-STYLE, KA-BAND
CALIBRATION KITS

Superior Rotary Joints and Sliprings for
- Civil applications - automotive, satellite tracking
- Defence applications - air, sea, land
- Fibre optic - single chanel, multichannel up to 21

Test and Measurement Equipment
- Standard and compact calibration kits
- Precision connectors and adaptors

CALIBRATION KITS

High Frequency Performance Worldwide

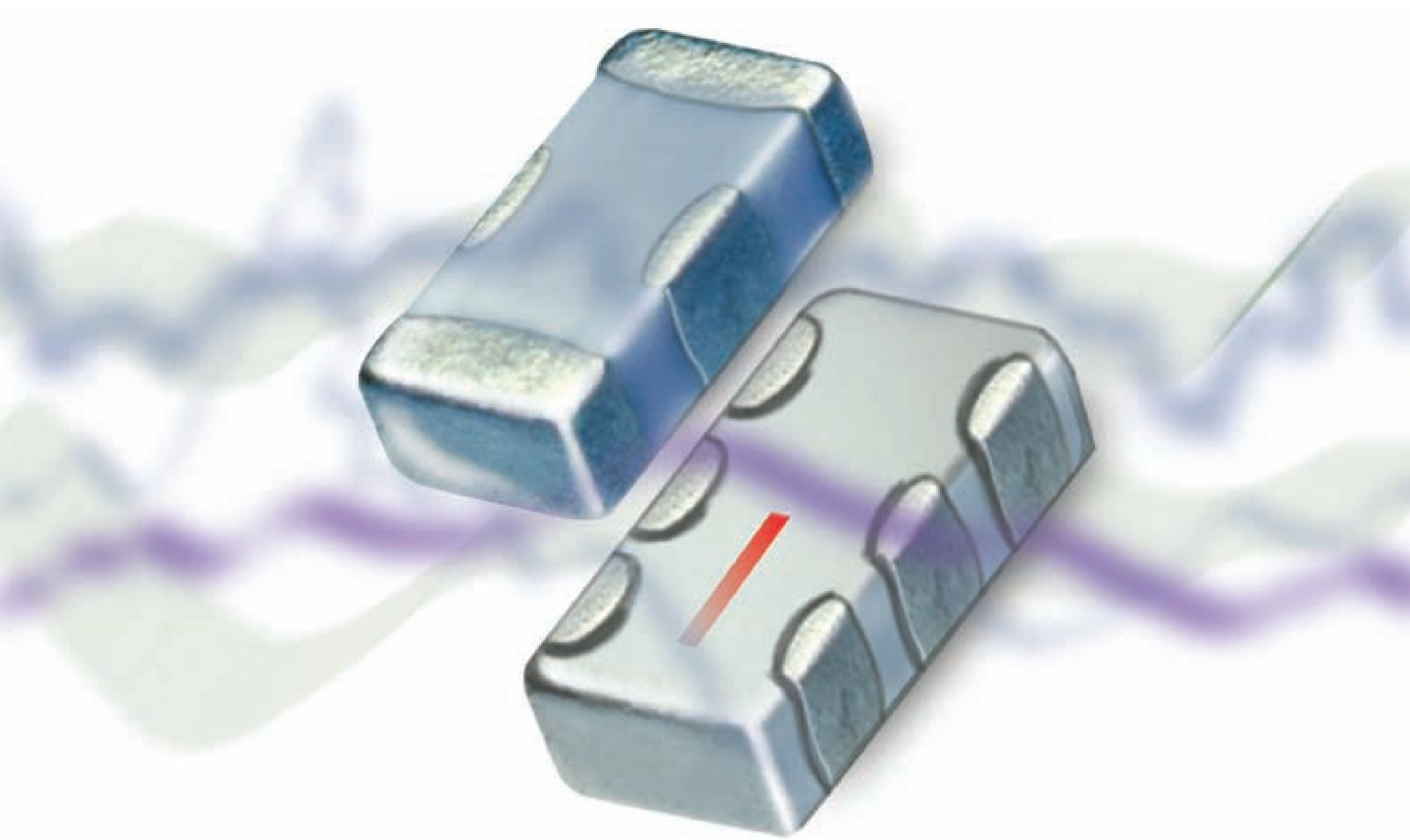
SPINNER is a global leader in developing and manufacturing state-of-the-art RF components. Since 1946, the industries leading companies have trusted SPINNER to provide them with innovative products and outstanding customised solutions.

Headquartered in Munich, and with production facilities in Germany, Hungary, USA, China and Brazil the SPINNER Group now has over 1,300 employees worldwide.

Visit us at the
IMS in Montreal
at booth 2208

SPINNER Atlanta, Inc.
info-atlanta@spinner-group.com
www.spinner-group.com

SPINNER



CERAMIC FILTERS

LOW PASS BANDPASS HIGH PASS

45 MHz to 13 GHz from 99¢ *ea. qty.3000*

Over **167** ***~~141~~ models...only 0.12 x 0.06"*** These tiny hermetically sealed filters utilize our advanced Low Temperature Co-fired Ceramic **(LTCC)** technology to offer superior thermal stability, high reliability, and very low cost, making them a must for your system requirements. Visit our website to choose and view comprehensive performance curves, data sheets, pcb layouts, and everything you need to make your choice. You can even order direct from our web store and have a unit in your hands as early as tomorrow!

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

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

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

Now available in small-quantity reels at *no extra charge:*
Standard counts of 20, 50, 100, 200, 500, 1000 or 2000. Save time, money, and inventory space!

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

Mini-Circuits®
ISO 9001 ISO 14001 AS 9100

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

YONI2® ***The Design Engineers Search Engine*** *finds the model you need, Instantly* • For detailed performance specs & shopping online see **minicircuits.com**

U.S. Patents
7739260, 7761442

IF/RF MICROWAVE COMPONENTS

432 rev S

Cost Effective High Power E- and W-Band Amplifier MMICs

Traditionally, GaAs based technologies capable of providing solutions at E- and W-Band have been limited to three- and four-inch wafer processing techniques with associated higher running costs. These technologies have generally provided excellent performance but with limited acceptance in moderate volume markets due to associated high MMIC component cost. With the emergence of volume markets in these bands, low-cost GaAs based component solutions are required to meet the cost demands of markets such as E-Band point-to-point communication applications (71 to 76 GHz and 81 to 86 GHz), automotive radar (76 to 77 GHz) and radar systems (93 to 95 GHz).

High frequency point-to-point communication bands at E-Band offer the potential for ultra-high capacity links. The large allocated band offers fiber-like Gbps data rates that far exceed the present performance of the lower frequency microwave radio bands. The ease of installation of the links compared with fiber based solutions point toward this being a long-term solution for high data rate communications in many countries. In the automotive market, autonomous cruise control and emergency braking systems have been developed and successfully deployed on top-end models but until now wider usage has been restricted by the high cost of millimeter-wave components. In these markets and the mainly aerospace focused 94 GHz radar markets, the availability of low cost MMIC based components offers the route to wider market expansion.

Therefore, a key enabling technology for the long-term volume uptake will be the availability of cost-effective semiconductors capable of delivering the required performance at E-Band and above. Recently, GaAs foundries have focused on employing many of the processing techniques and equipment used in the high volume applications of mobile terminals to provide low-cost solutions targeted at these higher frequencies. This has resulted in the release of high performance GaAs based technologies capable of delivering significant gain and power up to W-Band. High performance GaAs based solutions on six-inch wafer technology have the potential to yield low-cost products in the frequency range from 60 to 100 GHz. The enhanced performance of GaAs based solutions, particularly in terms of power and linearity, together with lower development costs makes this the technology of choice on which to develop key functions for volume E- and W-Band applications.

This article describes the design and manufacture of a set of E- and W-Band MMIC power amplifiers based on six-inch 0.1 µm GaAs technology. An overview of the circuit architectures for 22 dBm output power amplifier designs is provided. Measured results of manufactured MMICs show good agreement with simulated results thus demonstrating GaAs MMIC capability to meet the requirements for high performance, low cost E- and W-Band applications.

Jim Mayock
VIPER RF Ltd., Weafield, UK

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

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

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

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

732-460-0212

www.aeroflex.com/ACCQuick

See us at IMS Booth 2305

AEROFLEX

A passion for performance.

TABLE I

E- AND W-BAND HPA MMIC DESIGN SPECIFICATIONS

	E-Band (81 to 86 GHz)			W-Band (93 to 95 GHz)		
	LPA	MPA	HPA	LPA	MPA	HPA
Gain (dB)	20	12	10	20	12	10
Output Power (dBm)	17	19.5	22	17	19.5	22
Linearity (dBm)	>23	>25	>27			

E- AND W-BAND MMIC AMPLIFIER DESIGN

The aim of the design process was to realize amplifiers at a range of power levels in the commercial E-Band communication band at 81 to 86 GHz and in the radar band in the 93 to 95 GHz range. Successful demonstration of frequency and power in these bands can be easily translated to the less challenging design at the lower frequency applications in the 60 to 76 GHz range.

The design philosophy was based on realizing low power amplifiers (LPA), medium power amplifiers (MPA) and high power amplifiers (HPA) in each of the bands. The target specification for each of the amplifiers is shown in ***Table 1***. The LPA can be configured as a local oscillator (LOA), low-noise amplifier (LNA) or as a driver amplifier in the transmit or receive chain. The aim of the HPA specification is to meet the requirements for the output stage of the transmit section for an E-Band radio or as a single MMIC in a multi-MMIC combined HPA for radar applications. In the three design cases, similar circuit features, design approaches and simulation techniques were employed.

The set of E- and W-Band amplifiers were designed on WIN Semiconductor's PP10 technology which is a 0.1 μm GaAs PHEMT process manufactured on 150 mm wafers. PP10 has an $F_t > 135$ GHz and $F_{max} > 185$ GHz and is capable of 4 V operation.[1] Measured data of the PP10 PHEMT devices was used to ascertain the optimum periphery in terms of power and gain to meet the requirements for each of the amplifiers. Small-signal S-parameter data was supplied by the foundry for a range of different devices sizes (unit gate width and number of fingers). Also, loadpull data was available for a 2×50 μm sized device measured at 30 GHz.[2] A G_{MAX} of greater than 10 dB is available for 2×25 and 2×50 μm sized devices. In circuit, this level of gain will not be achieved due to interstage and output network losses, matching for optimum power rather than gain and the influence of any lossy stabilization networks. Published loadpull data indicates that a saturated power density of approximately 0.8 W/mm from a 4 V supply can be achieved. Higher frequency power density data was not available during the design process which offered a level of risk in extrapolating the power density to E- and W-Band. However, the level of gain and low frequency power density indicated that the technology was capable of


Wright Technologies
Microwave Millimeter Specialists
Military Grade at Commercial Pricing

Additional Options
- Bit Detection
- Temperature Compensation
- Integrated Isolator
- AGC Control
- Custom Frequency Bands
- Power Limiting
- Drop-in Surface Mount Package

Our Products Can Multi-task

X3 Frequency Products 20-40 Ghz
20-40 Ghz Mixer
40-60 Ghz Mixer
Custom Filtering to 60 Ghz
TTL Control Switching 0.1-50 Ghz
Prescale 2-25 Ghz

Ultra Broadband
0.1-20 Ghz
0.1-26.5 Ghz

Broadband
2-18 Ghz, 18-40 Ghz
33-50 Ghz, 40-60 Ghz
Output power up to 2 watts

(Output)
X2 Doublers: 6-12 Ghz
12-20 Ghz, 20-40 Ghz
40-60 Ghz, 50-75 Ghz
0 dBm Input RF Drive
Option Available

1352 Blue Oaks Blvd Suite 140
Roseville CA 95678 (916) 773-4424

4 YEAR WARRANTY
Built to Last
www.wrighttec.com

CERNEX, Inc.

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

AMPLIFIERS UP 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)

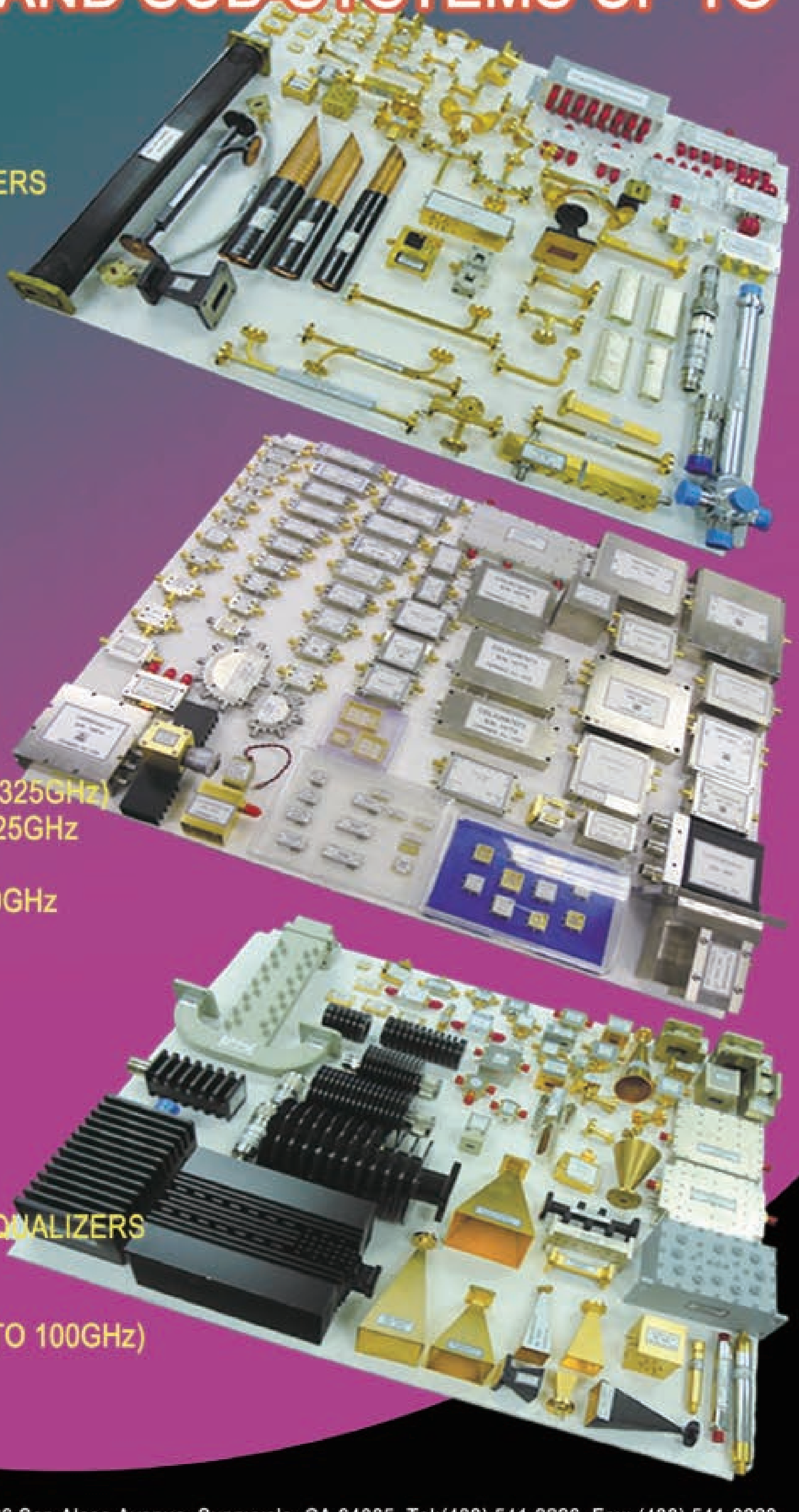
ATTENUATORS(UP TO 160GHz)
DETECTORS(UP TO 160GHz)

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

POWER COMBINERS/DIVIDERS EQUALIZERS

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

See us at IMS Booth 921



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

realizing good amplifier performance in the E- and W-Band.

The LPA was realized as a three-stage design based on 2×50 μm cells for each stage. Although the 2×25 μm cell offered the potential for higher gain, the 2×50 μm cell offered adequate gain coupled with the potential for meeting the power requirements. The four fingered cell approach (4×25 μm) indicated a lower available gain, which may be due to phasing issues across the device due to the narrow input and output feeds for available devices. A common 50 Ω matched structure was used for each stage. This allowed for the potential to easily convert to more stages, or to employ the common cell in multi-function MMICs with other circuit types. The matching networks at the input and output of the 2×50 μm device consisted of a short transmission line and an open circuit stub. Bias was applied to the gate and drain of the PHEMT cells through a bias network consisting of a resonant radial stub and a one quarter wavelength high impedance line. On the power supply side of the radial stub, further lossy decoupling networks were employed to provide a non-reactive termination at low frequencies to ensure oscillation free operation. MIM capacitors were employed to provide DC blocks in the input, interstage and output networks. Further stabilization networks were employed in the input and interstage networks through a parallel R-C network. The intention of this structure was to reduce the lower frequency gain while having a negligible impact on the in-band performance.

A critical aspect of the design is to understand sensitivity of the circuit and to find the best solution for simulation. Previous experience with HPA and amplifier design at lower frequencies pointed toward an approach based on intensive EM simulation of all passive elements; AWR Axiem was employed for the EM simulations. The procedure involves EM simulating entire matching structures and understanding the influence of the active devices on the passive circuit performance. Some level of discrepancy between schematic based and initial EM simulated behavior was present. The circuit was re-tuned until the EM based modeled performance met the electrical requirements.

A similar process was employed for the design of the MPAs. The MPA consisted of two stages of gain. In this case, the output periphery was realized as 2×2×50 μm cells. The two cells were directly combined together in a corporate matched configuration. Although an in-circuit gain of greater than 6 dB is present, the same size driver periphery as the output periphery was employed. This was to ensure that the driver stage had a negligible impact on the power saturation and linearity of the MMIC over the full temperature range and expected process spread. The downside of employing the larger driver is an increase in the DC power consumption and thus a reduction in the total efficiency. Similar circuit features were employed in the MPA as the LPA, in order to apply bias, stabilize the circuit and extract maximum power. Further stability analysis was employed in the MPA to


KRYTAR®
Microwave Components & Instruments
DC to 67 GHz

Directional Couplers to 67 GHz

3 dB 90° Hybrid Couplers to 40 GHz

Directional Detectors to 50 GHz

Double Arrow 3 dB 180° Hybrid Couplers to 26.5 GHz

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

MLDD Power Divider/ Combiner to 45 GHz

RF & Microwave Power Meter 100 KHz to 40 GHz

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

Coaxial Terminations to 50 GHz

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

35 Years of Excellence KRYTAR Since 1975

MIL Qualified Components Available

KRYTAR® 1288 Anvilwood Ave. Sunnyvale, CA 94089
Toll Free: (877) 734-5999 • Fax: (408) 734-3017 • sales@krytar.com
www.krytar.com lists complete specifications
and application ideas for all products

See us at IMS Booth 3016

WAVEX™ Z

A Seamless EMI & RF Solution For Cumbersome Cables

Cables Coated with WAVEX™ Z

- Maximize Signal Integrity
- Pass Compliance Testing
- Eliminate Ferrite Chokes
- Streamline Cable Assemblies

IMS 2012
MONTRÉAL

June 17-22
Visit Us At Booth #2337

ARC
TECHNOLOGIES, INC.
ABSORBED IN TECHNOLOGY

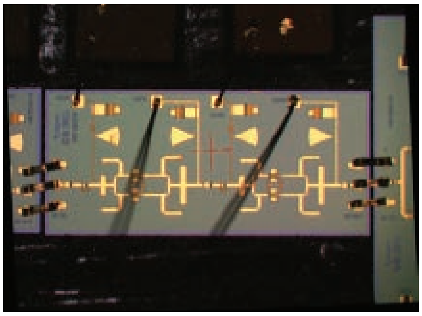
WWW.ARC-TECH.COM/CABLES

ensure the absence of 'odd-mode' and loop oscillation.[3,4]

The HPA designs employed 4×2×50 μm cells in the output stage in order to realize greater than 22 dBm of output power. A two stage design was used in order to meet the gain requirements as presented in Table 1. The HPAs were based on two channels of the MPAs which are combined in a corporate approach. This offers a relatively simple and modular approach to increasing the periphery and thus the output power. Further EM simulations were employed in order to ensure that coupling between the two channels was minimal. The symmetry of the HPA is critical, in order to ensure that power is combined in phase.

MEASUREMENTS

All amplifiers were mounted on a copper tungsten carrier with thermal epoxy. In order to obtain oscillation free operation, external decoupling networks must be applied to the gates and drains of each stage. In a production test environment this can be readily achieved with a custom probe card with integrated decoupling. In this characterization 100 pF single layer ceramic capacitors were bonded to each gate. Further decoupling was applied through bonding universal DC boards consisting of higher value 0402 capacitors onto each gate and drain. Bias was applied to the amplifiers through connecting DC probes to the DC boards. The amplifiers were all directly RF probed and characterized from 75 to 110 GHz. ***Figure 1*** shows a typical configuration for characterization showing a photograph of the E-Band MMIC line-up with associated decoupling networks.



▲ *Fig. 1 Assembled carrier for E-Band HPA device measurements.*

Small-signal measurements were carried out at the Technical University of Graz in Austria. The set uses a ZVA-67 with frequency extensions up to 110 GHz. A set of large-signal measurements were carried out at Filtronic Broadband Ltd. in order to ascertain the power saturation and linearity characteristics of the 81 to 86 GHz amplifier sets. In order to provide sufficient source power, the LPA and MPAs were used as driver devices to provide high gain chains for the HPAs.

Figure 2a shows the small-signal measured performance of the 81 to 86 GHz LPA. Approximately 20 to 22 dB of gain is achieved across the band with an output return loss of better than 11 dB and an input return loss of greater than 8 dB. ***Figure 2b*** shows the measured performance of the W-Band LPA that is designed to operate in the 93 to 95 GHz band. Approximately 18 dB of gain is achieved with an input return loss of better than 10 dB and an output return loss of greater than 10 dB. Levels of gain and return losses are close to the sim-

Cost-Efficient & High Performance Integrated Microwave Assemblies

ASELSAN offers both ready-made products and custom solutions to meet your specific needs.

Product range available for land, naval, submarine, airborne and spaceborne platforms includes:

- Tx/Rx modules
- Channelizer Down Converters
- Superheterodyne Up/Down Converters
- Antenna Front Ends & Switch Assemblies
- PA Modules
- LO Multipliers
- Radar & ESM Synthesizers
- DLVAs.

aselsan
Your microwave solution provider

For more information, visit www.aselsan.com.tr or contact marketing@aselsan.com.tr

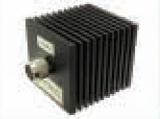
See us at IMS Booth 105

Fairview Microwave Inc.

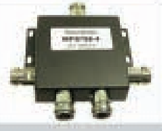
ADAPTERS

							
SM5250 $58.16 SMA SWEPT 27 GHZ	SM4979 $38.77 SMA 27 GHZ	SM4923 $97.25 SMA FLANGE 27 GHZ	SM3224 $226.17 2.92 BULKHEAD 40 GHZ	SM3221 $148.48 3.5-3.5 34 GHZ	SM3935 $440.50 1.85-1.85 65 GHZ	SM8867 $195.00 SMP-2.4 40 GHZ	SM2927 $138.94 GMS-SMA 23 GHZ
							
SM3358 $226.17 7mm-3.5 18 GHZ	SM3397 $51.76 7/16 90° 6 GHZ	SM4531 $172.00 N 90° 18 GHZ	SM3547 $38.77 TNC-BNC 8 GHZ	SM5514 $145.40 ZMA-SMA 18 GHZ	SMW75ACN $297.95 WR75-N 10-15 GHZ	28AC206 $363.60 WR28-2.92 26-40 GHZ	SM4835 $172.53 SSMA-2.92 40 GHZ

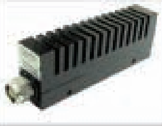
ATTENUATORS

							
SA18N5WA $60.17 N 5W 18 GHZ	SA18N25WA $232.24 N 25 W 18 GHZ	SA18N507 $343.09 N 50 W 18 GHZ	SA3015 $13.55 SMA 2 W 3 GHZ	SA18S50W $337.81 SMA 50 W 18 GHZ	SA3N511 $162.41 N 50 W 3 GHZ	SA4020 $738.96 2.92 10 W 40 GHZ	SA5074 $274.47 2.4 1 W 50 GHZ

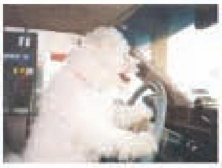
COUPLERS, POWER DIVIDERS

							
MC0626 $1,045.15 2.92 COUPLER 6-26 GHZ	MC0618 $341.38 SMA COUPLER 6-18 GHZ	MC4061 $757.50 N-SMA COUPLER 1-12 GHZ	SMC4037 $52.52 N COUPLER 700-2700 MHZ	MP0218-4 $600.95 SMA 4-WAY 2-18 GHZ	MP1540-2 $1,045.15 2.92 2-WAY 15-40 GHZ	MP8769 $472.68 N 2-WAY 2-8 GHZ	MP8758-4 $82.98 N 4-WAY 800-2500 MHZ

TERMINATIONS

							
ST27N301 $434.98 N 700-700 MHZ LOW PIM	ST3N501 $129.56 N 50 W 3 GHZ	ST3D-50 $206.96 7/16 50 W 3 GHZ	ST1831 $19.57 SMA PUSH ON 1 W 18 GHZ	ST2671 $51.11 SMA 2 W 27 GHZ	ST6T-5W $53.29 TNC 5 W 6 GHZ	ST4021 $521.98 2.92 5 W 40 GHZ	ST5038 $299.05 2.4 1 W 50 GHZ

INTRODUCING NEW PRODUCTS: GAIN HORNS AND LOW PIM SERIES



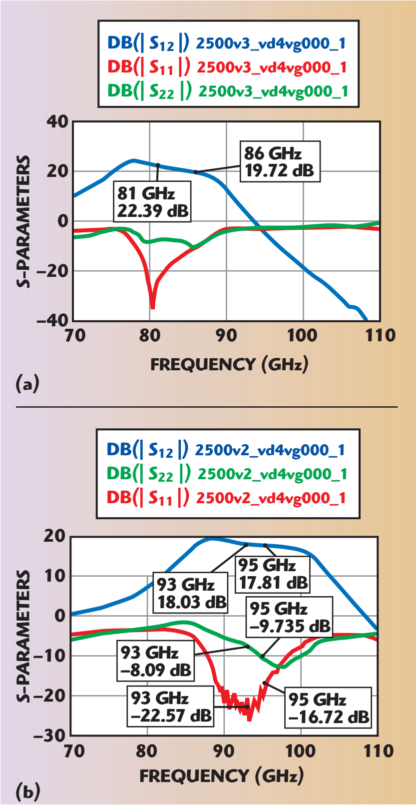
FAST DELIVERY!

CHECK OUT OUR INVENTORY LEVELS, PRICING, DATA SHEETS, & PLACE ORDERS **ONLINE** AT

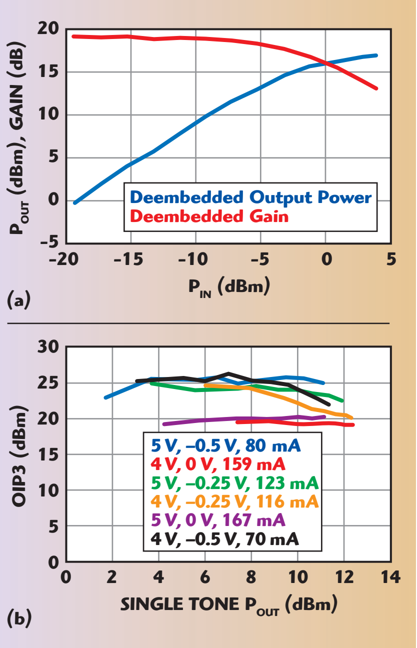
WWW.FAIRVIEWMICROWAVE.COM 1-800-715-4396

1130 JUNCTION DR. STE 100 ALLEN, TX 75013 1-800-715-4396 FAX: 972-649-6689 EMAIL:SALES@FAIRVIEWMICROWAVE.COM ulated performance for both MMICs. ***Figure 3a*** shows a measured power sweep for the E-Band LPA at 83 GHz. The saturated power is greater than 17 dBm at the center of the band. This indicates an 'in-circuit' power density of approximately 0.6 W/mm that is similar to the expected performance based on the lower frequency extrapolated loadpull data. The best P1dB was achieved when biasing the LPA in a Class AB mode that is at an operating condition away from the peak gain bias point. ***Figure 3b*** shows the measured OIP3 as a function of swept power. The best performance was achieved with a bias point of V_{DS}=4 V and V_{GS}=–0.5 V for each stage. A peak output OIP3 of 24 dBm was achieved at a total output power of +10 dBm.

Figure 4a shows the small-signal measured performance of the 81 to 86 GHz MPA. The design is based on a two-stage configuration and exhibits a measured small-signal gain of 12 dB with return losses of better than 10 dB across the band. ***Figure 4b*** shows the measured performance of the corresponding W-Band MPA with 11 dB of small-signal gain and return losses



▲ *Fig. 2 Measured small-signal performance of E-Band LPA (a) and W-Band LPA (b).*



▲ *Fig. 3 Measured power sweep for E-Band LPA at 83 GHz (a) and OIP3 at 84 GHz (b).*

Research
Development
IMST Products
Services

VISIT US ON IMS // Booth 2717

NEW EMPIRE RELEASE 6.0
INCLUDING THERMAL SOLVER

XPU:
BEYOND LIMITS

→ EMPIRE XCel™

Empire XCel™ features the unique XPU[1] technology which surpasses full-wave EM simulations of limited GPU solutions.
XPU executes tasks more efficiently and is the best choice for any simulation size. In addition, this technology is perfectly suited for cluster computing for faster results solving even larger simulation tasks.
With EMPIRE XCel™ you will optimize your workflow in no time.

Try it yourself with a free evaluation.
Created by engineers for engineers.

T +49-2842-981-400
F +49-2842-981-499
E empire@imst.de
I www.empire.de

EMPIRE XCel™ is a product of IMST GmbH

[1] XPU is an innovative proven software controlled workflow among CPUs - invented at IMST

Join us at IMS-MTTS • Booth 601

Emerson Connectivity Solutions

Emerson Connectivity Solutions delivers custom-engineered products and solutions to satisfy the most demanding and complex requirements. Our wide variety of microwave components, connectors and cable assemblies are widely used on many high reliability programs, both military and commercial.

Connector and cable integrity is critical to the execution of highly reliable microwave systems. System performance can be enhanced and assured by our wide variety of connectors, fixed length, flexible and semi-rigid cable assemblies, and high performance quick connect and test adapters.

EmersonConnectivity.com
Toll free: 800-247-8256
Phone: 507-833-8822

EMERSON™
Network Power
Connectivity Solutions

Johnson
Connectivity Solutions

Midwest Microwave
Connectivity Solutions

Semflex
Connectivity Solutions

Trompeter
Connectivity Solutions

Emerson Network Power and the Emerson Network Power logo are trademarks and service marks of Emerson Electric Co. ©2011 Emerson Electric Co.

EMERSON. CONSIDER IT SOLVED.™

of greater than 10 dB across the required frequency band. The E-Band MPA was measured under large-signal conditions and a saturated power of greater than 19.5 dBm was achieved. This is typically in-line with the power density measured for the E-Band LPA previously.

Figure 5a shows the measured small-signal performance of the E-Band HPA. A measured gain of greater than 10 dB and with return losses of greater than 10 dB was achieved. ***Figure 5b*** shows the measured small-signal performance of the W-Band HPA; greater than 10 dB of gain was achieved with good return losses across the required frequency range. As mentioned previously, in order to measure the power and linearity characteristics of the HPA, the LPA and MPA were employed as driver stages. The devices were connected together through low-inductance chip to chip tape bonds. ***Figure 6a*** shows the power sweep for this configuration,

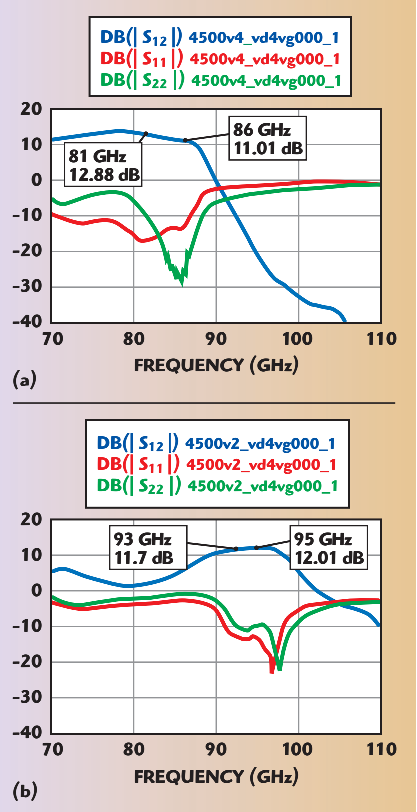


Fig. 4 Measured small-signal performance of E-Band MPA (a) and W-Band MPA (b).

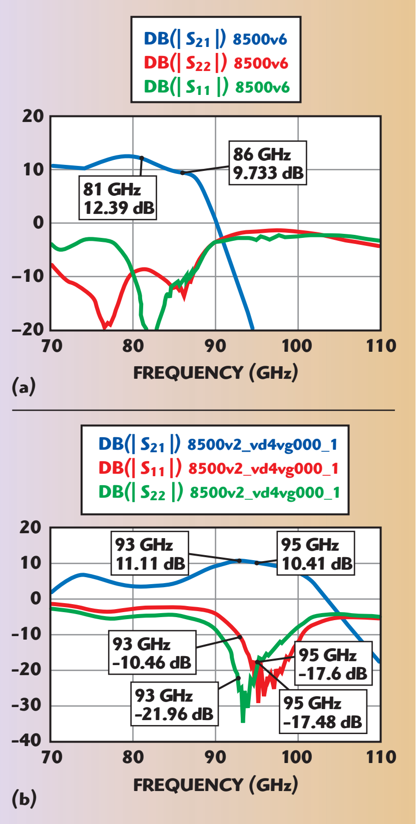


Fig. 5 Measured small-signal performance of E-Band HPA (a) and W-Band HPA (b).


AIR Heads

At State of the Art, keeping things up in the air is part of our business, and mission-critical resistors our specialty.

If you're in a fog about dependable manufacturers, don't be. We assure the quality and reliability you need – in every resistor, with superior design and manufacturing, with every delivery.

Down to earth solutions for mission-critical applications... Only from State of the Art.

Made in the USA.

State of the Art, Inc.
RESISTIVE PRODUCTS
www.resistor.com

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

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

See us at IMS Booth 2325

We are ready to work with you!

Pivotone specializes in designing, manufacturing and selling RF & microwave components, device and module products for communication systems.

Vision drives the future

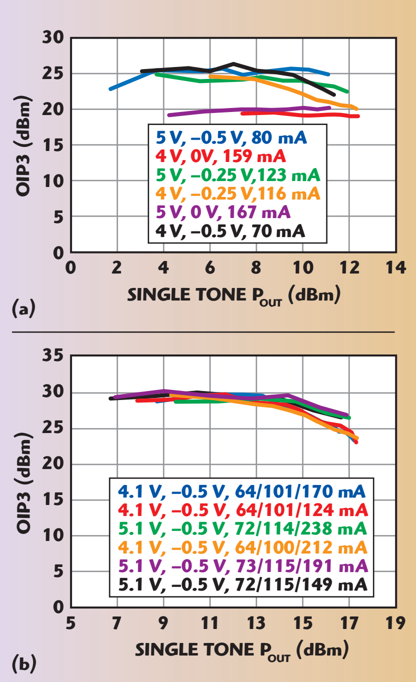
PIVOTONE

PIVOTONE COMMUNICATION TECHNOLOGIES, INC.

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

See us at IMS Booth 726

biased in a Class AB mode for the center of the frequency band. A saturated power of greater than 22 dBm is achieved in the center of the band, with a P1dB of 21 dBm. This level of saturated power density is similar to that achieved for the LPA and MPA. A slight degradation of the in-circuit power density would be expected due to the extra output combining losses. The OIP3 of the line-up of gain stages is shown in ***Figure 6b***. The measured OIP3 is between 29 to 30 dB for total powers up to +17 dBm. As the output power reaches close to the onset of power saturation, a roll-off in OIP3 is evident. The total gain of the amplifier chain in this configuration is approximately 30 dB.



▲ *Fig. 6 Measured power sweep for E-Band HPA at 83 GHz (a) and OIP3 at 82 GHz (b).*

CONCLUSION

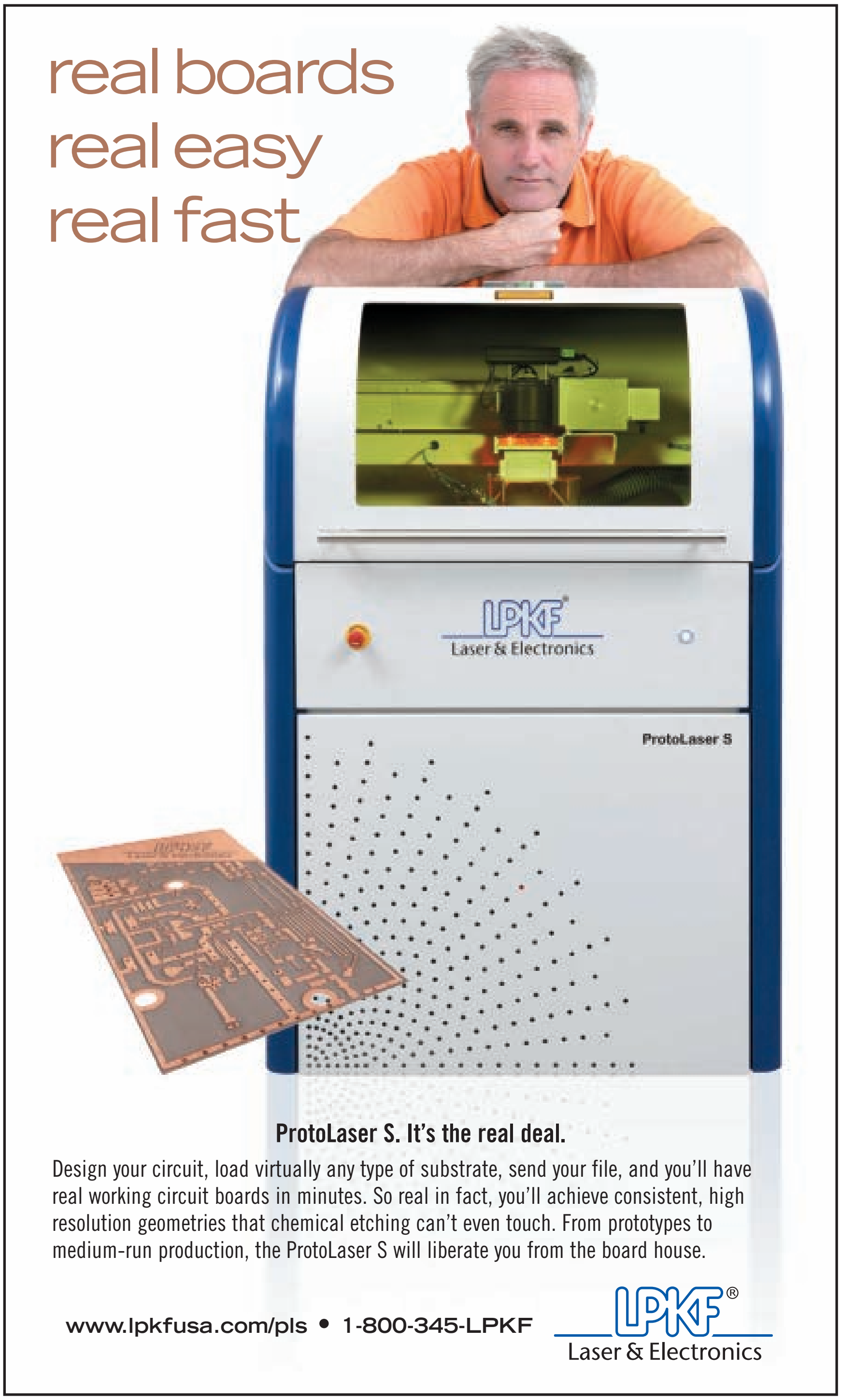
E- and W-Band power amplifier MMICs have been designed on six-inch 0.1 μm GaAs technology. Measured results of the manufactured MMICs demonstrated good agreement with simulated results: low power amplifier devices achieved good levels of gain in excess of 20 dB for both E- and W-Band devices. The HPA devices achieved saturated output powers in excess of 22 dBm; tuning of the matching environment will provide further optimized performance. Furthermore, the circuit architecture employed can be easily extended to provide higher levels of output powers. The results presented here demonstrate GaAs MMIC capability is available today to meet the next generation requirements of high performance, low cost E- and W-Band applications. ■

ACKNOWLEDGMENTS

We would like to thank the Technical University of Graz (www.ihf.tugraz.at) and Filtronic Broadband (www.filtronic.co.uk) for assistance with measurements.

References

1. WIN Semiconductors Corp., "0.1 μm pHEMT Process for E-band Power Applications," *Microwave Journal*, Vol. 53, No. 12, December 2010, pp. 36-38.
2. WIN Semiconductors PP10 Process Design Kit.
3. M. Jankowski, E. Limiti and P.E. Longhi, "Freitag Method Application to PA Stability Test," *IEEE Workshop Integrated Nonlinear Microwave and Millimetre-Wave Circuits, 2008*, INMMIC 2008, Issue 24-25, November 2008, pp. 149-152.
4. M. Ohmoto, *IEEE Transactions Microwave Theory & Techniques*, Vol. 41, No. 6/7, June/July 1993, pp. 983-988.


real boards
real easy
real fast

LPKF Laser & Electronics

ProtoLaser S

ProtoLaser S. It's the real deal.

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

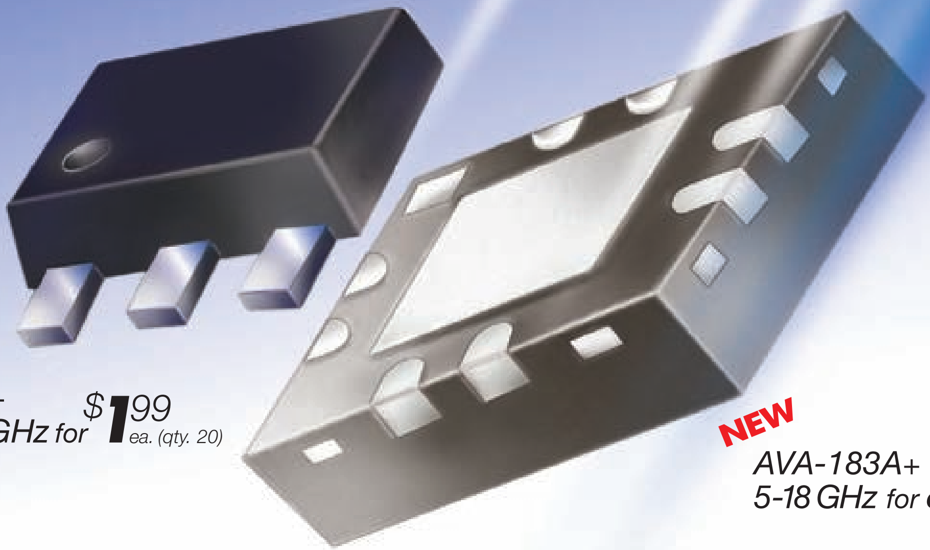
www.lpkfusa.com/pls • 1-800-345-LPKF

LPKF® Laser & Electronics

See us at IMS Booth 2409

MMIC AMPLIFIERS

50 MHz to 18 GHz with just 2 models!



PHA-1+
0.05-6 GHz for $1^{99} ea. (qty. 20)

NEW
AVA-183A+
5-18 GHz for **only** $6^{95} ea. (qty. 20)

You *can* get outstanding electrical performance across a wide operating bandwidth, and these two Mini-Circuits MMICs prove it once again. Together, they cover the entire spectrum from 50 MHz to 18 GHz with **no external matching components required**, saving costs, design time, and board space—an exceptional value at any price!

The **PHA-1+** is a highly advanced E-pHEMPT amplifier poised to be a workhorse for your wireless applications. With an ultra-high dynamic range, low noise, and exceptional IP3 performance (42 dBm typical at 2 GHz), it's ideal for LTE and TD-SCDMA systems (see our website for ACLR and EVM data). And good input and output return losses—across almost 7 octaves—extend its use to CATV, wireless LANs, base station infrastructure, and more!

The new **AVA-183A+** covers 5 to 18 GHz with excellent gain flatness (+/-1.0 dB) across its entire frequency range. High isolation (37dB typical) makes it very useful as a buffer amplifier, and if you look a little closer, you'll find an extremely flexible 3 x 3 mm MMIC that is simple and straightforward to use for a wide variety of applications, from satellite systems to P2P, military electronic warfare, and radar, to name just a few!

They're so adaptable, our design engineers like to keep a few on hand—and you can get 10 of each, in Designer Kit **K1-AVA+**, for only $88.95! See minicircuits.com for full electrical, mechanical, and environmental specifications, as well as S-parameters and performance curves—these models are in stock and ready to ship today! ***RoHS compliant***

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

Mini-Circuits®
ISO 9001 ISO 14001 AS 9100
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

Yoni2® ***The Design Engineers Search Engine*** *finds the model you need, Instantly* • For detailed performance specs & shopping online see **minicircuits.com**
U.S. Patents
7739260, 7761442

IF/RF MICROWAVE COMPONENTS

478 rev G

Technical Feature

Compact UHF Fifth Order Bandpass Filter Using Cascaded Triplet CRLH-ZORs

A bandpass filter is proposed, miniaturized by composite right- and left-handed (CRLH) zeroth order resonators (ZOR), which form a cascaded triplet (CT) to have a significantly sharp skirt for high frequency selectivity. A fifth order UHF bandpass case is tested. First, an in-line ZOR bandpass filter is designed, whose total size is almost 20 percent of a parallel-edge coupled filter. Second, multiple transmission zeros (TZ) are created by changing the three innermost ZORs of the in-line filter to a CT. As a result, with an insertion loss better than 1.5 dB and a return loss better than 15 dB, the size-reduction effect and the skirt of the proposed filter are 24 times smaller than a lower-order parallel-edge coupled filter and as sharp as a 10th order Chebyshev filter. The simulation and measurement validate the proposed design method and the CRLH ZOR properties are proven by the no-phase variation electric field and dispersion diagram.

As the social and business network is expanded and globalized, the demands and users of mobile communications increase by the day. Mobile communication uses several channels, which should be isolated from the adjacent channels. In wireless communication systems, high selectivity of a channel is made possible by bandpass filters with sharp skirts.

Quendo et al introduced a combline filter with a small occupied size and sharp frequency selectivity.[1] Vince also brought the design of a combline filter to have channel selectivity and reduced size.[2] But the performance of the combline filters was not completely optimized. Their design can be improved with TZs near the passband edge, like the gapped and coupled loop filter Park et al showed.[3] However, their filter does not have a steep skirt and has a narrow matched band, due to the fact that its transfer function has a low order and TZs are not in the effective vicinity of the passband. Tang used multiple resonators to increase the order of the bandpass filter and loaded the structure with capacitive coupling elements to determine the locations of TZs and obtained a steeper skirt in the form of a stacked parallel-edge coupled filter.[4] In line with increasing the

Boram Lee and Sungtek Kahng
University of Incheon, Incheon, Korea

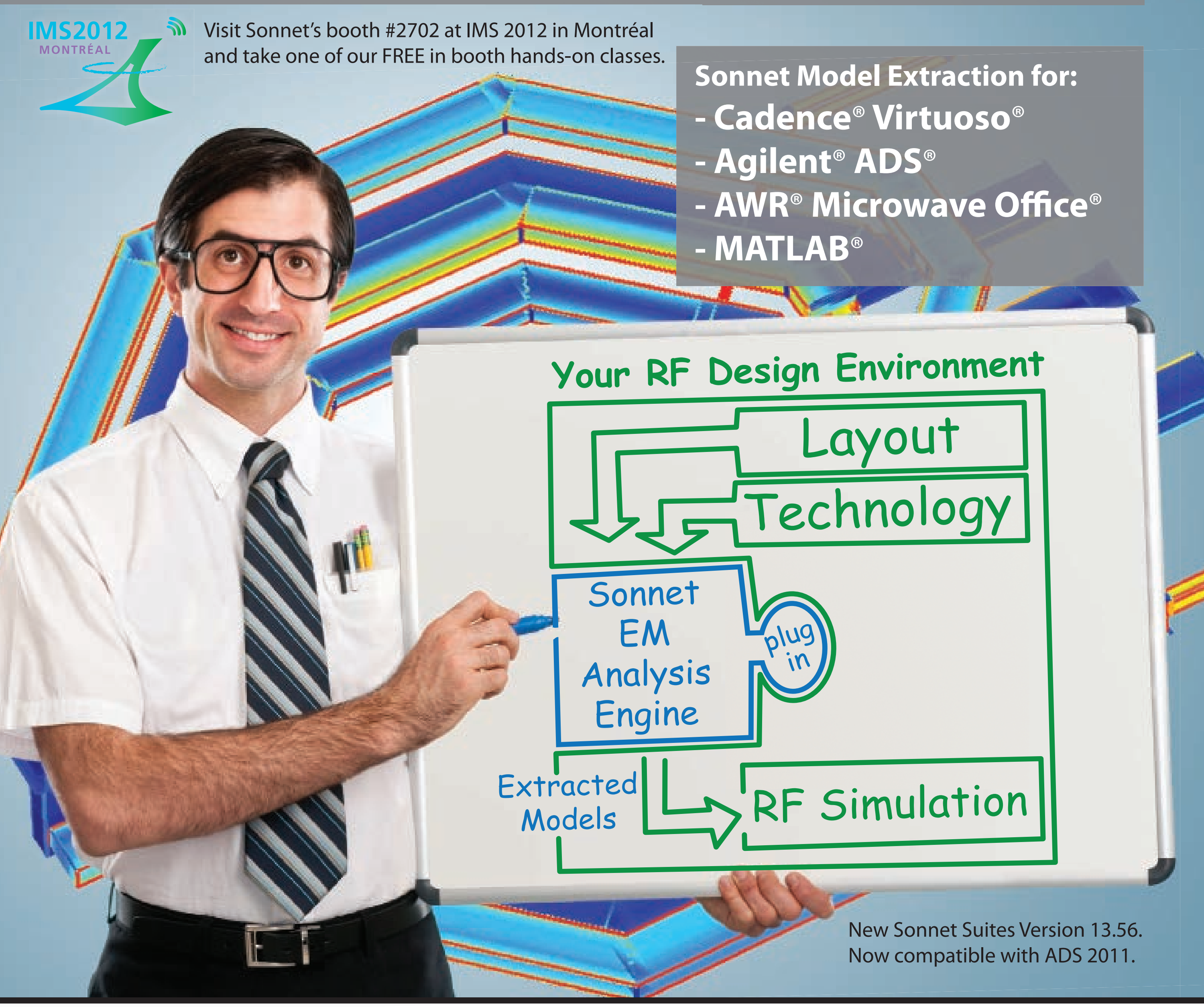
Work smarter.

Sonnet® integrates fullwave EM Model Extraction within your design flow.

IMS2012
MONTRÉAL

Visit Sonnet's booth #2702 at IMS 2012 in Montréal and take one of our FREE in booth hands-on classes.

Sonnet Model Extraction for:
- **Cadence® Virtuoso®**
- **Agilent® ADS®**
- **AWR® Microwave Office®**
- **MATLAB®**



New Sonnet Suites Version 13.56.
Now compatible with ADS 2011.

Smart engineers demand smart software.

Sonnet provides unmatched accuracy as both a standalone EM modeling tool, or as an integrated EM model extraction client for your preferred RF EDA design framework. Our robust framework interfaces and translators keep the "flow" in your RF EDA design flow.

Download a free QR barcode app on your smartphone.

SONNET®
High Frequency Electromagnetic Software

Call, click or scan for more information
(877) 7-SONNET
www.sonnetsoftware.com/ims

©2012 Sonnet Software, Inc. All rights reserved. SONNET® is a registered trademark of Sonnet Software, Inc.
Agilent and ADS are registered trademarks of Agilent Technologies
AWR and Microwave Office are registered trademarks of Applied Wave Research, Inc.
Cadence and Virtuoso are registered trademarks of Cadence Design Systems, Inc.
MATLAB is a registered trademark of MathWorks

order of a filter, multiple resonators or modes are adopted and cascaded in groups, with cross-coupling paths (CCP) embedded to maximize the frequency selectivity and minimize the overall size, in the name of cascaded quadruplet (CQ), cascaded triplet (CT), etc.[5-8] In most cases, CT and CQ methods go with waveguide cavity filter and multiplexer development and their synthesis scheme is described, accompanying the frequency responses with extremely sharp skirts due to high quality factors, TZs and filter orders.[5-7]

A CT filter can be made with microstrip lines, which has a center frequency of 1.05 GHz.[8] The CCP of the CT results in a TZ and steepens its skirt. All the aforementioned filters have restrictions in significant size-reduction, since their resonators are multiples of half-wavelength, determined by the frequency of interest. Particularly, waveguides are not proper for the commercial communication bands such as the UHF, PCS, DCS and ISM. To overcome the limitations of the conventional design methodologies, metamaterials can help RF component designers.[9-12] Since the CRLH lines and ZOR were suggested by Caloz et al,[9] the no-phase variation phenomenon as $\beta = 0$ and the nonlinear dispersion relation have been used to design sub-wavelength resonators and compact filters.[10,12] The CRLH ZOR filters and the ENZ and MNZ filter[11] show improvement in reducing the size, but have relatively low frequency selectivity.

In this article, a compact CRLH ZOR bandpass filter is designed to have a remarkably enhanced frequency selectivity, working in the UHF band. First, a fifth order in-line ZOR bandpass filter is designed as the initial step. In this step, it is shown that the overall size of the initial filter is approximately 20 percent of that of a parallel edge coupled filter and the metamaterial characteristics are verified by the no-phase varying electric field and the dispersion diagram of the ZOR through simulations. Second, to have a steep skirt, a CT is formed by providing the phase-difference type of cross-coupling in the three innermost ZORs of the in-line ZOR filter, which creates TZs in the proximity of the passband edges. A further size-reduction due to the CT formation is addressed, with the total size of the proposed filter 24 times smaller than even a fourth order parallel edge coupled filter, along with the high frequency selectivity equivalent to the 10th order Chebyshev filter. Besides, the low insertion loss better than 1.5 dB and the low return loss better than 15 dB are obtained with a lossy FR-4 substrate. To examine the validity of the proposed design method, the circuit and 3D EM simulations are carried out and are in good agreement with the measurements of the fabricated prototype of the CT CRLH ZOR bandpass filter.

TABLE I

SPECIFICATIONS OF THE BANDPASS FILTER

Items	***Specification***
Center Freq. (f_0)	950 MHz
Bandwidth (BW)	350 MHz
Insertion Loss	≤ 2 dB
$\lvert S_{11}\rvert$ in the Passband	≤ 15 dB
Sharp Skirt (Attenuation at f_{ue}+50 MHz)	≥ 20 dB

DESIGN OF THE IN-LINE CRLH ZOR BANDPASS FILTER

The bandpass filter is designed on the basis of the specifications shown in ***Table 1***. The GSM communications in the UHF band require that f_{ue}, as the band upper edge, equals f_0 + BW/2. To avoid the unwanted interference from the PCS, S_{21} should be attenuated to lower than –20 dB at the frequency f_{ue} + 50 MHz. The sharp skirt will be excluded in this step to design the in-line ZOR bandpass filter, but will be included in the next step. To begin with, the aforementioned specifications, except for the skirt, can be obtained with the following transfer function:

$$S_{21}(s)=\frac{.1789}{s^5+1.172s^4+1.937s^3+1.31s^2+.7525s+.1789} \tag{1}$$

where s is jω and ω is the angular frequency.

The fifth order equivalent circuit is shown in ***Figure 1***. It comprises resonators 1 through 5 and their coupling ele-

Massachusetts Bay Technologies (MBT) is a design and full service manufacturer of both standard and application specific silicon RF/Microwave diodes and semiconductor devices.

MBT offers full test and assembly services for your specific application needs. Please visit our website or contact our engineering department to discuss your specific diode or passive application requirement.

COMING SOON – MBT SURFACE MOUNT SWITCH AND LIMITER MODULES

VISIT US AT BOOTH 3309.

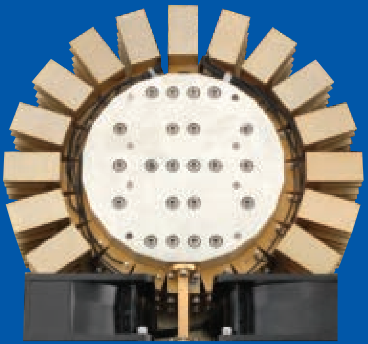
378 Page Street, Stoughton, MA 02072 • Tel: 781-344-8809 • Fax: 781-341-8177
www.massbaytech.com • sales@massbaytech.com

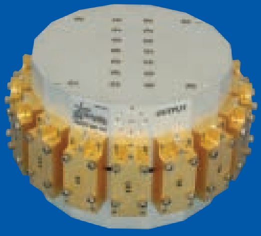
IMS2012
MONTREAL

Visit Us At Booth #2209

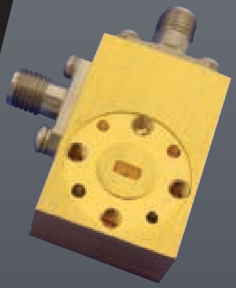
State-of-the-Art Components, Integrated Modules, and Subsystems

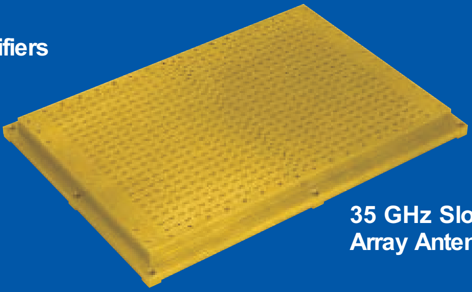
QUINSTAR
TECHNOLOGY, INC.

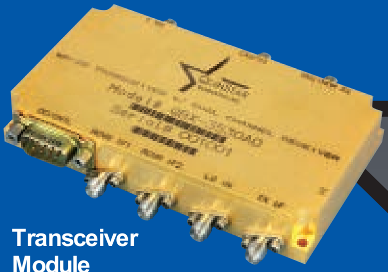

60 GHz - 20 Watt
High Power Amplifier



94 GHz
Power Amplifiers


Second Harmonic Mixers


35 GHz Slot
Array Antenna


Transceiver
Module

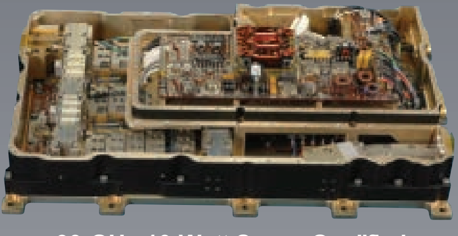

105 GHz Interferometer

Products for Next Generation Systems


Rack-Mounted
Amplifiers and Sources

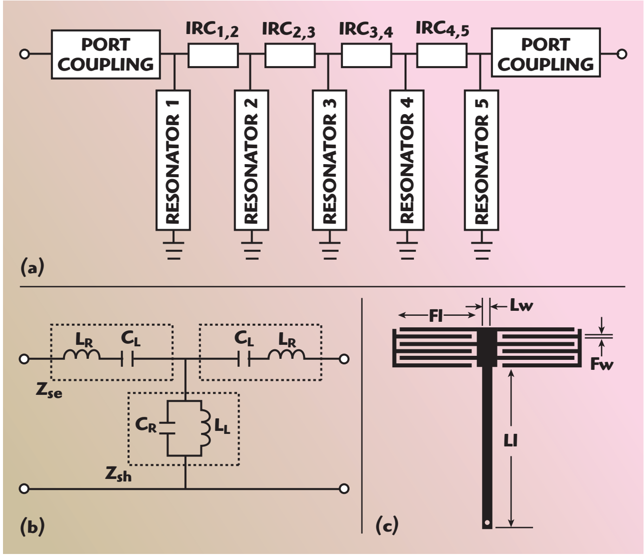
Millimeter-Wave Products 18-220 GHz

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


39 GHz 10 Watt Space Qualified
Power Amplifier (SSPA)

QUINSTAR TECHNOLOGY, INC.
24085 Garnier Street, Torrance, CA 90505
Tel 310-320-1111 • Fax 310-320-9968
sales@quinstar.com • www.quinstar.com

QuinStar Technology, Inc., is an AS9100:2004 / ISO 9001:2008 certified company for the Design and Manufacture of RF, Microwave and Millimeter-Wave Front End Solutions for Communications, Sensor, Scientific, and Test Applications.



▲ *Fig. 1 Equivalent circuit (a), CRLH equivalent circuit of the CLRH ZOR resonator (b), and its physical shape (c).*

ments named $IRC_{i,j}$, which means that the inter-resonator coupling is between resonators i and j. Each resonator is made of a shunt inductor and capacitor. $IRC_{i,j}$ is chosen as a series inductor. In the conventional filter design, the physical structure for the resonators will be half-wavelength open-ended microstrip. But here, the CRLH ZOR for each of the resonators and the ordinary shunt inductor and capacitor in the resonator should be changed to the CRLH configuration, following the formula given by Jang and Kahng,[10] with the following equations for the band-edge (or cut-off) frequencies, center frequency and impedance of the CRLH ZOR.

$$\omega_L = \frac{1}{\sqrt{L_L C_L}}, \omega_R = \frac{1}{\sqrt{L_R C_R}}, \omega_{se} = \frac{1}{\sqrt{L_R C_L}},$$
$$\omega_{sh} = \frac{1}{\sqrt{L_L C_R}}, \omega_0 = \sqrt{\omega_R \omega_L} \tag{2}$$

$$Z_L = \sqrt{\frac{L_L}{C_L}}, Z_R = \sqrt{\frac{L_R}{C_R}}, Z_{se} = \frac{1-\omega^2 L_R C_L}{j\omega C_L},$$
$$Z_{sh} = \frac{j\omega L_L}{1-\omega^2 L_L C_R} \tag{3}$$

where the subscripts R, L, se and sh are the right-handed, left-handed, series and shunt, in that order.

The circuit elements for the CRLH ZORs 1 through 5 are calculated as C_L = 1.31 pF, C_R = 0.70 pF, L_L = 7.37 nH, L_R = 0.80 nH for ZOR 1 and ZOR 5, C_L = 1.34 pF, C_R = 1.40 pF, L_L = 5.67 nH, L_R = 0.50 nH for ZOR 2 and ZOR 4 and C_L = 1.31 pF, C_R = 0.70 pF, L_L = 7.43 nH, L_R = 0.80 nH for ZOR 3. These circuit elements are converted to the initial values of the physical dimensions using the following approximate formulas considering a microstrip on a 50 mil thick substrate of relative dielectric constant 4.4.

$$L_L = \frac{Z_C}{\omega}\tan(\beta_{eff} l) \tag{4}$$

$$C_L \approx (\varepsilon_r + 1) l [(n-3)A_1 + A_2](pF) \tag{5}$$

$$A_1 = 4.409 \tanh\left[0.55\left(\frac{h}{w}\right)^{0.45}\right]10^6\left(\frac{pF}{\mu m}\right) \tag{6}$$

$$A_2 = 9.92 \tanh\left[0.52\left(\frac{h}{w}\right)^{0.5}\right]10^6\left(\frac{pF}{\mu m}\right) \tag{7}$$

The physical dimensions are varied from the initial values in the 3D EM simulation and reach the final values, when they give the center frequency at the desired value (950 MHz). The final physical dimensions are summarized for ZORs 1 and 5 in ***Table 2***. With these values, the S_{21} and S_{11} parameters of

TABLE II

CIRCUIT AND PHYSICAL ELEMENT VALUES IN FIGURE 1

Variable	*Value*	*Variable*	*Value*
C_L	1.31 pF	L_w	1.4 mm
C_R	0.70 pF	L_e	17.4 mm
L_L	7.37 nH	F_l	6.3 mm
L_R	0.80 nH	F_w	0.1 mm

CHIP SCALE ATOMIC CLOCK GPSDO

Cesium Vapor Cell frequency and timing reference-Available in four different versions:

CSAC GPSDO:
Warmup to sub 0.5ppb accuracy in <2 minutes
Largest selection of I/O's and features
Built-in distribution amplifier and Phase Noise filter
8V to 36V Vehicle Power
GPS receiver with <5ns (rms) typ. stability

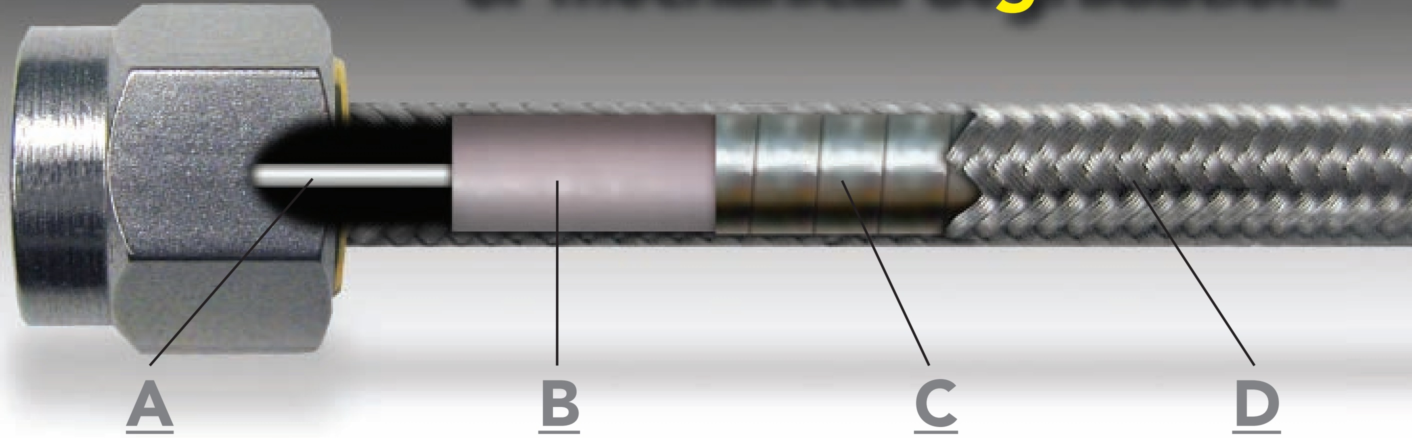
HD CSAC:
Small footprint, low power (low SWAP)
Designed for man-pack applications
50 Channel WAAS GPS receiver
LVDS and CMOS outputs

Low Noise CSAC:
Ultra Low Noise SC-cut post-filter
-110dBC/Hz @ 1Hz Phase Noise
1E-012 ADEV stability @ 1s
Built-in distribution amplifier

Low Power CSAC:
0.035W average power consumption
Designed for long-term underwater operation
High-stability crystal post filter
Data capture to SD-card memory

Jackson Labs Technologies, Inc. Tel: +1 (408) 354-7888 • www.jackson-labs.com • Email: sales@jackson-labs.com

Our **Re-Flex™ Cables** have been tested to more than **24,000 bends** with ***no electrical or mechanical degradation.***



A **Center Conductor**
Silver plated OFHC
copper per ASTM B-298

B **Dielectric**
Multi-ply PTFE laminate
per ASTM D-1457

C **Shield**
Silver plated
OFHC copper foil

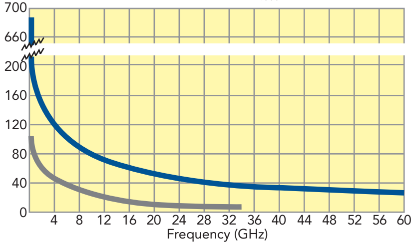
D **Braid**
Tin plated
copper braid

IW's Re-Flex Cables were designed to offer an alternative to standard semi-rigid & conformable cables. The unique design of these cables features a laminated PTFE dielectric, a silver plated copper foil shield, and a tightly woven copper braid. They have the same leakage characteristics and mechanical dimensions as standard semi-rigid cable. Stock assemblies use shell style & direct solder SMA plugs. Non-stock assemblies are available with relevant popular RF connector styles. Standard cable diameters are RF .085 & .141, with ***RF .047 & .250 Now Available!*** An FEP jacket is also available for all four cable types to eliminate any risk of a shorting hazard.

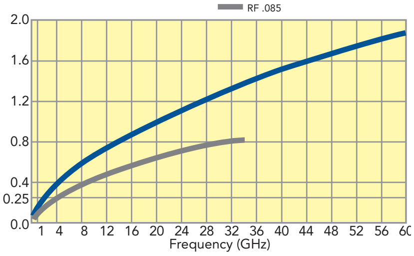
Impedence: 50 Ω
Time delay: 1.4 ns/ft
Cut off frequency: 60 GHz for RF 085
34 GHz for RF 141

RF leakage: Equivalent to
semi-rigid cable
Temp range: -55˚C to 135˚C
Bend radius: 1/16 inch for RF 085
1/8 inch for RF 141

Max RF Power
20˚C at Sea Level



Attenuation in dB/ft



Call us today with your project specs and we'll show you the most reliable way to ***get wired*** in the industry.

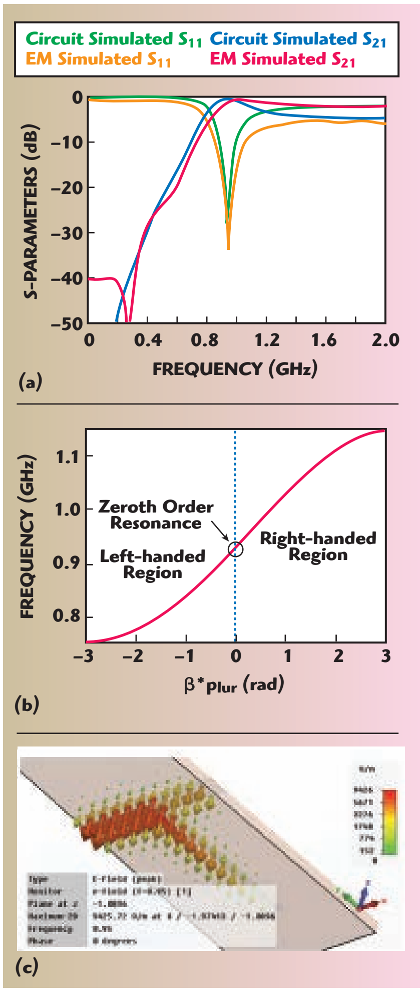
INSULATED WIRE, INC.
203.791.1999
www.iw-microwave.com
sales@iw-microwave.com

Visit
us at the
IMS 2012
Booth
#509

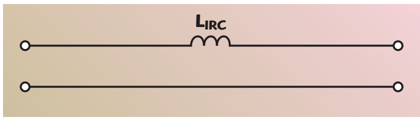
Scan code to find
out how you can
get wired

We're how the microwave industry ***gets wired!***

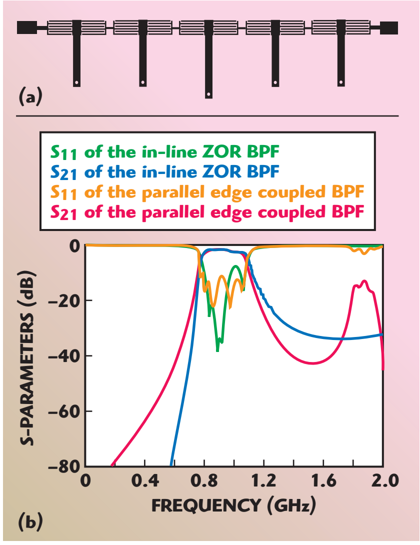
ZOR, the dispersion diagram, and the metamaterial field distribution are shown in ***Figure 2***. The figure reveals that the ZOR is appropriately implemented to resonate at f_0 and the circuit simulation agrees well with the 3D EM analysis result of the ZOR, whose size is $0.05\lambda_g$ (with respect to f_0). It is noted that because this is the resonator level, the desired passband will be made in the upcoming level for a complete filter. The dispersion diagram, which has β times the unit-cell length vs. frequency, shows $\beta = 0$ as the ZOR coincides with f_0. Besides, the right- and left-handed regions occur beyond and below the ZOR as the positive and negative β, respectively. Together with the dispersion diagram, another property of this CRLH metamaterial structure is given as the no-phase variation electric field. All the field vectors of $\beta = 0$ have the same direction at the ZOR frequency point.



▲ *Fig. 2 S_{21}, S_{11} (a), dispersion diagram (b) and field distribution (c) of the CRLH ZOR.*



▲ *Fig. 3 Equivalent circuit of the inductive coupling between ZORs.*



▲ *Fig. 4 Geometry (a) and S-parameters (b) of the fifth order in-line CRLH ZOR filter.*

Until now, the resonators have been addressed. Now, the coupling between neighboring ZORs is added to make a filter with the passband and stopband satisfying the specifications. In a symmetric in-line bandpass filter, the outer and inner inductive lines, named L_{IRC} in ***Figure 3***, of 3.0 and 3.8 nH as the initial numbers for $IRC_{1,2}$ and $IRC_{2,3}$, respectively, are considered and varied in the iterative 3D EM simulations until the bands are made close to and coincident with the specifications.

The inductive line can be realized by the inductance from the distributed transmission line, as shown in the figure, not needing the extra inductance of a lumped element like a chip inductor. So the filters are fully printed throughout this article.

The in-line filter in ***Figure 4*** has five of the ZORs proposed with the coupling elements to effectively miniaturize the overall size. In detail, the total length of the proposed in-line filter is less than 65 mm, while one resonator of the conventional parallel edge coupled filter is approximately 90 mm long. This means a significant effect in the size reduction brought by the present

Waveguide Components
OFF-THE-SHELF OR CUSTOM DESIGNS
• Attentuators • Couplers • Switches • Loads • Terminations • Adapters • Assemblies • Horns • Ferrite Components

We're Ready When You Are... Next Day Delivery Of Catalog Components

From The Largest Inventory Of Waveguide Components In The Industry

RECTANGULAR, MM-WAVE, & DOUBLE-RIDGED COMPONENTS

CUSTOM DESIGNS

Custom designs are a Waveline specialty. If you don't see the product or design in our catalog, we probably have your "special" in our design files. Waveline now offers a complete line of Pin Diode Switches, Attenuators & Phase Shifters. Waveline has the expertise and capabilities to integrate waveguide and solid-state designs for subassemblies.

CALL OR WRITE
waveline®
P.O. Box 718, West Caldwell, NJ 07006
(973) 226-9100 Fax: 973-226-1565
E-mail: wavelineinc.com
VISA

THE VIEW FROM NIC'S SATELLITE OFFICE

- ✓ 15 Year Space Heritage
- ✓ Innovative Engineering Solutions
- ✓ Full-Environmental Testing per MIL-STD-202 and MIL-STD-883
- ✓ Hi-Reliability per IAW MIL-HDBK-217F
- ✓ Element Evaluation per MIL-PRF-38534

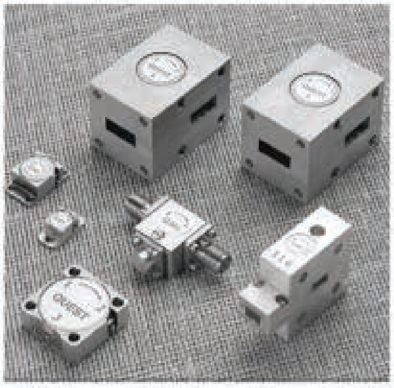
Cavity Filters & Diplexers | LC Filters | Crystal Filters | RF Assemblies | Switch Filter Banks | Ceramic Filters

ISO 9001:2008
AS9100C
CERTIFIED

NIC
www.nickc.com

913.685.3400
15237 Broadmoor
Overland Park, KS
e-mail: sales@nickc.com
See us at IMS Booth 2418

CIRCULATORS & ISOLATORS



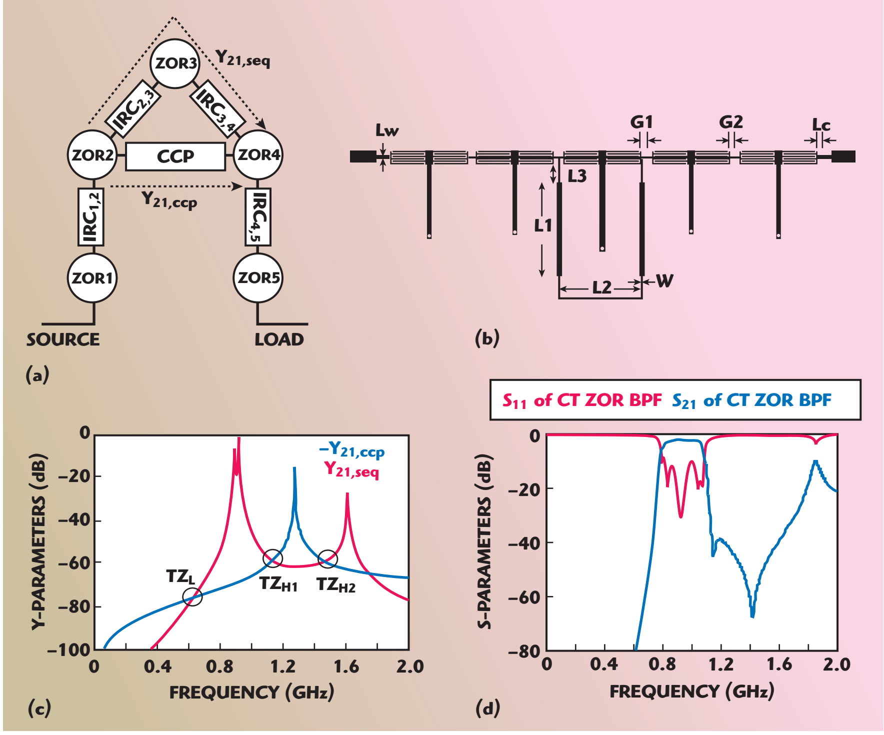
QUEST for Quality
QUEST for Performance
QUEST for the BEST…
JOIN US

Quality products with quick delivery and competitive prices are our standard

QUEST Microwave Inc.

225 Vineyard Court
Morgan Hill, California 95037

877-QUESTMW (783-7869)
(408) 778-4949 Phone
(408) 778-4950 Fax
circulators@questmw.com e-mail
http://www.questmw.com website



▲ *Fig. 5 Schematic of the proposed CT ZOR bandpass filter (a), the preliminary shape of the filter (b),* $Y_{21,seq}$ *and* $-Y_{21,ccp}$ *(c) and S-parameters (d) .*

work. In the next section, the size will be further reduced by taking the form of a CT. As another benefit, this in-line ZOR filter provides that the first harmonic at 1.9 GHz (= $2f_0$) of the parallel edge coupled filter is shifted away and the stopband is widened for the in-line ZOR filter, which the nonlinear dispersion accounts for. With regard to the insertion loss and the return loss, the related specifications are not satisfied with the in-line filter, but this is the first step in the entire design of this article, and this matter will be mitigated in the next step. Also, the smoothly varying skirt ($S_{21} \approx -11$ dB at f_{ue}+50 MHz) will be totally changed in the upcoming section.

DESIGN OF THE PROPOSED CT ZOR BANDPASS FILTER

Compliant to the passband, insertion loss and return loss of the specifications, the initial design as the fifth order in-line ZOR filter must be improved for steeper skirts with this configuration. The schematic of ***Figure 5*** looks similar to that of Figure 1, but it becomes different as the three innermost ZORs (ZOR two, three and four) from the first design step are grouped into a CT, which plays the key-role in generating TZs, by providing the phase difference between the sequential path and cross-coupling path (CCP). The figure also shows the CCP for the CT. As the preliminary CT ZOR filter, the line parallel coupled to the stubs from the interconnection between the ZORs two and three and another from ZORs three and four is the CCP that couples ZORs two and four. To find the geometric elements of the preliminary CT ZOR filter, the goal is set at the TZs from $Y_{21,seq} + Y_{21,ccp} = 0$ to be located in the vicinity of the band edges for the purpose of increasing the slope of the skirt, according to the specification, and vary the important physical dimensions until the goal is achieved. The TZ points where $Y_{21,seq}$ is equal to $-Y_{21,ccp}$ are shown. These frequency points are shown to be the same TZs of the S-parameters. In addition, the skirt becomes much steeper by more than 10 dB, owing to TZ_{H1}. This is made possible with the physical dimensions shown in ***Table 3***.

TABLE III

PHYSICAL ELEMENT VALUES OF THE PRELIMINARY CT ZOR BPF

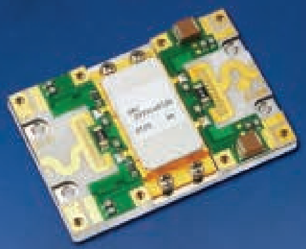
Name	*Value (mm)*	*Name*	*Value (mm)*
L1	18.1	G1	2
L2	16.9	G2	0.8
L3	4.1	Lc	2.5
W	0.1	Li	0.8

See us at IMS Booth 1917

600 Watts of Solid GaN Performance and Reliability for S-Band Radar

Your best source for high power GaN solutions is from the world leader in GaN Microwave Products

600 W Discrete
2.9 - 3.3 GHz Gp = 13 dB
50 Ω Matched Pair



600 W Pallet
Quick Installation
Small Form Factor

<table>
<tr><th colspan="7">Discrete Transistors</th></tr>
<tr><th rowspan="2">Power</th><th>L-Band</th><th colspan="5">S-Band</th></tr>
<tr><th>1.2 – 1.4 GHz</th><th>2.7 GHz</th><th>2.9 GHz</th><th>3.1 GHz</th><th>3.3 GHz</th><th>3.5 GHz</th></tr>
<tr><td>600 W</td><td></td><td></td><td colspan="3">🟩 SGN2933-600D-R</td><td></td></tr>
<tr><td>400 W</td><td></td><td colspan="2">🟪 EGN28B400M1B-R</td><td></td><td></td><td></td></tr>
<tr><td>320 W</td><td></td><td></td><td colspan="3">🟩 SGN2933-320D-R</td><td></td></tr>
<tr><td>300 W</td><td></td><td></td><td colspan="4">🟩 SGN2935-300D-R</td></tr>
<tr><td rowspan="3">200 W</td><td></td><td></td><td colspan="3">🟪 EGN31B200IV-R</td><td></td></tr>
<tr><td></td><td colspan="3">🟪 EGN29B200IV-R</td><td></td><td></td></tr>
<tr><td>🟧 EGN13B200IV-R</td><td colspan="2">🟪 EGN28B200IV-R</td><td></td><td></td><td></td></tr>
<tr><td>150 W</td><td></td><td></td><td colspan="3">🟩 SGN2933-150D-R</td><td></td></tr>
<tr><td rowspan="4">100 W</td><td></td><td></td><td></td><td colspan="3">🟪 EGN33B100IV-R</td></tr>
<tr><td></td><td></td><td colspan="3">🟪 EGN31B100IV-R</td><td></td></tr>
<tr><td></td><td colspan="3">🟪 EGN29B100IV-R</td><td></td><td></td></tr>
<tr><td>🟦 EGNB090MK</td><td colspan="2">🟪 EGN28B100IV-R</td><td></td><td></td><td></td></tr>
<tr><td>30 W</td><td>🟦 EGNB030MK</td><td colspan="5">🟦 EGN31B030MK</td></tr>
<tr><td>10 W</td><td colspan="6">🟦 EGNB010MK</td></tr>
</table>

<table>
<tr><th colspan="5">Pallets (50 Ω Matched Input/Output)</th></tr>
<tr><th rowspan="2">Power</th><th colspan="4">S-Band</th></tr>
<tr><th>2.9 GHz</th><th>3.1 GHz</th><th>3.3 GHz</th><th>3.5 GHz</th></tr>
<tr><td>600 W</td><td colspan="3">🟩 SMC2933L6012R</td><td></td></tr>
<tr><td>320 W</td><td colspan="3">🟩 SMC2933L3212R</td><td></td></tr>
<tr><td>300 W</td><td colspan="4">🟩 SMC2935L3012R</td></tr>
<tr><td>200 W</td><td colspan="3">🟪 EMC2933L2011R</td><td></td></tr>
<tr><td>150 W</td><td colspan="3">🟩 SMC2933L1512R</td><td></td></tr>
<tr><td rowspan="2">100 W</td><td></td><td colspan="3">🟪 EMC3135L1011R</td></tr>
<tr><td colspan="3">🟪 EMC2933L1011R</td><td></td></tr>
</table>

Maximum Pulse Conditions

- 🟦 CW Operatable
- 🟧 3 msec, 10% or 750 μsec, 25%
- 🟪 5 msec, 10% or 1.5 msec, 25%
- 🟩 300 μsec, 10%

Radar Application Engineering

USA	usaradar@sei-device.com
Other	globalradar@sei-device.com
Website	www.sei-device.com

SUMITOMO ELECTRIC
Ingenious Dynamics

See us at IMS Booth 2003

RF&MICROWAVE COMPONENTS AND SUB-SYSTEMS UP TO 40GHz

Low Noise Amplifiers

Model	Freq. Range (GHz)	Min. Gain (dB)	Max. N.F. (dB)	Min. P_1dB (dBm)
XKLA2040N3010	2-4	30	0.7	10
XKLA2080N3010	2-8	30	1.5	10
XKLA8012N3012	8-12	30	1.3	12
XKLA6018N3010	6-18	30	1.8	10

High Speed Frequency Synthesizers

Model	Freq. Range (GHz)	Step size (KHz)	Tuning speed (μS)	Phase noise (dBc/Hz @1K)	Spurious (dBc)
DSY1020	1-2	1	<200	-95/-98	-65
DSY2040	2-4	1	<200	-92/-95	-65
DSY4080	4-8	1	<200	-92/-95	-65
DSY8012	8-12	1	<200	-92/-95	-65
DSY2018	2-18	1	<200	-90/-95	-65

C-band SATCOM Multi-channel Down-converter

- Input 5 channels RF signal: 3400MHz - 4200MHz
- Output 10 channels IF signal: 70MHz±20MHz
- Gain: 30dB - 32dB

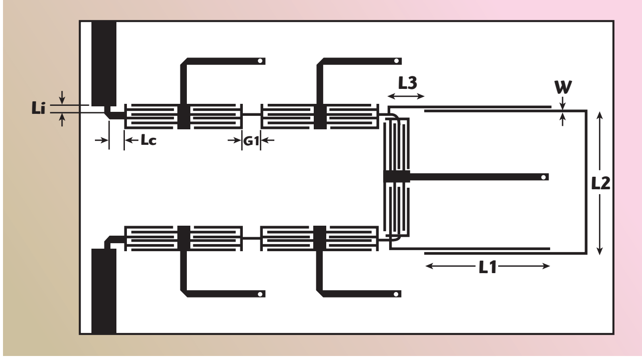
OEM&ODM and Custom Designs Available

SEEKON MICROWAVE

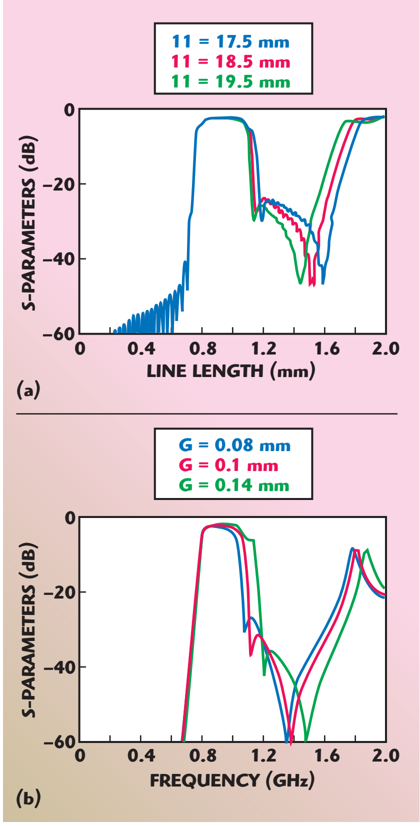
For detailed info and other products pls contact at
Daisy Huang/Regional sales manager daisy@seekonrf.com
Apple Yang/Regional sales manager sales@seekonrf.com
Tel: 86-28-81705322 Fax: 86-28-81708173
Website: http://www.seekonrf.com

If the preliminary shape of the proposed CT ZOR bandpass filter is examined, there is still room for reducing its total length. The preliminary structure can be folded with reference to ZOR three, while not distorting the previous frequency behaviors and the improved skirt. ***Figure 6*** is the folded version of the preliminary structure of the proposed CT ZOR bandpass filter. Obviously, it undergoes a change in S_{21} and S_{11}, due to the accompanying structural change in $IRC_{2,3}$, $IRC_{3,4}$, etc. So it is inevitable to correct the bandpass filter through another optimization.

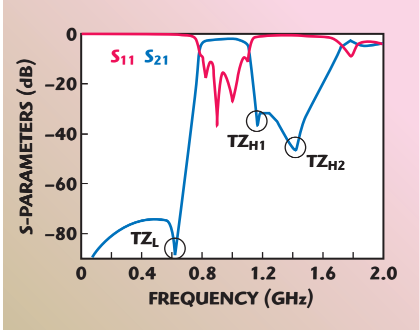
As shown in ***Figure 7***, S_{21} is mainly influenced by L1 in terms of the bandwidth and skirt, due to change of TZ_{H1}, and slightly by L2 and L3. Simultaneously, the variation of the interdigital lines' gap affects the TZs more seriously. With these observations, other geometrical parameters are adjusted to provide the optimal performance. They are finalized as Li = 0.8 mm, Lc = 1.6 mm, L1 = 18.6 mm, L2 = 16.9 mm, L3 = 4.1 mm, G1 = 2.3 mm, G2 = 0.8 mm, G3 = 0.45 mm, W = 0.1 mm. As is shown in ***Figure 8***, the passband



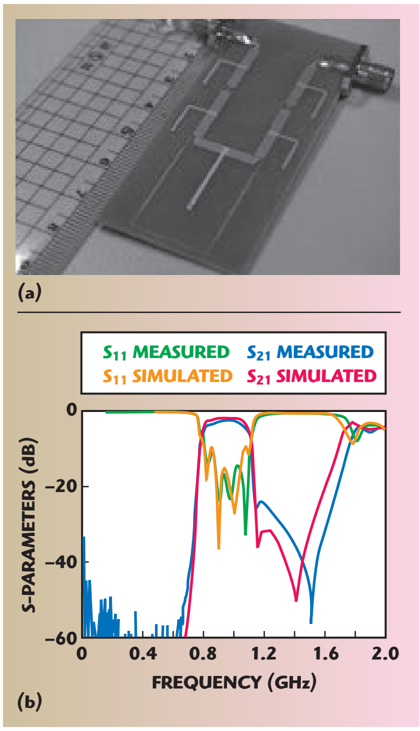
▲ *Fig. 6 Final, folded CT ZOR bandpass filter.*



▲ *Fig.7 S_{21} vs. line length of the CCP in the CT (a), vs. the gap of the interdigital lines (b).*



▲ *Fig. 8 Simulated S_{11} and S_{21} of the final CT ZOR bandpass filter.*



▲ *Fig. 9 Photograph of the fabricated filter (a) and measurements vs. 3D EM simulation (b).*

See us at IMS Booth 3404

Ordering custom microwave test cables has never been this easy!

Just click on the Micro-Coax Web site...and save up to 25%!

At Micro-Coax, we know that time is money. That's why we want to save you both. Now all you have to do is visit our Web site, build the test cable that's right for you, and order it. Our custom-made flexible cable assemblies feature a short turnaround and are ideal for defense, telecommunications and test instrument design applications. Best of all, you can save up to 25% when you order online.

Put our online cable store to the test...today. Visit us at www.micro-coax.com/testcables

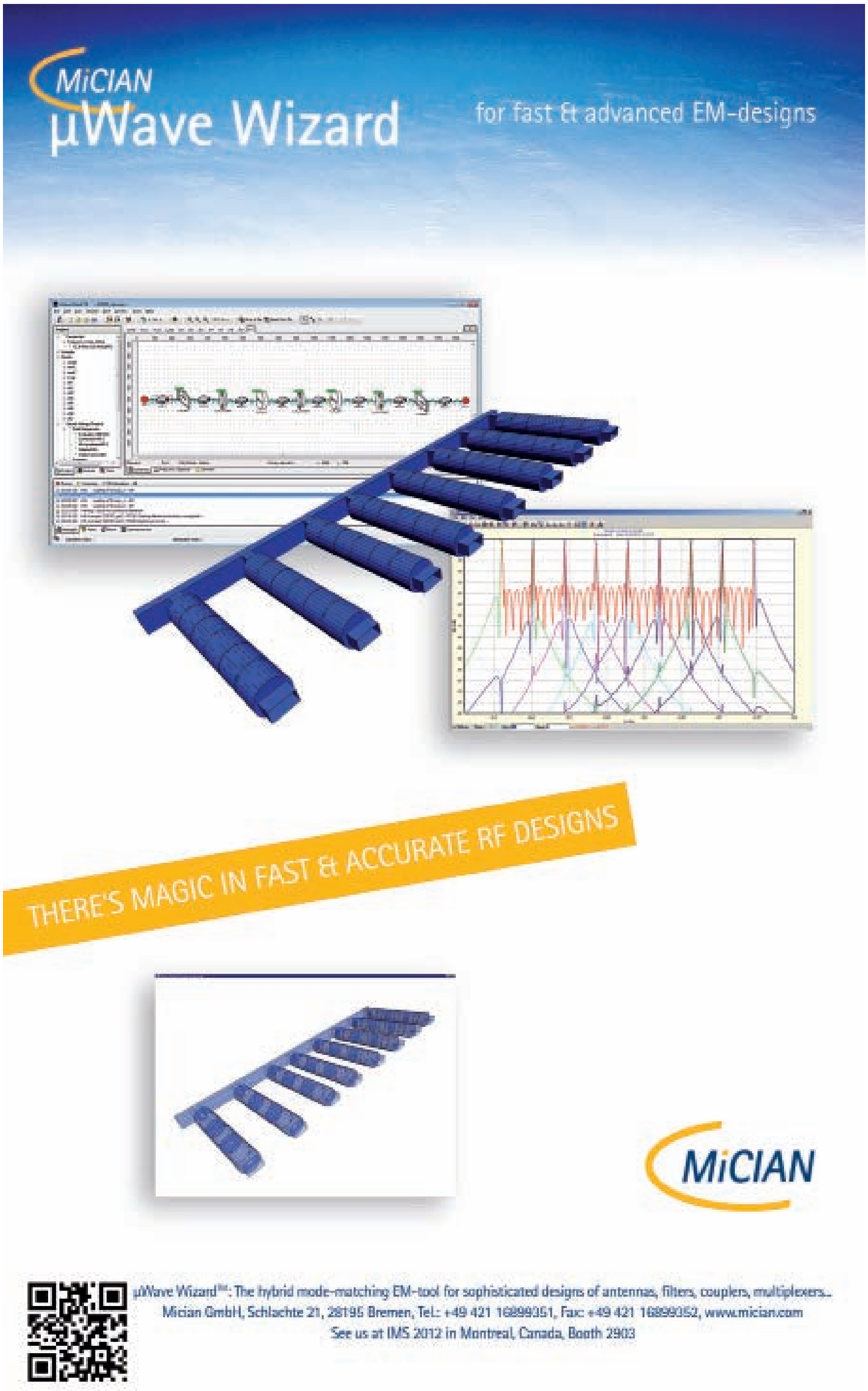
MICRO-COAX®

Leading the way in transmission line solutions.

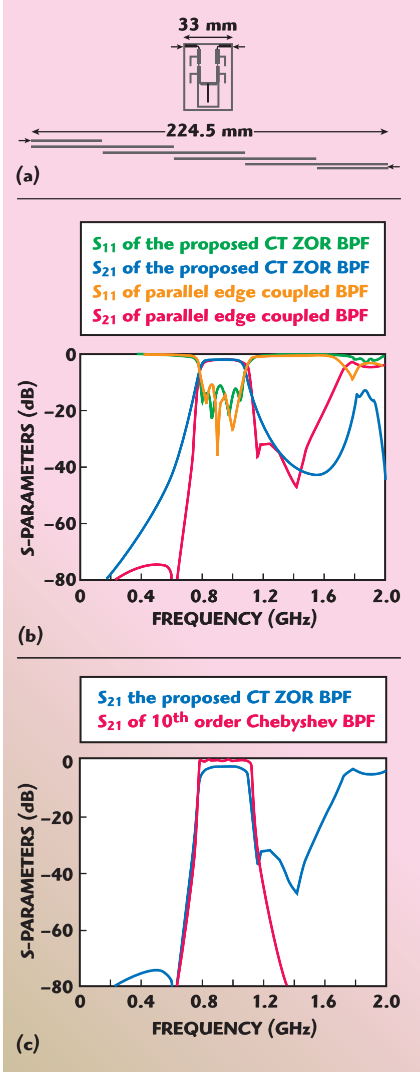
See us at IMS Booth 2024

is obtained as specified before, and the insertion loss and return loss are 1.2 dB and 15 dB, respectively. Especially, S_{21} has an attenuation of greater than 20 dB at f_{ue}+50 MHz by creating TZs. Including this finding, the 3D EM analysis results, as well as circuit simulation, are validated by comparison with the measurement of the fabricated prototype.

Taking advantage of a simple microstrip structure and feasible geometric parameters, the manufacturing cost is very low. As shown in ***Figure 9***, the area of the prototype is estimated to be 74 × 33 mm, which is small for a UHF-band printed RF component. The measurements meet the target specifications and agree well with the 3D EM simulation, without manual tuning at the time of testing. The passband has an insertion loss better than 2 dB and the return loss is better than 15 dB. The sharp skirt is achieved with S_{21} greater than 20 dB at the specified frequency point. Mentioning the insertion loss, it is very low despite using FR-4 as a lossy and cheap substrate. Lastly, to clearly show the advantages of the proposed CT ZOR filter over the conventional methods, the total size, passband performance and skirt are compared between the two cases. Apparently, the proposed CT ZOR bandpass filter is smaller than 1/7 of the parallel edge coupled bandpass filter as compared in ***Figure 10***. The proposed filter has a much steeper skirt than the conventional filter. Furthermore, to find out how high the order of a conventional filter should be to have the same frequency selectivity as the proposed filter, it is uncovered that the slope of a 10th order conventional Chebyshev filter is the closest to the proposed filter. In



µWave Wizard™: The hybrid mode-matching EM-tool for sophisticated designs of antennas, filters, couplers, multiplexers...
Mician GmbH, Schlachte 21, 28195 Bremen, Tel.: +49 421 16899351, Fax: +49 421 16899352, www.mician.com
See us at IMS 2012 in Montreal, Canada, Booth 2903



▲ *Fig. 10 Comparison of sizes (a), S-parameters (b) and skirt (c) of the proposed and conventional filters.*

Recently our components have been built into the Juno Spacecraft, and Mars Rovers.

Please contact us for a long list of spectacular performance.

Juno Spacecraft image: JPL, Mars Rover image: NASA

Since 1990 Dielectric Laboratories Inc. has been manufacturing Space qualified parts to MIL Standards.

In late 2012 QPL will be launched.

EARTH TESTED, SPACE PROVEN.

Our Capacitors, Hi-K Ceramics, and Custom Thin Film Components have over

200,000,000

LIFE TEST HOURS*

WITH NO FAILURES!

When failure is not an option, reliability means everything. You can turn to DLI with confidence for Space rated components.

With ***nearly 40 years of experience*** DLI is the pre-eminent ceramic component manufacturer in the industry.

See us at
IMS 2012
MONTREAL

BOOTH
1404

*Between 1990 and 1995 over 92 million hours of life test data (MIL-C-49464) was accumulated with zero failures. Between 1997 and 2003 DLI collected an accelerated amount of life test hours of > 71 million hours with zero failures, performed per the requirements of MIL-C-49464. Between 2005 and 2010 DLI collected an accelerated amount of life test hours of > 74 million hours with zero failures, performed per the requirements of MIL-PRF-49464. Testing is in progress for the 2011 – 2016 period.

There Is No Substitute For Experience

DLI
DIELECTRIC LABORATORIES
A DOVER COMPANY
CMP

www.dilabs.com

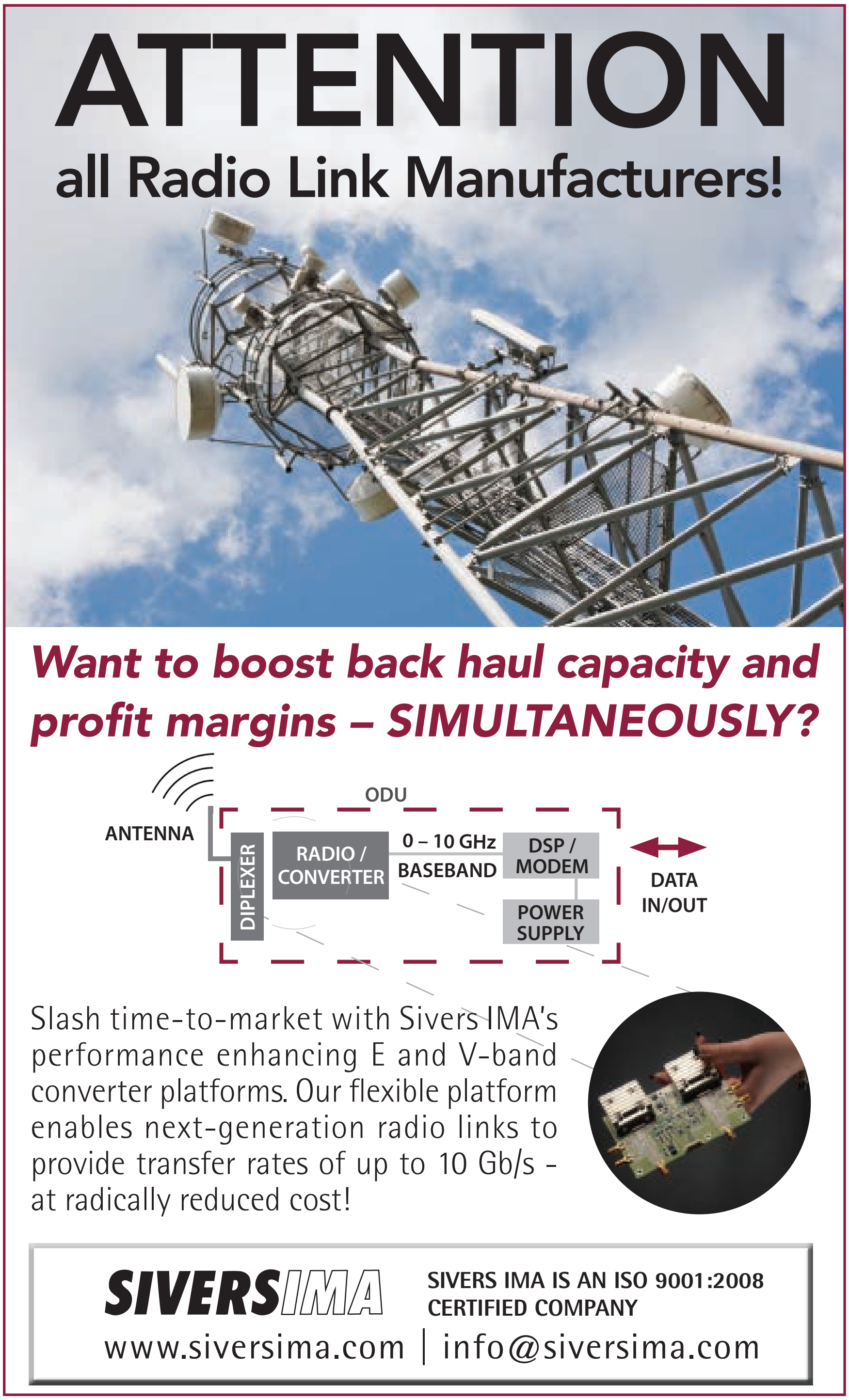
CERAMIC & MICROWAVE PRODUCTS
Electronic Components & Microwave Solutions
A DOVER COMPANY
CMP

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

other words, the proposed filter has five resonators, but its effect is equivalent to the 10th order Chebyshev as:

$$S_{21}^{\text{conv.}}(s) = \frac{b_9 s^9 + b_8 s^8 + \cdots + b_2 s^2 + b_1 s + b_0}{s^{10} + a_9 s^9 + \cdots + a_2 s^2 + a_1 s + a_0} \qquad (8)$$

where the coefficients are $a_9 = 1.14$, $a_8 = 3.15$, $a_7 = 2.71$, $a_6 = 3.44$, $a_5 = 2.14$, $a_4 = 1.53$, $a_3 = 0.63$, $a_2 = 0.24$, $a_1 = 0.049$, $a_0 = 0.0059$, $b_9 = b_8 = b_7 = b_6 = b_5 = b_4 = b_3 = b_2 = b_1 = 0.0$ and $b_0 = 0.0059$. The indication is that a very high rate of miniaturization is achieved by the function of the 10th order filtering from the physically fifth order filter.


ATTENTION
all Radio Link Manufacturers!

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

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

SIVERSIMA
SIVERS IMA IS AN ISO 9001:2008 CERTIFIED COMPANY
www.siversima.com | info@siversima.com

CONCLUSION

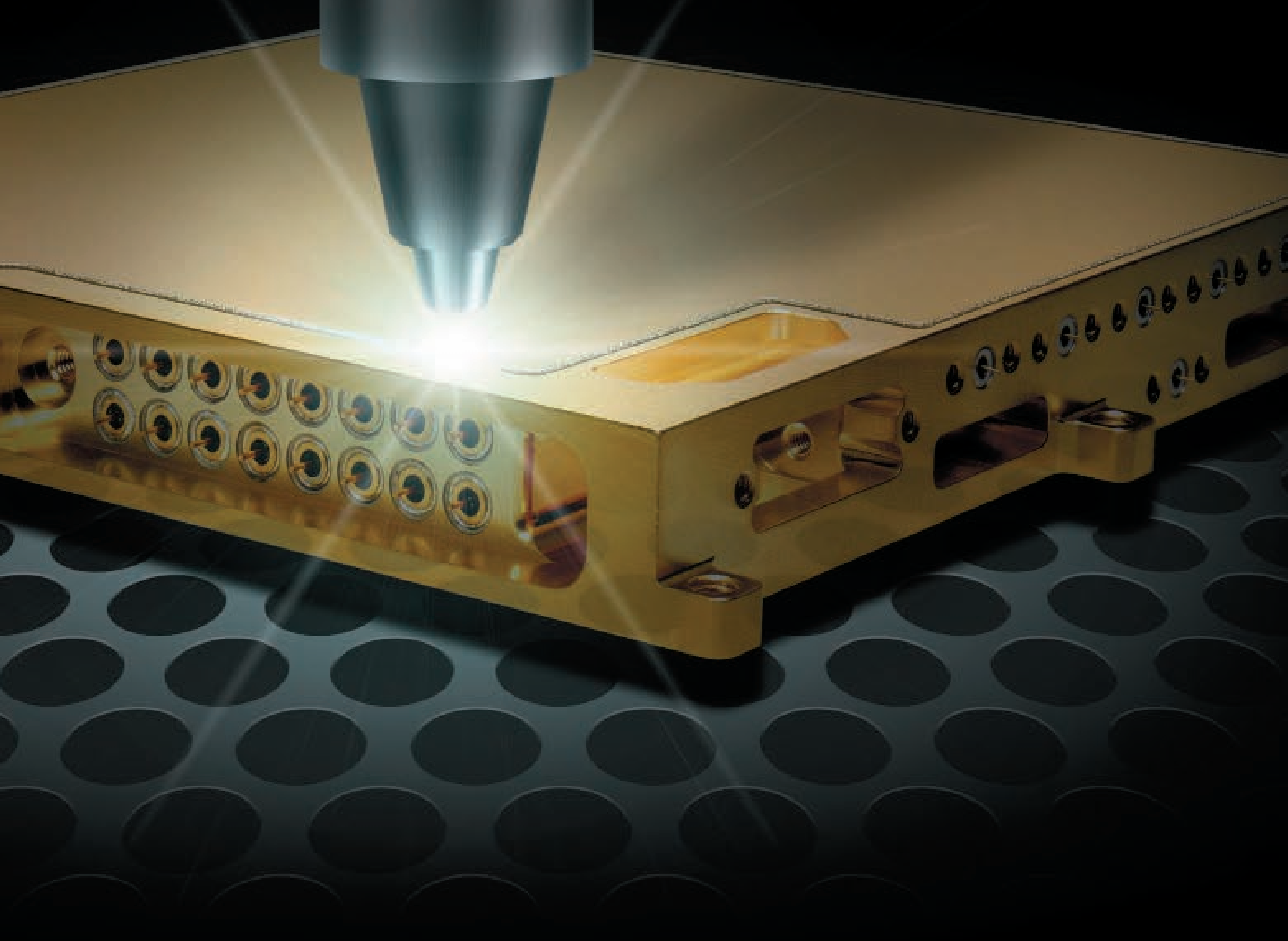
This article proposed a bandpass filter made very compact by implementing the CRLH ZORs and their coupling and forming a CT to have a steep skirt for high frequency selectivity. First, an in-line ZOR bandpass filter was designed as the initial step, whose total size is nearly 20 percent of the parallel-edge coupled filter. Second, the CT and its TZs were provided for improving the skirt of the initial ZOR filter. As a result, with the insertion loss better than 1.5 dB and the return loss better than 15 dB, the size-reduction effect and the skirt of the proposed filter were 24 times smaller than even a fourth order parallel-edge coupled filter and as sharp as a 10th order Chebyshev filter, respectively. The simulation and measurements validated the proposed design method, and the CRLH ZOR properties were proven by the no-phase variation electric field and dispersion diagram. ■

ACKNOWLEDGMENT

S. Kahng, the lead author, thanks the University of Incheon Research Promotion Program for their support.

References

1. C. Quendo, E. Rius and C. Person, "Narrow Bandpass Filters Using Dual-behavior Resonators," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 51, No. 3, March 2003, pp. 734-743.
2. A.D. Vince, "Practical Design Approach to Microstrip Combline-type Filters," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 22, No. 12, December 1971, pp. 1171-1181.
3. S.J. Park, K.V. Caekenberghe and G. Rebeiz, "A Miniature 2.1 GHz Low-loss Microstrip Filter with Independent Electric and Magnetic Coupling," *IEEE Microwave and Wireless Components Letters*, Vol. 14, No. 10, October 2004, pp. 496-498.
4. C.W. Tang, "Design of a Microstrip Filter Using Multiple Capacitively Loaded Coupled Lines," *IET Microwave Antennas and Propagation*, Vol. 1, No. 3, June 2007, pp. 651-657.
5. R. Levy, "Direct Synthesis of Cascaded Quadruplet (CQ) Filters," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 43, No. 12, Part 2, December 1995, pp. 2940-2945.
6. R. Hershtig, R. Levy and K. Zaki, "Synthesis and Design Of Cascaded Trisection (CT) Dielectric Resonator Filters," *1997 European Microwave Conference Digest*, pp. 784-791.
7. S. Kahng, M. Uhm and S. Lee, "A Dual-Mode Narrow-Band Channel Filter and Group-Delay Equalizer for a Ka-Band Satellite Transponder," *ETRI Journal*, Vol. 25, No. 5, October 2003, pp. 379-386.
8. M.V. Nedelchev and I.G. Iliev, "Accurate Design of Triplet Microstrip Square Open-Loop Resonator Filters," *Microwave Review*, Vol. 12, No. 2, November 2006, pp. 36-40.
9. C. Caloz and T. Itoh, *Electromagnetic Metamaterials: Transmission Line Theory and Microwave Applications*, Wiley-Interscience, Somerset, NJ, 2006.
10. G. Jang and S. Kahng, "Design of a Dual-band Metamaterial Bandpass Filter Using Zeroth Order Resonance," *Progress in Electromagnetics Research C*, Vol. 12, 2010, pp. 149-162.
11. B. Lopez-Garcia, D.V.B. Murthy and A. Corona-Chavez, "Half-mode Microwave Filters Based on Epsilon Near Zero and Mu Near Zero Concepts," *Progress in Electromagnetics Research*, Vol. 113, 2011, pp. 379-393.
12. G. Jang and S. Kahng, "Design of a Metamaterial Bandpass Filter Using the ZOR of a Modified Circular Mushroom Structure," *Microwave Journal*, Vol. 54, No. 5, May 2011, pp. 158-167.



The final stage.

Thunderline-Z laser sealing completes the packaging cycle.

One-stop packaging? Case closed. From the #1 name in hermetic feedthrus and custom RF housings, comes the final stage in the cycle. Thunderline-Z now offers high-powered laser sealing of your hi-rel components and modules. From final lidding to component insertion and our own innovative surface mount Bell Pin technology, turn to Thunderline-Z to help you create the perfect hermetic package.

Backed by the strength of Emerson and powered by a 500 W laser in a vacuum sealed glovebox and a 150 W laser workstation, you can now trust your packages to one source from design through fine and gross leak testing.

It's the next chapter to a hermetic packaging legacy like no other. Contact Thunderline-Z engineering for further details.

THUNDERLINE-Z®

www.thunderlinez.com
603.329.4050

EMERSON™

EMERSON. CONSIDER IT SOLVED.™

MICROWAVE JOURNAL
REVIEWED
EDITORIAL BOARD

Quarter Substrate Integrated Waveguide Resonator Applied to Fractal-Shaped BPFs

A quarter substrate integrated waveguide resonator (QSIWR) and a fractal-shaped defected structure (FDS) are used to design miniaturized substrate integrated waveguide (SIW) bandpass filters. With the QSIWR, a conventional SIW filter can be reduced in size by approximately 75 percent and the size can be further reduced with FDS. Using QSIWR and FDS, a type of one-pole and a type of two-pole bandpass filters are proposed and optimized. The two-pole bandpass filter has more merits, such as a simple structure, compact size and an extra transmission zero in the upper stopband. The measured and simulated results of a two-pole filter are in good agreement.

In recent years, there has been a growing interest in the SIW technology,[1-8] which has the advantages of light weight, high power capacity and easy integration with other planar microwave circuits. But, compared to microstrip circuits, the SIW circuits are of larger sizes, especially in low microwave frequency bands. By using half mode substrate integrated waveguide (HMSIW)[3-6] and substrate integrated folded waveguide (SIFW)[8] structures, the total size of a SIW is nearly reduced by a half, but still keeps comparable performances.

Many kinds of miniaturized filters[4,5,7] and antennas[6] have been proposed using these technologies. The propagation modes of SIW are similar to those of a rectangular waveguide, so cavity resonators are the basic shapes used in the design of SIW filters. Utilizing the symmetry of SIW, the HMSIW is obtained by cutting the SIW along the perfect magnetic wall. It still keeps half of the field distribution of the dominant mode TE_{10}. The same idea can be applied to shrink the square SIW resonator. By cutting the square SIW resonator along magnetic walls, a quarter SIW resonator (QSIWR) is derived. Using QSIWR, two types of bandpass filter are proposed, achieving approxi-

Sheng Zhang, Tian-Jian Bian and Yao Zhai
China University of Mining and Technology, Xuzhou, China
Wei Liu, Guang Yang and Fa-Lin Liu
University of Science and Technology of China, Hefei, China

SV introduces a family of high flexibility low loss 0.047" diameter cable assemblies. Available in multiple variants based on your unique need for speed and flexibility. Choose from a wide variety of industry standard connector styles or a custom design to meet your specific requirements.

To meet the challenge of high performance RF cable assemblies in small spaces – think SV!

See us at IMS Booth 1724

DFINE

DFINE manufactures a complete line of RF and Microwave components covering nearly every application in the DC to 50GHz frequency range.

- Power Divider
- Directional Coupler
- Waveguide
- Filter
- Combiner
- Isolator &Circulator

Tel: 86-28-85306131
Fax: 86-28-85316136
Building A2, Tianfu Software Park,
Chengdu 610041, China
E-mail: huangyuan@dfine-tech.com
Website: www.dfine-tech.com

mately a 75 percent reduction in size compared to conventional ones. At the same time, the fractal-shaped[9-11] defected structures (FDS) are etched in the QSIWR, which can further reduce the filters' size and improve their selectivities.

QUARTER SUBSTRATE INTEGRATED WAVEGUIDE RESONATOR

In ***Figure 1***, if the width of the rectangular resonator is equal to the length a, the TE_{101} mode can be expressed as follows, which is the same as the square SIW resonator.[1]

$$\begin{cases} E_y = -j\dfrac{\omega\mu a}{\pi} H_m \sin\left(\dfrac{\pi}{a}x\right)\sin\left(\dfrac{\pi}{a}z\right) \\ H_x = -H_m \sin\left(\dfrac{\pi}{a}x\right)\cos\left(\dfrac{\pi}{a}z\right) \\ H_z = H_m \cos\left(\dfrac{\pi}{a}x\right)\sin\left(\dfrac{\pi}{a}z\right) \\ E_x = E_z = H_y = 0 \end{cases} \qquad (1)$$

According to Equation 1, the magnetic field intensity **H** perpendicular to the Plane AA' (x = z) and the plane BB'(x = -z) are similar, so at the fundamental resonant mode (TE_{101}), the AA' and BB' planes are equivalent to perfect magnetic walls. On the condition that the substrate is very thin, by cutting along AA' and BB', quarter SIW resonators are left. The QSIWR's open sides are nearly equivalent to perfect magnetic walls. As shown in ***Figure 2***, comparing with the electric fields of SIW and QSIW, the field is kept almost undamaged. There is only a small wave leakage along two magnetic walls. So the QSIWR can be used to design various cavity filters with 75 percent reduction in size.

FRACTAL ONE-POLE FILTER USING QSIWR

In order to verify the resonant characteristics of QSIWR, first a new fractal one-pole filter is designed, which is shown in ***Figure 3***. The geometry of QSIWR is a right angled isosceles triangle (RAIT). Two microstrip feed lines are at the center of each right-angle side. The 50 Ω microstrip line with $\varepsilon_r = 2.2$ and loss tangent of 0.0009, height h = 0.508 mm, conductor strip width w = 1.58 mm is chosen for all filters. At the same time, the diameter of the vias is d = 0.5 mm and the pitch between vias is p = 1.1 mm. The resonant frequency is mainly decided by the hypotenuse length b.[1] To lower the resonant frequency, a RAIT

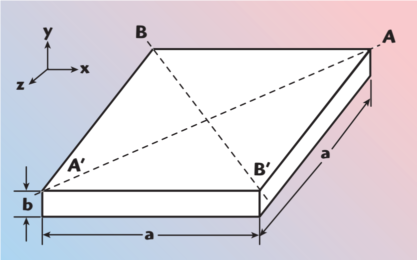


Fig. 1 Schematic of the square waveguide resonator.

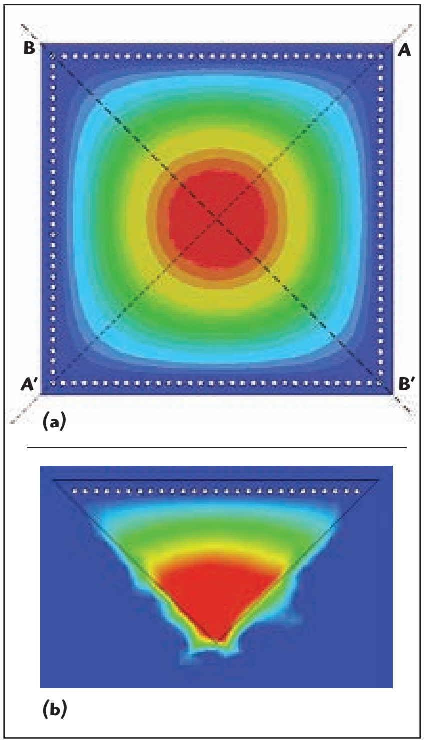


Fig. 2 Electric field distribution of a square SIW (a) and QSIWR (b).

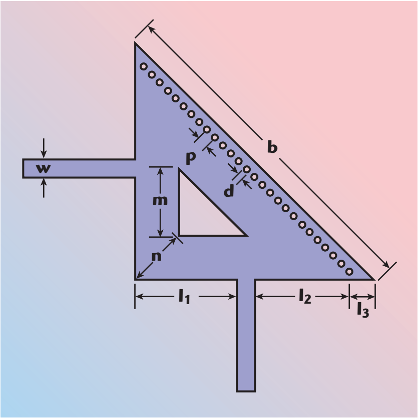


Fig. 3 One-pole QSIWR with a fractal-shape structure.

RF/Wireless Training Courses

BESSER ASSOCIATES®

The Worldwide Leader in RF and Wireless Training

Besser Associates Web Classroom℠

Attend classes from anywhere!

RF Fundamentals
Jun 25-29, 2012 - 90 minutes/day

RF & Microwave Transistor Tutorial
July 12, 2012 - New!

Power Amplifier ABC's
September 10-14, 2012 - 90 minutes/day

Impedance Matching Tutorial
October 9, 2012

Phase Noise and Jitter
October 24-26, 2012 - 2 hours/day

GaN Power Amplifier Design
November 26-30, 2012 - 90 minutes/day

EMC/Shielding/Grounding Techniques for Chip & PCB Layout
Jan 21-25, 2013 - 90 minutes/day

San Jose: August 2012

• Semiconductor Materials for RF and Wireless Applications • Power Conversion & Regulation Circuits for VLSI Systems • Applied RF Techniques I • Applied RF II: Advanced Wireless and Microwave Techniques • RF Power Amplifier Techniques • Advanced Radio System Architectures

San Jose: Oct., Nov. 2012

Radio Frequency Basics for Electronics Professionals • Fundamentals of LTE, HSPA, & WCDMA • RF Measurements:Principles & Demonstration • EMI/EMC Design and Troubleshooting • RF and Wireless Transceiver Design & Evaluation Techniques • Wireless LANs

San Jose: December 2012

• RF and Wireless Concepts and Terminology • Behavioural Modeling & Digital Pre-Distortion of RF Power Amplifiers • DSP: Understanding Digital Signal Processing • RF and High Speed PC Board Design Fundamentals • *January 2013:* Monolithic Microwave Integrated Circuit (MMIC) Design

San Diego: February 2013

• Antennas & Propagation for Wireless Communications • Applied RF Techniques I • Practical Digital Wireless Signals

Besser Associates' On-site Courses can be conducted at any US or International location and any course can be customized to fit the specific needs of your group.

Many of our courses can also be offered to your company via our Corporate-Exclusive Web Classroom - an increasingly popular choice!

San Jose • San Diego • On-Site • Web Classroom

www.besserassociates.com

Schedule at a Glance

Web Classroom Courses		Dates	Earlybird Deadline & Price		Reg. Price
059-4461	RF Fundamentals	Jun 25-29	June 18	$449.00	$495.00
233-4505	RF and Microwave Transistor Tutorial	Jul 12	Jul 5	$69.00	$99.00
216-4489	Power Amplifier ABC's	Sep 10-14	Sep 3	$449.00	$495.00
229-4506	Introduction to Impedance Matching	Oct 9-9	Oct 2	$69.00	$99.00
220-4507	Phase Noise and Jitter	Oct 24-26	Oct 19	$449.00	$495.00
228-4524	GaN Power Amplifier Design	Nov 26-30	Nov 19	$449.00	$495.00
140-4508	EMC/Shielding/Grounding Techniques for Chip & PCB Layout	Jan 21-25	Jan 14	$449.00	$495.00

San Jose, CA August 2012		Dates	Earlybird Deadline & Price		Reg. Price
214-4491	Advanced Radio System Architectures	Aug 22-24	Jul 16	$1,595.00	$1,695.00
086-4492	Applied RF II: Advanced Wireless and Microwave Techniques	Aug 20-24	Jul 16	$1,995.00	$2,295.00
001-4490	Applied RF Techniques I	Aug 20-24	Jul 16	$1,995.00	$2,295.00
224-4472	Power Conversion & Regulation Circuits for VLSI Systems	Aug 20-23	Jul 16	$1,695.00	$1,895.00
222-4493	RF Power Amplifier Techniques	Aug 21-24	Jul 16	$1,795.00	$1,995.00

San Jose, CA October 2012		Dates	Earlybird Deadline & Price		Reg. Price
231-4509	Radio Frequency Basics for Electronics Professionals	Oct 10-12	Sep 3	$1,495.00	$1,595.00
230-4510	EMI/EMC Design and Troubleshooting	Oct 15-17	Sep 10	$1,495.00	$1,595.00
223-4511	Fundamentals of LTE, HSPA, & WCDMA	Oct 15-17	Sep 10	$1,495.00	$1,595.00
135-4512	RF Measurements:Principles & Demonstration	Oct 15-19	Sep 10	$2,295.00	$2,495.00

San Jose, CA November 2012		Dates	Earlybird Deadline & Price		Reg. Price
199-4513	RF and Wireless Transceiver Design & Evaluation Techniques	Nov 5-9	Oct 1	$1,995.00	$2,295.00
227-4514	Wireless LANs	Nov 5-7	Oct 1	$1,495.00	$1,595.00

San Jose, CA December 2012		Dates	Earlybird Deadline & Price		Reg. Price
212-4517	Behavioural Modeling & Digital Pre-Distortion of RF PAs	Dec 3-5	Oct 29	$1,495.00	$1,595.00
042-4518	RF and High Speed PC Board Design Fundamentals	Dec 5-7	Oct 29	$1,495.00	$1,595.00
234-4516	RF and Wireless Concepts and Terminology	Dec 3-4	Oct 29	$995.00	$1,095.00
027-4519	Understanding Digital Signal Processing (DSP)	Dec 3-5	Oct 29	$1,495.00	$1,595.00
181-4520	Monolithic Microwave Integrated Circuit (MMIC) Design	Jan 16-18, 2013	Dec 10	$1,495.00	$1,595.00

San Diego, CA February 2013		Dates	Earlybird Deadline & Price		Reg. Price
037-4515	Antennas & Propagation for Wireless Communications	Feb 25-27	Jan 21	$1,495.00	$1,595.00
001-4521	Applied RF Techniques I	Feb 25-1	Jan 21	$1,995.00	$2,295.00
232-4522	Practical Digital Wireless Signals	Feb 25-27	Jan 21	$1,495.00	$1,595.00

Course Descriptions

WEB - Web Class, AUG, OCT, NOV, DEC - San Jose, CA, FEB - San Diego, CA

214 Advanced Radio System Architectures

The ideas associated with sampling and digital signals that revolutionised modulation systems and are now revolutionising radio system design. This course continues the theme of block diagram rather than circuit diagram design, presenting an up to date view on concepts for advanced radio systems that incorporate digital signal processing at RF frequencies and the concepts of software defined radio. It is a practical approach for technical professionals to understand the latest designs and architectures for radio systems that include DSP. **Aug**

037 Antennas & Propagation for Wireless Communications

This three-day course provides participants with comprehensive coverage of a wide variety of antenna and propagation topics. The course provides an understanding of basic antenna property definitions, antenna design fundamentals and considerations, numerous antenna types and RF propagation fundamentals. The course also provides an overview of how antenna properties and propagation characteristics affect communication system performance. Topics covered include antenna fundamentals, basic antenna types, elementary antennas, electrically small antennas, microstrip patch antennas, low profile antennas, aperture and reflector antennas, circular polarized antennas, antenna arrays, propagation channel characteristics, and an overview of different antennas used in today's wireless communication devices and markets. **Feb**

86 Applied RF II: Advanced Wireless and Microwave Techniques

This five-day course provides participants with an in-depth examination of advanced RF and microwave design techniques. Antennas and filters are covered briefly, followed by a detailed discussion of figures of merit. Mixers and oscillator designs are also evaluated. Considerable attention is devoted to defining, classifying, and improving the efficiency and linearity of power amplifiers. Numerous design examples are provided for participant exploration. **Aug**

001 Applied RF Techniques I

Switching from traditional definitions based on voltages and currents, to power-flow concepts and scattering parameters, the course has smooth transition into the wireless domain. We review S-parameter measurements and applications for both single-ended (unbalanced) and balanced circuits and have a brief introduction to RF systems and their components. Impedance matching is vitally important in RF systems and we use both graphical (Smith Chart) and analytical techniques throughout the course. We also examine discrete and monolithic component models in their physical forms, discussing parasitic effects and losses, revealing reasons why circuit elements behave in surprising manners at RF. **Aug,Feb**

212 Behavioural Modeling & Digital Pre-Distortion of RF Power Amplifiers

The goals of RF power amplifier design are high efficiency and linearity. With modern cellular communications modulation formats such as LTE

Besser Associates .com
The Worldwide Leader in RF & Wireless Training

and WCDMA these goals are difficult to achieve simultaneously with traditional RF PAs, and high-efficiency architectures such as Doherty, Envelope Tracking, and so forth are becoming more commonplace. These PAs require an additional linearization system to achieve the mandated linearity specifications. The emergence of high-speed digital signal processing techniques has enabled the linearization to be accomplished in the digital signal domain, and digital pre-distortion (DPD) is now the preferred linearization technique.

This course explains the nonlinear behaviour of RF power amplifiers, developing general modeling techniques to describe the nonlinearities and memory effects. A system-level approach to the modeling and linearization of the PA is adopted, and techniques for implementation of DPD in practical situations are described. **Dec**

140 EMC/Shielding/Grounding Techniques for Chip & PCB Layout

This seminar discusses techniques for identifying the sources of unwanted coupling and radiation, and systematic approaches for their minimization. **Web**

230 EMI/EMC Design and Troubleshooting

This course covers the methodology of designing an electronic product to minimize the possibility of having problems of electromagnetic interference (EMI) or Electromagnetic Compatibility (EMC). Useful techniques for troubleshooting an EMI/EMC problem are presented to help with products where problems exist. **Oct**

223 Fundamentals of LTE, HSPA, & WCDMA

Understanding the evolution of wireless data transmission from 3G to 4G technologies is critical to today's commercial component and system vendors. This comprehensive three day program covers the key technologies in a clear and concise manner. **Oct**

228 GaN Power Amplifier Design

This course introduces attendees to the GaN transistor, its properties, various structures, discrete devices and MMIC sources, including the latest GaN power amplifier (PA) design techniques. The properties of GaN will be presented showing the advantage of these devices over GaAs and Si. GaN HEMT transistors will be shown delineating the various geometries, semiconductor processes and structures with associated breakdown voltages, power capability, gain, efficiency, and frequency performance. Guidelines for reliable operation will be presented considering device junction temperature including thermal management techniques. **Web**

229 Introduction to Impedance Matching

The need for impedance matching is rooted in basic AC circuit analysis principles. In basic terms, maximum power transfer occurs when the current and voltage are in phase. This workshop examines the ins and outs of delivering the most power possible to an RF load. Q factor and its effect on matching network bandwidth are also described. **Web**

181 Monolithic Microwave Integrated Circuit (MMIC) Design

The successful design of monolithic microwave integrated circuits (MMICs) is the fruit of a disciplined design approach. This three-day course covers, in detail, the theory, and practical strategies required to achieve first-pass design success. Specifically, the course covers the monolithic implementation of microwave circuits on GaAs substrates including instruction on processing, masks, simulation, layout, design rule checking, packaging, and testing. Numerous design examples are provided with emphasis on increasing yield, and reliability. **Jan San Jose**

220 Phase Noise and Jitter

Timing-related problems associated with signal sources are one of the major bottlenecks in designing today's highly complex systems. Over many decades, jitter has been extensively studied and utilized to characterize timing inaccuracies in both digital and analog systems. Conversely, phase noise has been exclusively used in RF systems to represent frequency or phase inaccuracy. For both timing and frequency sensitive systems, phase noise measurement is emerging to be the most accurate method of characterizing all types of signal sources (RF, analog or digital). This short course covers the fundamentals of phase noise and jitter, which ultimately set the limit to PLL performance in applications such as frequency synthesis, serial data communication and clock/data recovery. Simple techniques to model phase noise at the circuit component-level and relate it to the overall phase noise and jitter performance of PLLs are presented. The course will also provide a detailed analysis of the different phase noise measurement techniques along with in-depth noise floor analysis. The focus throughout this course will be on providing practical measures utilizing numerous real life examples. **Web**

216 Power Amplifier ABC's

This course aims to bring participants up to speed on the basics of RF power amplifier design and operation in the shortest possible amount of time. Considerable attention is devoted to defining, classifying, and improving the efficiency and linearity of power amplifiers. Numerous design examples are provided for participant exploration. The class offers approximately one day's worth of material, but is typically offered in five 90-minute sessions via web-classroom. **Web**

224 Power Conversion & Regulation Circuits for VLSI Systems

Developing power conversion/regulation solutions for VLSI systems and mixed-signal analog/RF System-on-Chip (SoC) types of loads require engineers with solid background in both traditional power converters design as well as analog/RF mixed-signal VLSI design. Power conversion/regulation circuits with such a VLSI and SoC focus are rarely covered in graduate or undergraduate power electronics courses. With the growing demand in semiconductor industries for expertise in this area, there is a serious shortage in engineers who have the necessary background combination to design efficient and cost-effective solutions for such loads. This course will introduce the fundamental principles of power conversion/regulation circuits such as Linear/switching regulators and battery chargers used in VLSI systems. This includes: Architectures, Performance metrics, characterization, stability and noise analysis, practical implementations, on-chip integration issues, and design considerations for portable, wireless, and RF SoCs. **Aug**

232 Practical Digital Wireless Signals

This three day course is designed to provide all participants with a physically intuitive understanding of wireless communication signals and why they work the way they do. With the growing impact of wireless communications on the basic operation of society, the need for a more general understanding of the basis for this technology is more important than ever. This course approaches wireless communications signals through the window of physics and physical principles. While a solid understanding of the mathematical theory of wireless communications signals is essential for detailed system design and analysis, the fundamental choices in system application and approach are often best approached physically. We do not shun math in this presentation, but instead of using math as the presentation base we instead use it as a follow up illustrator of the principles discussed. **Feb**

231 Radio Frequency Basics for Electronics Professionals

This course covers the fundamentals of high frequency (RF) design for engineers and technicians in the electronic market. The course is not intended for telecomm specialists but for design, production and installation engineers who need to increase or review their curriculum with radiofrecuency technology.

Many products, non related classically with RF, give a growing importance to high frequency techniques: products where radio is included through ZigBee or Bluetooth, electromagnetic interference problems (EMI/EMC), high speed digital circuits, signal integrity, high speed switching (power) circuits, switching power supplies, filters, need for shielding in both susceptibility and emissions, spectrum analysis, RF instruments, etc. **Oct**

42 RF and High Speed PC Board Design Fundamentals

This three-day course enables practicing engineers and CAD technicians to develop design rules for RF and high-speed designs, choose an optimal design tool, and organize the design process to most efficiently execute the design that will insure circuit performance, and minimize costs and production time. **Dec**

234 RF and Microwave Transistor Tutorial

This 2 hour tutorial provides microwave circuit designers with an overview of their “toolkit” of semiconductor devices. We look at functional descriptions of the basic semiconductor devices: the P-N junction, the bipolar transistor and the FET. Further material describes basic transistor operation, using heterojunctions for higher performance, as well as the effects of material properties on performance and reliability. **Web**

234 RF and Wireless Concepts and Terminology

This two-day day course provides nontechnical professionals with a firm understanding of basic RF principles and technical concepts. RF technology, wave propagation and transmission techniques will be characterized for various performance requirements. This course will also convey a conceptual understanding of RF wireless systems and how they work for the multiple wireless standards. All explanations use simple physical descriptions without complex mathematics. **Dec**

199 RF and Wireless Transceiver Design & Evaluation Techniques

This 5-day course provides technical professionals with the design concepts and development tools required to architect RF transceivers for most wireless applications. The course is intended for working engineers that are in the design, test or support phase of new transceiver technology.. Also, Critical system specifications will be discussed based on worldwide standards and an in-depth review of transceiver configurations will be evaluated. The use of RF simulation tools will be used to show design concepts and the trade-offs between modulation techniques and RF performance. RF air interface requirements and specifications will be presented for various wireless standards including LTE and systems like GPS, Bluetooth, 802.11, wideband CDMA, EDGE and others. Radio architectures based on digital modulation techniques like OFDM, OFDMA, SC-FDMA, QAM, BPSK, QPSK, GSM, 8PSK, GFSK will be analyzed using simulation tools and design examples. Designs of the latest architectures including 4G LTE transceivers will be presented with class participation using the lasted CAD design tools. Finally, transceiver test and troubleshooting procedures from RF to baseband will be described. **Nov**

59 RF Fundamentals

This course provides circuit-level designers with the essential concepts needed to work effectively with high frequency electronics. Participants gain analytical, graphical, and computer-aided techniques to analyze and optimize RF circuits in practical situations. The course addresses linear active circuit design, focusing on stability, bandwidth, and noise considerations. **Web**

135 RF Measurements:Principles & Demonstration

This 5-day lecture-based course explains essential RF measurements that must be made on modern wireless communications equipment - mobile/smart phones, wireless LANs, GPS navigation systems, and others. Current models of the essential test instruments will be explained and demonstrated, including vector network analyzers, power meters, spectrum analyzers, digitally modulated signal generators and vector signal analyzers. All of the measurements will be demonstrated on actual RF wireless components including power amps, LNAs, mixers, upconverters, and filters. These measurements will include traditional tests of power, gain, group delay, S parameters, AM to PM, intermodulation products, harmonics and noise figure. The unique measurements of wireless communications will then be made with PSK and FSK digitally modulated signals including spectral regrowth, constellation diagram distortion, error vector magnitude (EVM), and bit error rate. **Oct**

222 RF Power Amplifier Techniques

Power amplifiers are crucially important in determining a communications system cost, efficiency, size, and weight. Designing high power / high efficiency amplifiers that satisfy the system requirements (bandwidth, linearity, spectral mask, etc.) is challenging. It involves difficult trade-offs, proper understanding of the theory, and careful attention to details. Additionally, designing, building, and testing power amplifiers usually pushes test equipment and lab components to their limits and frequently results in damage to the circuit or lab equipment. This course will examine the different aspects of this challenge with emphasis on hand-on exercises and practical tips to build power amplifiers successfully. **Aug**

27 DSP -Understanding Digital Signal Processing

This three-day course is the beginner’s best opportunity to efficiently learn DSP. Intuitive, nonmathematical explanations and well-chosen examples develop the student’s fundamental understanding of DSP theory. The practical aspects of signal processing techniques are stressed over discrete system theory. Participants will leave with a collection of tricks-of-the-trade used by DSP professionals to make their processing algorithms more efficient. Public course attendees will receive a copy of the book - *Understanding Digital Signal Processing* by Rick Lyons **Dec**

227 Wireless LANs

This three-day course is an experiment-oriented course that integrates topics at the MAC layer (and above) of Wireless LANs (WLANs) and Wireless Personal Area Networks (WPANs). The course emphasizes hands-on learning through experiments and case studies. It will offer attendees the ability to conduct laboratory experiments and design projects that cover a broad spectrum of issues in WLANs and WPANs. The characteristics and operations of IEEE 802.11a/b/g/n WLANs will be described as well as that of Bluetooth WPANs. Laboratory experiments will be conducted to show the tradeoffs of the virtual carrier sensing mechanism, observe interference issues with other devices operating on the ISM band, describe Mobile Ad-hoc NETwork (MANET) operations and routing protocols, configure secure infrastructure and MANET WLANs, deploy hotspots, and use modeling, simulation, and emulation tools to evaluate WLANs (including system in the loop capabilities). Real infrastructure and MANET WLANs will be deployed and configured in class under different network scenarios. Different tools and techniques will be introduced to monitor, measure, and characterize their performance (and realize the tradeoffs). Known techniques to attack WLANs will be shown and proper security practices to avoid well-known threats will be discussed. All concepts will be summed up in an experiment that aims at deploying a secure hotspot **Nov**

BesserNet™

"Training and tools to help you perform your job better"

Visit www.bessernet.com for industry news, applets and our glossary of RF terms.

Register Online Now!

BESSER ASSOCIATES®

The Worldwide Leader in RF and Wireless Training

480 San Antonio Road
Suite 215
Mountain View, CA 94040
Phone: (650) 949-3300
Fax: (650) 949-4400
E-mail: info@besserassociates.com
Web: www.besserassociates.com

eLEARNING center

May Short Course Webinars

Besser Training Series

Mixers and Frequency Conversion
Live webcast: 5/22/12, 11:00 AM ET
Sponsored by: Mini-Circuits

Technical Education Series

Improving GaN HEMT PA Design with Cree's Large Signal Models and AWR's Microwave Office™
Live webcast: 5/3/12, 11:00 AM ET
Sponsored by: Cree/AWR

Understanding Radio Channel-Part 2: Reaching a Data Rate of 100 Mbit/s with LTE
Live webcast: 5/23/12, 12:00 PM ET
Sponsored by: EB (Elektrobit)

RF and Microwave Heating with COMSOL Multiphysics
Live webcast: 5/24/12, 2:00 PM ET
Sponsored by: COMSOL

Presented by: Agilent Technologies

Innovations in EDA

Comprehensive mmWave Design Solutions for TSMC's 60-GHz CMOS RDK
Live webcast: 5/3/12, 1:00 PM ET

Agilent in Wireless Communications

Next Generation 802.11ac WLAN MIMO Design & Test Challenges
Live webcast: 5/10/12, 1:00 PM ET

Agilent in Aerospace/Defense

Mixed Signal Testing Challenges in FPGA-based Radar Systems
Live webcast: 5/17/12, 1:00 PM ET

Innovations in LTE

LTE Channel State Testing: An Overview of CQI, PMI, and RI for LTE
Live webcast: 5/31/12, 1:00 PM ET

Over-the-Air (OTA) Signal Challenges and Implications – Recommendation for LTE RAN
Live webcast: 5/9/12, 12:00 PM ET
Sponsored by:
Anritsu, Azimuth Systems, Electro Rent and Rohde & Schwarz

Official Show Partner
International CTIA WIRELESS 2012

MIMO OTA Measurements – The Next Generation Platform for Wireless Testing
Live webcast: 5/10/12, 1:00 PM ET
Sponsored by:
Agilent Technologies, ETS-Lindgren, EB (Elektrobit) and Spirent Communications

Official Show Partner
International CTIA WIRELESS 2012

Past Webinars On Demand

RF/Microwave Training Series

Presented by: Besser Associates
- LTE Broadband Wireless Access

Market Research Series

Presented by: Strategy Analytics
- AESA Radar Market Trends: Fast-Jets and Beyond
- The Strategic Impact of MilSatComs on Electronic Warfare

Technical Education Series

- Radar Fundamentals
- Mini-Circuits' Smart Portable Test Equipment

Leading Technology Webinar Series

Presented by: CST
- CST STUDIO SUITE 2012:
  Update Webinar on Low Frequency Simulation
  Update Webinar on EDA/EMC Simulation
  Update Webinar on MW&RF Simulation

Innovations in EDA/Signal Generation & Analysis Series

Presented by: Agilent EEsof EDA/Agilent Technologies
- Fast Characterization of Power Amplifier Performance with Modulated Signals
- Multi-Signal, Multi-Format Analysis with the 89600 VSA
- Nonlinear Characterization and Modeling Through Pulsed IV/S-Parameters

Agilent in Aerospace/Defense Series

Presented by: Agilent Technologies
- Fast and Accurate Frequency Converter Characterization
- RF Streaming, Analysis and Playback in Aerospace & Defense Applications

Agilent in LTE/Wireless Communications Series

Presented by: Agilent Technologies
- Optimize UE Design for Greater Battery Run-Time
- It's Time for TD-LTE
- IEEE 802.11ad PHY Layer Testing

Register to attend at mwjournal.com/webinars

See us at IMS Booth 2018

Microwave Journal
Frequency Matters.


10 MHz to 67 GHz Components

Directional Couplers

Power Dividers

Antenna Beamformers

90°/180° Hybrids

QPSK Modulators

et industries

Electromagnetic Technologies Industries, Inc.
50 Intervale Rd. Boonton, NJ 07005 U.S.A.
Tel: 973-394-1719 • Fax: 973-394-1710
sales@etiworld.com • www.ETIworld.com

TABLE I

DIMENSIONS OF THE ONE-POLE FILTER WITH QSIWR

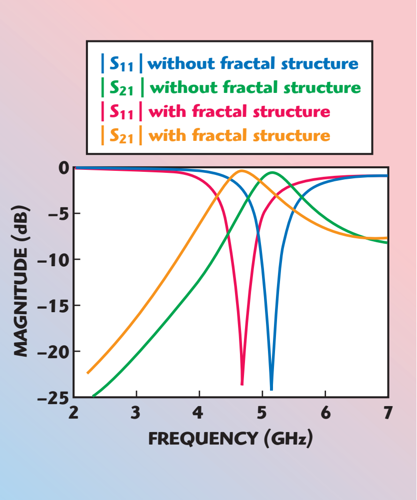
Symbol	*Value (mm)*
w	2.4
p	1.1
d	0.5
b	30
m	6
n	5.5
l_1	9.1
l_2	8.4
l_3	1.9

defected structure is etched in the center of its upper metal plane. The final dimensions are listed in ***Table 1***. As shown in ***Figure 4***, comparing with the filter without fractal structure, the resonant frequency of the filter with fractal structure shifts to a lower frequency, which is approximately 4.67 GHz, the –3 dB bandwidth is approximately 0.98 GHz. For only one cavity with one resonant mode, there is only one pole in the passband and the upper stopband is not satisfied.

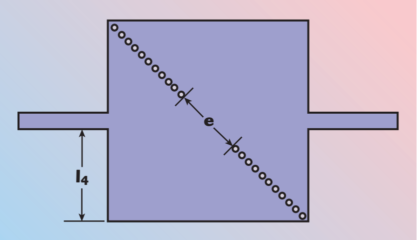
FRACTAL-SHAPED TWO-POLE FILTER USING QSIWR

To widen the usefulness of the QSIWR, a kind of two-pole filter is proposed. ***Figure 5*** depicts the main configuration of this filter. First, two identical QSIWR are set back to back. With the central metal vias removed, the remaining vias act as the inductive iris. The microstrip feed lines are placed at the symmetrical sides of the filter. The resonant frequency f_0 of this filter is specified at 4.5 GHz with a fractional bandwidth (FBW) of 12 percent. A two-order Chebyshev lowpass filter with passband ripple of 0.01 dB is chosen as the prototype.[12] The main factors of the two-pole filter are as follows: M_{12} = 0.28047, Q_{ei} = 3.74083, Q_{eo} = 3.74089.

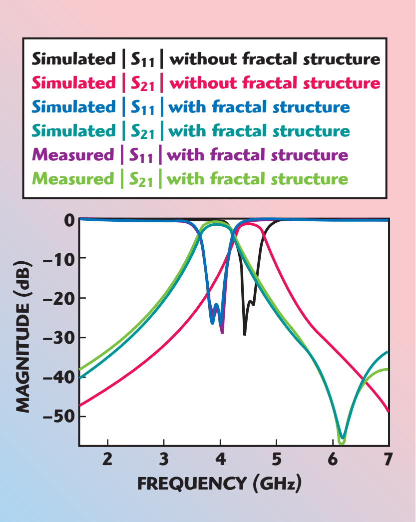
M_{12} denotes the coupling coefficient between two neighbor resonators and Q_{ei} and Q_{eo} are the input and output external quality factor, respectively. Keeping the diameter of the vias d and the pitch p between vias unchanged, the other size parameters of the two-pole filter are as follows: l_4 = 7.5 mm, e = 9.82 mm. As shown in ***Figure 6***, in the whole passband, the insertion loss is approximately 1.2 dB and the return loss is better than 20 dB from 4.40 to 4.62 GHz, the –3 dB bandwidth is approximately 0.6 GHz. The rejection is improved, especially at the upper stopband.



▲ *Fig. 4 S-parameters for the one-pole QSIWR filters, with and without fractal structure.*

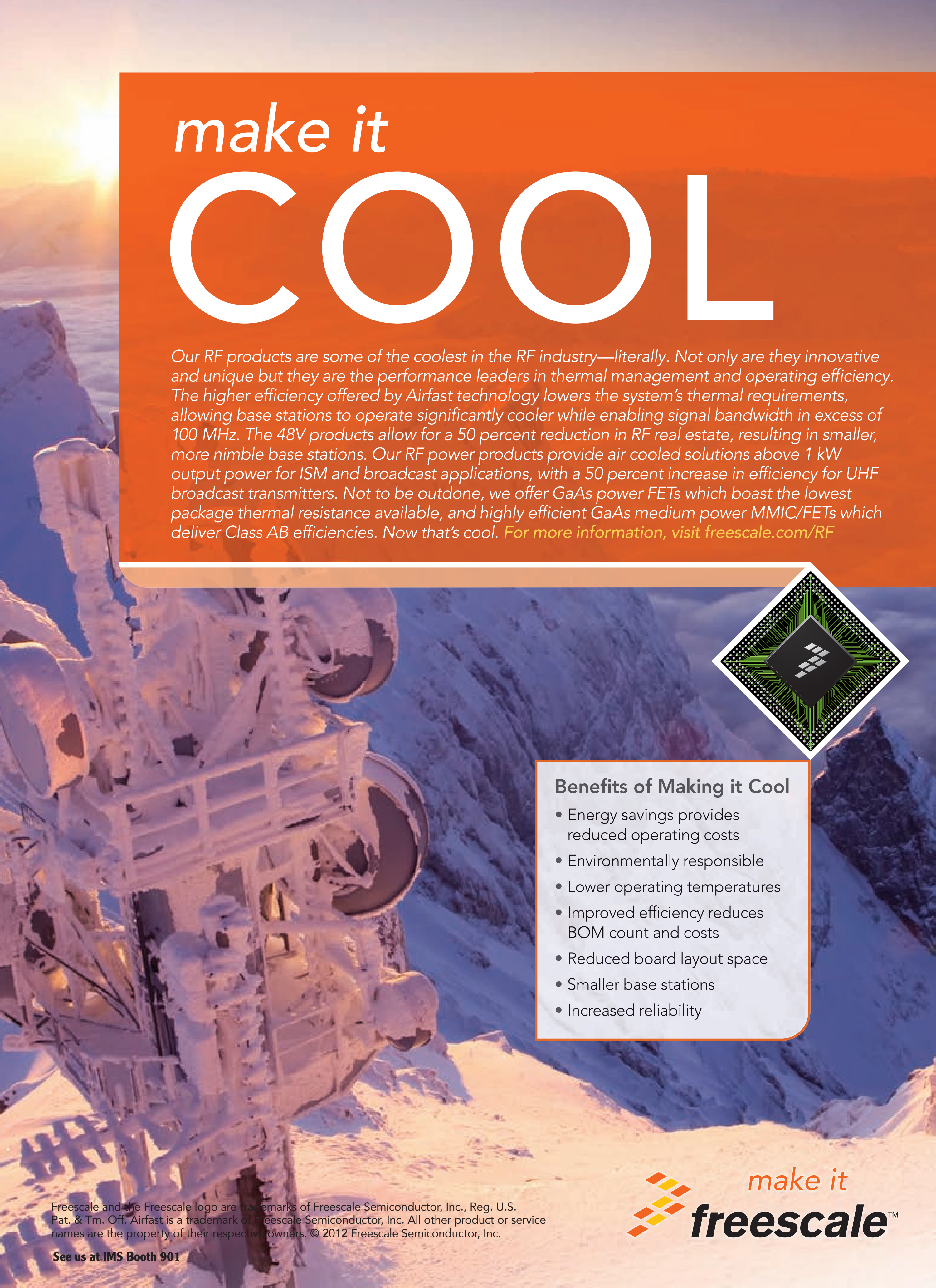


▲ *Fig. 5 Two-pole bandpass filter with QSIWR.*



▲ *Fig. 6 S-parameters for two-pole QSIWR filter with and without fractal structure.*

To make the filter more compact, Sierpinski triangles are etched in this two-pole filter. Its fractal dimension



make it

COOL

Our RF products are some of the coolest in the RF industry—literally. Not only are they innovative and unique but they are the performance leaders in thermal management and operating efficiency. The higher efficiency offered by Airfast technology lowers the system's thermal requirements, allowing base stations to operate significantly cooler while enabling signal bandwidth in excess of 100 MHz. The 48V products allow for a 50 percent reduction in RF real estate, resulting in smaller, more nimble base stations. Our RF power products provide air cooled solutions above 1 kW output power for ISM and broadcast applications, with a 50 percent increase in efficiency for UHF broadcast transmitters. Not to be outdone, we offer GaAs power FETs which boast the lowest package thermal resistance available, and highly efficient GaAs medium power MMIC/FETs which deliver Class AB efficiencies. Now that's cool. For more information, visit freescale.com/RF

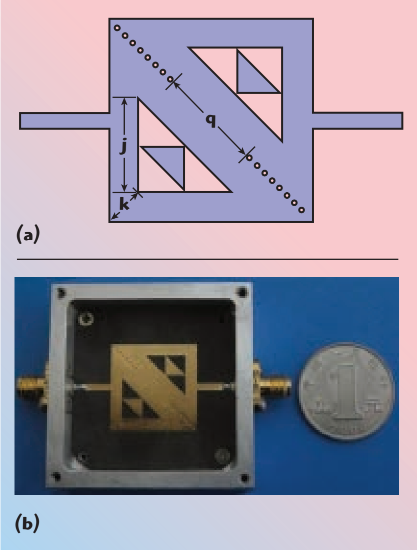
Benefits of Making it Cool

- Energy savings provides reduced operating costs
- Environmentally responsible
- Lower operating temperatures
- Improved efficiency reduces BOM count and costs
- Reduced board layout space
- Smaller base stations
- Increased reliability

make it freescale™

Freescale and the Freescale logo are trademarks of Freescale Semiconductor, Inc., Reg. U.S. Pat. & Tm. Off. Airfast is a trademark of Freescale Semiconductor, Inc. All other product or service names are the property of their respective owners. © 2012 Freescale Semiconductor, Inc.

See us at IMS Booth 901



▲ *Fig. 7 Two-pole bandpass filter with fractal-shape QSIWR (a) layout and (b) photograph.*

is $D = In\,3/In\,2 = 1.585$.[11] As shown in ***Figure 7***, three identical RAITs are etched in the center of each QSIWR. The fractal structure has a distinct effect on the transmission zero of the right side, which makes the filter have a sharp attenuation in the upper stopband. By optimizing the distance q equivalent to two inductive irises and the length j of the right-angle side, the passband shifts to a lower frequency dramatically. The dimensions of the RAIT are as follows: $k = 6.52$ mm, $q = 14.1$ mm, $j = 8$ mm. The simulated and measured results agree well, as shown in Figure 7. With the dimensions of QSIWR unchanged, the resonant frequency of the filter using fractal structures is 3.86 GHz. One transmission zero with an attenuation of 56.9 dB is implemented at 6.13 GHz, which highly improve the selectivity of the upper stopband. The fractal structure plays an important role in improving the performance of the two-pole filter; it perturbs the fields of QSIWR and couples well with the two QSIWRs. This fractal structure affects the filter's transmission zero, bandwidth and return loss in the passband. At the same time, it makes the filter more compact.

CONCLUSION

In this article, according to the magnetic walls theory, a new quarter substrate integrated waveguide resonator is first proposed. Then a fractal-shaped structure is etched off the QSIWR, which makes the QSIWR's resonant frequency shift to a lower frequency. Then, a fractal-shaped QSIWR is used to design a two-pole bandpass filter. Compared to the filter without a fractal-shaped structure, the fractal-shaped one has many advantages, such as lower resonant frequency, more compact dimensions and high selectivity in the upper stopband. In short, the proposed fractal-shaped QSIWR can significantly shrink the filter's size and improve the filters' selectivity, which extend the usability of these shrunk resonators in filter applications. ■

ACKNOWLEDGMENT

This work is supported by the Fundamental Research Funds for the Central Universities (2010QNA49).


Components for Ku and Ka Band Data Link Applications

Folded Ku Band Waveguide Diplexers

Ku Band Waveguide Diplexers

Surface Mount Ku Band Diplexer

RF Assemblies for TCDL applications. Designs available from bandpass filters up through fully integrated multifunction assemblies including amplifiers, switching, test couplers, and gain control.

Delta Microwave
An AS9100 Registered Company

www.deltamicrowave.com ~ sales@deltamicrowave.com ~ 805-751-1122

See us at IMS Booth 722

LOGUS The Leader in MIL-Qualified RF/Microwave Switches offers *More Solutions* for WARFIGHTER Mission Assurance


WR28


WR42


WR112

PROVEN RELIABILITY

WR10 thru WR112 Sizes Available UWB Ridgeguide Upon Request

1961 50 Years 2011

LOGUS MICROWAVE

t: 561-842-3550

LOGUS

Family Owned

www.Logus.com

f: 561-842-2196

See us at IMS Booth 3006

References

1. R.Q. Li, X.H. Tang and F. Xiao, "Substrate Integrated Waveguide Dual-mode Filter Using Slot Lines Perturbation," *IET Electronics Letters*, Vol. 46, No. 12, June 2010, pp. 845-846.
2. X.P. Chen and K. Wu, "Substrate Integrated Waveguide Cross-coupled Filter with Negative Coupling Structure," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 56, No. 1, January 2008, pp. 142-149.
3. W. Hong, B. Liu, Y. Wang, Q.H. Lai, H.J. Tang, X. Yin et al, "Half Mode Substrate Integrated Waveguide: a New Guided Wave Structure for Microwave and Millimeter Wave Application," *2006 Joint 31st International Conference on Infrared and Millimeter Waves and 14th International Conference on Terahertz Electronics Proceedings*, pp. 219-219.
4. Y. Wang, W. Hong, Y. Dong, B. Liu, H.J. Tang, J. Chen et al, "Half Mode Substrate Integrated Waveguide (HMSIW) Bandpass Filter," *IEEE Microwave and Wireless Components Letters*, Vol. 17, No. 4, April 2007, pp. 265-267.
5. X. Zhang, J. Xu, Z. Yu and Y.L. Dong, "C-band Half Mode Substrate Integrated Waveguide (HMSIW) Filter," *Microwave and Optical Technology Letters*, Vol. 50, No. 2, February 2008, pp. 275-277.
6. Y.J. Cheng, W. Hong and K. Wu "Millimeter-wave Half Mode Substrate Integrated Waveguide Frequency Scanning Antenna with Quadri-polarization," *IEEE Transactions on Antennas and Propagation*, Vol. 58, No. 6, June 2010, pp. 1848-1855.
7. C.H. Zhang, W. Hong, X.P. Chen, J.X. Chen, K. Wu and T.J. Cui, "Multilayered Substrate Integrated Waveguide (MSIW) Elliptic Filter," *IEEE Microwave and Wireless Components Letters*, Vol. 15, No. 2, February 2005, pp. 95-97.
8. N. Grigoropoulos, B. Sanz-Izquierdo and P.R. Young, "Substrate Integrated Folded Waveguides (SIFW) and Filters," *IEEE Microwave and Wireless Components Letters*, Vol. 15, No. 12, December 2005, pp. 829-831.
9. D. Oloumi, A. Kordzadeh and A.A.L. Neyestanak, "Size Reduction and Bandwidth Enhancement of a Waveguide Bandpass Filter Using Fractal-shaped Irises," *IEEE Antennas and Wireless Propagation Letters,* Vol. 8, No. 24, November 2009, pp. 1214-1217.
10. H.X. Xu, G.M. Wang and C.X. Zhang, "Fractal-shaped UWB Bandpass Filter Based on Composite Right/left Handed Transmission Line," *IET Electronics Letters*, Vol. 46, No. 4, April 2010, pp. 285-287.
11. S. Hebib, H. Aubert, O. Pascal, N. Fonseca, L. Ries and J.M.E. Lopez, "Sierpinski Pyramidal Antenna Loaded with a Cutoff Open-ended Waveguide," *IEEE Antennas and Wireless Propagation Letters,* Vol. 8, No. 5, May 2009, pp. 352-355.
12. J.S. Hong and M.J. Lancaster, *Microstrip Filters for RF-Microwave Applications*, John Wiley & Sons, New York, NY, 2001.

COST-EFFECTIVE
HERMETIC MICRO D CONNECTORS

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

SHP
SPECIAL HERMETIC PRODUCTS, INC.
Hi-Rel By Design

CONTACT US TODAY
(P) 603-654-2002 (F) 603-654-2533
www.shp-seals.com email: sales@shp-seals.com
CERTIFIED ISO 9001:2008

MTT-S BOOTH #2115

WHEN YOU CAN'T AFFORD TO LOSE

choose **TELEDYNE STORM** cable assemblies

LOW LOSS
TRUE BLUE®

An unmatched combination of low loss, durability, and value

TRUE BLUE® 290

0.260 dB/ft nom @ 18 GHz

TRUE BLUE® 205

0.444 dB/ft nom @ 26.5 GHz

ULTRA LOW LOSS
dB MISER™

The clear choice when loss is the most important consideration

dB MISER™ 300

0.205 dB/ft nom @ 18 GHz

dB MISER™ 210

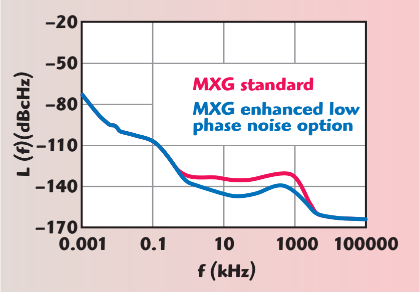
0.367 dB/ft nom @ 26.5 GHz

TELEDYNE
STORM MICROWAVE
Everywhere**you**look™

888-347-8676
www.teledynestorm.com/mj0512

Signal Generators Provide Perfect and Precisely Imperfect Signals

RF technology marches on at a furious rate, whether it is for wireless communications, aerospace/defense, or ever-faster wireless networking applications. Test equipment performance and capabilities have been driven forward at a similar pace. Interestingly, one of the more remarkable developments in Agilent's new X-Series RF signal generators is unique technology that provides "precisely impaired" signals. Available in analog and vector modulation models – from the pure and precise MXG to the cost-effective EXG – these new instruments provide both perfect and precisely imperfect signals.



▲ *Fig. 1 The MXG's phase noise, different levels of phase noise performance are available as options.*

PUSHING THE PERFORMANCE ENVELOPE

Development of new RF technologies depends on test equipment that pushes the performance envelope. A prime example of this is the MXG, which is now setting new standards in phase noise and spurious performance, signal purity, modulation bandwidth and output power.

The MXG uses a new triple-loop synthesizer design that leverages Agilent's own fractional-N ASIC to achieve industry-leading phase noise and spurious performance. As shown in ***Figure 1***, several levels of optional phase noise performance are available to optimize price/performance for different applications. At 1 GHz and a 20 kHz offset, the standard MXG unit has a phase noise of –134 dBc/Hz. When options UNX/UNY are employed, phase noise improves to –146 dBc/Hz. Spurious performance from the multi-loop implementation is –96 dBc/Hz (all figures typical).

The synthesizer architecture pays similar dividends in terms of broadband noise, being reduced to –163 dBc/Hz at 1 GHz for both the MXG and the new cost effective EXG. All of these specifications are improved by 10 dB or more from Agilent's previous generation ESG signal generators. Other measures of signal purity have also improved. ACPR, for example, is as good as –73 dBc for W-CDMA (TM1, 64

Agilent Technologies Inc.
Santa Clara, CA

Millimeter Wave Compliance Test
40 GHz to 220 GHz

Certify Transmitters per FCC Part 15 Regulations:

- Harmonic mixers measure up to the fifth harmonic or to 200 GHz
- Four waveguide bands: WR-19, WR-12, WR-08 & WR-05
- Standard gain horns comply with ANSI C63.4, C63.5 & C63.10
- Standard waveguide interface MIL-DTL-3922/54 & MIL-DTL-3922/67D
- Solutions available for emerging human exposure tests to 300 GHz

See us at IEEE MTT-S IMS Booth #1126. June 19-21, 2012

Visit *www.omlinc.com* for more information.

Innovation in Millimeter Wave Measurements

www.omlinc.com

(408) 779-2698

OML

DPCH). This signal purity is achieved without a loss of frequency agility. Switching speed for all X-Series signal generators is now specified at better than 900 μs in list sweep mode.

Coupled with the signal purity of the new X-Series signal generators is their availability to deliver power. For applications such as amplifier test, pure signals must be supplied at high power levels to exercise and quantify nonlinearities such as harmonics, intermodulation and compression. To help engineers avoid the expense and inconvenience of external amplifiers, the MXG specifies an industry leading +24 dBm (27 dBm typical) to 3 GHz and +19 dBm to 5 GHz. This combination of power and purity is made possible by Agilent's own low-loss pin diode electronic attenuators that also offer extended life and reliability in manufacturing environments where they may be cycled very frequently.

ACEWAVETECH
AWT Co., Ltd.

Portable PIM Analyzer
- LTE, GSM, UMTS/IMT2000, DCS1800/PCS, PCS1900, AMPS/CDMA, EGSM, WiMAX, WiBro, etc.
- Measurement Level : -32 dBm to -132 dBm (-75 dBc to -175 dBc)
- Measure the Distance to Faulty PIM Position
- Measure the Distance to Faulty VSWR Position

* 19" Rack Mount Types are also available

RFID Protocol Analyzer/Simulator
- Emulate the Standard RFID Reader or Tag
- Measure and Evaluate RFID Tags' and Readers' protocol.
- Verify the compliance of all ISO18000 series
- Measurement of Frequency, Power, and Modulation
- Display Timing Waveform / Code Data (Demodulation)

Radar Signal Generator
- Variety of Models (Portable, Rack Mountable, or Customizing Models), Wideband (0.5~40GHz)
- Multiple Signal Generation (1~48 signals or more, simultaneous)
- PRI, PW, SCAN, FREQ, PHASE Modulation (Programmable or Pre-stored Library)
- AOA ouput for RWR/MWR Receiver Test & Evaluation
- Visual Scenario Editing on 2D or 3D maps.

Visit us @
2012 IMS Montreal Booth 220 Jun 19-21, 2012
2012 CommunicAsia Singapore Jun 19~22, 2012

#313 IDTVC. 7-50 Songdo Dong. Yeonsu-Gu. Incheon. Korea. 406-840
Tel : +82-32-831-0401~2 / Fax : +82-32-831-0298
Homepage : http://www.acewavetech.com/
E-mail : sales@acewavetech.com

A NEW STANDARD FOR MODULATION ACCURACY AND WIDE BANDWIDTH

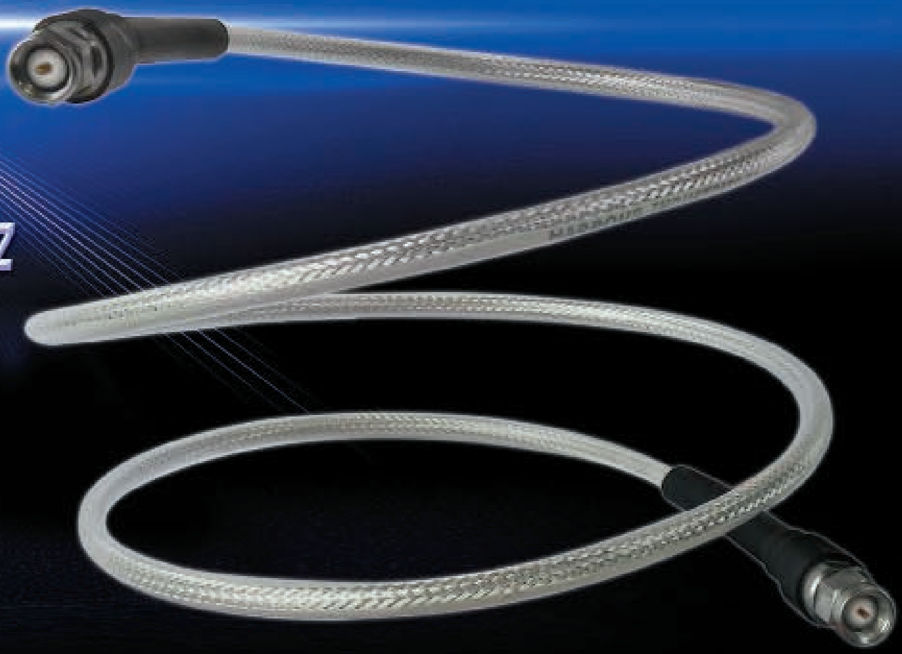
Data rates for mobile communications and wireless networking continue to rise rapidly, leading to a combination of dense constellations and wide modulation bandwidths. The IEEE 802.11ac standard is a prime example, promising gigabit speeds through the use of 256QAM modulation at bandwidths up to 160 MHz. The MXG uses advanced modulator circuits and innovative calibration techniques to overcome the I/Q and frequency response problems that generally worsen with increasing bandwidth. The result is a modulated signal that removes any doubt about the source or magnitude of a system's modulation error.

Pushing technology to the next level often rules out the use of off-the-shelf ASICs. The IQ modulator in the vector MXG and EXG models prove this fact. Developed and manufactured by Agilent, it sits at the core of a modulation section that delivers industry leading ACPR over bandwidths as wide as 160 MHz internally, and up to 300 MHz from external sources. This modulation section is linearized by an internal calibration source and algorithm that provides vector correction factors to a real-time baseband processor. The result is an 802.11ac 256QAM error vector magnitude (EVM) of 0.4 percent (typical) over 160 MHz in the MXG and 80 MHz in the EXG.

Built-in channel calibrations also provide full vector correction from the modulator through RF output. This ensures a high dynamic range and flatness of ±0.2 dB across the MXG's 160 MHz bandwidth and EXG's 120 MHz bandwidth. Moreover, no user intervention (e.g., manual IQ adjustment) is required. Wide modulation bandwidth and high dynamic range provide user benefits even when individual signals are narrower. The crowded nature of today's spectral environment means that receivers must cope with problems such as adjacent channel interference and multiple types of blocking. A modern smartphone, for example, can have three or more transceivers operating at the same time, and often operates close to other similarly complex devices. The

MiCable inc

ISO9001:2008 CERTIFIED



C04 Series DC–26.5GHz
High Performance
Test Cable Assemblies

Advantages and features:

- Excellent phase & amplitude stability vs. flexure
- Extra rugged, triple shielded
- Passivated stainless steel connectors
- Outstanding Durability

Applications:

- Ideal test cable for day-to-day test operation
- Use in stringent test lab environment
- Electronic Warfare(EW) system
- Phased array radar

C04 series are highly reliable and cost-effective cable assemblies, ideal for broadband, lab tests and various connection. The triple-shielded cable has rugged construction employing an advanced strain relief system and is equipped with enhanced stainless steel connectors. They are so rugged to be qualified over 20,000 flex cycles without performance degradation up to 26.5GHz. Custom lengths with SMA or N type connectors are available. You can rely on C04 for daily test operation with high number of bends.

MIcable is your quality fast and low cost solution!

affiliated with SSI Cable Corp

MIcable Inc.
Tel: 86 591-87382856
Email: sales@micable.cn
Website: www.micable.cn

USA Distributor Center:
SSI Cable Corporation
Tel: (360)426-5719
Email: bsmith@ssicable.com

See us at IMS Booth 2429

X-Series' wide bandwidth modulator can produce a test signal composed of a complete spectral segment, including the desired signal plus adjacent and alternate channels as potential interferers, and perhaps spurious or transient signals as well.

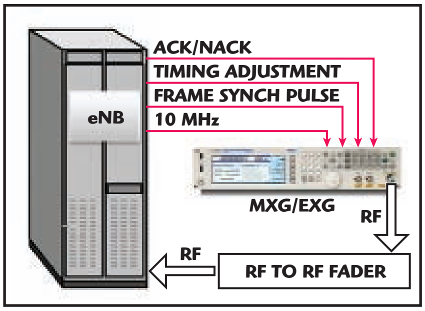
WIDE REAL-TIME SIGNAL GENERATION AND DEEP ARB MEMORY

Both real-time baseband generation and arb playback memory approaches have advantages in creating modulated signals; some applications are better satisfied by one approach than the other. The MXG and EXG vector models combine these baseband generators in one unit, ensuring the best approach is always available to the user.

The real-time baseband generator and its processor-accelerator support a large number of applications in cellular communications, wireless networking, audio/video broadcasting and navigation (e.g., GPS and GLONASS). Real-time modes also include custom or flexible modulation types, including dense constellations up to 1024QAM. The real-time mode allows for creation of complex signal scenarios with very long durations. For satellite navigation, the MXG and EXG can generate signals representing up to 32 line-of-sight GPS/GLONASS satellites, including real-time control of satellite visibility and power for up to 24 hours without repeating.

The feedback loops in mobile wireless systems also benefit from real-time generation, where closed-loop testing is used to evaluate the throughput of real-world channels. An example configuration is shown in ***Figure 2***. In testing such as LTE HARQ, the X-Series signal generators can receive TTL-level feedback signals and reconfigure the transmission signal while maintaining the link. This enables more realistic testing of throughput over impaired channels.

The other mode available in the X-Series is an extremely deep arb memory. Playback of baseband data from a deep arb memory is a flexible way to generate many different signal types at RF. The signals for the arb memory are typically generated by a PC program, such as Agilent's Signal Studio, that is available for many wireless, video and navigation standards like LTE, W-CDMA, HSPA, 802.11, DVB-T/H, GPS and GLONASS. The MXG and EXG provide up to 1 GSample and 512 MSamples of memory, respectively, for a capability that exceeds conformance requirements and can, in some cases, offer an alternative to real-time signal generation.



▲ *Fig. 2 Transistor-transistor logic (TTL) feedback signals control a real-time baseband generator in the RF source for closed-loop testing.*

WHAT NEXT FOR THE
WHITE SPACE ?

Succeed in this spectrum market with RFHIC's Newest Possibilities

GaN Pallet Amplifier

Part Number	Frequency (MHz)	Gain (dB)	P3dB (dBm)	ACLR @ Po=28dBm W-CDMA, 64DPCH, 4FA (dB)		OIP3 Po=33dBm (dBm)
				±5MHz	±10MHz	
RWP06040-WH	500 ~ 700	42	45	50	53	53
RWP05080-10	500 ~ 600	46	47	53	56	55
RWP06080-10	600 ~ 700	43	47	53	56	55

LNA

Part Number	Frequency (MHz)	Gain (dB)	Flatness (dB)	NF (dB)	P1dB (dBm)	OIP3 (dBm)	Vd (V)	Id (mA)	Package
LCL0612-L	500 ~ 700	32.7	1.5	0.9	22	42	5	180	CP-16A

Duplexer

Part Number	Frequency (MHz)	Bandwidth (MHz)	I.L (dB)	Ripple (dB)	VSWR (dB)	Isolation (dB)	Input Power (W)	Dim.[mm] (W x L x H)
RADX-78PC909C	CH1:557	90	1.8	1.0	1.4	20@CH2	5	47 x 50.8 x 8
	CH2:659	78	1.8	1.0	1.4	20@CH1	5	47 x 50.8 x 8

Switch

Part Number	Frequency (MHz)	I.L (dB)	Flatness (dB)	Isolation (dB)	P1dB (dBm)	OIP3 (dBm)	Vd (V)	Id (mA)	Package
SE902	50 ~ 3000	-0.5	-	-55	21	36	3 ~ 5	1	QFN4x4

MMIC

Part Number	Frequency (MHz)	Gain (dB)	Flatness (dB)	NF (dB)	P1dB (dBm)	OIP3 (dBm)	Vd (V)	Id (mA)	Package
AE305	30 ~ 2650	14.5	3.5	2.7	21	38	5	110	SOT-89

√ Please contact us for your customized solution.

Come & enjoy RFHIC booth # 2508 at IEEE MTT-S IMS 2012

RF & MW is our business & passion

USA Office
Tel : 919-677-8780 / E-mail : sales@rfhicusa.com

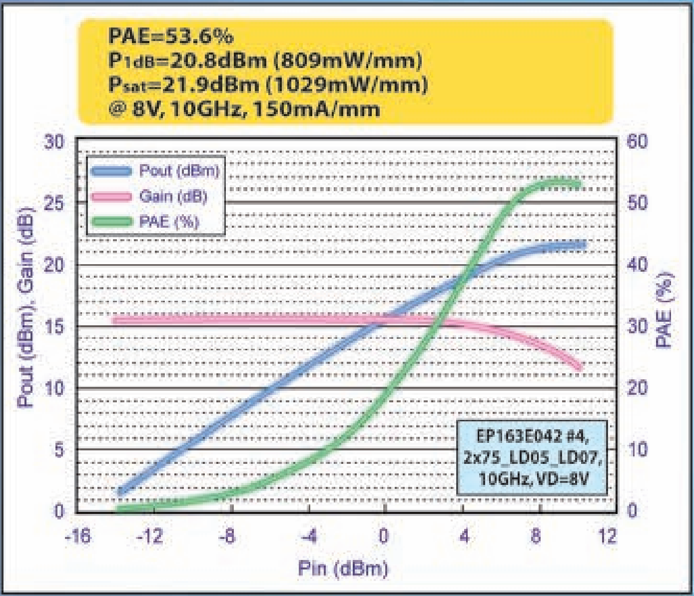
Worldwide
Tel : 82-31-250-5078 / E-mail : rfsales@rfhic.com

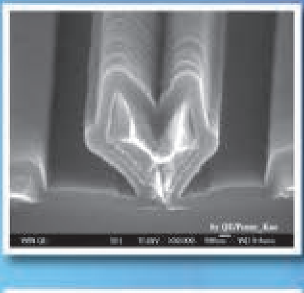
RFHIC
www.rfhic.com

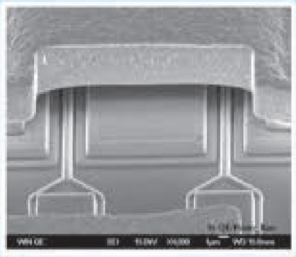
High Voltage 8V Ku-Band
0.25µm Power pHEMT

- Stepper based 0.25µm gate length
- 8V operation / 70 GHz Ft
- 1 W/mm saturated power density
- BCB encapsulation for repeatable packaged performance

PP25-21 Power Performance







Comparison Table for 0.1µm, 0.15µm, 0.25µm and 0.5µm pHEMT

	PP10	PP15	PP25-21	PP50-11
Vto (V)	-0.9	-1.2	-1.2	-1.4
Idss (mA/mm)	450	500	345	350
Idmax (mA/mm)	720	650	460	480
GM (mS/mm)	750	495	380	310
VDG (V)	9	10	19.2	20
ft (GHz)	130	85	65~72	32
Fmax (GHz)	175	180	160	85
PldB (mW/mm)	533.25 (3.5V)	670 (5V)	809 (8V)	587 (8V)
Psat (mW/mm)	764.3 (3.5V)	820 (5V)	1029 (8V)	851 (8V)
Gain (dB)	14.35	18.1	15.6	15.5
PAE (%)	53.57	55	53.6	53.5
Frequency	29 GHz	10 GHz	10 GHz	10 GHz

See us at IMS Booth 2816

WIN
SEMICONDUCTORS

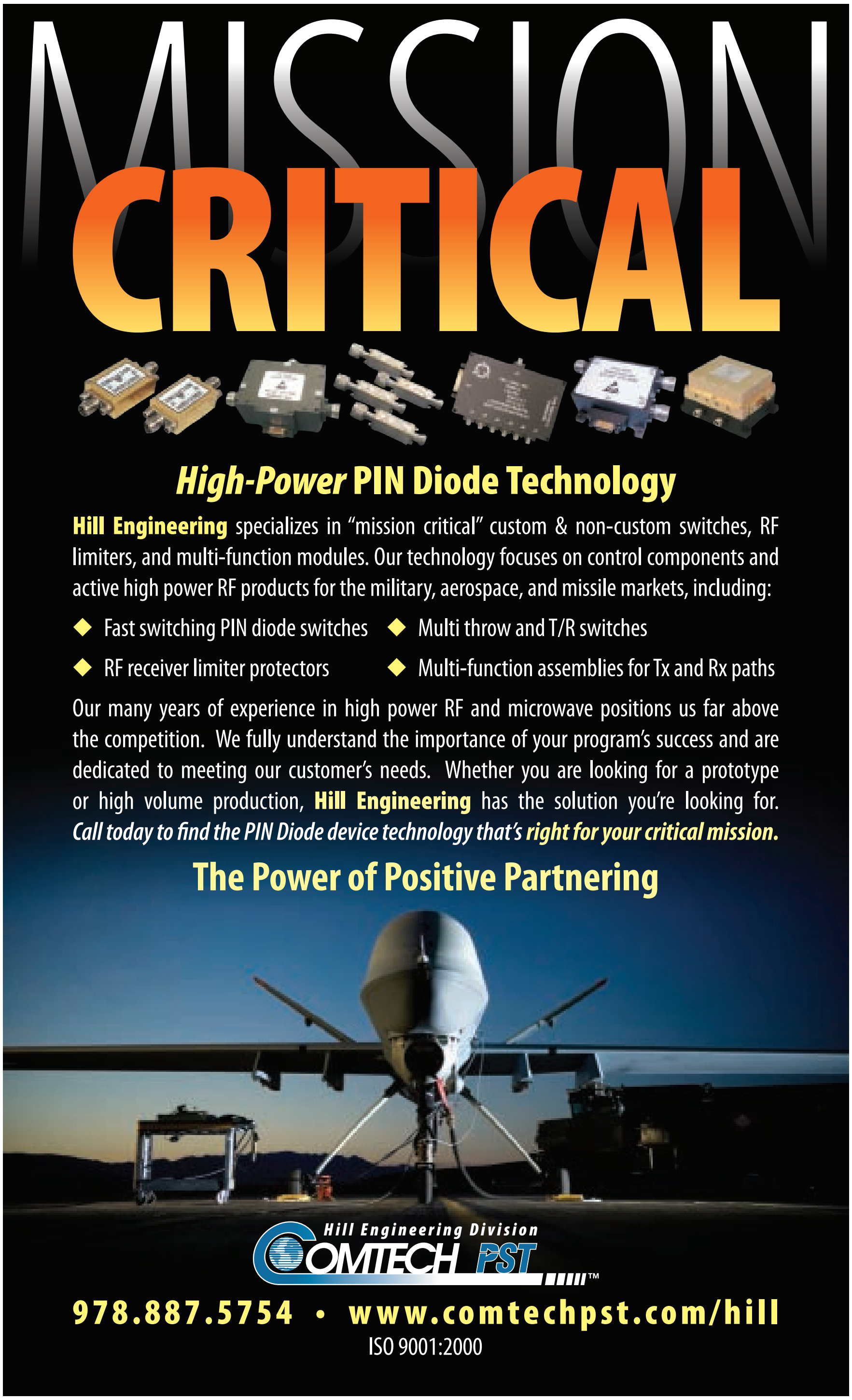
Tel:+886-3-397-5999
E-mail:sales@winfoundry.com

Fax: +886-3-397-5069
http://www.winfoundry.com

PRECISELY IMPERFECT SIGNALS: CUSTOMIZED PHASE NOISE

Real-time vector signal processing can modify or predistort signals to correct for system or channel problems, but can also be used to selectively degrade signals. While the typical purpose of a signal generator is to provide a clean stimulus or reference, they are also vital in testing a system's response to representative impairments.

The low phase noise of the MXG is not a benefit in all cases. Real-world systems must deal with phase noise in both continuous wave (CW) and modulated signals. Therefore, the ability of a signal generator to act as an adjustable and accurate substitute can shorten development time and reduce the chances (and resulting costs) of under- or over-performance. In the MXG, a real-time signal-processing ASIC customizes phase noise levels for both CW and modulated signals. In an important innovation, phase noise can be adjusted to different levels at different offsets, including the steep slopes of close-in noise, the flat slopes of synthesizer pedestal noise and the shallow slopes of wide offset noise.


MISSION CRITICAL

High-Power PIN Diode Technology

Hill Engineering specializes in "mission critical" custom & non-custom switches, RF limiters, and multi-function modules. Our technology focuses on control components and active high power RF products for the military, aerospace, and missile markets, including:

- Fast switching PIN diode switches
- Multi throw and T/R switches
- RF receiver limiter protectors
- Multi-function assemblies for Tx and Rx paths

Our many years of experience in high power RF and microwave positions us far above the competition. We fully understand the importance of your program's success and are dedicated to meeting our customer's needs. Whether you are looking for a prototype or high volume production, Hill Engineering has the solution you're looking for. *Call today to find the PIN Diode device technology that's right for your critical mission.*

The Power of Positive Partnering

Hill Engineering Division
COMTECH PST

978.887.5754 • www.comtechpst.com/hill

ISO 9001:2000

REDUCING THE COST-OF-TEST

The total cost-of-test, especially over time, is far more complicated than the equipment cost. The X-Series signal generators were designed to minimize costs over their entire life cycle in real-world manufacturing. They begin by offering a range of choices to optimize performance, capability and cost.

Multiple MXG and EXG models include both moderate- and high-performance generators with analog and vector capabilities, and different frequency coverage to match application needs. This flexibility supports agile manufacturing, where the flexible options and application software structure allow signal generators to be re-purposed to remain productive over a longer life.

Once in place, the ideal signal generator does its job forever with a minimum of attention. The low-loss, solid-state attenuators of the EXG/MXG make countless amplitude changes without wear, contributing to a three-year instrument calibration cycle. Unproductive downtime is minimized with self diagnostics, a refurbished assembly exchange program, and an innovative hardware design that requires no post-repair calibration or adjustment.

RF technology may be marching on at a furious rate, but the performance and capabilities of the new X-Series signal generators are definitely keeping pace. By pushing the envelope on performance, functionality and cost, they are now providing engineers with better choices for both design and manufacturing.

VENDORVIEW

Agilent Technologies Inc.,
Santa Clara, CA
(800) 829-4444,
www.agilent.com.

Smart RF SWITCH MATRIX

DC to 18 GHz from $385^{00}

Increased efficiency for almost any electronics lab.
Nothing beats a Mini-Circuits Switch Matrix for quick production or design lab setups. Our innovative, stand-alone GUI is so user-friendly, you'll put it to work within minutes! Highly portable, and compatible with most lab software,* these models also add capabilities to legacy systems with ease—for full automation, step-by-step control, or remote operation via the internet.

To meet different needs, we offer different models containing up to four 50 Ω SPDT switches, all of which are absorptive in the "off" state. Whichever model you choose, and wherever you use it, you'll enjoy the quick expansion of multi-unit and multi-parameter capabilities, and easily configured test automation that simply helps you get more done more quickly, and at a lower cost, than ever before.

Outstanding performance, unmatched reliability.
Very low insertion loss (≤0.3 dB typ.), excellent isolation (>66 dB typ.), and low VSWR (1.2:1 typ.) across the full DC-18 GHz frequency range mean accurate data, with fewer false rejects and less retesting. The rugged aluminum cases house our patented mechanical switches—the only ones available anywhere, at any price, that offer up to 10 years and 100 million cycles of guaranteed performance.†Just go to minicircuits.com for technical specifications, performance data, pricing, and real-time availability, and *consider how much time and money you'll save* with faster setup, quick automation, and results you can rely on, day after day and year after year!

---

*See data sheet for an extensive list of compatible software.

†The mechanical switches internal to each model are offered with an optional 10 year extended warranty. Agreement required, see data sheets on our website for terms and conditions. Switches protected by patents 5,272,458 6,650,210 6,414,577 7,633,361 7,843,289 and additional patents pending.

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

Mini-Circuits®
ISO 9001 ISO 14001 AS9100
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

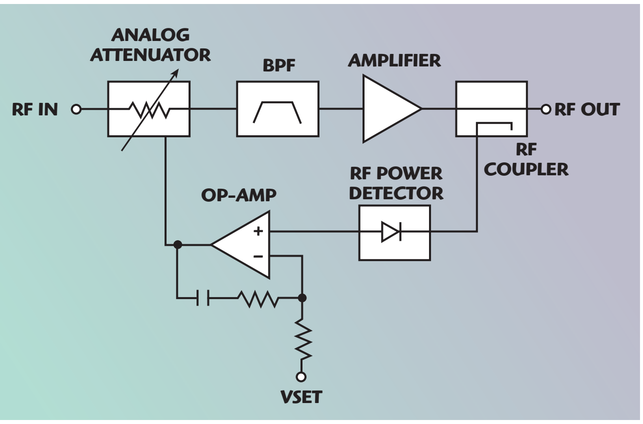
YONI2® *The Design Engineers Search Engine* *finds the model you need, Instantly* • For detailed performance specs & shopping online see **minicircuits.com**

U.S. Patents
7739260, 7761442

IF/RF MICROWAVE COMPONENTS

Single Chip AGC Solutions for Communications

Automatic gain control (AGC) or automatic power control (APC) circuits are used primarily to maintain a constant power level in the signal chain of a communication transceiver. A simple AGC circuit involves attenuation, amplification, power detection and gain control mechanisms. In an AGC system, the average output signal level is fed back to adjust the gain to an appropriate level for a range of input signal levels. For example, without AGC, the audio level emitted from an AM radio receiver would vary depending on the received signal strength; the AGC effectively reduces the volume when the signal is strong and raises it when it is weaker. AGC algorithms often use controllers that can adjust the gain of the signal chain in inverse proportion to the error between desired and measured power levels. ***Figure 1*** shows a discrete implementation of an AGC circuit controlling gain in accordance with the power level detected via a feedback loop.



▲ *Fig. 1 Block diagram of a typical AGC solution implemented with discrete components.*

Unfortunately, AGC loops implemented with discrete components often suffer from a number of deficiencies. For example, the analog voltage variable attenuator (VVA) element in a discrete AGC loop often exhibits large OIP3 dips at certain control voltages, or OIP3 degradation as the attenuation is increased. Since the AGC loop is implemented with multiple discrete components, the power control accuracy is more sensitive to part-to-part and temperature variations. Additionally, each of these components often requires external circuitry that requires extra PCB space and further complicates the overall AGC loop design.

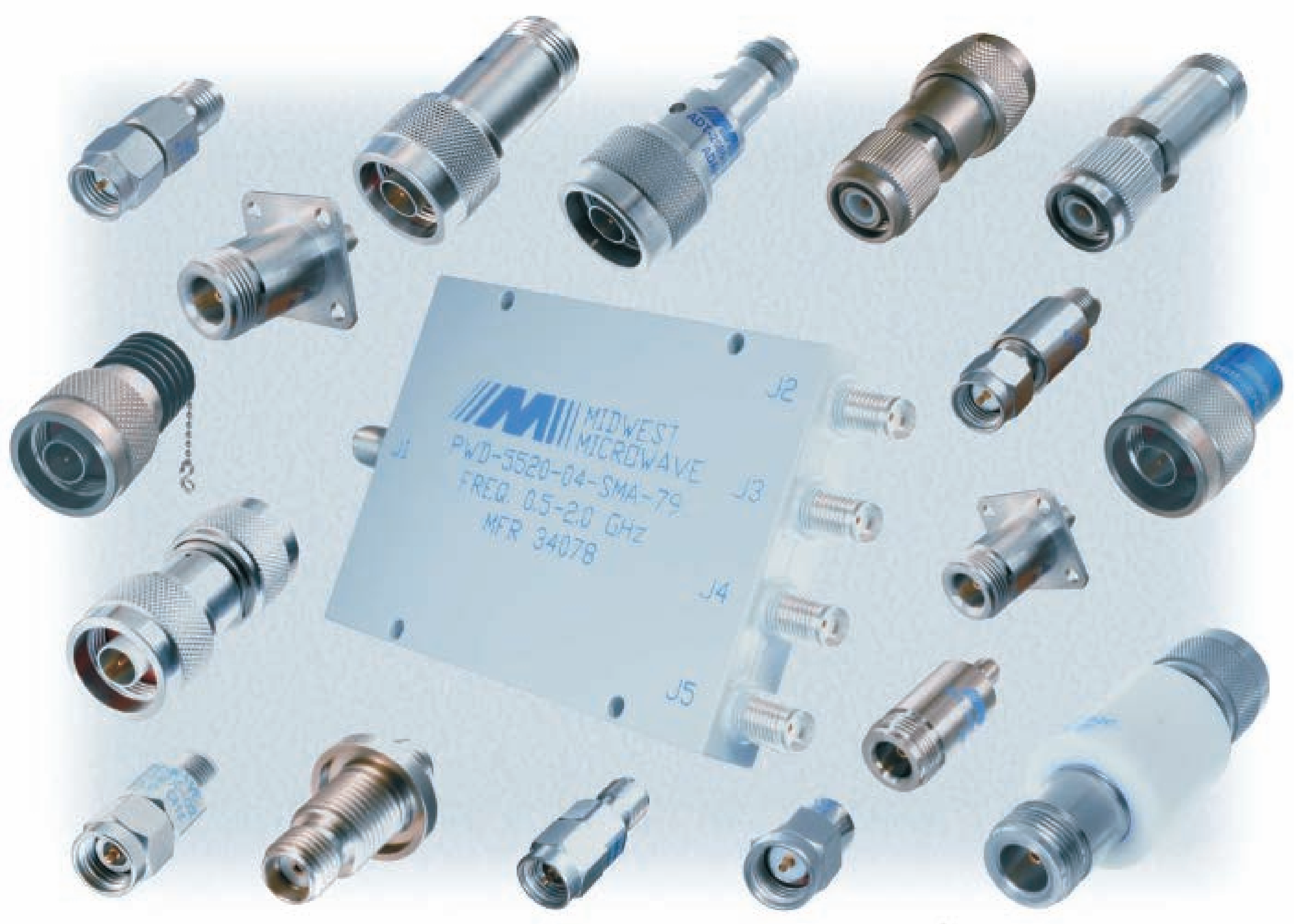
Hittite Microwave has developed a unique new product line of highly integrated analog AGC solutions that address many of the complex challenges of designing high performance AGC loops. ***Table 1*** summarizes the key specifications of these new products. The HMC992LP5E is an IF analog controlled variable gain amplifier (VGA) that operates from 50

Hittite Microwave Corp.
Chelmsford, MA

DISTRIBUTOR AND MANUFACTURER'S REPRESENTATIVES

C. W. SWIFT & Associates, Inc.

C.W. Swift & Associates distributes our extensive inventory of Midwest Microwave's quality products ... OFF THE SHELF!



Midwest Microwave
Connectivity Solutions

Attenuators
Adapters
Terminations
& More

EMERSON
Network Power

Midwest Microwave Components are In Stock — Call Today for a Quote!

C. W. SWIFT & Associates, Inc.
15216 Burbank Blvd.
Van Nuys, CA 91411
Tel: 800-642-7692 or 818-989-1133
Fax: 818-989-4784
sales@cwswift.com
www.cwswift.com

CLOSED EVERY ST. PATRICK'S DAY!

See us at IMS Booth 1519

TABLE I

HITTITE'S AGC SOLUTIONS

Key Feature	HMC992LP5E	HMC993LP5E
Operating Frequency Range	50 to 800 MHz	700 MHz to 3 GHz
Linearity	+40 dBm OIP3 across entire attenuation range	+40 dBm OIP3 across entire attenuation range
Gain Control Range (dB)	–10 to +38	–11 to +32
Highly Flexible	Configurable with 1 or 2 attenuators	Configurable with 1 or 2 attenuators
Power Detector Function	On chip	On chip
Positive Analog Control Voltage (V)	0 to +5	0 to +5
Noise Figure (dB)	6	7.6
P1 dB (dBm)	19	25
Supply Voltage (V)	+5	+5
Supply Current (mA)	215	260
Package	LP5 (5 × 5 mm SMT)	LP5 (5 × 5 mm SMT)

to 800 MHz, and the HMC993LP5E is an RF analog controlled gain amplifier that operates from 700 MHz to 3 GHz.

Both the HMC992LP5E and the HMC993LP5E combine a high performance analog VGA core with a high speed power detector in a compact 5×5 mm plastic package for a complete AGC solution. The VGA core includes two identical voltage variable attenuators followed up by two gain block amplifiers and a high accuracy log detector. The HMC992LP5E and the HMC993LP5E offer a flexible architecture, where the VGA core is configurable with 1 or 2 attenuators depending upon the dynamic range requirements. These devices can also be used either as standalone high performance VGAs in open loop configuration, or as a compact AGC solution in closed loop operation. The HMC992LP5E and HMC993LP5E AGC solutions are available in compact 25 mm^2 SMT packages and provide an excellent alternative to discrete AGC loops by reducing the complexity of the loop design, and the total number of components required.

The unique VGA core of the HMC992LP5E and the HMC993LP5E exhibits a well-balanced gain slope vs. control voltage characteristic over a wide range of control voltages (see ***Figure 2***), which greatly simplifies the implementation of AGC loop configurations.

Another key advantage of the HMC992LP5E and the HMC993LP5E is their ability to provide constant high OIP3 over the entire attenuation range. HMC992LP5E and HMC993LP5E differentiate themselves from traditional VGAs by providing constant

Visit us at
IMS2012
Booth# 310

ANOISON
...we create connection for technologies

Continental REP Inquiries Welcomed

4525 La Portalada Drive, Carlsbad, CA 92010 Tel: (760) 729-1992 Fax: (760) 683-3342 Email: info@anoison.com www.anoison.com

High Reliability

Military and Aerospace applications require materials with excellent electrical and physical properties, and above all, a history of proven performance.

Cuming Microwave offers RF and dielectric materials for microwave applications, from electronic assembly, antenna design, to turn-key construction of anechoic test facilities. We allow the design engineer to meet tight performance specifications, on time and within budget.

Solid Solutions For...... Tomorrows Applications

Our experienced Engineers can assist you with your design requirements

Raptor photo: Rick Llinares www.dash2.com

See us at IMS Booth 2428

CUMING
MICROWAVE
CORPORATION

Cuming Microwave
264 Bodwell Street, Avon, MA 02322
508-521-6700
www.cumingmicrowave.com
sales@cumingmicrowave.com

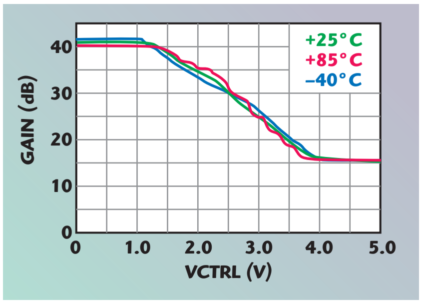
OIP3 at any control voltage or attenuation level. ***Figures 3A*** and ***3B*** show that a constant OIP3 of greater than +40 dBm is achieved over the entire gain range.

The integrated power detector of the HMC992LP5E and HMC993LP5E exhibits excellent temperature stability. Both devices provide very accurate AGC closed loop power control, which is independent of part-to-part and temperature variations.

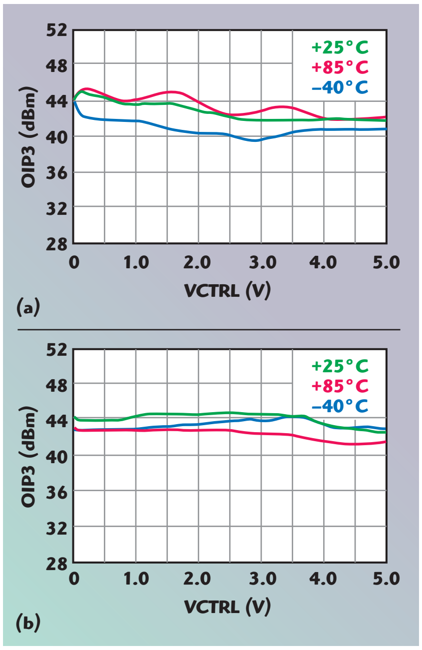
In open loop operation, VGA operation is achieved with two attenuators and two amplifiers by applying different gain voltages to the VCTRL pin. This pin is common to both attenuators in the VGA core, and operates between 1 and 4 V. Increasing the VCTRL pin voltage reduces the gain of the HMC992LP5E and HMC993LP5E VGAs and increases the input power level required for power saturation. These AGCs are well suited for transceiver applications that require a single gain or power calibration setting during the manufacturing process.

In closed loop operation, the control voltage of the attenuator is driven by the RF detector, and the output power is automatically adjusted for a given VSET value. In other words, the output power is controlled by the VSET pin (see ***Figure 4***). In such configurations, Hittite AGCs automatically compensate for the variations over temperature and part-to-part through the high accuracy power detector, to achieve repeatable linear power adjustments. Both the HMC992LP5E and the HMC993LP5E are designed to be used in closed loop operation, require only DC blocking capacitors and resistors, and are specified for operation from –40° to +85°C.

Figure 5 shows the output power vs. input power transfer characteristics of the HMC992LP5E over dif-



▲ *Fig. 2 HMC992LP5E gain vs. VCTRL at 100 MHz.*



▲ *Fig. 3 HMC992LP5E OIP3 vs. VCTRL at 300 MHz (a) and HMC993LP5E OIP3 vs. VCTRL at 900 MHz (b).*

IMAgine.

Innovative | Multifunction | Adaptable

Integrated Microwave Assemblies

FPGAs

Analog. Meet Digital.

Digital and microwave technologies have finally come together, in the **Field-Programmable Gate Array (FPGA)**. FPGAs can do anything ASICs can, but each of its configurable logic blocks can be programmed *and reprogrammed* for many functions, from simple-state machines to complete microprocessors. That means FPGAs are not only incredibly versatile, they're also easily upgradeable. Combine them with microwave circuit functions in IMAs, and you can make dense, highly functional modules that need less space and less power.

Take Narda's Model 10512. It's a programmable signal source that digitally creates frequency-modulated noise waveforms and applies them to a carrier whose center frequency can be varied ±50 MHz in less than 100 ns. Many of its functions are built into a single FPGA that's only 4″ x 4″ x 0.6″, weighs under an ounce, consumes just 11W...and meets military shock and vibration requirements. *How's that for SWaP?*

IMAs using FPGAs might just be what you're looking for.
Contact us today to learn more.

Visit us at
IMS 2012
Booths 2916
& 2917

Scan using your
Smart Phone or Tablet
to learn more!

narda

Engineering, without compromise since 1954.

an L3 communications company

www.nardamicrowave.com • 631.231.1700

The choice is clear
for all your RF needs.

Custom solutions and standard products from a single source.

With decades of experience in the interconnect industry, we know what's important to engineers. That's why Molex manufactures the world's broadest line of radio frequency connectors, cable assemblies and custom products. Our RF solutions can be optimized to minimize signal loss over a wide range of frequencies in a broad spectrum of sizes and styles of connectors. Plus, our service-oriented team can turn around drawings in 48 hours and deliver custom products in less than eight weeks — so you can get your products to market faster.

Molex-Tean, our new operation in China, manufactures DIN 7/16, jumper cables, lightning protection, splitters, hybrid couplers, bias tees and terminations for wireless telecom applications.

For the industry's largest array of product options backed by reliable service, turn to Molex — your clear choice for RF interconnect products and solutions.

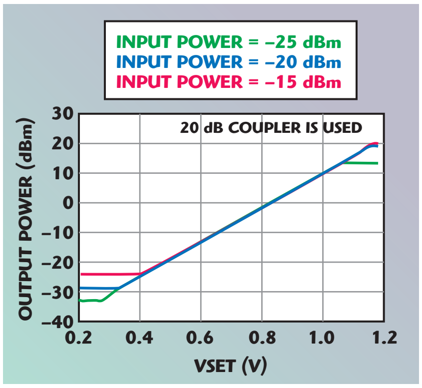
molex®
one company › a world of innovation

www.molex.com/product/rf.html

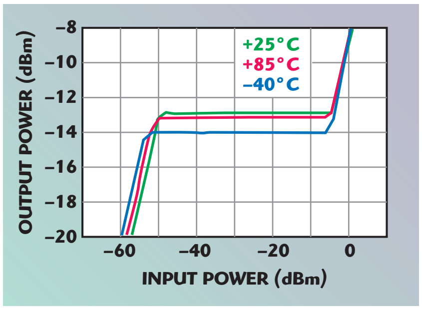
See us at IMS Booth 515

ferent temperatures for a closed AGC loop configuration when VSET is 0.6 V. The figure shows that the device exhibits over 45 dB of dynamic range with a minimal output power variation of less than 1 dB over temperature.

Hittite Microwave's design philosophy involves choosing the best semiconductor processes and design techniques available to provide customers with market-leading solutions. This allows the system's designer to maximize the true potential of the design and ultimately deliver a superior product. In most microwave radio and BTS receiver system configurations, the HMC992LP5E and the HMC993LP5E can be used to provide a space saving, single chip solution for each AGC block, while eliminating more than 18 discrete circuit elements. Moreover, these AGC devices can be combined with a number of additional catalog components from Hittite to implement high performance, end-to-end communication solutions.



▲ *Fig. 4 HMC992LP5E output power vs. VSET over input power at 300 MHz (closed loop configuration).*



▲ *Fig. 5 HMC992LP5E output power vs. input power at 400 MHz and VSET = 0.6 V.*

The HMC992LP5E and the HMC993LP5E provide complete, high value and highly accurate IF and RF power control solutions for a wide range of communications applications. Designed to be used in both open and closed loop operation, they both offer excellent linearity, a wide gain control range and configuration options with one or two attenuators depending upon the dynamic range requirements of the application. Compared with discrete implementations, the HMC992LP5E and the HMC993LP5E deliver a simpler, more flexible and compact design that reduces PCB space and features excellent temperature stability which is independent of part-to-part variations. The HMC992LP5E and the HMC993LP5E can be combined with a number of different Hittite high performance catalog components to implement a wide range of market solutions for LTE/WiMAX/4G, microwave radio, VSAT, test equipment and sensor applications.

VENDOR**VIEW**

**Hittite Microwave Corp.,
Chelmsford, MA,
sales@hittite.com,
www.hittite.com.**

Still worry about LTE ?

"Not anymore, you now have RFHIC's Affordable GaN!"

- Simple Design
- Cost Saving
- Time to Market
- High Quality

= RFHIC Doherty GaN

DPD GaN Pallet Amplifier

Frequency (MHz)	10W	25W	30W	50W	70W	80W
728 ~ 842.5				★		
746 ~ 780				★	★	
860 ~ 894			★	★		★
925 ~ 960	★			★		★
1525 ~ 1559				★		
1805 ~ 1880				★		★
1930 ~ 1980	★			★		★
2110 ~ 2170	★	★		★		
2300 ~ 2400	★					★
2469 ~ 2690				★		★
2570 ~ 2690	★	★		★		

GaN Hybrid PICO PAM

Part Number	Frequency (MHz)	Pout (W)	ACLR without DPD (dBr)	Efficiency (%)	Power Gain (dB)	Dimension (mm)
RTH07007-10	728 ~ 768	7.07	-30	40	18	28 x 19 x 6
RTH08007-10	860 ~ 894	7.07	-30	40	17	28 x 19 x 6
RTH09007-10	925 ~ 960	7.07	-30	40	17	28 x 19 x 6
RTH15007-10	1475.9 ~ 1510.9	7.07	-30	40	16	28 x 19 x 6
RTH18007-10	1805 ~ 1880	7.07	-30	40	16	28 x 19 x 6
RTH21007-10	2110 ~ 2170	7.07	-30	40	15	28 x 19 x 6
RTH27007-10	2620 ~ 2690	7.07	-30	40	14	28 x 19 x 6

√ Please contact us for your customized solution.

Come & enjoy RFHIC booth # 2508 at IEEE MTT-S IMS 2012

RF & MW is our business & passion

USA Office
Tel : 919-677-8780 / E-mail : sales@rfhicusa.com

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

RFHIC
www.rfhic.com

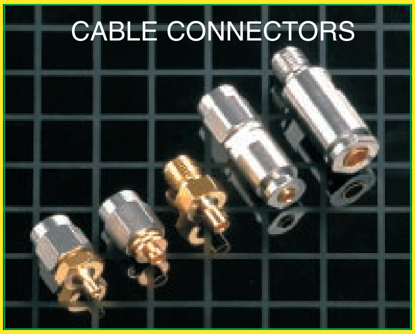
QUALITY, PERFORMANCE AND RELIABILITY IN PRECISION COAXIAL CONNECTORS


EDGE LAUNCH CONNECTORS


BETWEEN SERIES ADAPTERS


BULKHEAD & PANEL ADAPTERS


IN SERIES ADAPTERS


CABLE CONNECTORS


CUSTOM DESIGNS

ADAPTERS · CABLE CONNECTORS · RECEPTACLES · CUSTOM DESIGNS

Including These Connector Series

1.85mm	DC-65 GHz	2.92mm	DC-40 GHz	7mm	DC-18 GHz
2.4mm	DC-50 GHz	3.5mm	DC-34 GHz	SSMA	DC-40 GHz

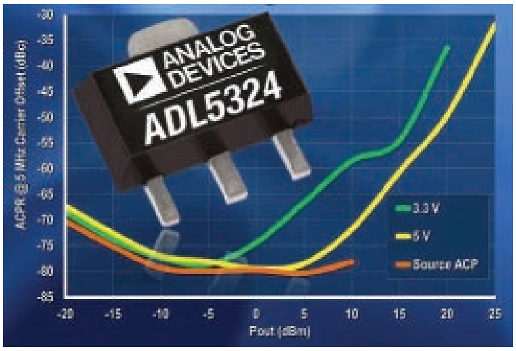
ISO 9001:2008

SGMC Microwave — The name to count on for Quality, Performance and Reliability! Please contact us today by Phone, Fax or Email.

SGMC MICROWAVE

Manufacturer of Precision Coaxial Connectors
620 Atlantis Road, Melbourne, FL 32904
Phone: 321-409-0509 Fax: 321-409-0510
sales@sgmcmicrowave.com
www.sgmcmicrowave.com

See us at IMS Booth 2536



Half Watt Driver Amplifier with Dynamically Adjustable Bias

Today's radio designs, and other RF communication equipment, are being made to consume less power while occupying less physical space, which leads to less available board area for heat sinking. In addition, these systems are being deployed in more extreme environmental conditions where only passive cooling is being used, which leads to the need for very reliable ICs that can withstand greater temperature variations. When the factor of system output power scalability gets added in, then the need emerges for a new equally scalable RF driver amplifier. To satisfy all of these goals, Analog Devices introduces the ADL5324 ½ W SOT-89 RF driver amplifier.

The ADL5324 incorporates a dynamically adjustable biasing circuit that allows for the customization of OIP3 and P1dB performance from 3.3 to 5 V, without the need for an external bias resistor. This feature gives the designer the ability to tailor driver amplifier performance to the specific needs of the design. The adjustable bias also allows for the driver to be dynamically biased in order to conserve power consumption when the full performance of the driver amplifier is not required, such as when a system is in stand-by mode. This scalability reduces the need to evaluate and inventory multiple driver amplifiers for different output power requirements, from 25 to 29 dBm output power levels. The ADL5324 is also rated to operate across the widest temperature range of -40° to +105°C for reliable performance in designs that will experience higher temperatures, such as power amplifiers. The ½ W driver amplifier also covers the wide frequency range of 400 to 4000 MHz, and only requires a few external components to be tuned to a specific band within that wide range. This high performance broadband RF driver amplifier is well-suited for a variety of wired and wireless applications including cellular infrastructure, ISM band power amplifiers, defense equipment and instrumentation equipment.

The ADL5324 GaAs HBT ½ W driver amplifier consumes a low 5 V current of 133 mA and delivers best-in-class performance with an OIP3 of 43.1 dBm, a P1dB of 29.1 dBm, a gain of 14.6 dB and a low noise figure of 3.8 dB at 2140 MHz. When the bias voltage is reduced to 3.3 V the driver only consumes 62 mA and delivers an OIP3 of 34.4 dBm, a P1dB of 25.3 dBm, a gain of 13.6 dB and a lower noise figure of 3.2 dB at 2140 MHz. The driver amplifier can also be biased anywhere from 3.3 to 5 V to meet system needs that are in between the performance stated at 3.3 or 5 V. This feature creates the opportunity for dynamic biasing of the driver amplifier where a variable supply is used to allow for full 5 V biasing under large signal conditions, and then reduced supply

Analog Devices
Norwood, MA

dynawave®

CABLE INCORPORATED

Visit **dynawavecable.com** today

to see the most comprehensive line of low loss cable, connectors and cable assemblies

CABLES

The **DynaFlex®** Cable Series easily handles the most challenging design specifications where size, weight, power, loss, phase stability, flexure or other requirements are critical. This is accomplished by employing our **DynaCore®** PTFE dielectric technology along with the latest computer controlled manufacturing processes.

- **DynaFlex®** Series DF 100 (DC—50 GHz) **"Best All Around Performance"**
- **DynaFlex®** Series DF 200 (DC—40 GHz) **"Best Electrical Performance"**
- **DynaFlex®** Series DF 300 (DC—40 GHz) **"Best Weight Performance"**
- **DynaFlex®** Series DF 400 (DC—65 GHz) **"Best Flexure Performance"**

REQUEST A COPY OF OUR NEW 2012 CATALOG

The **D-Flex®** Cable Series replaces semi rigid cables with a flexible equivalent and the **D-Flex® Microporous** Cable Series offers extended frequencies and temperature ranges by incorporating **DynaCore®**. All **D-Flex®** cables accept standard semi rigid connectors to simplify connectorization.

- **D-Flex®** Series (DC—18 GHz) sizes equivalent to (Semi Rigid .086, .141)
- **D-Flex® Microporous** Series (DC—40 GHz) with **DynaCore®**, sizes equivalent to (Semi Rigid .047, .086, .141)

CONNECTORS

We offer electrically matched connectors for the **DynaFlex®** and **D-Flex®** Cable Series to ensure the best possible performance for your assemblies.

ASSEMBLIES

We offer standard and custom coaxial cable assemblies with design assistance provided to insure all products meet your system specifications.

IMS 2012
June 17-22
Visit Us At Booth
2431

world wide Lan Tec
A WORLD OF CONNECTIONS
FROM THE SYSTEM WIRING SPECIALISTS

Products now available through distribution at World Wide Lan Tec Inc.
Tel (972) 980-6878 • www.wwlantec.com

Dynawave Incorporated ISO 9001 : 2008. Certificate No. 10002306 QM08 sales@dynawavecable.com
135 Ward Hill Avenue, P.O. Box 8189, Haverhill, MA 01835 Tel (978) 469-9448 Fax (978) 521-1113

UL REGISTERED FIRM


ES MICROWAVE LLC.

Since 1985 we have offered our custom design filters and sub-assemblies in combline, interdigital and suspended-substrate technologies.

Broadband
Suspended-Substrate
Filters, Diplexers, Triplexers, Quadruplexers, Quintuplexers, Sextuplexers...

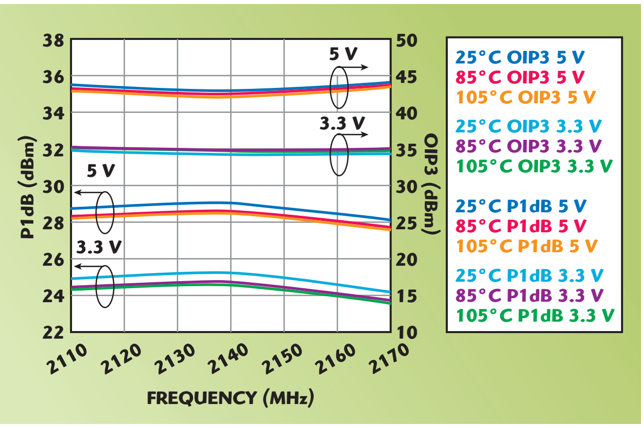
DC-40 GHz Filters
Multiplexers &
Switch Filter Banks

ES Microwave, LLC
8031 Cessna Avenue, Gaithersburg, MD 20879
P: 301-519-9407 F: 301-519-9418
www.esmicrowave.com

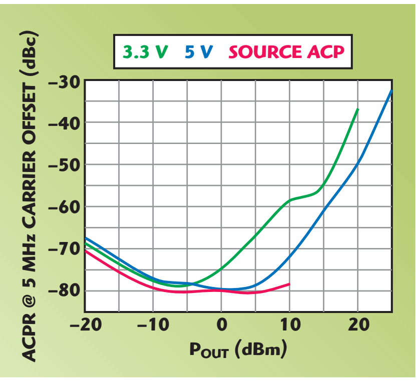

R&K RF High Power Amplifier
MODEL : CA509MBW6-7373R
- All Solid State Amplifier. (300W×128parallel)
- Frequency Range : 509MHz±3MHz
- Output Power : 20kW (min.) @P-1dB
- Forced Air Cooling, Best MTBF Design.

All Solid State
≧20k W!!

R&K Company Limited
721-1 MAEDA, FUJI-City, SHIZUOKA-Pref. 416-8577 JAPAN
Tel : +81-545-31-2600 http://rk-microwave.com
Fax : +81-545-31-1600 E-mail: info@rkco.jp



▲ *Fig. 1 ADL5324 OIP3 and P1dB vs. V_{cc} and temperature showing that 3.3 to 5 V bias meets system needs.*



▲ *Fig. 2 ADL5324 ACPR vs. output power and V_{cc} (3GPP 3.5 TM1-64 at 2.14 GHz) showing a minimal reduction to 15 dBm in the –55 dBc ACPR at 3.3 V bias.*

voltage when signal levels are smaller and lower power consumption is desirable (see ***Figure 1***).

The ADL5324 also delivers excellent ACPR versus output power and bias voltage. The driver can deliver greater than 17 dBm of output power at 2140 MHz, while achieving an ACPR of –55 dBc at 5 V. If the bias is reduced to 3.3 V, the –55 dBc ACPR output power only minimally reduces to 15 dBm (see ***Figure 2***).

The ADL5324 further simplifies RF design by eliminating the need for complicated external tuning. The driver only uses 50 Ω lines at the input and output of the amplifier and does not require a bias resistor. The ADL5324 only needs one shunt capacitor at its input and one shunt capacitor at its output for frequency tuning. The usual AC coupling capacitors and DC bias choke inductor are also required, along with the standard bypass capacitance on the DC bias trace.

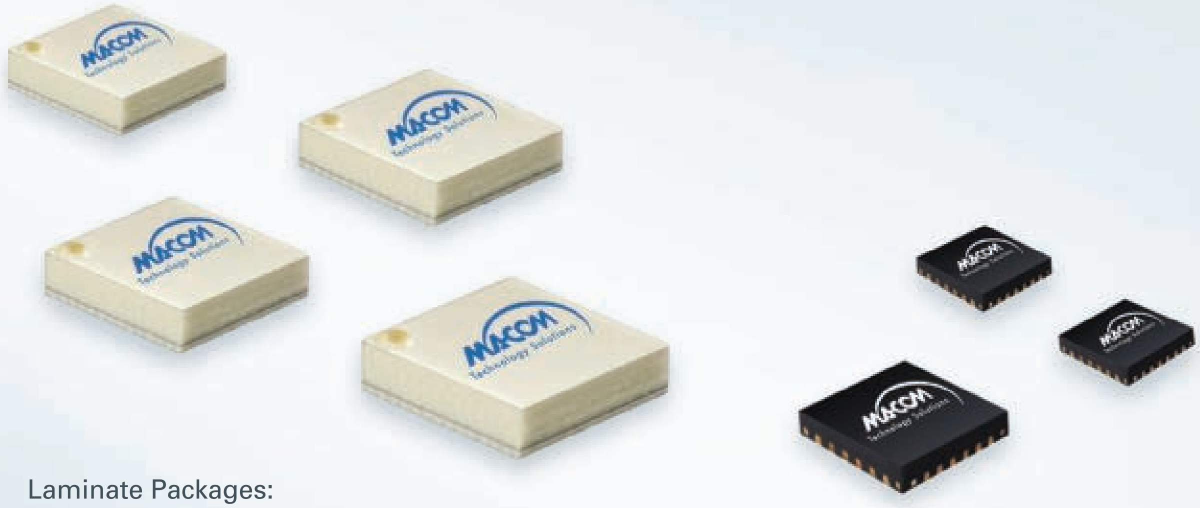
The ADL5324 was also designed and packaged to simplify thermal considerations. The driver has best-in-class current consumption of 133 mA with 5 V, which reduces the amount of heat that is created. The 3.3 V current consumption is reduced to 62 mA, which further reduces the amount of heat created. The standard SOT-89 package also has a large backside ground paddle that allows for an efficient thermal transfer path from the driver amplifier. The data sheet shows the recommended circuit board land pattern with added thermal transfer vias to further improve thermal transfer from the driver amplifier. This allows the driver to be kept within safe operating temperatures without the need for forced air cooling, and the driver is fully specified over the widest operating temperature range of –40° to +105°C. The driver amplifier is also rated to an ESD rating of ±3 kV (HBM, Class 2), which makes it equally robust in high volume manufacturing environments.

Another way Analog Devices helps improve RF design is with the amount of information provided in the ADL5324 data sheet. Data provided such as critical parameter variation versus temperature, from –40° to +105°C, voltage supply, from 3.3 to 5 V, and operating frequency, from 400 to 4000 MHz, reduces the amount of qualification time a designer needs to spend. That reduction in qualification time can significantly improve a projects' time-to-market. The comprehensive data sheet also allows the designer to accurately determine the least amount of power consumption achievable to meet the performance goals for their given application.

Analog Devices improves RF design in multiple ways; through innovative circuit design, simplified tuning requirements and detailed data sheet information. These attributes allow RF designers to go to market quickly with solutions that meet their needs for smaller, lower power consuming systems.

Analog Devices,
Norwood, MA,
www.analog.com/rf.

42 GHz SMARTSET FOR WIRELESS BACKHAUL



Laminate Packages:

MAUC-010515: Up Converter
MAAM-010513: Driver Amplifier
MAAP-010512: Power Amplifier
MADC-010736: Down Converter

Product scale 1:3

QFN Packages:

MAFC-010511: LO Doubler
MAAT-010521: Attenuator
MAOC-009259 to 009270: VCO

M/A-COM Tech introduces its 42 GHz Smartset Chipset for point-to-point radio applications. Using a systems-driven approach to integration, coupled with innovative IC and package design capabilities, the chipset enables OEM customers to achieve faster time-to-market with optimal performance.

Sampling now and scheduled for full release by Summer 2012, the chipset is offered in convenient surface mount packages. This facilitates the use of common high-volume assembly lines in manufacturing operations.

Visit **macomtech.com/42GHz** for more information.

M/A-COM
Technology Solutions
THE FIRST NAME IN MICROWAVE®

See us at IMS Booth 815

Exploit the Radio Channel for Improved MIMO Performance

Janne Kolu, Vice President of Test Tools, EB (Elektrobit), explains the company's global reach, elaborates on the evolution of test systems in the wireless sector and discusses EB's latest product developments.

Visit www.mwjournal.com to read this in-depth interview.

Wireless systems are evolving toward high-quality services with higher data rates, requiring new wireless technology innovations that are able to meet the increased demand for high data rate applications. Physical layer performance improvements are being implemented, e.g. LTE technology is based on wider bandwidths, adaptive multi-antenna technologies – multiple-input, multiple-output (MIMO) – and in further 3GPP LTE-Advanced technology, enhanced transmission schemes like carrier aggregation and coordinated multipoint (CoMP).

Physical layer performance depends strongly on radio channel characteristics, especially in MIMO technologies, since MIMO offers significant performance gain in data throughput, quality of service (QoS) and cell coverage without additional bandwidth or signal transmit power. Hence, MIMO technologies, such as spatial multiplexing (SM), beamforming (BF) and spatial diversity are setting challenging requirements for radio channel modeling and emulation capability in testing wireless communication networks and devices. At the same time as the technology evolution, time to market expectations are rising despite the more complex technology, requiring more effective design and verification methods and calling for more capacity, accuracy and effectiveness compared to past development methods.

EB (ELEKTROBIT)
Oulu, Finland

World-Class Technology & Support Worldwide Availability

JZ
4.5 x 3.2 x 1.5 mm

JR
3.5 x 3.1 x 1.15 mm

JV
3.2 x 2.5 x 1.25 mm

JQ
2.7 x 2.2 x 1.0 mm

JN
1.7 x 1.5 x 0.9 mm

NEW

J-Series Half-Turn Ceramic Trimmer Capacitors

Product Features Include:

- High Performance, High Q
- Small Size
- Surface Mount Installation
- Less than 1% Capacitance Drift
- Frequencies to 1 GHz
- High Volume and Small Lots Available
- Crosses to Sanshin Part Numbers
- Tape and Reel Packaging
- **New High Voltage JZ Series Supporting up to 300 Volts**

The Trimmer Capacitor Company

Voltronics
A DOVER COMPANY

CMP

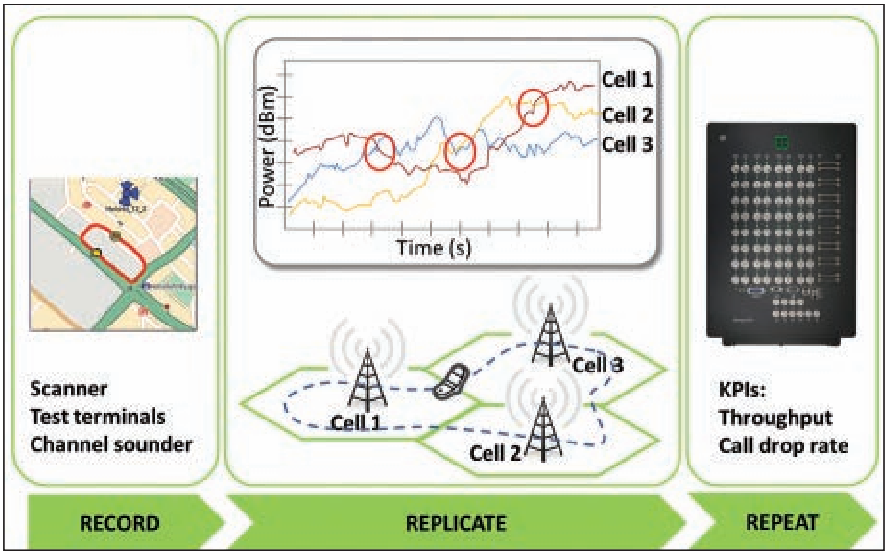
CERAMIC & MICROWAVE PRODUCTS
Electronic Components & Microwave Solutions
A DOVER COMPANY

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

See us at IMS Booth 1410

www.voltronicscorp.com

Therefore, EB (Elektrobit) has introduced a new EB Propsim® F32 radio channel emulator product to meet the demanding design and verification challenges of today's and future wireless technologies. It is designed for testing complex MIMO scenarios as well as enhanced transmission schemes. In addition, all these different test scenarios can be carried out either traditionally as conductive test via coaxial cable connections or Over-the-Air (OTA) together with the EB MIMO OTA application.



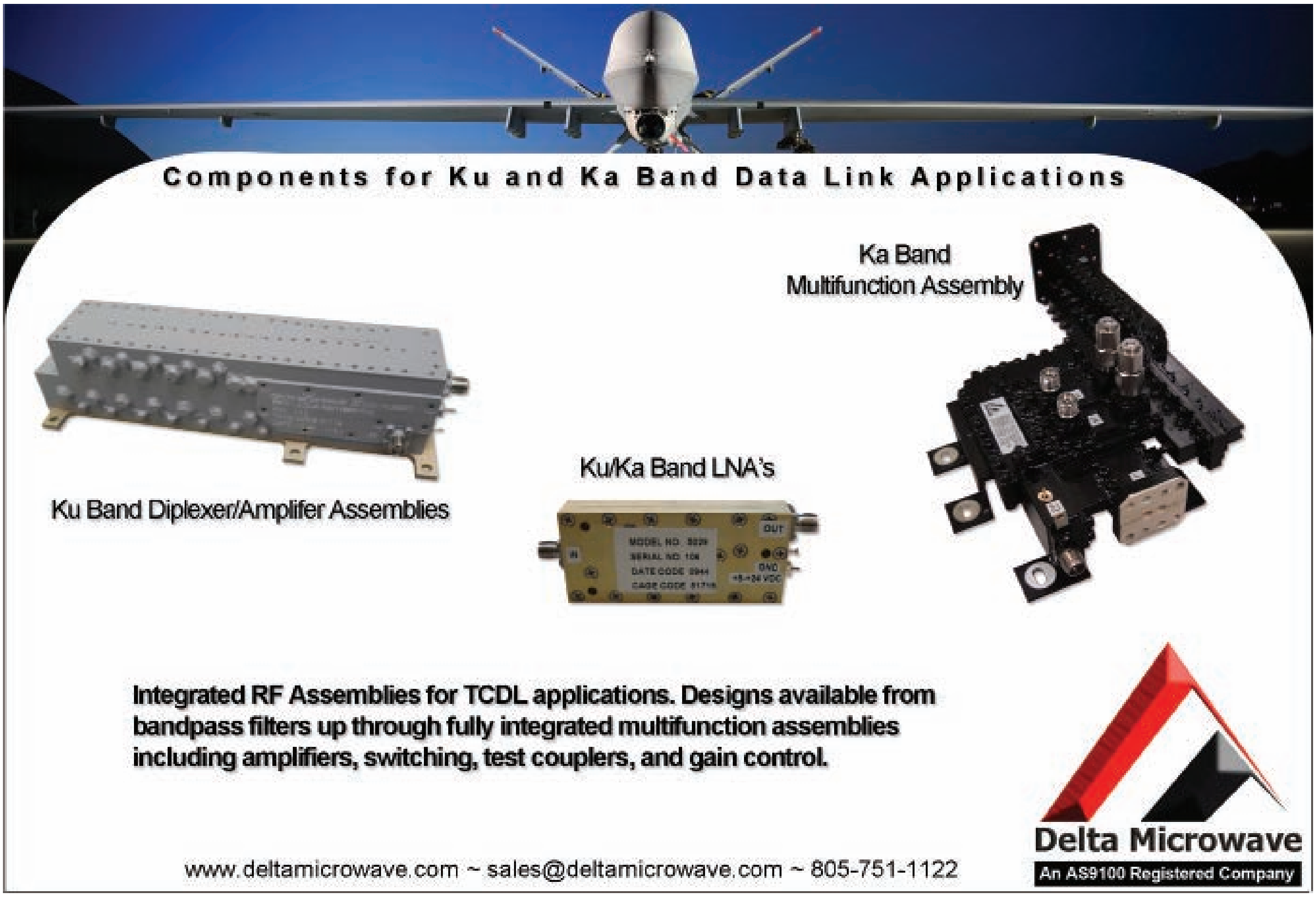
▲ *Fig. 1 Virtual drive testing with EB Propsim F32 enables MIMO handover scenarios incorporating three or more simultaneous base stations in a single lab instrumentation.*

MIMO TESTING

EB Propsim F32 emulates the typical radio channel characteristics like path loss, multipath fading, delay spread, Doppler spread, polarization and spatial parameters such as Angle of Arrival (AoA) and Angular Spreads (AS), which are critical for MIMO system performance. It is designed for LTE testing supporting carrier bandwidth up to 40 MHz and frequency bands up to 2700 MHz, and features a compact and highly integrated design.

The new channel emulator is also scalable and allows the tailoring of the product configuration to current needs and the upgrading of features as technologies evolve. EB Propsim F32 can emulate up to 128 independent fading channels simultaneously representing bi-directional 8×8 MIMO emulation capability needed, e.g. in multi-user MIMO testing.

Now, typical TD-LTE beamforming or advanced MIMO OTA test systems can be equipped with a single radio channel emulator, making test setup and configuration cost effective, quick and easy, without the need for external hardware components and complicated synchro-


Components for Ku and Ka Band Data Link Applications

Ka Band
Multifunction Assembly

Ku Band Diplexer/Amplifer Assemblies

Ku/Ka Band LNA's

Integrated RF Assemblies for TCDL applications. Designs available from bandpass filters up through fully integrated multifunction assemblies including amplifiers, switching, test couplers, and gain control.

www.deltamicrowave.com ~ sales@deltamicrowave.com ~ 805-751-1122

Delta Microwave
An AS9100 Registered Company

See us at IMS Booth 722

MICROTECH INC.

is Everywhere

in Space

in the Air

at Sea

and on Land

AS9100 / IS09001

Space Qualified Technology

• ADAPTERS • BENDS • HORNS • BULKHEAD ASSEMBLIES
• SPECIALS • TRANSITIONS • TERMINATIONS • RIGID ASSEMBLIES
• STRAIGHT SECTIONS • TWISTS • FLANGES • PRESSURE WINDOWS
• PRESSURE UNITS • MILLIMETER FLEX • FLEXIBLE WAVEGUIDE
• RIGID WAVEGUIDE • FLANGES • W/G TO COAX • ADAPTERS
• TORTIONAL JOINTS • ROTARY JOINTS • ANTENNAS • FILTERS
• GASKETS • TWISTS • COUPLERS • ARC DETECTORS

MICROTECH INC.

PRECISION
MICROWAVE COMPONENTS

1425 Highland Avenue • Cheshire, CT 06410 USA
• Tel 203-272-3234 • Fax 203-271-0352
Email: sales@microtech-inc.com • Visit us at: www.microtech-inc.com

See us at IMS Booth 2716

Learn From the Experts About GaN Business Opportunities

Special Panel Session at IMS 2012

Where are the Emerging RF Market Opportunities for GaN?

Wednesday, June 20
8:00-10:00 AM
Room 516
Palais des Congrès de Montréal

Industry experts from Strategy Analytics, RFMD, TriQuint, Cree, NXP, Nitronex and UMS will make brief presentations about their view on GaN market opportunities followed by a question and answer session with the audience. This event is open to all attendees and complimentary breakfast will be served.

Organized and sponsored by:

Microwave Journal
Frequency Matters.

STRATEGY ANALYTICS
...insights for success

IMS2012
MONTRÉAL

nization of multiple instruments in the test system. High emulation capacity and high channel fidelity combined with excellent RF performance simplifies the test system installation and configuration for multi-antenna and multi-radio testing.

INTELLIGENCE BUILT-IN

EB Propsim F32 has intelligent internal signal summing and splitting designed for testing of different link topologies with user-defined antenna connections to the instrument. Flexibility in physical antenna connections, integrated local oscillators and signal duplexers together provide convenient and reliable test system installation with good support for remote use and 24/7 test automation, even for multi-RAT testing.

It is equipped with the standard Windows XP embedded operating system that is familiar to any user and therefore the emulator is easy to configure for remote desktop use when the laboratory facility and office desk are in different locations. The radio channel emulator ensures low operating costs by fast test system configuration and convenience of channel modeling capabilities.

VIRTUAL DRIVE TESTING

The EB Propsim F32 makes it easy to improve test effectiveness by creating realistic Virtual Drive Testing (VDT) (see ***Figure 1***) or network level test scenarios including multiple base stations and user terminals in repeatable lab conditions. Traditional field-testing of wireless systems is labor intensive, time-consuming and expensive. Also, getting consistent results is a challenge. EB's VDT application together with the high capacity EB Propsim F32 solves these problems by enabling VDT in laboratory conditions.

VDT utilizes the field measurement data from real live networks captured by drive test tools or channel sounders in order to create repeatable real-world like conditions to laboratory testing. All the elements of the real environment: fast fading, Doppler, signal level variations, interference and antenna parameter effects can be replicated, making it possible to isolate performance issues early in the development and design verification phase.

Being compatible with various drive test tools, EB VDT with the new EB Propsim F32 is a powerful solution for operators, network, device and chipset manufacturers by verifying the performance and interoperability under different realistic field conditions. The new radio channel emulator allows simultaneous connection, e.g. three base stations and five terminals or five groups of terminals for bi-directional LTE 2×2 MIMO testing. This setup enables true performance testing, including different handover scenarios, scheduling, power control, etc., under dynamic and realistic propagation conditions.

MIMO OTA TESTING

EB MIMO OTA application expands the usage of the EB Propsim F32 from traditional conductive testing to MIMO OTA testing. MIMO OTA testing is a state-of-the-art test method for mobile device, chipset and antenna designers and manufacturers working on MIMO technologies. MIMO OTA testing with the new radio channel

IMS2012
MONTRÉAL

MICROWAVES WITHOUT BORDERS
MICRO-ONDES SANS FRONTIÈRES

International Microwave Symposium
IEEE 17-22 June 2012, Montréal, Canada MTT-S
http://ims2012.mtt.org/

MTT IMS
NEW YORK 1952 MONTRÉAL 2012
60 YEARS 60

IMS2012

17-22 June 2012 - MONTRÉAL, CANADA

IT'S NOT TOO LATE TO REGISTER

FOR MICROWAVE WEEK IN MONTRÉAL, CANADA!

There's still time to be a part of the

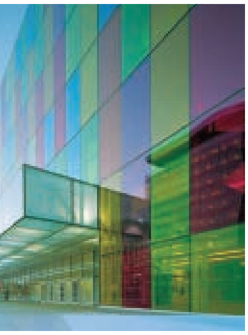
PREMIER MICROWAVE AND RF CONFERENCE

featuring over

600 Vendors' Technologies and Services

- **Visit http://ims2012.mtt.org to register until 15 June**
- **On-site registration begins 16 June**

WE LOOK FORWARD TO SEEING YOU AT IMS2012!



IEEE MTT-S

http://ims2012.mtt.org

FeaturedWhitePapers

The information you need, from the technology leaders you trust.

Wireless Telecom Group
Statistical Analysis of Modern Communication Signals
Bob Muro, Wireless Telecom Group

NATIONAL INSTRUMENTS
Redefining RF and Microwave Instrumentation Through Open Software and Modular Hardware
Tutorial, National Instruments

RichardsonRFPD
An Arrow Company
Selecting Ferrite Circulators for Radar Applications
Presented by: Richardson RFPD and Skyworks

AWR
Leverage Circuit-Envelope Simulation to Improve 4G PA Performance
Dr. John M. Dunn, AWR Corp.

TEXAS INSTRUMENTS
LO Harmonic Effects on TRF3705 Sideband Suppression
Bill Wu and Russell Hoppenstein, Texas Instruments

Check out these new online Technical Papers featured on the home page of Microwave Journal at www.mwjournal.com.

Microwave Journal
Frequency Matters.

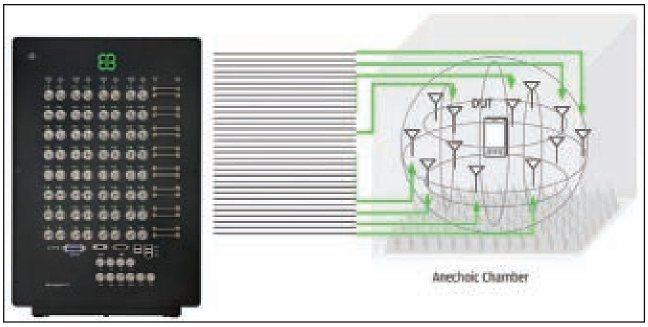


Fig. 2 The EB Propsim® F32's compact design also allows a higher number of probes in the MIMO OTA chamber.

emulator enables the evaluation of the end user experience of the final product, e.g., in terms of data throughput, against realistic radio channel conditions where performance varies greatly according to environment.

The unit's compact design also allows a higher number of probes in the MIMO OTA chamber (see ***Figure 2***), thus radiated multipath signals generate more accurate radio channel environment around the DUT. EB Propsim F32 in MIMO OTA testing enables the real-world performance evaluation by providing the answer to the question, "How good is my terminal?"

ACCELERATED DEVELOPMENT CYCLES

Realistic field scenarios in laboratory testing at the early development stages provide immediate feedback and facilitate the improvement of product maturity before field trials, thus accelerating the product development cycles and yielding better product quality. EB Propsim F32 provides high capacity and convenience for testing demanding broadband multi-antenna wireless devices as well as complex and realistic network level test scenarios in laboratory conditions. Testing with the new radio channel emulator provides good network performance, high quality user experience of devices and hastens the time to market of new wireless devices and systems.

EB (Elektrobit),
Oulu, Finland
+358 40 344 3759,
email: rcpsales@elektrobit.com,
www.elektrobit.com/ebpropsim.

IMS2012 MONTRÉAL
MICROWAVES WITHOUT BORDERS
MICRO-ONDES SANS FRONTIÈRES
International Microwave Symposium
IEEE 17-22 June 2012, Montréal, Canada MTT-S
http://ims2012.mtt.org/
MTT IMS NEW YORK 1952 MONTRÉAL 2012 60 YEARS 60

Catch our exclusive conference
information, news, social networking,
photos, videos, and more at
mwjournal.com/IMS2012,
proud sponsor of the
IMS 2012 Cyber Café.

See us at IMS Booth 2018

Need mission-critical frequency control?

Choose Crystek VCOs

Reliable frequency control is crucial to mission-critical applications. Expect the best VCO performance – from Crystek. VCOs from Crystek give you low phase noise, low harmonics, excellent linearity, and high frequency (up to 6.9GHz). Crystek VCOs are competitively priced and available in a wide range of packaging options, from industry-standard SMD to hermetically-sealed TO-8. A leader in frequency solutions for more than 50 years, Crystek manufactures all VCOs in the USA and subjects each one to rigorous electrical testing before it leaves the factory.

Expect the best.
Choose Crystek VCOs.

Low Phase Noise | High Frequency | In Stock

Find your high-performance VCO at
www.crystek.com

See us at IMS Booth 2824

CRYSTEK
MICROWAVE

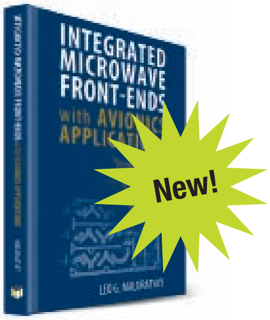
Wideband Synthesized Signal Generators

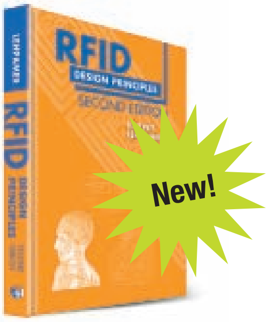
Mini-Circuits has developed two new wideband synthesized signal generators. The SSG-4000HP is a wideband synthesized signal generator that operates over the frequency range of 250 to 4000 MHz providing a 70 dB power range from -50 to +20 dBm in 0.25 dB steps and the SSG-4000LH (both RoHS compliant) operates over the same frequency range providing a 70 dB power range from -60 to +10 dBm in 0.25 dB steps. They can be set to sweep either power or frequency up, down or bi-directionally (sawtooth). The SSG-4000HP is encased in a rugged metal shielded package of 8.37" × 8.5" × 2.15" while the SSG-4000LH is packaged in a case of 11" × 8.5" × 2.15". Both are equipped with an N-type 50 Ω connector at the RF output port. They are powered by a supplied three wire 24 V AC/DC power adapter (grounded) and controlled through a USB 2.0 interface using a unique user friendly GUI software allowing the user to select one of several different output modes including both frequency sweep and power sweep (up, down or bidirectional) options.

Both wideband synthesized signal generators are plug-and-play (no need to install a driver for the device) and supplied with a CD containing programming instructions for Linux® and Windows® operating systems (32 and 64 bit systems) and a Windows® GUI control program containing an API DLL com object is included. Also included are a 2.7 ft USB cable and a power adapter suitable for U.S., EU and other power systems. Longer USB cables and a mounting bracket are available as additional options.

VENDORVIEW

Mini-Circuits,
Brooklyn, NY,
www.minicircuits.com.





ARTECH HOUSE

ENJOY 20% OFF YOUR ENTIRE PURCHASE! USE PROMO CODE **MWJ20**

Authoritative, Practical Resources for RF & Microwave Engineers

New!

RF Linear Accelerators for Medical and Industrial Applications
Samy Hanna
Hardcover. 210 pp. 2012
ISBN: 978-1-60807-090-9
$119/£79

Passive RF Component Technology: Materials, Techniques, and Applications
Guoan Wang and Bo Pan
Hardcover. 312 pp. 2012
ISBN: 978-1-60807-199-9
$139/£92

Integrated Microwave Front-Ends with Avionics Applications
Leo G. Maloratsky
Hardcover. 368 pp. 2012
ISBN: 978-1-60807-205-7
$159/£109

RFID Design Principles, Second Edition
Harvey Lehpamer
Hardcover. 363 pp. 2012
ISBN: 978-1-60807-470-9
$129/£89

US: **Call** 1-800-225-9977 (in the U.S. or Canada), or 1-781-769-9750, ext. 4030
Fax to: 1-781-769-6334
E-mail to: artech@ArtechHouse.com

UK: **Call** +44 (0)20 7596 8750
Fax to: +44 (0)20 7630-0166
E-mail to: artech-uk@ArtechHouse.com

For complete descriptions and to order, visit
ArtechHouse.com

All orders plus shipping/handling and applicable taxes.
Offer expires 6/30/2012. Cannot be combined with any other offer.

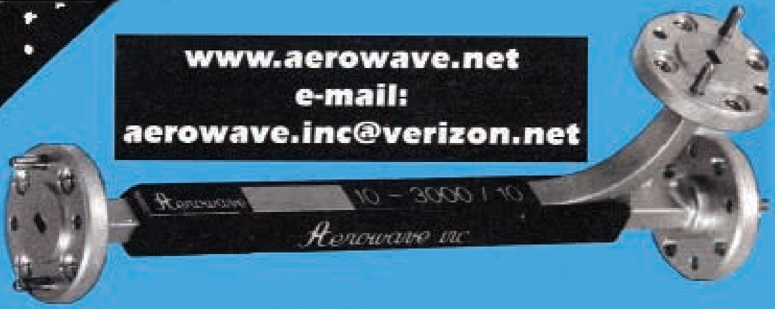
ARTECH HOUSE
BOSTON | LONDON

685 Canton Street, Norwood, MA 02062 USA
16 Sussex Street, London SW1V 4RW UK

Tel. 1-781-391-1555
Fax. 1-781-391-5338

M/M
WAVE
DEVICES
18.0
To
325.0
GHz

www.aerowave.net
e-mail:
aerowave.inc@verizon.net



THINK BIG???
NOT US!!!

We think small. We have to. Fabricating millimeter-wave components requires tolerances and exceptional surface finishing requirements unique in the microwave industry. Whether it's catalog components or custom plumbing, we apply our expertise and workmanship to produce items we are proud to place our name on. For your next millimeter waveguide requirement, think small. Think Aerowave - Taking Care of the Little Things Since 1985.

www.aerowave.net
e-mail:
aerowave.inc@verizon.net

Aerowave inc.
344 Salem St.
Medford, Ma. 02155

Small Vector Reflectometer

Copper Mountain Technologies has developed a new class of vector network analyzer, the virtual vector reflectometer PLANAR R54, operating in the frequency range of 85 MHz to 5.4 GHz (specified to 4.2 GHz). The device functions with a virtual UI and is powered and operated via a single USB interface on any external Windows PC.

PLANAR R54 implements many of the functions of advanced vector reflectometers, measuring various characteristics of the S_{11} parameter: return loss, VSWR, phase, impedance (Smith chart), etc. It also operates in time domain measuring DTF with high accuracy. With a frequency setting resolution of 10 Hz and up to 10,001 measurement points per sweep, R54 performs on par with industry leaders, but at a fraction of the cost.

The device has a uniquely compact form factor: 117 × 39 × 19 mm and weighs only 8.8 ounces, using less than 2 W for power. These dimensions are no accident – the device is as small as the minimum bend radius of a test cable which allows for direct connection to any DUT where a test cable could be connected. The ability to easily connect to a DUT without the use of a test cable improves the accuracy of testing, decreases cost and allows for more efficient and less frequent calibration.

The combination of advanced features, high accuracy and value of the PLANAR R54 makes this vector reflectometer well suited for daily use by specialists in the field as well as in the lab and production environment. The software interface of the R54 is compatible with the latest in notebook and tablet technology (including touch screens), allowing for the portability in the field.

VENDORVIEW

Copper Mountain Technologies,
Indianapolis, IN (317) 222-5400,
sales@coppermountaintech.com,
www.coppermountaintech.com.

CALL FOR BOOK AUTHORS

You can enhance your professional prestige and earn substantial royalties by writing a book. With over 1,500 titles published, Artech House is a leading publisher of professional-level books in microwave, radar, communications and related subjects. We are seeking to publish new microwave engineering books and software in areas such as microwave and RF device design, wireless communications, advanced radar and antenna design, electromagnetic analysis, RF MEMS, sensors, and more.

We are currently seeking potential authors among engineers and managers who believe that they can make a contribution to the literature in their areas of expertise. If you have published technical papers, conducted professional seminars or solved important real-world problems, then you are an excellent candidate for authorship.

We invite you to submit your manuscript or software proposal for review. For a complete publications catalog and Author's Questionnaire please contact:

Mark Walsh, Senior Editor
1-800-225-9977
mwalsh@artechhouse.com

Artech House, Inc.
685 Canton St.
Norwood, MA 02062

ARTECH HOUSE
www.artechhouse.com

See us at IMS Booth 2014

Microwave Journal
Frequency Matters.

IMS 2012 Products Scavenger Hunt

An IMS exhibition attendee has a lot of vendors to visit in a short period of time. To find what you need, you need to know where to look. Take the challenge and complete this month's Scavenger Hunt on pg. 282.

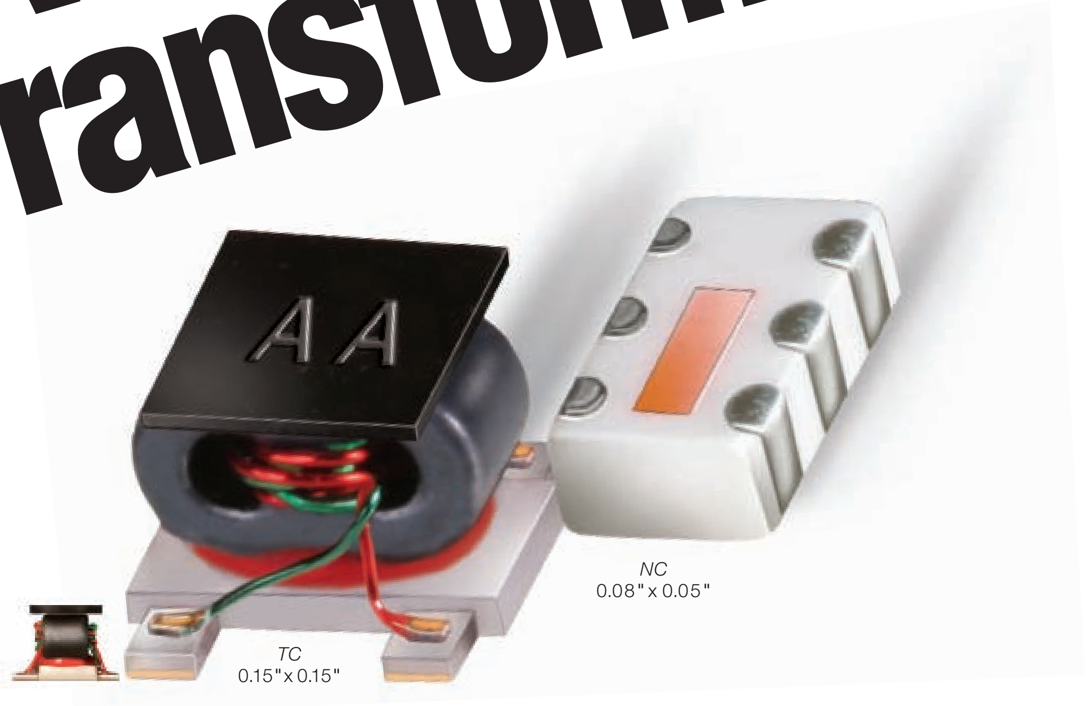
Drop off the completed puzzler to MWJ Booth #2018 and be entered into a daily prize drawing for a Kindle Fire.

Sponsored by:

Mini-Circuits®
ISO 9001 ISO 14001 AS 9100

TINY

Wideband Transformers



0.15-6200 MHz as low as 99¢ each (qty. 1000) RoHS compliant.

Rugged, repeatable performance.
At Mini-Circuits, we're passionate about transformers. We even make own transmission line wire under tight manufacturing control, and utilize all-welded connections to maximize performance, reliability, and repeatability. And for signals up to 6 GHz, our rugged LTCC ceramic models feature wrap-around terminations for your visual solder inspection, and they are even offered in packages as small as 0805!

Continued innovation: Top Hat.
A Mini-Circuits exclusive, this new feature is now available on every open-core transformer we sell. Top Hat speeds customer pick-and-place throughput in four distinct ways: (1) faster set-up times, (2) fewer missed components, (3) better placement accuracy and consistency, and (4) high-visibility markings for quicker visual identification and inspection.

More models, to meet more needs
Mini-Circuits has over 200 different SMT models in stock. So for RF or microwave baluns and transformers, with or without center taps or DC isolation, you can probably find what you need at minicircuits.com. Enter your requirements, and Yoni2, our patented search engine, can identify a match in seconds. And new custom designs are just a phone call away, with surprisingly quick turnaround times gained from over 40 years of manufacturing and design experience!

See minicircuits.com for technical specifications, performance data, pricing, and real-time, in-stock availability!
Mini-Circuits...we're redefining what Value is all about!

Mini-Circuits®
ISO 9001 ISO 14001 AS 9100
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

Yoni2® ***The Design Engineers Search Engine*** *finds the model you need, Instantly* • For detailed performance specs & shopping online see **minicircuits.com**
U.S. Patents
7739260, 7761442

IF/RF MICROWAVE COMPONENTS

377 rev Y

Montréal
Canada

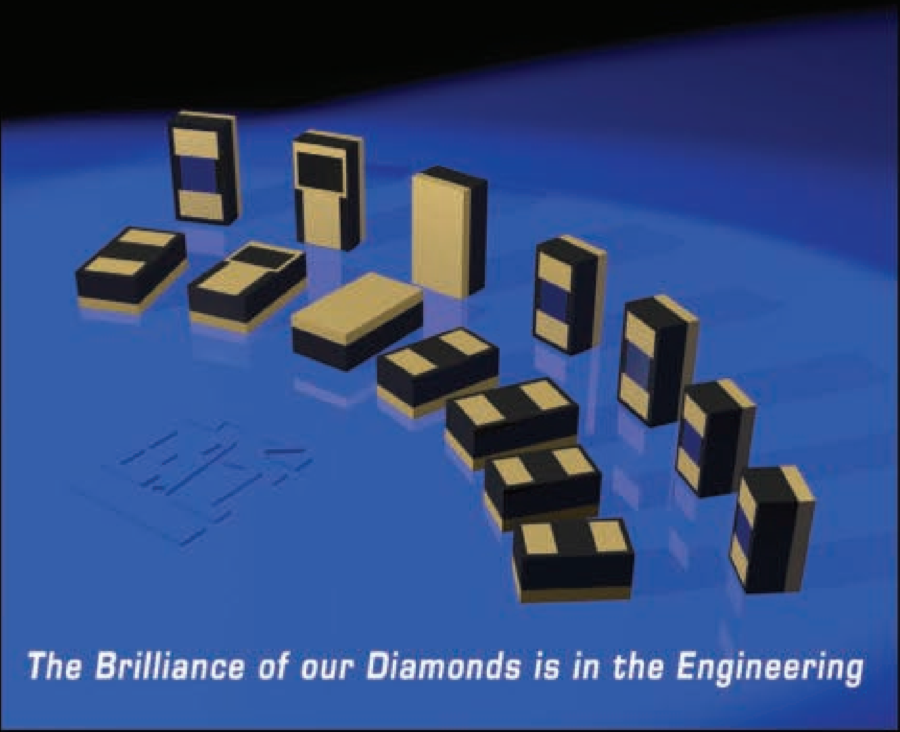
IMS 2012 Exhibitor List

The following list is complete as of April 12, 2012. Exhibitors in red have an ad in this issue.

2COMU	3021
3G Metalworx Inc.	1026
A-Alpha Waveguide Co.	2925
A.J. Tuck Co.	2826
A.T. Wall Co.	2622
AA-MCS	81
Accumet Engineering Corp.	2245
ACEWAVETECH Inc.	220
ADMOTECH Co. Ltd.	211
AdTech Ceramics	3204
Advance Reproduction Corp.	129
Advanced Chemical Co.	318
Advanced Circuitry International	2526
Advanced Research Systems Inc.	216
Advanced Switch Technology	**100**
Advanced Test Equipment Rentals	**3220**
AdvanSys Electronix	3012
Aeroflex Inc.	**2305**
Aethercomm Inc.	**2237**
Agilent Technologies	**1015**
AI Technology Inc.	402
Aldetec Inc.	2107
Aliner Industries Inc.	420
Alliance Corp.	2546
AMCAD Engineering	1125
Amcom Communications Inc.	2444
AMCrf	315
American Beryllia Inc.	2246
American Microwave Corp.	**1829**
American Standard Circuits Inc.	3316
American Technical Ceramics	**3027**
Ametek HCC Industries	624
Amphenol Printed Circuits	2340
Amplical Corp.	3023
AMT Solutions Co. Ltd.	228
ANADIGICS	3514
Analog Devices Inc.	**1725**
Anapico Ltd.	3317
Anaren Inc.	**709**
Anatech Electronics	315
Anoison Electronics	**310**
Anritsu Co.	**807**
ANSYS Inc.	**907**
APA Wireless Technologies	**112**
Apollo Microwaves Ltd.	109
Applied Thin-Film Products (ATP)	2727
AR RF/Microwave Instrumentation	**1201**
ARC Technologies Inc.	**2337**
Arlon Tech. Enabling Innovation	2819
Artech House	**2014**
ASB Inc.	3205
Aselsan	**105**
Association of Old Crows/ Naylor Pub.	114
Astrolab Inc.	2504
ATE Systems Inc.	3422
Auriga Microwave	**1122**
Aurora Software & Testing SL	3024
Avago Technologies	1909
Averna	3425
AVX Corp.	3327
AWR Corp.	**1514**
Axiom Test Equipment Inc.	3408
B&Z Technologies	**1927**
Barry Industries Inc.	2703
BEEcube Inc.	925
Beijing Chenxing Huanyu High-Tech Dev. Co.	3523
Beijing Suntech Technology Development Co.	3511
Besser Associates Inc.	**1603**
Bliley Technologies Inc.	414
Bonding Source	503
Boonton	**1719**
Bowei Integrated Circuits Co. Ltd.	319
BSC Filters Ltd.	1400
C W Swift	**1519**
Cadence Design Systems Inc.	2558
Cambridge University Press	2416
CAP Wireless Inc.	614
CapeSym Inc.	1515
Carlisle Interconnect Technologies	**715**
Cascade Microtech Inc.	1016
Centellax Inc.	2822
Centerline Technologies LLC	2625
Century Seals Inc.	320
Cernex & Cernexwave	**921**
Channel Microwave	1709
Charter Engineering Inc.	**3217**
Chengdu Omicron Microwave Tech. Co. Ltd.	3519
Chengdu Seekon Microwave Comm. Co. Ltd.	**3404**
Chengdu Tiger Microwave Tech.	103
Chin Nan Precision Electronics Co.	2611
Ciao Wireless Inc.	**2606**
Cirexx International Inc.	2723
CMRSummit Technologies	119
Cobham	1411
Coilcraft Inc.	**825**
Coining Inc.	2454
Coleman Cable Systems Inc.	1005
Coleman Microwave Co.	**2442**
Colorado Microcircuits	219
COM DEV Ltd.	2317
Communication Power Corp.	2353
Communications & Power Industries	**2438**
Compex Corp.	720
Component Distributors Inc.	701
Constant Wave	1226
Continental Resources Inc.	2623
Copper Mountain Technologies	**317**
Corning Gilbert Inc.	2405
Corry Micronics Inc	629
Crane Aerospace & Electronics	**2610**
Crane Polyflon	2707
Cree Inc.	**2125**
Crystek Corp.	**2824**
CST of America Inc.	**1615**
CTS Valpey Corp.	**1728**
CTT Inc.	**2414**
Cuming Microwave Corp.	**2428**
Custom Cable Assemblies Inc.	3008
Custom Interconnects	2202
Custom Microwave Components Inc.	3221
Custom MMIC Design Services Inc.	**3210**
Daa-Sheen Technology Co. Ltd.	2825
Daisy RS	**929**
dBm	**2336**
Dearborn Electronics	3505
Defense Tech Briefs	101
Delta Electronics Mfg. Corp.	**1825**
Delta Microwave Inc.	**722**
Design Workshop Technologies Inc.	3222
Diamond Antenna & Microwave Corp.	2345
Dielectric Laboratories Inc.	**1305,1404**
Diemat Inc.	3313
DITF Thin Film	728
DiTom Microwave Inc.	1104
Dong Jin Technology Innovation Co. Ltd.	3503
Dow Key Microwave Corp.	1301
Ducommun LaBarge Technologies Inc.	716
DuPont Electronic Technologies	526
Dyconex AG	2447
Dynawave Inc.	**2431**
Dyne-Tech Co. Ltd.	102
e2v aerospace and defense inc.	304
EADS North America	2724
Eclipse Microwave Inc.	**429**
EE-Evaluation Engineering	2720
eesy-id GmbH	3203
Elbit Systems EW & SIGINT-Elisra	**519**
Elcom Technologies Inc.	427
Elcon Precision LLC	416
Electro Rent Corp.	1924, 1925
ElectroMagneticWorks Inc.	3124
Elliptika	3416
EM Research Inc.	2613
EM Software & Systems – FEKO	2922
EMC Technology/Florida RF Labs	**1704**
EMCO Electronik GmbH	3203
Emerson & Cuming Microwave Products	2308
Emerson Connectivity Solutions	**601**
Empower RF Systems	**2203**
Empowering Systems Inc.	3120
EMSCAN	1128
ENS Microwave LLC	524
Epoxy Technology Inc.	2248
ETL Systems	525
ETS-Lindgren	1023
EuMW2012/Horizon House Publ. Ltd.	**2025**

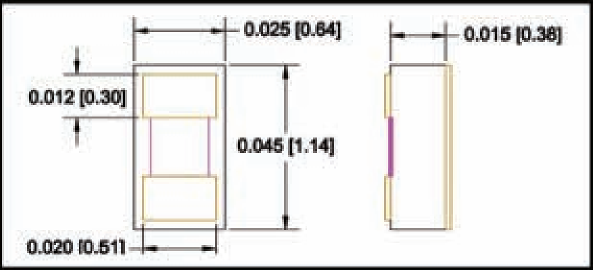
HIGH POWER HIGH FREQUENCY CVD DIAMOND CHIP RESISTORS

The RPC0402DR series of resistors offers excellent power handling capabilities and frequency response to 30GHz. The superior thermal properties of CVD diamond (high conductivity and low expansion) makes these resistors ideal for pulsed power applications. The mechanical and electrical characteristics of these chips provide a robust solution for many aerospace and militaryapplications while its standardized production process keeps the cost competitive for commercial use.


The Brilliance of our Diamonds is in the Engineering

Specifications:

- Resistance: 50 and 100 Ohms, +/-5%
- Frequency: DC – 30 GHz
- Power: 20 Watts
- Capacitance: 0.1 pF Max
- Operating temperature: -55 °C to 150 °C
- CVD diamond substrate
- Solderable or wire bondable terminals



Features:

- High frequency response DC-30GHz
- High power, 20W CW in 0402 size
- 5x power dissipation than equivalent size BeO components
- Ultra small, compact design
- Low capacitance < 0.1 pF
- Total thin film constriction
- Surface mount or flanged (integrated heat sink)
- Excellent pulse power handling
- RoHS compliant
- Hi – Rel version available

Applications:

- Satellite communications
- Phased array radar
- Telemetry
- Test and measurements
- High power amplifiers
- Phase shifters

ELECTRO TECHNIK
EI
RES-NET

RES-NET MICROWAVE, INC.
P.O. Box 1260
Clearwater, FL 33757
Ph: 727.530.9555
Fx: 727.531.8215
www.res-netmicrowave.com

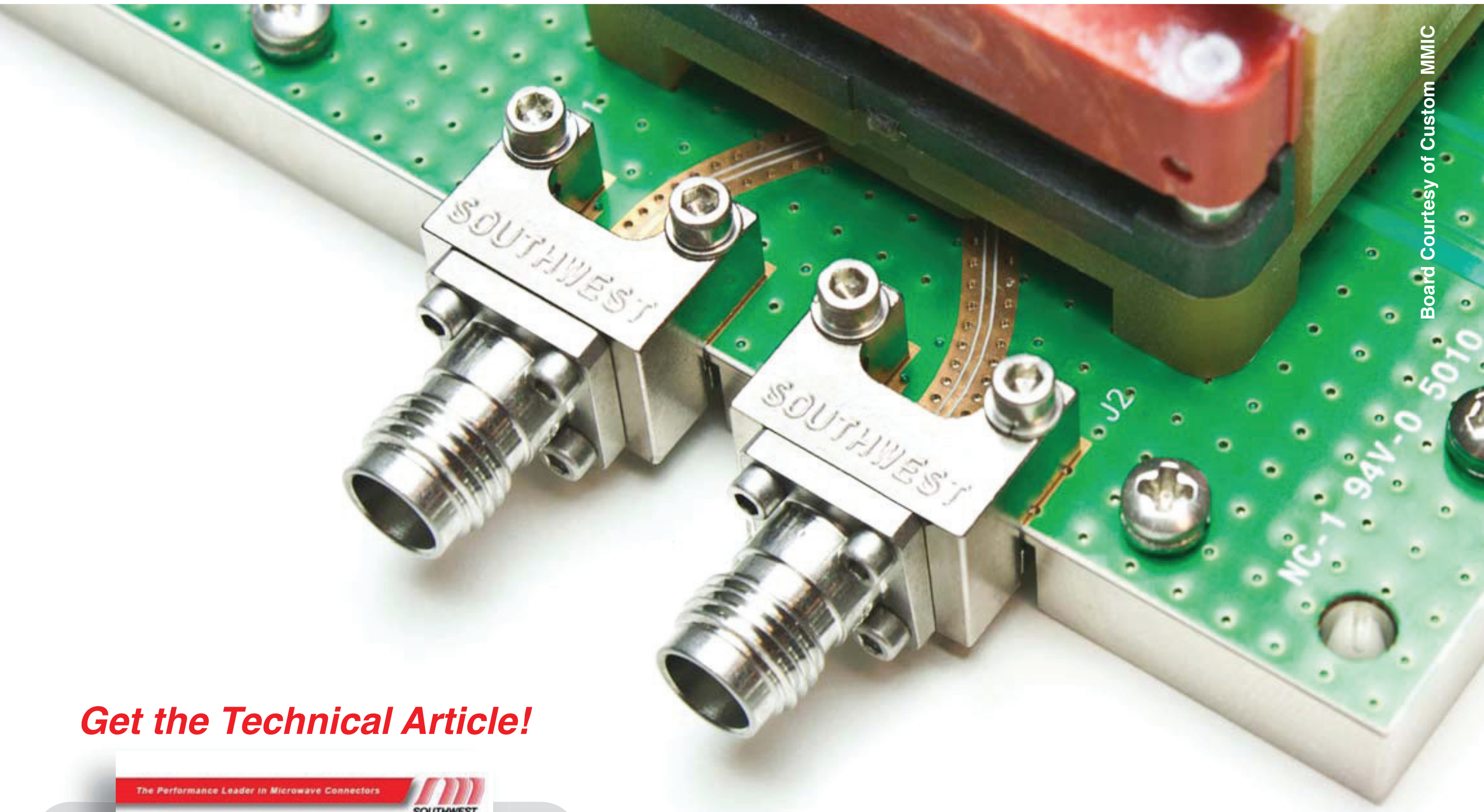
L'éclat de nos diamants réside en notre ingénierie.

Visit us in Montreal at Booth 3323

Excalibur Engineering Inc.	826
EZ Form Cable Corp.	1926
F&K Delvotec Inc.	2028
Farran Technology Ltd.	1807
Ferrite Microwave Technologies	2347
Ferro-Ceramic Grinding	2240
First Level Inc.	3402
Flann Microwave	3104
Flexco Microwave Inc.	2817
Focus Microwaves Inc.	1007
Fotofab	2316
Freescale Semiconductor	**901**
Frontlynk Technologies Inc.	**619**
FTG Corp.	3010
G-Way Microwave/G-Wave Inc.	2215
Gap Wireless Inc.	3417
Geib Refining Corp.	2244
Gerotron Communication GmbH	3203
GGB Industries Inc.	3004
Gigacomp GmbH	3203
GigaLane Co. Ltd.	407
GigOptix Inc.	**2118**
Global Communication Semiconductors LLC	3026
Gova Advanced Material Tech Co. Ltd.	927
Gowanda Electronics	2420
Greenray Industries Inc.	**3206**
Guangdong DAPU Telecom Tech Co. Ltd.	127
GuangShun Electronic Tech. Research Inst.	408
Harbour Industries Inc.	2109
Hefei Research Institute of Cryogenics & Electronics	3509
HEI Inc.	2145
Herley Industries	**1607**
Herotek Inc.	**3105**
Hesse & Knipps Inc.	2147
High Frequency Electronics	1906
Hirose Electric Co. Ltd.	424
Hittite Microwave Corp.	**1701**
Holzworth Instrumentation Inc.	**2926**
Hong Kong Sun Fung Co. Ltd.	3504
HRL Laboratories LLC	203
Huada Intl. Electronics & Tech. Co. Ltd.	3109
Hughes Circuits Inc.	3311
Hunter Technology	425
IBM Corp.	2206
IEEE Microwave Magazine	600
IEEE Xplore Digital Library	2225
IHP GmbH	3213
IKE Micro	**501**
IMST GmbH	**2717**
In-Phase Technologies Inc.	1222
Infineon Technologies	1715
Infinite Graphics	3324
INGUN Pruefmittelbau GmbH	3203
Innertron Inc.	321
Innovative Fabrication	218
Instek America Corp.	2719
Instruments for Industry (IFI)	222
Integra Technologies Inc.	3020
Integrand Software Inc.	3123
Intercept Technology Inc.	625
International Manufacturing Services Inc.	**2310**
Intertronic Solutions Inc.	106
inTEST Thermal Solutions	3108
Ion Beam Milling Inc.	2436
IPDiA	118
IQD Frequency Products Inc.	328
Ironwood Electronics	3312
Isola	2352
ISOTEC Corp.	2827
ITEM Media	89
ITF Co. Ltd.	3202
iTherm Technologies	3307
ITT Exelis Microwave Systems	**1814**
IW Insulated Wire Microwave Products Div.	**509**
JFW Industries Inc.	**2019**
Johanson Manufacturing Corp.	2124
Johanson Technology Inc.	2314
JQL Electronics Inc.	**508**
Jye Bao Co. Ltd.	3018
K&L Microwave Inc.	**1309**
Kaben Wireless Silicon Inc.	3521
KCB Solutions	3513
Keragis Corp.	1003
KEYCOM Corp./Sales Dept.	828
Krytar Inc.	**3016**
KVG Quartz Crystal Technology GmbH	2542
Kyocera America Inc.	820
LadyBug Technologies LLC	3019
Lake Shore Cryotronics Inc.	305
LanJian Electronics	217
Lark Engineering Co.	928
Laser Process Mfg.	2243
Laser Processing Technology Inc.	2718
Laser Services	**215**
LCF Enterprise	522
Leader Tech. Inc.	324
Liberty Test Equipment	1108
Linearizer Technology Inc.	507
Linwave Technology Ltd.	2143
Litron Inc.	2229
Logus Microwave	**3006**
Lorch Microwave	**1709**
LPKF Laser & Electronics	**2409**
M/A-COM Technology Solutions	**815**
M2 Global Technology Ltd.	2907
Marcel Electronics International	2609
Marki Microwave Inc.	204
Massachusetts Bay Technologies	**3309**
Materion	2318
MathWorks	3320
Maury Microwave Corp.	**1215**
McGraw-Hill Professional	307
MECA Electronics Inc.	**2437**
Mega Circuit Inc.	406
MegaPhase	**2721**
Meggitt Safety Systems Inc.	1525
Mercury Computer Systems Inc.	**618**
Mersen	417
Mesuro	1029
Metropole Products Inc.	1001
Micable Inc.	**2429**
Mician GmbH	**2903**
Micreo Ltd.	2338
Micro Communications Inc.	2227
Micro Electronic Tech. Development	3526
Micro Lambda Wireless Inc.	**1700**
Micro Systems Engineering GmbH	2447
Micro-Coax Inc.	**2024**
Micro-Mode	2331
MicroApps	1223
MicroAssembly Technologies	2722
MicroFab Inc.	2241
Microlab	1719
Micronetics Inc.	2424, 2425
Microsemi Corp.	**1424**
Microtech Inc.	**2716**
Microwave Applications Group	1928
Microwave Communications Labs Inc.	2921
Microwave Development Labs Inc.	**723**
Microwave Dynamics	1106
Microwave Engineering Europe	2346
Microwave Journal	**2018**
Microwave Product Digest	616
Microwave Technologies Co. Ltd.	3306
Microwave Technology Inc.	523
Microwavefilters S.R.L	3211
Microwaves & RF/Penton Electronics Group	306
MIG Microwave Innovation Group	3216
Millitech Inc.	**1809**
Mini-Systems Inc.	2920
MITEQ Inc.	**1425**
Mitsubishi Electric & Electronics	801
MnS Industries	88
Modelithics Inc.	1123
Modular Components National Inc.	404
Molex RF/Microwave Business Unit	**515**
Momentive Performance Materials	2449
Morion Inc.	2459
Mosis	2544
MPDevice Co. Ltd.	3209
MtronPTI	2103
Municom Communication GmbH	3203
Murata Electronics	1910
Nanjing Electronic Devices Institute	205
Nanjing Jiexi Technologies Co. Ltd.	2604
NARDA	**2916, 2917**
National Instruments	**1315**
NDK	602
NEL Frequency Controls Inc.	3421
Networks International Corp. (NIC)	**2418**
Noise XT	409
Noisecom	1719
NoiseWave Corp.	**3023**
Norden Millimeter Inc.	**3326**
Northrop Grumman	2111
NSI	1025
Nuhertz Technologies LLC	3418
Nuvotronics	3119
NuWaves Engineering	85
NXP Semiconductors	**607**
OEwaves Inc.	1629
OML Inc.	**1126**
OMMIC	3319
ON Semiconductor	729
OPHIR RF Inc.	**2602**
Orient Microwave Corp.	2137
P/M Industries Inc.	121
P1dB	1801

Southwest Microwave, Inc.

End Launch Connectors NOW up to 67 GHz



Board Courtesy of Custom MMIC

Get the Technical Article!

The Performance Leader in Microwave Connectors

SOUTHWEST MICROWAVE

Optimizing Test Boards for 50 GHz End Launch Connectors
Grounded Coplanar Launches and Through Lines on
30 mil Rogers 4350 with Comparison to Microstrip

Southwest Microwave, Inc.
www.southwestmicrowave.com ■ Tempe, Arizona USA

Optimizing Test Boards for 50 GHz End Launch Connectors

For your ***FREE*** *copy email:*
connectors@southwestmicrowave.com
or visit us at:

IMS MTT-S in Montreal, Canada
June 19-21 Booth # 2910

Connectors Assure Optimal Signal Integrity

End Launch Connectors up to 67 GHz

- **Available in:**
  SMA (27 GHz)
  2.92 mm (40 GHz)
  2.40 mm (50 GHz)
  1.85 mm (67 GHz)
- Multiple launch configurations to optimize match to circuit
- Unique clamping mechanism for a wide range of board thicknesses and maintains proper grounding
- Robust & reusable
- No soldering required
- Launches to single layer microstrip or multilayer with grounded coplanar
- Launch design assistance available
- Connectors ship fully assembled *(board not included)*

The Performance Leader in Microwave Connectors
www.southwestmicrowave.com ■ 480.783.0201 ■ Tempe, AZ

SOUTHWEST MICROWAVE

Montréal Canada

Paciwave Inc.	2114
Palomar Technologies	2238
Paricon Technologies Corp.	2627
Pascall Electronics Ltd.	**3413**
Passive Plus Inc.	829
Peregrine Semiconductor Corp.	2009
PHARAD LLC	2341
Phase Matrix Inc.	**1315**
Photo Sciences Inc.	200
Pickering Interfaces Inc.	418
Piconics Inc.	3116
Pivotone Communication Tech. Inc.	**726**
Planar	317
Planar Monolithics Industries Inc.	**403**
Plansee Thermal Management Solutions	423
Plextek Ltd.	505
Pole/Zero Corp.	1402
Polyfet RF Devices	3102
Ponn Machine Cutting Co.	3405
Power Module Technology	3412
Precision Connector Inc.	**3303**
Precision Manufacturing Group	2603
Presidio Components Inc.	2325
Presto Engineering Inc.	3208
Q Microwave Inc.	3127
Q3 Laboratory	3304
Qingdao Xingyi Electronic Equipment Co.	3520
Quest Microwave Inc.	**1917**
Quik-Pak	2823
QuinStar Technology Inc.	**2209**
QWED Sp. z o.o	3426
R&K Company Ltd.	**2315**
Radant MEMS Inc.	2343
Reactel Inc.	**2210**
RelComm Technologies Inc.	**1627**
Remcom Inc.	**2430**
Remtec Inc.	214
Renaissance Electronics Corp.	**500**
Res-Net Microwave Inc.	**3323**
Research Electronics International REI	226
Resin Systems Corp.	2001
Response Microwave Inc.	401
RF Depot Inc.	**1100**
RF Globalnet	3113
RF Industries	3212
RF Logic	3305
RF Morecom Corea	3118
RF Technology International	2328
RFcore Co. Ltd.	2446
RFHIC Corp.	**2508**
RFMD	**1210**
RFMW Ltd.	1801
RFS Ferrocom Ferrite Division	311
RH Laboratories Inc.	400
Richardson RFPD	**1818**
Riv Inc.	2242
RJR Polymers Inc.	721
RLC Electronics Inc.	**510**
Rogers Corp.	**2902**
Rohde & Schwarz	**2415**
Rosenberger North America LLC	**2015**
RT Logic	124
RUPPTRONIK	3203
S3 Group	3420
Sainty-Tech Communications Ltd	115
Samtec Inc.	1517
San-tron Inc.	**2219**
Sangshin Elecom Co. Ltd.	1801
Sanmina-SCI OMED	3406
Sawnics Inc.	2247
Schmid & Partner Engineering AG	917
Scientific Microwave Corp.	1503
Scintera Inc.	208
SDP Telecom Inc.	2453
Select-Test	2626
Semi Dice Inc.	3224
SemiGen	**301**
Semtech Corp.	221
SGC Technologies Inc.	207
SGMC Microwave	**2536**
Shanghai Eagle Industrial Co. Ltd.	627
Shanghai Huaxiang Computer Comm. Eng.	2445
Shenzhen Huayang Tech. Development Co.	303
Shenzhen Yulongtong Electron	309
Shin-Etsu Chemical Co. Ltd.	3411
Signatone	2443
Silicon Cert Laboratories	3310
Sinclair Manufacturing Co.	2524
SIPAT Co	209
Skyworks Solutions Inc.	**1507**
Smiths Interconnect	**1702**
Sonnet Software Inc.	**2702**
SOURIAU PA&E	3110
Southwest Microwave Inc.	**2910**
Spanawave Corp.	1110
Spectra - Mat Inc.	322
Spectrum Elektrotechnik GmbH	**1917**
Spectrum Microwave Inc.	1306
Spinner Atlanta	**2208**
Sprague Goodman	1030
SRI Connector Gage Co.	518
SRTechnology Corp.	3424
SSI Cable Corp.	**2429**
State Of The Art Inc.	**2325**
Stellar Industries Corp.	2026
StratEdge Corp.	1625
Sumida America Components	316
Sumitomo Electric Device Innovations	**2003**
SV Microwave Inc.	**1724**
Symmetricom	3219
Synergy Microwave Corp.	**1600, 1601**
T-Tech Inc.	1022
Taconic	1501
Tactron Elektronik GmbH	3203
Tahoe RF Semiconductor Inc.	3226
Tai-Saw Technology Co. Ltd.	3427
TDK-Lambda Americas	3308
TE Connectivity	419
Tecdia Inc.	**2806**
Techmaster Electronics Inc.	2141
Tektronix Inc.	2810
Teledyne Coax Switches	**2115**
Teledyne Cougar	2115
Teledyne Defence Ltd.	2115
Teledyne Labtech	2115
Teledyne MEC	2115
Teledyne Microelectronics	2115
Teledyne Microwave	2115
Teledyne Microwave Solutions	**2115**
Teledyne Relays	**2115**
Teledyne Scientific	2115
Teledyne Storm Products	**2115**
Teledyne Technologies Inc.	**2115**
Telegartner Inc.	506
Telemakus LLC	1801
Telonic Berkeley Inc.	229
Temex Ceramics	3505
Teseq Inc.	82
TestEquipment.com Inc.	2618, 2619
TestEquity LLC	201
Testforce Systems Inc.	915
Texas Instruments	3527
Thales Components Corp.	617
THINFILMS Inc.	3517
Times Microwave Systems	**514**
TMD Technologies Ltd.	2605
Toshiba America Electronic Cmpts.	2710
TotalTemp Technologies Inc.	2617
TowerJazz	1024
TRAK Microwave Corp.	**1709**
Transcom Inc.	3318
Transline Technology Inc.	2452
TriQuint Semiconductor	1815
TRM Microwave	3017
TRS-RenTelco	3325
TRU Corp.	**924**
TTE Inc.	300
TTM Technologies Inc.	3502
TYDEX	80
UltraSource Inc.	2802
UMS (United Monolithic Semiconductors)	**1616**
UTE Microwave Inc.	**2321**
Vacuum Engineering & Materials Co. Inc.	2348
Valtronic	120
Vaunix Technology Corp.	**1129**
VECTRAWAVE	3423
Vectria Ltd.	3117
Vectron International	**1300**
Verspecht-Teyssier-Degroote	1127
VidaRF	1521
Viking Tech America Corp.	326
Viper RF Ltd.	3525
Virginia Diodes Inc.	**1228**
Vishay Intertechnology Inc.	2002
Voltronics Corp./Dover	**1410**
VTI Instruments Corp.	915
W. L. Gore & Associates Inc.	**2324**
Weinschel Associates	**2616**
Wenzel Associates Inc.	**3112**
Werlatone Inc.	**2236**
West Bond Inc.	**1901**
WEVERCOMM Co. Ltd.	2239
Wibicom	410
Wiley-IEEE	2253
WIN Semiconductors Corp.	**2816**
WIPL-D D.O.O.	623
Wireless Design & Development	3419
Wireless Telecom Group	**1719**
WiSpry Inc.	727
X-Com Systems	1224
X5 Systems Inc.	622
Xi'an Forstar S&T Co. Ltd.	2029
Xi'an Gold Waves S&T Co. Ltd.	3107
Yantel Corp.	3407
Yokowo Co. Ltd.	117
Yortec Inc.	202
Z-Communications Inc.	**2528**

GREAT SERVICE ISN'T EXPENSIVE...
...IT'S PRICELESS.

EXCELLENCE BY DESIGN

EXCELLENT SERVICE

EXCELLENT DELIVERY

EXCELLENT QUALITY

RF COAXIAL RELAYS

SMA, N AND PCB LAUNCH

STANDARD AND CUSTOM DESIGNS

RELCOMM
TECHNOLOGIES, INC.

- Mission Critical Communications:
  - Security, Safety and Intelligence
  - Commercial Telecom Infrastructure
  - Military Defense Fixed, Mobile & Shipboard
- Instrumentation:
  - Test and Measurement

RF Relay Store.com is the answer to your urgent small quantity needs.
RF Coaxial Relays available from Stock at www.rfrelaystore.com
sales@relcommtech.com • www.relcommtech.com • 410-749-4488
See us at IMS Booth 1627

IMS SHOW FLOOR

IMS PRODUCT SHOWCASE
AISLES 100-500

The following booth numbers are complete as of April 12, 2012.

APA Wireless **Booth 112**
4200 to 4600 MHz of Bandwidth

Running 128QAM and starving for bits? You need the phase noise that only APA's Physics Based Technology can provide. Fundamental mode operation, 400 MHz of continuous bandwidth, best-in-class phase noise within the 4 to 5 GHz band and linear tuning that won't wreck your loop dynamics. Fully characterized over the industrial temperature range, phase hit free and 100 percent factory tested ensures every bit you send is "in the clear."

www.apawireless.com

Laser Services **Booth 215**
Circuit and Material Laser Cutting

Stop by booth #215 to learn about Laser Services and its one-stop job shop that includes laser cutting of your EMI and bonding materials and solder damming in circuits using laser ablation. The company also has an extensive inventory of ceramic substrate, frozen epoxies, and adhesives that can be custom cut or drilled for just-in-time delivery.

VENDORVIEW
www.laserservicesusa.com

SemiGen **Booth 301**
RF Assembly Services and Supply Center

Anoison Electronics **Booth 310**
Coaxial Terminations

Anoison Electronics announces that it has expanded its product offering to include a full line of RF coaxial terminations. In addition to standard SMAs, 7/16, QMAs, SMPs, and Ns in both male and female configurations, it also offers high performance QNs (HPQN), high performance TNCs (TNCA), and 2.92s (SMK). Male SMAs and Ns are also available as Push-Ons.

www.anoison.com

Copper Mountain Technologies **Booth 317**
Virtual Vector Reflectometer

Copper Mountain Technologies introduces a new class of vector network analyzer, the virtual vector reflectometer PLANAR R54, operating in frequencies from 85 MHz to 5.4 GHz. Portable and lightweight, R54 is powered and operated via a single USB interface by external PC. Comparable to industry leaders, but at a fraction of the cost, R54 is ideal for use on DUTs in the field accurately and without the use of testing cables.

VENDORVIEW
www.coppermountaintech.com

Planar Monolithics Industries **Booth 403**
Log Video Amplifier

Renaissance Electronics **Booth 500**
Ultra High Power Circulator

Renaissance's latest ultra high power circulator is designed for VHF, cellular and military communication applications and is robust enough to handle harsh environments. Learn more about it here: www.rec-usa.com/Data%20Sheets/ultrahighpowercircusm.pdf.

VENDORVIEW
www.rec-usa.com, www.hxi.com.

IKE Micro **Booth 501**
Build to Print Manufacturing

For over 30 years, IKE Micro has been providing precision build to print manufacturing of RF/microwave packages and modules. Latest model automated die attach, wire/ribbon wedge bonding, ball bonding, and top notch manual assemblers insure repeatable results. IKE targets mid to large sized production runs, serving the defense and commercial markets. ISO Certified and ITAR Registered.

www.ikemicro.com

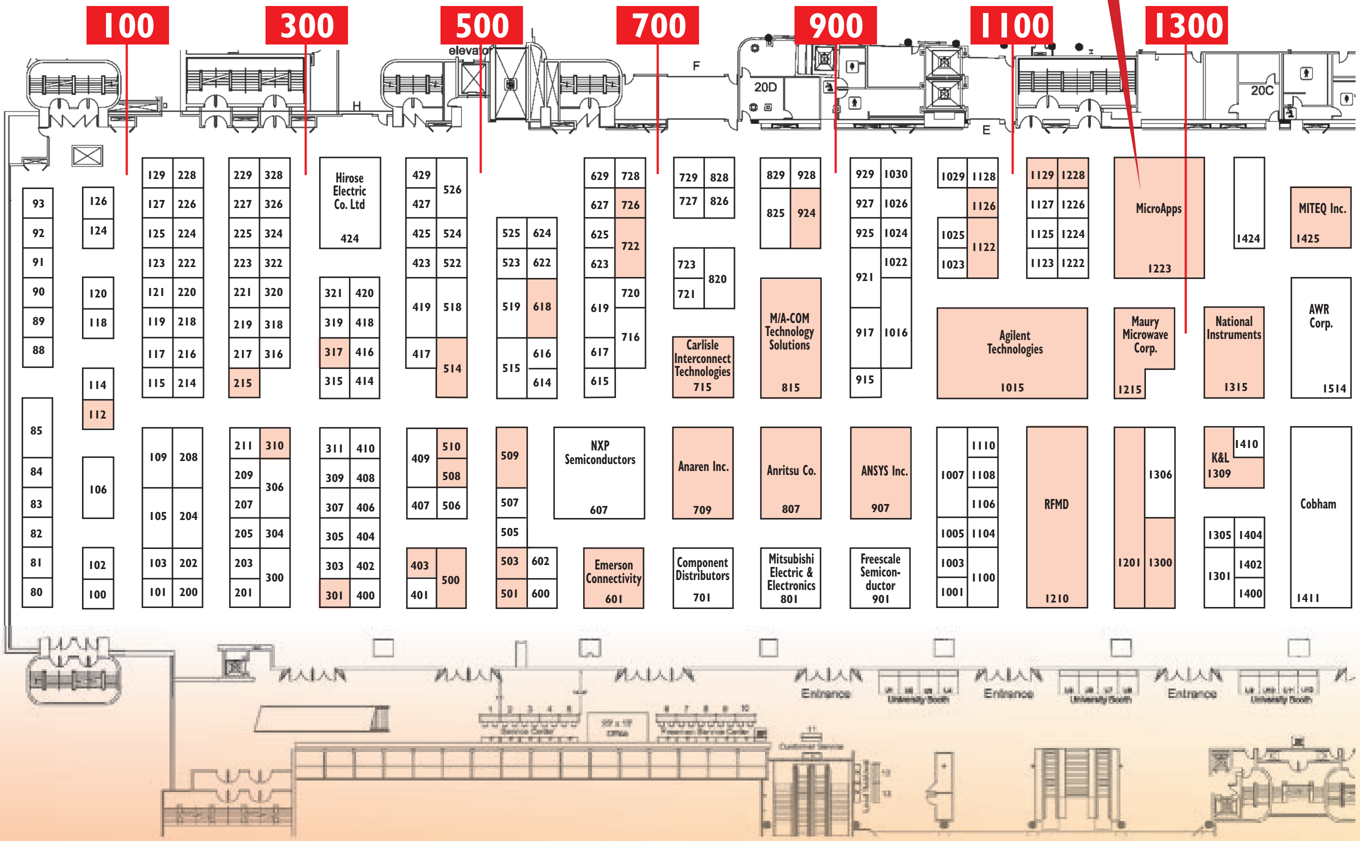
Bonding Source **Booth 503**
Epoxy Pre-Forms

Bonding Source offers quick delivery epoxy pre-forms to its defense and cial cus- nd has

Your Product Guide to the Show Floor

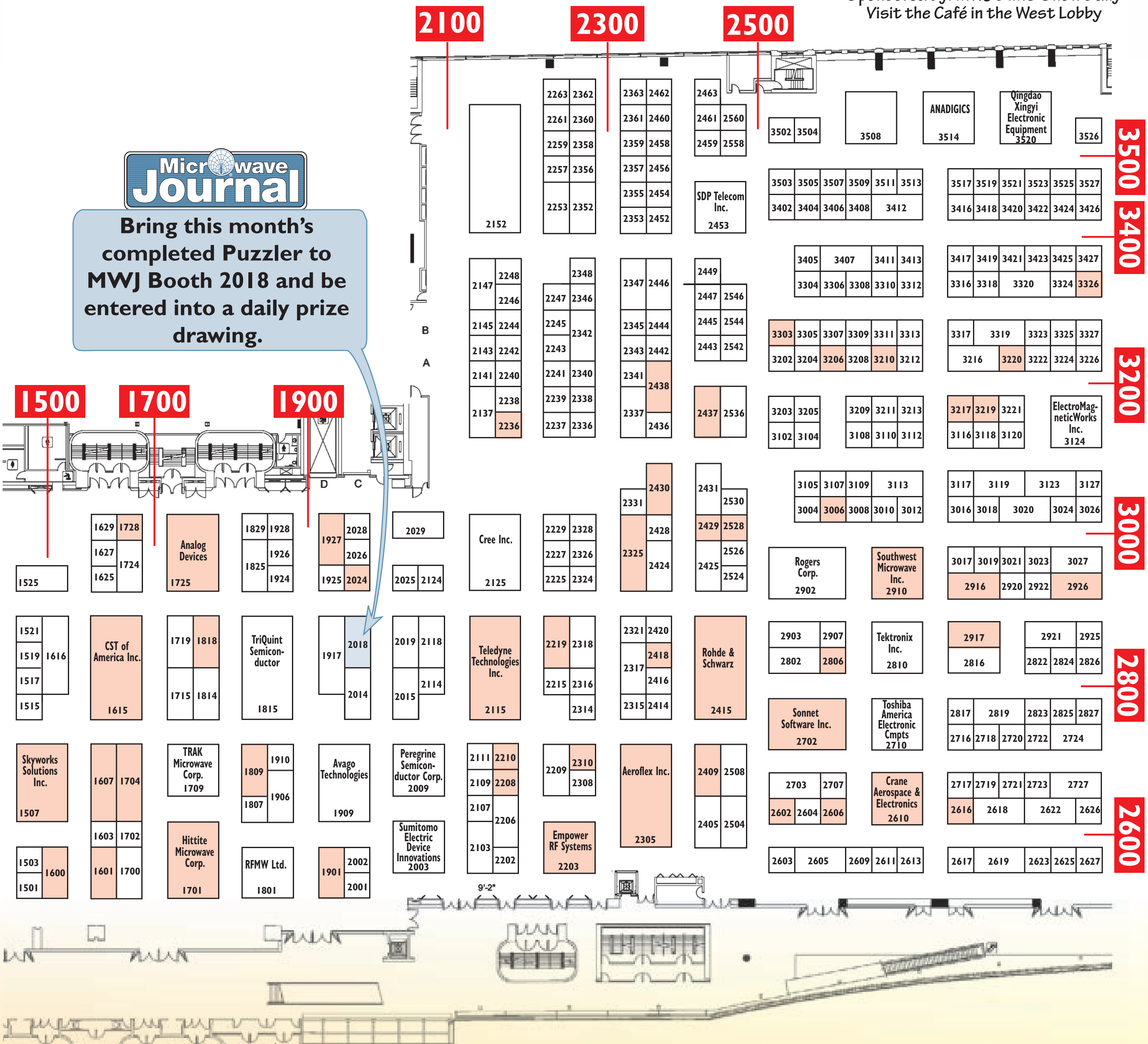
Shaded exhibitors have a product featured in the IMS Product Showcase pages to follow. Look for these products at this year's IMS 2012.

MicroApps Expert Forum
Device Characterization and Design
Wed. at 12:00 PM, June 20th



Sponsored by: MWJ's IMS Show Daily
Visit the Café in the West Lobby

Bring this month's completed Puzzler to MWJ Booth 2018 and be entered into a daily prize drawing.



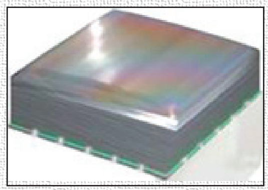
The booth numbers are complete as of April 12, 2012.

IMS PRODUCT SHOWCASE
AISLES 100–500

The following booth numbers are complete as of April 12, 2012.

APA Wireless Booth 112

4200 to 4600 MHz of Bandwidth

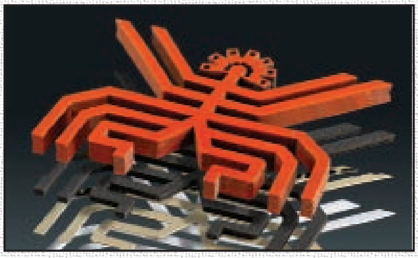


Running 128QAM and starving for bits? You need the phase noise that only APA's Physics Based Technology can provide. Fundamental mode operation, 400 MHz of continuous bandwidth, best-in-class phase noise within the 4 to 5 GHz band and linear tuning that won't wreck your loop dynamics. Fully characterized over the industrial temperature range, phase hit free and 100 percent factory tested ensures every bit you send is "in the clear."

www.apawireless.com

Laser Services Booth 215

Circuit and Material Laser Cutting

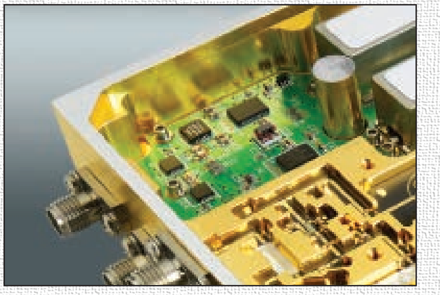


Stop by booth #215 to learn about Laser Services and its one-stop job shop that includes laser cutting of your EMI and bonding materials and solder damming in circuits using laser ablation. The company also has an extensive inventory of ceramic substrate, frozen epoxies, and adhesives that can be custom cut or drilled for just-in-time delivery.

VENDORVIEW
www.laserservicesusa.com

SemiGen Booth 301

RF Assembly Services and Supply Center



Stop by booth #301 to learn about SemiGen and its RF/microwave hybrid assembly and testing, automated PCB manufacturing capabilities and semiconductor diodes and capacitor products. The company recently opened an eCommerce RF Supply Center, which is fully stocked with some of the most popular bonding supplies, adhesives and epoxies ready for just-in-time delivery.

www.semigen.net

Anoison Electronics Booth 310

Coaxial Terminations

Anoison Electronics announces that it has expanded its product offering to include a full line of RF coaxial terminations. In addition to standard SMAs, 7/16, QMAs, SMPs, and Ns in both male and female configurations, it also offers high performance QNs (HPQN), high performance TNCs (TNCA), and 2.92s (SMK). Male SMAs and Ns are also available as Push-Ons.

www.anoison.com

Copper Mountain Technologies Booth 317

Virtual Vector Reflectometer

Copper Mountain Technologies introduces a new class of vector network analyzer, the virtual vector reflectometer PLANAR R54, operating in frequencies from 85 MHz to 5.4 GHz. Portable and lightweight, R54 is powered and operated via a single USB interface by external PC. Comparable to industry leaders, but at a fraction of the cost, R54 is ideal for use on DUTs in the field accurately and without the use of testing cables.

VENDORVIEW
www.coppermountaintech.com

Planar Monolithics Industries Booth 403

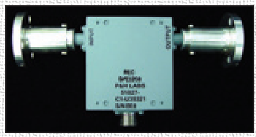
Log Video Amplifier

PMI model SDLVA-8G18G-40-5-SFF is an 8 to 18 GHz successive detection log video amplifier that is supplied in a ruggedized, hermetically sealed housing that measures only 1.2" L × 0.85" W × 0.4" H. This model operates on a single +5 V DC supply and consumes less than 130 mA of current. It is highly temperature compensated such that the log linearity is better than ±1 dB over the temperature range of -54° to +85°C. This model has a logging range of -40 dBm to 0 dBm with an output log video voltage of 10 mV to 2.25 V. This model features a fast rise/fall time of 25 ns/30 ns and a recovery time of less than 40 ns.

VENDORVIEW
www.pmi-rf.com

Renaissance Electronics Booth 500

Ultra High Power Circulator

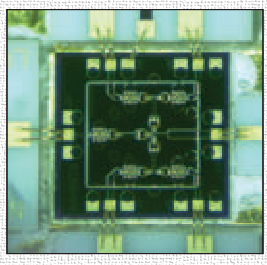


Renaissance's latest ultra high power circulator is designed for VHF, cellular and military communication applications and is robust enough to handle harsh environments. Learn more about it here: www.rec-usa.com/Data%20Sheets/ultrahighpowercircusm.pdf.

VENDORVIEW
www.rec-usa.com, www.hxi.com.

IKE Micro Booth 501

Build to Print Manufacturing



For over 30 years, IKE Micro has been providing precision build to print manufacturing of RF/microwave packages and modules. Latest model automated die attach, wire/ribbon wedge bonding, ball bonding, and top notch manual assemblers insure repeatable results. IKE targets mid to large sized production runs, serving the defense and commercial markets. ISO Certified and ITAR Registered.

www.ikemicro.com

Bonding Source Booth 503

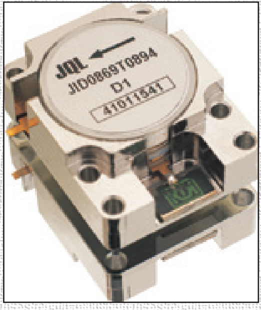
Epoxy Pre-Forms

Bonding Source offers quick delivery epoxy pre-forms to its defense and commercial customers and has complete storage and handling control with its in-house laser cutting capability. Bonding Source also stocks epoxy pastes and film, bonding wire and tools and accessories. Bonding Source has served over 500 customers worldwide.

www.bondingsource.com

JQL Electronics Booth 508

Circulator and Isolator



JQL Electronics Inc. introduced a new series of drop-in circulator and isolator with ultra low intermodulation performance at -90 dBc max, designed for LTE. The new model series of drop-in circulator and isolator covers all 25 LTE bands with typical insertion loss of 0.18 dB, isolation and return loss of 23 dB.

www.jqlelectronics.com

NOW!

ULTRA•REL®

CERAMIC MIXERS

300 MHz to 12 GHz

from only **$5.95** ea. qty. 10

- **Hermetically Sealed,** *100% Tested*
- Rugged LTCC Construction
- Easy Visual Solder Inspection, *gold-plated terminals*
- Low Profile, *only 0.06"/1.5 mm thick*
- Highly Repeatable Performance
- Flat Conversion Loss & High Isolation across the whole band
- Outstanding Thermal Stability, *-55 to +125°C*

Mini-Circuits new MAC mixer family combines rugged ceramic construction with monolithic quad semiconductor technology to produce the most reliable mixers available in the marketplace today—the only mixers anywhere backed by a ***3-year guarantee!*** Top to bottom, inside and out, they're designed and built for long-term reliability under hostile conditions such as high moisture, vibration, acceleration, and thermal shock from -55 to +125°C.

Excellent electrical performance across the entire frequency range makes them ideal not only for aerospace and military ground applications, but anywhere long-term reliability adds bottom-line value: instrumentation, heavy industry, high-speed production, and unmanned facilities, to name just a few. So why wait? Go to minicircuits.com for performance data, technical specifications, and ***remarkably low prices***, and see what MAC mixers can do for your applications today!

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

Mini-Circuits®
ISO 9001 ISO 14001 AS 9100
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

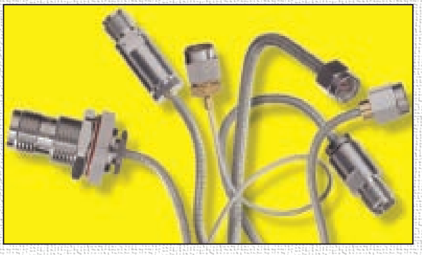
YONI2® ***The Design Engineers Search Engine*** *finds the model you need, Instantly* • For detailed performance specs & shopping online see **minicircuits.com**
U.S. Patents
7739260, 7761442

IF/RF MICROWAVE COMPONENTS

IMS PRODUCT SHOWCASE
AISLES 500–700

IW Microwave Booth 509

Cables and Assemblies



IW's Re-Flex™ cables have been tested to more than 24,000 bends with no electrical or mechanical degradation. These cables were designed to offer an alternative to standard semi-rigid and conformable cables. They have the same leakage characteristics and mechanical dimensions as standard semi-rigid cable. Stock assemblies use SMA plugs. Other connector styles are available. Standard cable diameters are RF .047", .085", .141" and .250". An FEP jacket is also provided upon request.

www.iw-microwave.com

RLC Electronics Booth 510

Waveguide Switches

RLC Electronics' electromechanical waveguide switches offer a compact design utilizing a proprietary non-contacting actuator mechanism that requires low current. These units are available in SPDT and transfer configurations, manual or remote, with a choice of coil voltages and optional indicator contacts. Solid state de-energizing circuiting insures high reliability and is available with common positive, common negative and TTL control options. A precision machined waveguide transition assembly is combined with coaxial switch technology to produce a device that features the low current and fast switching time of a coaxial switch with waveguide inputs and outputs.

www.rlcelectronics.com

Times Microwave Booth 514

Coaxial Cables

PhaseTrack® coaxial cables are now available in standard flexible, low smoke flexible, in-the-box flex and semi-rigid versions. Exhibiting superior phase performance with temperature changes, they eliminate the common "phase knee" found in PTFE-based cables. Systems requiring phase stable or phase tracking interconnects will benefit from the performance offered by the Times PhaseTrack products, which offer superior absolute phase performance, with tracking better than 50 ppm, and low insertion loss and VSWR characteristics.

www.timesmicro.com

Emerson Connectivity Solutions Booth 601

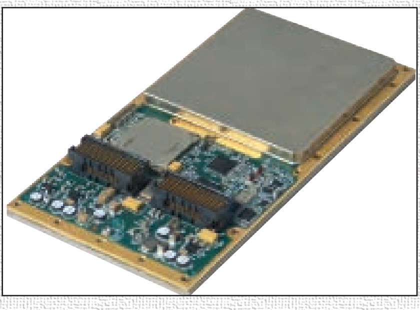
QPL Attenuators

Emerson Connectivity Solutions' Midwest Microwave product line of Qualified Parts List (QPL) attenuators are qualified, manufactured and tested to the strict requirements of the MIL-DTL-M3933 product specification. The company's QPL line of M3933/14, /16, /17 and /25 SMA and TNC attenuators are ruggedly constructed to meet performance needs in the harshest of military environments. To service your delivery needs, Emerson strives to make most dB values available in short lead times or even off the shelf, for the most common values.

www.emersonconnectivity.com

Mercury Computer Systems Booth 618

Echotek Series Tuner



The Echotek Series RFM-251-XMC tuner from Mercury is engineered for applications that require RF tuning and data conversion flexibility within a compact slot-saving package. Tuning over a broad frequency range and then converting to digital IF, this XMC delivers the functionality required for applications that must operate under SWaP-constrained platforms. The RFM-251-XMC tuner supports a broad frequency range from 20 to 2500 MHz. This coverage is ideal for intercepting frequencies associated with a wide range of communication bands.

www.mc.com

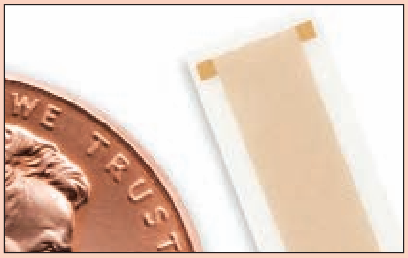
Let this month's Product Showcase help you fill-in the Scavenger Hunt questions on page 282.

Anaren Booth 709

Surface-Mount Delay Lines

Anaren's new surface-mount delay lines use a slow wave coupling structure that maximizes the amount of delay per unit area over other distributed delay structures. These delay lines can be used in amplifier linearization applications or in the main loop of feed forward and pre-distortion amplifiers. They are low cost, high quality alternatives to the traditional coaxial and filter solutions presently available. Moreover, parts have been subjected to rigorous qualification testing and units are 100 percent tested. Available in RoHS-compliant finishes.

APECS Ceramic Solution



Anaren Precision Etched Ceramic Substrates (APECS) from Anaren Ceramics Inc. can be combined with standard thick film technology to create a highly integrated, more cost-effective solution while improving overall substrate yield. The process also allows for integrate components, as APECS substrates accept embedded precision resistors, Lange couplers and capacitors into the substrate itself, rather than applying discrete components using the more labor-intensive, less-consistent traditional component-mounting approach.

www.anaren.com

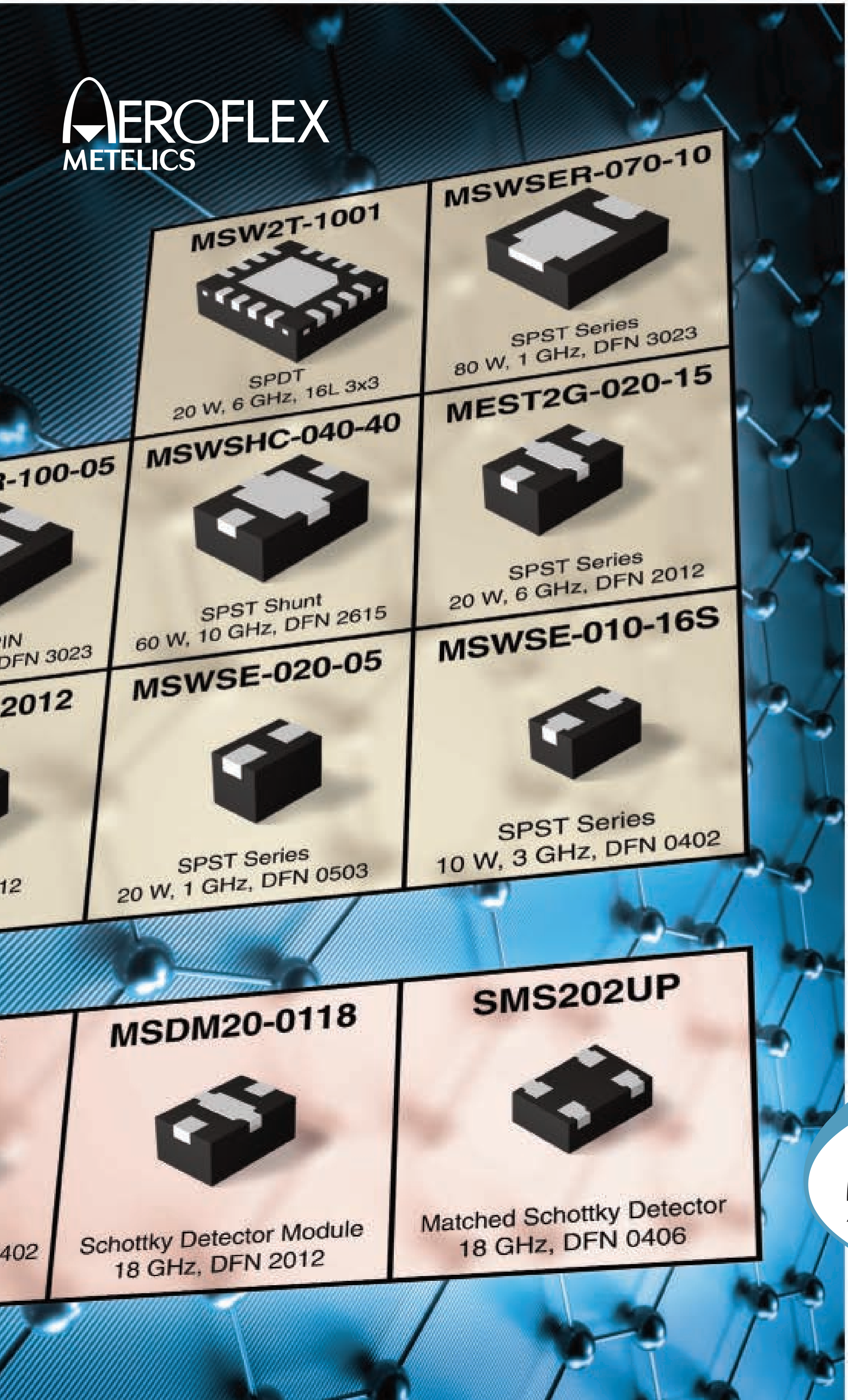
Carlisle Interconnect Technologies Booth 715

Push-On Connector Lines

CarlisleIT has added two new connector lines to its push-on family – the TMP® and WMP® series. The TMP family was designed to provide higher power handling capacity for Radar applications, while the WMP line provides the smallest form factor for space restricted applications. Both connector series provide the benefits of a push-on interface – i.e., simple connection and ease of use in dense package configurations – and include PCB mount, field replaceable, microwave cable, and custom connectors.

www.carlisleit.com

Engineer the ideal switch from a brand new table of elements



Aeroflex / Metelics has created a suite of versatile control elements designed to move your next switch to another level of efficiency. The core component of the group is an integrated SPDT switch in a 3x3 mm QFN package. MSW2T-1001 gives you 0.3 dB of insertion loss and 24 dB of isolation up to 6 GHz. Five other SPST components offer a broad range of high power, low inductance, low capacitance choices that also deliver through 6 GHz, while 2 complimentary Schottky's give you detection solutions you can push to 18 GHz. They're all efficiently priced for high volume commercial applications.

Make the switch with Aeroflex / Metelics.

408-328-3321

www.aeroflex.com/metelics

See us at IMS Booth 2305

AEROFLEX
A passion for performance.

IMS PRODUCT SHOWCASE
AISLES 700-1000

Delta Microwave Booth 722

TCDL Diplexer

The model Ku5939 Ku-Band TCDL Diplexer has passbands from 14.4 to 14.83 GHz and 15.15 to 15.35 GHz with less than 1.6 dB insertion loss in each of the channels in a compact 3.8" × 2.75" × 0.5" package. The unit shown has SMP Male connectors but is also available with SMA Female connectors under model number Ku5937. The maximum VSWR is 1.5:1 and the minimum channel-to-channel isolation is 110 dB. Either channel can handle +40 dBm at 40,000 feet.

www.deltamicrowave.com

Pivotone Communication Technologies Booth 726

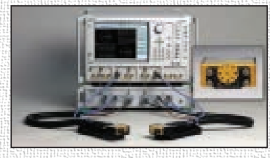
Passive Components

Pivotone designs and manufactures RF and microwave passive components up to 50 GHz in frequency. The company operates from an ISO9001:2008 facility in an ISO14000 business park in Wuxi, China – about 100 km from Shanghai center. A full range of products is offered including: filters, diplexers, combiners, hot standby couplers, loads, dielectric resonator filters, TMA for cellular applications and adapters, with passive and active involved (LNA monitoring communication card, etc. for the RF devices and modules).

www.pivotone.com

Anritsu Co. Booth 807

Network Analysis System



Anritsu Co. will be showcasing its new VectorStar® Waveguide-Band Vector Network Analysis System. This follows-on from the highly successful coaxial 70 kHz to 125 GHz Broadband Vector Analysis System. Available for E, and W-Band, it uses the same industry-leading nonlinear transmission line technology contained in the broadband system providing the same advantages of compact size, performance and stability. A wide range of applications is covered, including E-Band communications, automotive radar, imaging radars, on-wafer semiconductor measurements and materials research.

VENDORVIEW

www.anritsu.com

M/A-COM Technology Solutions Booth 815

Smartset Chipset

M/A-COM Technology Solutions will showcase its broad portfolio of products across 38 product lines. New product releases include M/A-COM Tech's 42 GHz Smartset Chipset for point-to-point wireless backhaul and GaN Smart Pallets for aerospace and defense radar applications. Also featured are a new set of standard catalog products including LNA, VGA, GPA and power detectors in ultra small packages for multimarket applications.

www.macomtech.com

ANSYS Inc. Booth 907

Design Software

ANSYS will demonstrate new features in HFSS™, the industry standard software for RF and microwave design. Learn how HFSS can solve your largest electromagnetic field simulations using advanced simulation techniques including domain decomposition, hybrid finite element/boundary integral, physical optics and high-performance computing. See the new HFSS ECAD option that allows you to operate HFSS from the ANSYS DesignerRF layout or from within the Cadence® software tools. These new advanced features deliver a comprehensive Simulation Driven Product Development environment.

www.ansys.com

TRU Corp. Booth 924

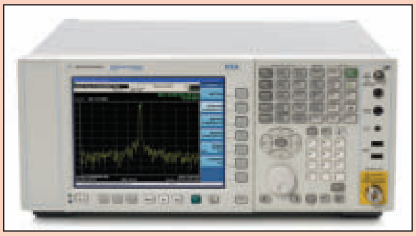
Cable Assemblies

TRU Corp. introduces a new standard in high performance, enhanced durability cable assemblies. TRU-core™ 300 offers superior resistance to crushing, kinking and twisting of the cable without the need for any additional external armoring. This saves weight and cost while enhancing flexibility. The unique expanded PTFE core of the cable provides excellent phase and thermal stability. The assemblies are available with stainless steel SMA, Type N and ATNC interfaces for broadband DC to18 GHz performance.

www.trucorporation.com

Agilent Technologies Booth 1015

Signal Analyzers

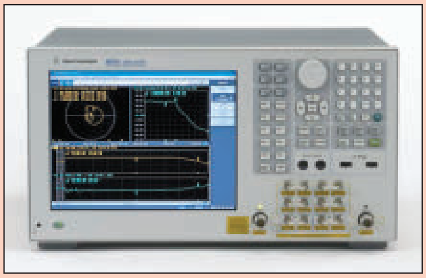


The Agilent EXA X-Series now has extended frequency coverage to 44 GHz – and up to 325 GHz with external mixing – making it the most cost-effective millimeter-wave signal analyzers on the market. Their exceptional sensitivity, < -140 dBm/Hz across the V-Band with smart harmonic mixers, enables accurate measurement of spurs and harmonics. Along with their excellent phase noise of -106 dBc/Hz typical (10 kHz offset at 1 GHz), EXA Series analyzers can meet the tighter regulations and test requirements for millimeter-wave device design and performance in aerospace and defense and wireless communications. The model N9010A-E32 provides frequency coverage up to 32 GHz and the model N9010A-E44 up to 44 GHz.

Handheld RF Analyzers

Agilent enhances the FieldFox handheld RF analyzer family by adding two new options, time domain analysis (Option 010) and a built-in channel power meter (Option 311). The built-in power measurement capability provides a simple and cost effective approach to power measurements without the need for a USB power sensor. Using time domain and gating, you can test devices such as transmission lines, fixtures and connectors to characterize device discontinuities and identify impedance variations. Both options can be added to new units or existing customers can purchase as a software upgrade.

PIM Test Solution



Agilent Technologies introduces a new test solution for passive intermodulation (PIM) of passive components for wireless communication industries. The innovative solution with the E5072A ENA series network analyzer combines both PIM and S-parameter tests with a single connection of devices under test to achieve measurement capabilities that are flexible, fast and accurate. With high receiver sensitivity of the E5072A, the solution offers measurements of extremely low PIM products, with levels of -170 dBc or better.

www.agilent.com

VENDORVIEW

You work in all kinds of conditions, so should your spectrum analyzer.

Scan the QR code or visit http://goo.gl/Rfbde to see a HSA N9344C demo guide video

Worst-case scenario: You've got minutes to troubleshoot RF interference that has shut down communications on the ground, at dusk, in the desert.

Best-case scenario: You've got the only spectrum analyzer with benchtop performance in a lightweight MIL-PRF 28800F Class 2 compliant handheld—with secure erase to keep classified data classified.

That's thinking ahead. That's Agilent.

Handheld Spectrum Analyzers (HSA)

Key Specs	N9344C	N9343C	N9342C
Frequency	1 MHz–20 GHz	1 MHz–13.6 GHz	100 kHz–7 GHz
DANL	-155 dBm/Hz	-155 dBm/Hz	-164 dBm/Hz
Sweep time	< 0.9 s	< 0.7 s	< 0.4 s
Weight with battery	3.6 kg (7.9 lbs)	3.6 kg (7.9 lbs)	3.6 kg (7.9 lbs)

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

metrictest
866-436-0887
www.metrictest.com/agilent

View online HSA video demos
Download demonstration guides
www.metrictest.com/agilent/specan.jsp

© 2011 Agilent Technologies, Inc. *(U.S. Army photo by Spc. Patrick Tharpe) (Released)*

See us at IMS Booth 1015

Agilent Technologies

IMS PRODUCT SHOWCASE
AISLES 1100-1300

Auriga Microwave Booth 1122

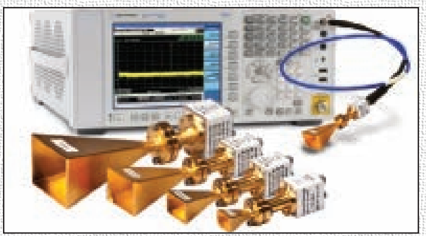
Component Test System

Auriga's turn-key, fully-automated, component test system radically changes the dynamics of complex, RF measurements. CTS-3, the company's third generation custom test system, is a fully-automated, component test system that provides a single-connection, multiple measurement architecture used in both low-volume and high-volume manufacturing of high-frequency commercial and military modules and MMIC devices, such as transmit and receive modules (T/R), LMDS and MMDS, CPE, and base station testing.

www.aurigamicrowave.com

OML Inc. Booth 1126

Harmonic Mixers



OML offers harmonic mixers and standard gain horn antennas for testing compliance according to FCC Part 15 regulations on transmitters operating in the 10 to 100 GHz spectrum. Per FCC 15.33, four waveguide bands (WR-19, WR-12, WR-08 and WR-05) enable measurements of the highest fundamental up to the fifth harmonic (or to 200 GHz). Standard gain horn antennas (+24 dBi) also satisfy ANSI C63.4, C63.5 and C63.10. This solution is compatible with most high performance spectrum analyzers offering optional external mixer capabilities (e.g., Agilent PXA).

www.omlinc.com

Vaunix Booth 1129

Lab Brick Test Equipment

Stop by booth 1129 to check out Vaunix's Lab Brick family of low cost USB powered digital attenuators, LSG and LMS Signal Generators, and their latest LSW Series Switch that offers reliable, high isolation and low cost solid state switching in both SPDT and SP4T configurations. Solutions up to 20 GHz are detailed at www.vaunix.com.

VENDORVIEW

www.vaunix.com

AR RF/Microwave Instrumentation Booth 1201

Dual-Band Amplifiers

With AR's dual-band amplifiers, you have freedom like never before. You pick the power from 5 to 80 W. You pick the bandwidth from 0.7 to 8 GHz, 0.7 to 10.6 GHz or 0.7 to 18 GHz. AR puts it together for you in one package that costs less, weighs less and takes less space than two separate amplifiers.

VENDORVIEW

www.arworld.us

RFMD Booth 1210

Single FEM

The RFMD RFFM4501 provides a complete integrated solution in a single FEM for WiFi 802.11a/n/ac systems. Its small footprint and integrated matching minimizes the layout area in the customer's application and reduces the number of external components. This translates to reduced BOM, footprint and manufacturing costs. The RFFM4501 integrates a PA, SPDT, LNA with bypass, and a power detector coupler for improved accuracy. It meets or exceeds the RF Front End needs of IEEE 802.11a/n/ac WiFi RF systems.

VENDORVIEW

www.rfmd.com

Virginia Diodes Inc. Booth 1228

VNA Extension Modules

VDI's VNA extension modules provide high performance frequency extension of VNAs into the THz range. Models are currently available that cover 50 GHz to 1.1 THz and combine high test-port power with superb dynamic range to offer unparalleled performance. For instance, at WR1.5 (500 to 750 GHz) typical dynamic range is 100 dB with -25 dBm test port power. The modules are compatible with all modern network analyzers. Contact VDI to discuss configurations that will yield the best performance for your application.

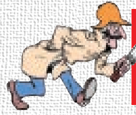
www.vadiodes.com

Vectron Booth 1300

Ultra Low Noise OCXO

The 10 MHz OX-204 is an ultra low noise OCXO achieving phase noise performance of -135 dBc/Hz at 10 Hz offset and -175 dBc/Hz at 100 KHz offset. The OX-204 has exceptional ADEV at 0.5 e-12 at 1 sec tau and low long term stability of 100 ppb/year. The temperature stability is impressive at ±20 ppb over the temperature range of -40° to +85°C. This is all achievable in a compact 25 × 25 mm enclosure.

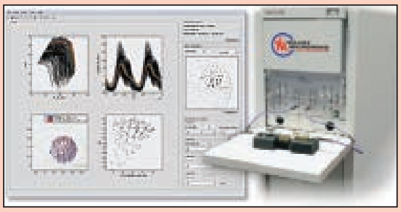
www.vectron.com



Let this month's Product Showcase help you fill-in the Scavenger Hunt questions on page 282.

Maury Microwave Booth 1215

Measurement and Modeling Solutions



Maury Microwave will be demonstrating state-of-the-art measurement and modeling solutions including: a patent-pending noise parameter system, a pulsed IV/S-Parameter and compact modeling system, a hybrid-active harmonic loadpull solution based on the PNA-X, and a patented mixed-signal active loadpull system capable of up to 1000 impedance/power measurements per minute and 120 MHz of instantaneous impedance control. Maury's component division will showcase its new Stability line of amplitude- and phase-stable cable assemblies as well as calibration kits, metrology and instrument-grade adapters and test essentials.

Ruggedized Cable Assemblies

Maury Microwave's Stability™ series sets the standard for high-performance ruggedized cable assemblies. Designed specifically for phase-stable and amplitude-stable applications, Stability offers excellent measurement repeatability even after cable flexure. With a ruggedized, durable construction, Stability will outlast and outperform other assemblies resulting in a reduced total cost-of-test. Stability's light weight, superior flexibility and small form factor make it ideal for daily use with VNAs, test instruments, bench-top testing and ATE systems.

www.maurymw.com

SPACEK LABS INC.
MILLIMETER-WAVE TECHNOLOGY

Systems and Components
from 10 to 110 GHz

Exceeding the Highest
Industry Standards for
Performance & Quality

Serving the
Millimeter-Wave Industry
for Over 30 Years.

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

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

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

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

IMS PRODUCT SHOWCASE
AISLES 1300-1600

K&L Microwave Booth 1309

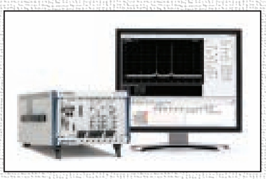
Narrowband Cavity Filter

From K&L Microwave's new CS series, this 3-section narrowband cavity filter has a center frequency of 1217.2 MHz with an equiripple bandwidth of 2.3 MHz minimum, yielding an insertion loss of 3 dB maximum. The out-of-band attenuation for this 3-pole filter is 52 dB minimum from DC to 1200 MHz and 46 dB minimum at 1230 MHz. VSWR is less than 1.5:1 over the passband. The size of this part is 5.7" × 5.3" × 3." SMA female connectors are shown, with other standard connector types available. The CS series of filters is excellent for narrowband applications where low insertion loss is required in the mid-band areas. Typical lead time is 5 to 6 weeks ARO.

www.klmicrowave.com

National Instruments Booth 1315

Vector Signal Analyzer

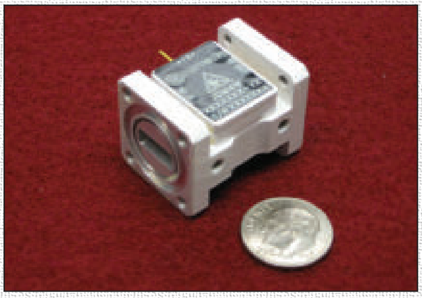


Engineers are looking for a faster, smaller, more cost-effective solution than classic rack-and-stack options. Compare the speed and performance of NI PXI products to traditional boxed instruments. Experience the power of the NI PXIe-5665, 14 GHz RF vector signal analyzer in this video: www.ni.com/lp/comparepxi/?metc=mtjuaw.

www.ni.com

MITEQ Booth 1425

Low Noise Amplifier



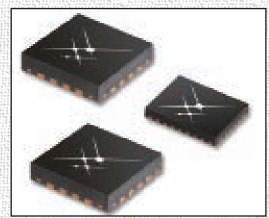
The JDMW series of low noise amplifiers can cover the full 18 to 21 GHz Satellite Communications band. This series of LNAs are lightweight (less than 23 grams) and are hermetic making them an easy choice for extreme environments. The small size (1.18" × 0.87" square) and low power dissipation of less than a watt (12 V DC at 75 mA) make for versatile mounting locations in any application. This unit has a noise temperature of 97 K (1.25 dB NF) and 30 dB of gain at +25°C. The full operating temperature range is -30° to +65°C with a power output (at 1 dB) of +8 dBm. Optional RF input limiters, DC power connections and waveguide flanges are also available.

VENDORVIEW

www.miteq.com

Skyworks Solutions Inc. Booth 1507

SPDT Switches



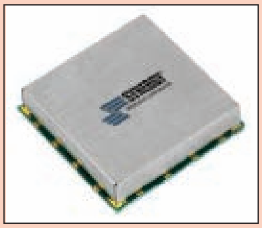
The 50 W SKY12207-478LF (0.9 to 4 GHz) and SKY12208-306LF (0.02 to 2.7 GHz), and the 100 W SKY12210-478LF (0.9 to 4 GHz) switches deliver low insertion loss, excellent power handling, superb linearity with low DC power consumption and high antenna-to-receive isolation for T/R and failsafe switching in TDD-LTE, TD-SCDMA base stations, repeater and low frequency military radios. They are available in small 4 × 4 × 1.5 mm, 16-pin QFN packages.

VENDORVIEW

www.skyworksinc.com

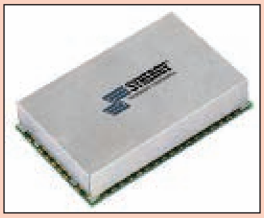
Synergy Microwave Corp.
Booth 1600, 1601

High Frequency Oscillator



The HFSO1000-5 is an ultra-low phase noise oscillator that can be phase locked for single frequency applications as reference frequency translators for instrumentation and radar markets. These products are vital for carrier signal sources in radar and as clocks in high speed ADC in DDS synthesizers. This voltage tuned oscillator offers significant noise floor improvement over multiplied crystal oscillator solutions employed today.

High Resolution Synthesizer



This ultra wide band (400 to 1100 MHz) small surface-mount synthesizer model MTS2500-40110-10 delivers a powerful performance. This small 1.95" × 1.25" surface-mount synthesizer delivers step size resolution down to 1 Hz. A low "close-in" phase noise (-105 dBc/Hz at 1 KHz, -106 dBc/Hz at 10 KHz offset, and -115 dBc/Hz at 100 kHz), a powerful buffered output (+8 dBm minimum), and a fast settling time (< 6 msec. within 10 Hz).

www.synergymwave.com

Herley General Microwave Booth 1607

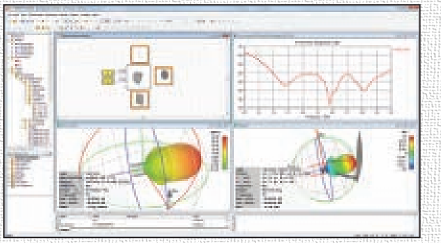
Indirect Synthesizer

Herley General Microwave presents its model SF6218 – a state-of-the-art Fast Indirect Synthesizer designed to meet the high performance requirements of today's most demanding airborne, naval and ground electronic warfare systems. In addition, model SF6218 can also serve as a cost effective signal source for use in ATE and BIT applications. Its fast settling time, very low phase noise and wide frequency coverage are based upon a proprietary design utilizing high performance VCOs and DDS resulting in model SF6218 setting a new standard for performance-to-cost value.

www.herley.com

Computer Simulation Technology Booth 1615

Project Management Software



Version 2012 of CST STUDIO SUITE benefits from a new project management environment "System Assembly and Modeling" (SAM) which simplifies the management of simulation projects. SAM helps engineers to compare the results of different model configurations within one simulation project. A linked sequence of solver runs can also be initiated. All simulations and links can be defined in SAM to enable for example a seamless multiphysics work flow.

VENDORVIEW

www.cst.com

Let this month's Product Showcase help you fill-in the Scavenger Hunt questions on page 282.

WIDEBAND
TRANSFORMERS

Features

- > Low Cost
- > Wide Bandwidth
- > Good Amplitude / Phase Unbalance
- > Rugged Welded Construction
- > RoHS Compliant
- > Patented REL-PRO® Technology
- > 0.150″ x 0.150″ x 0.150″

Model Number	Frequency (MHz)	Impedance Ratio	Schematic
TM4-0	0.2 - 350	4:1	
TM1-0	0.3 - 1000	1:1	
TM1-1	0.4 - 500	1:1	
TM1.5-2	0.5 - 550	1.5:1	
TM2-1	1 - 600	2:1	
TM1-6	5 - 3000	1:1	
TM2-GT	5 - 1500	2:1	
TM4-GT	5 - 1000	4:1	
TM8-GT	5 - 1000	8:1	
TM4-1	10 - 1000	1:4	
TM4-4	10 - 2500	1:4	
TM1-2	20 - 1200	1:1	
TM1-9	100 - 5000	1:1	
TM1-8	800 - 4000	1:1	

RoHS
COMPLIANT

SYNERGY®
MICROWAVE CORPORATION

For additional information, contact Synergy's sales and application team.
Phone: (973) 881-8800 Fax: (973) 881-8361 E-mail: sales@synergymwave.com

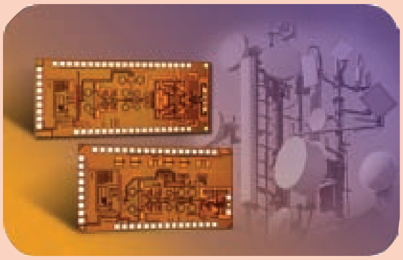
Visit Our Web Site At WWW.SYNERGYMWAVE.COM

See us at IMS Booth 1600

IMS PRODUCT SHOWCASE
AISLES 1700-1800

Hittite Microwave Corp.
Booth 1701

PLL with Integrated VCO



PLLs with Integrated VCOs are used throughout modern high performance communication systems. Hittite recently released a new 25 to 6000 MHz HMC833LP6GE PLL with integrated VCO for use as an LO in a transceiver. This device has a maximum phase detector frequency of 100 MHz in fractional mode and 125 MHz in integer mode. Floor figure of merit (FOM) is -227 dBc/Hz in fractional mode and -230 dBc/Hz in integer mode. At 2 GHz, its LO achieves -114 dBc/Hz at 10 kHz offset. Hittite Microwave Corp. will show the benefits of using its new LO in a communication system demonstration.

Clock Generator

Hittite recently released a new 125 to 3000 MHz HMC1034LP6GE clock generator for use with ADC, DAC, FPGA, DSP and processor clocking applications. Hittite's clock generator noise floor is typically -165 dBc/Hz. Also recently released is the company's HMC1031MS8E clock generator that can be used with a low-cost VCXO to convert a typical 10 MHz input reference to an output of up to 500 MHz. This then provides an ideal reference input for an LO or clock generator. Hittite Microwave Corp. will show the benefits of using its new clock generation device in a communication system demonstration.

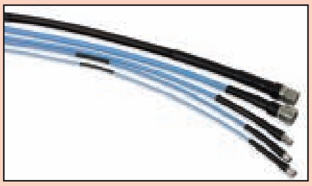
VENDORVIEW

www.hittite.com

Vendors on this page will help you find answers to this month's Scavenger Hunt on page 282.

Florida RF Labs
Booth 1704

Stranded Center Conductor



Florida RF Labs' Lab-Flex S Family is a stranded center conductor version of its popular Lab-Flex product. It offers high flexure rates, increased durability and improved electrical stability over the solid center conductor designs and is especially well-suited for test set-ups as well as radar and antenna systems that require coaxial interconnects that are being subjected to constant motion. Designs up to 65 GHz.

EMC Technology

SMA Coaxial Attenuators

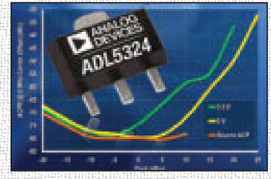
EMC Technology has released the new 42 W series of high performance precision SMA coaxial attenuators. This product expands the company's current offering of coaxial products out to 18 GHz and is offered in values from 0 to 30 dB. In EMC tradition, this product is offered in commercial or high reliability versions. EMC coaxial attenuators are manufactured with a stainless steel body and standard SMA male/female interface. The rugged construction of these devices ensures reliability and continuous performance in the most demanding environments.

VENDORVIEW

www.emc-rflabs.com

Analog Devices Booth 1725

RF Driver Amplifier

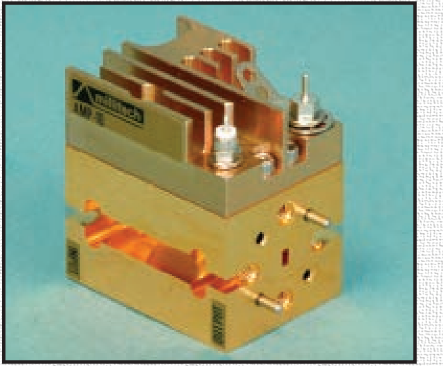


ADI's booth will spotlight complete system solutions and demos of new offerings, including RF/IF amplifiers, frequency synthesizers and data converters, including the industry first ADL5324 half-watt RF driver amplifier with dynamically adjustable bias and extended temperature range for wired and wireless applications. In addition, ADI will demo the ADRF660x series of mixers and ADRF670x series of modulators, which achieve a breakthrough level of integration, enabling LTE and 4G base station manufacturers to realize an unprecedented 60 percent reduction in board space and a significant savings on bill of materials costs.

www.analog.com/rf

Millitech Booth 1809

GaN Power Amplifiers



The bar has been raised! Millitech now offers differentiating E-Band and W-Band solid-state power amplifiers able to achieve small size and high power never before realizable. From 0.5 W to over 10 W available.

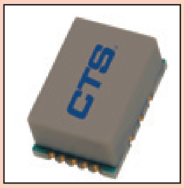
www.millitech.com

CTS Valpey Corp.
Booth 1728

Power Dividers

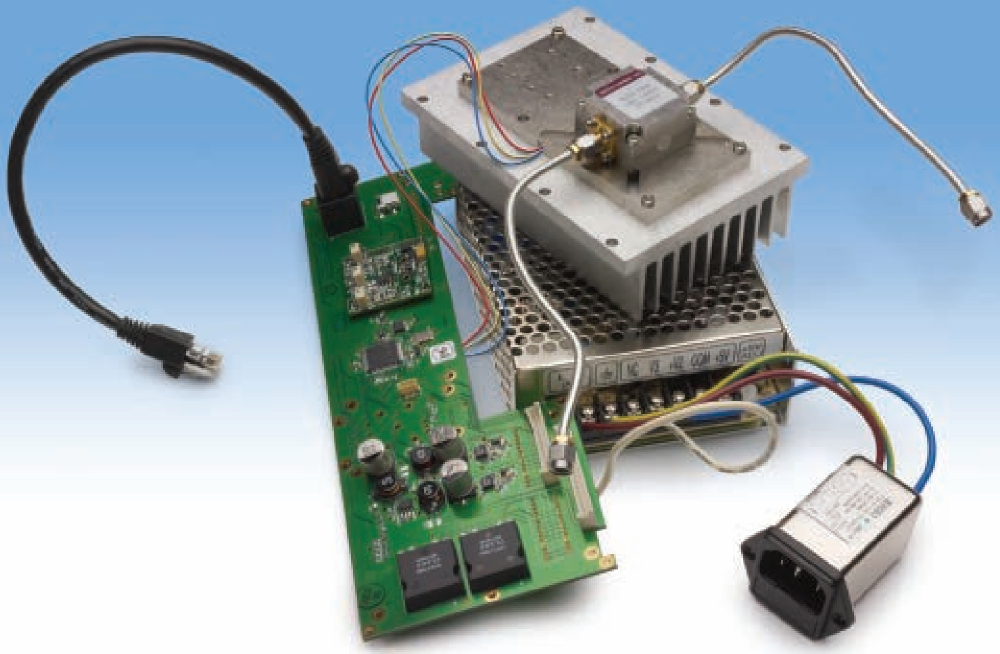
CTS Valpey Corp.'s is VFPD400 series of 4-way 0° power dividers offer the designer excellent RF performance in a compact 3 × 3 mm QFN. The design is a fully passive monolithic IC that provides extreme part-to-part repeatability. The VFPD400 series is a family of devices that span across the frequency range of 500 MHz to 4 GHz and provide excellent phase and amplitude balance, high isolation, low insertion loss and VSWR.

Oven Oscillators



The DFO-S1 is the latest in CTS Valpey Corp.'s line of oven oscillators (OCXO) and it is available in a miniature 9 × 14 surface-mount package. The device offers tight stability (±20 ppb) over the frequency range of 10 to 50 MHz. The DFO-S1 has an HCMOS output, 3.3 V supply voltage and uses significantly lower power (0.3 W) than the competition. It is ideally used in applications such as base stations, IP timing, femto-cell, LTE, network timing and synchronization.

www.ctsvalpey.com



Don't Waste Time and Money Designing Your Own Filter Test Box

Get your hands on Micro Lambda's tunable bench test filter

The MLBF-Series bench top filter from Micro Lambda Wireless provides designers and test engineers an easy to use wideband filtering capability in design labs and test environments.

Engineers no longer have to do their own design with individual components. The MLBF-Series can be supplied as a wide band tunable bandpass or bandreject filter with frequency coverage from 500 MHz to 50 GHz. Tuning is accomplished via Mechanical Knob, Keyboard Input, USB or Ethernet.

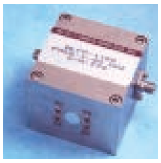
Get one today and simply plug it in and start testing!

For more information about the MLBF Series or other products, please contact Micro Lambda Wireless.

See our complete line of YIG-Tuned filters

Mini-filters
.5 to 10 GHZ

1" cube filters
.5 to 18 GHZ



Bandpass filters
.5 to 50 GHZ

Bandreject
.5 to 22 GHZ

www.microlambdawireless.com

MICRO LAMBDA
WIRELESS, INC.

"Look to the leader in YIG-Technology"

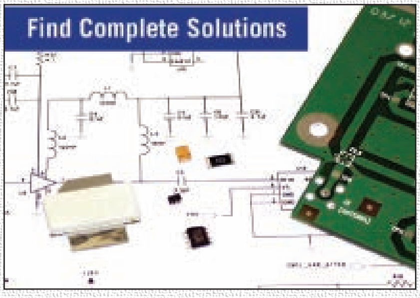
46515 Landing Parkway, Fremont CA 94538 • (510) 770-9221 • sales@microlambdawireless.com

See us at IMS Booth 1700

IMS PRODUCT SHOWCASE
AISLES 1800-2200

Richardson RFPD Booth 1818

Electronic Component Distributor



Richardson RFPD is a specialized electronic component distributor providing design engineers with deep technical expertise and localized global design support for the latest new products from the world's leading suppliers of RF, wireless and energy technologies. At the show, Richardson RFPD will offer a full schedule of presentations relating to new products, design tools and more. Stop by booth #1818 for insight into how you can accelerate time-to-market, find complete solutions, save development costs and, ultimately, improve design performance.

VENDORVIEW

www.richardsonrfpd.com

West Bond Booth 1901

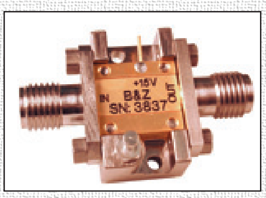
Wire Bonder

West Bond Inc. is pleased to present one of the most popular manual machines made today. The 747677E-79 Triple Combination Wire Bonder: Wedge, Ball, and Ribbon. Since 1966, West Bond has been a designer and manufacturer of assembly and test equipment for the microelectronic industry. Including automatic, semiautomatic and manual ESD protected bonders, with ultrasonic, thermosonic, and thermocompression wire/ribbon capability. Included in its product line are eutectic and epoxy die bonders, insulated wire bonders, and pull testers with the company's patented X-Y-Z, 8/1 ratio micromanipulator.

www.westbond.com

B&Z Technologies Booth 1927

Amplifiers



B&Z Technologies is pleased to announce it's new "BZE" series of amplifiers for the EMC measurement market. These new amplifiers are specifically designed to resist damage to the input gain stages that is a common occurrence with amplifiers used for this application. Using "BZE" amplifiers for EMC receive testing will significantly reduce measurement interruptions typically caused by amplifiers damaged by ESD or other out of range signals at the amplifier input. The BZE-0118-251035-252520 0.1 to 18 GHz amplifier has a 2.3 dB typical noise figure, 35 dB minimum gain, 10 dBm output P1 dB and 2.5:1 VSWR.

www.bnztech.com

Micro-Coax Inc. Booth 2024

Self-Locking Connectors

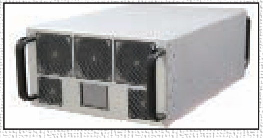
MICRO-COAX introduces Safe-D-LOCK technology that allows SMA, 2.92, 3.5 mm and other threaded connectors to lock against D-flat connectors of the same series. Unlike other solutions that only lock to the cable, Safe-D-LOCK offers resistance to cable installation torque and acceleration forces imparted on the cables. The result is a reliable, locked connection without the addition of adhesives, safety wires or other staking means. Best of all, Safe-D-LOCK's simplicity allows economical implementation, with few added components and no envelope enlargement.

www.micro-coax.com

Let this month's Product Showcase help you fill-in the Scavenger Hunt questions on page 282.

Empower RF Systems Booth 2203

Amplifier and Switch Filter Bank



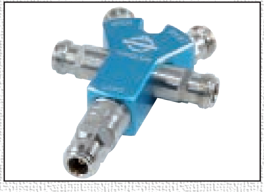
Empower model 2066-BBS3K4AUU delivers 1 kW power over the frequency band 500 to 1000 MHz. The amplifier and switch filter bank that will be on display is constructed within one single 5RU drawer including the forced air-cooling. The system can be configured for 180 to 260 VAC single phase supply or a three phase AC supply. An embedded web server allows for network management and control via the unit's Ethernet port connection. A web browser and the unit's IP address (IPV6) allows ease of access with the benefit of multilevel security.

VENDORVIEW

www.empowerrf.com

SPINNER Atlanta Booth 2208

Compact Calibration Kits

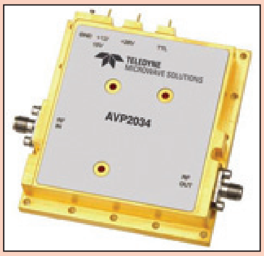


The combination of all calibration standards in one handy unit is the optimum solution for simple, comfortable handling during the calibration of network analyzers with the methods OSL and OSLT. The ergonomic arrangement of the components, small size and low weight are appreciated. The company's 4-in-1 calibration kits include open, short, load and through-line for the complete calibration of a network analyzer with two or more ports. The company's 3-in-1 calibration kits include all necessary standards for a complete OSL calibration of single port network analyzers.

www.spinner-group.com

Teledyne Microwave Booth 2115

Broadband Amplifiers



Teledyne Microwave Solution's new line of medium-power broadband amplifiers is a unique family of performance-based solutions designed for demanding applications. This family covers 20 to 2600 MHz and uses GaN technology. Each amplifier is hermetically sealed and includes multiple RF performance options so engineers can specify standard catalog or custom-tuned performance. The amplifiers include an internal sequencer, assuring application of the proper gate voltage applied to the FET prior to voltage applied to the drain. Higher gain versions include pre-amps, providing excellent noise figure and IP performance. The small package footprint is designed for high performance applications and operates from -40° to +85°C.

www.teledynemicrowave.com

Teledyne Storm Products

Test Cable

Introducing DuraTest, an extra durable, general purpose 0.180" test cable operating to 26.5 GHz with SMA SP connectors. With the proven toughness of Storm RF cable, captivated stainless steel connectors, and Storm's proprietary Hard-To-Hurt strain relief technology, DuraTest assemblies have a minimum flex life of 50,000 cycles and provide connector retention of 40 lbs min. Assemblies available for next day shipment in standard lengths, with any combination of SMA SP and N SP connectors. Phase matching available on request.

www.teledynestorm.com

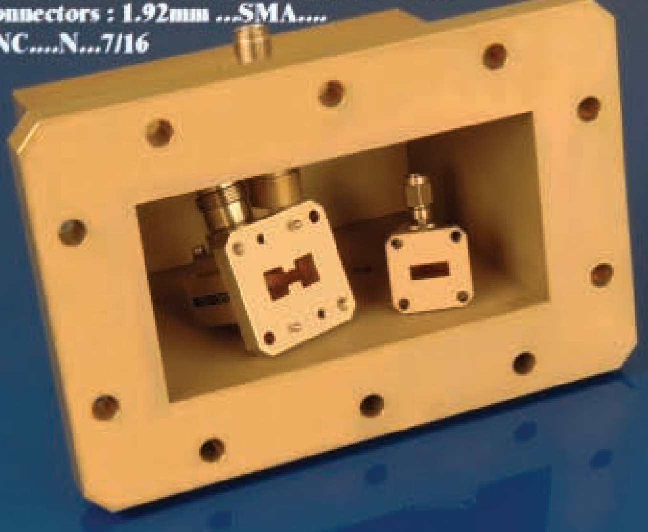
SQ-, TQ-, IQ-, BQ-, CQ- =
connecting 4, 7, 8, 10 or 12 coaxial RF-Lines at once
RQ23-DC26 =
connecting 23 coax RF-
& 26 Signal Lines at once

Spectrum
Elektrotechnik GmbH
when Quality is needed

Hermetically
Sealed Adapters
2.92mm, TNC, N, Feedthroughs
with venting holes for Vacuum Test Chambers

Phase Adjusters

Big and Small,
we have 'em all
Almost any Waveguide to almost any Coax Connector
WG Materials : Aluminum, Copper, Brass
Connectors : 1.92mm ...SMA....
TNC....N...7/16



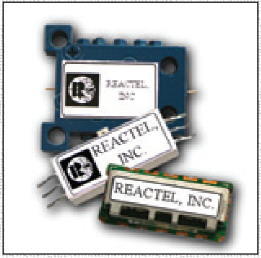
www.spectrum-et.com
Email: Sales@Spectrum-et.com
Telephone: +49-89-3548-040 See us at IEEE MTT-S IMS Booth #1917 Facsimile: +49-89-3548-0490

Quartett-E1A

IMS PRODUCT SHOWCASE
AISLES 2200-2400

Reactel Booth 2210

Small Form Factor Filters



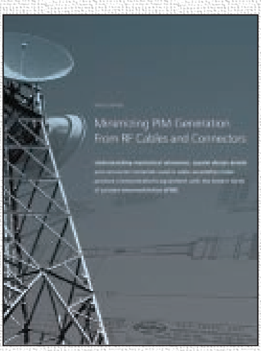
Reactel will feature a line of small form factor filters that are suitable for densely populated boards, portable systems or any application where size is at a premium. These tiny units are available in discrete component, ceramic, cavity or combline designs. With profiles as low as 1/8" these robust units pack all of the performance of their larger counterparts into a much smaller package. They are available across a frequency range of 100 MHz to 20 GHz with bandwidths of 5 to 100 percent and are available in 4 to 12 sections.

VENDORVIEW

www.reactel.com

San-tron Booth 2219

PIM White Paper



Minimizing PIM Generation From RF Cables and Connectors

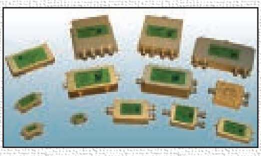
Stop by booth #2219 and pick up a copy of San-tron's latest white paper, "Minimizing PIM Generation From RF Cables and Connectors." This is an extremely practical white paper on passive intermodulation (PIM), its effects on modern communication systems, and how it can be minimized in high-frequency cables, connectors and cable assemblies.

VENDORVIEW

www.santron.com

Werlatone Booth 2236

Combiners and Directional Couplers



Werlatone's high power combiners and directional couplers include a new product line, supporting a full 20 to 1000 MHz bandwidth. The new, low loss combiners address power requirements ranging from 10 to 500 W CW and tolerate severe power unbalances, while maintaining excellent port-to-port isolation. The company's new line of dual-directional couplers provides a low loss solution for broadband amplifier manufacturers seeking non-connectorized couplers at the module level or connectorized components at the amplifier output. These broadband units are a perfect fit for military and commercial applications.

VENDORVIEW

www.werlatone.com

Aeroflex/ Weinschel Booth 2305

Bidirectional High Power Fixed Attenuator

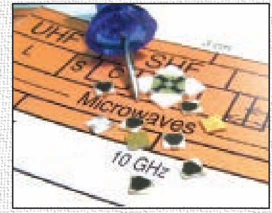
This new convection cooled design operates from DC to 6 GHz frequency range with power handling up to 200 W average (Bidirectional) and 10 kilowatt peak (5 µsec pulse width; 1 percent duty cycle). Model 251 is designed to meet environmental requirements of MIL-DTL-3933 and is RoHs complaint. Available in 10, 20, 30 and 40 dB values with a choice of Type N male/female connector combinations. Other electrical specifications include VSWR of 1.20 maximum and a deviation over frequency of ±1.5 dB (maximum) across the operating frequency band.

VENDORVIEW

www.aeroflex.com

International Manufacturing Services Booth 2310

Resistive Splitters

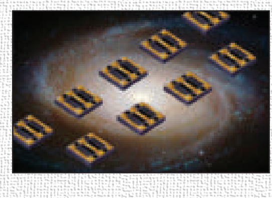


International Manufacturing Services Inc. (IMS) announces the availability of the IPS Series – wideband two, three and four-way resistive splitters. The two-way (6 dB) resistive splitter functions optimally from DC to 20 GHz with accuracy starting at ± 0.5 dB while the three-way (9.5 dB) and four-way (12 dB) splitters function from DC to 7 GHz with accuracy starting at ±0.7 dB. These devices are available for surface-mount, microstrip or wirebond. Rated power is as high as 3 W.

www.ims-resistors.com

State of the Art Booth 2325

Chip Resistors



State of the Art Inc. (SOTA) announces its Z Termination line of miniature, high reliability chip resistors. The resistors range in size from 0402 (0.040" × 0.020") to 2512 (0.025" × 0.025"), with tolerances from 0.1 percent, power ratings from 50 to 1500 mW temperature coefficients of resistance as low as 25 ppm, and voltage ratings from 30 to 200 V. The operating range for these resistors is from -55° to +125°C. The Z Termination is a gold over nickel finish which can be attached with solder, conductive epoxy or gold wire bonds.

www.resistor.com

LPKF Laser & Electronics Booth 2409

UV Laser System

Create PCBs on-demand right in the electronic lab with the LPKF ProtoLaser U3. This affordable UV laser system quickly processes a wide variety of material substrates and applications without the use of tools or chemicals, and switches between projects with a little more than a click of the button. From cutting/depaneling any material from flex to fired ceramics, to drilling, skiving, decaping, and direct surface metal etching of the artwork, the ProtoLaser U3 has the ability to process applications that were previously only possible with the help of large and expensive industrial systems.

www.lpkfusa.com

Rohde & Schwarz
Booth 2415

ZNB Network Analyzer

The four-port R&S ZNB models cover the frequency ranges from 9 kHz to 4.5 GHz or 8.5 GHz. Rohde & Schwarz has designed the powerful instruments for demanding applications in the production and development of RF components with multiple ports. Two internal signal sources and a frequency-converting mode enable comprehensive measurements on mixers or amplifiers. Using mixed-mode S-parameter measurements, the R&S ZNB fully characterizes even balanced DUTs such as SAW filters used in mobile phones. Users benefit from the extremely wide dynamic range, short measurement times and exceptionally easy operation.

Signal Generator

Rohde & Schwarz has enhanced its R&S SMB100A by adding new frequency options: The analog mid-range signal generator can now handle everything from analog RF to microwave applications. The R&S SMB-B120/B120L and R&S SMB-B140/B140L options (L versions without step attenuator) enable the generator to cover the frequency range from 100 kHz to 20 GHz and 40 GHz, respectively. In the new frequency ranges, the R&S SMB100A still offers a very wide dynamic range of -120 dBm to +14 dBm as standard. New high power options make it possible to achieve an output power of max. +25 dBm.

VENDORVIEW

www.rohde-schwarz.com

Purity & Precision
Speed & Ease
Rohde & Schwarz FSW

The most advanced signal and spectrum analyzer for aerospace and defense applications. The highest bandwidth, lowest phase noise, clearest user interface and a host of convenient new tools — all on the largest touchscreen available. The R&S®FSW is the perfect analyzer for testing all types of radar signals in aerospace and defense. Execute the most complex measurements with ease. See things that were previously undetectable. Go where no one has been before. The R&S®FSW. Compatible with today's technology. Built for tomorrow.

- Analyze oscillators and synthesizers with a phase noise of –137 dBc (1 Hz)
- Measure frequency-hopping and chirp signals with a bandwidth of up to 160 MHz
- Find spurious signals five times faster
- Measure pulses, spurious and modulation at the same time with MultiView
- See more and obtain faster results on the large touchscreen

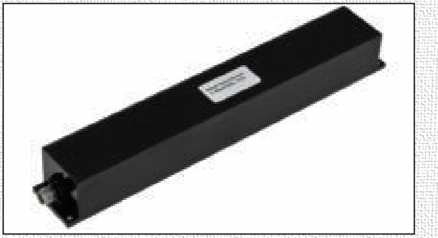
The R&S®FSW. **Create the future.**
www.rohde-schwarz.com/ad/fsw
See us at IMS Booth 2415

ROHDE&SCHWARZ

IMS PRODUCT SHOWCASE
AISLES 2400–2600

Networks International Corp. Booth 2418

C-Band Filter/LNA



NIC introduces a ruggedized C-Band filter/LNA for use in eliminating interference caused by navigational communications (radar) of commercial and military aircraft, as well as coastal and marine vessels operating above and below the C-Band. This filter/LNA operates in the 4200 to 4600 MHz band and offers 23 dB gain, low noise figure of 1.1 dB, high selectivity and phase matching as low as ±1° in a hermetically sealed package.

VENDORVIEW

www.nickc.com

MIcable Inc. Booth 2429

Cable Assemblies

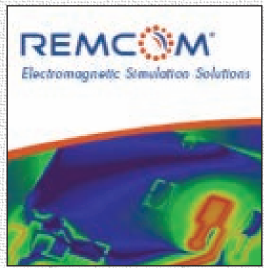
C04 series is highly reliable and cost-effective cable assemblies, ideal for broadband tests and various connections. The triple-shielded cable has rugged construction employing an advanced strain relief system and is equipped with reinforced stainless steel connectors. They are so tough to be qualified for over 20, 000 flex cycles without any change in electrical performance up to 18 GHz. They are available in custom lengths with SMA or N type connectors. You can rely on C04 for daily test operation to repeatedly connect and disconnect.

www.micable.cn

Remcom Inc. Booth 2430

EM Simulation Software

Remcom introduces its XFdtd, a 3D EM Simulation Software for microwave device design and analysis. Whether the application is waveguides, power dividers, filters, or couplers, XFdtd can provide quick, efficient and accurate simulation results. Visit Remcom's Microwave Application web page for a wealth of examples on power dividers, circulators, Rotman Lens, and Waveguides: www.remcom.com/microwave-devices.



VENDORVIEW

www.remcom.com

MECA Electronics Inc. Booth 2437

Power Divider/Splitters

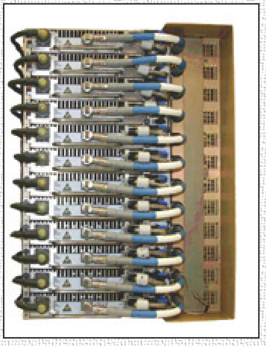
New low frequency range 2-, 3-, 4- and 9-way power divider/combiners are optimized for excellent performance across all bands from 5 to 500 MHz. Their rugged construction makes them ideal for all low frequency systems. Always available from stock – four weeks ARO in N and SMA connector configurations. Made in the USA – 36 month warranty.

VENDORVIEW

www.e-meca.com

Communications & Power Industries Booth 2438

Power Amplifier



CPI introduces the VSS3610, a high-power S-Band solid-state power amplifier using 1300 W modules, efficiently power combined. The 1300 W peak-power modules utilize state-of-the-art GaN HEMTs for the most compact and efficient design. The VSS3610 is designed to produce a very reliable air-cooled amplifier for mobile radar requirements, including Air Traffic Control radar systems. Standard peak power ranges from 7 to 25 KW (or higher).

www.cpii.com/bmd

Z-Communications Inc. Booth 2528

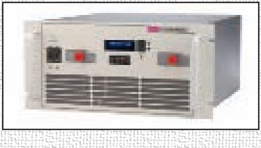
Ultra-Miniature VCO

Z-Communications Inc. introduces the USSP2450-LF for demanding portable radio applications. The ultra-miniature USSP2450-LF generates frequencies between 2400 to 2485 MHz within a control voltage range of 0.5 to 2.5 V DC making it enticing for PLL designs needing a low cost, high quality performance VCO in the 2.4 GHz ISM band. This oscillator measures a mere 0.2" × 0.2" × 0.07" and provides an SSB spectral purity of -82 dBc/Hz, typically, at 10 kHz while only drawing 6 mA of current from a 2.7 V DC supply.

www.zcomm.com

Ophir RF Booth 2602

RF Amplifier



This class A RF power amplifier operates in a frequency range from 2 to 6 GHz and offers 100 W minimum output power. This is the perfect choice for test measurement systems needing high power in the smallest commercially available package possible. This RFPA is backed by a three year warranty and Ophir RF's commitment to total customer satisfaction.

www.ophirrf.com

Ciao Wireless Booth 2606

Broadband Amplifiers

Ciao Wireless introduces its line of high power, broadband amplifiers covering 0.5 to 20 GHz, 1 to 20 GHz, 2 to 20 GHz, and 2 to 22 GHz with Output Power Levels up to +30 dBm at 1 dB PT. Various operating voltage levels are available. Delivery is two to four weeks ARO & Ciao can customize any unit to meet your exact gain, noise figure, VSWR, and size requirements.

www.ciaowireless.com

Crane Aerospace & Electronics Microwave Solutions Booth 2610

Beamforming Networks

Crane Aerospace & Electronics Microwave Solutions offers a wide range of beamforming products for advanced antenna and beamsteering applications. Utilizing lumped element (toroid), stripline or Multi-Mix® technology; frequency ranges from 50 MHz to 26 GHz are supported. Simple two port types to many input and output ports can be provided with the advanced fabrication and test technologies offered. Applications include directional signal reception for intercept applications, radar beamforming for phased array and directional applications and signal geolocation. All designs are custom and tailored to customer's specific requirements. Exceptional performance is obtained through careful CAD designs and critical process control.

www.craneae.com/mw

Weinschel Associates Booth 2616

100 W Attenuators and Terminations

Weinschel Associates introduces a line of 100 W attenuators and terminations designed to improve flexibility for integrators with a new cylindrical

Innovative GaAs integration technologies without compromise

HBT + pHEMT @ WIN = H^2W

e-Mode + d-Mode pHEMT @ WIN = e/d

It's a **whole new world** for designers with breakthrough integration technologies from WIN Semiconductors.
Combining GaAs HBT, enhancement and depletion pHEMT technologies on a single wafer enables innovative, highly integrated product solutions.

www.winfoundry.com

See us at IMS Booth 2816

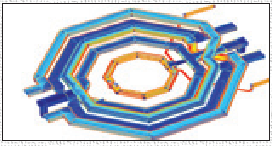
WIN
SEMICONDUCTORS
CORP.

body. Supporting a wide range of attenuation values (up to 30 dB in a bidirectional configuration and from 40 to 50 dB in a unidirectional design), the standard WA26 attenuator and WA1432 termination operate over the DC to 4 GHz frequency band with extended frequency operation up to 10 GHz available. The new body design enhances the ability for this attenuator/termination to interface seamlessly with cable configurations where a rectangular body might complicate mounting.

www.weinschelassociates.com

Sonnet Software Booth 2702

Sonnet Suites Release 13



Visit Sonnet's booth for a free 20-minute, hands-on training class featuring its Sonnet Suites Release 13. Take a class and receive a complimentary Sonnet LitePlus license ($495 value). The Sonnet Suites Release 13 features up to 3X faster analysis for large circuits, diagonal ports and components, smart via array meshing, and enhanced integration to Sonnet's EDA partners.

www.sonnetsoftware.com

Tecdia Inc. Booth 2806

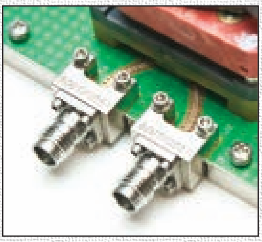
Dual Function Chip

Combining a SLC capacitor and thin film resistor on a single ceramic chip is a Tecdia innovation that pays big dividends. The IRC or integrated resistor and capacitors are available in a variety of sizes and values to help engineers shrink designs, improve installation efficiency and lower material cost with superb quality. These parts can be customized to your specific application. Visit booth #2806 to discover this and other space saving designs for your demanding applications.

www.tecdia.com/us

Southwest Microwave Inc. Booth 2910

End Launch Connector



Southwest Microwave's High Performance 1.85 mm End Launch Connector is now offered with a 5 mil diameter launch pin. This high performing connector is designed to provide low VSWR, wideband response up to 67 GHz for single-layer or multi-layer printed circuit boards where the microwave layer is on top. It is ideally suited for high frequency chip set evaluation/demo boards, test fixtures and board characterization. It provides optimum performance when board launch geometry is grounded coplanar (CPWG) or top ground microstrip. The connector requires no soldering, is repairable and reusable.

www.southwestmicrowave.com

Holzworth Instrumentation Booth 2926

Synthesis and Phase Noise Analysis

Holzworth Instrumentation is a global provider of high performance RF synthesis and phase noise analysis products. Holzworth's broadband (250 kHz to 20 GHz) RF synthesizer module designs are based on a proprietary non-PLL architecture that is optimized for ultimate stability, switching speed and ultra low phase noise performance. Holzworth's phase noise analyzer products are of the same innovative design philosophy optimized for speed, accuracy and reliability. Exciting new products will be launched at IMS 2012. Visit the Holzworth booth for a live demo.

www.holzworth.com

Logus Microwave Booth 3006

Waveguide Switch

The LOGUS WR10 ultra-light waveguide switch operates across the 75 to 110 GHz band and boasts a maximum VSWR of 1.20:1, insertion loss of 0.40 dB maximum and a minimum Isolation of 50 dB. The switching time is 50 ms maximum and it is available with indicators, TTL interface control and 3 or 4 Port configurations. The Ultra-Light Series from Logus can be Airborne Application constructed and is also available from WR10 thru WR112 and Double-Ridge WRD180 thru WRD750.

www.logus.com

Greenray Industries Inc. Booth 3206

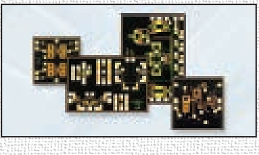
TCXO

The T72 incorporates a rugged 5 × 7 mm ceramic package and a high performance crystal from Greenray's sister company Statek. The T72 offers stability to ±0.2 ppm (-40° to +85°C), g-Sensitivity of ≤2.5 × 10^{-9}/g, a phase noise floor of -155 dBc/Hz (typ. 10 MHz), and very low current consumption to 1.9 mA (typ. with clipped sine output). A low g-sensitivity option to ≤7 × 10^{-10}/g is available. The T72 TCXO, available from 10 to 50 MHz, offers clipped sine wave output and 3.3 V supply voltage.

www.greenrayindustries.com

Custom MMIC Design Booth 3210

Low Noise Amplifier



Stop by booth #3210 to learn about Custom MMIC's growing IP design library. Their latest product is a high efficiency GaAs low noise amplifier. The CMD162 boasts a noise figure of 1.7 dB with a small-signal gain of 22 dB. It reduces typical industry DC power dissipation from approximately 160 mW down to 50 mW. The simplified design requires only positive drain and gate voltages, thereby eliminating complicated sequencer circuits commonly associated with LNAs in this range.

VENDORVIEW

www.custommmic.com

Narda Booth 2916, 2917

Two-Way Power Divider

The new Narda model 2372A-2 high-power, two-way power divider operates from 500 MHz to 2.5 GHz, handles up to 250 W CW input power (2 kW peak power) and provides exceptional phase and amplitude balance. This unit also operates as a non-coherent 125 Watt-per-signal power combiner. Currently in production, the unit incorporates proprietary high-power, thin-film resistors that ensure broadband impedance matching and high isolation between inputs when used as a combiner rather than a divider. Model 2372A-2 measures just 3.5" × 2.5" × 1".

Two-Way Power Divider

The new Narda model 2382-2 high-power, two-way power divider operates from 500 MHz to 6 GHz, handles up to 250 W CW input power (2 kW peak power) and provides exceptional phase and amplitude balance. This unit also operates as a non-coherent 125 Watt-per-signal power combiner. The unit incorporates proprietary high-power, thin-film resistors that ensure broadband impedance matching and high isolation between inputs when used as a combiner rather than a divider. Model 2382-2 measures just 3.5" × 2.5" × 1". This unit will be available in late summer 2012.

VENDORVIEW

www.nardamicrowave.com

Don't forget your passport!

Passport to
IMS
2012
MONTRÉAL

An Itinerary for Winning Great Prizes:

Travel Day Tuesday, Passport Stamps
Travel to as many participant booths as possible and get at least 6 stamps in your passport

Facebook Wednesday, Tourist Photo Day
Take your best creative & fun "tourist" photos and post them on Passport to IMS Facebook Page

Twitter Thursday, Postcard & Souvenir Day
Tweet about participating company's products, booth "souvenirs", booth staff, etc. using **#PPtoIMS**

- Every Tweet = 1 entry

Participate in contest, vote and follow updates:
Facebook.com/MicrowaveWorld
Twitter.com/MicrowaveWorld

To learn more about all the fun & prizes available in Montréal at IMS2012 be sure to visit:
www.landingportal.com/IMSpassport/

Get your **Passport to IMS2012** at the booth of any participating sponsor!

Brought to you by sln MARKETING COMMUNICATIONS and TTI TRANSLINE TECHNOLOGY INCORPORATED

Microwave Journal
Media sponsor

ROGERS CORPORATION
Modelithics
MDL
HUNTER TECHNOLOGY CORP Reliable. Solutions. Delivered.
ARC TECHNOLOGIES, INC
dynawave INCORPORATED
Amphenol Printed Circuits
OPHIR RF THE ART OF WIRELESS

Rugged....

What makes our switches rugged?
All AST switches come 100% sealed, but when outdoor weather is a factor, AST switches are unbeatable. Our unique "Weather" option provides protection against the most severe weather that mother nature can dish out. Our "Weather Cap" protects the manual override and can be removed without the use of tools. Come and see why AST switches are used in a majority of outdoor applications

AST Advanced Switch Technology

www.astswitch.com

See us at IMS Booth 100

Access BOTH SIDES of your PC board

MODPAK RF ENCLOSURES use a unique connector design that supports and allows access to both sides of your PC board. The enclosures are offered in 27 standard models with BNC, TNC, N or SMA 50 ohm female connectors. Custom enclosures fabricated to your specs. Contact us today.

Ph: 207.884.8285 • Fax: 207.884.8712

www.modpak.com

LASER DRILLING

LASER FAST

Kyocera, Coorstek and CeramTec substrates in stock.

Westford, MA
978-692-6180
LaserServicesUSA.com

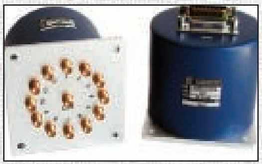
LASER SERVICES

See us at IMS Booth 215

IMS PRODUCT SHOWCASE
AISLES 3200-3300

Charter Engineering Inc. Booth 3217

SP12T RF Switch



CEI model S12P-141518 is a SP12T latching switch with indicator circuitry operating from DC to 13 GHz. The ultra low PIM switch features a –160 dBc minimum 3rd order IM. The S12 series is also offered as a failsafe or normally open switch along with various actuator and mounting options. CEI has been a leading producer of low PIM switches for over 10 years. The low PIM specifications are available with all CEI switches. Delivery: stock to two weeks.

www.ceiswitches.com

Jackson Labs Booth 3219

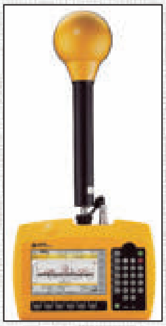
Chip Scale Atomic Clock

The CSAC GPS-DO is the first commercial Chip Scale Atomic Clock (CSAC) available on the market. Jackson Labs Technologies Inc. teamed with Symmetricom to integrate its Sa.45s CSAC into the CSAC GPS-DO module. This technology culminates from decades of research sponsored by the U.S. Government. The breakthrough technology allows a Cesium Vapor Cell Atomic Reference Oscillator to be packaged in a unit smaller than legacy products, with more than an order of magnitude in power reduction, while out-performing many industry-standard Atomic Oscillators.

www.jackson-labs.com

Advanced Test Equipment Rentals Booth 3220

Radiation Meter



The Narda SRM-3006, the 9 kHz to 6 GHz selective radiation meter, has been specially developed as a frequency-selective measuring system for safety issues in electromagnetic fields. The operating modes are precisely tailored to the applications: Spectrum Analysis, Safety Evaluation UMTS P-CPICH Demodulation, Level Recorder, and Scope. Narda SRM-3006 is a complete measuring system: The SRM-3006 basic unit detects and takes account of antenna and calibration data automatically, eliminating a common source of errors. A further advantage: all measuring antennas in the SRM family are mutually compatible. Antennas from other manufacturers can also be used with the Narda SRM-3006.

www.atecorp.com

Precision Connector Inc. Booth 3303

Semi-Rigid Cable Connectors

Precision Connector Inc. has introduced a new line of precision connectors designed for 0.047 semi-rigid cable. Both 1.85 mm and 2.92 mm male and female connectors are available and have been designed for low VSWR and insertion loss. The 1.85 mm series performs to 65 GHz and the 2.92 mm series performs to 46.5 GHz. Both designs incorporate fully captivated center contacts with rear sockets that accept a pointed cable center conductor, eliminating the need for center contact soldering. A solder ferrule is used to attach the cable outer jacket to the main connector body with a threaded clamp nut. All bodies are manufactured from passivated stainless steel and contacts and solder ferrules are constructed from gold plated beryllium copper.

www.precisionconnector.com

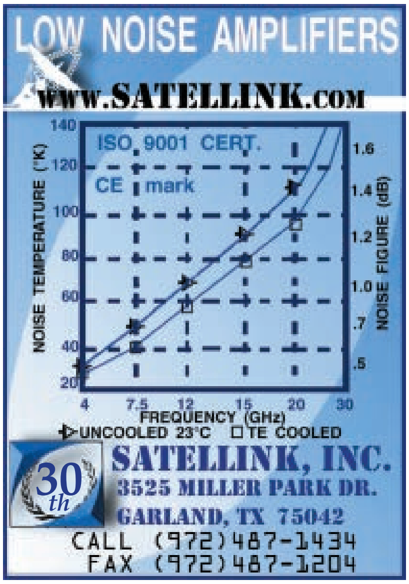
Norden Millimeter Booth 3326

Down Converter

To assist system designers in expanding the frequency capabilities of their systems, Norden engineers have designed and are manufacturing a 24 to 40 GHz down converter with an integrated bypass to provide a single IF output covering the 0.8 to 24 GHz band. The IF frequency of the down converter is used as the input RF frequency for an ELINT receiver, such as the Norden ELINT receiver. Norden combines multiple assembly technologies with the latest MMIC and packaging technology to reduce size, weight and power, while maintaining superior performance.

www.nordengroup.com

Bring this month's completed Puzzler to MWJ booth 2018 at IMS and be entered into a daily prize drawing.

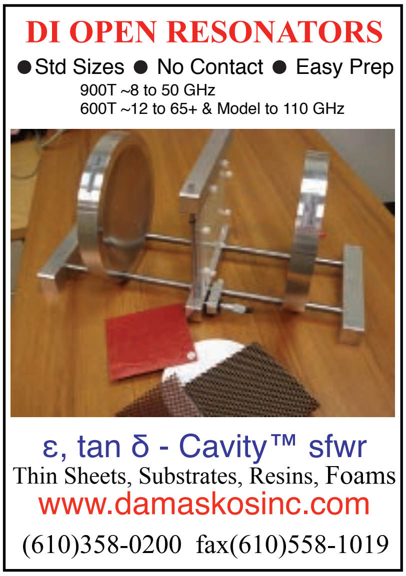

LOW NOISE AMPLIFIERS
WWW.SATELLINK.COM

SATELLINK, INC.
3525 MILLER PARK DR.
GARLAND, TX 75042
CALL (972)487-1434
FAX (972)487-1204


GIGOPTIX
iT2009 2-26.5GHz High Power Amplifier
www.gigoptix.com
See us at IMS Booth 2118


SignalCore™
PRESERVING SIGNAL INTEGRITY
RF Up/Downconverter
PXI/PXIe/USB/SPI/RS-232
DC to 3.9 GHz
DC to 1.3 GHz
- Low phase noise
- High dynamic range
- Best price-to-performance ratio
- Software-defined radio/LTE wireless communication
- Signal intelligence
- Instrumentation
- Commercial/Military

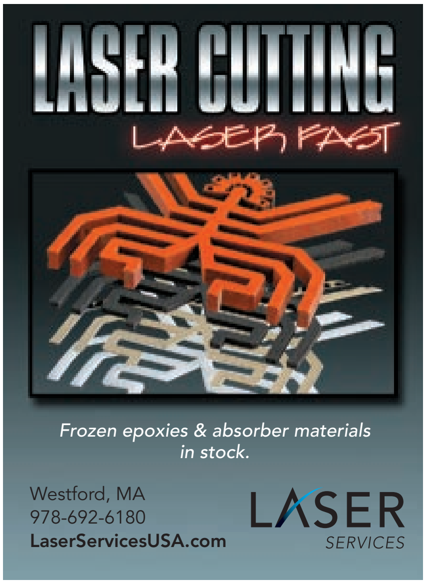
www.signalcore.com


DI OPEN RESONATORS
● Std Sizes ● No Contact ● Easy Prep
900T ~8 to 50 GHz
600T ~12 to 65+ & Model to 110 GHz
ε, tan δ - Cavity™ sfwr
Thin Sheets, Substrates, Resins, Foams
www.damaskosinc.com
(610)358-0200 fax(610)558-1019


FREQUENCY SYNTHESIZERS
- Output freq. to 25 GHz (up to octave bands)
- Low phase noise, low spurious
- Freq. control:RS-485
- +5V operation
- EMI housing

PHASE-LOCKED OSCILLATORS
- Crystal oscillators to 1400 MHz
- CROs to 5 GHz
- DROs to 15 GHz
- Ref: External or Internal
- +5V operation

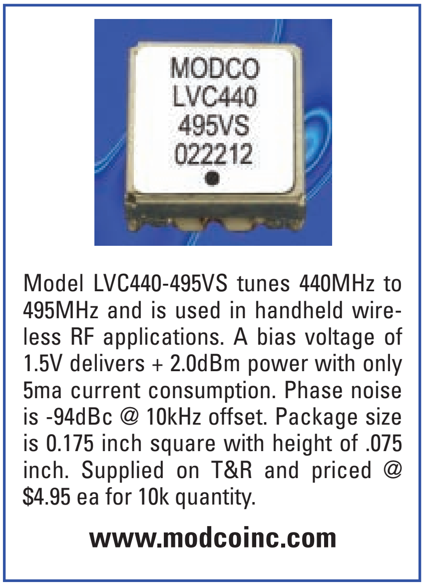
Custom designs are our specialty
luff RESEARCH
20 N. Tyson Ave, Floral Park, NY 11001
Tel: (516) 358-2880 Fax: (516) 358-2757
Email: sales@luffresearch.com
Web: www.luffresearch.com


LASER CUTTING
LASER FAST
Frozen epoxies & absorber materials in stock.
Westford, MA
978-692-6180
LaserServicesUSA.com
LASER SERVICES
See us at IMS Booth 215


KR Electronics
www.krfilters.com
ISO 9001:2000 Certified
Custom & Standard Filters to 3 GHz
35+ Years of Military & Commercial Applications

Bandpass	Lowpass
Anti-Aliasing	Notch
Highpass	Root Cosine
Video Filters	Equalizers
Diplexers	Linear Phase
Delay Equalized	Absorptive
Surface Mount	Matched

KR Electronics, Inc.
Avenel, NJ
www.krfilters.com
sales@krfilters.com
Phone 732.636.1900
Fax 732.636.1982


MODCO
LVC440
495VS
022212

Model LVC440-495VS tunes 440MHz to 495MHz and is used in handheld wireless RF applications. A bias voltage of 1.5V delivers + 2.0dBm power with only 5ma current consumption. Phase noise is -94dBc @ 10kHz offset. Package size is 0.175 inch square with height of .075 inch. Supplied on T&R and priced @ $4.95 ea for 10k quantity.

www.modcoinc.com


SECTOR MICROWAVE INDUSTRIES, INC.
WR10
WR15
WR22
WR28
WR34
WR42
WR51
WR62
WR75
WR90
WR102
WR112
WR137
WR159
WR187
WR229
WR284
WR430
WR650
WR975
smi
(631) 242-2300 FAX (631) 242-8158
www.sectormicrowave.com

Microwave Life Savers:

Small Companies at IMS That May Keep You Afloat

It would be very difficult to see every booth at a tradeshow. But isn't it great to come away from a show with a hidden gem that you stumbled upon? Here are a few to put on your schedule. From components for infrastructure to custom MMICs for an aerospace/defense application, these companies just might be the solution you will need in a pinch this year.

If you have been anywhere near a base station lately, no doubt you or someone you know has uttered "passive intermodulation" or "PIM", more than likely with some angst. Unlike low-level noise, which tends to cover broad bandwidths, PIM results in discrete signals that fall within the operating bandwidth of a wireless communications receiver, capable of interfering with desired signals. At sufficiently high magnitudes, PIM distortion can desensitize a communications receiver, resulting in poor quality of calls or even dropped calls. To learn more about PIM and some simple, yet robust cable assembly solutions, stop by some of the industry leading cable companies. San-tron (booth #2219) will be demonstrating how their new line of low-PIM jumper cables deliver PIM performance of -158 dBc standing still and then when heavy vibration is applied, continues to remain extremely stable, degrading just 2 dB.

Does your specific application call for performance not available in a catalog MMIC? Visit the team at Custom MMIC in booth #3210 to learn how attainable a uniquely designed MMIC can actually be. This particular design house offers three levels of engagement including access to their private stock of performance driven designs for rapid delivery. From single-function to multi-function, Custom MMIC is a good fit for companies that wish to outsource their design activity, especially when you need a custom design in a specific compound semiconductor technology such as GaAs, GaN, SiC or InP. Custom MMIC will be demonstrating their latest GaAs MMIC low-noise amplifier (LNA) chip optimized for 30 GHz satellite communications with a typical noise figure of 1.7 dB in their booth. With dozens of years of combined experience designing MMICs for microwave and millimeter-wave applications, it is worth a booth visit to talk about how your own unique design requirements could be realized.

LPKF in booth #2409 may be the biggest tease at the show. There is not an engineer in the business that would not want to have a machine on their bench that outputs their circuit ideas like a desktop printer. Don't believe me? Eighty-five percent of the respondents to Microwave Journal's April online poll question named the PCB prototype milling machine as the most important tool in their design arsenal. I am talking about real boards. Boards that can be tested, tweaked and tried again, without the interruption of going outside to the board house. Sure, it would be great if you could grab one of these at Staples, but unfortunately these German-engineered laser machines cost a couple of bucks. But the payoff in design efficiency is immeasurable and the LPKF booth staff can show you how to sell the value of your productivity to even the stingiest CFO.

Moving from design to manufacturing, other companies using lasers to save the day are Laser Services in booth #215, Thunderline-Z in booth #601 and Litron in booth #2229. With the bulk of vendors highlighting new RF components, software and test instruments, its easy to overlook the smaller group of companies providing manufacturing services, but IMS is a great place to meet the folks who understand the special physical requirements that go into microwave products. Laser Services is an experienced high power laser job shop using YAG and $C0_2$ lasers to perform any number of laser precise cutting, drilling, marking, etching and welding jobs for you. They maintain a stash of name brand alumina substrates and frozen epoxies and offer unique design-for-manu-

David Strand
Strand Marketing, Newburyport, MA

European Microwave Week 2012
Amsterdam RAI, The Netherlands
October 28th - November 2nd 2012

EUROPEAN MICROWAVE WEEK
EuMW 2012
RAI Amsterdam
28 October – 2 November 2012
www.eumweek.com

Space for Microwaves

Europe's Premier Microwave, RF, Wireless and Radar Event

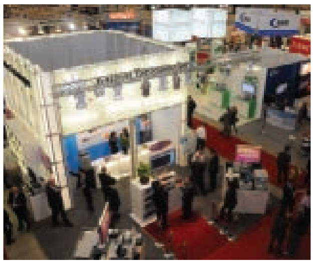
The EuMW2012 Exhibition will see:

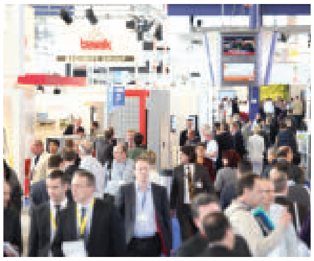
- 7,500 sqm of gross exhibition space
- 5,000 key visitors from around the globe
- 1,700 - 2,000 conference delegates
- In excess of 250 exhibitors

Running alongside the exhibition are 3 separate, but complementary Conferences:

- European Microwave Integrated Circuits Conference (EuMIC)
- European Microwave Conference (EuMC)
- European Radar Conference (EuRAD)

Plus a one day Defence and Security Conference





EuMA
European Microwave Association

Official Publication:
Microwave Journal

Organised by:
horizon house

Supported by:
IET The Institution of Engineering and Technology

Co-sponsored by:
MTT-S

Co-sponsored by:
IEEE

EuRAD 2012
The 9th European Radar Conference

42ND EUROPEAN MICROWAVE CONFERENCE 2012
The 42nd European Microwave Conference

EuMIC 2012
The 7th European Microwave Integrated Circuits Conference
Co-sponsored by:
Electron Devices Society
GAAS

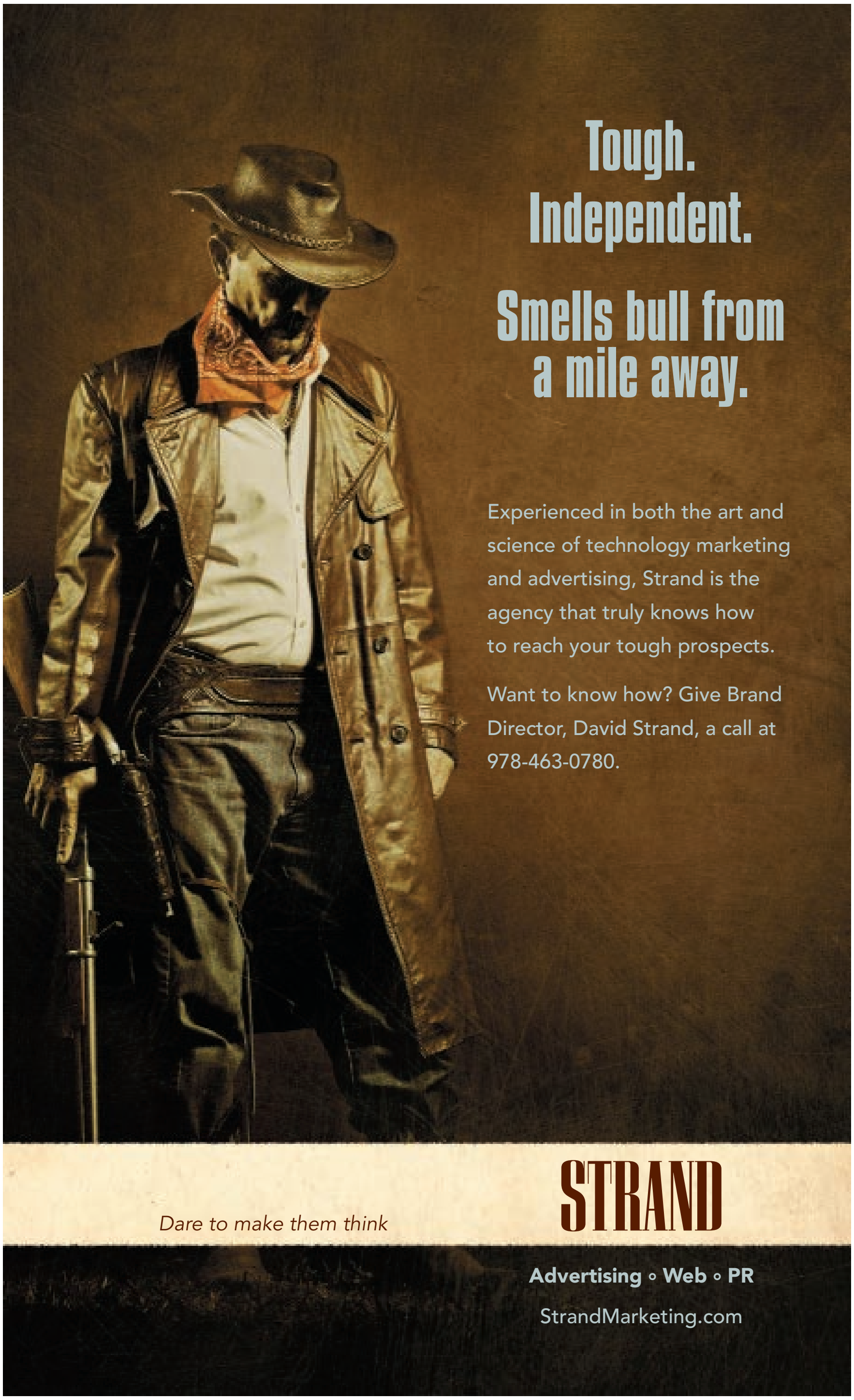
Interested in exhibiting?

Call +44(0) 20 7596 8742 or visit www.eumweek.com

See us at IMS Booth 2025

facturability solutions such as an innovative laser ablation technique for solder damming.

Many of the components found on the exhibition floor are used in harsh environments and require advanced packaging. Thunderline-Z opened their own laser center last year, focused on augmenting their full-service packaging services. Their solutions include laser lidding and testing of hermetic modules, and laser feedthru installation that will allow you to obtain some of the tightest pin-to-pin tolerances imaginable. Litron Inc. also provides laser welding, laser sealing and laser cutting services for aerospace, industrial and medical components from hi-rel electronic microwave packages to class three medical implant devices.


Tough.
Independent.
Smells bull from a mile away.

Experienced in both the art and science of technology marketing and advertising, Strand is the agency that truly knows how to reach your tough prospects.

Want to know how? Give Brand Director, David Strand, a call at 978-463-0780.

Dare to make them think

STRAND

Advertising ◦ Web ◦ PR

StrandMarketing.com

Speaking of harsh environments, are you working in space or just looking for space-level type design and manufacturing capabilities? Hi-rel multi-chip modules and RF semiconductor packaging solutions are a specialty of KCB Solutions in booth #3513. If you are concerned about thermal or electrical stability in high power applications, talk to them about their new weightless, void-free approach to eutectic die attach.

Wondering where you might possibly turn to handle overflow in production or high frequency test without going off-shore? SemiGen in booth #301 is the partner you're looking for. Microwave assembly and semiconductor packaging is an art that is not lost on this assembly house and they also offer you fast delivery of bonding supplies and diodes and capacitors from their own in-house RF Supply Center.

Speaking of high frequency testing, do you need a signal generator for your ATE set up, but do not need all the bells and whistles of a big brand piece of equipment? Lab Bricks from Vaunix in booth #1129 are a complete line of USB powered, miniature, yet robust, signal generators, attenuators and now an RF switch that are software-controlled and easy to use. Each device comes with a USB flash drive containing the GUI software and digital version of the programming guide, along with a 6-ft. USB cable. The Lab Brick is compatible with NI's Labview so that you can easily incorporate them into your custom test set-up. Several small companies are now offering compact, USB powered testing solutions so look for them at the show.

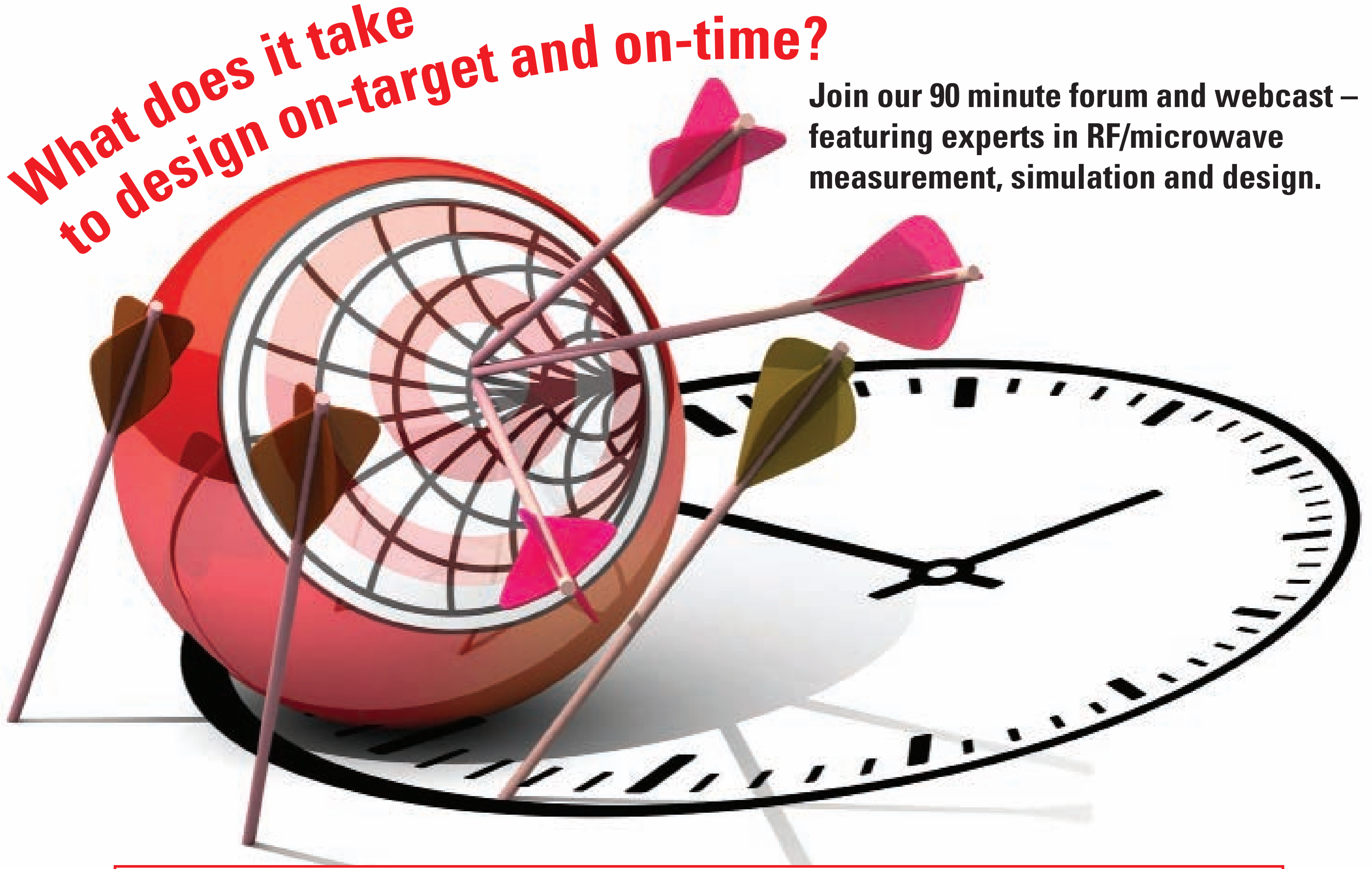
Have a great show and let me know if I can dig up any other gems for you. ■

David Strand *is CEO and Brand Director of Strand Marketing and a microwave industry insider. You can follow his insights on Twitter @ StrandMkt or reach him at dstrand@strandmarketing.com.*

IEEE MTT-S IMS 2012 MicroApps Expert Forum

Device Characterization Methods & Advanced RF/Microwave Design

Montreal, Canada: June 20, 12:00 – 1:30 pm



What does it take to design on-target and on-time?

Join our 90 minute forum and webcast – featuring experts in RF/microwave measurement, simulation and design.

Register for the FREE webcast at www.mwjournal.com/IMS12_uAPPS_Webcast

To meet the demands set by commercial and defense related wireless communication systems, radar and avionics, designers of high-frequency electronics are required to develop products with greater performance and functionality, often with a smaller physical footprint and shorter design cycle.

Our panel of experts will discuss these challenges and the latest solutions available to designers to reduce design failure. An open panel discussion session will follow the presentations including audience questions from both live and online participants.

Speakers:

Todd Cutler, General Manager, Agilent EEsof EDA
Steve Reyes, Product Marketing Manager Network Analyzers, Anritsu
Gary Simpson, CTO, Maury Microwave
Josh Moore, Solution Architect, AWR Corporation

Organized By:

Microwave Journal & IMS 2012
MicroApps Steering Commitee

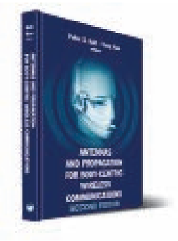
Moderated by: Dr. Larry Dunleavy, President and CEO of Modelithics, Inc.

Sponsored By:

Agilent Technologies
Anritsu
AWR
Maury Microwave Corporation
Anteverta
AMCAD Engineering Advanced Modeling for Computer-Aided Design

Microwave Journal
Frequency Matters.
See us at IMS Booth 2018

The Book End



Antennas and Propagation for Body-Centric Wireless Communications

Edited by Peter S. Hall and Yang Hao

Antennas and Propagation for Body-Centric Wireless Communications, second edition, is updated and revised providing complete and current details on the theory, design and applications of wireless antennas for on-body electronic systems. The book offers readers brand new material on advances in physical phantom design and production, recent developments in simulation methods and numerical phantoms, descriptions of methods for simulation of moving bodies, and the use of the body as a transmission channel. There is also a completely revised chapter on channel characterization and antenna design at microwave frequencies. This book includes the latest information for existing applications like Bluetooth headsets together with detailed treatment of techniques, tools and challenges in developing on-body antennas for an array of medical, emergency response, law enforcement, personal entertainment, and military applications on the horizon.

The book covers energy propagation around and into the body and how to estimate performance of on-body wireless links. Then it dives into the nuts-and-bolts of designing antenna systems that deliver the goods. It covers on-body communication channels at microwave frequency bands and at low frequency bands, as well as ultra wideband systems for WPANs and WBANs. It also includes details on body-centric UWB antennas and channels, as well as advances in wearable mobile, EBG, and "smart fabric" antennas for cellular and WLAN communications. Chapters on telemedicine applications, such as remote diagnoses and implantable medical devices cover crucial propagation issues and other obstacles that need to be addressed. Rounding out the coverage is a section on antenna design for body-sensor networks and their emerging military and space applications. The editors have gathered the latest information from noted experts in the field making this volume a very useful tool for engineers designing and improving body-centric communication systems.

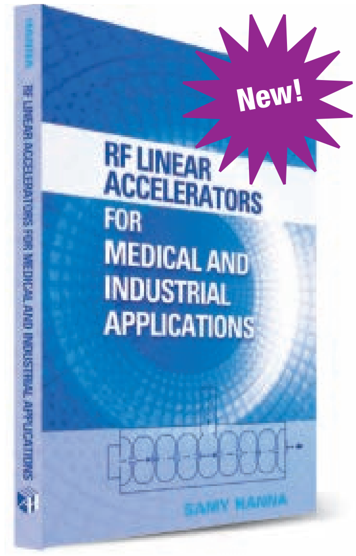
To order this book, contact:

Artech House
685 Canton Street
Norwood, MA 02062
(800) 225-9977
or
16 Sussex St., London, SW1V 4RW, UK
+44 (0) 20 7596 8750

340 pages; $169
ISBN: 978-1-60807-376-4

ARTECH HOUSE

ENJOY 20% OFF YOUR ENTIRE PURCHASE! USE PROMO CODE MWJ20



RF Linear Accelerators for Medical and Industrial Applications
Samy Hanna, Ph.D., P.E., *Microwave Innovative Accelerators (MINA)*

This unique resource offers you a clear overview of medical and industrial accelerators. Using minimal mathematics, this book focuses on offering thorough explanations of basic concepts surrounding the operation of accelerators.

- Presents well illustrated discussions designed to help you use accelerator-based systems in a safer, more productive, and more reliable manner;
- Details the manufacturing process for producing accelerators for medical and industrial applications;
- Examines the commonly encountered real-world manufacturing issues and potential sources of defects, helping you avoid costly production problems.

Contents: Introduction. Basic Concepts of Operation of Accelerators. Role of Accelerators in Cancer Radiation Therapy (RT). Accelerator-Based Commercial Applications. Manufacturing Techniques of Accelerators. Research Accelerators. Future Trends in Accelerator Design and Applications. Biography. Index.

Hardcover | 210 pp. | 2012 | ISBN: 978-1-60807-090-9 | $119/£79

US: **Call** 1-800-225-9977 (in the U.S. or Canada),
or 1-781-769-9750, ext. 4030
Fax to: 1-781-769-6334
E-mail to: artech@ArtechHouse.com

UK: **Call** +44 (0)20 7596 8750
Fax to: +44 (0)20 7630-0166
E-mail to: artech-uk@ArtechHouse.com

For complete descriptions and to order, visit
ArtechHouse.com

All orders plus shipping/handling and applicable taxes.
Offer expires 6/30/2012. Cannot be combined with any other offer.

ARTECH HOUSE
BOSTON | LONDON

685 Canton Street, Norwood, MA 02062 USA
16 Sussex Street, London SW1V 4RW UK

See us at IMS Booth 2014

微波 microwave 高速数字式 high speed digital

EDI CON

Electronic Design Innovation Conference

电子设计创新会议 2013

A new kind of technical conference and exhibition,
developed for and by the high-frequency/high-speed electronics industry
and Microwave Journal China.

March 12-14, 2013
Beijing, China
www.EDICONCHINA.com

Learning to Innovate at GHz and Gbps Rates …

EDI Con is an opportunity for design engineers and system integrators to learn about the latest RF/microwave and high speed digital products, design tools and technologies for today's communication, computing, RFID, industrial wireless monitoring, navigation, aerospace and related markets. A focus on enhancing physical design, emerging technologies and practical engineering solutions, brings together designers at the forefront of Chinese innovation and the world's leading technology companies.

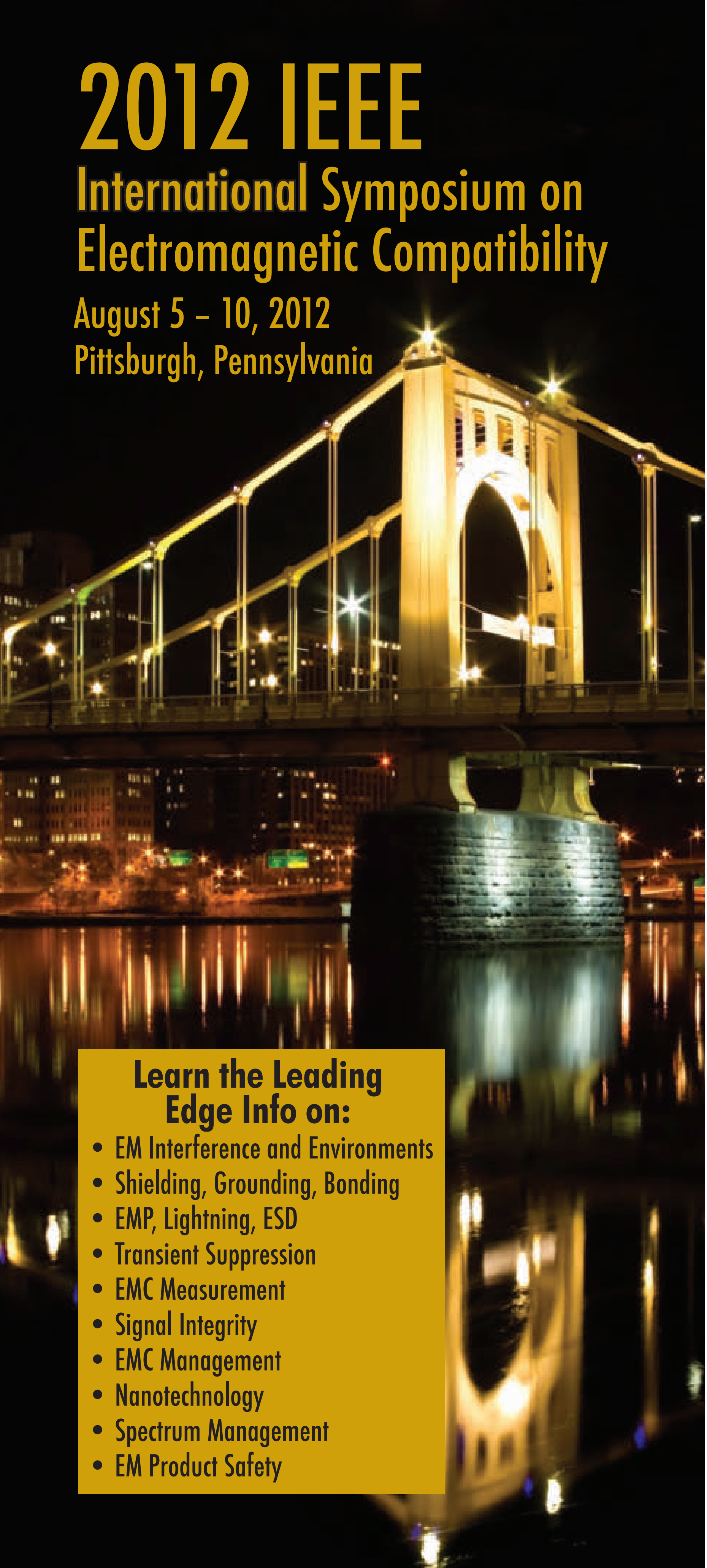
To learn more visit us at IMS Booth 2018.

Organized by

Microwave Journal
Frequency Matters.

horizon house®

Advertising Index



2012 IEEE
International Symposium on
Electromagnetic Compatibility

August 5 – 10, 2012
Pittsburgh, Pennsylvania

Learn the Leading Edge Info on:

- EM Interference and Environments
- Shielding, Grounding, Bonding
- EMP, Lightning, ESD
- Transient Suppression
- EMC Measurement
- Signal Integrity
- EMC Management
- Nanotechnology
- Spectrum Management
- EM Product Safety

EMC 2012
PITTSBURGH, PA

BRIDGE TO EMC

Cross over with us to the city of bridges. This event will have something for everyone — from the novice EMC engineer to the advanced practitioner. This is an opportunity to advance your knowledge, build new relationships, and reconnect with industry friends from around the world.

EMC SOCIETY®

IEEE

For Complete Event Details Visit:
www.emc2012.isemc.org

Advertising Index

®

Coming in June:

Semiconductors/MMICs/RFICs

- **MARKET OPPORTUNITIES FOR GAN: VIEWS FROM INDUSTRY EXPERTS**
- **WIDE BANDGAP GAN POWERS HIGH SPEED WIRELINE NETWORKS**
- **TECHNIQUES FOR TIME SIDELOBE MEASUREMENTS**

Sales Representatives

Frequency Matters.

CARL SHEFFRES, PUBLISHER

ED KIESSLING, TRAFFIC MANAGER

Eastern and Central Time Zones
Chuck Boyd
Northeast Reg. Sales Mgr.
(New England, New York, Eastern Canada)
685 Canton Street
Norwood, MA 02062
Tel: (781) 769-9750
FAX: (781) 769-5037
cboyd@mwjournal.com

Michael Hallman
Eastern Reg. Sales Mgr.
(Mid-Atlantic, Southeast, Midwest)
4 Valley View Court
Middletown, MD 21769
Tel: (301) 371-8830
FAX: (301) 371-8832
mhallman@mwjournal.com

Pacific and Mountain Time Zones
Wynn Cook
Western Reg. Sales Mgr.
208 Colibri Court
San Jose, CA 95119
Tel: (408) 224-9060
FAX: (408) 224-6106
wcook@mwjournal.com

International Sales
Richard Vaughan
International Sales Manager
16 Sussex Street
London SW1V 4RW, England
Tel: +44 207 596 8742
FAX: +44 207 596 8749
rvaughan@horizonhouse.co.uk

Germany, Austria, and Switzerland (German-speaking)
WMS.Werbe- und Media Service
Brigitte Beranek
Gerhart-Hauptmann-Street 33,
D-72574 Bad Urach
Germany
Tel: +49 7125 407 31 18
FAX: +49 7125 407 31 08
bberanek@horizonhouse.com

Israel
Oreet Ben Yaacov
Oreet International Media
15 Kineret Street
51201 Bene-Berak, Israel
Tel: +972 3 570 6527
FAX: +972 3 570 6526
obenyaacov@horizonhouse.com

Korea
Young-Seoh Chinn
JES Media International
2nd Floor, ANA Bldg.
257-1, Myungil-Dong
Kangdong-Gu
Seoul, 134-070 Korea
Tel: +82 2 481-3411
FAX: +82 2 481-3414
yschinn@horizonhouse.com

Japan
Katsuhiro Ishii
Ace Media Service Inc.
12-6, 4-Chome,
Nishiiko, Adachi-Ku
Tokyo 121-0824, Japan
Tel: +81 3 5691 3335
FAX: +81 3 5691 3336
amskatsu@dream.com

China
Michael Tsui
ACT International
Tel: 86-755-25988571
Tel: 86-21-62511200
FAX: 86-10-58607751
michaelT@actintl.com.hk

Hong Kong
Mark Mak
ACT International
Tel: 852-28386298
markm@actintl.com.hk

Enter the MWJ Puzzler Contest For a chance to Win a Kindle Fire!

3 Chances to Win!

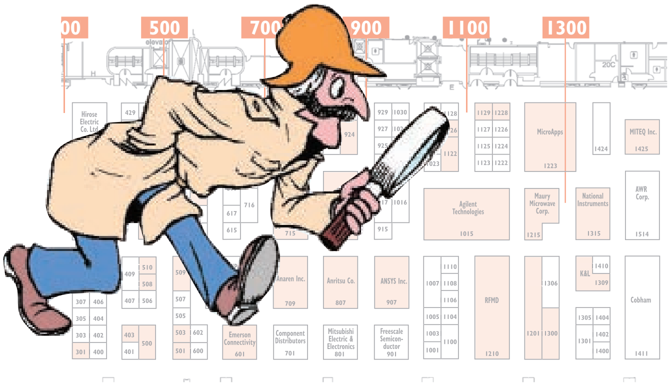
Winners Announced One Hour Prior to the Close of the Show Each Day:

Tuesday, June 19th at 4:00pm
Wednesday, June 20th at 4:00pm
Thursday, June 21st at 2:00pm

Drop off your Completed Puzzler Sheet at MWJ Booth #2018
You don't have to be present at the drawing to win
(But then you'll miss all the fun)

IMS 2012 Products Scavenger Hunt

See the next page for details and the form



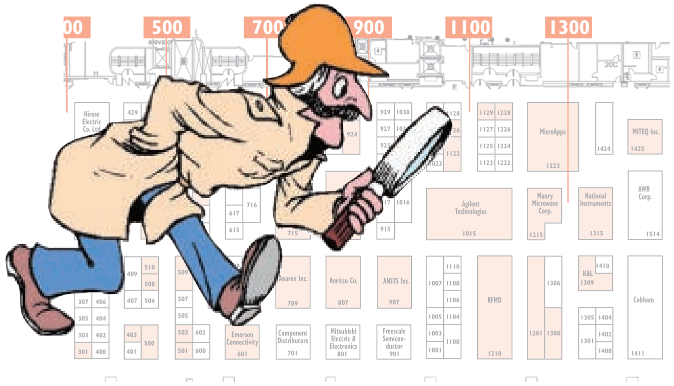
Microwave Journal
Frequency Matters.

Montréal
Canada

MWJ
PUZZLER

IMS 2012 Scavenger Hunt

An IMS exhibition attendee has a lot of vendors to visit in a short period of time. To find what you need, you need to know where to look. The missing term in the following sentences can be found among the vendors in this issue's IMS Product Showcase. Use the clue and look up the vendor's product description (pg. 250) by booth number to find the correct missing word.



1. The ___ ___ ___ is one of the first components after the antenna in the signal chain of a noise sensitive receiver. Find one by going to vendors in Booths 815, 1210, 1425 or 2418.

2. To keep out unwanted signals, vendors in Booths 1728, 2236, 2916 and 3006 are displaying components with high ___ ___ ___ ___ ___ ___ ___ ___ ___.

3. If you need to extend the dynamic range of an instrument, you may need an ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ from one of the vendors in Booths 601, 1129, 1704 or 2616.

4. Component and test equipment manufacturers in Booths 112, 1015, 1300, 1600, 1607, 2926 and 3206 know the importance of providing their customers with low ___ ___ ___ ___ ___   ___ ___ ___ ___ ___.

5. The solid outer metal sheath gives the ___ ___ ___ ___   ___ ___ ___ ___ ___   ___ ___ ___ ___ ___ offered by vendors in Booths 509, 514 and 3303 excellent shielding properties.

6. A ___ ___ ___ ___   ___ ___ ___ ___ ___ ___ can be realized in many technologies, from waveguide to semiconductors, but vendors in Booths 510, 1129, 1210 and 1507 will help you route your signals with minimal insertion loss into two signal paths.

7. Vendors in Booths 907, 1615 and 2430 use 3D electromagnetics to provide ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ of your high frequency structures.

8. A harmonic and mixed-signal active ___ ___ ___ ___   ___ ___ ___ ___ system can be found in Booth 1215.

9. To understand and mitigate the impact of in-band spurious signals due to ___ ___ ___, look for products and test solutions from vendors in Booths 1015, 2219, and 3217.

10. Anyone designing components at E- and W-Band will benefit from using the ___ ___ ___ ___ ___ ___ ___ ___ ___ Vector Analysis System available in Booth 807.

Bonus Puzzler Points

Use the letters in this popular component to spell out a famous Canadian icon. Letters may be used more than once.

AMPLIFIER

___ ___ ___ ___ ___   ___ ___ ___ ___

Drop off the completed puzzler at MWJ Booth #2018 for a chance to win a daily drawing of a Kindle Fire.

Name:____

Mobile Phone:______________________________________

E-Mail:____

Sponsored By:

Mini-Circuits®
ISO 9001 ISO 14001 AS 9100

As good as PTS synthesizers look on paper...

Low Spurious, Low Noise
As low as -152 dBc/Hz
(100 MHz output,
100 KHz offset)

Fast Switching
20 µs frequency
switching broadband

Reliability
3-year warranty,
first in the industry

Value
Configure a system to
fit your needs with our vast
selection of options

Selection
Over a dozen models from
0.1 MHz to 6.4 GHz; custom
configurations available

...they look even better in your system.

For years, engineers and OEMS alike have relied on PTS frequency synthesizers for unmatched stability, speed, and spectral purity. With the most complete line of frequency synthesizers available in the industry, PTS produces fast switching, low noise synthesizers with the best performance-to-price ratio on the market. Choose from over a dozen different models or design your own custom configuration to meet your testing needs. Visit our website for complete product specifications and to download a catalog, or call today to request a printed catalog.

www.programmedtest.com

1-978-486-3400

PTS
FREQUENCY SYNTHESIZERS

WERLATONE

Mismatch Tolerant®

HIGH POWER, MULTI-OCTAVE PERFORMANCE

20-1000 MHz

IN-PHASE COMBINERS & DIRECTIONAL COUPLERS

- **Tolerate Severe Power Unbalances**
- **Lowest Loss**
- **Excellent Port-to-Port Isolation**
- **Small Package Sizes**
- **Conservative Power Ratings**

- **POWER COMBINERS/DIVIDERS**
- **DIRECTIONAL COUPLERS**
- **90° HYBRID COUPLERS**
- **0°/180° HYBRID JUNCTIONS**

Werlatone, Inc.
17 Jon Barrett Road
Patterson, New York 12563
T 845.278.2220
F 845.278.3440
www.werlatone.com

In-Phase Combiners/Dividers

Model	Type	Frequency (MHz)	Power (WCW)	Size (Inches)	Insertion Loss (dB)	VSWR	Isolation (dB)
D6233	2-Way	10-1000	25	3.25 x 2 x 1.1	0.75	1.35:1	20
D8632	2-Way	20-1000	50	2.2 x 2.02 x 1.5	0.7	1.40:1	20
D8300	2-Way	20-1000	100	2.45 x 2 x 0.91	0.5	1.35:1	20
D8544W*	2-Way	20-1000	100	2.85 x 2.5 x 1	0.5	1.35:1	18
D8682	2-Way	20-1000	500	5.2 x 2.65 x 1.8	0.6	1.35:1	15
D8851W*	2-Way	20-1000	500	5.6 x 3.05 x 1.8	0.6	1.35:1	15
D7365	4-Way	20-1000	100	5 x 2 x 1	0.75	1.35:1	20
D7439	4-Way	20-1000	250	5 x 5 x 1.5	0.75	1.35:1	18
D8746	4-Way	20-1000	500	7.2 x 3.5 x 1.4	0.7	1.35:1	15
D9048	4-Way	20-1000	500	5 x 4.7 x 1.4	0.6	1.35:1	17

* "W" references a Watertight Design

Dual Directional Couplers

Model	Coupling (dB)	Frequency (MHz)	Power (WCW)	Size (Inches)	Insertion Loss (dB)	VSWR	Directivity (dB)
C8858	40	10-1000	250	2.09 x 1.16 x 0.57	0.4	1.30:1	20
C8631*	40	20-1000	150	1.5 x 0.95 x 0.5	0.35	1.25:1	20
C8696	40	20-1000	150	1.76 x 1.16 x 0.57	0.35	1.25:1	20
C8686	40	20-1000	500	5.2 x 2.7 x 1.7	0.35	1.25:1	20

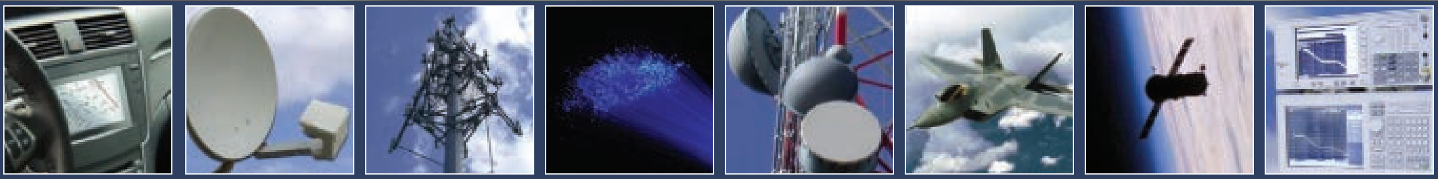
* Non-Connectorized / Tabs

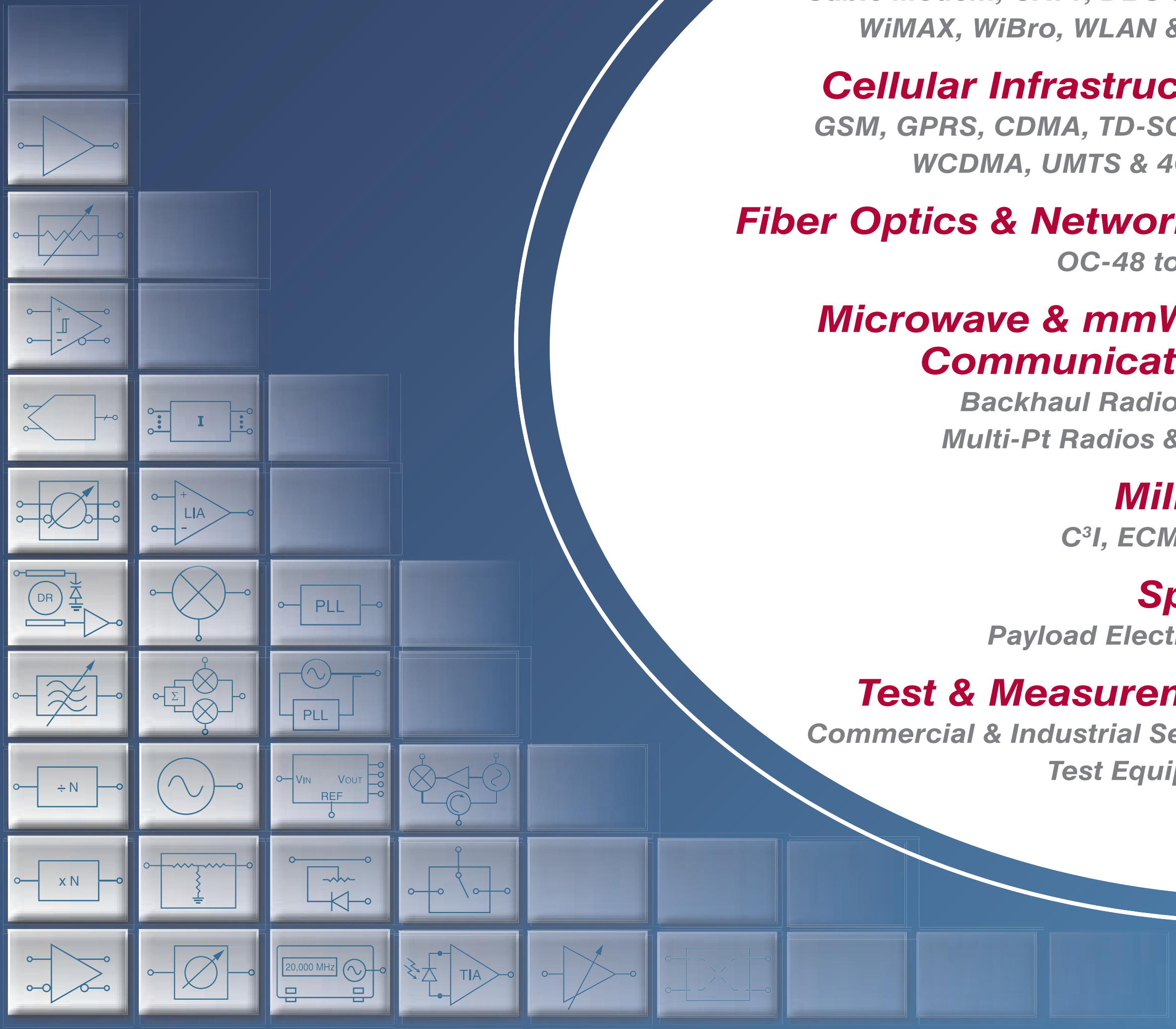
Our Patented, Low Loss designs tolerate high unbalanced input powers, while operating into severe Load Mismatch conditions.

See us at IMS Booth 2236

PRODUCT SELECTION GUIDE

*Analog, Digital & Mixed-Signal ICs, Modules,
Subsystems & Instrumentation, DC - 110 GHz*





Automotive
Telematics & Sensors

Broadband
Cable Modem, CATV, DBS & VoIP
WiMAX, WiBro, WLAN & UWB

Cellular Infrastructure
GSM, GPRS, CDMA, TD-SCDMA,
WCDMA, UMTS & 4G / LTE

Fiber Optics & Networking
OC-48 to 100G

Microwave & mmWave Communications
Backhaul Radio Links
Multi-Pt Radios & VSAT

Military
C^3I, ECM & EW

Space
Payload Electronics

Test & Measurement
Commercial & Industrial Sensors
Test Equipment

Hittite
MICROWAVE CORPORATION

MAY 2012

REF# SG-0512

TABLE OF CONTENTS

Hittite Microwave Corporation is pleased to introduce our May 2012 Product Selection Guide summarizing over 1025 products including 21 new products. This selection guide organizes Hittite's portfolio by product line. Full specifications for each product are available at www.hittite.com. Click on "My Subscription" to receive the latest product releases.

HOW TO BUY:

Hittite Microwave Corporation offers many convenient ways to order products and/or receive pricing and delivery information. Our order entry/MRP system assures customer sample requests and orders will be entered quickly, tracked easily, and completed accurately on-time.

Direct Sales

- **HMC Field Sales Offices:**
  You may contact our corporate or field sales offices listed on the back cover for assistance in purchasing Hittite products.
- **Purchase On-line: www.hittite.com**
  With Hittite Microwave's E-Commerce capability customers can enjoy the convenience of on-line ordering via a secure shopping cart interface. Products can be purchased using either a MasterCard, Visa, American Express or JCB card. Orders are confirmed within one business day with delivery information. Orders ship within 2 business days of confirmation, based on availability.
- **Purchase Orders via HMC Corporate Sales:**
  You may contact Hittite Microwave directly at (978) 250-3343. Purchase orders can be faxed to (978) 250-3373 or sent via email to sales@hittite.com. There is a minimum purchase order value of $500.00 (U.S. Dollars).

Worldwide Network of Sales Representatives

You may purchase our products through our network of manufacturer representatives listed on the back cover.

- ***European customers may also purchase products in Euros (€) directly from Hittite Microwave Deutschland GmbH (germany@hittite.com).***
- ***Japanese customers may also purchase products in Yen (¥) directly from Hittite KK - Japan (japan@hittite.com).***

OUR QUALITY POLICY:

Hittite Microwave Corporation is Committed to:

- *Being a supplier of products of the highest quality.*
- *Advancing state-of-the-art technology to support our products.*
- *Enhancing our competitive position with superior products.*

Hittite's Quality Policy Recognizes Responsibilities for Every Individual to:

- *Take the initiative to promote quality.*
- *Create an environment where the highest quality standards are maintained.*
- *Participate in continuous improvement practices.*

QUALITY & PRODUCT SUPPORT:

The Quality & Product Support Section of Our Web Site Includes:

- *Quality Assurance -*
  Product manufacturing, qualification & screening flows
- *Product Reliability*
- *Qualification Test Reports*

Product Application Support

- *Application Engineering Support*
- *Application Notes*
- *Mixer Spur Chart Calculator, Parametric Search & PLL Phase Noise Calculator*
- *Product Cross Reference*
- *Package & Layout Drawings -*
  Product outline, PCB land pattern and tape & reel drawings
- *Published Papers*
- *S-Parameter Files*

Data Sheets

- *Complete product data sheets can be found on our web site.*

HMC is ISO 9001:2000, AS9100 and ANSI/ESD S20.20-2007 certified. Every component is backed by every Hittite employee and subcontractor's commitment to total quality, thus providing our customers with products that meet or exceed all requirements, are delivered on-time and function reliably throughout their useful life.

WHAT WE DO

Hittite Microwave Corporation is an innovative designer and manufacturer of high performance integrated circuits (ICs), modules, subsystems and instrumentation for technically demanding digital, RF, microwave and millimeterwave applications covering DC to 110 GHz. The Company's standard and custom products apply analog, digital and mixed-signal semiconductor technologies, which are used in a wide variety of wireless / wired communication and sensor applications for Automotive, Broadband, Cellular Infrastructure, Fiber Optics & Networking, Microwave & Millimeterwave Communications, Military, Test & Measurement and Space markets. We offer over 1025 products across 35 product lines.

RF & Microwave ICs
Amplifiers
Attenuators
Automatic Gain Control
DC Power Conditioning
Filters - Tunable
IF / Baseband Processing
I/Q Mixers/IRMs
I/Q Downconverter/Receivers
I/Q Upconverters/Transmitters
Mixers
Modulators/Demodulators
Passives
Phase Shifters
Power Detectors
SDLVAs
Switches
Transceivers
Variable Gain Amplifiers

Analog & Mixed-Signal ICs
Broadband Time Delays
Comparators
Crosspoint Switches
Data Converters
DC Power Conditioning
DC Power Management
High Speed Digital Logic
IF/ Baseband Processing
Interface
Limiting Amplifiers
Mux & Demux
Optical Modulator Drivers
Transimpedance Amplifiers

Clocks & Timing ICs
Clock Distribution
Clock Generators
PLL with Integrated VCOs

LO Freq. Generation ICs
DC Power Conditioning
Filters - Tunable
Freq. Dividers & Detectors
Freq. Mulitipliers
Phase Locked Loop
PLL with Integrated VCOs
VCOs
PLOs

Connectorized Modules
Amplifiers
Attenuators
DROs
Freq. Dividers & Detectors
Freq. Multipliers
High Speed Digital Logic
I/Q Mixers
Mixers
Phase Shifters
SDLVAs
Switches
Synthesizer Module, MicroSynth®
VCOs

Instrumentation
Signal Generators

We design and supply custom analog and digital ICs, modules, subsystems and instrumentation, combining multiple functions for specific requirements. We select the most appropriate semiconductor and package technologies, uniquely balancing digital and analog integration techniques.

Our custom and standard products support a wide range of wireless / wired communications & radar applications for the following markets:

Automotive
Telematics & Sensors

Broadband
CATV, DBS, WiBro, WiMAX, WLAN, Fixed Wireless & UW

Cellular Infrastructure
GSM, GPRS, CDMA, WCDMA, UMTS, TD-SCDMA & 4G/LTE

Fiber Optic & Networking
OC-48 to 100G

Microwave & mmWave Communications
Backhaul Radio Links
Multi-Pt Radios & VSAT

Military
C^{3}I, ECM & EW

Space
Payload Electronics

Test & Measurement
Commercial / Industrial Sensors & Test Equipment

AMPLIFIERS - *Linear & Power*

Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	ECCN Code	Part Number
9 - 13.3	2W Power Amplifier	34	42	5.5	33	+6V @ 1400 mA	Chip	3A001.b.2.b	**HMC952**
9 - 14	2W Power Amplifier	33	43	-	34	+6V @ 1400 mA	LP5G	3A001.b.2.b	**HMC952LP5GE**
33.5 - 46.5	0.5W Medium Power Amplifier	21	35	-	24.5	+6V @ 500 mA	Chip	3A001.b.2.d	**HMC1014**
27.5 - 33.5	1W Power Amplifier	24	40	-	29	+6V @ 600 mA	Chip	3A001.b.2.d	**HMC1024**
29 - 37	2W Power Amplifier	22	42	6	32	+6V @ 1200 mA	Chip	3A001.b.2.d	**HMC1029**
24 - 43.5	Low Noise Amplifier	23	22	2.3	12	+2.5V @ 70 mA	LP3C	3A001.b.2.d	**HMC1040LP3CE**

CLOCKS & TIMING

Clock Distribution

Max. Clock Rate (GHz)	Function	Input	Output	Phase Jitter (12 k to 20 MHz)	Rise/Fall Time (ps)	Channel Skew (ps)	Disable Mode	Power Supply (V)	Package	ECCN Code	Part Number
4	Clock Divider & Delay Management	LVPECL, LVDS, CML, CMOS	LVPECL	13 fs RMS	90	300 to 1500	Yes	5 or 3.3	LP3	3A001.a.11.b	**HMC988LP3E**

Clock Generators

Max. Frequency (MHz)	Function	Typical Phase Jitter (fsRMS)	Phase Noise Floor (dBc/Hz)	Maximum Reference Freq. (MHz)	Typical Power Consumption (W)	Figure of Merit (Frac/Int) (dBc/Hz)	Package	ECCN Code	Part Number
500	Integer Mode PLL (x1, x5, x10)	Defined by VCXO	Defined by VCXO	140	0.0064	-208	MS8	EAR99	**HMC1031MS8E**

DATA CONVERTERS

Low Power Analog-to-Digital Converters

Sample Rate	Function / Mode	Resolution (bits)	# of Channels	Power Dissipation	SNR (dBFS)	SFDR (dBc)	Package	ECCN Code	Part Number
20/40/50/65 MSPS	Octal Channel	10	8	12/20/25/30 mW / Channel	61.6	81	LP9E	EAR99	**HMCAD1104**

Ultra High Speed Analog-to-Digital Converters

Input Frequency (GHz)	Function	Sample Rate (Gsps)	Resolution (Bits)	ENOB	SFDR (dBFS)	Package	ECCN Code	Part Number
20	3-Bit ADC with 1:2 Demux	26	3	2.9	26	LP9	3A001.a.11.b	**HMCAD5831LP9BE**

Track-and-Hold Amplifiers

Input Frequency (GHz)	Function	Single Tone THD/SFDR (dB)	Maximum Clock Rate (GS/s)	Output Noise (mV RMS)	Hold Mode Feed-through Rejection (dB)	Package	ECCN Code	Part Number
DC - 18	Track-and-Hold	-65 / 67	4.0	1.65	> 60	LC4B	3A001.a.11.b	**HMC661LC4B**
DC - 5	Track-and-Hold	-65 / 67	4.0	0.86	> 60	LC4B	3A001.a.11.b	**HMC760LC4B**

DC POWER MANAGEMENT - *Active Bias Controller*

Supply Range (V)	Function	VDRAIN Range (V)	IDRAIN Bias Current (mA)	IGATE Drive Current (mA)	VGATE Range(V)	Over/Under IDRAIN Current Alarm	Package	ECCN Code	Part Number
5 - 16.5	Active Bias Controller	5 - 16.5	50 - 1600	-4 to 4	-2.46 to +2.04	Yes	Chip	EAR99	**HMC980**

FILTERS - *Tunable*

Programmable Harmonic

Frequency Range (GHz)	Function	Return Loss (dB)	3 dB Bandwidth(GHz)	Stopband Frequency (Rej. >10 dB)	Tuning Response (ns)	Package	ECCN Code	Part Number
0.25 - 3.025	Programmable Harmonic Low Pass	10	1 - 3	1.2 Fcutoff	10	LP3	EAR99	**HMC1044LP3E**

Band Pass

Frequency Range (GHz)	Function	Return Loss (dB)	3 dB Bandwidth (%)	Low Side Rejection Frequency (Rej. >20 dB)	High Side Rejection Frequency (Rej. >20 dB)	Tuning Response (ns)	Package	ECCN Code	Part Number
9 - 19	Band Pass	9.5	18	0.81 x Fcenter	1.17 x Fcenter	200	Chip	EAR99	**HMC897**

I/Q Mixers / IRMs

RF Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Package	ECCN Code	Part Number
15 - 33.5	I/Q Mixer / IRM	DC - 3.5	-10	40	22	LC4	EAR99	**HMC1042LC4**

MIXERS - *Downconverter RF ICs & +13 to +14 dB LO Double & Triple Balanced*

RF Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Package	ECCN Code	Part Number
0.7 - 3.5	High IP3 Dual Downconverter	0.05 - 0.35	7	55	+25	LP4	EAR99	**HMC990LP4E**
2 - 18	Double Balance Mixer	DC - 2	-10	35	19	LC3B	EAR99	**HMC91048LC3B**

OPTICAL MODULATOR DRIVERS

Data Rate Max. (Gbps)	Function	Gain (dB)	Group Delay Variation (ps)	Additive Jitter (ps)	Output Voltage Max. (Vp-p)	Package	ECCN Code	Part Number
32	8Vpp Optical Modulator Driver, SMT Package	32	±7	0.25	8	BGA	EAR99	**HMC5850BG**

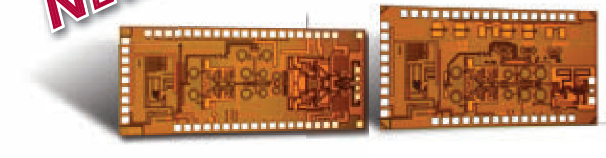
TRANSCEIVERS - *New Product Line!*

Frequency (GHz)	Function	P1dB (dBm) NF (dB)	Max Gain (dB)	Gain Adjust (dB)	Phase Noise @ 1 MHz Offset (dBc/Hz)	Power Dissipation (W)	Package	ECCN Code	Part Number
57 - 64	60 GHz Integrated Transmitter	12 dBm	38	17	-86	0.8	Chip	5A991.b	**HMC6000**
57 - 64	60 GHz Integrated Receiver	6 dB	67	65	-86	0.61	Chip	5A991.b	**HMC6001**

New & Expanded Product Lines

HMC6000 & HMC6001 Millimeterwave Transmitter & Receiver ICs, 57 - 64 GHz

New!

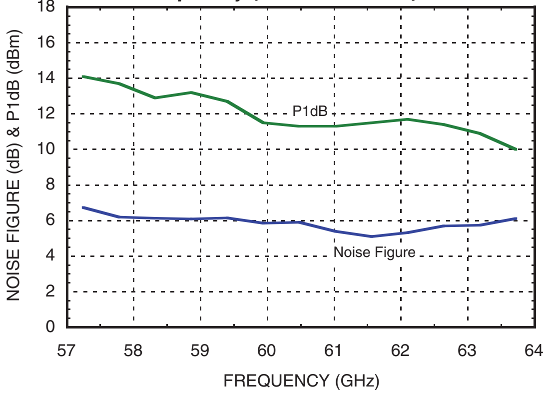


Supports WiGig & IEEE 802.11ad Multi-Gbps Solutions!

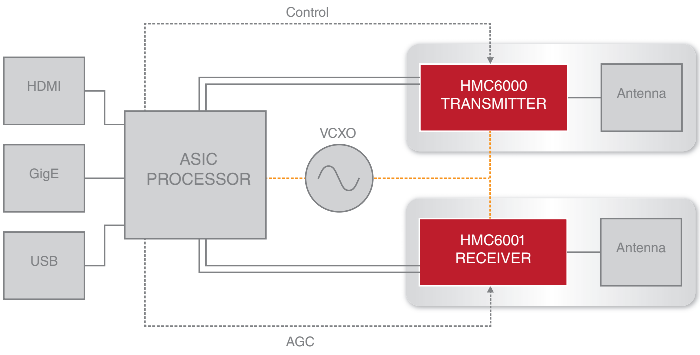
Features

- Covers 57 - 64 GHz Frequency Band
- Complete Baseband to RF Solutions
- Integrated Frequency Synthesizer
- Universal Analog I/Q Baseband Interface
- Up to 1.8 GHz RF Bandwidth

Rx Noise Figure & Tx P1dB vs. Frequency (Maximum Gain)



INDOOR Gbps LINKS



Highly Integrated IC Radio Solutions for Low-Cost 60 GHz Applications!

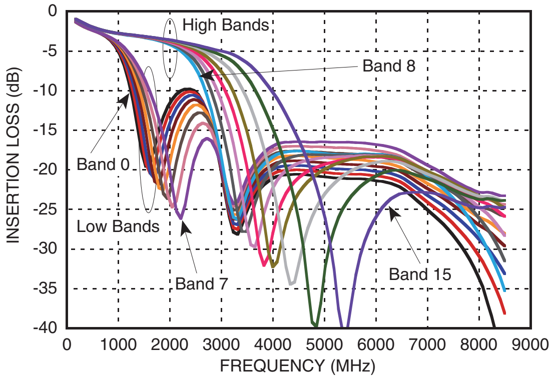
HMC1044LP3E Industry's First Programmable Harmonic Filter Ideally Suited for Multi-Standard, Multi-Carrier Applications

New!

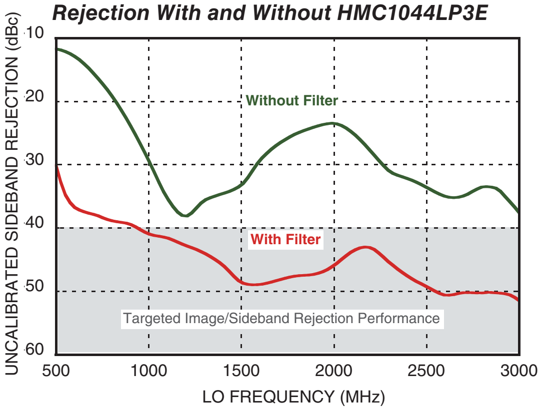
Features

- Programmable Bandwidth to Track Wideband Sources to 3 GHz
- 20 dB Typical LO Harmonic Rejection Improves Modulator/Demodulator Sideband/Image Rejection
- Integrated Filter, No Calibration Required
- Footprint up to 90% Smaller than Fixed Passive LO Filters

HMC1044LP3E for Programmable Harmonic LPF Gain vs. Frequency

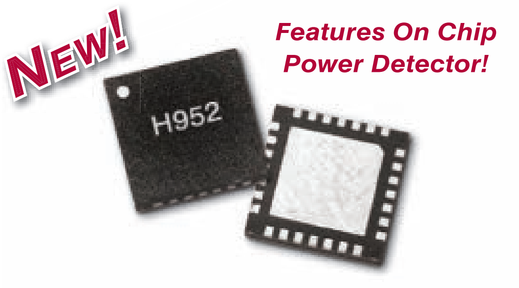


Example of Modulator Sideband Rejection With and Without HMC1044LP3E



Reduced Harmonic Content Dramatically Reduces Sideband Rejection When Driving Wideband Quadrature Mixers!

HMC952LP5GE GaAs pHEMT MMIC 2W Power Amplifier with Power Detector, SMT, 9 - 14 GHz

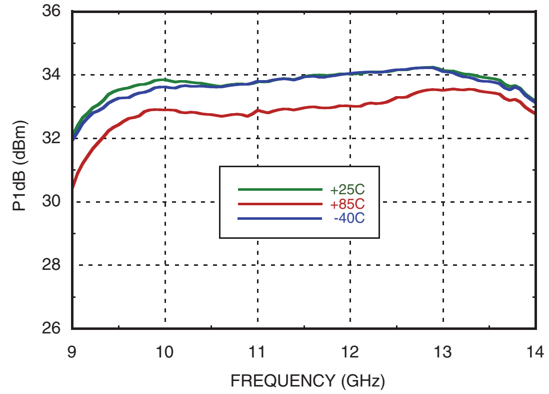


Features On Chip Power Detector!

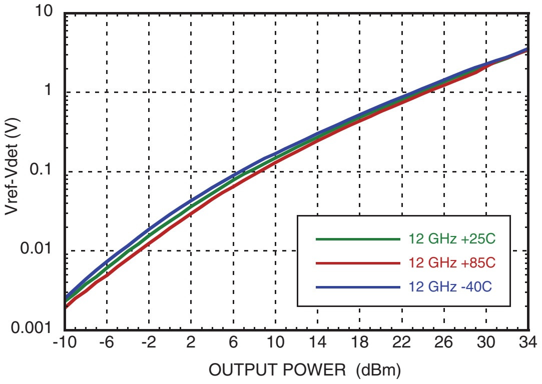
Features

- ***High P1dB Output Power: +34 dBm***
- ***High Psat Output Power: +35 dBm***
- ***High Gain: 33 dB***
- ***High Output IP3: +43 dBm***
- ***Supply Voltage: Vdd = +6V @ 1400 mA***

P1dB vs Temperature



Detector Voltage vs. Frequency & Temperature



Ideal for High Linearity Microwave Radio, Military SATCOM Applications!

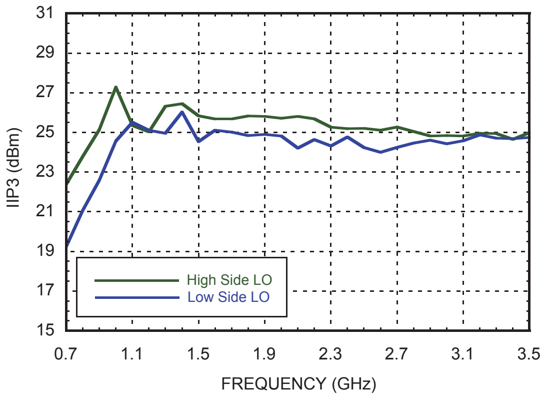
HMC990LP4E Broadband High IP3 Dual Channel Downconverter, 0.7 - 3.5 GHz

Compact Solution, 4 x 4 mm² QFN Package!

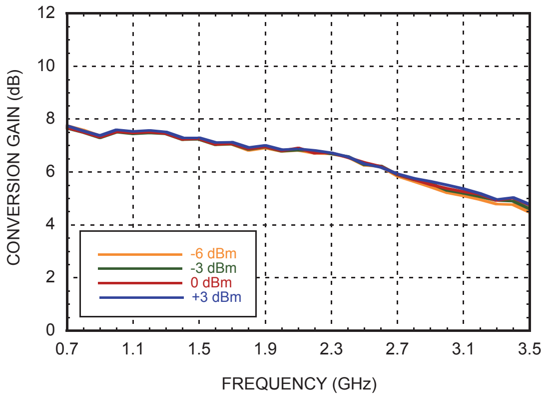
Features

- ***0.7 - 3.5 GHz Broadband Operation with No External Matching***
- ***High Input IP3: +25 dBm***
- ***SSB Noise Figure: 9 dB***
- ***Power Conversion Gain: 7 dB***

Input IP3 vs. High Side LO & Low Side LO @ VGATE = 4.8V



Conversion Gain vs. LO Drive @ VGATE = 4.8V



Ideal for Multi-Standard Cellular Base Station and Wideband Radio Link Receivers!

SMT & Chip (Die) Products

AMPLIFIERS

Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	ECCN Code	Part Number
Low Noise Amplifiers									
0.175 - 0.66	Low Noise	24	37	0.5	19	+5V @ 90 mA	LP3	EAR99	HMC616LP3E
0.23 - 0.66	Low Noise, Dual Channel	22	37	0.5	19	+5V @ 97 mA	LP4	EAR99	HMC816LP4E
0.3 - 3.0	Low Noise, High IP3	15	37	1.5	22	+5V @ 90 mA	SOT26	EAR99	HMC374E
0.55 - 1.2	Low Noise	16	37	0.5	21	+5V @ 88 mA	LP5	EAR99	HMC617LP3E
0.55 - 1.2	Low Noise, Dual Channel	16	37	0.5	20.5	+5V @ 95 mA	LP4	EAR99	HMC817LP4E
0.6 - 1.4	Low Noise	32	40	0.9	21.5	+5V @ 254 mA	LP4	EAR99	HMC718LP4E
0.7 - 1.2	Low Noise with Failsafe Bypass	16	33	0.9	13	+5V @ 57 mA	LP3	EAR99	HMC668LP3E
0.7 - 2.2	Low Noise	22	36	1.7	24	+5V @ 227 mA	LP3	EAR99	HMC758LP3E
1 - 11	Low Noise	17	30	1.5	18	+5V @ 55 mA	LP4	EAR99	HMC753LP4E [1]
1 - 12	Low Noise	17	28	1.5	19	+5V @ 55 mA	Chip	EAR99	HMC-ALH444 [1]
1.2 - 3.0	Low Noise	26	21	1.3	11.5	+5V @ 21 mA	LP3	EAR99	HMC548LP3E
1.3 - 2.9	Low Noise	34	39	1	21.5	+5V @ 272 mA	LP4	EAR99	HMC719LP4E
1.7 - 2.2	Low Noise	19	36	0.75	20	+5V @ 117 mA	LP3	EAR99	HMC618LP3E
1.7 - 2.2	Low Noise with Failsafe Bypass	17	29	1.4	12	+5V @ 86 mA	LP3	EAR99	HMC669LP3E
1.7 - 2.2	Low Noise, Dual Channel	20.5	35	0.85	21	+5V @ 112 mA	LP4	EAR99	HMC818LP4E
2 - 4	Low Noise	10	36	2.6	21	+6V @ 100 mA	Chip	EAR99	HMC594 [1]
2 - 4	Low Noise	10	36	3	21	+6V @ 100 mA	LC3B	EAR99	HMC594LC3B [1]
2 - 4	Low Noise	20.5	36	3	21	+6V @ 170 mA	Chip	EAR99	HMC609 [1]
2 - 4	Low Noise	20	36.5	3.5	21.5	+6V @ 170 mA	LC4	EAR99	HMC609LC4 [1]
2 - 12	Low Noise	15	25	1.8	13	+4V @ 45 mA	LC4	EAR99	HMC772LC4 [1]
2.1 - 2.9	Low Noise	19	33	0.9	19	+5V @ 95 mA	LP3	EAR99	HMC715LP3E
2.3 - 2.5	Low Noise	19	12	1.7	6	+3V @ 8.5 mA	SOT26	EAR99	HMC286E
2.3 - 2.7	Low Noise	19	29.5	0.75	16.5	+5V @ 59 mA	LP2	EAR99	HMC667LP2E
2.3 - 2.7	Low Noise with Bypass	20	31	1.1	17	+5V @ 74 mA	LP3	EAR99	HMC605LP3E
2.4 - 2.5	Transceiver, Front End	13	10	3	5	+3V @ 24 mA	MS8G	EAR99	HMC310MS8GE
3.1 - 3.9	Low Noise	18	33	1	19	+5V @ 65 mA	LP3	EAR99	HMC716LP3E
3.3 - 3.8	Low Noise with Bypass	19	29	1.2	16	+5V @ 40 mA	LP3	EAR99	HMC593LP3E
3.4 - 3.8	Low Noise with Bypass	16	18	2	7	+3V @ 9 mA	LP3	EAR99	HMC491LP3E
3.5 - 7.0	Low Noise	15.5	28	2.4	16	+5V @ 50 mA	Chip	EAR99	HMC392
3.5 - 7.0	Low Noise	16	30	2.5	16	+5V @ 55 mA	LC4	EAR99	HMC392LC4
3.5 - 7.0	Low Noise	15	28	3	16	+5V @ 65 mA	LH5	EAR99	HMC392LH5
4.8 - 6.0	Low Noise with Bypass	15	26	1.5	14	+5V @ 42 mA	LP3	EAR99	HMC604LP3E
4.8 - 6.0	Low Noise	16.5	31.5	1.1	18.5	+5V @ 73 mA	LP3	EAR99	HMC717LP3E
5 - 6	Low Noise	9	13	2.5	2	+3V @ 6 mA	MS8G	EAR99	HMC318MS8GE
5 - 6	Low Noise	12	10	2.5	9	+3V @ 25 mA	MS8G	EAR99	HMC320MS8GE
5 - 10	Low Noise	20	28	1.7	16	+3.5V @ 80 mA	Chip	EAR99	HMC902
5 - 10	Low Noise	19	28	1.8	16	+3.5V @ 80 mA	LP3	EAR99	HMC902LP3E
5 - 20	Low Noise	13	26	2.2	16	+5V @ 30 mA	Chip	EAR99	HMC-ALH435 [1]
6 - 17	Low Noise	18	25	1.7	14	+3.5V @ 80 mA	LP3	EAR99	HMC903LP3E
6 - 18	Low Noise	19	26	1.6	15	+3.5V @ 80 mA	Chip	EAR99	HMC903
6 - 20	Low Noise	22	20	2.3	10	+3V @ 53 mA	Chip	EAR99	HMC565
6 - 20	Low Noise	21	20	2.5	10	+3V @ 53 mA	LC5	EAR99	HMC565LC5
6 - 26.5	Low Noise	22	18	2.5	10	+3.5V @ 45 mA	LC4	EAR99	HMC963LC4
7 - 13.5	Low Noise	17	24	1.8	12	+3V @ 51 mA	Chip	EAR99	HMC564
7 - 14	Low Noise	17	25	1.8	13	+3V @ 51 mA	LC4	EAR99	HMC564LC4
7 - 17	Low Noise	21	20	1.8	15	+3V @ 65 mA	Chip	EAR99	HMC516
7.5 - 26.5	Low Noise	13	23	2.5	13	+3.5V @ 70 mA	LC4	EAR99	HMC962LC4
9 - 18	Low Noise	20	25	2	14	+3V @ 65 mA	LC5	EAR99	HMC516LC5
12 - 16	Medium Power LNA	23	34	2.5	25	+5V @ 200 mA	LP5	EAR99	HMC490LP5E [1]
12 - 17	Medium Power LNA	27	35	2	26	+5V @ 200 mA	Chip	EAR99	HMC490 [1]
13 - 25	Low Noise	21	13	3.5	5	+3V @ 41 mA	Chip	EAR99	HMC342
13 - 25	Low Noise	22	20	3.5	9	+3V @ 43 mA	LC4	EAR99	HMC342LC4
14 - 27	Low Noise	19.5	-	2.2	17	+4V @ 90 mA	LC4B	5A991.h	HMC504LC4B
14 - 27	Low Noise	18	-	2.5	14	+4V @ 90 mA	Chip	5A991.h	HMC-ALH216 [1]
14 - 27	Low Noise	20	-	2	14	+4V @ 90 mA	Chip	5A991.h	HMC-ALH476 [1]
17 - 26	Low Noise	19	23	2.2	11	+3V @ 65 mA	Chip	EAR99	HMC517
17 - 26	Low Noise	19	23	2.5	13	+3V @ 67 mA	LC4	EAR99	HMC517LC4
17 - 27	Low Noise	25	25	2.2	13	+4V @ 73 mA	LC4	EAR99	HMC751LC4
18 - 31	Low Noise	15	23	3.5	11	+3V @ 75 mA	LC4	EAR99	HMC519LC4
18 - 32	Low Noise	15	23	2.8	12	+3V @ 65 mA	Chip	3A001.b.2.d	HMC519
18 - 40	Low Noise	10	-	3.9	12	+5V @ 45 mA	Chip	3A001.b.2.d	HMC-ALH445

[1] Amplifiers that benefit from Hittite Active Bias Controllers

AMPLIFIERS

Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	ECCN Code	Part Number
20 - 32	Low Noise	15	23	3	12	+3V @ 65 mA	Chip	3A001.b.2.d	HMC518
21 - 29	Low Noise	13	19	2.5	8	+3V @ 35 mA	LC3B	EAR99	HMC341LC3B
22 - 26.5	Low Noise	25	-	3	12	+2.5V @ 52 mA	Chip	5A991.h	HMC-ALH311 [1]
24 - 28	Low Noise	25	26	2.5	13	+3V @ 70 mA	LC4	EAR99	HMC752LC4 [1]
24 - 30	Low Noise	13	16	2.5	6	+3V @ 30 mA	Chip	EAR99	HMC341
24 - 32	Low Noise	21	-	2	7	+5V @ 68 mA	Chip	3A001.b.2.d	HMC-ALH364
24 - 36	Low Noise	23	17	2	8	+3V @ 58 mA	Chip	3A001.b.2.d	HMC263
24 - 36	Low Noise	20	18	2.2	8	+3V @ 58 mA	LP4	3A001.b.2.d	HMC263LP4E
24 - 40	Low Noise	12	-	3.5	13	+4V @ 45 mA	Chip	3A001.b.2.d	HMC-ALH244
24 - 40	Low Noise	22	-	2	11	+5V @ 66 mA	Chip	3A001.b.2.d	HMC-ALH369
24 - 40	Low Noise	11.5	-	4	15	+4V @ 60 mA	Chip	3A001.b.2.d	HMC-ALH140 [1]
NEW! 24 - 43.5	Low Noise	23	22	2.3	12	+2.5V @ 70 mA	LP3C	3A001.b.2.d	HMC1040LP3CE
27 - 33	Low Noise	20	-	3	12	+2.5V @ 52 mA	Chip	3A001.b.2.d	HMC-ALH313 [1]
28 - 36	Low Noise	21	24	2.8	12	+3V @ 82 mA	LP4	3A001.b.2.d	HMC566LP4E
29 - 36	Low Noise	20	23.5	2.8	12	+3V @ 80 mA	Chip	3A001.b.2.d	HMC566
35 - 45	Low Noise	16	-	2	6	+4V @ 87 mA	Chip	3A001.b.2.d	HMC-ALH376
37 - 42	Low Noise	22	-	3.5	12	+2.5V @ 52 mA	Chip	3A001.b.2.d	HMC-ALH310 [1]
57 - 65	Low Noise	21	-	4	12	+2.5V @ 64 mA	Chip	3A001.b.2.f	HMC-ALH382 [1]
71 - 86	Low Noise	13	-	5	7	+2.4V @ 30 mA	Chip	3A001.b.2.f	HMC-ALH508
71 - 86	Low Noise	14	-	5	7	+2V @ 50 mA	Chip	3A001.b.2.f	HMC-ALH509
***Broadband Gain Blocks** (Listed by P1dB Output Power)*									
DC - 6	SiGe Gain Block	15.5	22	3	8	+5V @ 25 mA	MP86	EAR99	HMC474MP86E
DC - 6	SiGe Gain Block	15	20	3	8	+3V @ 25 mA	SC70	EAR99	HMC474SC70E
DC - 6	SiGe Gain Block	20	25	2.5	12	+5V @ 35 mA	MP86	EAR99	HMC476MP86E
DC - 6	SiGe Gain Block	19	24	2.5	12	+5V @ 35 mA	SC70	EAR99	HMC476SC70E
DC - 10	HBT Gain Block	15	24	4.5	13	+5V @ 56 mA	Chip	EAR99	HMC397
DC - 10	HBT Gain Block	15	25	4	13	+5V @ 50 mA	Chip	EAR99	HMC405
DC - 6	HBT Gain Block	17	27	6.5	14	+5V @ 50 mA	SOT26	EAR99	HMC313E
DC - 8	HBT Gain Block	12	30	6	14	+5V @ 56 mA	Chip	EAR99	HMC396
DC - 4	HBT Gain Block	15	28	4.5	15	+5V @ 54 mA	Chip	EAR99	HMC395
DC - 8	HBT Gain Block	15	30	5	15	+5V @ 54 mA	SC70	EAR99	HMC311SC70E
DC - 6	HBT Gain Block	14.5	32	4.5	15.5	+5V @ 56 mA	LP3	EAR99	HMC311LP3E
DC - 6	HBT Gain Block	16	31.5	4.5	15.5	+5V @ 54 mA	ST89	EAR99	HMC311ST89E
DC - 4	SiGe Gain Block	24	31	2.5	17	+5V @ 62 mA	SC70	EAR99	HMC478SC70E
DC - 4	SiGe Gain Block	22	32	2	18	+5V @ 62 mA	MP86	EAR99	HMC478MP86E
DC - 4	SiGe Gain Block	22	33	3	18	+5V @ 62 mA	ST89	EAR99	HMC478ST89E
DC - 5	SiGe Gain Block	15	34	4	18	+8V @ 72 mA	MP86	EAR99	HMC479MP86E
DC - 5	SiGe Gain Block	15	34	4	18	+8V @ 75 mA	ST89	EAR99	HMC479ST89E
DC - 5	Dual SiGe Gain Block	15	34	4	18	+8V @ 75 mA	MS8G	EAR99	HMC469MS8GE
DC - 5	SiGe Gain Block	20	33	3.5	19	+8V @ 79 mA	ST89	EAR99	HMC481ST89E
DC - 10	pHEMT Gain Block	14	30	7	20	+5V @ 76 mA	LP2	EAR99	HMC788LP2E
DC - 5	SiGe Gain Block	19	34	2.9	20	+8V @ 82 mA	ST89	EAR99	HMC480ST89E
DC - 5	SiGe Gain Block	20	33	3.5	20	+8V @ 74 mA	MP86	EAR99	HMC481MP86E
DC - 5	Dual SiGe Gain Block	20	34	3.2	20	+8V @ 80 mA	MS8G	EAR99	HMC471MS8GE
DC - 4	HBT Gain Block	21	33	4	21	+5V @ 82 mA	ST89	EAR99	HMC589ST89E
0.2 - 4.0	Low Noise, High IP3, pHEMT Gain Block	13	38	2.3	22	+5V @ 110 mA	ST89	EAR99	HMC639ST89E
0.2 - 4.0	Low Noise, High IP3, pHEMT Gain Block	13	40	2.2	22	+5V @ 155 mA	ST89	EAR99	HMC636ST89E
DC - 1	HBT Gain Block	22	37	2.8	22	+5V @ 88 mA	ST89	EAR99	HMC580ST89E
DC - 4.5	HBT Gain Block	21	35	3.5	22	+8V @ 110 mA	ST89	EAR99	HMC475ST89E
DC - 5	SiGe Gain Block	19	36	4	22	+8V @ 110 mA	ST89	EAR99	HMC482ST89E
CATV Amplifiers									
0.04 - 0.96	Low Noise, Dual Output	5	27	3.5	12	+5V @ 120 mA	MS8G	EAR99	HMC549MS8GE
0.05 - 1.0	Low Noise, 75 Ohm	14	39	2.2	19	+5V @ 120 mA	ST89	EAR99	HMC599ST89E
0.04 - 1.0	50 / 75 Ohm Differential Gain Block	16	40	2.5	23.5	+5V @ 270 mA	LP4B	EAR99	HMC770LP4BE
0.05 - 3.0	HBT Gain Block	15	40	3.5	18	+5V @ 88 mA	ST89	EAR99	HMC740ST89E
0.05 - 3.0	HBT Gain Block	20	42	2.5	18.5	+5V @ 96 mA	ST89	EAR99	HMC741ST89E
DC - 1	HBT Gain Block, 75 Ohm	14	38	5.5	21	+5V @ 160 mA	S8G	EAR99	HMC754S8GE
Driver Amplifiers									
0.7 - 2.8	HBT Driver Amplifier	18	42	3.8	25	+5V @ 125 mA	ST89	EAR99	HMC789ST89E
0.8 - 3.8	Driver Amplifier	18	30	7.5	17	+5V @ 53 mA	SOT26	EAR99	HMC308E
3.0 - 4.5	HBT Driver Amplifier	21	36	5	23.5	+5V @ 130 mA	MS8G	EAR99	HMC326MS8GE
17.5 - 41	Driver Amplifier	21	27	-	20	+5V @ 295 mA	Chip	3A001.b.2.d	HMC-AUH256

[1] Amplifiers that benefit from Hittite Active Bias Controllers

SMT & Chip (Die) Products

AMPLIFIERS

Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	ECCN Code	Part Number
Linear & Power Amplifiers									
0.4 - 2.5	High IP3 Amp, 1/2 Watt	12.5	42	6	27	+5V @ 150 mA	ST89	EAR99	HMC454ST89E
1.6 - 2.2	Medium Power Amplifier	22	40	5.5	27	+3.6V @ 270 mA	QS16G	EAR99	HMC413QS16GE
5 - 6	Medium Power Amplifier	17	38	6	26	+5V @ 300 mA	MS8G	EAR99	HMC406MS8GE
5 - 7	Medium Power Amplifier	15	40	5.5	25	+5V @ 230 mA	MS8G	EAR99	HMC407MS8GE
5 - 18	Medium Power Amplifier	18	28	7	19.5	+5V @ 120 mA	LP3	EAR99	HMC451LP3E
5 - 20	Medium Power Amplifier	22	30	6.5	20	+5V @ 127 mA	Chip	EAR99	HMC451
5 - 20	Medium Power Amplifier	19	30	7	19	+5V @ 114 mA	LC3	EAR99	HMC451LC3
6 - 18	Medium Power Amplifier	15.5	32	4.5	20	+5V @ 95 mA	Chip	EAR99	HMC441
6 - 18	Medium Power Amplifier	17	32	4.5	20	+5V @ 95 mA	LC3B	EAR99	HMC441LC3B
6.5 - 13.5	Medium Power Amplifier	14	29	4.5	18	+5V @ 95 mA	LP3	EAR99	HMC441LP3E
7 - 15.5	Medium Power Amplifier	15	32	4.8	20	+5V @ 95 mA	LH5 Hermetic	EAR99	HMC441LH5
7 - 15.5	Medium Power Amplifier	16	30	4.5	19	+5V @ 90 mA	LM1	EAR99	HMC441LM1
9.5 - 11.5	Medium Power Amplifier	29.5	33	6	27	+5V @ 310 mA	LC4	EAR99	HMC608LC4
12 - 30	Medium Power Amplifier	16	25	7	16	+5V @ 101 mA	Chip	EAR99	HMC383
12 - 30	Medium Power Amplifier	15	25	7.5	16.5	+5V @ 100 mA	LC4	EAR99	HMC383LC4
16 - 33	Medium Power Amplifier	17	33	-	24	+5V @ 400 mA	Chip	5A991.h	HMC-APH596
17 - 24	Medium Power Amplifier	24	34	4	25	+5V @ 250 mA	Chip	EAR99	HMC498
17 - 24	Medium Power Amplifier	22	36	4	25	+5V @ 250 mA	LC4	EAR99	HMC498LC4
17 - 30	Medium Power Amplifier	20	31	-	22	+4.5V @ 400 mA	Chip	5A991.h	HMC-APH196
17.5 - 24	Medium Power Amplifier	14	28	6.5	21.5	+5V @ 85 mA	LM1	EAR99	HMC442LM1
17.5 - 25.5	Medium Power Amplifier	15	28	5.5	22	+5V @ 85 mA	Chip	EAR99	HMC442 [1]
17.5 - 25.5	Medium Power Amplifier	13	27	8	22	+5V @ 84 mA	LC3B	EAR99	HMC442LC3B [1]
21 - 32	Medium Power Amplifier	16	33	5	24	+5V @ 200 mA	Chip	3A001.b.2.d	HMC499 [1]
21 - 32	Medium Power Amplifier	17	34	5	23	+5V @ 200 mA	LC4	3A001.b.2.d	HMC499LC4 [1]
NEW! 33.5 - 46.5	Medium Power Amplifier, 0.5 Wattr	21	35	-	24.5	+6V @ 500 mA	Chip	3A001.b.2.d	HMC1014
34 - 42	Medium Power Amplifier	18.5	29	6.5	18	+5V @ 120 mA	Chip	3A001.b.2.d	HMC-ABH264 [1]
34 - 46.5	Medium Power Amplifier	22	34	-	24	+6V @ 250 mA	Chip	3A001.b.2.f	HMC1016
37 - 40	Medium Power Amplifier	20	35	-	26	+5V @ 640 mA	Chip	3A001.b.2.d	HMC-APH510
37 - 45	Medium Power Amplifier	21	32	-	23	+5V @ 475 mA	Chip	3A001.b.2.d	HMC-APH403
50 - 66	Medium Power Amplifier	24	25	-	17	+5V @ 220 mA	Chip	3A001.b.2.f	HMC-ABH241
55 - 65	Medium Power Amplifier	13	25	-	16	+5V @ 80 mA	Chip	3A001.b.2.f	HMC-ABH209 [1]
71 - 76	Medium Power Amplifier	24	-	-	17.5	+4V @ 130 mA	Chip	3A001.b.2.f	HMC-AUH318 [1]
71 - 76	Medium Power Amplifier	13	-	-	20	+4V @ 240 mA	Chip	3A001.b.2.f	HMC-APH633
71 - 86	Medium Power Amplifier	15	-	-	15	+4V @ 130 mA	Chip	3A001.b.2.f	HMC-AUH320 [1]
81 - 86	Medium Power Amplifier	22	-	-	17.5	+4V @ 160 mA	Chip	3A001.b.2.f	HMC-AUH317 [1]
81 - 86	Medium Power Amplifier	12	-	-	19	+4V @ 240 mA	Chip	3A001.b.2.f	HMC-APH634
0.01 - 10	GaN Power Amplifier, 10 Watt	11	47	-	38	+48V @ 1100 mA	Chip	3A001.b.2.b	HMC999
0.1 - 22	Power Amplifier, 2 Watt	12	41	5	31	+15V @ 500 mA	Chip	3A001.b.2.c	HMC998
0.4 - 2.2	Power Amplifier, 1 Watt	21	49	6.5	30	+5V @ 510 mA	ST89	EAR99	HMC452ST89E
0.4 - 2.2	Power Amplifier, 1.6 Watt	20.5	49	6.5	32	+5V @ 725 mA	ST89	EAR99	HMC453ST89E
0.4 - 2.7	Power Amplifier, 2 Watt	16	48	8.5	33	+5V @ 700 mA	LP4	EAR99	HMC921LP4E
0.45 - 2.2	Power Amplifier, 1 Watt	22.5	48	7	30	+5V @ 485 mA	QS16G	EAR99	HMC452QS16GE
0.45 - 2.2	Power Amplifier, 1.6 Watt	21.5	51	6.5	33	+5V @ 725 mA	QS16G	EAR99	HMC453QS16GE
DC - 32	Power Amplifier, 1/2 Watt	14	36	4	28	+10V @ 250 mA	Chip	EAR99	HMC994
1.7 - 2.2	Power Amplifier, 1 Watt	27	46	5	30.5	+5V @ 500 mA	QS16G	EAR99	HMC457QS16GE
2.3 - 2.8	Power Amplifier, 1 Watt	31	45	5	32.5	+5V @ 430 mA	LP4	EAR99	HMC755LP4E
3 - 4	Power Amplifier, 1/2 Watt	21	40	5	27	+5V @ 250 mA	MS8G	EAR99	HMC327MS8GE
3.3 - 3.8	Power Amplifier, 1 Watt	31	45.5	5.8	30.5	+5V @ 615 mA	LP4	EAR99	HMC409LP4E
5.1 - 5.9	Power Amplifier, 1 Watt	20	43	6	30	+5V @ 750 mA	LP3	EAR99	HMC408LP3E
6 - 9.5	Power Amplifier, 1 Watt	21	40	-	30.5	+7V @ 820 mA	LP5	EAR99	HMC590LP5E
6 - 9.5	Power Amplifier, 2 Watt	18	41	-	33	+7V @ 1340 mA	LP5	3A001.b.2.b	HMC591LP5E
6 - 10	Power Amplifier, 1 Watt	25	41	-	31.5	+7V @ 820 mA	Chip	3A001.b.2.b	HMC590
6 - 10	Power Amplifier, 2 Watt	23	43	-	33.5	+7V @ 1340 mA	Chip	3A001.b.2.b	HMC591
7 - 9	Power Amplifier, 2 Watt	26	40	6.5	33.5	+7V @ 1.3A	Chip	3A001.b.2.b	HMC486
7 - 9	Power Amplifier, 2 Watt	22	40	7	32	+7V @ 1.3A	LP5	3A001.b.2.b	HMC486LP5E
9 - 12	Power Amplifier, 2 Watt	20	36	8	32	+7V @ 1.3A	LP5	3A001.b.2.b	HMC487LP5E
NEW! 9 - 13.3	Power Amplifier, 2 Watt	34	42	5.5	33	+6V @ 1400 mA	Chip	3A001.b.2.b	HMC952
NEW! 9 - 14	Power Amplifier, 2 Watt	33	43	-	34	+6V @ 1400 mA	LP5G	3A001.b.2.b	HMC952LP5GE
10 - 13	Power Amplifier, 1 Watt	19	38	-	31	+7V @ 750 mA	Chip	3A001.b.2.b	HMC592
12 - 16	Power Amplifier, 1 Watt	13	34	9	31	+7V @ 1.3A	LP5	3A001.b.2.b	HMC489LP5E
12.5 - 15.5	Power Amplifier, 2 Watt	30	42	-	34.5	+7V @ 1200 mA	Chip	3A001.b.2.b	HMC949

[1] Amplifiers that benefit from Hittite Active Bias Controllers

AMPLIFIERS

Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	ECCN Code	Part Number
12.5 - 15.5	Power Amplifier, 4 Watt	28	44	-	36	+7V @ 1200 mA	Chip	3A001.b.2.b	HMC950
12.5 - 15.5	Power Amplifier, 2 Watt	27	40	-	32	+6V @ 1200 mA	LP5	3A001.b.2.b	HMC965LP5E
12 - 16	PA with Power Detector, 3 Watt	27	41	-	34.5	+7V @ 1200 mA	LP5G	3A001.b.2.b	HMC995LP5GE
15 - 27	Power Amplifier, 1 Watt	17	37	-	29	+5V @ 1.44A	Chip	3A001.b.2.c	HMC-APH462
16 - 24	Power Amplifier, 1 Watt	23	41	-	31	+7V @ 790 mA	Chip	3A001.b.2.c	HMC756
16 - 24	Power Amplifier, 1/2 Watt	22	37	-	29	+7V @ 395 mA	Chip	EAR99	HMC757
16 - 24	Power Amplifier, 1/2 Watt	20.5	34.5	-	26.5	+5V @ 400 mA	LP4	EAR99	HMC757LP4E
18 - 20	Power Amplifier, 1 Watt	17.5	38.5	-	30	+5V @ 900 mA	Chip	3A001.b.2.c	HMC-APH478
21 - 24	Power Amplifier, 1 Watt	17	39	-	30.5	+5V @ 950 mA	Chip	3A001.b.2.c	HMC-APH518
22 - 26.5	Power Amplifier, 1/2 Watt	20	33	7	26.5	+5V @ 400 mA	LP4	EAR99	HMC863LP4E
22.5 - 26.5	Power Amplifier, 1 Watt	17	40	-	30	+5V @ 950 mA	Chip	3A001.b.2.c	HMC-APH608
24 - 29.5	Power Amplifier, 1/2 Watt	22	-	-	26.5	+6V @ 360 mA	Chip	EAR99	HMC863
24 - 29.5	Power Amplifier, 1 Watt	27	40	-	29	+6V @ 750 mA	Chip	3A001.b.2.c	HMC864
24 - 31.5	Power Amplifier, 1.5 Watt	22	43	-	34	+5.5V @ 1200 mA	LP5	3A001.b.2.c	HMC943LP5E
27 - 31.5	Power Amplifier, 1/2 Watt	14	37	-	28	+5V @ 900 mA	Chip	3A001.b.2.c	HMC-APH460
27 - 34	Power Amplifier, 1 Watt	17.5	37	-	29	+5V @ 800 mA	Chip	3A001.b.2.d	HMC693
27.3 - 33.5	Power Amplifier, 2 Watt	23	43	-	33	+6V @ 1200 mA	Chip	3A001.b.2.d	HMC906
NEW! 27.5 - 33.5	Power Amplifier, 1 Watt	24	40	-	29	+6V @ 600 mA	Chip	3A001.b.2.d	HMC1024
NEW! 29 - 37	Power Amplifier, 2 Watt	22	42	6	32	+6V @ 1200 mA	Chip	3A001.b.2.d	HMC1029
37 - 40	Power Amplifier, 1 Watt	15	37	-	28	+5V @ 1.08A	Chip	3A001.b.2.d	HMC-APH473
37 - 40	Power Amplifier, 1 Watt	21	38	-	30.5	+6V @ 900 mA	Chip	3A001.b.2.d	HMC968
40 - 43.5	Power Amplifier, 1 Watt	22	38	-	29	+6V @ 900 mA	Chip	EAR99	HMC969
Wideband (Distributed) Amplifiers									
DC - 20	Wideband LNA	14	28	2.5	16	+8V @ 60 mA	Chip	EAR99	HMC460 [1]
DC - 20	Wideband LNA	14	29.5	2.5	17	+8V @ 75 mA	LC5	EAR99	HMC460LC5 [1]
2 - 20	Wideband LNA	15	26.5	2.5	15	+5V @ 63 mA	Chip	EAR99	HMC462
2 - 20	Wideband LNA	13	25	2.5	14	+5V @ 66 mA	LP5	EAR99	HMC462LP5E
2 - 20	Wideband LNA with AGC	14	28	2.5	19	+5V @ 60 mA	Chip	EAR99	HMC463 [1]
2 - 20	Wideband LNA with AGC	13	26	3	18	+5V @ 60 mA	LP5	EAR99	HMC463LP5E [1]
2 - 20	Wideband LNA with AGC	14	28	2.5	18	+5V @ 60 mA	LH250	EAR99	HMC463LH250
2 - 20	Wideband LNA	10	-	3.5	10	+2V @ 55 mA	Chip	EAR99	HMC-ALH102
2 - 22	Wideband LNA	16	-	1.7	14	+4V @ 45 mA	Chip	EAR99	HMC-ALH482
DC - 20	Wideband Driver	17	30	2.5	22	+8V @ 160 mA	Chip	EAR99	HMC465 [1]
DC - 20	Wideband Driver	15	28	3	23	+8V @ 160 mA	LP5	EAR99	HMC465LP5E [1]
DC - 35	Wideband Driver	15	-	-	21	+5V @ 200 mA	Chip	3A001.b.2.d	HMC-AUH249
DC - 43	Wideband Driver	14	-	5.4	16.5	+5V @ 180 mA	Chip	3A001.b.2.d	HMC-AUH232
0.5 - 65	Wideband Driver	10	-	-	-	+8V @ 60 mA	Chip	3A001.b.2.d	HMC-AUH312
2 - 35	Wideband Driver	12.5	27	3	18	+8V @ 80 mA	Chip	3A001.b.2.d	HMC562 [1]
5 - 17	Wideband Driver	31	30	8	23	+5V @ 180 mA	Chip	EAR99	HMC633 [1]
5 - 20	Wideband Driver	22	31	7.5	23	+5V @ 180 mA	Chip	EAR99	HMC634 [1]
5 - 20	Wideband Driver	21	29	7.5	22	+5V @ 180 mA	LC4	EAR99	HMC634LC4 [1]
5.5 - 17	Wideband Driver	30	30	8	23	+5V @ 180 mA	LC4	EAR99	HMC633LC4 [1]
18 - 40	Wideband Driver	19.5	29	8	23	+5V @ 280 mA	Chip	3A001.b.2.e	HMC635
18 - 40	Wideband Driver	18.5	27	7	22	+5V @ 280 mA	LC4	3A001.b.2.d	HMC635LC4
DC - 48	Wideband Power Amplifier	12	32	-	22	+10V @ 150 mA	Chip	3A001.b.2.f	HMC1022
DC - 6	Wideband Power Amplifier	14	45	5	29	+12V @ 400 mA	Chip	EAR99	HMC637
DC - 6	Wideband Power Amplifier	13	40	5	29	+12V @ 400 mA	LP5	EAR99	HMC637LP5E
DC - 10	Wideband Power Amplifier	12	41	6	28.5	+12V @ 300 mA	Chip	EAR99	HMC619
DC - 10	Wideband Power Amplifier	12	41	6	28	+12V @ 300 mA	LP5	EAR99	HMC619LP5E
DC - 15	Wideband Power Amplifier	19	35	2	26.5	+8V @ 300 mA	Chip	EAR99	HMC659
DC - 15	Wideband Power Amplifier	19	35	2.5	27.5	+8V @ 300 mA	LC5	EAR99	HMC659LC5
DC - 18	Wideband Power Amplifier	17	32	3	25	+8V @ 290 mA	Chip	EAR99	HMC459
DC - 20	Wideband Power Amplifier	14	36	4	28	+10V @ 400 mA	Chip	3A001.b.2.c	HMC559
DC - 22	Wideband Power Amplifier	14	40	2.5	28	+11V @ 400 mA	Chip	3A001.b.2.c	HMC797
DC - 22	Wideband Power Amplifier	13.5	39	4	28	+10V @ 400 mA	LP5	EAR99	HMC797LP5E
DC - 40	Wideband Power Amplifier	13	33.5	5	22	+10V @ 175 mA	Chip	3A001.b.2.d	HMC930 [1]
0.2 - 22	Wideband Power Amplifier	13	38	3	27	+11V @ 365 mA	Chip	EAR99	HMC907
0.2 - 22	Wideband Power Amplifier	12	36	3.5	26	+10V @ 350 mA	LP5	EAR99	HMC907LP5E

[1] Amplifiers that benefit from Hittite Active Bias Controllers

SMT & Chip (Die) Products

AMPLIFIERS

Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	ECCN Code	Part Number
2 - 20	Wideband Power Amplifier	16	30	4	26	+8V @ 290 mA	Chip	EAR99	HMC464
2 - 20	Wideband Power Amplifier	14	30	4	26	+8V @ 290 mA	LP5	EAR99	HMC464LP5E

[1] Amplifiers that benefit from Hittite Active Bias Controllers

AMPLIFIERS - *Low Phase Noise*

Frequency (GHz)	Function	Gain / NF (dB)	OIP3 (dBm)	10 kHz SSB Phase Noise (dBc/Hz)	P1dB / Psat (dBm)	Bias Supply	Package	ECCN Code	Part Number
2 - 18	Wideband, Low Phase Noise	14 / 4.5	27	-160	15 / 18	+5V @ 64 mA	Chip	EAR99	HMC606
2 - 18	Wideband, Low Phase Noise	13.5 / 5	27	-160	15 / 17	+5V @ 64 mA	LC5	EAR99	HMC606LC5

ATTENUATORS

Frequency (GHz)	Function	Insertion Loss (dB)	Attenuation Range (dB)	IIP3 (dBm)	Control Input (Vdc)	Package	ECCN Code	Part Number
Attenuators - Analog								
0.45 - 2.2	Analog VVA	1.9	0 to 48	20	0 to +3V	MS8	EAR99	HMC473MS8E
0.5 - 6.0	Analog VVA	2.5	0 to 26	35	0 to +5V	LP3	EAR99	HMC973LP3E
DC - 8	Analog VVA	1.5	0 to 32	10	0 to -3V	MS8G	EAR99	HMC346MS8GE
DC - 8	Analog VVA	2	0 to 30	10	0 to -3V	C8	EAR99	HMC346C8
DC - 8	Analog VVA	2	0 to 30	10	0 to -3V	G8 Hermetic	EAR99	HMC346G8
DC - 14	Analog VVA	2	0 to 30	10	0 to -3V	LP3	EAR99	HMC346LP3E
DC - 18	Analog VVA	1.5	0 to 30	10	0 to -3V	LC3B	EAR99	HMC346LC3B
DC - 20	Analog VVA	2.2	0 to 25	10	0 to -3V	Chip	EAR99	HMC346
5 - 26.5	Analog VVA	3.5	0 to 28	32	0 to -3V	LP3C	EAR99	HMC712LP3CE
5 - 30	Analog VVA	2.5	0 to 30	32	0 to -3V	Chip	EAR99	HMC712
5 - 30	Analog VVA	2	0 to 28	28	0 to -3V	LC4	EAR99	HMC812LC4
17 - 27	Analog VVA	1.5	0 to 22	17	-4 to +4V	Chip	5A991.h	HMC-VVD102
20 - 50	Analog VVA	3	0 to 35	33	0 to +3V	Chip	EAR99	HMC985
36 - 50	Analog VVA	1.5	0 to 22	17	0 to +4V	Chip	5A991.h	HMC-VVD106
70 - 86	Analog VVA	2	0 to 14	-	-5 to +5V	Chip	5A991.h	HMC-VVD104
Attenuators - Digital								
DC - 5	1-Bit Digital	1	10	50	TTL/CMOS	LP3	EAR99	HMC541LP3E
DC - 10	1-Bit Digital	2	10	54	0 / +3 to +5V	LP3	EAR99	HMC800LP3E
DC - 10	1-Bit Digital	1.5	15	53	0 / +3 to +5V	LP3	EAR99	HMC801LP3E
DC - 10	1-Bit Digital	2.5	20	53	0 / +3 to +5V	LP3	EAR99	HMC802LP3E
0.7 - 4.0	2-Bit Digital	0.5	2 to 6	52	0 / +3V	SOT26	EAR99	HMC290E
0.7 - 4.0	2-Bit Digital	0.9	4 to 12	54	0 / +3V	SOT26	EAR99	HMC291E
DC - 6	2-Bit Digital	0.5	2 to 6	50	TTL/CMOS	LP3	EAR99	HMC467LP3E
0.75 - 2.0	3-Bit Digital	1.8	4 to 28	45	0 / +3V	MS8	EAR99	HMC230MS8E
0.7 - 3.7	3-Bit Digital	1.3	2 to 14	51	0 / +3V	MS8	EAR99	HMC288MS8E
DC - 6	3-Bit Digital	0.7	1 to 7	50	TTL/CMOS	LP3	EAR99	HMC468LP3E
DC - 5.5	4-Bit Digital	0.8	1 to 15	50	TTL/CMOS	LP3	EAR99	HMC540LP3E
DC - 6	4-Bit Digital, Serial & Parallel Control	2.5	3 to 45	50	0 / +5V	LP4	EAR99	HMC629LP4E
0.1 - 30	5-Bit Digital	2.5	0.5 to 15.5	45	0 / +3 to +5V	Chip	EAR99	HMC941
0.1 - 30	5-Bit Digital, Serial Control	5	1 to 31	43	0 / +3 to +5V	LP4	EAR99	HMC1018LP4E
0.1 - 30	5-Bit Digital, Serial Control	4	0.5 to 15.5	45	0 / +3 to +5V	LP4	EAR99	HMC1019LP4E
0.1 - 33	5-Bit Digital	5	1 to 31	43	0 / +3 to +5V	LP4	EAR99	HMC939LP4E
0.1 - 33	5-Bit Digital	4	0.5 to 15.5	45	0 / +3 to +5V	LP4	EAR99	HMC941LP4E
0.1 - 40	5-Bit Digital	3.5	1 to 31	43	0 / +3 to +5V	Chip	EAR99	HMC939
0.7 - 2.7	5-Bit Digital	2.3	1 to 31	54	0 / +3V	QS16	EAR99	HMC274QS16E
0.7 - 3.7	5-Bit Digital, Serial Control	2.1	1 to 31	48	Serial/CMOS	LP4	EAR99	HMC271ALP4E
0.7 - 3.8	5-Bit Digital	2.1	1 to 31	48	0 / +3V	MS10G	EAR99	HMC273MS10GE
0.7 - 3.8	5-Bit Digital, Serial Control	1.5	0.5 to 15.5	52	Serial/CMOS	LP4	EAR99	HMC305ALP4E
0.7 - 3.8	5-Bit Digital	1.5	0.5 to 15.5	52	0 / +3V	MS10	EAR99	HMC306MS10E
0.7 - 3.8	5-Bit Digital	1.3	0.5 to 15.5	48	0 / +3V	MS10	EAR99	HMC603MS10E
0.7 - 3.8	5-Bit Digital	1.3	0.5 to 15.5	48	0 / +3V	QS16	EAR99	HMC603QS16E
DC - 3	5-Bit Digital	2.0	1 to 31	44	0 / -5V	G16 Hermetic	EAR99	HMC335G16
DC - 3	5-Bit Digital	1.3	1 to 31	45	TTL/CMOS	LP3	EAR99	HMC470LP3E
DC - 4	5-Bit Digital	1.9	1 to 31	44	0 / -5V	QS16G	EAR99	HMC307QS16GE
DC - 4	5-Bit Digital	0.7	0.25 to 7.75	50	TTL/CMOS	LP3	EAR99	HMC539LP3E
0.06 - 0.5	6-Bit Digital, Serial & Parallel Control	1.2	0.5 to 31.5	55	0 / +3 to +5V	LP4	EAR99	HMC624LFLP4E

ATTENUATORS

Frequency (GHz)	Function	Insertion Loss (dB)	Attenuation Range (dB)	IIP3 (dBm)	Control Input (Vdc)	Package	ECCN Code	Part Number
DC - 3.8	6-Bit Digital	1.5	0.5 to 31.5	45	TTL/CMOS	LP4	EAR99	HMC472LP4E
DC - 3	6-Bit Digital	3.0	0.5 to 31.5	32	0 / -5V	G16 Hermetic	EAR99	HMC424G16
DC - 4	6-Bit Digital, Serial Control	1.2	0.5 to 31.5	45	Serial/CMOS	LP4	EAR99	HMC542ALP4E
DC - 6	6-Bit Digital, Serial & Parallel Control	1.8	0.5 to 31.5	55	0 / +5V	LP4	EAR99	HMC624LP4E
DC - 6	6-Bit Digital, Serial & Parallel Control	1.8	0.25 to 15.75	55	TTL/CMOS	LP4	EAR99	HMC792LP4E
DC - 13	6-Bit Digital	4.0	0.5 to 31.5	32	0 / -5V	Chip	EAR99	HMC424
DC - 13	6-Bit Digital	3.2	0.5 to 31.5	32	0 / -5V	LH5 Hermetic	EAR99	HMC424LH5
DC - 13	6-Bit Digital	4.0	0.5 to 31.5	32	0 / -5V	LP3	EAR99	HMC424LP3E
2.4 - 8.0	6-Bit Digital	3.5	0.5 to 31.5	40	0 / +5V	Chip	EAR99	HMC425
2.2 - 8.0	6-Bit Digital	3.2	0.5 to 31.5	40	0 / +5V	LP3	EAR99	HMC425LP3E
0.01 - 0.3	7-Bit Digital	3.3	0.25 to 31.75	40	TTL/CMOS	LP3	EAR99	HMC759LP3E

AUTOMATIC GAIN CONTROL

Frequency (MHz)	Function	Gain Control Range (dB)	NF (dB)	OIP3 (dBm)	P1dB (dBm)	Bias Supply	Package	ECCN Code	Part Number
50 - 800	IF Automatic Gain Controller	-10 to +38	6	40	19	+5V @ 215 mA	LP5	EAR99	HMC992LP5E
700 - 3000	RF Automatic Gain Controller	-11 to +32	7.6	46	25	+5V @ 260 mA	LP5	EAR99	HMC993LP5E

DC POWER CONDITIONING - *Linear Voltage Regulators*

Input Voltage (V)	Function	Output Voltage (V)	Output Current (mA)	Power Supply Rejection Ratio (PSRR) (dB)		Output Noise Spectral Density (nV/√Hz)		Regulated Outputs	Package	ECCN Code	Part Number
				1 kHz	1 MHz	1 kHz	10 kHz				
3.35 - 5.6	Quad High PSRR	2.5 - 5.2	15 - 100	80	60	7	3	4	LP3	EAR99	HMC860LP3E
3.35 - 5.6	Low Noise, High PSRR	1.8 - 5.2	500	80	60	7	3	4	LP3	EAR99	HMC1060LP3E
4.8 to 5.6	Low Noise, High PSRR	1.8 to 5.1	400	60	30	6	3	1	LP3	EAR99	HMC976LP3E

FILTERS - *Tunable*

Programmable Harmonic

Frequency Range (GHz)	Function	Return Loss (dB)	3 dB Bandwidth (GHz)	Stopband Frequency (Rej. >10 dB)	Tuning Response (ns)	Package	ECCN Code	Part Number
NEW! 0.25 - 3.025	Programmable Harmonic Low Pass	10	1 - 3	1.2 Fcutoff	10	LP3	EAR99	HMC1044LP3E

Band Pass

Frequency Range (GHz)	Function	Return Loss (dB)	3 dB Bandwidth (%)	Low Side Rejection Frequency (Rej. >20 dB)	High Side Rejection Frequency (Rej. >20 dB)	Tuning Response (ns)	Package	ECCN Code	Part Number
1 - 2	Band Pass	10	11	0.8 x Fcenter	1.2 x Fcenter	200	LP5	EAR99	HMC890LP5E
2 - 3.9	Band Pass	10	9	0.9 x Fcenter	1.15 x Fcenter	200	LP5	EAR99	HMC891LP5E
4 - 7.7	Band Pass	15	9	0.9 x Fcenter	1.13 x Fcenter	200	LP5	EAR99	HMC892LP5E
4.8 - 9.5	Band Pass	7	6.5	0.9 x Fcenter	1.1 x Fcenter	200	LP5	EAR99	HMC893LP5E
5.9 - 11.2	Band Pass	7.5	6	0.92 x Fcenter	1.08 x Fcenter	200	LP5	EAR99	HMC894LP5E
6.8 - 12.6	Band Pass	12	10	0.88 x Fcenter	1.1 x Fcenter	200	LP4	EAR99	HMC895LP4E
NEW! 9 - 19	Band Pass	9.5	18	0.81 x Fcenter	1.17 x Fcenter	200	Chip	EAR99	HMC897
9 - 19	Band Pass	9.5	18	0.81 x Fcenter	1.17 x Fcenter	200	LP4	EAR99	HMC897LP4E
10 - 18	Band Pass	11	9	0.89 x Fcenter	1.1 x Fcenter	200	LP4	EAR99	HMC896LP4E
11.5 - 21.5	Band Pass	9	17	0.81 x Fcenter	1.16 x Fcenter	200	LP4	EAR99	HMC898LP4E
18.5 - 37.0	Band Pass	10	18	0.81 x Fcenter	1.20 x Fcenter	200	LP4	EAR99	HMC899LP4E
19 - 38	Band Pass	10	18	0.81 x Fcenter	1.20 x Fcenter	< 100	Chip	EAR99	HMC899

Low Pass

Frequency Range (GHz)	Function	Return Loss (dB)	Cutoff Frequency Range (GHz)	Stopband Frequency (Rej. >20 dB)	Tuning Response (ns)	Package	ECCN Code	Part Number
DC - 4.0	Low Pass	10	2.2 - 4.0	1.25 x Fcutoff	150	LP5	EAR99	HMC881LP5E
DC - 7.6	Low Pass	10	4.5 - 7.6	1.23 x Fcutoff	150	LP5	EAR99	HMC882LP5E

Band Reject

Frequency Range (GHz)	Function	Rejection Band Tuning Freq. (GHz)	Pass Band Insertion Loss (dB)	Stop Band Rejection (dB)	20 dB Bandwidth (%)	Tuning Response (ns)	Package	ECCN Code	Part Number
0.1 - 25	Band Reject	3.6 - 12.2	3	25	8	200	LP5	EAR99	HMC1000LP5E

SMT & Chip (Die) Products

IF / BASEBAND PROCESSING - Dual Baseband Low Pass Filter & Dual Baseband Digital VGA

Dual Baseband Low Pass Filter

3 dB Bandwidth Setting (MHz)	Function	3 dB Bandwidth Accuracy (%)	Gain (dB)	NF (dB)	OIP3 (dBm)	Package	ECCN Code	Part Number
3.5 - 50	Dual Low Pass with ADC Driver	± 2.5	0 / 10	12	30	LP5	EAR99	HMC900LP5E

Please Note: 400 Ohm Reference Impedance Are Shown

Dual Baseband Digital VGA

Frequency (MHz)	Function	NF (dB)	Variable Gain (dB)	OIP3 (dBm)	OIP2 (dBm)	Sideband Supp. (dB)	Magnitude (dB) / Phase (deg) Balance	Bias Supply	Package	ECCN Code	Part Number
DC - 100	Digital, Serial & Parallel Control	6	0 to 40	+30	+65	55	±0.1 / ±1	+5V @ 70 mA	LP4	EAR99	HMC960LP4E

Please Note: 100 Ohm Reference Impedance Are Shown

I/Q MIXERS / IRMs

RF Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Image Rejection (dB)	IIP3 (dBm)	Package	ECCN Code	Part Number
3 - 7	I/Q Mixer / IRM	DC - 3.5	-7.5	33	23	Chip	EAR99	HMC620
3 - 7	I/Q Mixer / IRM	DC - 3.5	-7.5	32	22	LC4	EAR99	HMC620LC4
4 - 8.5	I/Q Mixer / IRM	DC - 3.5	-7.5	40	23	Chip	EAR99	HMC525
4 - 8.5	I/Q Mixer / IRM	DC - 3.5	-7.5	40	23	LC4	EAR99	HMC525LC4
5.9 - 12.0	I/Q Mixer / IRM	DC - 1.5	-8	30	18	Chip	EAR99	HMC256
6 - 10	I/Q Mixer / IRM	DC - 3.5	-7	40	22	Chip	EAR99	HMC520
6 - 10	I/Q Mixer / IRM	DC - 3.5	-7	40	23	LC4	EAR99	HMC520LC4
6 - 10	I/Q Mixer / IRM	DC - 3.5	-7.5	40	28	Chip	EAR99	HMC526
6 - 10	I/Q Mixer / IRM	DC - 3.5	-7.5	40	28	LC4	EAR99	HMC526LC4
8.5 - 13.5	I/Q Mixer / IRM	DC - 3.5	-7.5	40	24	Chip	EAR99	HMC521
8.5 - 13.5	I/Q Mixer / IRM	DC - 3.5	-7.5	38	24	LC4	EAR99	HMC521LC4
8.5 - 13.5	I/Q Mixer / IRM	DC - 2	-7.5	35	28	Chip	EAR99	HMC527
8.5 - 13.5	I/Q Mixer / IRM	DC - 2	-7.5	34	28	LC4	EAR99	HMC527LC4
10 - 16	I/Q Mixer / IRM	DC - 3.5	-8	25	25	LC5	EAR99	HMC775LC5
11 - 16	I/Q Mixer / IRM	DC - 3.5	-7.5	35	24	Chip	EAR99	HMC522
11 - 16	I/Q Mixer / IRM	DC - 3.5	-7.5	35	24	LC4	EAR99	HMC522LC4
11 - 16	I/Q Mixer / IRM	DC - 3.5	-8	35	27	Chip	EAR99	HMC528
11 - 16	I/Q Mixer / IRM	DC - 3.5	-8	35	26	LC4	EAR99	HMC528LC4
15 - 23	I/Q Mixer / IRM	DC - 3.5	-8	25	25	LC4	EAR99	HMC523LC4
15 - 23.6	I/Q Mixer / IRM	DC - 3.5	-8	27	25	Chip	EAR99	HMC523
NEW! 15 - 33.5	I/Q Mixer / IRM	DC - 3.5	-10	40	22	LC4	EAR99	HMC1042LC4
17 - 27	I/Q Mixer / IRM	DC - 3.5	-9	36	20	LC4	EAR99	HMC1041LC4
19 - 33	I/Q Mixer / IRM	DC - 5	-8	25	17	Chip	5A001.h	HMC-MDB172
22 - 32	I/Q Mixer / IRM	DC - 3.5	-10	23	20	Chip	EAR99	HMC524
22 - 32	I/Q Mixer / IRM	DC - 4.5	-10	20	20	LC3B	EAR99	HMC524LC3B
15 - 33.5	I/Q Mixer / IRM	DC - 3.5	-10	30	22	LC4	EAR99	HMC1042LC4
31 - 38	I/Q Mixer / IRM	DC - 3.5	-10.5	17	21	Chip	EAR99	HMC555
35 - 45	I/Q Mixer / IRM	DC - 5	-8	25	17	Chip	5A991.h	HMC-MDB171
36 - 41	I/Q Mixer / IRM	DC - 3.5	-11	18	23	Chip	EAR99	HMC556
55 - 64	I/Q Mixer / IRM	DC - 3	-9	30	16	Chip	5A991.h	HMC-MDB207
26 - 33 RF	Sub-Harmonic, I/Q Mixer / IRM	DC - 3	-11	22	16	Chip	EAR99	HMC404
54 - 64 RF	Sub-Harmonic, I/Q Mixer / IRM	DC - 3	-12.5	30	7	Chip	5A991.h	HMC-MDB218

I/Q DOWNCONVERTER / RECEIVERS

RF Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Noise Figure (dB)	Image Rejection (dB)	IIP3 (dBm)	Package	ECCN Code	Part Number
5.6 - 8.6	I/Q Downconverter / Receiver	DC - 3	12	2.2	20	2	LP4	EAR99	HMC951LP4E
7 - 9	I/Q Downconverter / Receiver	DC - 3.5	10	2.5	35	1.5	LC5	EAR99	HMC567LC5
9 - 12	I/Q Downconverter / Receiver	DC - 3.5	11	2.2	25	2	LC5	EAR99	HMC908LC5
12 - 16	I/Q Downconverter / Receiver	DC - 3.5	14	2.8	32	-1	LC5	EAR99	HMC869LC5
17 - 20	I/Q Downconverter / Receiver	DC - 3.5	14	2.5	40	0	LP4	EAR99	HMC966LP4E
17 - 21	I/Q Downconverter / Receiver	DC - 3.5	10	3	17	3	Chip	EAR99	HMC570
17 - 21	I/Q Downconverter / Receiver	DC - 3.5	10	3	18	2	LC5	EAR99	HMC570LC5
17 - 24	I/Q Downconverter / Receiver	DC - 3.3	11	2.2	21	2	LC5	EAR99	HMC904LC5
17 - 24	I/Q Downconverter / Receiver	DC - 3.5	15	2.5	25	1	LP4	EAR99	HMC967LP4E
20 - 28	I/Q Downconverter / Receiver	DC - 3.5	14	2.5	21	1	LP4	EAR99	HMC977LP4E
21 - 25	I/Q Downconverter / Receiver	DC - 3.5	11	3	24	5	Chip	EAR99	HMC571
21 - 25	I/Q Downconverter / Receiver	DC - 3.5	10	2	20	5	LC5	EAR99	HMC571LC5
24 - 28	I/Q Downconverter / Receiver	DC - 3.5	8	3.5	20	5	Chip	EAR99	HMC572
24 - 28	I/Q Downconverter / Receiver	DC - 3.5	8	3.5	18	5	LC5	EAR99	HMC572LC5

I/Q UPCONVERTER / TRANSMITTERS

RF Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Sideband Rejection (dBc)	OIP3 (dBm)	Package	ECCN Code	Part Number
5.5 - 8.6	I/Q Upconverter / Transmitter w/ VGA	DC - 3	16.5	-30	29	LC5	EAR99	HMC925LC5
10 - 16	I/Q Upconverter / Transmitter w/ VGA	DC - 3	17	-30	14	LC5	EAR99	HMC924LC5
11 - 17	I/Q Upconverter / Transmitter	DC - 2	13	-20	26	LC5	EAR99	HMC709LC5
16 - 21	I/Q Upconverter / Transmitter	DC - 3.5	12	-20	30	LC5	EAR99	HMC710LC5
17.7 - 23.6	I/Q Upconverter / Transmitter	DC - 3.5	15	-35	35	LC5	EAR99	HMC819LC5
21 - 27	I/Q Upconverter / Transmitter	DC - 3.75	12	-20	27	LC5	EAR99	HMC815LC5

MIXERS

RF Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Package	ECCN Code	Part Number
High IP3 Mixers								
0.4 - 0.65	High IP3, 0 LO	DC - 0.25	-9	7	33	MS8G	EAR99	HMC585MS8GE
0.45 - 0.5	High IP3, SGL-END	DC - 0.15	-9.5	20	32	MS8	EAR99	HMC387MS8E
0.5 - 2.7	High IP3, DBL-BAL, +2 LO	DC - 1	-8	28	28	LP4	EAR99	HMC915LP4E
0.7 - 1.0	High IP3, SGL-END	DC - 0.25	-8.5	24	35	MS8	EAR99	HMC399MS8E
0.7 - 1.0	High IP3, DBL-BAL, 0 LO	DC - 0.45	-7	23	32	LP4	EAR99	HMC684LP4E
0.7 - 1.1	High IP3, DBL-BAL, 0 LO	0.05 - 0.25	-7.5	24	40	LP4	EAR99	HMC786LP4
0.7 - 1.2	High IP3, DBL-BAL	DC - 0.3	-9	42	25	S8	EAR99	HMC351S8E
0.7 - 1.5	High IP3, 0 LO	DC - 0.35	-9	20	33	MS8G	EAR99	HMC483MS8GE
0.7 - 1.5	High IP3, DBL-BAL, 0 LO	DC - 0.5	-7.5	24	34	LP4	EAR99	HMC686LP4E
0.8 - 1.2	High IP3, DBL-BAL, 0 LO	DC - 0.3	-8	27	27	LP4	EAR99	HMC551LP4E
1.5 - 3.5	High IP3, DBL-BAL	DC - 1	-8	38	25	MS8	EAR99	HMC316MS8E
1.6 - 3.0	High IP3, DBL-BAL, 0 LO	DC - 1	-8	30	25	LP4	EAR99	HMC552LP4E
1.7 - 2.2	High IP3, SGL-END	DC - 0.3	-8.8	30	36	MS8	EAR99	HMC400MS8E
1.7 - 2.2	High IP3, DBL-BAL, 0 LO	DC - 0.5	-8	30	35	LP4	EAR99	HMC685LP4E
1.7 - 2.2	High IP3, DBL-BAL, 0 LO	DC - 0.5	-8	31	34	LP4	EAR99	HMC687LP4E
1.7 - 2.2	High IP3, DBL-BAL, 0 LO	0.05 - 0.30	-8	30	38	LP4	EAR99	HMC785LP4E
1.7 - 2.4	High IP3, SGL-END	0.05 - 0.3	-9.2	10	34	MS8G	EAR99	HMC485MS8GE
1.7 - 3.0	High IP3, SGL-BAL	DC - 0.8	-9	30	30	MS8	EAR99	HMC304MS8E
1.7 - 4.0	High IP3, DBL-BAL, +4 LO	DC - 1.0	-8	32	25	LP4	EAR99	HMC215LP4E
1.8 - 2.2	High IP3, SGL-END	DC - 0.5	-8.5	25	31	MS8	EAR99	HMC402MS8E
2.0 - 2.7	High IP3, DBL-BAL, 0 LO	DC - 0.45	-7.5	25	31	LP4	EAR99	HMC688LP4E
2.0 - 2.7	High IP3, DBL-BAL, 0 LO	DC - 0.45	-7.5	26	31	LP4	EAR99	HMC689LP4E
2.3 - 4.0	High IP3, +4 LO	DC - 1	-10	15	35	LP4	EAR99	HMC615LP4E
2.4 - 4.0	High IP3, SGL-END	DC - 1	-10	30	34	MS8	EAR99	HMC214MS8E
3.1 - 3.9	High IP3, DBL-BAL, 0 LO	DC - 0.6	-8.5	28	30	LP4	EAR99	HMC666LP4E
6 - 12	High IP3, DBL-BAL	DC - 4	-8	40	30	LC3	EAR99	HMC663LC3
9 - 15	High IP3, DBL-BAL	DC - 2.5	-7.5	40	24	MS8G	EAR99	HMC410AMS8GE
Downconverter RF ICs								
NEW! 0.7 - 3.5	High IP3 Dual Downconverter	0.05 - 0.35	7	55	+25	LP4	EAR99	HMC990LP4E
0.7 - 1.0	Downconverter	0.05 - 0.25	12.5	25	15	QS16	EAR99	HMC420QS16E
0.7 - 1.0	High IP3, Dual Downconverter	0.06 - 0.5	7.5	16	23	LP6C	EAR99	HMC683LP6CE
0.8 - 0.96	High IP3 Dual Downconverter	0.05 - 0.3	9	4	26	LP6	EAR99	HMC581LP6E
0.8 - 1.0	High IP3 Downconverter	0.05 - 0.25	13.8	28	15	QS16G	EAR99	HMC377QS16GE
0.8 - 2.7	Hi-IP3 Wideband Downconverter	0.001 - 0.6	-1	48	26	LP4	EAR99	HMC334LP4E
0.9 - 1.6	Hi-IP3 Downconverter with RF Amplifier	0.05 - 0.5	30	45	6	LP4	EAR99	HMC621LP4E
1.4 - 2.3	High IP3 Downconverter	0.05 - 0.3	9	33	19	QS16G	EAR99	HMC421QS16E
1.7 - 2.2	High IP3 Downconverter	0.05 - 0.3	11	25	19	QS16G	EAR99	HMC380QS16GE
1.7 - 2.2	High IP3, Dual Downconverter	50 - 300	9	10	27	LP6	EAR99	HMC381LP6E
1.7 - 2.2	High IP3, Dual Downconverter	0.06 - 0.4	6	25	25	LP6C	EAR99	HMC682LP6CE
1.8 - 2.7	High IP3 Downconverter with RF Amplifier	0.05 - 0.65	33	45	11	LP4	EAR99	HMC623LP4E
0 to +7 dBm LO Double & Single Balanced Mixers								
0.6 - 1.3	Low LO, DBL-BAL	DC - 0.4	-8	35	15	MS8	EAR99	HMC423MS8E
0.7 - 1.2	0 LO, DBL-BAL	0.25 - 0.45	10	36	23	LP4	EAR99	HMC665LP4E
1.2 - 2.6	Low LO, DBL-BAL	DC - 1	-8	30	15	MS8	EAR99	HMC422MS8E
1.8 - 3.9	+3 LO, DBL-BAL	0.2 - 0.55	9	33	23	LP4	EAR99	HMC622LP4E
3 - 3.8	Low LO, SGL-BAL	DC - 1	-8.5	15	10	SOT26	EAR99	HMC333E

MIXERS

RF Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Package	ECCN Code	Part Number
4 - 7	0 LO, DBL-BAL	DC - 2.5	-7	32	15	MS8G	EAR99	HMC488MS8GE
4.5 - 6.0	+7 LO, DBL-BAL	DC - 1.6	-7	30	18	MS8	EAR99	HMC218MS8E
+10 dBm LO Double & Single Balanced Mixers								
0.7 - 2.0	+10 LO, DBL-BAL	DC - 0.3	-9	45	17	S8	EAR99	HMC207AMS8E
0.7 - 2.0	+10 LO, DBL-BAL	DC - 0.5	-9	24	17	MS8	EAR99	HMC208AMS8E
1.5 - 4.5	+10 LO, DBL-BAL	DC - 1.5	-8.5	40	19	MS8	EAR99	HMC213AMS8E
1.7 - 3.0	+10 LO, SGL-BAL	DC - 0.8	-9	30	21	MS8	EAR99	HMC272AMS8E
1.7 - 3.5	+10 LO, SGL-BAL	DC - 0.9	-9	30	21	SOT26	EAR99	HMC285E
4.5 - 8.0	+10 LO, DBL-BAL	DC - 2	-8.2	35	16	C8	EAR99	HMC168C8
5 - 12	+10 LO, DBL-BAL	DC - 4	-7.5	25	17	MS8	EAR99	HMC220AMS8E
7 - 10	+10 LO, DBL-BAL	DC - 2	-9	32	16	C8	EAR99	HMC171C8
+13 to +14 dBm LO Double & Triple Balanced Mixers								
0.7 - 1.2	+13 LO, SGL-BAL	DC - 0.3	-9	26	21	MS8	EAR99	HMC277MS8E
1.7 - 4.5	+13 LO, DBL-BAL	DC - 1	-8	30	20	MS8	EAR99	HMC175MS8E
1.7 - 4.5	+13 LO, Dual Channel	DC - 1.5	-8	-	23	LP5	EAR99	HMC340ALP5E
NEW! 2 - 18	Double Balance Mixer	DC - 2	-10	35	19	LC3B	EAR99	HMC1048LC3B
2.5 - 4.0	+13 LO, DBL-BAL	DC - 2	-9	45	18	C8	EAR99	HMC170C8
4.5 - 9.0	+13 LO, DBL-BAL	DC - 2.5	-8.5	25	21	MS8	EAR99	HMC219AMS8E
6 - 26	+13 LO, DBL-BAL	DC - 10	-9	32	20	Chip	EAR99	HMC773
6 - 26	+13 LO, DBL-BAL	DC - 8	-9	38	22	LC3B	EAR99	HMC773LC3B
7 - 14	+13 LO, DBL-BAL	DC - 5	-7	48	22	Chip	EAR99	HMC553
7 - 14	+13 LO, DBL-BAL	DC - 5	-7	50	22	LC3B	EAR99	HMC553LC3B
7 - 34	+13 LO, DBL-BAL	DC - 8	-11	35	22	LC3B	EAR99	HMC774LC3B
7 - 43	+13 LO, DBL-BAL	DC - 10	-9	35	22	Chip	EAR99	HMC774
9 - 15	+13 LO, DBL-BAL	DC - 2.5	-7.5	40 - 50	17	MS8G	EAR99	HMC412AMS8GE
10 - 15	+13 LO, SGL-BAL	DC - 3	-9	27	16	MS8G	EAR99	HMC411MS8GE
11 - 20	+13 LO, DBL-BAL	DC - 6	-7	46	18	Chip	EAR99	HMC554
11 - 20	+13 LO, DBL-BAL	DC - 6	-7	46	18	LC3B	EAR99	HMC554LC3B
14 - 26	+13 LO, DBL-BAL	DC - 8	-7.5	39	20	Chip	EAR99	HMC260
14 - 26	+13 LO, DBL-BAL	DC - 8	-7.5	38	20	LC3B	EAR99	HMC260LC3B
16 - 30	+13 LO, DBL-BAL	DC - 8	-8	40	21	LC3B	EAR99	HMC292LC3B
17 - 31	+13 LO, DBL-BAL	DC - 6	-8	32	19	LM3C	EAR99	HMC292LM3C
18 - 32	+13 LO, DBL-BAL	DC - 8	-7.5	38	19	Chip	EAR99	HMC292
24 - 32	+13 LO, DBL-BAL	DC - 8	-10	38	19	LC3B	EAR99	HMC329LC3B
24 - 40	+13 LO, DBL-BAL	DC - 18	-8	35	21	Chip	EAR99	HMC560
24 - 40	+13 LO, DBL-BAL	DC - 17	-10	35	21	LM3	EAR99	HMC560LM3
25 - 40	+13 LO, DBL-BAL	DC - 8	-9.5	42	19	Chip	EAR99	HMC329
26 - 32	+13 LO, TPL-BAL	16 - 22	-10	45	22	Chip	EAR99	HMC1015
26 - 32	+13 LO, TPL-BAL	16 - 22	-10	45	23	LC3	EAR99	HMC1043LC3
26 - 40	+13 LO, DBL-BAL	DC - 8	-8	37	19	LM3	EAR99	HMC329LM3
54 - 64	+13 LO, DBL-BAL	DC - 5	-8	30	13	Chip	5A991.h	HMC-MDB169
70 - 90	+14 LO, DBL-BAL	DC - 18	-12	-	-	Chip	5A991.h	HMC-MDB277
+15 to +20 dBm LO Single, & Double Balanced Mixers								
1.8 - 5.0	+15 LO, DBL-BAL	DC - 3	-7	42	18	Chip	EAR99	HMC128
1.8 - 5.0	+15 LO, DBL-BAL	DC - 2	-10	40	18	G8 Hermetic	EAR99	HMC128G8
2.5 - 7	+15 LO, DBL-BAL	DC - 3	-7	48	22	Chip	EAR99	HMC557
2.5 - 7	+15 LO, DBL-BAL	DC - 3	-7	48	22	LC4	EAR99	HMC557LC4
4 - 8	+15 LO, DBL-BAL	DC - 3	-7	40	17	Chip	EAR99	HMC129
4 - 8	+15 LO, DBL-BAL	DC - 3	-8	30	18	G8 Hermetic	EAR99	HMC129G8
4 - 8	+15 LO, DBL-BAL	DC - 3	-7	40	17	LC4	EAR99	HMC129LC4
5.5 - 14	+15 LO, DBL-BAL	DC - 6	-7	45	24	Chip	EAR99	HMC558
5.5 - 14	+15 LO, DBL-BAL	DC - 6	-7	45	24	LC3B	EAR99	HMC558LC3B
6 - 11	+15 LO, DBL-BAL	DC - 2	-7	40	17	Chip	EAR99	HMC130
6 - 15	+15 LO, DBL-BAL	DC - 2	-8.5	35	20	C8	EAR99	HMC141C8 / 142C8
6 - 18	+15 LO, DBL-BAL	DC - 6	-10	25	21	Chip	EAR99	HMC141 / 142
7 - 14	+15 LO, DBL-BAL	DC - 2	-10	35	20	LH5 Hermetic	EAR99	HMC141LH5
14 - 23	+15 LO, DBL-BAL	DC - 2	-10.5	38	18	Chip	EAR99	HMC203
3 - 10	+17 LO, DBL-BAL	DC - 4	-9	55	23	LC3B	EAR99	HMC787LC3B
5 - 20	+20 LO, DBL-BAL	DC - 3	-10	30	25	Chip	EAR99	HMC143 / 144
6 - 20	+20 LO, DBL-BAL	DC - 3	-10	35	23	LC4	EAR99	HMC144LC4
6 - 20	+20 LO, DBL-BAL	DC - 3	-10	35	24	LH5 Hermetic	EAR99	HMC144LH5

MIXERS

RF Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Package	ECCN Code	Part Number
Sub-Harmonic Mixers								
14 - 20	Sub-Harmonic	DC - 3	-10	40	7	LM3	EAR99	HMC258LM3
14 - 21	Sub-Harmonic	DC - 3	-10	40	7	Chip	EAR99	HMC258
14.5 - 19.5	Sub-Harmonic	DC - 3.5	-10	45	5	LC3B	EAR99	HMC258LC3B
17 - 25	Sub-Harmonic	DC - 3	-9	27	10	Chip	EAR99	HMC337
17.7 - 23.6	Sub-Harmonic, Upconverter	DC - 3.5	15	40	13	LC5	EAR99	HMC711LC5
20 - 30	Sub-Harmonic	DC - 4	-9	30	10	LM3	EAR99	HMC264LM3
20 - 31	Sub-Harmonic, Downconverter	0.7 - 3.0	3	28	8	LM3	EAR99	HMC265LM3
20 - 32	Sub-Harmonic	DC - 6	-10	40	13	Chip	EAR99	HMC264
20 - 32	Sub-Harmonic, Downconverter	0.7 - 3.0	3	30	10	Chip	EAR99	HMC265
20 - 40	Sub-Harmonic	1 - 3	-12	24	13	Chip	EAR99	HMC266
21 - 31	Sub-Harmonic	DC - 6	-9	40	13	LC3B	EAR99	HMC264LC3B
24 - 34	Sub-Harmonic	DC - 3	-11	33	13	LC3B	5A991.b	HMC338LC3B
24 - 34	Sub-Harmonic	DC - 4	-10	30	22	LC4	EAR99	HMC798LC4
26 - 33	Sub-Harmonic	DC - 2.5	-9	33	11	Chip	5A991.b	HMC338
33 - 42	Sub-Harmonic	DC - 3	-10	37	10	Chip	EAR99	HMC339

DEMODULATORS - *I/Q Demodulator*

Input Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Noise Figure (dB)	IIP3 / IIP2 (dBm)	Package	ECCN Code	Part Number
0.1 - 4.0	I/Q Demodulator	DC - 0.6	-3.5	15	+25 / +60	LP4	EAR99	HMC597LP4E

MODULATORS - *Bi-Phase Modulator*

Input Frequency (GHz)	Function	Loss (dB)	Amp / Phase Balance (dB/Deg)	Carrier Suppression (dBc)	Bias Control (mA)	Package	ECCN Code	Part Number
1.8 - 5.2	Bi-Phase	8	0.2 / 2.5	30	+ / - 5	Chip	EAR99	HMC135
4 - 8	Bi-Phase	8	0.1 / 4.0	30	+ / - 5	Chip	EAR99	HMC136
6 - 11	Bi-Phase	9	0.25 / 10.0	20	+ / - 5	Chip	EAR99	HMC137

MODULATORS - *Direct Quadrature Modulator*

Input Freq. (GHz)	Function	OIP3 (dBm) / Carrier Suppression (dBc)	Modulation Bandwidth (MHz)	Output Noise Floor (dBc/Hz)	Bias Supply	Package	ECCN Code	Part Number
0.02 - 2.7	Direct Quadrature	23 / 42	DC - 700	-162	+5V @ 160 mA	LP4	EAR99	HMC696LP4E
0.05 - 2.8	Direct Quadrature with VGA	25 / 50	DC - 440	-159	+5V @ 120 mA	LP5	3A001.a.11.b	HMC795LP5E
0.1 - 4.0	Direct Quadrature	23 / 42	DC - 700	-159	+5V @ 170 mA	LP4	EAR99	HMC497LP4E
0.1 - 6.0	Direct Quadrature	30 / 40	DC - 700	-160	+5V @170 mA	LP4	EAR99	HMC1097LP4E
0.25 - 3.8	Direct Quadrature	14 / 38	DC - 250	-158	+3.3V @ 108 mA	LP3	EAR99	HMC495LP3E
0.45 - 4.0	Direct Quadrature	22 / 43	DC - 700	-165	+5V @ 168 mA	LP4	EAR99	HMC697LP4E
4 - 7	Direct Quadrature	17 / 34	DC - 250	-157	+3V @ 93 mA	LP3	EAR99	HMC496LP3E

MODULATORS - *Vector Modulators*

Frequency (GHz)	Function	Gain Range (dB)	Continuous Phase Control (deg)	IP3 / Noise Floor (Ratio)	IIP3 @ Max. Gain (dBm)	Package	ECCN Code	Part Number
0.7 - 1.0	Vector	-50 to -10	360	186.5	34	LP3	EAR99	HMC630LP3E
1.8 - 2.7	Vector	-50 to -10	360	186	35	LP3	EAR99	HMC631LP3E
1.8 - 2.2	Vector	-50 to -10	360	185	33	LP3	EAR99	HMC500LP3E

PASSIVES - *Fixed Attenuators*

Frequency (GHz)	Function	Attenuation Accuracy (dB)	Nominal Attenuation (dB)	Maximum Input Power (dBm)	Chip Size (Mils)	Package	ECCN Code	Part Number
DC - 50	Thru Line	±0.2	0.15	-	17 x 18	Chip	EAR99	HMC650
DC - 50	Thru Line	±0.3	0.15	-	23 x 18	Chip	EAR99	HMC651
DC - 50	Passive	±0.2	2	27	17 x 18	Chip	EAR99	HMC652
DC - 25	Passive	±0.5	2	27	-	LP2	EAR99	HMC652LP2E
DC - 50	Passive	±0.2	3	26	17 x 18	Chip	EAR99	HMC653
DC - 25	Passive	±0.5	3	26	-	LP2	EAR99	HMC653LP2E
DC - 50	Passive	±0.2	4	25	17 x 18	Chip	EAR99	HMC654
DC - 25	Passive	±0.5	4	25	-	LP2	EAR99	HMC654LP2E
DC - 50	Passive	±0.2	6	26	17 x 18	Chip	EAR99	HMC655
DC - 25	Passive	±0.5	6	26	-	LP2	EAR99	HMC655LP2E
DC - 50	Passive	±0.1	10	25	17 x 18	Chip	EAR99	HMC656
DC - 25	Passive	±1.5	10	25	N/A	LP2	EAR99	HMC656LP2E
DC - 50	Passive	±0.4	15	25	17 x 18	Chip	EAR99	HMC657

SMT & Chip (Die) Products

PASSIVES - *Fixed Attenuators*

Frequency (GHz)	Function	Attenuation Accuracy (dB)	Nominal Attenuation (dB)	Maximum Input Power (dBm)	Chip Size (Mils)	Package	ECCN Code	Part Number
DC - 25	Passive	±2	15	25	N/A	LP2	EAR99	HMC657LP2E
DC - 50	Passive	±0.5	20	25	23 x 18	Chip	EAR99	HMC658
DC - 25	Passive	±2	20	25	N/A	LP2	EAR99	HMC658LP2E

PHASE SHIFTERS - *Analog*

Frequency (GHz)	Function	Insertion Loss (dB)	Phase Range (deg)	2nd Harmonic Pin = -10 dBm (dBc)	Control Voltage Range (Vdc)	Package	ECCN Code	Part Number
1 - 2	Analog	3.5	400°	-40	0 to +13V	LP5	EAR99	HMC934LP5E
2 - 4	Analog	3.5	480° @ 2 GHz 450° @ 4 GHz	-40	0V to +13V	LP5	EAR99	HMC928LP5E
2 - 20	Analog	4	270° @ 2 GHz 180° @ 20 GHz	-45	0.5 to +11V	LP5	EAR99	HMC935LP5E
4 - 8	Analog	4	450° @ 4 GHz 430° @ 8 GHz	-40	0V to +13V	LP4	EAR99	HMC929LP4E
5 - 18	Analog	4	500° @ 5 GHz 100° @ 18 GHz	-80	0V to +10V	Chip	EAR99	HMC247
6 - 15	Analog	7	750° @ 6 GHz 500° @ 15 GHz	-40	0V to +5V	LP4	EAR99	HMC538LP4E
8 - 12	Analog	3.5	425° @ 8 GHz 405° @ 12 GHz	-35	0 to +13V	LP4	EAR99	HMC931LP4E
8 - 23	Analog	-	500°	-35	2.7 to 3.9V	LC3	3A001.a.11.b	HMC877LC3
12 - 18	Analog	4	405° @ 12 GHz 385° @ 18 GHz	-40	0 to +13V	LP4	EAR99	HMC932LP4E
18 - 24	Analog	4.5	495° @ 18 GHz 460° @ 24 GHz	-37	0 to +13V	LP4	EAR99	HMC933LP4E

PHASE SHIFTERS - *Digital*

Frequency (GHz)	Function	Insertion Loss (dB)	Phase Range (deg)	IIP3 (dBm)	Control Input (Vdc)	Package	ECCN Code	Part Number
8 - 12	-Bit Digital	5	22.5 to 360	40	0 / -3V	Chip	EAR99	HMC543
8 - 12	4-Bit Digital	6.5	22.5 to 360	37	0 / -3V	LC4B	EAR99	HMC543LC4B
15 - 18.5	5-Bit Digital	7	11.25 to 360	40	0 / -3	Chip	EAR99	HMC644
15 - 18.5	5-Bit Digital	7	11.25 to 360	40	0 / -3	LC5	EAR99	HMC644LC5
1.2 - 1.4	6-Bit Digital	4	5.625 to 360	45	0 / +5V	LP6	EAR99	HMC936LP6E
2.5 - 3.1	6-Bit Digital	4	5.625 to 360	54	0 / +5	Chip	EAR99	HMC647
2.5 - 3.1	6-Bit Digital	4	5.625 to 360	54	0 / +5	LP6	EAR99	HMC647LP6E
2.9 - 3.9	6-Bit Digital	4	5.625 to 360	45	0 / +5	Chip	EAR99	HMC648
2.9 - 3.9	6-Bit Digital	5	5.625 to 360	45	0 / +5	LP6	EAR99	HMC648LP6E
3 - 6	6-Bit Digital	6.5	5.625 to 360	44	0 / +5	Chip	EAR99	HMC649
3 - 6	6-Bit Digital	8	5.625 to 360	44	0 / +5	LP6	EAR99	HMC649LP6E
9 - 12	6-Bit Digital	6.5	5.625 to 360	38	0 / -3	Chip	EAR99	HMC643
9 - 12	6-Bit Digital	7	5.625 to 360	38	0 / -3	LC5	EAR99	HMC643LC5
9 - 12.5	6-Bit Digital	6.5	5.625 to 360	41	0 / +5	Chip	EAR99	HMC642
9 - 12.5	6-Bit Digital	7	5.625 to 360	41	0 / +5	LC5	EAR99	HMC642LC5

POWER DETECTORS - *Log Detector/Controllers & RMS Detectors*

Frequency (GHz)	Function	Dynamic Range (dB)	RSSI Slope (mV/dB)	RF Threshold Level (dBm)	Bias Supply	Package	ECCN Code	Part Number
50 Hz - 3.0	Log Detector / Controller	74 ±3	19	-66	+3.3V @ 29 mA	LP4	EAR99	HMC612LP4E
0.001 - 8.0	Log Detector / Controller	70 ±3	-25	-61	+5V @ 113 mA	LP4	EAR99	HMC602LP4E
0.001 - 10.0	Log Detector / Controller	73 ±3	-25	-65	+5V @ 103 mA	Chip	EAR99	HMC611
0.001 - 10.0	Log Detector / Controller	70 ±3	-25	-65	+5V @ 106 mA	LP4	EAR99	HMC611LP4E
0.01 - 4.0	Log Detector / Controller	70 ±3	19	-68	+3.3V @ 30 mA	LP4	EAR99	HMC601LP4E
0.05 - 4.0	Log Detector / Controller	70 ±3	19	-69	+3.3V @ 29 mA	LP4	EAR99	HMC600LP4E
0.05 - 8.0	Log Detector / Controller	54 ±1	17.5	-55	+5V @ 17 mA	LP3	EAR99	HMC713LP3E
0.1 - 2.7	Log Detector / Controller	54 ±1	17.5	-52	+5V @ 17 mA	MS8	EAR99	HMC713MS8E
8 - 30	Log Detector	54 ±3	13.3	-55	+3.3V @ 88 mA	LP3	EAR99	HMC662LP3E
1 - 23	mmW Power Detector	56 ±3	14.2	-52	+3.3V @ 91 mA	LP3	3A001.b.2.c	HMC948LP3E
DC - 3.9	RMS Power Detector	60 ±1	37	-69	+5V @ 50 mA	LP4	EAR99	HMC1010LP4E
DC - 3.9	RMS, Single-Ended	72 ±1	35	-68	+5V @ 55 mA	LP4	EAR99	HMC1020LP4E
DC - 3.9	RMS, Single-Ended with Envelope Tracker	70 ±1	35	-68	+5V @ 75 mA	LP4	EAR99	HMC1021LP4E
DC - 3.9	Dual RMS, Single-Ended	70 ±1	38.5	-66	+5V @ 143 mA	LP5	EAR99	HMC1030LP5E
DC - 5.8	RMS Power Detector	40 ±1	37	-69	+5V @ 42 mA	LP4	EAR99	HMC909LP4E

SDLVAs - *Successive Detection Log Video Amplifiers*

Frequency (GHz)	Function	Dynamic Range (dB)	RSSI Slope (mV/dB)	RF Threshold Level (dBm)	Bias Supply	Package	ECCN Code	Part Number
0.1 - 20	SDLVA	59	14	-54	+3.3V @ 83 mA	LC4B	EAR99	HMC613LC4B
0.5 - 18.5	SDLVA, Extended Range	67	15	-62	+3.3V @ 183 mA	LP4	EAR99	HMC1013LP4E
0.6 - 20	SDLVA	59	14	-54	+3.3V @ 80 mA	Chip	EAR99	HMC913
0.6 - 20	SDLVA	59	14	-54	+3.3V @ 80 mA	LC4B	EAR99	HMC913LC4B
1 - 20	SDLVA with Limited RF Output	55	15	-53	+3.3V @ 153 mA	LC4B	EAR99	HMC813LC4B
1 - 26	SDLVA with Limited RF Output	55	14.5	-53	+3.3V @ 150 mA	Chip	EAR99	HMC813

SWITCHES

Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package	ECCN Code	Part Number
SPST & SPDT Switches								
DC - 6	SPST, Failsafe	0.7	25	27	0 / +2.2 to +5V	SOT26	EAR99	HMC550E
DC - 6	SPST, High Isolation	1.4	52	27	0 / -5V	G7 Hermetic	EAR99	HMC231G7
DC - 2.5	SPDT, Reflective	0.4	36	29	0 / -5V	S8	EAR99	HMC239AS8E
DC - 3	SPDT, Reflective	0.4	27	30	0 / +3V	MS8	EAR99	HMC190AMS8E
DC - 3	SPDT, High Isolation	0.7	50	23	0 / +5V	MS8	EAR99	HMC194MS8E
DC - 3	SPDT, Reflective	0.4	28	30	0 / +3V	SOT26	EAR99	HMC197AE
DC - 3	SPDT, Reflective	0.4	28	30	0 / +3V	SOT26	EAR99	HMC221AE
DC - 3	SPDT, Reflective	0.3	31	34	0 / +3 to +8V	SOT26	EAR99	HMC545E
DC - 3.5	SPDT, High Isolation	0.5	45	25	0 / +5V	MS8G	EAR99	HMC284MS8GE
DC - 4	SPDT, Reflective	0.5	28	29	0 / -5V or +5V / 0	Chip	EAR99	HMC240A
DC - 4	SPDT, High Isolation	0.9	65	31	0 / +5V	LP4C	EAR99	HMC349LP4CE
DC - 4	SPDT, High Isolation	0.9	57	31	0 / +5V	MS8G	EAR99	HMC349MS8GE
DC - 4	SPDT, High Isolation	1.1	47	31	0 / +5V	MS8G	EAR99	HMC435MS8GE
DC - 4	SPDT, Differential	0.8	45	35	0 / +3V to	LP4	EAR99	HMC922LP4E
DC - 6	SPDT, High Isolation	1.4	50	26	0 / -5V	G7 Hermetic	EAR99	HMC232G7
DC - 6	SPDT, High Isolation	1.4	43	26	0 / -5V	G8 Hermetic	EAR99	HMC232G8
DC - 6	SPDT, High Isolation	1.4	43	26	0 / -5V	G8 Hermetic	EAR99	HMC233G8
DC - 6	SPDT, High Isolation	1.6	42	25	0 / +5V	MS8G	EAR99	HMC336MS8GE
DC - 6	SPDT, High Isolation	1.4	46	27	0 / -5V	G7 Hermetic	EAR99	HMC607G7
DC - 6	SPDT, High Isolation	0.8	60	35	0 / +3 to +5V	LP4C	EAR99	HMC849LP4CE
DC - 8	SPDT, High Isolation	1.4	50	26	0 / -5V	C8	EAR99	HMC232C8
DC - 8	SPDT, High Isolation	1.5	45	26	0 / -5V	C8	EAR99	HMC234C8
DC - 8	SPDT, High Isolation	1.2	48	23	0 / -5V	MS8G	EAR99	HMC270MS8GE
DC - 8	SPDT, High Isolation	2.0	44	23	0 / -5V	C8	EAR99	HMC347C8
DC - 8	SPDT, High Isolation	2.2	35	23	0 / -5V	G8 Hermetic	EAR99	HMC347G8
DC - 12	SPDT, High Isolation	1.5	55	27	0 / -5V	LP4	EAR99	HMC232LP4E
DC - 14	SPDT, High Isolation	1.7	44	23	0 / -5V	LP3	EAR99	HMC347LP3E
DC - 15	SPDT, High Isolation	1.4	50	26	0 / -5V	Chip	EAR99	HMC232
DC - 15	SPDT, High Isolation	1.7	60	26	0 / -5V	Chip	EAR99	HMC607
DC - 20	SPDT, High Isolation	1.7	45	23	0 / -5V	Chip	EAR99	HMC347
DC - 20	SPDT, High Isolation	1.8	47	23	0 / -5V	LP3	EAR99	HMC547LP3E
DC - 28	SPDT, High Isolation	1.8	47	23	0 / -5V	LC3	EAR99	HMC547LC3
0.1 - 50	SPDT, Reflective	1.9	31	25	0 / -3V	Chip	EAR99	HMC986
55 - 86	SPDT, PIN MMIC	2	30	-	-5 / +5	Chip	5A991.h	HMC-SDD112
0.1 - 2.1	SPDT, 40W, Failsafe	0.4	22	46	0 / +3V to +8V	LP2	EAR99	HMC646LP2E
0.2 - 2.2	SPDT, 10W, Failsafe	0.4	40	> 40	0 / +3 to +8V	MS8G	EAR99	HMC546MS8GE
0.2 - 2.7	SPDT, 10W, Failsafe	0.4	35	43	0 / +3 to +8V	LP2	EAR99	HMC546LP2E
0.824 - 0.894	SPDT, 10W, T/R	0.6	22	> 40	0 / +5V	SOT26	EAR99	HMC446E
DC - 2.5	SPDT, CATV	0.6	58	28	0 / +5V	LP3	EAR99	HMC348LP3E
DC - 3	SPDT T/R	0.5	25	39	0/ +3V to +8V	MS8	EAR99	HMC174MS8E
DC - 3	SPDT, 5W, T/R	0.3	30	39	0 / +3 to +10V	MS8	EAR99	HMC574MS8E
DC - 3	SPDT, 3W, T/R	0.3	30	37	0 / +3 to +10V	SOT26	EAR99	HMC595E
DC - 4	SPDT T/R	0.25	23	39	0 / +3 to +5V	SOT26	EAR99	HMC544E
DC - 4	SPDT, 10W, T/R	0.4	30	40	0 / +3 to +8V	MS8G	EAR99	HMC784MS8GE
DC - 6	SPDT T/R	0.5	27	37	0 / +3 to +5V	MS8G	EAR99	HMC536MS8GE
DC - 6	SPDT T/R	0.6	27	37	0 / +3 to +5V	LP2	EAR99	HMC536LP2E
5 - 6	SPDT T/R	1.2	31	33	TTL/CMOS	MS8	EAR99	HMC224MS8E

SMT & Chip (Die) Products

SWITCHES

Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package	ECCN Code	Part Number
Multi-Throw Switches								
DC - 3.5	SP3T	0.5	44	26	TTL/CMOS	QS16	EAR99	HMC245QS16E
DC - 2	SP4T	0.8	32	24	0 / -5V	S14	EAR99	HMC182S14E
DC - 3.5	SP4T	0.5	45	25	TTL/CMOS	QS16	EAR99	HMC241QS16E
DC - 4	SP4T	0.6	47	26	TTL/CMOS	LP3	EAR99	HMC241LP3E
DC - 4	SP4T	0.7	40	25	TTL/CMOS	G16 Hermetic	EAR99	HMC244G16
DC - 8	SP4T	1.8	42	21	0 / -5V	Chip	EAR99	HMC344
DC - 8	SP4T	2.0	45	26	0 / -5V	LC3	EAR99	HMC344LC3
DC - 8	SP4T	1.8	40	21	0 / -5V	LP3	EAR99	HMC344LP3E
DC - 8	SP4T	2.2	32	21	0 / 5V	LP3	EAR99	HMC345LP3E
DC - 12	SP4T	1.8	42	27	0 / -5V	LH5 Hermetic	EAR99	HMC344LH5
DC - 18	SP4T	2.1	42	24	0 / -5V	Chip	EAR99	HMC641
DC - 20	SP4T	2.1	42	23	0 / -5V	LC4	EAR99	HMC641LC4
DC - 20	SP4T	2.3	45	22	0 / -5V	LP4	EAR99	HMC641LP4E
23 - 30	SP4T	2.8	35	25	0 / -3V	LC4	EAR99	HMC944LC4
DC - 3	SP6T	0.8	41	24	TTL/CMOS	QS24	EAR99	HMC252QS24E
DC - 2	SP8T	1.3	30	20	0 / -5V	QS24	EAR99	HMC183QS24E
DC - 2.5	SP8T	1.1	36	23	TTL/CMOS	QS24	EAR99	HMC253QS24E
DC - 3.5	SP8T	1.2	36	24	TTL/CMOS	LC4	EAR99	HMC253LC4
DC - 8	SP8T	2.3	40	23	0 / 5V	LP4	EAR99	HMC321LP4E
DC - 8	SP8T	2.5	25	23	0 / -5V	LP4	EAR99	HMC322LP4E
DC - 10	SP8T	2	38	23	0 / -5V	Chip	EAR99	HMC322
Bypass, Diversity, Matrix & Transfer Switches								
DC - 2.5	Bypass DPDT	0.3	25	23	0 / +5V	MS8	EAR99	HMC199MS8E
5 - 6	DPDT, Diversity	1.2	20	30	0 / +5V	MS8G	EAR99	HMC393MS8GE
0.2 - 3.0	4x2 Matrix	6	44	26	0 / +5V	LP4	EAR99	HMC276LP4E
0.2 - 3.0	4x2 Matrix	6.5	43	22	0 / +3 to +5V	LP4	EAR99	HMC596LP4E
0.7 - 3.0	4x2 Matrix	5.8	33	26	0 / +5V	QS24	EAR99	HMC276QS24E
DC - 8	Transfer	1.2	42	26	0 / +5V	LP3	EAR99	HMC427LP3E

TRANSCEIVERS - *New Product Line!*

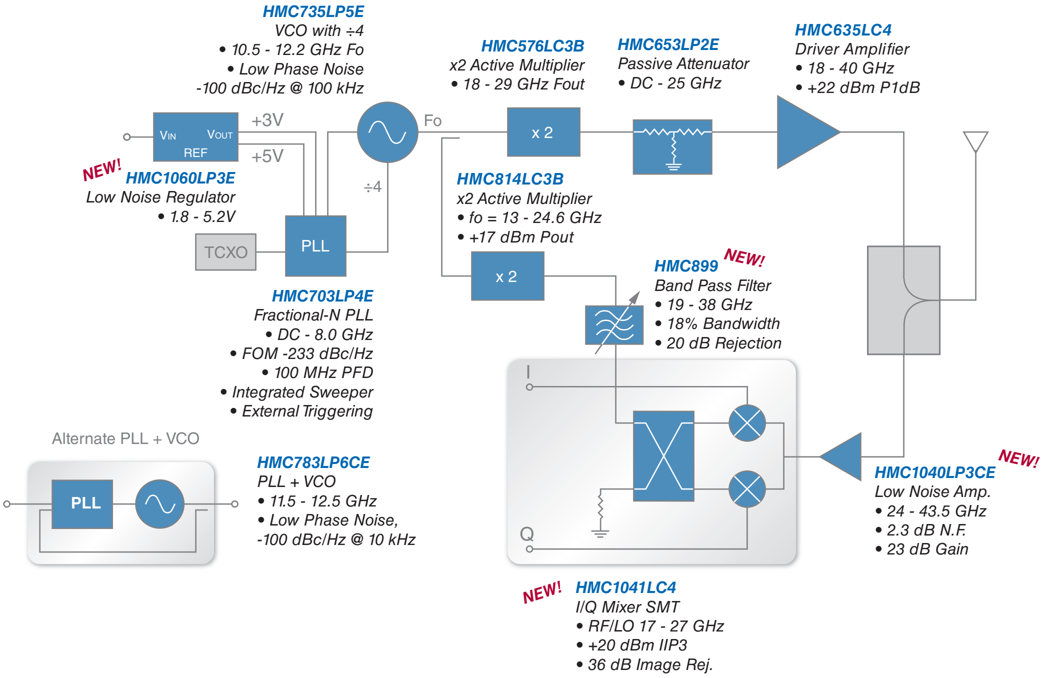
	Frequency (GHz)	Function	P1dB (dBm) NF (dB)	Max Gain (dB)	Gain Adjust (dB)	Phase Noise @ 1 MHz Offset (dBc/Hz)	Power Dissipation (W)	Package	ECCN Code	Part Number
NEW!	57 - 64	60 GHz Integrated Transmitter	12 dBm	38	17	-86	0.8	Chip	5A991.b	HMC6000
NEW!	57 - 64	60 GHz Integrated Receiver	6 dB	67	65	-86	0.61	Chip	5A991.b	HMC6001

VARIABLE GAIN AMPLIFIERS

Frequency (GHz)	Function	Gain Control Range (dB)	NF * (dB)	OIP3 * (dBm)	P1dB (dBm)	Bias Supply	Package	ECCN Code	Part Number
0.5 - 6.0	Analog	-35 to 15	7.5	28	21	+5V @ 90 mA	LP5	EAR99	HMC972LP5E
2.3 - 2.5	Analog	-8 to 22	2.5	7	3	+3V @ 9 mA	MS8	EAR99	HMC287MS8E
5 - 12	Analog	22	2	34	23	+5V @ 120 mA	LP4	EAR99	HMC996LP4E
6 - 17	Analog	0 to 23	5	30	22	+5V @ 170 mA	Chip	EAR99	HMC694
6 - 17	Analog	0 to 23	6	30	22	+5V @ 175 mA	LP4	EAR99	HMC694LP4E
17 - 27	Analog	15	3.5	30	24	+5V @ 170 mA	LC4	EAR99	HMC997LC4
0.03 - 0.4	5-Bit digital, Differential Outputs	-4 to 19	5	40	25	+5V @ 240 mA	LP4	EAR99	HMC680LP4E
0.05 - 0.8	5-Bit Digital	-8 to 15	5	35	18	+5V @ 65 mA	LP4	EAR99	HMC628LP4E
0.07 - 4.0	6-Bit Digital, Serial & Parallel Control	-19.5 to 12	4	39	23	+5V @ 150 mA	LP5	EAR99	HMC742LP5E
0.5 - 4.0	6-Bit Digital, Serial & Parallel Control or Latched Parallel Control	-19 to 12.5	4	39	21.5	+5V @ 150 mA	LP5	EAR99	HMC742HFLP5E
0.7 - 1.2	6-Bit Digital, Serial & Parallel Control	-2.5 to 29	0.8	38.5	21	+5V @ 236 mA	LP5	EAR99	HMC707LP5E
0.7 - 2.7	6-Bit Digital	6.5 to 38	4.4	45	25	+5V @ 218 mA	LP5	EAR99	HMC926LP5E
DC - 1	6-Bit Digital, Serial & Parallel Control	-11.5 to 20	4.3	36	20	+5V @ 90 mA	LP5	EAR99	HMC627LP5E
DC - 1	6-Bit Digital, Parallel Control	8.5 to 40	2.8	36	20	+5V @ 176 mA	LP5	EAR99	HMC626LP5E
DC - 1	6-Bit Digital, Serial Control	13.5 to 45	2.7	36	20	+5V @ 176 mA	LP5	EAR99	HMC681LP5E
DC - 6	6-Bit Digital, Serial & Parallel Control	-13.5 to 18	6	33	19	+5V @ 88 mA	LP5	EAR99	HMC625LP5E
0.5 - 6.0	6-Bit Digital, Serial & Parallel Control	-13.5 to 18	6	33	19	+5V @ 88 mA	LP5	EAR99	HMC625HFLP5E
1.7 - 2.2	6-Bit Digital, Serial & Parallel Control	-2.5 to 29	1.0	37.5	21.5	+5V @ 252 mA	LP5	EAR99	HMC708LP5E
DC - 4	Dual 6-Bit Digital, Serial Control	-45 to 18	6	33	18	+5V @ 82 mA	LP6C	EAR99	HMC743LP6CE

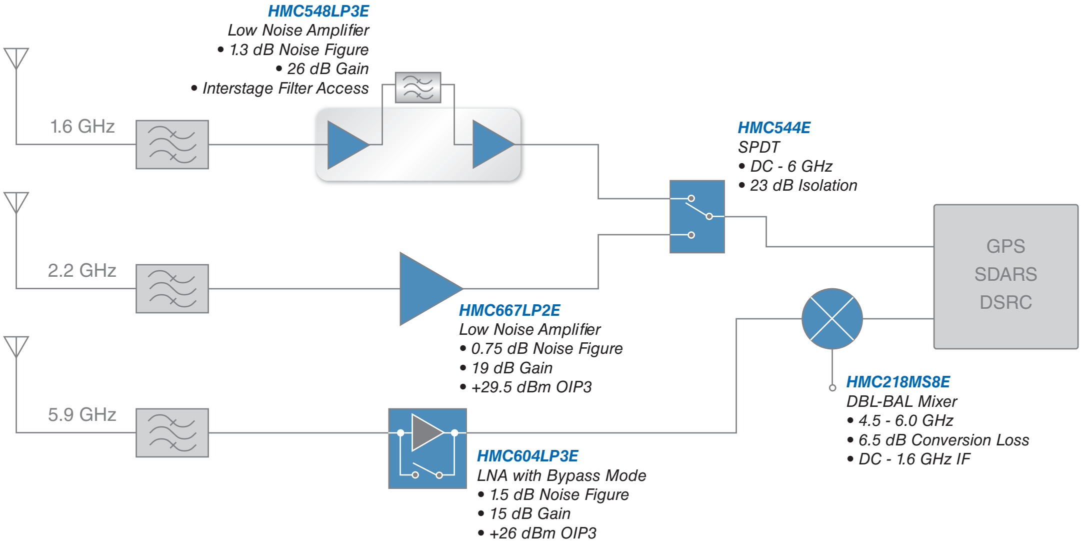
** Maximum Gain State*

24 GHz FMCW AUTOMOTIVE SENSOR



Typical Automotive application is illustrated.
See the full product listing for alternatives to the HMC products shown in each functional block.

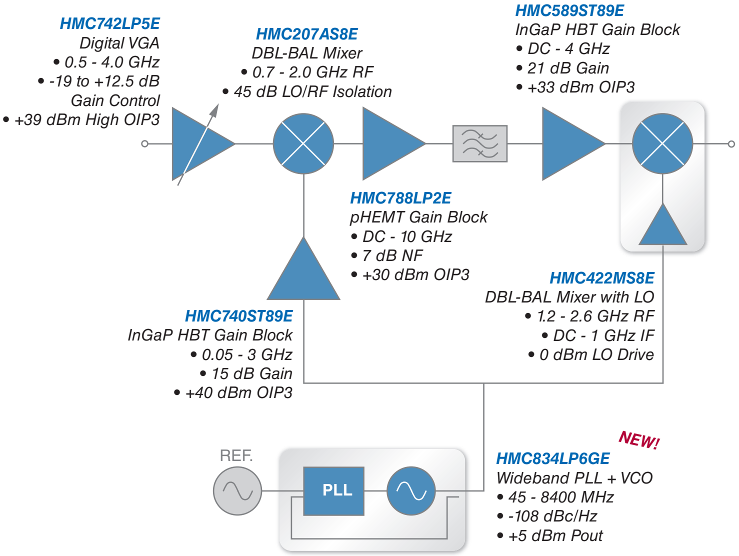
GPS, SDARS & DSRC RF FRONT-END FOR TELEMATICS



Typical Automotive application is illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

CABLE MODEM, CATV, DBS & VOIP SOLUTIONS, 5 - 2150 MHz

Cable Modem Termination System (CMTS)



HMC742LP5E
Digital VGA
- 0.5 - 4.0 GHz
- -19 to +12.5 dB Gain Control
- +39 dBm High OIP3

HMC207AS8E
DBL-BAL Mixer
- 0.7 - 2.0 GHz RF
- 45 dB LO/RF Isolation

HMC589ST89E
InGaP HBT Gain Block
- DC - 4 GHz
- 21 dB Gain
- +33 dBm OIP3

HMC788LP2E
pHEMT Gain Block
- DC - 10 GHz
- 7 dB NF
- +30 dBm OIP3

HMC422MS8E
DBL-BAL Mixer with LO
- 1.2 - 2.6 GHz RF
- DC - 1 GHz IF
- 0 dBm LO Drive

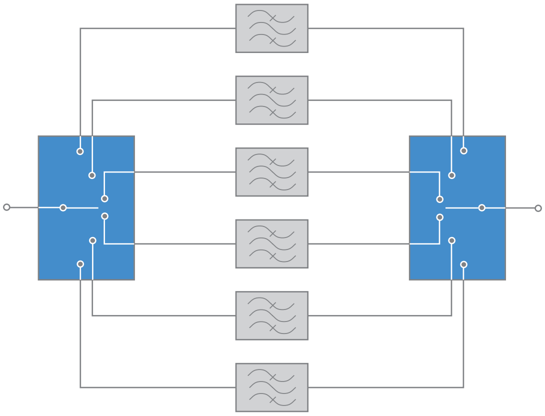
HMC740ST89E
InGaP HBT Gain Block
- 0.05 - 3 GHz
- 15 dB Gain
- +40 dBm OIP3

NEW!
HMC834LP6GE
Wideband PLL + VCO
- 45 - 8400 MHz
- -108 dBc/Hz
- +5 dBm Pout

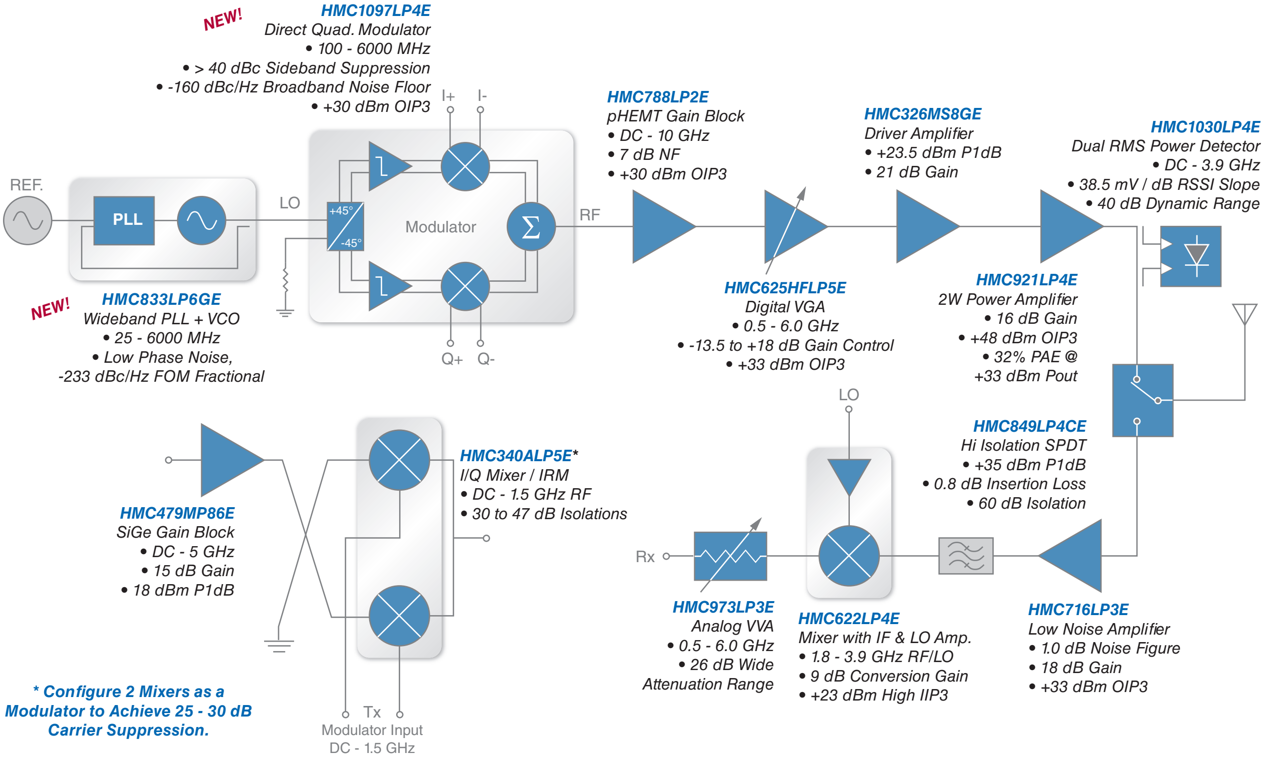
Typical Broadband applications are illustrated. See the full product listing for alternatives to the select HMC products shown in each functional block.

A Selection of SPNT Switches for CATV Filter & Signal Routing

Part Number	Frequency (GHz)	Function	1 GHz Loss / Isolation (dB)
HMC348LP3E	DC - 2.5	SPDT, 75 Ω	0.6 / 58
HMC349LP4CE	DC - 4	SPDT	0.9 / 65
HMC347LP3E	DC - 14	SPDT	1.7 / 44
HMC245QS16E	DC - 3.5	SP3T	0.5 / 44
HMC345LP3E	DC - 8	SP4T	2.2 / 32
HMC252QS24E	DC - 3	SP6T	2.0 / >45
HMC321LP4E	DC - 8	SP8T	2.0 / >45



WiMAX & FIXED WIRELESS, 2 - 6 GHz



NEW!
HMC1097LP4E
Direct Quad. Modulator
- 100 - 6000 MHz
- > 40 dBc Sideband Suppression
- -160 dBc/Hz Broadband Noise Floor
- +30 dBm OIP3

NEW!
HMC833LP6GE
Wideband PLL + VCO
- 25 - 6000 MHz
- Low Phase Noise, -233 dBc/Hz FOM Fractional

HMC788LP2E
pHEMT Gain Block
- DC - 10 GHz
- 7 dB NF
- +30 dBm OIP3

HMC326MS8GE
Driver Amplifier
- +23.5 dBm P1dB
- 21 dB Gain

HMC1030LP4E
Dual RMS Power Detector
- DC - 3.9 GHz
- 38.5 mV / dB RSSI Slope
- 40 dB Dynamic Range

HMC625HFLP5E
Digital VGA
- 0.5 - 6.0 GHz
- -13.5 to +18 dB Gain Control
- +33 dBm OIP3

HMC921LP4E
2W Power Amplifier
- 16 dB Gain
- +48 dBm OIP3
- 32% PAE @ +33 dBm Pout

HMC849LP4CE
Hi Isolation SPDT
- +35 dBm P1dB
- 0.8 dB Insertion Loss
- 60 dB Isolation

HMC479MP86E
SiGe Gain Block
- DC - 5 GHz
- 15 dB Gain
- 18 dBm P1dB

HMC340ALP5E*
I/Q Mixer / IRM
- DC - 1.5 GHz RF
- 30 to 47 dB Isolations

Modulator Input
DC - 1.5 GHz

HMC973LP3E
Analog VVA
- 0.5 - 6.0 GHz
- 26 dB Wide Attenuation Range

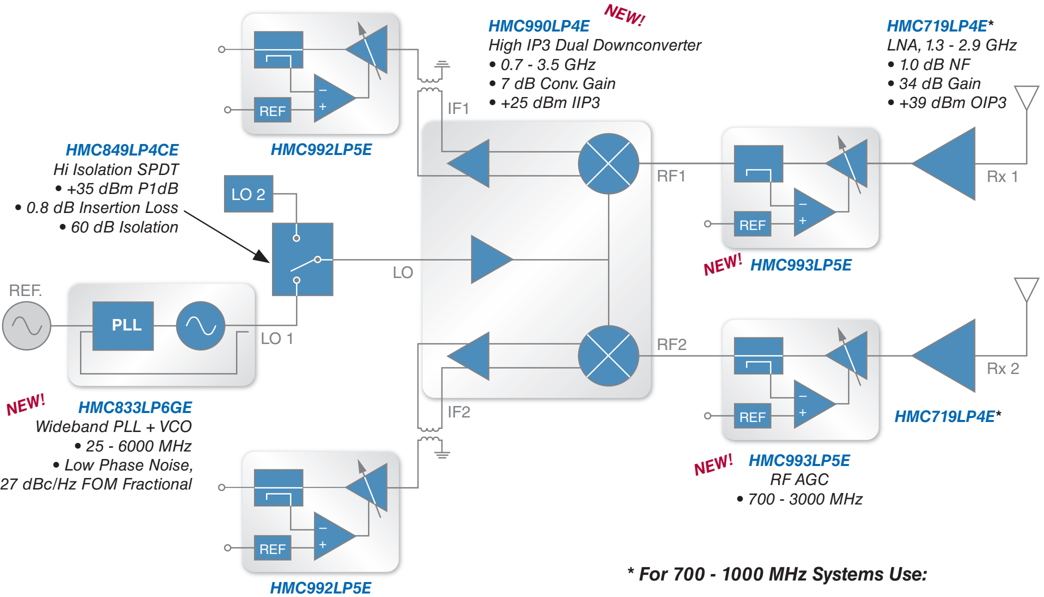
HMC622LP4E
Mixer with IF & LO Amp.
- 1.8 - 3.9 GHz RF/LO
- 9 dB Conversion Gain
- +23 dBm High IIP3

HMC716LP3E
Low Noise Amplifier
- 1.0 dB Noise Figure
- 18 dB Gain
- +33 dBm OIP3

**** Configure 2 Mixers as a Modulator to Achieve 25 - 30 dB Carrier Suppression.***

Typical WiMAX / FWA Transceiver is illustrated. See the full product listing for alternatives to the select HMC products shown in each functional block.

BTS RECEIVER SOLUTIONS FEATURING DUAL CHANNEL RFIC DOWNCONVERTER



NEW! **HMC990LP4E**
High IP3 Dual Downconverter
- 0.7 - 3.5 GHz
- 7 dB Conv. Gain
- +25 dBm IIP3

HMC719LP4E*
LNA, 1.3 - 2.9 GHz
- 1.0 dB NF
- 34 dB Gain
- +39 dBm OIP3

HMC849LP4CE
Hi Isolation SPDT
- +35 dBm P1dB
- 0.8 dB Insertion Loss
- 60 dB Isolation

HMC992LP5E

NEW! **HMC993LP5E**

NEW! **HMC833LP6GE**
Wideband PLL + VCO
- 25 - 6000 MHz
- Low Phase Noise, -227 dBc/Hz FOM Fractional

HMC719LP4E*

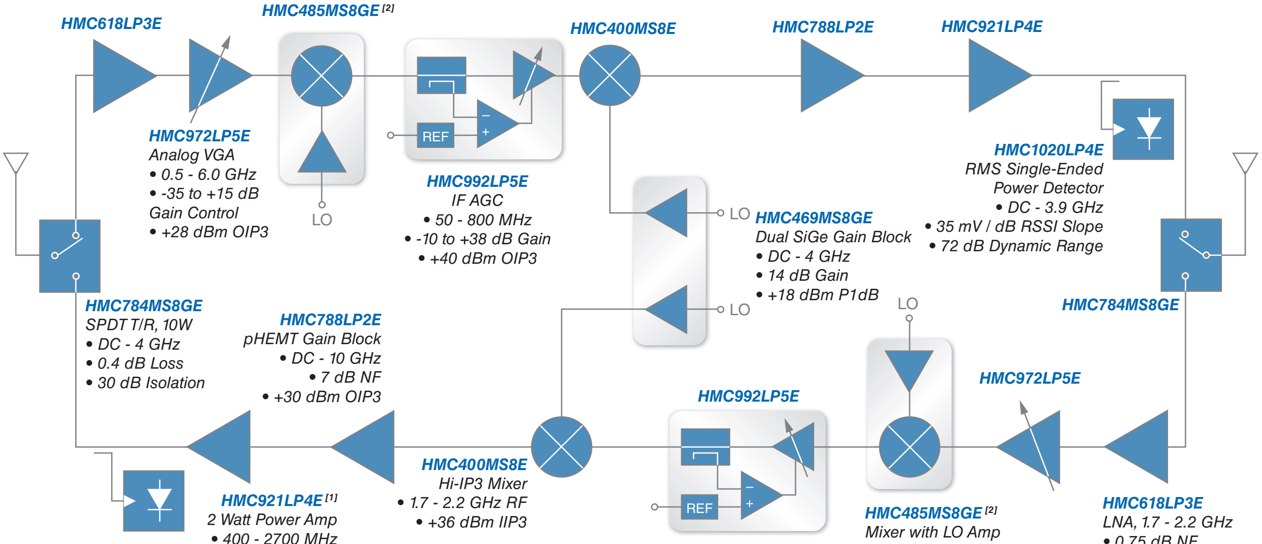
NEW! **HMC993LP5E**
RF AGC
- 700 - 3000 MHz

HMC992LP5E
IF AGC
- 50 - 800 MHz
- -10 to +38 dB Gain
- +40 dBm OIP3

*** For 700 - 1000 MHz Systems Use:**

HMC718LP4E
Low Noise Amplifier
- 0.6 - 1.4 GHz
- 0.9 dB Noise Figure
- 32 dB Gain
- +40 dBm OIP3

CDMA / GSM / TD-SCDMA REPEATER SOLUTIONS



HMC618LP3E

HMC485MS8GE [2]

HMC400MS8E

HMC788LP2E

HMC921LP4E

HMC972LP5E
Analog VGA
- 0.5 - 6.0 GHz
- -35 to +15 dB Gain Control
- +28 dBm OIP3

HMC992LP5E
IF AGC
- 50 - 800 MHz
- -10 to +38 dB Gain
- +40 dBm OIP3

HMC1020LP4E
RMS Single-Ended Power Detector
- DC - 3.9 GHz
- 35 mV / dB RSSI Slope
- 72 dB Dynamic Range

HMC469MS8GE
Dual SiGe Gain Block
- DC - 4 GHz
- 14 dB Gain
- +18 dBm P1dB

HMC784MS8GE
SPDT T/R, 10W
- DC - 4 GHz
- 0.4 dB Loss
- 30 dB Isolation

HMC788LP2E
pHEMT Gain Block
- DC - 10 GHz
- 7 dB NF
- +30 dBm OIP3

HMC784MS8GE

HMC972LP5E

HMC992LP5E

HMC400MS8E
Hi-IP3 Mixer
- 1.7 - 2.2 GHz RF
- +36 dBm IIP3

HMC921LP4E [1]
2 Watt Power Amp
- 400 - 2700 MHz
- +48 dBm OIP3
- 16 dB Gain

HMC1020LP4E
RMS Single-Ended Power Detector
- DC - 3.9 GHz
- 35 mV / dB RSSI Slope
- 72 dB Dynamic Range

HMC485MS8GE [2]
Mixer with LO Amp
- 1.7 - 2.2 GHz
- +34 dBm IIP3
- 9 dB Conv. Loss

HMC618LP3E
LNA, 1.7 - 2.2 GHz
- 0.75 dB NF
- 19 dB Gain
- +36 dBm OIP3

[1] High Gain Option:

HMC457QS16GE
1 Watt Power Amp
- 1.7 - 2.2 GHz
- +46 dBm OIP3
- 27 dB Gain

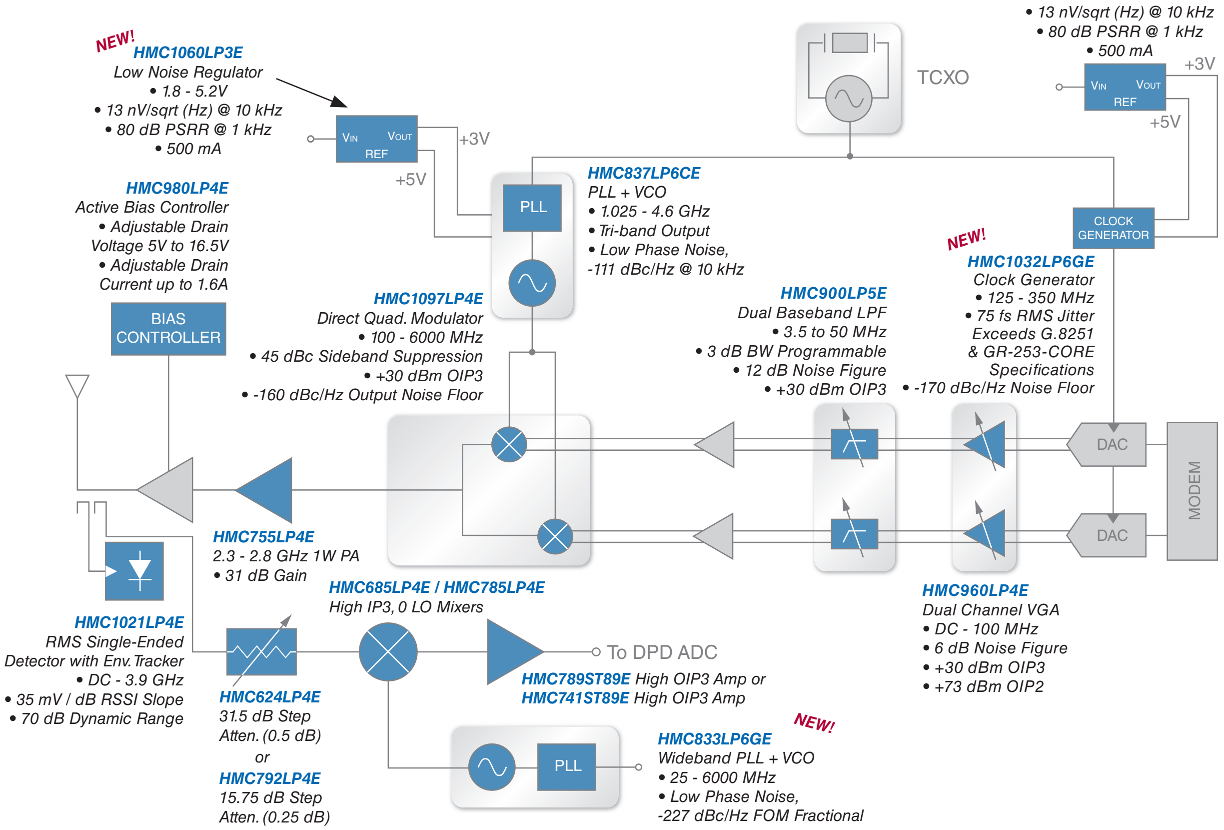
[2] For 700 - 1000 MHz Systems Use:

HMC483MS8GE
Mixer with LO Amp
- 0.7 - 1.5 GHz
- 33 dBm IIP3

Typical Cellular/PCS/3G applications are illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

Cellular Infrastructure, 380 - 2690 MHz

WiMAX / LTE / 4G TRANSMITTER SOLUTIONS



NEW! **HMC1060LP3E**
Low Noise Regulator
- 1.8 - 5.2V
- 13 nV/sqrt (Hz) @ 10 kHz
- 80 dB PSRR @ 1 kHz
- 500 mA

NEW! **HMC1060LP3E**
Low Noise Regulator
- 1.8 - 5.2V
- 13 nV/sqrt (Hz) @ 10 kHz
- 80 dB PSRR @ 1 kHz
- 500 mA

HMC980LP4E
Active Bias Controller
- Adjustable Drain Voltage 5V to 16.5V
- Adjustable Drain Current up to 1.6A

HMC837LP6CE
PLL + VCO
- 1.025 - 4.6 GHz
- Tri-band Output
- Low Phase Noise, -111 dBc/Hz @ 10 kHz

NEW! **HMC1032LP6GE**
Clock Generator
- 125 - 350 MHz
- 75 fs RMS Jitter Exceeds G.8251 & GR-253-CORE Specifications
- -170 dBc/Hz Noise Floor

HMC1097LP4E
Direct Quad. Modulator
- 100 - 6000 MHz
- 45 dBc Sideband Suppression
- +30 dBm OIP3
- -160 dBc/Hz Output Noise Floor

HMC900LP5E
Dual Baseband LPF
- 3.5 to 50 MHz
- 3 dB BW Programmable
- 12 dB Noise Figure
- +30 dBm OIP3

HMC755LP4E
2.3 - 2.8 GHz 1W PA
- 31 dB Gain

HMC685LP4E / HMC785LP4E
High IP3, 0 LO Mixers

HMC960LP4E
Dual Channel VGA
- DC - 100 MHz
- 6 dB Noise Figure
- +30 dBm OIP3
- +73 dBm OIP2

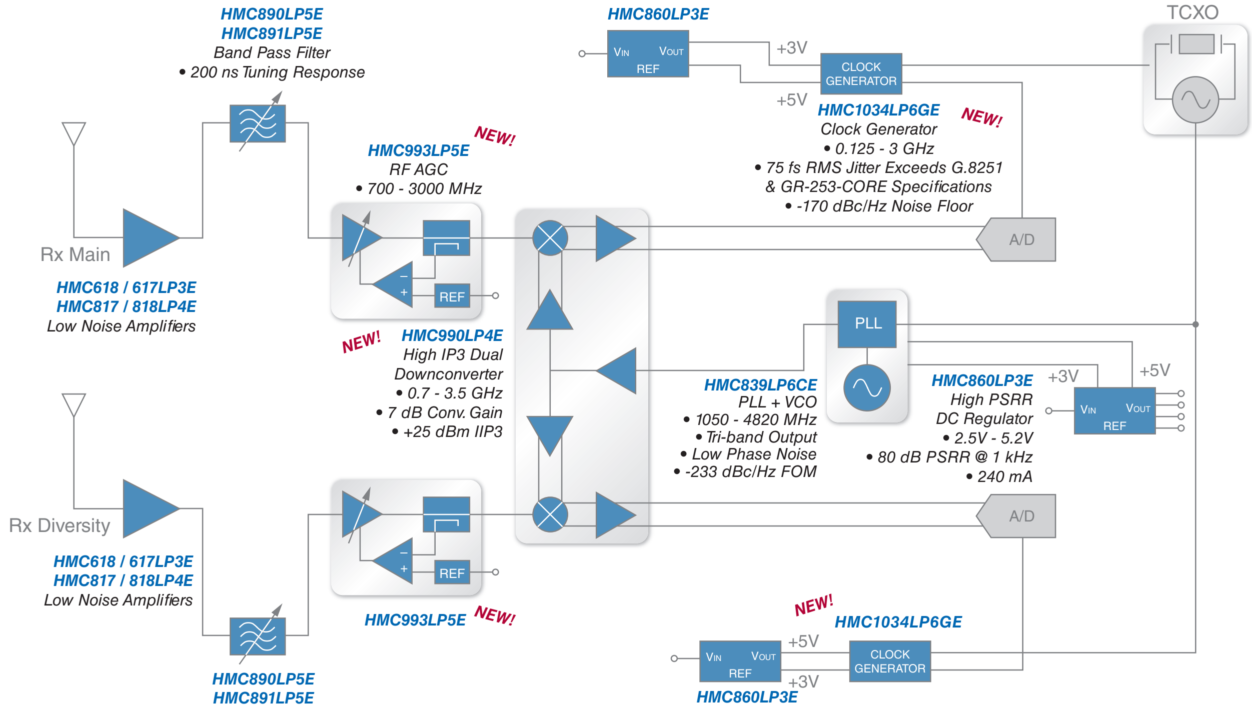
HMC1021LP4E
RMS Single-Ended Detector with Env. Tracker
- DC - 3.9 GHz
- 35 mV / dB RSSI Slope
- 70 dB Dynamic Range

HMC624LP4E
31.5 dB Step Atten. (0.5 dB)
or
HMC792LP4E
15.75 dB Step Atten. (0.25 dB)

HMC789ST89E High OIP3 Amp or
HMC741ST89E High OIP3 Amp

NEW! **HMC833LP6GE**
Wideband PLL + VCO
- 25 - 6000 MHz
- Low Phase Noise, -227 dBc/Hz FOM Fractional

WiMAX / LTE / 4G RECEIVER SOLUTIONS FEATURING HETERODYNE DOWNCONVERSION



HMC890LP5E
HMC891LP5E
Band Pass Filter
- 200 ns Tuning Response

HMC860LP3E

HMC1034LP6GE NEW!
Clock Generator
- 0.125 - 3 GHz
- 75 fs RMS Jitter Exceeds G.8251 & GR-253-CORE Specifications
- -170 dBc/Hz Noise Floor

HMC993LP5E NEW!
RF AGC
- 700 - 3000 MHz

HMC618 / 617LP3E
HMC817 / 818LP4E
Low Noise Amplifiers

NEW! **HMC990LP4E**
High IP3 Dual Downconverter
- 0.7 - 3.5 GHz
- 7 dB Conv. Gain
- +25 dBm IIP3

HMC839LP6CE
PLL + VCO
- 1050 - 4820 MHz
- Tri-band Output
- Low Phase Noise
- -233 dBc/Hz FOM

HMC860LP3E
High PSRR DC Regulator
- 2.5V - 5.2V
- 80 dB PSRR @ 1 kHz
- 240 mA

HMC618 / 617LP3E
HMC817 / 818LP4E
Low Noise Amplifiers

HMC993LP5E NEW!

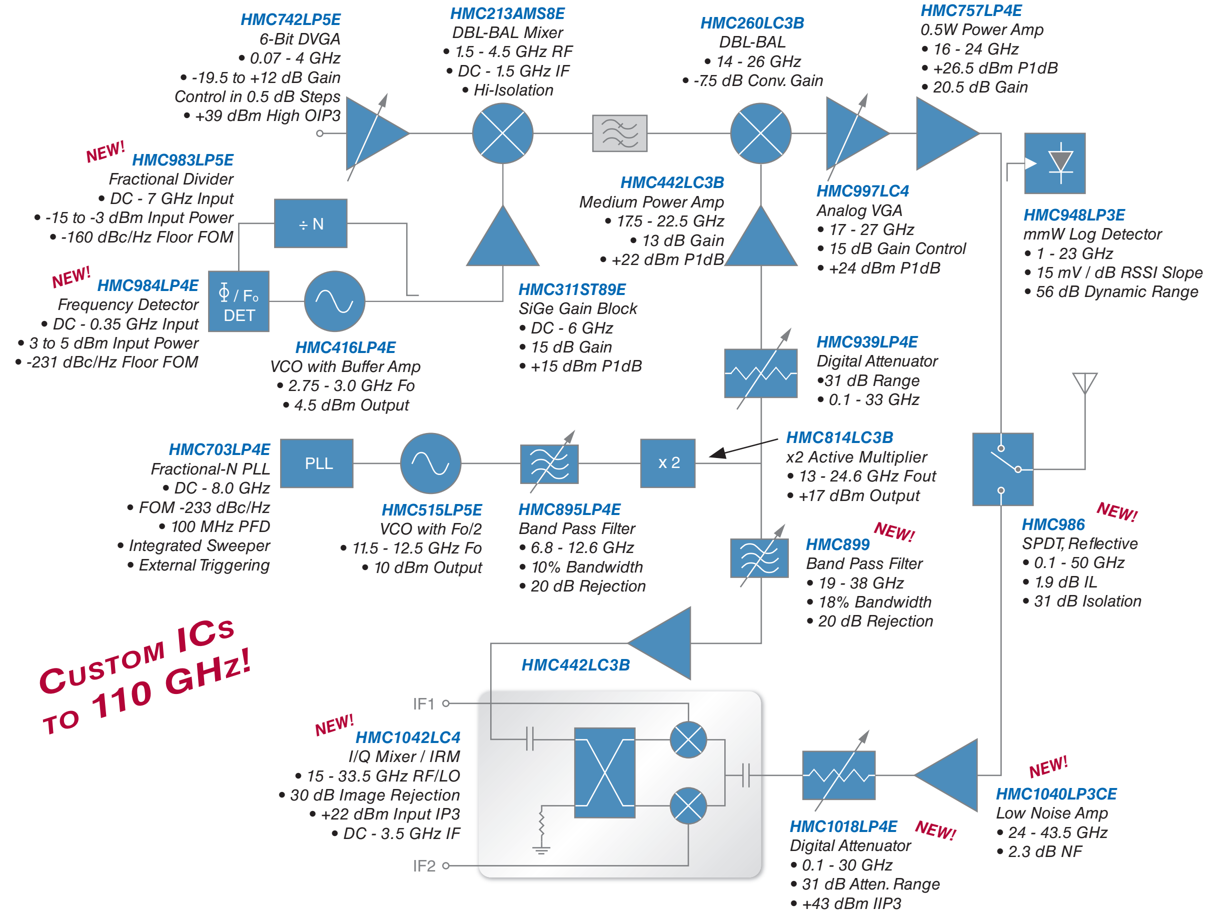
NEW! **HMC1034LP6GE**

HMC890LP5E
HMC891LP5E

HMC860LP3E

Typical WiMAX/LTE/4G applications are illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

DOUBLE UPCONVERSION & DIRECT DOWNCONVERSION



HMC742LP5E
6-Bit DVGA
- 0.07 - 4 GHz
- -19.5 to +12 dB Gain Control in 0.5 dB Steps
- +39 dBm High OIP3

HMC213AMS8E
DBL-BAL Mixer
- 1.5 - 4.5 GHz RF
- DC - 1.5 GHz IF
- Hi-Isolation

HMC260LC3B
DBL-BAL
- 14 - 26 GHz
- -7.5 dB Conv. Gain

HMC757LP4E
0.5W Power Amp
- 16 - 24 GHz
- +26.5 dBm P1dB
- 20.5 dB Gain

NEW! **HMC983LP5E**
Fractional Divider
- DC - 7 GHz Input
- -15 to -3 dBm Input Power
- -160 dBc/Hz Floor FOM

HMC442LC3B
Medium Power Amp
- 17.5 - 22.5 GHz
- 13 dB Gain
- +22 dBm P1dB

HMC997LC4
Analog VGA
- 17 - 27 GHz
- 15 dB Gain Control
- +24 dBm P1dB

HMC948LP3E
mmW Log Detector
- 1 - 23 GHz
- 15 mV / dB RSSI Slope
- 56 dB Dynamic Range

NEW! **HMC984LP4E**
Frequency Detector
- DC - 0.35 GHz Input
- 3 to 5 dBm Input Power
- -231 dBc/Hz Floor FOM

HMC311ST89E
SiGe Gain Block
- DC - 6 GHz
- 15 dB Gain
- +15 dBm P1dB

HMC416LP4E
VCO with Buffer Amp
- 2.75 - 3.0 GHz Fo
- 4.5 dBm Output

HMC939LP4E
Digital Attenuator
- 31 dB Range
- 0.1 - 33 GHz

HMC814LC3B
x2 Active Multiplier
- 13 - 24.6 GHz Fout
- +17 dBm Output

HMC703LP4E
Fractional-N PLL
- DC - 8.0 GHz
- FOM -233 dBc/Hz
- 100 MHz PFD
- Integrated Sweeper
- External Triggering

HMC515LP5E
VCO with Fo/2
- 11.5 - 12.5 GHz Fo
- 10 dBm Output

HMC895LP4E
Band Pass Filter
- 6.8 - 12.6 GHz
- 10% Bandwidth
- 20 dB Rejection

NEW! **HMC899**
Band Pass Filter
- 19 - 38 GHz
- 18% Bandwidth
- 20 dB Rejection

NEW! **HMC986**
SPDT, Reflective
- 0.1 - 50 GHz
- 1.9 dB IL
- 31 dB Isolation

CUSTOM ICs TO 110 GHz!

HMC442LC3B

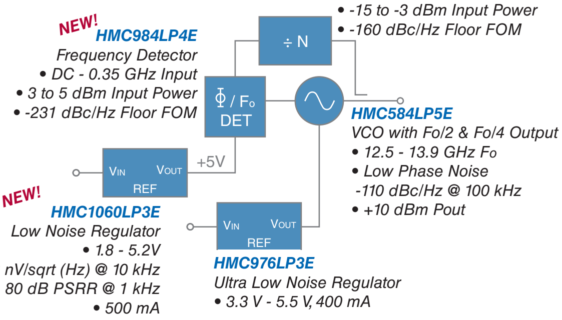
NEW! **HMC1042LC4**
I/Q Mixer / IRM
- 15 - 33.5 GHz RF/LO
- 30 dB Image Rejection
- +22 dBm Input IP3
- DC - 3.5 GHz IF

HMC1018LP4E NEW!
Digital Attenuator
- 0.1 - 30 GHz
- 31 dB Atten. Range
- +43 dBm IIP3

NEW! **HMC1040LP3CE**
Low Noise Amp
- 24 - 43.5 GHz
- 2.3 dB NF

HITTITE'S HIGH FREQUENCY LO SOURCE ALTERNATIVES

PLL & VCO CHIPSET



HMC983LP5E NEW!
Fractional Divider
- DC - 7 GHz Input
- -15 to -3 dBm Input Power
- -160 dBc/Hz Floor FOM

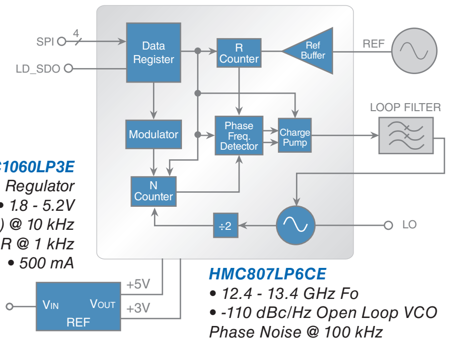
NEW! **HMC984LP4E**
Frequency Detector
- DC - 0.35 GHz Input
- 3 to 5 dBm Input Power
- -231 dBc/Hz Floor FOM

HMC584LP5E
VCO with Fo/2 & Fo/4 Output
- 12.5 - 13.9 GHz Fo
- Low Phase Noise
- -110 dBc/Hz @ 100 kHz
- +10 dBm Pout

NEW! **HMC1060LP3E**
Low Noise Regulator
- 1.8 - 5.2V
- 13 nV/sqrt (Hz) @ 10 kHz
- 80 dB PSRR @ 1 kHz
- 500 mA

HMC976LP3E
Ultra Low Noise Regulator
- 3.3 V - 5.5 V, 400 mA

PLL WITH INTEGRATED VCO IC



NEW! **HMC1060LP3E**
Low Noise Regulator
- 1.8 - 5.2V
- 13 nV/sqrt (Hz) @ 10 kHz
- 80 dB PSRR @ 1 kHz
- 500 mA

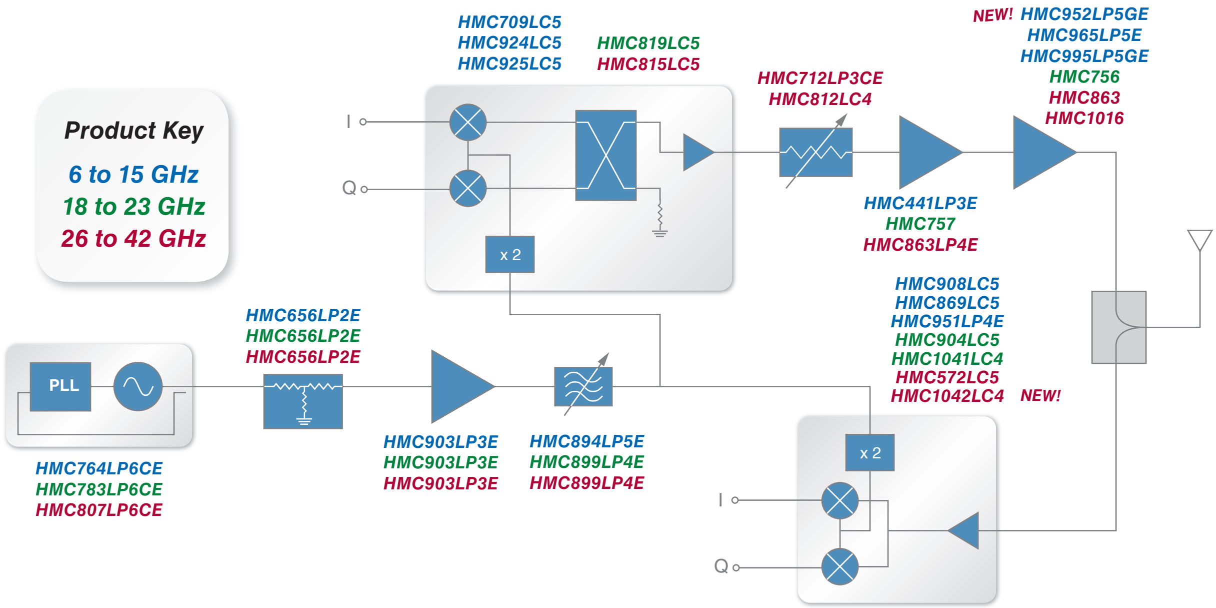
HMC807LP6CE
- 12.4 - 13.4 GHz Fo
- -110 dBc/Hz Open Loop VCO Phase Noise @ 100 kHz
- +8 dBm Pout

Typical Microwave / Millimeterwave application is illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

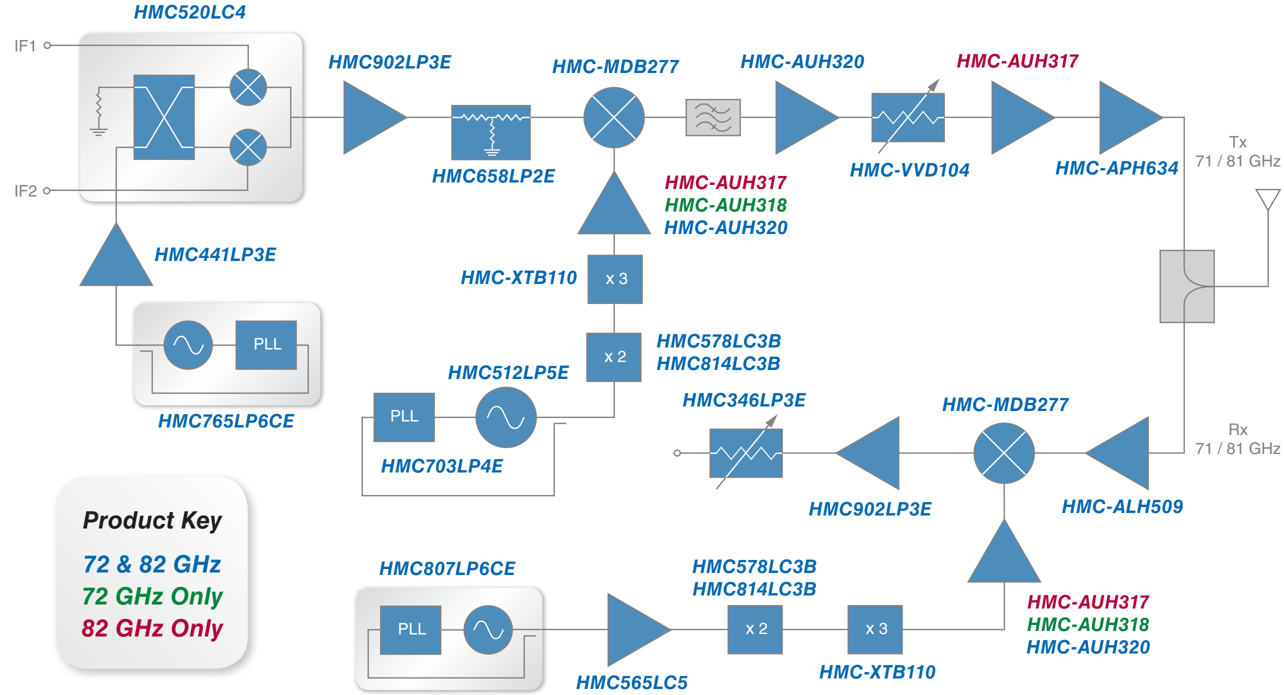
CHIPSETS FOR 6 TO 42 GHz MICROWAVE RADIO BACKHAUL

Features

- *Integrated IQ TX Upconverter IC with a X2 LO Buffer & a High Linearity Driver Amplifier*
- *High Linearity 17 - 24 GHz Power Amplifier with 40 dBm OIP3 & 32 dBm Saturated Power*
- *Low Noise Image Rejection Downconverter IC with a X2 Integrated LO Buffer*
- *Very Low Phase Noise PLL IC with an Integrated VCO*



70 / 80 GHz E-BAND RADIO CHIPSET



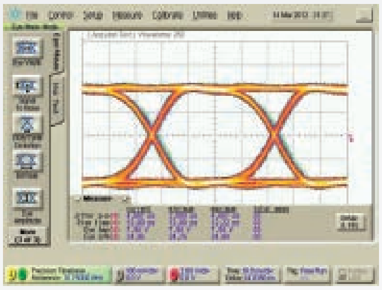
Typical Microwave / Millimeterwave application is illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

HMC5850BG 40 / 100G Optical Modulator Driver

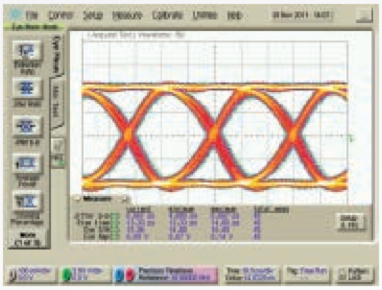
Features

- ♦ *Operational to 32 Gbps:*
  - *40 Gbps DQPSK*
  - *100 Gbps DP-QPSK (Coherent)*
  - *40 Gbps DP-BPSK*
- ♦ *Low DC Power Dissipation:*
  - *1.4W (for 8 Vpp Swing @ 6V Supply)*
  - *0.8W (for 6 Vpp Swing @ 5V Supply)*
- ♦ *Small Package Size: 9.75 x 6 x 3.29 mm*
- ♦ *Integrated Peak Detect Feature Enables Monitoring & Maintaining Output Swing Stability*
- ♦ *Integrated Bias-Tee Feature Eliminates External Coil, Simplifies PCB Design & Lowers BOM Cost*

21.5 Gbps NRZ Output Eye Diagram @ +6V



32 Gbps NRZ Output Eye Diagram @ +6V



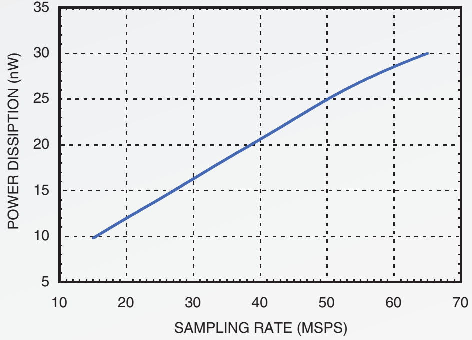
Low Power 40G / 100G Optical Modulator Driver for Long-Haul Applications!
Features Integrated Bias-Tee and Peak Detection Feature!

HMCAD1104 Octal 10-Bit 20/40/50/65 MSPS Analog-to-Digital Converter

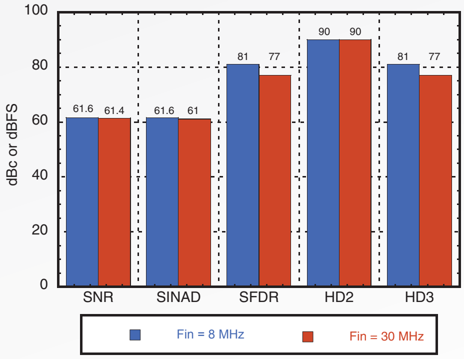
Features

- ♦ *50 MSPS Maximum Sampling Rate*
- ♦ *Ultra Low Power Dissipation*
  - *12 mW / Channel @ 20 MSPS*
  - *20 mW / Channel @ 40 MSPS*
  - *25 mW / Channel @ 50 MSPS*
  - *30 mW / Channel @ 65 MSPS*
- ♦ *61 dB SNR @ 8 MHz Fin*
- ♦ *Coarse and Fine Gain Control*
- ♦ *64 Lead 9 x 9 mm SMT Package*

Power Dissipation Per Channel



Performance



Ideal for ATE, MIMO Antennas & High Speed Data Acqusistion!

BROADBAND TIME DELAYS - *Analog & Digital*

Data / Clock Rate (Gbps / GHz)	Function	Rise / Fall (ps)	Deterministic Jitter (ps)	Differential Output Voltage Swing (Vp-p)	DC Power Consumption (mW)	Vcc Power Supply (Vdc)	Package	ECCN Code	Part Number
- / 23	Analog Time Delay	10 / 11	-	0.5 - 0.95	630	+3.3	LC3	3A001.a.11.b	HMC877LC3
32 / 24	Analog Time Delay	14 / 14	6	0.15 - 0.6	1450	+3.3	LC4B	3A001.a.11.b	HMC910LC4B
32 / 24	Analog Time Delay	15 / 14	6	0.8	1600	+3.3	LC4	3A001.a.11.b	HMC911LC4B
28 / 28	5-Bit Digital Time Delay	20 / 18	< 2	0.5 - 1.35	610	-3.3	LC5	3A001.a.11.b	HMC856LC5

COMPARATORS - *High Speed Clocked, Latched & Window Comparators*

Analog Input B/W (GHz) / Clock Rate (Gbps)	Function	Deterministic Jitter (ps)	Propagation Delay (ps)	Output Voltage Swing (Vdc)	DC Power (mW)	Vcco / V_{term} [1] Power Supply (Vdc)	Package	ECCN Code	Part Number
10 / 20	Clocked Comparator-RSPECL	<3	120	0.4	150	+3.3 / +1.3	LC3C	3A001.a.11.b	HMC874LC3C
10 / 20	Clocked Comparator-RSCML	<3	120	0.4	130	0 / 0	LC3C	3A001.a.11.b	HMC875LC3C
10 / 20	Clocked Comparator-RSECL	<3	120	0.4	150	0 / -2.0	LC3C	3A001.a.11.b	HMC876LC3C
10 / [2]	Latched Comparator-RSPECL	2	85	0.4	140	+3.3 / 1.3	LC3C	3A001.a.11.b	HMC674LC3C
10 / [2]	Latched Comparator-RSPECL	2	85	0.4	140	+3.3 / 1.3	LP3	3A001.a.11.b	HMC674LP3E
10 / [2]	Latched Comparator-RSCML	2	100	0.4	100	0 / 0	LC3C	3A001.a.11.b	HMC675LC3C
10 / [2]	Latched Comparator-RSCML	2	100	0.4	100	0 / 0	LP3	3A001.a.11.b	HMC675LP3E
10 / [2]	Latched Comparator-RSECL	2	100	0.35	120	0 / -2.0	LC3C	3A001.a.11.b	HMC676LC3C
10 / [2]	Latched Comparator-RSECL	2	100	0.35	120	0 / -2.0	LP3	3A001.a.11.b	HMC676LP3E
10 / -	Window Comparator	2	88	0.4	240	+2 / 0	LC3C	3A001.a.11.b	HMC974LC3C

[1] Vee = -3.0V & Vcci = +3.3V [2] These products are pin for pin compatible

CROSSPOINT SWITCH

Data / Clock Rate (Gbps / GHz)	Function	Rise / Fall Time (ps)	Deterministic Jitter (ps)	Differential Output Swing (Vp-p)	DC Power (mW)	DC Power Supply (Vdc)	Package	ECCN Code	Part Number
14 / 14	2x2 Crosspoint Switch*	21 / 21	2	0.5 - 1.2	345	-3.3	LC5	3A001.a.11.b	HMC857LC5

DATA CONVERTERS

Low Power Analog-to-Digital Converters

Sample Rate	Function / Mode	Resolution (bits)	# of Channels	Power Dissipation [2][3]	SNR (dBFS)	SFDR (dBc)	Package	ECCN Code	Part Number
640 MSPS	High Speed, Single Channel	12	1	490 mW	70	60 / 75 [1]	LP7DE	3A001.a.5.a.4	HMCAD1520
320 MSPS	High Speed, Dual Channel	12	2	490 mW	70	60 / 78 [1]		3A001.a.5.a.4	
160 MSPS	High Speed, Quad Channel	12	4	490 mW	70	60 / 78 [1]		3A001.a.5.a.4	
105 MSPS 80 MSPS	Precision, Quad Channel	14	4 4	603 mW 530 mW	74 75	83 85		3A001.a.5.a.4	
1 GSPS	High Speed, Single Channel	8	1	710 mW	49.8	49 / 64 [1]	LP7DE	3A001.a.5.a.1	HMCAD1511
500 MSPS	High Speed, Dual Channel	8	2	710 mW	49.8	44 / 63 [1]		3A001.a.5.a.1	
250 MSPS	High Speed, Quad Channel	8	4	710 mW	49.8	57 / 70 [1]		3A001.a.5.a.1	
500 MSPS	High Speed, Single Channel	8	1	295 mW	49.8	49 / 65 [1]	LP7DE	3A991.c.1	HMCAD1510
250 MSPS	High Speed, Dual Channel	8	2	295 mW	49.8	59 / 69 [1]		3A991.c.1	
125 MSPS	High Speed, Quad Channel	8	4	295 mW	49.7	60 / 69 [1]		3A991.c.1	
80 MSPS	Octal Channel	13 / 12	8	59 mW / Channel	70.1	77	LP9E	3A991.c.3	HMCAD1102
65 MSPS	Octal Channel	13 / 12	8	51 mW / Channel	72.2	82	LP9E	3A991.c.3	HMCAD1101
NEW! 20/40/50/65 MSPS	Octal Channel	10	8	12/20/25/30 mW / Channel	61.6	81	LP9E	EAR99	HMCAD1104
50 MSPS	Octal Channel	13 / 12	8	41 mW / Channel	72.2	82	LP9E	3A991.c.3	HMCAD1100
40 MSPS	Octal Channel	13 / 12	8	35 mW / Channel	72.2	82		3A991.c.3	
20 MSPS	Octal Channel	13 / 12	8	23 mW / Channel	72.2	82		3A991.c.3	
80 MSPS	Dual Channel	13 / 12	2	102 mW	72	77	LP9E	3A991.c.3	HMCAD1050-80
65 MSPS	Dual Channel	13 / 12	2	85 mW	72.6	81		3A991.c.3	
40 MSPS	Dual Channel	13 / 12	2	55 mW	72.7	81	LP9E	3A991.c.3	HMCAD1050-40
20 MSPS	Dual Channel	13 / 12	2	30 mW	72.2	85		3A991.c.3	

DATA CONVERTERS

Low Power Analog-to-Digital Converters

Sample Rate	Function / Mode	Resolution (bits)	# of Channels	Power Dissipation [2][3]	SNR (dBFS)	SFDR (dBc)	Package	ECCN Code	Part Number
80 MSPS	Single Channel	13 / 12	1	60 mW	72	77	LP6HE	3A991.c.3	HMCAD1051-80
65 MSPS	Single Channel	13 / 12	1	50 mW	72.6	81		3A991.c.3	
40 MSPS	Single Channel	13 / 12	1	33 mW	72.7	81	LP6HE	3A991.c.3	HMCAD1051-40
20 MSPS	Single Channel	13 / 12	1	19 mW	72.2	85		3A991.c.3	
80 MSPS	Dual Channel	10	2	78 mW	61.6	75	LP9E	EAR99	HMCAD1040-80
65 MSPS	Dual Channel	10	2	65 mW	61.6	77		EAR99	
40 MSPS	Dual Channel	10	2	43 mW	61.6	81	LP9E	EAR99	HMCAD1040-40
20 MSPS	Dual Channel	10	2	24 mW	61.6	81		EAR99	
80 MSPS	Single Channel	10	1	46 mW	61.6	75	LP6HE	EAR99	HMCAD1041-80
65 MSPS	Single Channel	10	1	38 mW	61.6	77		EAR99	
40 MSPS	Single Channel	10	1	25 mW	61.6	81	LP6HE	EAR99	HMCAD1041-40
20 MSPS	Single Channel	10	1	15 mW	61.6	81		EAR99	

[1] Excluding Interleaving Spurs.

Ultra High Speed Analog-to-Digital Converters

Input Frequency (GHz)	Function	Sample Rate (Gsps)	Resolution (Bits)	ENOB	SFDR (dBFS)	Package	ECCN Code	Part Number
NEW! 20	3-Bit ADC with 1:2 Demux	26	3	2.9	26	LP9	3A001.a.11.b	HMCAD5831LP9BE

Track-and-Hold Amplifiers

Input Frequency (GHz)	Function	Single Tone THD/SFDR (dB)	Maximum Clock Rate (GS/s)	Output Noise (mV RMS)	Hold Mode Feed-through Rejection (dB)	Package	ECCN Code	Part Number
NEW! DC - 5	Track-and-Hold	-65 / 67	4.0	0.86	> 60	LC4B	3A001.a.11.b	HMC760LC4B
NEW! DC - 18	Track-and-Hold	-65 / 67	4.0	1.65	> 60	LC4B	3A001.a.11.b	HMC661LC4B
0.02 - 4.5	Track-and-Hold	-66 / 67	3.0	0.95	> 60	LC4B	3A001.a.11.b	HMC660LC4B

DC POWER CONDITIONING - Linear Voltage Regulators

Input Voltage (V)	Function	Output Voltage (V)	Output Current (mA)	Power Supply Rejection Ratio (PSRR) (dB)		Output Noise Spectral Density (nV/√Hz)		Regulated Outputs	Package	ECCN Code	Part Number
				1 kHz	1 MHz	1 kHz	10 kHz				
3.35 - 5.6	Quad High PSRR	2.5 - 5.2	15 - 100	80	60	7	3	4	LP3	EAR99	HMC860LP3E
3.35 - 5.6	Low Noise, High PSRR	1.8 - 5.2	500	80	60	7	3	4	LP3	EAR99	HMC1060LP3E
4.8 to 5.6	Low Noise, High PSRR	1.8 to 5.1	400	60	30	6	3	1	LP3	EAR99	HMC976LP3E

DC POWER MANAGEMENT - Active Bias Controller

Supply Voltage Range (V)	Function	VDRAIN Voltage Range (V)	IDRAIN Bias Current (mA)	IGATE Drive Current (mA)	VGATE Voltage Range (V)	Over / Under IDRAIN Current Alarm	Low VDD Alarm	Package	ECCN Code	Part Number
4 to 12	Active Bias Controller	4 to 12	20 to 200	-0.8 to 0.8	-2.5 to 2.0	-	-	Chip	EAR99	HMC981
4 to 12	Active Bias Controller	4 to 12	0 to 200	-0.8 to 0.8	-2.5 to 2.5	-	-	LP3	EAR99	HMC981LP3E
5 to 16.5	Active Bias Controller	3 to 15	0 to 500	-4 to 4	-2.5 to 2.5	Yes	Yes	LP5	EAR99	HMC920LP5E
NEW! 5 - 16.5	Active Bias Controller	5 - 16.5	50 - 1600	-4 to 4	-2.46 to +2.04	Yes	-	Chip	EAR99	HMC980
5 to 16.5	Active Bias Controller	5 to 16.5	50 to 1600	-4 to 4	-2.46 to +2.04	Yes	-	LP4	EAR99	HMC980LP4E

HIGH SPEED DIGITAL LOGIC

Data / Clock Rate (Gbps / GHz)	Function	Rise / Fall Time (ps)	Deterministic Jitter (ps)	Differential Output Swing (Vp-p)	DC Power (mW)	DC Power Supply (Vdc)	Package	ECCN Code	Part Number
1:2 & 1:4 Fanout Buffers									
13 / 13	Fast Rise Time 1:2 Fanout Buffer*	19 / 18	2	0.6 - 1.1	300	-3.3	LP3	3A001.a.11.b	HMC720LP3E
13 / 13	Fast Rise Time 1:2 Fanout Buffer	19 / 18	2	1.1	300	-3.3	LC3C	3A001.a.11.b	HMC724LC3C
13 / 13	Fast Rise Time 1:2 Fanout Buffer*	22 / 20	2	0.6 - 1.2	290	+3.3	LC3C	3A001.a.11.b	HMC744LC3C
28 / 20	1:2 Fanout Buffer*	16 / 15	2	0.6 - 1.1	315	-3.3	LC3C	3A001.a.11.b	HMC850LC3C
45 / 28	1:2 Fanout Buffer*	11 / 11	3	0.4 - 1.2	465	-3.3	LC4B	3A001.a.11.b	HMC842LC4B
13 / 13	1:4 Fanout Buffer*	26 / 25	4	0.6 - 1.4	440	-3.3	LC4B	3A001.a.11.b	HMC940LC4B

HIGH SPEED DIGITAL LOGIC

Data / Clock Rate (Gbps / GHz)	Function	Rise / Fall Time (ps)	Deterministic Jitter (ps)	Differential Output Swing (Vp-p)	DC Power (mW)	DC Power Supply (Vdc)	Package	ECCN Code	Part Number
2:1 Selectors									
14 / 14	2:1 Differential Selector*	19 / 20	2	0.5 - 1.3	221	-3.3	LC4B	3A001.a.11.b	HMC858LC4B
13 / 13	2:1 Selector*	22 / 22	2	0.6 - 1.2	250	+3.3	LC3C	3A001.a.11.b	HMC748LC3C
14 / 14	4:1 Selector*	17 / 17	2	0.5 - 1.3	294	-3.3	LC5	3A001.a.11.b	HMC958LC5
AND / NAND / OR / NORs									
13 / 13	Fast Rise Time AND / NAND / OR / NOR*	19 / 18	2	0.6 - 1.1	230	-3.3	LP3	3A001.a.11.b	HMC722LP3E
13 / 13	Fast Rise Time AND / NAND / OR / NOR	19 / 18	2	1.1	230	-3.3	LC3C	3A001.a.11.b	HMC726LC3C
13 / 13	Fast Rise Time AND / NAND / OR / NOR*	22 / 21	2	0.6 - 1.2	230	+3.3	LC3C	3A001.a.11.b	HMC746LC3C
28 / 28	AND / NAND / OR / NOR*	15 / 14	2	0.6 - 1.5	241	-3.3	LC3C	3A001.a.11.b	HMC852LC3C
45 / 25	AND / NAND / OR / NOR*	10 / 10	2	0.2 - 0.9	530	-3.3	LC4B	3A001.a.11.b	HMC843LC4B
Clock Dividers									
- / 26	Clock Divide-by-4*	19 / 19	-	0.8 - 1.8	281	-3.3	LC3	3A001.a.11.b	HMC959LC3
- / 26	Clock Divide-by-8*	19 / 17	-	0.8 - 1.8	520	-3.3	LC3	3A001.a.11.b	HMC859LC3
D-Type Flip-Flops									
14 / 14	Dual D-Type Flip-Flop with Common Clock*	22 / 20	2	0.6 - 1.3	442	-3.3	LC4B	3A001.a.11.b	HMC953LC4B
13 / 13	Fast Rise Time D-Type Flip-Flop*	19 / 17	2	0.7 - 1.3	260	-3.3	LC3C	3A001.a.11.b	HMC723LP3E
13 / 13	Fast Rise Time D-Type Flip-Flop	19 / 17	2	1.1	260	-3.3	LC3C	3A001.a.11.b	HMC727LC3C
13 / 13	Fast Rise Time D-Type Flip-Flop*	22 / 20	2	0.7 - 1.2	264	+3.3	LC3C	3A001.a.11.b	HMC747LC3C
28 / 28	D-Type Flip-Flop*	15 / 14	2	0.7 - 1.3	260	-3.3	LC3C	3A001.a.11.b	HMC853LC3C
43 / 43	D-Type Flip-Flop*	12 / 12	2	0.2 - 0.85	630	-3.3	LC4B	3A001.a.11.b	HMC841LC4B
NRZ-to-RZ Converters									
13 / 13	NRZ-to-RZ Converter	15 / 13	2	0.3 - 1.2	594	+3.3	LC3C	3A001.a.11.b	HMC706LC3C
T Flip-Flops									
26 / 26	T Flip-Flop w/ Reset*	18 / 17	2	0.6 - 1.2	270	+3.3	LC3C	3A001.a.11.b	HMC749LC3C
XOR / XNORs									
13 / 13	Fast Rise Time XOR / XNOR*	19 / 18	2	0.6 - 1.2	230	-3.3	LP3	3A001.a.11.b	HMC721LP3E
13 / 13	Fast Rise Time XOR / XNOR	19 / 18	2	1.1	230	-3.3	LC3C	3A001.a.11.b	HMC725LC3C
13 / 13	Fast Rise Time XOR / XNOR*	21 / 19	2	0.6 - 1.2	240	+3.3	LC3C	3A001.a.11.b	HMC745LC3
28 / 28	XOR / XNOR*	15 / 14	2	0.6 - 1.4	241	-3.3	LC3C	3A001.a.11.b	HMC851LC3C
45 / 28	XOR / XNOR*	11 / 10	3	0.2 - 8.5	512	-3.3	LC4B	3A001.a.11.b	HMC844LC4B

** These products feature programmable output voltage swing.*

1:9 Fanout Buffer

Clock Rate (GHz)	Function	Input	Output	Phase Jitter (12 k to 20 MHz)	Rise/Fall Time (ps)	Channel Skew (ps)	Disable Mode	Power Supply (V)	Package	ECCN Code	Part Number
DC - 8	1:9 Fanout Buffer	LVPECL, LVDS, CML, CMOS	LVPECL	8 fs RMS	65	3.1	Yes	3.3	LP5	3A001.a.11.b	HMC987LP5E

IF / BASEBAND PROCESSING - *Dual Baseband Low Pass Filter & Dual Baseband Digital VGA*

Dual Baseband Low Pass Filter

3 dB Bandwidth Setting (MHz)	Function	3 dB Bandwidth Accuracy (%)	Gain (dB)	NF (dB)	OIP3 (dBm)	Package	ECCN Code	Part Number
3.5 - 50	Dual Low Pass with ADC Driver	±2.5	0 / 10	12	30	LP5	EAR99	HMC900LP5E

Dual Baseband Digital VGA

Frequency (MHz)	Function	NF (dB)	Variable Gain (dB)	OIP3 (dBm)	OIP2 (dBm)	Sideband Supp. (dB)	Magnitude (dB) / Phase (deg) Balance	Bias Supply	Package	ECCN Code	Part Number
DC - 100	Digital, Serial & Parallel Control	6	0 to 40	+30	+65	55	±0.1 / ±1	+5V @ 70 mA	LP4	EAR99	HMC960LP4E

INTERFACE - *RF Switch, Attenuator & Phase Shifter Digital Drivers*

Bit Rate (mbps)	Function	Input	Output Voltage (V)	Output Current (mA)	Bias Supply	Package	ECCN Code	Part Number
10	6-Bit Switch Driver / Controller	TTL/CMOS	-5 / +2.2	1	+5V @ 1.5 mA	LP5	EAR99	HMC677LP5E
10	6-Bit Switch Driver / Controller	TTL/CMOS	-5 / +2.2	1	+5V @ 1 mA	G32	EAR99	HMC677G32

LIMITING AMPLIFIERS

Data Rate (Gbps)	Function	Small Signal Bandwidth (GHz)	Differential Gain (dB)	Deterministic Jitter (ps p-p)	Additive Random Jitter (ps rms)	Supply Current	Package	ECCN Code	Part Number
12.5	Limiting Amplifier	11	44	5	0.2	+5V @ 106 mA	LP4	EAR99	HMC750LP4E
12.5	Limiting Amplifier with LOS	9.5	32	-	0.9	+3.3V @ 47 mA	LP4	EAR99	HMC914LP4E
32	Limiting with DC Offset	25	30	5	0.3	+3.3V @ 90 mA	LC3C	EAR99	HMC865LC3C
32	Limiting without DC Offset	25	29	7	0.3	+3.3V @ 85 mA	LC3C	EAR99	HMC866LC3C

MUX & DEMUX

Data / Clock Rate (Gbps / GHz)	Function	Rise / Fall (ps)	Deterministic Jitter (ps)	Differential Output Voltage Swing (Vp-p)	DC Power Consumption (mW)	Vee Power Supply (Vdc)	Package	ECCN Code	Part Number
32 / 16	2:1 Mux*	15 / 15	-	1.25	480	±3.3	LC4B	3A001.a.11.b	HMC954LC4B
28 / 14	4:1 Mux with Adj. Vout	16 / 16	4	0.7 - 1.25	510	-3.3	LC5	3A001.a.11.b	HMC854LC5
45 / 22.5	4:1 Mux*	11 / 12	3	0.25 - 0.9	1782	+3.3	LC5	3A001.a.11.b	HMC847LC5
32 / 16	1:2 Demux with High Speed Invert*	19 / 18	< 3	1.0	644	±3.3	LC4B	3A001.a.11.b	HMC955LC4B
28 / 14	1:4 Demux with Adj. Vout	22 / 22	-	0.45 - 1.14	644	-3.3	LC5	3A001.a.11.b	HMC855LC5
45 / 22.5	1:4 Demux with Adj. Vout	25 / 21	4	0.3 - 1.0	1782	+3.3	LC5	3A001.a.11.b	HMC848LC5

** With Programmable Output Voltage and/or Duty Cycle Control*

OPTICAL MODULATOR DRIVERS

Data Rate Max. (Gbps)	Function	Gain (dB)	Group Delay Variation (ps)	Additive Jitter (ps)	Output Voltage Max. (Vp-p)	Package	ECCN Code	Part Number
22.5	8Vpp Optical Modulator Driver	18	±15	0.3	8	LC5	EAR99	HMC870LC5 [1]
22.5	3Vpp Optical Modulator Driver	15	±15	0.3	3	LC5	EAR99	HMC871LC5 [1]
32	3Vpp Optical Modulator Driver, with Peak Detect	14	±5	0.3	3	Chip	EAR99	HMC1050 [1] [2]
32	8Vpp Optical Modulator Drive, with Peak Detect	16	±5	0.3	8	Chip	EAR99	HMC1051 [1] [2]
NEW! 32	8Vpp Optical Modulator Driver, SMT Package	32	±7	0.25	8	BGA	EAR99	HMC5850BG [1] [2]

[1] Drivers that benefit from Hittite Active Bias Controllers
[2] Request Data Sheet: FO@hittite.com

TRANSIMPEDANCE AMPLIFIERS

Data Rate (Gbps)	Function	Transimpedance (kΩ)	Input Overload (mApp)	Small Signal Bandwidth (GHz)	Deterministic Jitter (ps)	Noise (pA/√Hz)	Package	ECCN Code	Part Number
0.1 - 1.0	Low Noise Transimpedance Amplifier	10	20	0.7	< 100	4.6	LP3	EAR99	HMC799LP3E
1 - 10	Transimpedance Amplifier	1.25	3	7.5	< 10	11	Chip	EAR99	HMC690

DIRECT CONVERSION RECEIVER WITH DIVERSITY FEATURING THE HMCAD1520 A/D CONVERTER

NEW! ***HMC1060LP3E***
Low Noise Regulator
• 1.8 - 5.2V

NEW! ***HMC1034LP6GE***
Clock Generator
• 0.125 - 3 GHz
• 78 fs RMS Jitter Exceeds G.8251 & GR-253-CORE Specifications

HMC617LP3E
LNA, 550 - 1200 MHz
• 0.5 dB Noise Figure
• 16 dB Gain

HMC618LP3E
LNA, 1700 - 2200 MHz
• 0.75 dB Noise Figure
• 16 dB Gain

HMC993LP5E

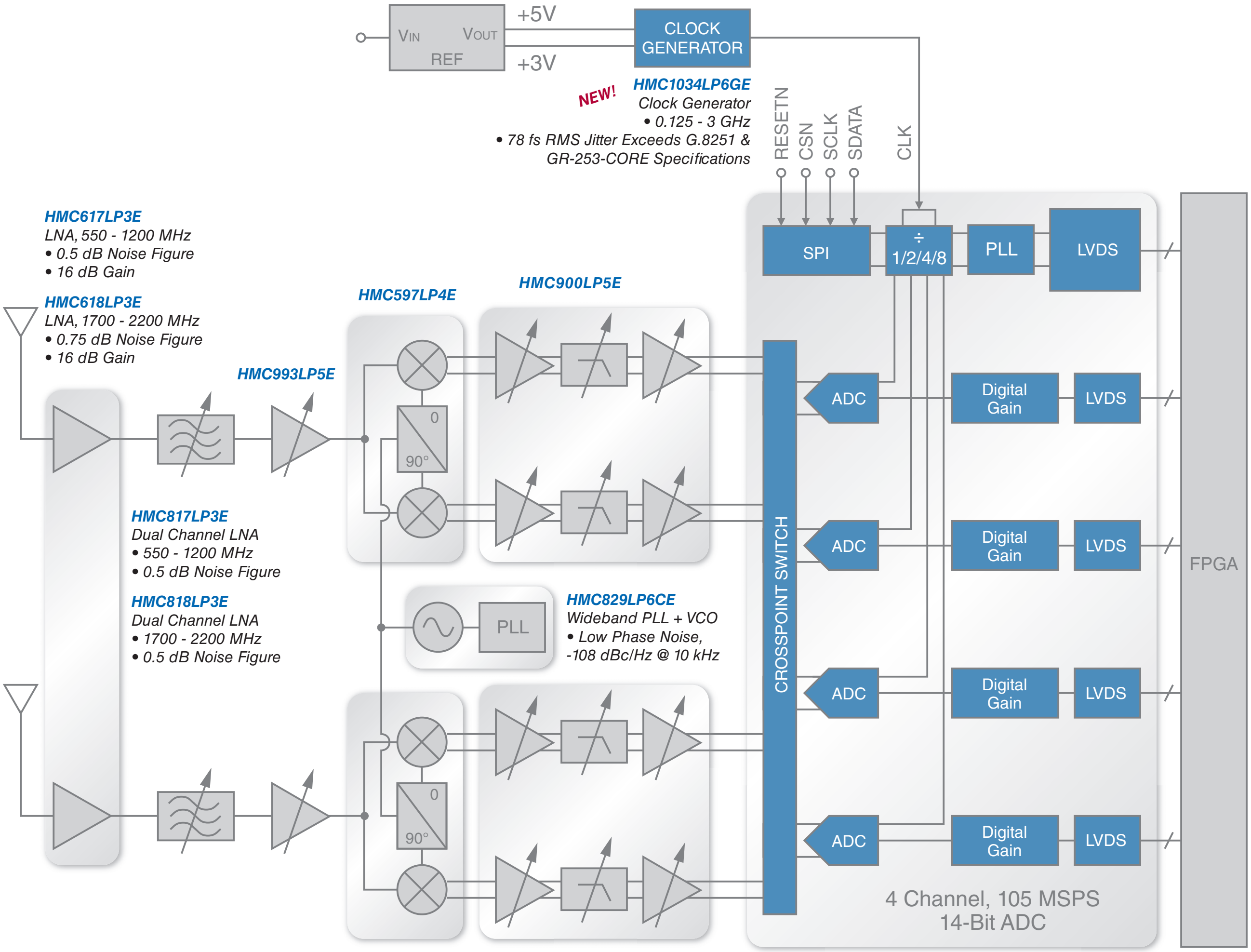
HMC597LP4E

HMC900LP5E

HMC817LP3E
Dual Channel LNA
• 550 - 1200 MHz
• 0.5 dB Noise Figure

HMC818LP3E
Dual Channel LNA
• 1700 - 2200 MHz
• 0.5 dB Noise Figure

HMC829LP6CE
Wideband PLL + VCO
• Low Phase Noise, -108 dBc/Hz @ 10 kHz



HMC597LP4E
Wideband Direct Demodulator
• 100 - 4000 MHz
• High Linearity: +25 dBm IIP3 & +60 dBm IIP2
• 15 dB Low Noise Floor

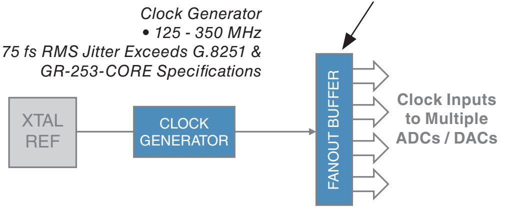
HMC900LP5E
Dual Baseband LPF
• 3.5 to 50 MHz
• 3 dB BW Programmable
• 12 dB Noise Figure
• +30 dBm OIP3

HMCAD1520
Precision Mode
14-Bit A-to-D Converter
• 105 MSPS
• 4 Channels

ADC / DAC CLOCK DRIVER CIRCUIT

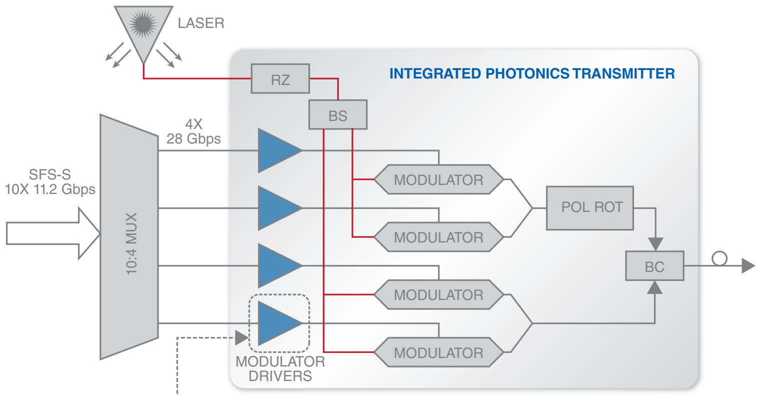
HMC987LP5E *NEW!*
1:9 Fanout Buffer
• 8 fs RMS Phase Jitter
• 65 ps Rise/Fall Time

NEW! ***HMC1032LP6GE***
Clock Generator
• 125 - 350 MHz
• 75 fs RMS Jitter Exceeds G.8251 & GR-253-CORE Specifications

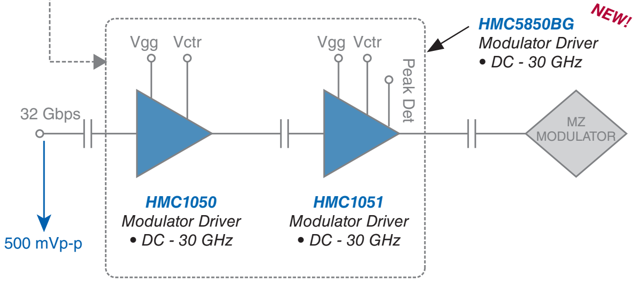


Typical Fiber Optic & Networking applications are illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

100G DWDM TRANSPONDER TRANSMIT PATH

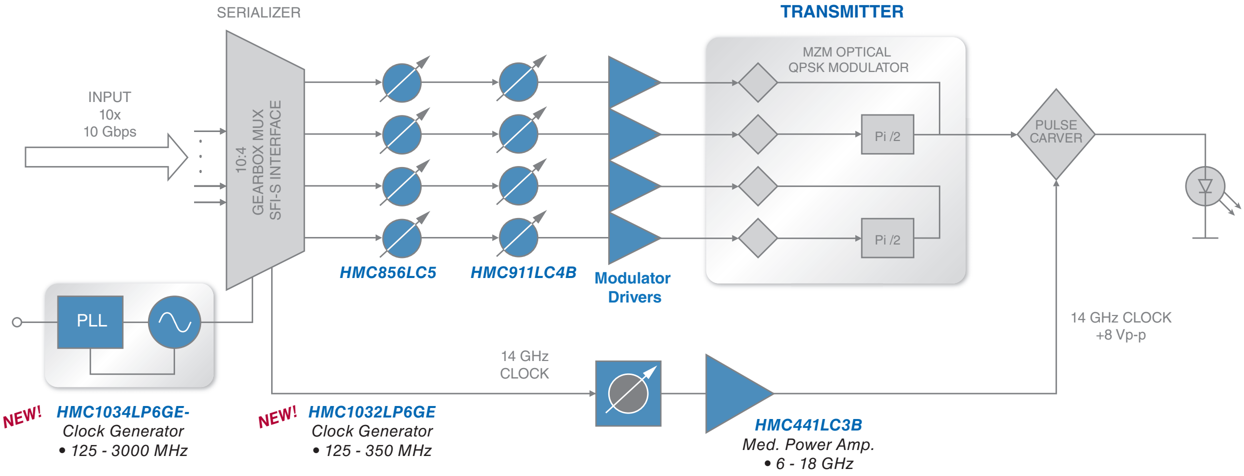


CASCADED CONFIGURATION FOR DRIVING MZ MODULATOR



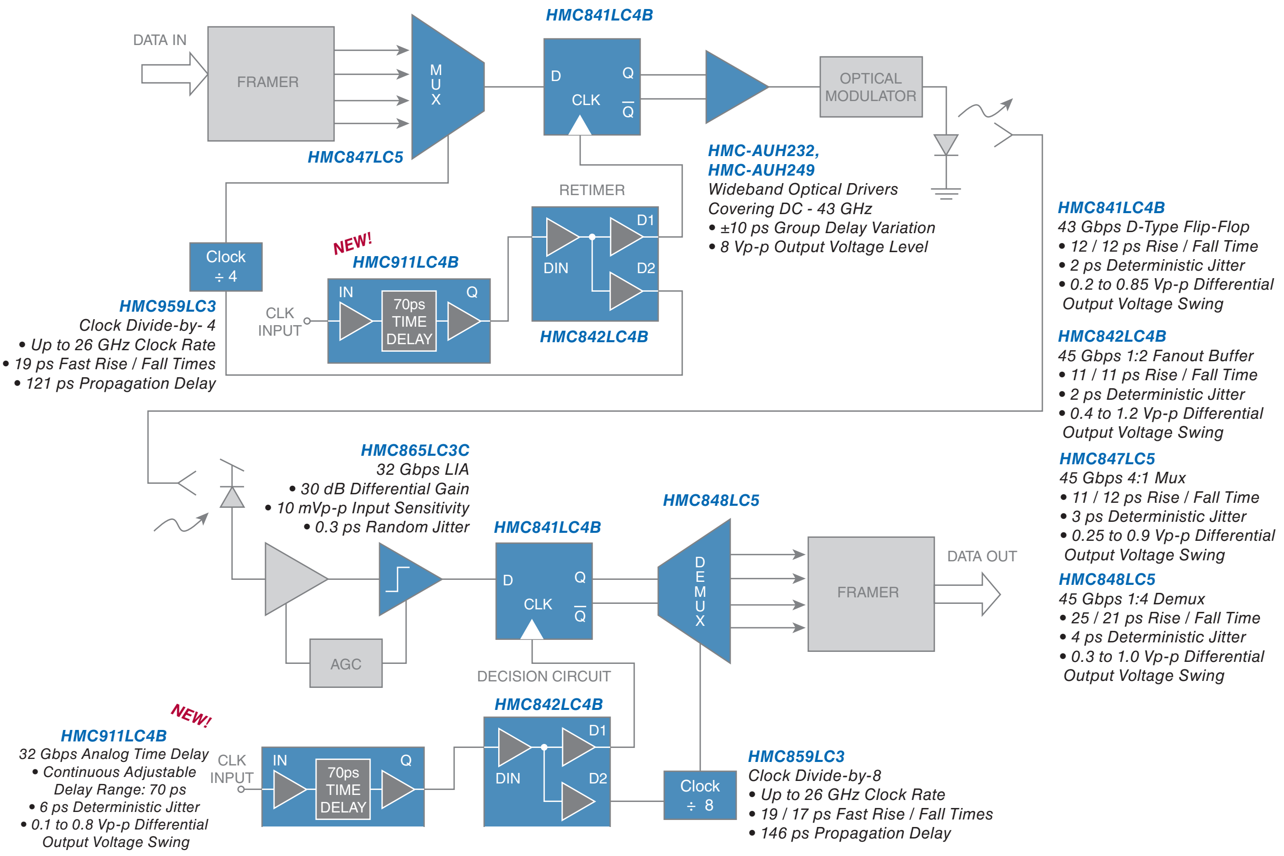
Total Power Consumption:
- 1.4 W @ 8 Vp-p
- 0.8 W @ 6 Vp-p

CASCADED CONFIGURATION FOR DRIVING MZ MODULATOR



Typical Fiber Optic & Networking applications are illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

TYPICAL SERIAL FIBER OPTIC DATA TRANSMISSION SYSTEM



HMC841LC4B

HMC847LC5

HMC-AUH232, HMC-AUH249
Wideband Optical Drivers Covering DC - 43 GHz
- *±10 ps Group Delay Variation*
- *8 Vp-p Output Voltage Level*

HMC911LC4B

HMC842LC4B

HMC959LC3
Clock Divide-by- 4
- *Up to 26 GHz Clock Rate*
- *19 ps Fast Rise / Fall Times*
- *121 ps Propagation Delay*

HMC865LC3C
32 Gbps LIA
- *30 dB Differential Gain*
- *10 mVp-p Input Sensitivity*
- *0.3 ps Random Jitter*

HMC841LC4B

HMC848LC5

HMC842LC4B

HMC911LC4B
32 Gbps Analog Time Delay
- *Continuous Adjustable Delay Range: 70 ps*
- *6 ps Deterministic Jitter*
- *0.1 to 0.8 Vp-p Differential Output Voltage Swing*

HMC859LC3
Clock Divide-by-8
- *Up to 26 GHz Clock Rate*
- *19 / 17 ps Fast Rise / Fall Times*
- *146 ps Propagation Delay*

HMC841LC4B
43 Gbps D-Type Flip-Flop
- *12 / 12 ps Rise / Fall Time*
- *2 ps Deterministic Jitter*
- *0.2 to 0.85 Vp-p Differential Output Voltage Swing*

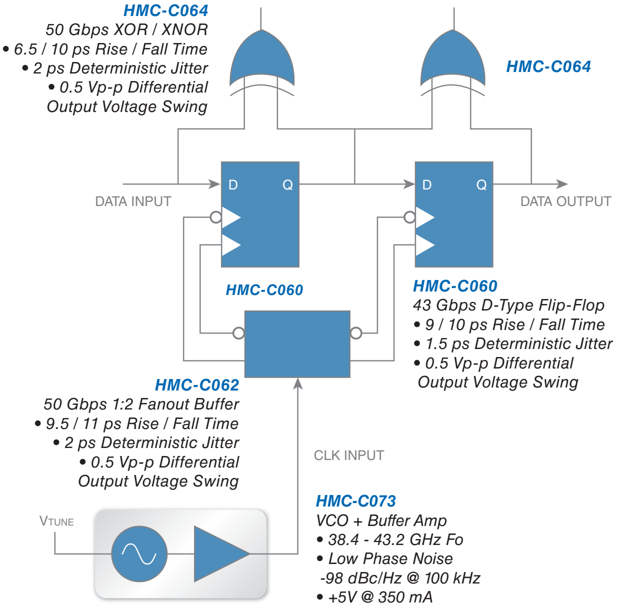
HMC842LC4B
45 Gbps 1:2 Fanout Buffer
- *11 / 11 ps Rise / Fall Time*
- *2 ps Deterministic Jitter*
- *0.4 to 1.2 Vp-p Differential Output Voltage Swing*

HMC847LC5
45 Gbps 4:1 Mux
- *11 / 12 ps Rise / Fall Time*
- *3 ps Deterministic Jitter*
- *0.25 to 0.9 Vp-p Differential Output Voltage Swing*

HMC848LC5
45 Gbps 1:4 Demux
- *25 / 21 ps Rise / Fall Time*
- *4 ps Deterministic Jitter*
- *0.3 to 1.0 Vp-p Differential Output Voltage Swing*

---

43 GBPS HOGGE PHASE DETECTOR FOR CLOCK & DATA RECOVERY



HMC-C064
50 Gbps XOR / XNOR
- *6.5 / 10 ps Rise / Fall Time*
- *2 ps Deterministic Jitter*
- *0.5 Vp-p Differential Output Voltage Swing*

HMC-C064

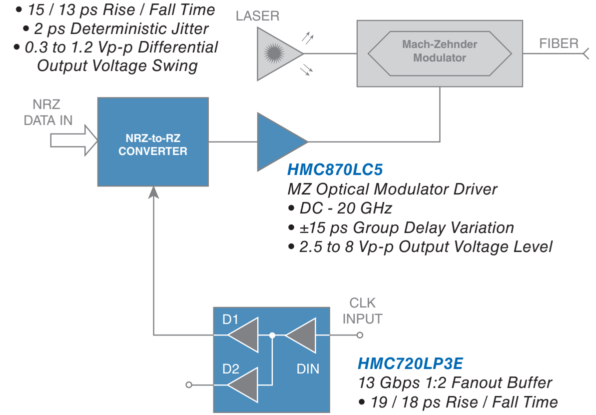
HMC-C060

HMC-C060
43 Gbps D-Type Flip-Flop
- *9 / 10 ps Rise / Fall Time*
- *1.5 ps Deterministic Jitter*
- *0.5 Vp-p Differential Output Voltage Swing*

HMC-C062
50 Gbps 1:2 Fanout Buffer
- *9.5 / 11 ps Rise / Fall Time*
- *2 ps Deterministic Jitter*
- *0.5 Vp-p Differential Output Voltage Swing*

HMC-C073
VCO + Buffer Amp
- *38.4 - 43.2 GHz Fo*
- *Low Phase Noise -98 dBc/Hz @ 100 kHz*
- *+5V @ 350 mA*

13 GBPS, NRZ-TO-RZ CONVERSION



HMC706LC3C
13 Gbps NRZ-to-RZ Converter
- *15 / 13 ps Rise / Fall Time*
- *2 ps Deterministic Jitter*
- *0.3 to 1.2 Vp-p Differential Output Voltage Swing*

HMC870LC5
MZ Optical Modulator Driver
- *DC - 20 GHz*
- *±15 ps Group Delay Variation*
- *2.5 to 8 Vp-p Output Voltage Level*

HMC720LP3E
13 Gbps 1:2 Fanout Buffer
- *19 / 18 ps Rise / Fall Time*
- *2 ps Deterministic Jitter*
- *0.6 to 1.1 Vp-p Differential Output Voltage Swing*

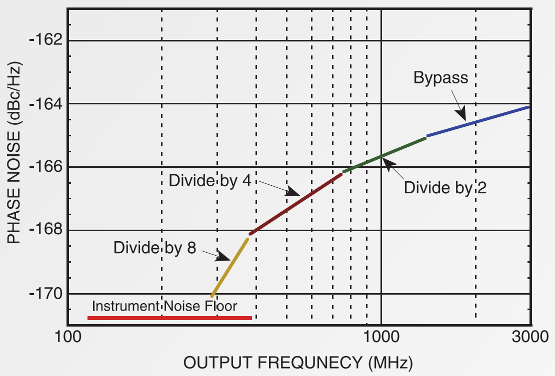
Typical Fiber Optic & Networking applications are illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

HMC988LP3E Programmable Clock Divider and Delay Management IC

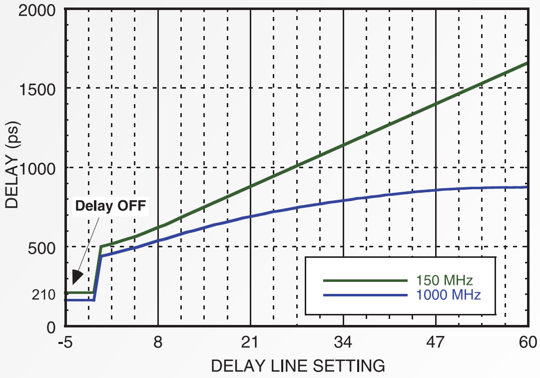
Features

- Programmable Clock Divide by 1/2/4/8/16/32
- Delay Adjustment in Multiples of 1/2 Clock Cycles or in 60 Steps of 20 ps (Typ.)
- -170 dBc/Hz Noise Floor @ 100 MHz Output
- Up to 4 GHz Operation with 800 mVp-p LVPECL Output
- 3.3V Operation (or 5V Operation with Optional On-Chip Regulator for Best Performance)

Phase Noise Floor Performance vs. Output Frequency



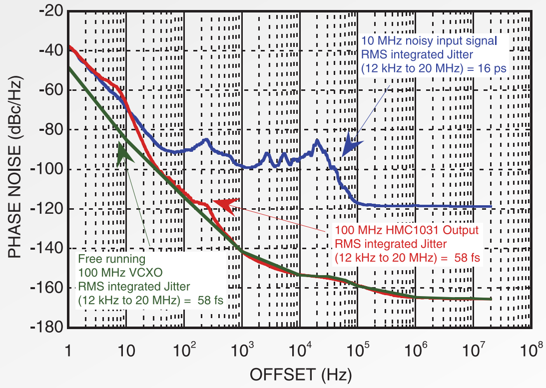
Delay vs. Delay Line Setpoint



Ideal for Data Converter Sample Clock Phase Adjustment in Basestation, ATE and Networking Applications!

HMC1031MS8E Clock Generator with Integer-N PLL

Typical Closed Loop Phase Noise, HMC1031MS8E as Jitter Attenuator



Features

- Integer-N PLL Clock Generator with External VCO/VCXO
- Ultra-Low Power Consumption: <2 mA Typical in Normal Operation
- Output Frequency: Up to 500 MHz
- Hardware Pin Programmable Reference Clock Multiplication Ratios of x1, x5 and x10
- Phase Noise Floor (Figure of Merit): -208 dBc/Hz (Typ.)

Ultra-Low Power Integer PLL Clock Generator for Jitter Attenuation and Frequency Translation!

CLOCKS & TIMING

Clock Distribution

	Max. Clock Rate (GHz)	Function	Input	Output	Phase Jitter (12 k to 20 MHz)	Rise/Fall Time (ps)	Channel Skew (ps)	Disable Mode	Power Supply (V)	Package	ECCN Code	Part Number
NEW!	4	Clock Divider & Delay Management	LVPECL, LVDS, CML, CMOS	LVPECL	13 fs RMS	90	300 to 1500	Yes	5 or 3.3	LP3	3A001.a.11.b	HMC988LP3E
	8	1:9 Fanout Buffer	LVPECL, LVDS, CML, CMOS	LVPECL	8 fs RMS	65	3.1	Yes	3.3	LP5	3A001.a.11.b	HMC987LP5E

Clock Generators

	Max. Frequency (MHz)	Function	Typical Phase Jitter (fsRMS)	Phase Noise Floor (dBc/Hz)	Maximum Reference Freq. (MHz)	Typical Power Consumption (W)	Figure of Merit (Frac/Int) (dBc/Hz)	Package	ECCN Code	Part Number
NEW!	500	Integer Mode PLL (x1, x5, x10)	Defined by VCXO	Defined by VCXO	140	0.0064	-208	MS8	EAR99	HMC1031MS8E
	350	Clock Generator with Fractional-N PLL+VCO	116 / 75	-165	350	0.86	-227 / -230	LP6G	3A001.a.11.b	HMC1032LP6GE
	3000	Clock Generator with Fractional-N PLL+VCO	118 / 78	-165	350	0.86	-227 / -230	LP6G	3A001.a.11.b	HMC1034LP6GE

PLLs with INTEGRATED VCOs - RF & Wideband PLLs with Integrated VCOs

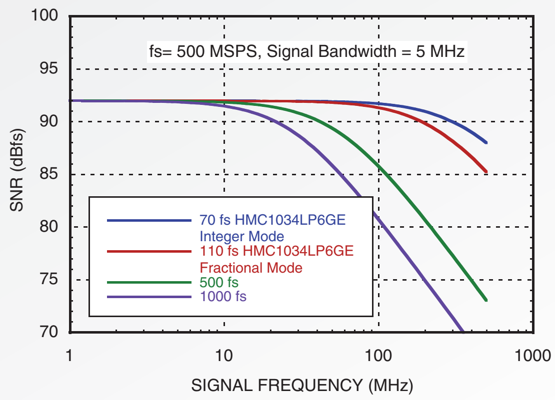
Frequency (MHz)	Function	Closed Loop SSB Phase Noise @ 10 kHz Offset	Open Loop VCO Phase Noise @ 1 MHz Offset	Pout (dBm)	RMS Jitter Fractional Mode (fs)	Integrated PN Fractional Mode (deg rms)	Package	ECCN Code	Part Number
fo/2									
665 - 825	Tri-Band RF VCO	-118 dBc/Hz	-148 dBc/Hz	11	180	0.05	LP6C	3A001.a.11.b	HMC822LP6CE
795 - 945	Tri-Band RF VCO	-123 dBc/Hz	-148 dBc/Hz	10	180	0.06	LP6C	3A001.a.11.b	HMC838LP6CE
780 - 870	RF VCO	-116 dBc/Hz	-148 dBc/Hz	14	180	0.06	LP6C	3A001.a.11.b	HMC824LP6CE
860 - 1040	Tri-Band RF VCO	-118 dBc/Hz	-147 dBc/Hz	10	180	0.07	LP6C	3A001.a.11.b	HMC821LP6CE
990 - 1105	RF VCO	-114 dBc/Hz	-146 dBc/Hz	11	180	0.07	LP6C	3A001.a.11.b	HMC826LP6CE
1025 - 1150	Tri-Band RF VCO	-123 dBc/Hz	-147 dBc/Hz	12	180	0.07	LP6C	3A001.a.11.b	HMC837LP6CE
1050 - 1205	Tri-Band RF VCO	-121 dBc/Hz	-146 dBc/Hz	10	180	0.08	LP6C	3A001.a.11.b	HMC839LP6CE
1095 - 1275	Tri-Band RF VCO	-118 dBc/Hz	-147 dBc/Hz	10	180	0.08	LP6C	3A001.a.11.b	HMC820LP6CE
1310 - 1415	Tri-Band RF VCO	-121 dBc/Hz	-145 dBc/Hz	10	180	0.09	LP6C	3A001.a.11.b	HMC840LP6CE
fo									
1285 - 1415	RF VCO	-112 dBc/Hz	-143 dBc/Hz	10	180	0.09	LP6C	3A001.a.11.b	HMC828LP6CE
1330 - 1650	Tri-Band RF VCO	-112 dBc/Hz	-142 dBc/Hz	6.5	180	0.11	LP6C	3A001.a.11.b	HMC822LP6CE
1590 - 1890	Tri-Band RF VCO	-118 dBc/Hz	-143 dBc/Hz	7.5	180	0.12	LP6C	3A001.a.11.b	HMC838LP6CE
1720 - 2080	Tri-Band RF VCO	-112 dBc/Hz	-141 dBc/Hz	6.5	180	0.13	LP6C	3A001.a.11.b	HMC821LP6CE
1815 - 2010	RF VCO	-112 dBc/Hz	-143 dBc/Hz	7.5	180	0.13	LP6C	3A001.a.11.b	HMC831LP6CE
2050 - 2300	Tri-Band RF VCO	-117 dBc/Hz	-141 dBc/Hz	10.5	180	0.15	LP6C	3A001.a.11.b	HMC837LP6CE
2100 - 2410	Tri-Band RF VCO	-115 dBc/Hz	-140 dBc/Hz	7.5	180	0.16	LP6C	3A001.a.11.b	HMC839LP6CE
2190 - 2550	Tri-Band RF VCO	-112 dBc/Hz	-141 dBc/Hz	6.5	180	0.17	LP6C	3A001.a.11.b	HMC820LP6CE
2620 - 2830	Tri-Band RF VCO	-115 dBc/Hz	-139 dBc/Hz	9	180	0.18	LP6C	3A001.a.11.b	HMC840LP6CE
2fo									
2660 - 3300	Tri-Band RF VCO	-106 dBc/Hz	-136 dBc/Hz	-4	180	0.21	LP6C	3A001.a.11.b	HMC822LP6CE
3180 - 3780	Tri-Band RF VCO	-112 dBc/Hz	-135 dBc/Hz	-4	180	0.24	LP6C	3A001.a.11.b	HMC838LP6CE
3365 - 3705	RF VCO	-107 dBc/Hz	-135 dBc/Hz	0	190	0.25	LP6C	3A001.a.11.b	HMC836LP6CE
3440 - 4160	Tri-Band RF VCO	-106 dBc/Hz	-135 dBc/Hz	-4	180	0.27	LP6C	3A001.a.11.b	HMC821LP6CE
4100 - 4600	Tri-Band RF VCO	-111 dBc/Hz	-135 dBc/Hz	-0.5	180	0.30	LP6C	3A001.a.11.b	HMC837LP6CE
4200 - 4820	Tri-Band RF VCO	-108 dBc/Hz	-135 dBc/Hz	-4	180	0.31	LP6C	3A001.a.11.b	HMC839LP6CE
4380 - 5100	Tri-Band RF VCO	-106 dBc/Hz	-135 dBc/Hz	-4	180	0.33	LP6C	3A001.a.11.b	HMC820LP6CE
5240 - 5660	Tri-Band RF VCO	-109 dBc/Hz	-133 dBc/Hz	-3	180	0.37	LP6C	3A001.a.11.b	HMC840LP6CE
Wideband Continuous Tuning									
25 - 3000	Wideband RF VCO	-114 dBc/Hz @ 2 GHz	-141 dBc/Hz @ 2 GHz	5	82 [1]	0.114 @ 2 GHz	LP6G	3A001.a.11.b	HMC830LP6GE
25 - 6000	Wideband RF VCO	-108 dBc/Hz @ 4 GHz	-135 dBc/Hz @ 4 GHz	-4	82 [1]	0.22 @ 4 GHz	LP6G	3A001.a.11.b	HMC833LP6GE
45 - 1050 1400 - 2100 2800 - 4200 Fo	Wideband RF VCO	-108 dBc/Hz @ 4 GHz	-134 dBc/Hz @ 4 GHz	4	82 [1]	0.229 @ 4 GHz	LP6G	3A001.a.11.b	HMC829LP6GE
45 - 1050 1400 - 2100 2800 - 4200 Fo 5600 - 8400	Wideband RF VCO	-102 dBc/Hz @ 8 GHz	-128 dBc/Hz @ 8 GHz	5 2 2 -10	82 [1]	0.43 @ 8 GHz	LP6G	3A001.a.11.b	HMC834LP6GE

[1] RMS Jitter Integration Bandwidth from 12 kHz to 20 MHz
**Please note the DC Power Conditioning Table is in the LO Generation ICs Section.*

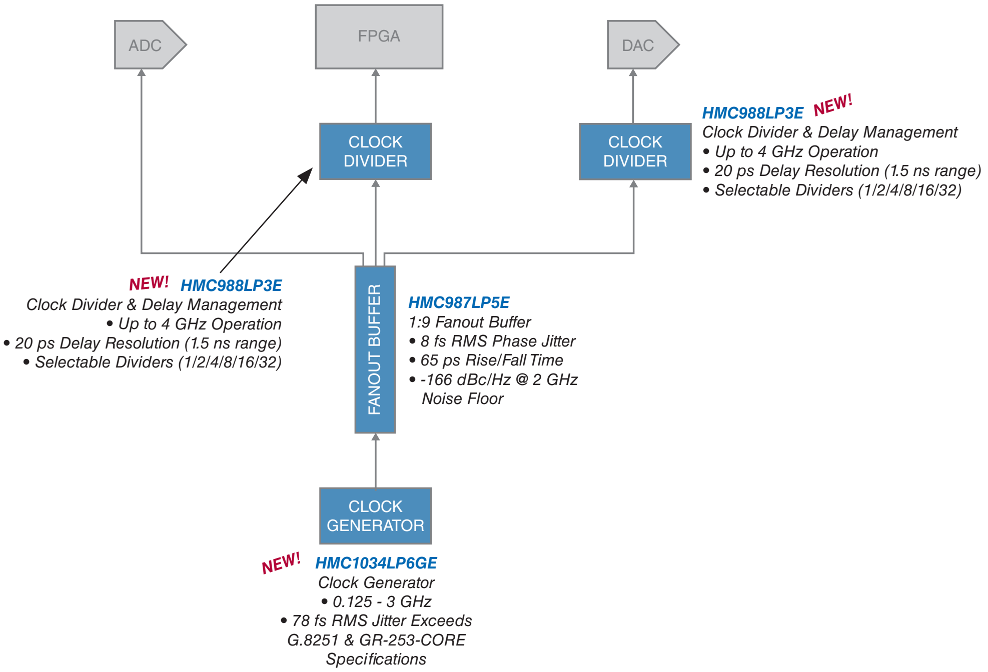
Please note the DC Power Conditioning Table is in the LO Generation ICs Section.

EXTRACT THE BEST SNR PERFORMANCE FROM YOUR DATA CONVERTERS!

- ♦ ***HMC1034LP6GE achieves <100 fs RMS Phase Jitter in Integer Mode***
- ♦ ***HMC987LP5E, 1:8 LVPECL Fan-Out Buffer Distributes Data Converter Sample Clocks with Only 8 fs RMS Additive Jitter (12 kHz - 20 MHz)***
- ♦ ***HMC988LP3E Clock Divider & Delay Management IC Adjusts Data Converter Sample Clock Windows in 20 ps Resolution and Offers -170 dBc/Hz Phase Noise Floor***


ADC SNR vs. Clock Jitter and Input Frequency

The low phase noise floor of a clock signal as well as its low integrated phase jitter helps to minimize the SNR degradation at high ADC / DAC input frequencies in multi-carrier, multi-acquisition applications. Hittite's Clock & Timing ICs are designed with data converter applications in mind, and work well with Hittite's High-Speed ADC devices.



NEW! ***HMC988LP3E***
Clock Divider & Delay Management
- *Up to 4 GHz Operation*
- *20 ps Delay Resolution (1.5 ns range)*
- *Selectable Dividers (1/2/4/8/16/32)*

HMC988LP3E *NEW!*
Clock Divider & Delay Management
- *Up to 4 GHz Operation*
- *20 ps Delay Resolution (1.5 ns range)*
- *Selectable Dividers (1/2/4/8/16/32)*

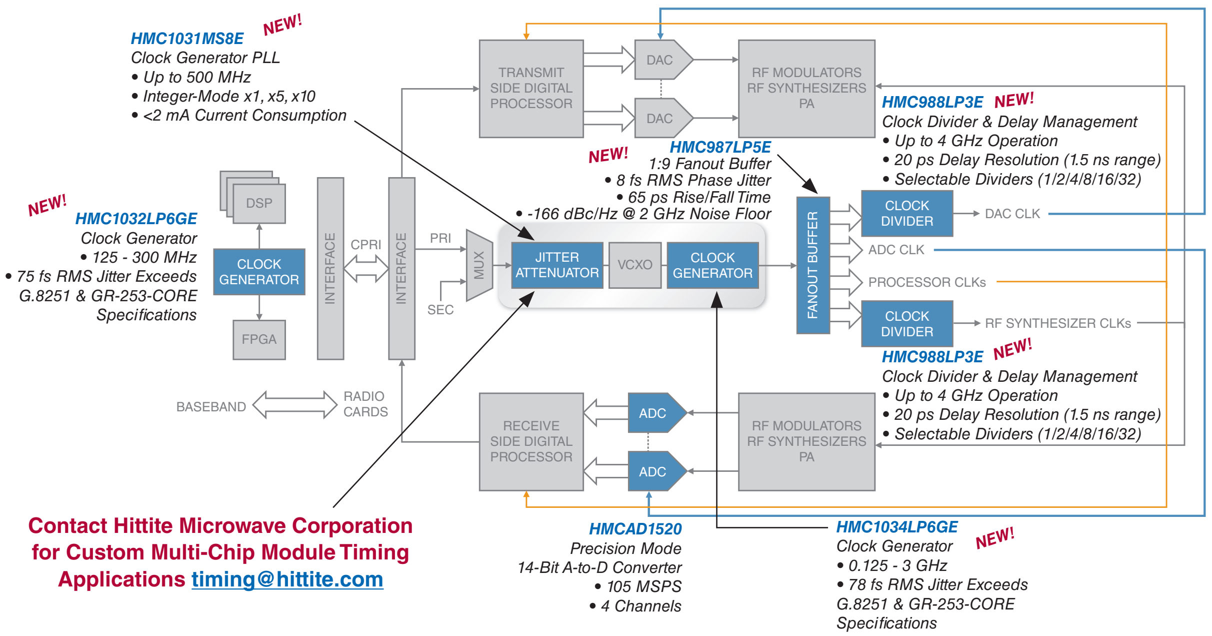
HMC987LP5E
1:9 Fanout Buffer
- *8 fs RMS Phase Jitter*
- *65 ps Rise/Fall Time*
- *-166 dBc/Hz @ 2 GHz Noise Floor*

NEW! ***HMC1034LP6GE***
Clock Generator
- *0.125 - 3 GHz*
- *78 fs RMS Jitter Exceeds G.8251 & GR-253-CORE Specifications*

FOR BROADBAND, CELLULAR INFRASTRUCTURE AND FIBER OPTIC & NETWORKING

Features

- ♦ **Low Noise Floor of -166 dBc/Hz Makes the HMC987LP5E Ideal for Clocking High Performance ADC / DAC & SERDES Devices**
- ♦ **HMC1031MS8E Ultra-Low Power Integer Mode PLL Enables Jitter Attenuation with 1.6 mA Typical Current Consumption from a Single 3.3V Supply**
- ♦ **HMC988LP3E Offers Selectable Frequency Division and Clock Delay Management with 20 ps Resolution Up to 1.5 ns Total Delay Range**
- ♦ **<100 fs Integrated Phase Jitter of the HMC1031LPGE Clock Generator Improves Data Converter SNR**



HMC1031MS8E NEW!
Clock Generator PLL
- *Up to 500 MHz*
- *Integer-Mode x1, x5, x10*
- *<2 mA Current Consumption*

NEW! **HMC1032LP6GE**
Clock Generator
- *125 - 300 MHz*
- *75 fs RMS Jitter Exceeds G.8251 & GR-253-CORE Specifications*

NEW! **HMC987LP5E**
1:9 Fanout Buffer
- *8 fs RMS Phase Jitter*
- *65 ps Rise/Fall Time*
- *-166 dBc/Hz @ 2 GHz Noise Floor*

HMC988LP3E NEW!
Clock Divider & Delay Management
- *Up to 4 GHz Operation*
- *20 ps Delay Resolution (1.5 ns range)*
- *Selectable Dividers (1/2/4/8/16/32)*

HMC988LP3E NEW!
Clock Divider & Delay Management
- *Up to 4 GHz Operation*
- *20 ps Delay Resolution (1.5 ns range)*
- *Selectable Dividers (1/2/4/8/16/32)*

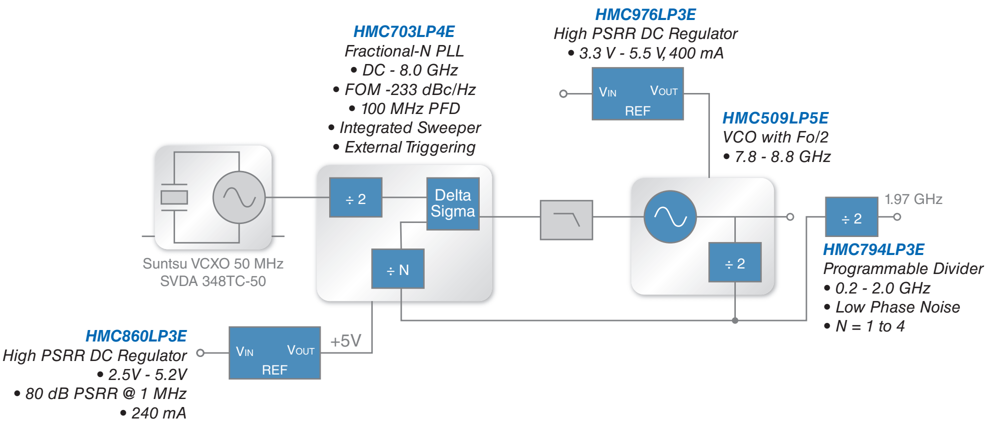
Contact Hittite Microwave Corporation for Custom Multi-Chip Module Timing Applications timing@hittite.com

HMCAD1520
Precision Mode 14-Bit A-to-D Converter
- *105 MSPS*
- *4 Channels*

HMC1034LP6GE NEW!
Clock Generator
- *0.125 - 3 GHz*
- *78 fs RMS Jitter Exceeds G.8251 & GR-253-CORE Specifications*

Contact Us: timing@hittite.com

REFERENCE CLOCK SOLUTIONS FOR 100G DP-QPSK



HMC703LP4E
Fractional-N PLL
- *DC - 8.0 GHz*
- *FOM -233 dBc/Hz*
- *100 MHz PFD*
- *Integrated Sweeper*
- *External Triggering*

HMC976LP3E
High PSRR DC Regulator
- *3.3 V - 5.5 V, 400 mA*

HMC509LP5E
VCO with Fo/2
- *7.8 - 8.8 GHz*

HMC794LP3E
Programmable Divider
- *0.2 - 2.0 GHz*
- *Low Phase Noise*
- *N = 1 to 4*

HMC860LP3E
High PSRR DC Regulator
- *2.5V - 5.2V*
- *80 dB PSRR @ 1 MHz*
- *240 mA*

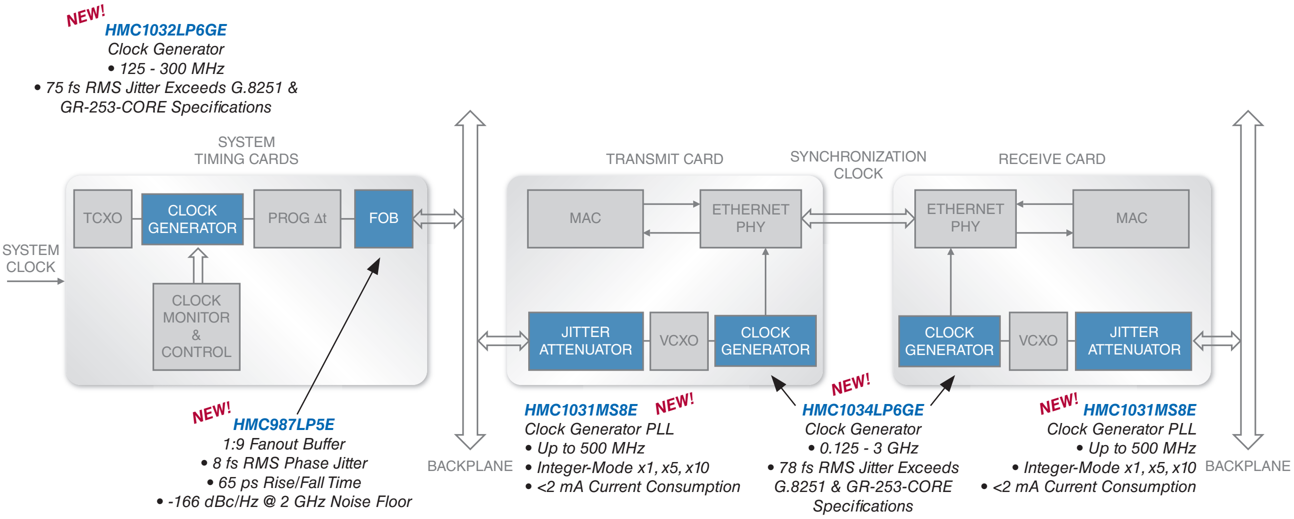
Contact Us: timing@hittite.com

Typical Clocks & Timing ICs applications are illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

FOR BROADBAND, CELLULAR INFRASTRUCTURE AND FIBER OPTIC & NETWORKING

Features

- ♦ *<10 fs 12 kHz - 20 MHz integrated Phase Jitter Performance of HMC987LP5E Enables High Performance Clock Distribution With Negligible Jitter Generation*
- ♦ *A Flexible Input Interface Allows The HMC987LP5E LVDS, CML & CMOS Inputs to 8 LVPECL Outputs*
- ♦ *HMC1034LP6GE May Be Used For Clock Generation & Fractional Multiplication With Outputs Up to 3 GHz*
- ♦ *The HMC1034LP6GE Achieves Industry Leading Phase Jitter of 78 fs RMS*



NEW! **HMC1032LP6GE**
Clock Generator
• 125 - 300 MHz
• 75 fs RMS Jitter Exceeds G.8251 & GR-253-CORE Specifications

NEW! **HMC987LP5E**
1:9 Fanout Buffer
• 8 fs RMS Phase Jitter
• 65 ps Rise/Fall Time
• -166 dBc/Hz @ 2 GHz Noise Floor

HMC1031MS8E *NEW!*
Clock Generator PLL
• Up to 500 MHz
• Integer-Mode x1, x5, x10
• <2 mA Current Consumption

NEW! **HMC1034LP6GE**
Clock Generator
• 0.125 - 3 GHz
• 78 fs RMS Jitter Exceeds G.8251 & GR-253-CORE Specifications

NEW! **HMC1031MS8E**
Clock Generator PLL
• Up to 500 MHz
• Integer-Mode x1, x5, x10
• <2 mA Current Consumption

Contact Us: timing@hittite.com

Typical Clocks & Timing ICs applications are illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

LO Frequency Generation ICs

SMT & Chip (Die) Products

DC POWER CONDITIONING - *Linear Voltage Regulators*

Input Voltage (V)	Function	Output Voltage (V)	Output Current (mA)	Power Supply Rejection Ratio (PSRR) (dB)		Output Noise Spectral Density (nV/√Hz)		Regulated Outputs	Package	ECCN Code	Part Number
				1 kHz	1 MHz	1 kHz	10 kHz				
3.35 - 5.6	Quad High PSRR	2.5 - 5.2	15 - 100	80	60	7	3	4	LP3	EAR99	HMC860LP3E
3.35 - 5.6	Low Noise, High PSRR	1.8 - 5.2	500	80	60	7	3	4	LP3	EAR99	HMC1060LP3E
4.8 to 5.6	Low Noise, High PSRR	1.8 to 5.1	400	60	30	6	3	1	LP3	EAR99	HMC976LP3E

FILTERS - *Tunable*

Programmable Harmonic

	Frequency Range (GHz)	Function	Return Loss (dB)	3 dB Bandwidth (GHz)	Stopband Frequency (Rej. >10 dB)	Tuning Response (ns)	Package	ECCN Code	Part Number
NEW!	DC - 9	Programmable Harmonic Low Pass	10	1 - 3	1.2 Fcutoff	10	LP3	EAR99	HMC1044LP3E

FREQUENCY DIVIDERS (PRESCALERS) & DETECTORS

Frequency Dividers & Phase / Frequency Detectors

Input Frequency (GHz)	Function	Input Power (dBm)	Output Power (dBm)	100 kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	ECCN Code	Part Number
DC - 8	Divide-by-2	-12 to +12	-6	-148	+3V @ 42 mA	SOT26	3A001.a.11.b	HMC432E
DC - 10	Divide-by-2	-15 to +10	3	-148	+5V @ 83 mA	S8G	3A001.a.11.b	HMC361S8GE
DC - 11	Divide-by-2	-15 to +10	3	-148	+5V @ 105 mA	Chip	3A001.a.11.b	HMC361
DC - 12.5	Divide-by-2	-15 to +10	2	-145	+5V @ 105 mA	S8G	3A001.a.11.b	HMC364S8GE
DC - 13	Divide-by-2	-15 to +10	3	-148	+5V @ 84 mA	G8	3A001.a.11.b	HMC361G8
DC - 13	Divide-by-2	-15 to +10	1	-145	+5V @ 105 mA	Chip	3A001.a.11.b	HMC364
DC - 13	Divide-by-2	-15 to +10	5	-145	+5V @ 110 mA	G8 Hermetic	3A001.a.11.b	HMC364G8
DC - 18	Divide-by-2	-15 to +10	-4	-150	+5V @ 77 mA	LP3	3A001.a.11.b	HMC492LP3E
DC - 7	Divide-by-3	-12 to +12	-2	-153	+5V @ 69 mA	MS8G	3A001.a.11.b	HMC437MS8GE
DC - 4	Divide-by-4	-15 to +10	3.5	-146	+3V @ 13 mA	MS8	3A001.a.11.b	HMC426MS8E
DC - 8	Divide-by-4	-12 to +12	-3	-150	+3V @ 53 mA	SOT26	3A001.a.11.b	HMC433E
DC - 11	Divide-by-4	-15 to +10	-6	-149	+5V @ 68 mA	Chip	3A001.a.11.b	HMC362
DC - 12	Divide-by-4	-15 to +10	-6	-149	+5V @ 68 mA	S8G	3A001.a.11.b	HMC362S8GE
DC - 13	Divide-by-4	-15 to +10	2	-151	+5V @ 110 mA	Chip	3A001.a.11.b	HMC365
DC - 13	Divide-by-4	-15 to +10	7	-151	+5V @ 120 mA	G8 Hermetic	3A001.a.11.b	HMC365G8
DC - 13	Divide-by-4	-15 to +10	2	-151	+5V @ 110 mA	S8G	3A001.a.11.b	HMC365S8GE
DC - 18	Divide-by-4	-15 to +10	-4	-150	+5V @ 96 mA	LP3	3A001.a.11.b	HMC493LP3E
10 - 26	Divide-by-4	-15 to +10	-4	-150	+5V @ 96 mA	LC3	3A001.a.11.b	HMC447LC3
DC - 7	Divide-by-5	-12 to +12	-1	-153	+5V @ 80 mA	MS8G	3A001.a.11.b	HMC438MS8GE
DC - 8	Divide-by-8	-5 to +12	-2	-150	+3V @ 62 mA	SOT26	3A001.a.11.b	HMC434E
DC - 12	Divide-by-8	-15 to +10	-9	-153	+5V @ 70 mA	Chip	3A001.a.11.b	HMC363
DC - 12	Divide-by-8	-15 to +10	4	-153	+5V @ 90 mA	G8 Hermetic	3A001.a.11.b	HMC363G8
DC - 12	Divide-by-8	-15 to +10	-9	-153	+5V @ 70 mA	S8G	3A001.a.11.b	HMC363S8GE
DC - 18	Divide-by-8	-15 to +10	-4	-150	+5V @ 105 mA	LP3	3A001.a.11.b	HMC494LP3E
0.1 - 6.5	Programmable Divider (N = 1 to 17)	-15 to +10	0	-153	+5V @ 200 mA	LP4	3A001.a.11.b	HMC705LP4E
0.1 - 13.0	Programmable Divider (N = 1, 3)	-10 to +10	2	-152	+5V @ 185 mA	LP3	3A001.a.11.b	HMC861LP3E
0.1 - 15	Programmable Divider (N = 1, 2, 4, 8)	-15 to 10	2	-153	+5V @ 105 mA	LP3	3A001.a.11.b	HMC862LP3E
0.2 - 2.0	Programmable Divider (N = 1 to 4)	-2 to +10	10	-160	+5V @ 135 mA	LP3	3A001.a.11.b	HMC794LP3E
0.4 - 6.0	Programmable Divider (N = 1 to 4)	0 to +9	5	-156	+3.3V @ 100 mA	LP3	3A001.a.11.b	HMC905LP3E
DC - 2.2	5-bit Counter, ÷2 to 32	-15 to +10	4	-153	+5V @ 194 mA	LP4	3A001.a.11.b	HMC394LP4E
0.01 - 1.3	Phase Frequency Detector	-10 to +10	2 Vp-p	-153	+5V @ 96 mA	QS16G	3A001.a.11.b	HMC439QS16GE

Fractional Divider & Frequency Detector

Input Frequency (GHz)	Function	Input Power (dBm)	Output Level (dBm)	Floor FOM (dBc/Hz)	Bias Supply	Package	ECCN Code	Part Number
DC - 7	48-Bit Delta Sigma Programmable Fractional Divider with Sweeper	-15 to -3	0.75 Vp-p to 2 Vp-p into 100 Ohm	-160	+5V @ 1 mA +3V @ 244 mA	LP5	3A001.a.11.b	HMC983LP5E
DC - 0.35	Frequency Detector & Charge Pump	3 to 15	0.02 to 2.5 mA	-231	+5V @ 97 mA +3V @ 27 mA	LP4	EAR99	HMC984LP4E

FREQUENCY MULTIPLIERS - *Active*

Input Frequency (GHz)	Function	Output Frequency (GHz)	Input Power (dBm)	Output Power (dBm)	100 kHz SSB Phase Noise (dBc/Hz)	Package	ECCN Code	Part Number
3 - 4	x2 Active	6 - 9	0	17	-140	LP4	EAR99	HMC575LP4E
4.0 - 10.5	x2 Active	8 - 21	5	17	-139	Chip	EAR99	HMC561
4.0 - 10.5	x2 Active	8 - 21	5	14	-139	LP3	EAR99	HMC561LP3E
4 - 11	x2 Active	8 - 22	5	12	-134	LC3B	EAR99	HMC573LC3B
4.5 - 8.0	x2 Active	9 - 16	2	15	-140	LP4	EAR99	HMC368LP4E
4.95 - 6.35	x2 Active	9.9 - 12.7	0	4	-142	LP3	EAR99	HMC369LP3E
6.5 - 12.3	x2 Active	13.0 - 24.6	4	17	-136	Chip	EAR99	HMC814

FREQUENCY MULTIPLIERS - *Active*

Input Frequency (GHz)	Function	Output Frequency (GHz)	Input Power (dBm)	Output Power (dBm)	100 kHz SSB Phase Noise (dBc/Hz)	Package	ECCN Code	Part Number
6.5 - 12.3	x2 Active	13.0 - 24.6	4	17	-136	LC3B	EAR99	HMC814LC3B
9.0 - 14.5	x2 Active	18 - 29	3	17	-132	Chip	EAR99	HMC576
9.0 - 14.5	x2 Active	18 - 29	3	15	-132	LC3B	EAR99	HMC576LC3B
9.5 - 12.5	x2 Active	19 - 25	0	11	-135	Chip	EAR99	HMC448
10.0 - 12.5	x2 Active	20 - 25	0	11	-135	LC3B	EAR99	HMC448LC3B
11 - 23	x2 Active	22 - 46	5	15	-	Chip	EAR99	HMC598
12.0 - 16.5	x2 Active	24 - 33	3	17	-132	Chip	EAR99	HMC578
12.0 - 16.5	x2 Active	24 - 33	3	15	-132	LC3B	EAR99	HMC578LC3B
12.5 - 15.5	x2 Active	25 - 31	3	21	-	LP4	EAR99	HMC942LP4E
13.5 - 15.5	x2 Active	27 - 31	0	9	-132	LC3B	EAR99	HMC449LC3B
13.5 - 15.5	x2 Active	27 - 31	5	20	-128	LC4B	EAR99	HMC577LC4B
13.5 - 16.5	x2 Active	27 - 33	0	10	-132	Chip	EAR99	HMC449
16 - 23	x2 Active	32 - 46	3	13	-127	Chip	EAR99	HMC579
2.66 - 5.33	x3 Active	8 - 16	5	2	-152	LP3	EAR99	HMC916LP3E
1.5 - 2.5	x4 Active	6 - 10	5	2	-148	LP3	EAR99	HMC917LP3E
2.45 - 2.8	x4 Active	9.8 - 11.2	-15	3	-142	LP4	EAR99	HMC443LP4E
2.85 - 3.3	x4 Active	11.4 - 13.2	-15 to +5	7	-140	LP4	EAR99	HMC695LP4E
3.6 - 4.1	x4 Active	14.4 - 16.4	-15	0	-140	LP4	EAR99	HMC370LP4E
14 - 16	x4 Active	56 - 64	2	-6	-	Chip	3A001.b.2.f	HMC-XDH158
1.2375 - 1.4	x8 Active	9.9 - 11.2	-15	6	-136	LP4	EAR99	HMC444LP4E
0.61875 - 0.6875	x16 Active	9.9 - 11	-15	7	-130	LP4	EAR99	HMC445LP4E

FREQUENCY MULTIPLIERS - *Passive*

Input Frequency (GHz)	Function	Output Frequency (GHz)	Conversion Loss (dB)	1Fo / 4Fo Isolation (dB)	Input Drive (dBm)	Package	ECCN Code	Part Number
0.7 - 2.4	x2 Passive	1.4 - 4.8	15	47 / 38	10 to 20	Chip	EAR99	HMC156
0.7 - 2.4	x2 Passive	1.4 - 4.8	15	47 / 38	10 to 20	C8	EAR99	HMC156C8
0.85 - 2.0	x2 Passive	1.7 - 4.0	15	45 / 40	10 to 20	MS8	EAR99	HMC187AMS8E
1.25 - 3.0	x2 Passive	2.5 - 6.0	15	45 / 45	10 to 20	MS8	EAR99	HMC188MS8E
1.3 - 4.0	x2 Passive	2.6 - 8.0	15	45 / 40	10 to 20	Chip	EAR99	HMC158
1.3 - 4.0	x2 Passive	2.6 - 8.0	15	45 / 40	10 to 20	C8	EAR99	HMC158C8
2 - 4	x2 Passive	4 - 8	13	34 / 40	10 to 15	MS8	EAR99	HMC189AMS8E
4 - 8	x2 Passive	8 - 16	20	45 / 38	10 to 15	Chip	EAR99	HMC204
4 - 8	x2 Passive	8 - 16	17	41 / 40	10 to 15	C8	EAR99	HMC204C8
4 - 8	x2 Passive	8 - 16	17	42 / 50	10 to 15	MS8G	EAR99	HMC204MS8GE
6 - 12	x2 Passive	12 - 24	17	32 / 32	10 to 15	Chip	EAR99	HMC205
10 - 15	x2 Passive	20 - 30	13	30	+13	Chip	5A991.h	HMC-XDB112
12 - 18	x2 Passive	24 - 36	14	50 / 60	11 to 15	Chip	EAR99	HMC331
24 - 30	x3 Passive	72 - 90	19	-	+13	Chip	5A991.h	HMC-XTB110

PHASE LOCKED LOOP - *Fractional-N & Integer-N ICs*

Frequency	Function	Max. PFD Frequency	Max. Reference Frequency	Figure of Merit (Frac/Int) (dBc/Hz)	Frequency Resolution w/ 50 MHz Ref.	Bias Supply	Package	ECCN Code	Part Number
10 kHz - 8 GHz	Fractional-N with Sweeper	75 MHz	200 MHz	-221 / -227	3 Hz	+5V @ 37 mA +3.3V @ 90 mA	LP6C	3A001.a.11.b	HMC701LP6CE
10 kHz - 14 GHz	Fractional-N with Sweeper	75 MHz	200 MHz	-221 / -227	6 Hz	+5V @ 37 mA +3.3V @ 136 mA	LP6C	3A001.a.11.b	HMC702LP6CE
10 MHz - 8 GHz	Fractional-N	70 MHz	200 MHz	-221 / -226	3 Hz	+5V @ 7 mA +3.3V @ 95 mA	LP4	3A001.a.11.b	HMC700LP4E
DC - 7	Fractional-N with Sweeper	150 MHz	-	-228 / -231	10 Hz	+5V @ 97 mA +3V @ 149 mA	LP5	3A001.a.11.b	HMC983LP5E
DC - 7	Fractional-N with Sweeper	150 MHz	-	-228 / -231	10 Hz	+5V @ 97 mA +3V @ 149 mA	LP4	3A001.a.11.b	HMC984LP4E
DC - 8 GHz	Fractional-N with Sweeper	100 MHz	350 MHz	-230 / -233	3 Hz	+5V @ 6 mA +3.3V @ 52 mA	LP4	3A001.a.11.b	HMC703LP4E
DC - 8 GHz	Fractional-N	100 MHz	350 MHz	-230 / -233	3 Hz	+5V @ 6 mA +3.3V @ 52 mA	LP4	3A001.a.11.b	HMC704LP4E
80 MHz - 7 GHz	Integer-N	1300 MHz	1300 MHz	-233	50 MHz	+5V @ 310 mA	LP5	3A001.a.11.b	HMC698LP5E
160 MHz - 7 GHz	Integer-N	1300 MHz	1300 MHz	-233	50 MHz	+5V @ 310 mA	LP5	3A001.a.11.b	HMC699LP5E
10 MHz - 2.8 GHz	Integer-N	1300 MHz	1300 MHz	-233	50 MHz	+5V @ 250 mA	QS16G	3A001.a.11.b	HMC440QS16GE

LO FREQUENCY GENERATION ICs

SMT & Chip (Die) Products

PLLs with INTEGRATED VCOs - Microwave & RF PLLs with Integrated VCOs

Frequency (MHz)	Function	Closed Loop SSB Phase Noise @ 10 kHz Offset	Open Loop VCO Phase Noise @ 1 MHz Offset	Pout (dBm)	RMS Jitter Fractional Mode (fs)	Integrated PN Fractional Mode (deg rms)	Package	ECCN Code	Part Number
fo/2									
665 - 825	Tri-Band RF VCO	-118 dBc/Hz	-148 dBc/Hz	11	180	0.05	LP6C	3A001.a.11.b	HMC822LP6CE
795 - 945	Tri-Band RF VCO	-123 dBc/Hz	-148 dBc/Hz	10	180	0.06	LP6C	3A001.a.11.b	HMC838LP6CE
780 - 870	RF VCO	-116 dBc/Hz	-148 dBc/Hz	14	180	0.06	LP6C	3A001.a.11.b	HMC824LP6CE
860 - 1040	Tri-Band RF VCO	-118 dBc/Hz	-147 dBc/Hz	10	180	0.07	LP6C	3A001.a.11.b	HMC821LP6CE
990 - 1105	RF VCO	-114 dBc/Hz	-146 dBc/Hz	11	180	0.07	LP6C	3A001.a.11.b	HMC826LP6CE
1025 - 1150	Tri-Band RF VCO	-123 dBc/Hz	-147 dBc/Hz	12	180	0.07	LP6C	3A001.a.11.b	HMC837LP6CE
1050 - 1205	Tri-Band RF VCO	-121 dBc/Hz	-146 dBc/Hz	10	180	0.08	LP6C	3A001.a.11.b	HMC839LP6CE
1095 - 1275	Tri-Band RF VCO	-118 dBc/Hz	-147 dBc/Hz	10	180	0.08	LP6C	3A001.a.11.b	HMC820LP6CE
1310 - 1415	Tri-Band RF VCO	-121 dBc/Hz	-145 dBc/Hz	10	180	0.09	LP6C	3A001.a.11.b	HMC840LP6CE
fo									
1285 - 1415	RF VCO	-112 dBc/Hz	-143 dBc/Hz	10	180	0.09	LP6C	3A001.a.11.b	HMC828LP6CE
1330 - 1650	Tri-Band RF VCO	-112 dBc/Hz	-142 dBc/Hz	6.5	180	0.11	LP6C	3A001.a.11.b	HMC822LP6CE
1590 - 1890	Tri-Band RF VCO	-118 dBc/Hz	-143 dBc/Hz	7.5	180	0.12	LP6C	3A001.a.11.b	HMC838LP6CE
1720 - 2080	Tri-Band RF VCO	-112 dBc/Hz	-141 dBc/Hz	6.5	180	0.13	LP6C	3A001.a.11.b	HMC821LP6CE
1815 - 2010	RF VCO	-112 dBc/Hz	-143 dBc/Hz	7.5	180	0.13	LP6C	3A001.a.11.b	HMC831LP6CE
2050 - 2300	Tri-Band RF VCO	-117 dBc/Hz	-141 dBc/Hz	10.5	180	0.15	LP6C	3A001.a.11.b	HMC837LP6CE
2100 - 2410	Tri-Band RF VCO	-115 dBc/Hz	-140 dBc/Hz	7.5	180	0.16	LP6C	3A001.a.11.b	HMC839LP6CE
2190 - 2550	Tri-Band RF VCO	-112 dBc/Hz	-141 dBc/Hz	6.5	180	0.17	LP6C	3A001.a.11.b	HMC820LP6CE
2620 - 2830	Tri-Band RF VCO	-115 dBc/Hz	-139 dBc/Hz	9	180	0.18	LP6C	3A001.a.11.b	HMC840LP6CE
2fo									
2660 - 3300	Tri-Band RF VCO	-106 dBc/Hz	-136 dBc/Hz	-4	180	0.21	LP6C	3A001.a.11.b	HMC822LP6CE
3180 - 3780	Tri-Band RF VCO	-112 dBc/Hz	-135 dBc/Hz	-4	180	0.24	LP6C	3A001.a.11.b	HMC838LP6CE
3365 - 3705	RF VCO	-107 dBc/Hz	-135 dBc/Hz	0	190	0.25	LP6C	3A001.a.11.b	HMC836LP6CE
3440 - 4160	Tri-Band RF VCO	-106 dBc/Hz	-135 dBc/Hz	-4	180	0.27	LP6C	3A001.a.11.b	HMC821LP6CE
4100 - 4600	Tri-Band RF VCO	-111 dBc/Hz	-135 dBc/Hz	-0.5	180	0.30	LP6C	3A001.a.11.b	HMC837LP6CE
4200 - 4820	Tri-Band RF VCO	-108 dBc/Hz	-135 dBc/Hz	-4	180	0.31	LP6C	3A001.a.11.b	HMC839LP6CE
4380 - 5100	Tri-Band RF VCO	-106 dBc/Hz	-135 dBc/Hz	-4	180	0.33	LP6C	3A001.a.11.b	HMC820LP6CE
5240 - 5660	Tri-Band RF VCO	-109 dBc/Hz	-133 dBc/Hz	-3	180	0.37	LP6C	3A001.a.11.b	HMC840LP6CE
7300 - 8200	Microwave PLL+VCO	-101 dBc/Hz	-140 dBc/Hz	15	196	0.58	LP6C	3A001.a.11.b	HMC764LP6CE
7800 - 8800	Microwave PLL+VCO	-101 dBc/Hz	-140 dBc/Hz	13	193	0.61	LP6C	3A001.a.11.b	HMC765LP6CE
8450 - 9550	Microwave PLL+VCO	-107 dBc/Hz	-138 dBc/Hz	12	93	0.30	LP6C	3A001.a.11.b	HMC767LP6CE
9050 - 10150	Microwave PLL+VCO	-106 dBc/Hz	-140 dBc/Hz	12	82	0.28	LP6C	3A001.a.11.b	HMC769LP6CE
9600 - 10800	Microwave PLL+VCO	-106 dBc/Hz	-140 dBc/Hz	9	83	0.31	LP6C	3A001.a.11.b	HMC778LP6CE
11500 - 12500	Microwave PLL+VCO	-99 dBc/Hz	-134 dBc/Hz	10	181	0.81	LP6C	3A001.a.11.b	HMC783LP6CE
12400 - 13400	Microwave PLL+VCO	-98 dBc/Hz	-132 dBc/Hz	8	175	0.84	LP6C	3A001.a.11.b	HMC807LP6CE
Wideband Continuous Tuning									
25 - 3000	Wideband RF VCO	-114 dBc/Hz @ 2 GHz	-141 dBc/Hz @ 2 GHz	5	82 [1]	0.114 @ 2 GHz	LP6G	3A001.a.11.b	HMC830LP6GE
25 - 6000	Wideband RF VCO	-114 dBc/Hz @ 2 GHz	-135 dBc/Hz @ 4 GHz	-4	82 [1]	0.22 @ 4 GHz	LP6G	3A001.a.11.b	HMC833LP6GE
45 - 1050 1400 - 2100 2800 - 4200 Fo	Wideband RF VCO	-108 dBc/Hz @ 4 GHz	-134 dBc/Hz @ 4 GHz	4	82 [1]	0.229 @ 4 GHz	LP6G	3A001.a.11.b	HMC829LP6GE
45 - 1050 1400 - 2100 2800 - 4200 Fo 5600 - 8400	Wideband RF VCO	-108 dBc/Hz @ 4 GHz	-128 dBc/Hz @ 8 GHz	5 2 2 -10	82 [1]	0.46 @ 8 GHz	LP6G	3A001.a.11.b	HMC834LP6GE

[1] RMS Jitter Integration Bandwidth from 12 kHz to 20 MHz

VOLTAGE CONTROLLED OSCILLATORS - VCOs with Buffer Amplifiers & Wideband VCOs*

Fo Frequency (GHz)	Function	Fo Output Power (dBm)	10 kHz SSB Phase Noise (dBc/Hz)	100 kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	ECCN Code	Part Number
2.05 - 2.25	VCO with Buffer	3.5	-89	-112	+3V @ 35 mA	LP4	EAR99	HMC384LP4E
2.25 - 2.5	VCO with Buffer	4.5	-89	-115	+3V @ 35 mA	LP4	EAR99	HMC385LP4E
2.6 - 2.8	VCO with Buffer	5	-88	-115	+3V @ 35 mA	LP4	EAR99	HMC386LP4E
2.75 - 3.0	VCO with Buffer	4.5	-89	-114	+3V @ 37 mA	LP4	EAR99	HMC416LP4E
3.15 - 3.4	VCO with Buffer	4.9	-88	-113	+3V @ 39 mA	LP4	EAR99	HMC388LP4E
3.35 - 3.55	VCO with Buffer	4.7	-89	-112	+3V @ 41 mA	LP4	EAR99	HMC389LP4E
3.55 - 3.9	VCO with Buffer	4.7	-87	-112	+3V @ 42 mA	LP4	EAR99	HMC390LP4E
3.9 - 4.45	VCO with Buffer	5	-81	-106	+3V @ 30 mA	LP4	EAR99	HMC391LP4E
4.45 - 5.0	VCO with Buffer	4	-79	-105	+3V @ 30 mA	LP4	EAR99	HMC429LP4E
5.0 - 5.5	VCO with Buffer	2	-80	-103	+3V @ 27 mA	LP4	EAR99	HMC430LP4E
5.5 - 6.1	VCO with Buffer	2	-80	-102	+3V @ 27 mA	LP4	EAR99	HMC431LP4E
5.8 - 6.8	VCO with Buffer	10	-82	-105	+3V @ 100 mA	MS8G	EAR99	HMC358MS8GE
6.1 - 6.72	VCO with Buffer	4.5	-73	-101	+3V @ 31 mA	LP4	EAR99	HMC466LP4E

VOLTAGE CONTROLLED OSCILLATORS - VCOs with Buffer Amplifiers & Wideband VCOs*

Fo Frequency (GHz)	Function	Fo Output Power (dBm)	10 kHz SSB Phase Noise (dBc/Hz)	100 kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	ECCN Code	Part Number
6.8 - 7.4	VCO with Buffer	11	-80	-106	+3V @ 80 mA	LP4	EAR99	HMC505LP4E
7.1 - 7.9	VCO with Buffer	14	-80	-101	+3V @ 85 mA	LP4	EAR99	HMC532LP4E
7.8 - 8.7	VCO with Buffer	14	-80	-103	+3V @ 77 mA	LP4	EAR99	HMC506LP4E
8.6 - 10.2	VCO with ÷4	18	-70	-100	+5V @ 220 mA	LP5	3A001.a.11.b	HMC734LP5E
10.5 - 12.2	VCO with ÷4	17	-75	-100	+5V @ 220 mA	LP5	3A001.a.11.b	HMC735LP5E
13.2 -13.5	VCO with ÷8	-8	-83	-110	+5V @ 230 mA	QS16G	3A001.a.11.b	HMC401QS16GE
14.0 - 15.0	VCO with ÷8	6	-75	-110	+5V @ 260 mA	QS16G	3A001.a.11.b	HMC398QS16GE
23.8 - 24.8	VCO with ÷16	12	-70	-95	+5V @ 220 mA	LP4	3A001.a.11.b	HMC533LP4E
4 - 8	Wideband VCO	5	-75	-100	+5V @ 55 mA	LC4B	EAR99	HMC586LC4B
5 - 10	Wideband VCO	5	-65	-95	+5V @ 55 mA	LC4B	EAR99	HMC587LC4B
6 - 12	Wideband VCO	1	-65	-95	+5V @ 57 mA	LC4B	EAR99	HMC732LC4B
8 - 12.5	Wideband VCO	5	-65	-93	+5V @ 55 mA	LC4B	EAR99	HMC588LC4B
10 - 20	Wideband VCO	3	-60	-90	+5V @ 70 mA	LC4B	EAR99	HMC733LC4B

** HMC VCOs integrate resonator, negative resistance generator and tuning varactor circuits on-chip. No external components are required.*

VOLTAGE CONTROLLED OSCILLATORS WITH Fo/2 OUTPUT

Fo Frequency (GHz)	Fo/2 Frequency (GHz)	Function	Fo Output Power (dBm)	10 kHz SSB Phase Noise (dBc/Hz)	100 kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	ECCN Code	Part Number
VCOs with Fo/2									
6.65 - 7.65	3.325 - 3.825	VCO with Fo/2	13	-90	-115	+5V @ 230 mA	LP5	EAR99	HMC507LP5E
7.3 - 8.2	3.65 - 4.1	VCO with Fo/2	15	-90	-116	+5V @ 240 mA	LP5	EAR99	HMC508LP5E
7.8 - 8.8	3.9 - 4.4	VCO with Fo/2	13	-90	-115	+5V @ 250 mA	LP5	EAR99	HMC509LP5E
9.05 - 10.15	4.525 - 5.075	VCO with Fo/2	13	-88	-115	+5V @ 265 mA	LP5	EAR99	HMC511LP5E
14.5 - 15.0	7.25 - 7.5	VCO with Fo/2	9	-80	-105	+4.2V @ 150 mA	LP4	EAR99	HMC736LP4E
14.9 - 15.5	7.45 - 7.75	VCO with Fo/2	9	-80	-105	+4.2V @ 150 mA	LP4	EAR99	HMC737LP4E
VCOs with Fo/2 & ÷4									
8.45 - 9.55	4.225 - 4.775	VCO with Fo/2 & ÷4	13	-92	-116	+5V @ 315 mA	LP5	3A001.a.11.b	HMC510LP5E
9.5 - 10.8	4.75 - 5.4	VCO with Fo/2 & ÷4	11	-85	-110	+5V @ 350 mA	LP5	3A001.a.11.b	HMC530LP5E
9.6 - 10.8	4.8 - 5.4	VCO with Fo/2 & ÷4	9	-85	-111	+5V @ 330 mA	LP5	3A001.a.11.b	HMC512LP5E
10.43 - 11.46	5.215 - 5.73	VCO with Fo/2 & ÷4	7	-85	-110	+3V @ 275 mA	LP5	3A001.a.11.b	HMC513LP5E
10.6 - 11.8	5.3 - 5.9	VCO with Fo/2 & ÷4	11	-82	-110	+5V @ 350 mA	LP5	3A001.a.11.b	HMC534LP5E
11.1 - 12.4	5.55 - 6.2	VCO with Fo/2 & ÷4	9	-83	-110	+5V @ 350 mA	LP5	3A001.a.11.b	HMC582LP5E
11.17 - 12.02	5.585 - 6.01	VCO with Fo/2 & ÷4	7	-87	-110	+3V @ 275 mA	LP5	3A001.a.11.b	HMC514LP5E
11.5 - 12.5	5.75 - 6.25	VCO with Fo/2 & ÷4	10	-83	-110	+5V @ 200 mA	LP5	3A001.a.11.b	HMC515LP5E
11.5 - 12.8	5.75 - 6.4	VCO with Fo/2 & ÷4	11	-80	-110	+5V @ 350 mA	LP5	3A001.a.11.b	HMC583LP5E
12.4 - 13.4	6.2 - 6.7	VCO with Fo/2 & ÷4	8	-83	-110	+5V @ 260 mA	LP5	3A001.a.11.b	HMC529LP5E
12.5 - 13.9	6.25 - 6.95	VCO with Fo/2 & ÷4	10	-81	-110	+5V @ 330 mA	LP5	3A001.a.11.b	HMC584LP5E
13.6 - 14.9	6.8 - 7.45	VCO with Fo/2 & ÷4	7	-82	-110	+5V @ 260 mA	LP5	3A001.a.11.b	HMC531LP5E
14.25 - 15.65	7.125 - 7.825	VCO with Fo/2 & ÷4	9	-80	-107	+5V @ 350 mA	LP5	3A001.a.11.b	HMC632LP5E
VCOs with Fo/2 & ÷16									
20.9 - 23.9	10.45 - 11.95	VCO with Fo/2 & ÷16	9	-65	-95	+5V @ 200 mA	LP4	3A001.a.11.b	HMC738LP4E
23.8 - 26.8	11.9 - 13.4	VCO with Fo/2 & ÷16	8	-64	-93	+5V @ 200 mA	LP4	3A001.a.11.b	HMC739LP4E

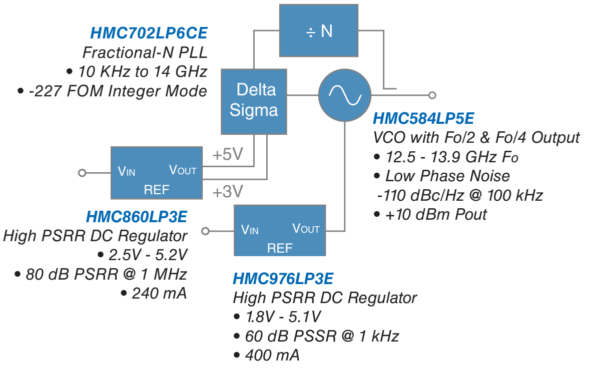
PHASE LOCKED OSCILLATOR

Fo Frequency (GHz)	Function	Fo Output Power (dBm)	10 kHz SSB Phase Noise (dBc/Hz)	100 kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	ECCN Code	Part Number
14.7 - 15.4	Phase Locked Oscillator	9	-80	-110	+5V @ 340 mA +12V @ 28 mA	LP4	3A001.a.11.b	HMC535LP4E

for LO Generation Applications

HITTITE'S HIGH FREQUENCY LO SOURCE ALTERNATIVES

PLL & VCO CHIPSET



HMC702LP6CE
Fractional-N PLL
- 10 KHz to 14 GHz
- -227 FOM Integer Mode

HMC584LP5E
VCO with Fo/2 & Fo/4 Output
- 12.5 - 13.9 GHz Fo
- Low Phase Noise -110 dBc/Hz @ 100 kHz
- +10 dBm Pout

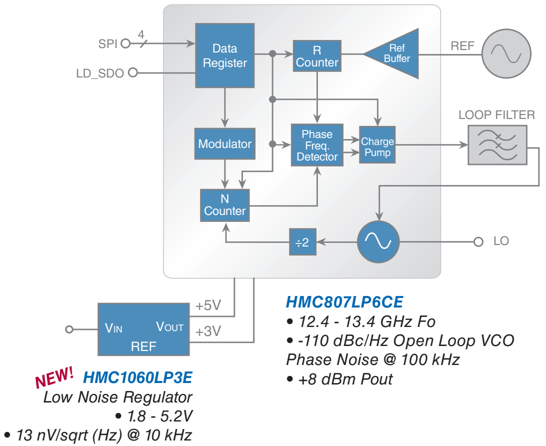
HMC860LP3E
High PSRR DC Regulator
- 2.5V - 5.2V
- 80 dB PSRR @ 1 MHz
- 240 mA

HMC976LP3E
High PSRR DC Regulator
- 1.8V - 5.1V
- 60 dB PSSR @ 1 kHz
- 400 mA

Improves VCO Phase Noise up to 14 dB @ 100 kHz Offset

Contact Us: PLL@hittite.com

PLL WITH INTEGRATED VCO IC

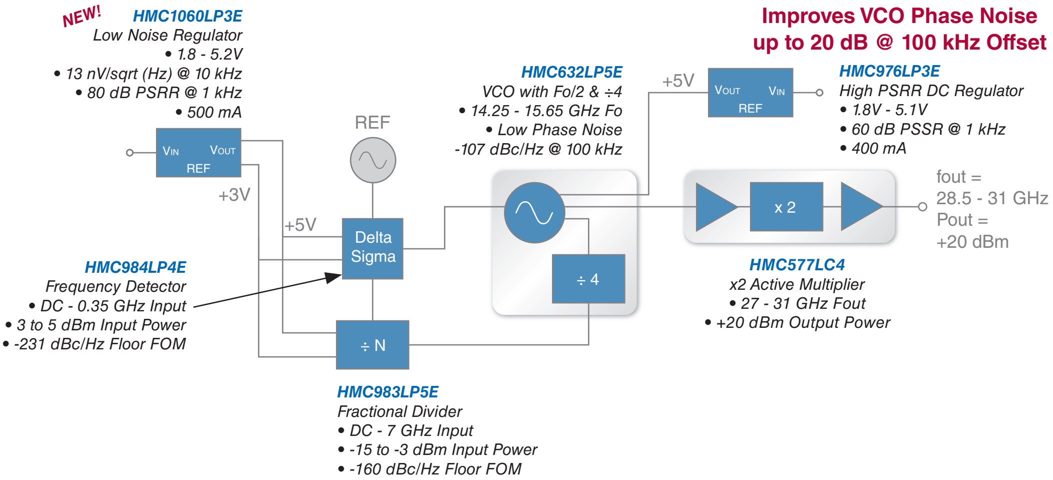


HMC807LP6CE
- 12.4 - 13.4 GHz Fo
- -110 dBc/Hz Open Loop VCO Phase Noise @ 100 kHz
- +8 dBm Pout

NEW! **HMC1060LP3E**
Low Noise Regulator
- 1.8 - 5.2V
- 13 nV/sqrt (Hz) @ 10 kHz
- 80 dB PSRR @ 1 kHz
- 500 mA

Improves VCO Phase Noise up to 14 dB @ 100 kHz Offset

KA BAND PHASE LOCKED OSCILLATOR FEATURING HITTITE'S DC POWER CONDITIONING & FREQUENCY GENERATION COMPONENTS



Improves VCO Phase Noise up to 20 dB @ 100 kHz Offset

NEW! **HMC1060LP3E**
Low Noise Regulator
- 1.8 - 5.2V
- 13 nV/sqrt (Hz) @ 10 kHz
- 80 dB PSRR @ 1 kHz
- 500 mA

HMC632LP5E
VCO with Fo/2 & ÷4
- 14.25 - 15.65 GHz Fo
- Low Phase Noise -107 dBc/Hz @ 100 kHz

HMC976LP3E
High PSRR DC Regulator
- 1.8V - 5.1V
- 60 dB PSSR @ 1 kHz
- 400 mA

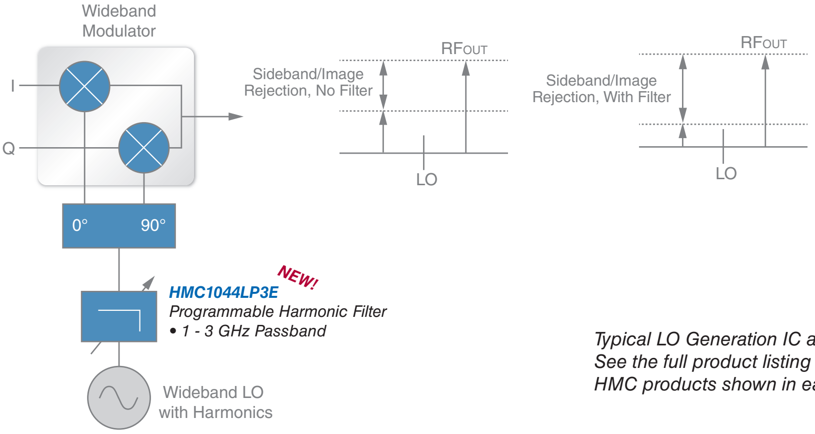
fout = 28.5 - 31 GHz
Pout = +20 dBm

HMC984LP4E
Frequency Detector
- DC - 0.35 GHz Input
- 3 to 5 dBm Input Power
- -231 dBc/Hz Floor FOM

HMC577LC4
x2 Active Multiplier
- 27 - 31 GHz Fout
- +20 dBm Output Power

HMC983LP5E
Fractional Divider
- DC - 7 GHz Input
- -15 to -3 dBm Input Power
- -160 dBc/Hz Floor FOM

USING HMC1044LP3E AS AN LO HARMONIC FILTER TO IMPROVE MODULATOR/DEMODULATOR SIDEBAND/IMAGE REJECTION

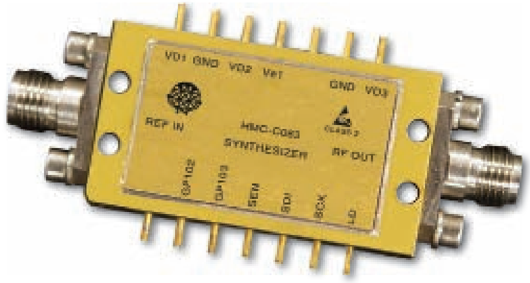


NEW! **HMC1044LP3E**
Programmable Harmonic Filter
- 1 - 3 GHz Passband

Typical LO Generation IC applications are illustrated. See the full product listing for alternatives to the select HMC products shown in each functional block.

Robust, High Performance RF to Light Solutions

Our hermetic module product line spans a wide range of popular product types including amplifiers, attenuators, DROs, high speed digital logic, frequency multipliers, MicroSynth® integrated synthesizers, mixers, phase shifters, prescalers, SDLVAs, switches & VCOs. Utilizing our standard MMIC products, we take advantage of our world-class design, manufacturing and quality expertise. Hittite can also up-screen modules for high-reliability/military specification applications. Contact us to discuss your custom module requirements.



Features:

- ***Off-The-Shelf Availability***
- ***Hermetically Sealed***
- ***Internal DC Power Regulation***
- ***Field Replaceable Connectors***
- ***Military & Space Upscreening***
- ***Customization Offered***

AMPLIFIERS

Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package / Connector	ECCN Code	Part Number
1 - 12	Low Noise	16	30	1.8	16	+6V @ 60 mA	C-10B / SMA	EAR99	HMC-C059
1.8 - 4.2	Low Noise	26	26	0.7	15.5	+8V @ 112 mA	C-10 / SMA	EAR99	HMC-C045
5 - 9	Low Noise	22.5	25	1.75	15	+12V @ 105 mA	C-10 / SMA	EAR99	HMC-C048
29 - 36	Low Noise	20	22	2.9	11	+3V @ 80 mA	C-10 / 2.92 mm	3A001.b.4.c	HMC-C027
2 - 20	Wideband LNA	15	25	2.5	14	+12V @ 65 mA	C-1 / SMA	EAR99	HMC-C001
2 - 20	Wideband LNA	14	26	2	18	+12V @ 60 mA	C-2 / SMA	EAR99	HMC-C002
2 - 20	Wideband LNA	14	27	2	16	+8V @ 75 mA	C-2B / SMA	EAR99	HMC-C022
7 - 17	Wideband LNA	22	25	2	14	+8V @ 93 mA	C-1 / SMA	EAR99	HMC-C016
17 - 27	Wideband LNA	18	25	3	14	+8V @ 96 mA	C-1B / 2.92 mm	EAR99	HMC-C017
0.01 - 20	Wideband Driver	16	33	3	23	+12V @ 195 mA	C-3 / SMA	3A001.b.4.f	HMC-C004
0.01 - 20	Wideband Driver	15	30	3	23	+12V @ 225 mA	C-3B / SMA	3A001.b.4.f	HMC-C024
2 - 35	Wideband Driver	12	29	3	18	+11V @ 92 mA	C-10 / 2.92 mm	3A001.b.4.c	HMC-C038
0.01 - 6.0	Single Stage Power Amplifier, 1 Watt	13	40	5	29.5	-5V @ 5 mA +15V @ 450 mA	C-17 / SMA	EAR99	HMC-C074
0.01 - 6.0	Two Stage Power Amplifier, 1 Watt	24	42	5	29.5	-5V @ 5 mA +15V @ 740 mA	C-17 / SMA	EAR99	HMC-C075
0.01 - 15	Wideband Power Amplifier, 1/2 Watt	12	36	4	28	+11V @ 360 mA	C-10B / SMA	3A001.b.4.f	HMC-C036
0.01 - 15	Wideband Power Amplifier, 1/2 Watt	12	36	4	28	+11V @ 360 mA	C-12 / SMA	3A001.b.4.f	HMC-C037
2 - 20	Wideband Power Amplifier	15	34	4	26	+12V @ 310 mA	C-2 / SMA	3A001.b.4.f	HMC-C003
2 - 20	Wideband Power Amplifier	15	34	4	26	+12V @ 310 mA	C-2B / SMA	3A001.b.4.f	HMC-C023
2 - 20	Wideband Power Amplifier	31	33	3	26	+12V @ 400 mA	C-3B / SMA	3A001.b.4.f	HMC-C026
17 - 24	Wideband Power Amplifier	22	33	3.5	24	+8V @ 250 mA	C-10 / 2.92 mm	EAR99	HMC-C020
21 - 31	Wideband Power Amplifier	15	32	5	24	+8V @ 215 mA	C-10 / 2.92 mm	3A001.b.4.c	HMC-C021
0.8 - 2.0	Power Amplifier, 10 Watt	43	56	12	40	+12V @ 6.5A	C-7 / SMA	EAR99	HMC-C013

AMPLIFIERS - Low Phase Noise

Frequency (GHz)	Function	Gain / NF (dB)	OIP3 (dBm)	10 kHz Phase Noise (dBc/Hz)	P1dB / Psat (dBm)	Bias Supply	Package / Connector	ECCN Code	Part Number
1.5 - 5.0	Low Phase Noise	14 / 4.5	26.5	-171	17 / 22	+7V @ 170 mA	C-16 / SMA	EAR99	HMC-C077
2 - 18	Low Phase Noise	13.5 / 5	22.5	-160	15 / 18.5	+5V @ 80 mA	C-1 / SMA	EAR99	HMC-C050
3 - 8	Low Phase Noise	9 / 6	33	-168	22 / 25	+7V @ 300 mA	C-16 / SMA	EAR99	HMC-C079
6 - 12	Low Phase Noise	11 / 4.5	34	-176	20 / 22	+7V @ 170 mA	C-16 / SMA	EAR99	HMC-C072
7 - 11	Low Phase Noise	9 / 6	33	-170	22 / 25	+7V @ 300 mA	C-16 / SMA	EAR99	HMC-C076

ATTENUATORS - Analog & Digital

Frequency (GHz)	Function	Loss (dB)	Attenuation Range (dB)	IIP3 (dBm)	Control Input (Vdc)	Package / Connector	ECCN Code	Part Number
DC - 20	Analog VVA	5.5	35	10	-5	C-10 / SMA	EAR99	HMC-C053
DC - 13	6-Bit Digital, Serial Control	3.6	0.5 to 31.5	32	Serial/CMOS	C-6 / SMA	EAR99	HMC-C018
DC - 13	6-Bit Digital	3.2	0.5 to 31.5	38	0 / +5V	C-6 / SMA	EAR99	HMC-C025

DIELECTRIC RESONATOR OSCILLATORS (DRO)

Frequency (GHz)	Function	Output Power (dBm)	10 kHz SSB Phase Noise (dBc/Hz)	100 kHz SSB Phase Noise (dBc/Hz)	Frequency Drift (ppm/°C)	Bias Supply	Package	ECCN Code	Part Number
8.0 - 8.3	Dielectric Resonator Oscillator	14.5	-122	-140	2	+6 to +15V @ 125 mA	C-18 / SMA	EAR99	HMC-C200

CONNECTORIZED MODULES

Robust, High Performance RF to Light Solutions

FREQUENCY DIVIDERS (PRESCALERS)

Input Freq. (GHz)	Function	Input Power (dBm)	Output Power (dBm)	100 kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package / Connector	ECCN Code	Part Number
DC - 18	Divide-by-2	-15 to +10	-4	-150	+5V @ 75 mA	C-1 / SMA	3A001.a.11.b	HMC-C005
DC - 18	Divide-by-4	-15 to +10	-4	-150	+5V @ 93 mA	C-1 / SMA	3A001.a.11.b	HMC-C006
0.5 - 8	Divide-by-5	-15 to +10	-1	-155	+5V @ 80 mA	C-1 / SMA	3A001.a.11.b	HMC-C039
DC - 18	Divide-by-8	-15 to +10	-4	-150	+5V @ 98 mA	C-1 / SMA	3A001.a.11.b	HMC-C007
0.5 - 17	Divide-by-10	-15 to +10	-1	-155	+5V @ 152 mA	C-1 / SMA	3A001.a.11.b	HMC-C040

FREQUENCY MULTIPLIERS - Active

Input Freq. (GHz)	Function	Output Freq. (GHz)	Input Power (dBm)	Output Power (dBm)	100 kHz SSB Phase Noise (dBc/Hz)	Package / Connector	ECCN Code	Part Number
3 - 5	x2 Active	6 - 10	3	17	-140	C-10 / SMA	EAR99	HMC-C031
9.0 - 14.5	x2 Active	18 - 29	3	16	-132	C-10 / 2.92 mm	EAR99	HMC-C032
12.0 - 16.5	x2 Active	24 - 33	3	17	-132	C-10 / 2.92 mm	EAR99	HMC-C033
16 - 23	x2 Active	32 - 46	3	13	-130	C-10 / 2.92 mm	EAR99	HMC-C034
4.0 - 10.5	x2 Active	8 - 21	6	14	-142	C-10 / SMA	EAR99	HMC-C056

HIGH SPEED DIGITAL LOGIC

Data / Clock Rate (Gbps / GHz)	Function	Rise / Fall Time (ps)	Deterministic Jitter (ps)	Differential Output Swing (Vp-p)	DC Power (mW)	Vee Power Supply (Vdc)	Package / Connector	ECCN Code	Part Number
50 / 30	1:2 Fanout Buffer	9.5 / 11	2	0.5	455	-3.3	C-13 / 1.85 mm	3A001.a.11.b	HMC-C062
50 / 25	AND / NAND / OR / NOR	9 / 10	2	0.5	560	-3.3	C-13 / 1.85 mm	3A001.a.11.b	HMC-C065
43 / 43	D-Type Flip-Flop	9 / 10	1.5	0.5	580	-3.3	C-13 / 1.85 mm	3A001.a.11.b	HMC-C060
50 / 25	D-Type Flip-Flop Double Edge Triggered	9 / 11	1.5	0.5	690	-3.3	C-13 / 1.85 mm	3A001.a.11.b	HMC-C061
50 / 25	XOR / XNOR	6.5 / 10	2	0.5	550	-3.3	C-13 / 1.85 mm	3A001.a.11.b	HMC-C064

I/Q MIXERS

RF / LO Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Image Rejection (dB)	IIP3 (dBm)	Package / Connector	ECCN Code	Part Number
4 - 8.5	I/Q Mixer / IRM	DC - 3.5	-7.5	35	23	C-4 / SMA	EAR99	HMC-C009
6 - 10	I/Q Mixer / IRM	DC - 3.5	-7.5	35	25	C-4 / SMA	EAR99	HMC-C041
8.5 - 13.5	I/Q Mixer / IRM	DC - 2	-8	28	25	C-4 / SMA	EAR99	HMC-C042
11 - 16	I/Q Mixer / IRM	DC - 3.5	-9	30	28	C-4 / SMA	EAR99	HMC-C043
15 - 23	I/Q Mixer / IRM	DC - 3.5	-8	30	25	C-4 / 2.92 mm & SMA	EAR99	HMC-C044
20 - 31	I/Q Mixer / IRM	DC - 4.5	-10	24	22.5	C-4B / 2.92 mm & SMA	EAR99	HMC-C046
30 - 38	I/Q Mixer / IRM	DC - 3.5	-10.5	15	19	C-4 / 2.92 mm & SMA	EAR99	HMC-C047

MIXERS

RF Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	LO/RF Isolation (dB)	IIP3 (dBm)	Package / Connector	ECCN Code	Part Number
7 - 14	+13 LO, DBL-BAL	DC - 5	-7	48	20	C-11 / SMA	EAR99	HMC-C049
11 - 20	+13 LO, DBL-BAL	DC - 6	-7	43	18	C-11 / 2.92 mm & SMA	EAR99	HMC-C051
16 - 32	+13 LO, DBL-BAL	DC - 8	-8	35	19	C-11 / 2.92 mm & SMA	EAR99	HMC-C014
23 - 37	+13 LO, DBL-BAL	DC - 13	-9	35	19	C-11 / 2.92 mm & SMA	EAR99	HMC-C035
24 - 38	+13 LO, DBL-BAL	DC - 8	-8.5	35	20	C-11 / 2.92 mm & SMA	EAR99	HMC-C015

PHASE SHIFTERS - Analog

Frequency (GHz)	Function	Insertion Loss (dB)	Phase Range (deg)	2nd harmonic Pin = 10 dBm (dBc)	Control Voltage Range (Vdc)	Package / Connector	ECCN Code	Part Number
6 - 15	Analog	7	750° @ 6 GHz 450° @ 15 GHz	40	0V to +5V	C-1 / SMA	EAR99	HMC-C010

PHASE SHIFTERS - Digital

Frequency (GHz)	Function	Insertion Loss (dB)	Phase Range (deg)	IIP3 (dBm)	Control Voltage Range (Vdc)	Package / Connector	ECCN Code	Part Number
8 - 12	4-Bit Digital	7	22.5 to 360	38	0V to +5V	C-6 / SMA	EAR99	HMC-C055

SDLVAs - Successive Detection Log Video Amplifier

Frequency (GHz)	Function	Dynamic Range (dB)	RSSI Slope (mV / dB)	RF Threshold Level (dBm)	Bias Supply	Package / Connector	ECCN Code	Part Number
1 - 20	SDLVA	59	14	-67	+12V @ 86 mA	C-10 / 2.92 mm	EAR99	HMC-C052
2 - 20	SDLVA with Limited RF Output	50	45	-45	+12V @ 370 mA -5V @ 20 mA	C-21 / SMA	EAR99	HMC-C078

CONNECTORIZED MODULES

Robust, High Performance RF to Light Solutions

SWITCHES - *SPST, SPDT & SP4T*

Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Switching Speed (ns)	Package / Connector	ECCN Code	Part Number
DC - 20	SPST, Hi Isolation	3	100	23	8.5	C-9 / SMA	EAR99	HMC-C019
DC - 18	SPDT, Hi Isolation	2	55	27	3	C-14 / SMA	EAR99	HMC-C058
DC - 20	SPDT, Hi Isolation	2	40	23	5	C-5 / SMA	EAR99	HMC-C011
DC - 20	SP4T, Hi Isolation	3	40	24	14	C-15 / SMA	EAR99	HMC-C071

SYNTHESIZED MODULES - *MicroSynth®*

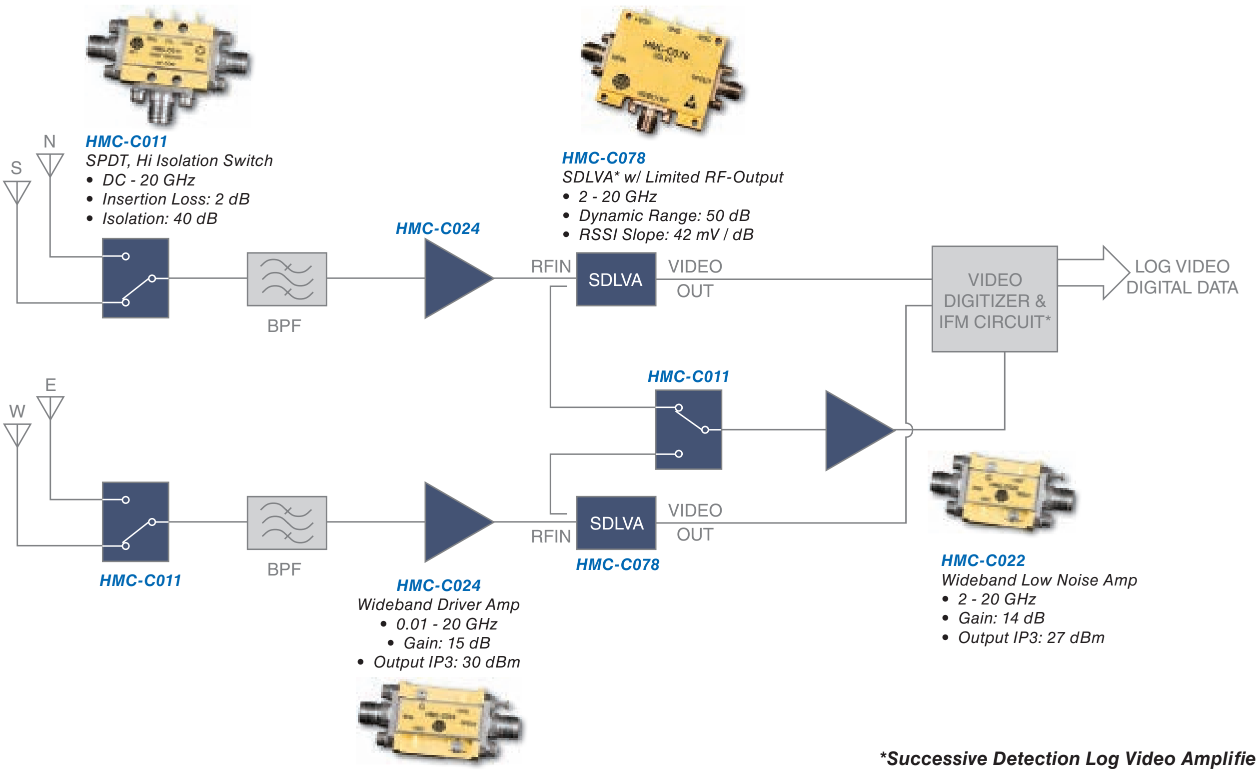
Frequency (GHz)	Function	Min. Step Size Resolution (Hz)	Reference Frequency (MHz)	SSB Phase Noise @ 100 kHz Offset (dBc/Hz)	Output Power (dBm)	Bias Supply	Package	ECCN Code	Part Number
2 - 6	MicroSynth® Synthesizer	0.6	10	-93	17	+20V @ 7 mA +6V @ 330 mA	C-20 / SMA	EAR99	HMC-C083
5.5 - 10.5	MicroSynth® Synthesizer	1.2	10	-92	21	+20V @ 20 mA +6V @ 300 mA +3.6V @ 100 mA	C-20 / SMA	EAR99	HMC-C070

VOLTAGE CONTROLLED OSCILLATORS

Frequency (GHz)	Function	Output Power (dBm)	10 kHz SSB Phase Noise (dBc/Hz)	100 kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package / Connector	ECCN Code	Part Number
4 - 8	Wideband VCO	20	-75	-95	+12V @ 185 mA	C-1 / SMA	EAR99	HMC-C028
5 - 10	Wideband VCO	20	-64	-93	+12V @ 195 mA	C-1 / SMA	EAR99	HMC-C029
8 - 12.5	Wideband VCO	21	-59	-83	+12V @ 195 mA	C-1 / SMA	EAR99	HMC-C030
38.4 - 43.2	VCO	13	-74	-98	+5V @ 350 mA	C-19 / 2.4 mm	EAR99	HMC-C073

Hittite Microwave Can Offer Any Of Our Die Or SMT IC Products In A Connectorized Module.
Full Specifications for Each Product Are Available at www.hittite.com.

MILITARY RADAR RECEIVER SOLUTION



HMC-C011
SPDT, Hi Isolation Switch
- *DC - 20 GHz*
- *Insertion Loss: 2 dB*
- *Isolation: 40 dB*

HMC-C078
SDLVA w/ Limited RF-Output*
- *2 - 20 GHz*
- *Dynamic Range: 50 dB*
- *RSSI Slope: 42 mV / dB*

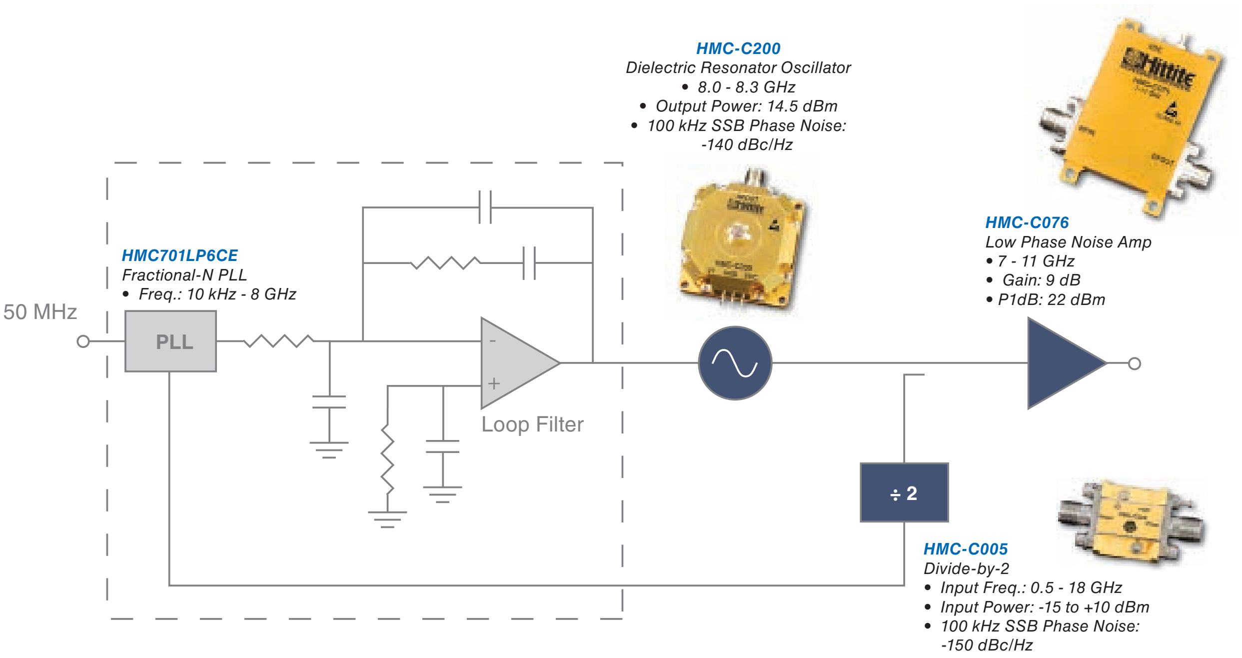
HMC-C022
Wideband Low Noise Amp
- *2 - 20 GHz*
- *Gain: 14 dB*
- *Output IP3: 27 dBm*

HMC-C024
Wideband Driver Amp
- *0.01 - 20 GHz*
- *Gain: 15 dB*
- *Output IP3: 30 dBm*

****Successive Detection Log Video Amplifier***

Robust, High Performance RF to Light Solutions

ULTRA LOW NOISE PHASE LOCKED OSCILLATOR (PLO), TEST EQUIPMENT SOLUTION



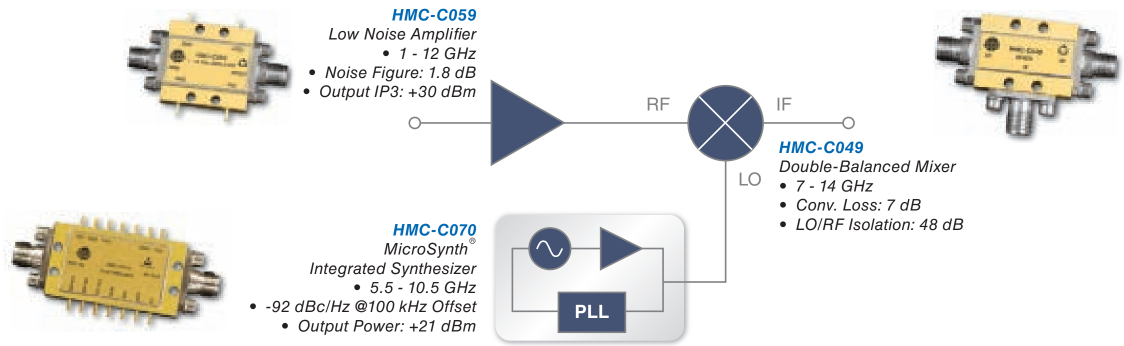
HMC-C200
Dielectric Resonator Oscillator
- 8.0 - 8.3 GHz
- Output Power: 14.5 dBm
- 100 kHz SSB Phase Noise: -140 dBc/Hz

HMC701LP6CE
Fractional-N PLL
- Freq.: 10 kHz - 8 GHz

HMC-C076
Low Phase Noise Amp
- 7 - 11 GHz
- Gain: 9 dB
- P1dB: 22 dBm

HMC-C005
Divide-by-2
- Input Freq.: 0.5 - 18 GHz
- Input Power: -15 to +10 dBm
- 100 kHz SSB Phase Noise: -150 dBc/Hz

X-BAND MILTARY DOWNCONVERTER SOLUTION

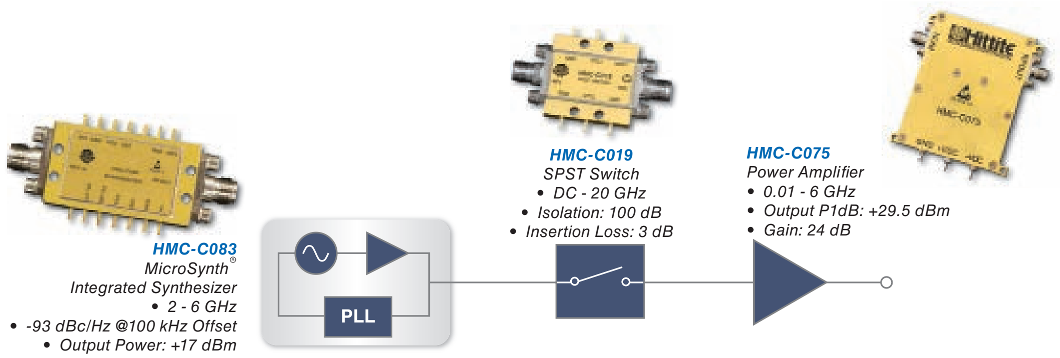


HMC-C059
Low Noise Amplifier
- 1 - 12 GHz
- Noise Figure: 1.8 dB
- Output IP3: +30 dBm

HMC-C049
Double-Balanced Mixer
- 7 - 14 GHz
- Conv. Loss: 7 dB
- LO/RF Isolation: 48 dB

HMC-C070
MicroSynth®
Integrated Synthesizer
- 5.5 - 10.5 GHz
- -92 dBc/Hz @100 kHz Offset
- Output Power: +21 dBm

PULSED 0.5W C-BAND MILTARY & TEST EQUIPMENT SYNTHESIZER SOLUTION



HMC-C019
SPST Switch
- DC - 20 GHz
- Isolation: 100 dB
- Insertion Loss: 3 dB

HMC-C075
Power Amplifier
- 0.01 - 6 GHz
- Output P1dB: +29.5 dBm
- Gain: 24 dB

HMC-C083
MicroSynth®
Integrated Synthesizer
- 2 - 6 GHz
- -93 dBc/Hz @100 kHz Offset
- Output Power: +17 dBm

Expanded Signal Generator Family to 70 GHz

$3,998

HMC-T2000
700 MHz to 8 GHz

$7,998

HMC-T2100
10 MHz to 20 GHz

$14,998

HMC-T2220B
10 MHz to 20 GHz
Battery Powered

Our Signal Generator Products

- ♦ ***Wide Frequency Range:** 10 MHz to 70 GHz*
- ♦ ***Versatile:** High Output Power Simplifies Test Set-Ups*
- ♦ ***Efficient:** Fast Frequency Switching Below 500 µs*
- ♦ ***Flexible:** Manual or USB / GPIB / Ethernet Control*

$9,998

HMC-T2220
10 MHz to 20 GHz

Visit Us at www.tm-hittite.com!

HMC-T2240
10 MHz to 40 GHz

$19,498

Performance

- ♦ *High Output Power: +20 dBm @ 40 GHz*
- ♦ *Excellent 10 GHz SSB Phase Noise: -98 dBc/Hz @ 10 kHz Offset*
- ♦ *Spurious: < -65 dBc @ 10 GHz*
- ♦ *Resolution: 0.1 dB & 1 Hz*
- ♦ *Fast Switching: 500 µs*

HMC-T2270
10 MHz to 70 GHz

$34,998

Performance

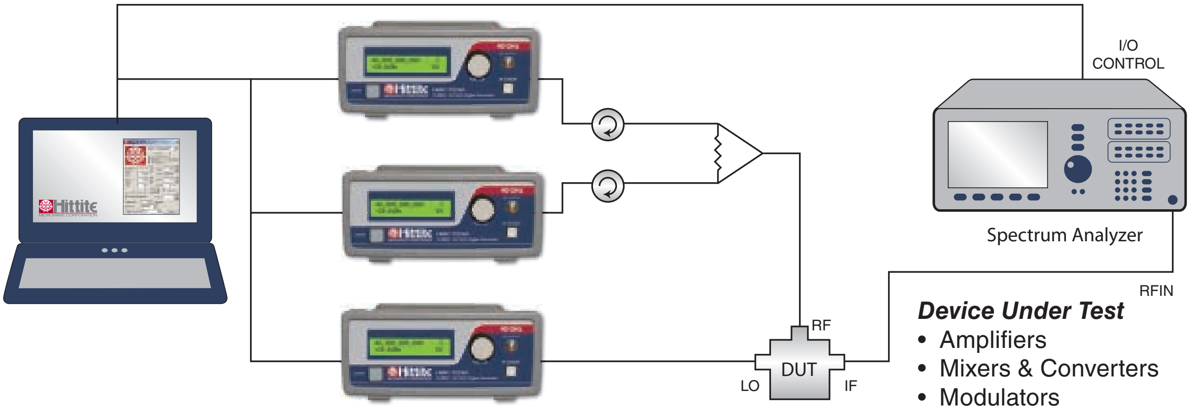
- ♦ *Output Power: +3dBm @ 70 GHz*
- ♦ *Excellent 70 GHz SSB Phase Noise: -79 dBc/Hz @ 10 kHz Offset*
- ♦ *Spurious: < -65 dBc @ 10 GHz*
- ♦ *Resolution: 0.1 dB & 1 Hz*
- ♦ *Fast Switching: 500 µs*

Expanded Signal Generator Family to 40 GHz

SIGNAL GENERATORS - *Precise RF Signal Generation for ATE & Lab Environments*

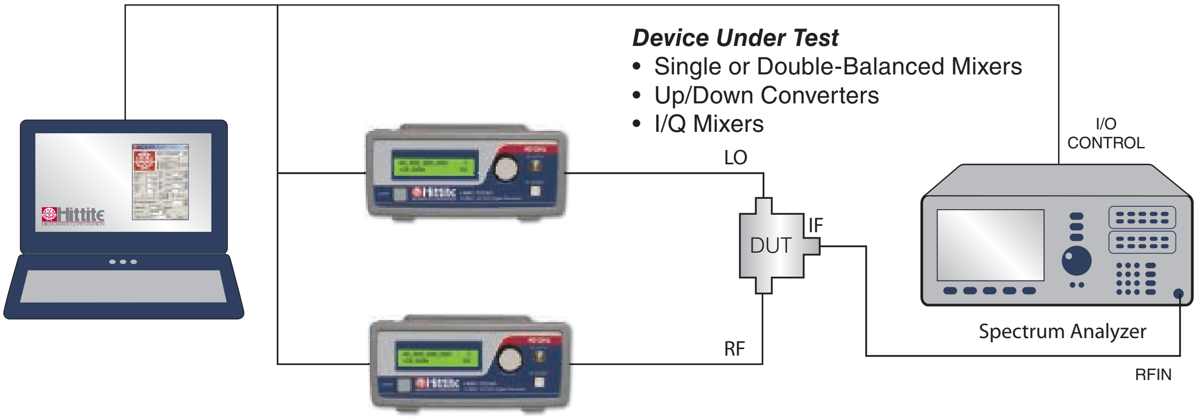
Frequency (GHz)	Function	Frequency Resolution	Maximum Power Output (dBm)	100 kHz SSB Phase Noise (dBc/Hz)	Spurious (dBc)	Switching Speed Steps (µs)	Package	ECCN Code	Part Number
0.7 - 8.0	Signal Generator	1 MHz	+17 @ 1 GHz +10 @ 8 GHz	-87 @ 4 GHz	< -45	200	Rack Mountable / Benchtop	EAR99	**HMC-T2000**
0.01 - 20	Signal Generator	10 kHz	+25 @ 1 GHz +22 @ 20 GHz	-93 @ 10 GHz	< -27	300	Rack Mountable / Benchtop	EAR99	**HMC-T2100**
0.01 - 20	Portable Signal Generator	1 Hz	+28 @ 1 GHz +24 @ 20 GHz	-99 @ 10 GHz	< -57	300	Portable / Benchtop	EAR99	**HMC-T2220B**
0.01 - 20	Signal Generator	1 Hz	+28 @ 1 GHz +24 @ 20 GHz	-99 @ 10 GHz	< -57	300	Rack Mountable / Benchtop	EAR99	**HMC-T2220**
0.01 - 40	Signal Generator	1 Hz	+30 @ 1 GHz +20 @ 40 GHz	-99 @ 10 GHz	< -52	500	Rack Mountable / Benchtop	EAR99	**HMC-T2240**
0.01 - 70	Signal Generator	1 Hz	+29 @ 1 GHz +3 @ 70 GHz	-118 @ 1 GHz -79 @ 70 GHz	< -46	500	Rackmountable / Benchtop	3A002.d.3.f	**HMC-T2270**

TWO TONE THIRD ORDER INTERCEPT TEST SET-UP



Device Under Test
- Amplifiers
- Mixers & Converters
- Modulators
- RFICs & Subsystems

EFFICIENT MIXER CONVERSION LOSS, ISOLATION & MxN SPURIOUS TEST SET-UP



Device Under Test
- Single or Double-Balanced Mixers
- Up/Down Converters
- I/Q Mixers

Contact Us Today with Your Custom Test Instrumentation Requirements at TE@hittite.com!

Visit our Instrument Web Site at www.tm-hittite.com.

Military & Space Screening

High Reliability Solutions for Land, Sea, Air & Space

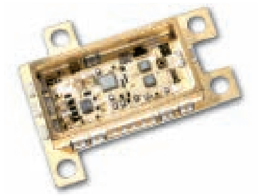
Military Level Components, Modules & Subsystems

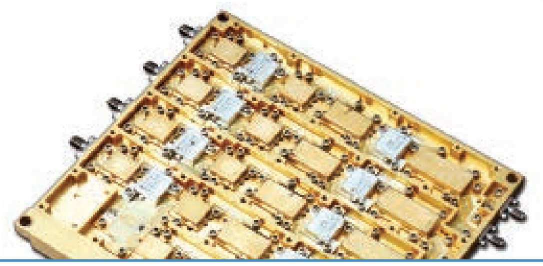
- Class B screening on standard & custom product die and SMT packaging.
- Design, production & screening of highly integrated MIC sub-assemblies for major defense OEMs.
- Military & Space Upscreening to Customer Specifications.

Military Solution Inquiries: MIL@hittite.com

Class B Screening & Qualification

- ***VI to Method 2010B & 2017H***
- ***Bond Pull & Die Shear Test***
- ***Solderability Test***
- ***High Temp Burn-In Test***
- ***Vibration Stress Test***
- ***Temp Cycle Stress Test***
- ***Constant Acceleration Stress Test***
- ***Fine & Gross Hermeticity Test***
- ***Serialized Test Data***
- ***ESD Characterization***





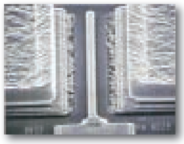
Space Level Components, Modules & Subsystems

Class S Screening & Qualification

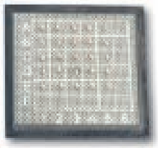
- ***VI to Methods 2010A & 2017K***
- ***Temp Cycle Stress Test***
- ***High Temp Burn-In & Life Test***
- ***Wafer Lot Acceptance Test***
  - ***Bond Pull & Die Shear Test***
  - ***SEM Inspection***
  - ***Metal & Glass Thicknesses***
- ***Serialized Test Data***
- ***Qualification Report***

- Class S screening on standard & custom product die and SMT packaging.
- Military & Space Upscreening to Customer Specifications.
- Qualified by major spacecraft OEMs worldwide.
- Over 45,000 S-Level components currently operational on dozens of commercial, scientific & military spacecraft.

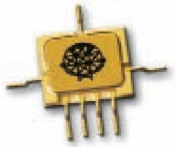
Space Solution Inquiries: SPACE@hittite.com



FET Channel SEM

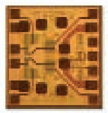


Serialized Die in GEL-PAK



Hermetic SMT Package

Hermetic Modules



Chip (Die)

Contact Us Today With Your High Reliability Mixed-Signal RF, Microwave & Millimeterwave Requirements!

DESIGNER’S KITS

Evaluation Boards & ICs Reduce Design Cycle Time

7 DESIGNER’S KITS AVAILABLE TO CHOOSE FROM!

- ♦ ***Gain Blocks DC - 6 GHz, HMC-DK001***
- ♦ ***Linear Driver Amplifiers 0.4 - 2.5 GHz, HMC-DK002***
- ♦ ***High IP3 Mixers 0.45 - 4.0 GHz, HMC-DK003***
- ♦ ***Digital Attenuators DC - 6 GHz, HMC-DK004***
- ♦ ***SPDT Switches DC - 12 GHz, HMC-DK005***
- ♦ ***Passive Attenuator Chips DC - 50 GHz, HMC-DK006***
- ♦ ***Serial/Parallel USB Interface Kit, HMC-DK008***

Design engineers can order pre-packaged MMIC Designer’s Kits which enable them to quickly assess which Hittite product is the best choice for their application. The end result is a design that goes to layout more quickly and with fewer subsequent changes.

Each Hittite Designer’s Kit contains an assembled & tested connectorized evaluation board, 5 to 10 ICs of each part and the latest Hittite CD-ROM catalog.

Designer’s Kit	**Kit Contents**			
	ICs		**Eval Boards**	
Gain Blocks DC - 6 GHz HMC-DK001	HMC474MP86E HMC476MP86E HMC313E HMC311ST89E HMC478MP86E HMC478ST89E	HMC479MP86E HMC479ST89E HMC481ST89E HMC480ST89E HMC481MP86E HMC482ST89E	104217 – HMC313E 110161 – HMC478ST89E 107490 – HMC481MP86E	
Linear Driver Amps 0.4 - 2.5 GHz HMC-DK002	HMC454ST89E HMC450QS16GE HMC413QS16GE	HMC452ST89E HMC453ST89E HMC457QS16GE	107749 – HMC454ST89E 108349 – HMC450QS16GE 105000 – HMC413QS16GE	108712 – HMC452ST89E 108718 – HMC453ST89E 106043 – HMC457QS16GE
Hi-IP3 Mixers 0.45 - 4.0 GHz HMC-DK003	HMC387MS8E HMC483MS8GE HMC399MS8E HMC316MS8E HMC400MS8E HMC485MS8GE	HMC402MS8E HMC214MS8E HMC478ST89E HMC481ST89E HMC480ST89E	110161 – HMC478ST89E 105188 – HMC485MS8GE	106334 – HMC399MS8E 101830 – HMC400MS8E
Digital Attenuators DC - 6 GHz HMC-DK004	HMC291E HMC468LP3E HMC274QS16E HMC271ALP4E HMC273MS10GE	HMC305ALP4E HMC306MS10E HMC470LP3E HMC472LP4E	103372 – HMC291E 107302 – HMC468LP3E 104976 – HMC274QS16E 108782 – HMC271ALP4E 103393 – HMC273MS10GE	108782 – HMC305AMS10E 103393 – HMC306MS10E 107006 – HMC470LP3E 107010 – HMC472LP4E
SPDT Switches DC - 12 GHz HMC-DK005	HMC221AE HMC284MS8GE HMC349MS8GE HMC232LP4E HMC544E	HMC595E HMC574MS8E HMC784MS8GE HMC536MS8GE	101675 – HMC221AE 107662 – HMC349MS8GE 107723 – HMC232LP4E	104124 – HMC574MS8E 104124 – HMC784MS8GE 105143 – HMC536MS8GE
Passive Attenuators DC - 50 GHz HMC-DK006	HMC650 HMC651 HMC652 HMC653 HMC654	HMC655 HMC656 HMC657 HMC658		
Serial/Parallel USB Interface Kit HMC-DK008	The HMC-DK008 Serial/Parallel Interface Designer’s kit enables users to interface with Hittite’s family of digital attenuators, interface and variable gain amplifiers.			
EKIT01-HMC6383	Programmable Direct Conversion Receiver, 700 to 3000 MHz. Hittite’s HMC6383 features unparalleled receiver flexibility and industry leading performance			

PACKAGE INFORMATION

Available Plastic, Ceramic, Hermetic SMT & Connectorized Module Packages

E

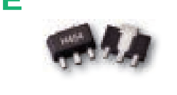
MP86 "Micro-P"
5.21 x 5.08 x 1.57 mm

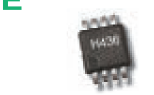
E

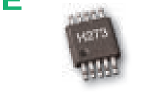
SC70
2.15 x 2.1 x 0.9 mm

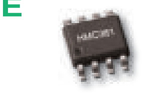
E

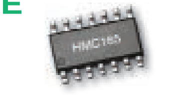
SOT26
2.8 x 2.9 x 1.2 mm

E

ST89
4.50 x 4.14 x 1.54 mm

E

MS8 / MS8G
4.9 x 3.0 x 1.0 mm

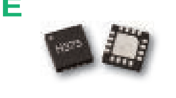
E

MS10 / MS10G
4.9 x 3.0 x 1.0 mm

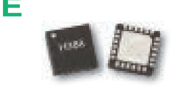
E

S8 / S8G
6.0 x 4.9 x 1.6 mm

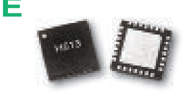
E

S14
6.0 x 8.7 x 1.6 mm

E

LP2 "DFN"
2.0 x 2.0 x 1.0 mm

E

LP3 "QFN"
3.0 x 3.0 x 1.0 mm

E

LP4 / LP4B / LP4C "QFN"
4.0 x 4.0 x 1.0 mm

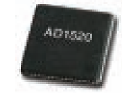
E

LP5 "QFN"
5.0 x 5.0 x 1.0 mm

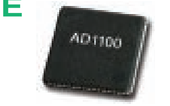
E

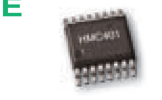
LP6 / LP6C "QFN"
6.0 x 6.0 x 1.0 mm

E

LP6H "QFN"
6.0 x 6.0 x 1.0 mm

E

LP7D "QFN"
7.0 x 7.0 x 1.0 mm

E

LP9 "QFN"
9.0 x 9.0 x 1.0 mm

E

QS16 / QS16G
6.0 x 4.9 x 1.5 mm

E

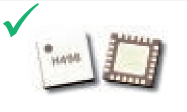
QS24
6.0 x 8.7 x 1.6 mm

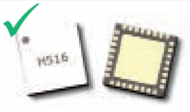
✓

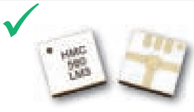
BGA
9.75 x 6.0 x 3.29 mm

✓

LC3 / LC3B / LC3C
3.0 x 3.0 x 1.0 / 1.45 mm

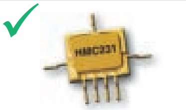
✓

LC4 / LC4B
4.0 x 4.0 x 1.0 / 1.2 mm

✓

LC5
5.0 x 5.0 x 1.0 mm

✓

LM1 / LM3
5.1 x 5.1 x 1.1 mm

✓

C8
7.4 x 5.1 x 2.4 mm

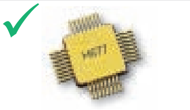
✓

G7 Hermetic
16.1 x 17.3 x 1.7 mm

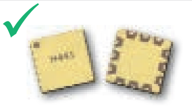
✓

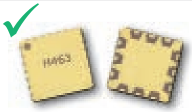
G8 Hermetic
10.2 x 4.6 x 1.8 mm

✓

G16 Hermetic
10.4 x 10.4 x 1.7 mm

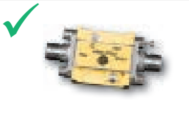
✓

G32 Hermetic
16 x 16 x 1.96 mm

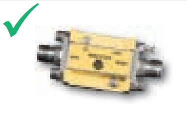
✓

LH250 Hermetic
6.35 x 6.35 x 1.27 mm

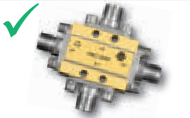
✓

LH5 Hermetic
5.0 x 5.0 x 1.0 mm

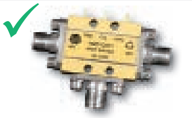
✓

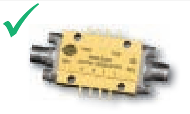
C-1 / C-1B
35.31 x 17.78 x 7.38 mm

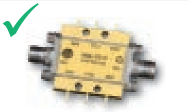
✓

C-2 / C-2B
38.1 x 17.78 x 7.38 mm

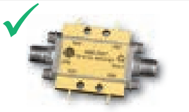
✓

C-3 / C-3B
40.89 x 17.78 x 7.38 mm

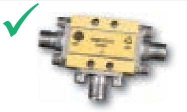
✓

C-4
41.66 x 36.32 x 8.50 mm

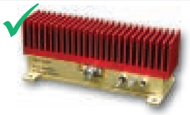
✓

C-5
41.66 x 26.8 x 8.79 mm

✓

C-6
45.34 x 17.27 x 8.50 mm

✓

C-9
44.45 x 21.59 x 8.76 mm

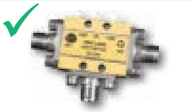
✓

C-10 / C-10B
46.63 x 21.59 x 8.50 mm

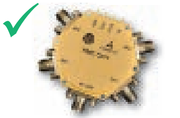
✓

C-11
41.66 x 26.8 x 8.64 mm

✓

C-12
107.6 x 43.0 x 43.0 mm

✓

C-13
39.43 x 47.12 x 11.42 mm

✓

C-14
41.91 x 29.85 x 9.65 mm

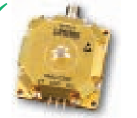
✓

C-15
59.69 mm DIA x 9.14 mm

✓

C-16
48.0 x 48.26 x 14.10 mm

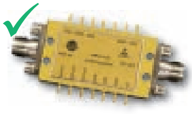
✓

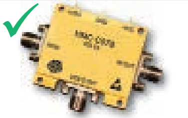
C-17
68.5 x 66.0 x 14.2 mm

✓

C-18
38.10 x 47.62 x 26.67 mm

✓

C-19
27.31 x 25.15 x 5.84 mm

✓

C-20
53.59 x 19.05 x 6.22 mm

✓

C-21
38.10 x 33.53 x 5.84 mm

E *or* ✓ *= RoHS Compliant.*

For more information on our "Green" component program, please contact earthfriendly@hittite.com for details on our RoHS Compliant products or see the RoHS Compliant Components link on our web site.

PART NUMBER INDEX

PART NUMBER INDEX

PART NUMBER INDEX

Order On-line at: www.hittite.com

Americas

Hittite Microwave Corporation
USA Corporate Headquarters
Phone: 978-250-3343
Fax: 978-250-3373
sales@hittite.com

Eastern - North America
Boston, MA
Phone: 978-270-3167
usa-east-north@hittite.com

Philadelphia, PA
Phone: 978-337-1226
usa-east-south@hittite.com

Central (North) - North America
Chicago, IL
Phone: 312-485-8730
usa-north@hittite.com

Central (South) - North America
Dallas, TX
Phone: 817-727-7146
usa-south@hittite.com

Western - North America
Los Angeles, CA
Phone: 626-961-5602
usa-west@hittite.com

Mexico, Central & South America
Dallas, TX
Phone: 978-250-3343 x1250
southamerica@hittite.com

Europe, Middle East & Africa

Hittite International Limited
International Headquarters
Phone: +353-21-240-7996
Fax: +353-21-240-7997
sales@hittite.com

United Kingdom, Ireland, Spain, Portugal, Greece & Turkey
Hittite Microwave Europe Limited
Phone: +44-7811-267418
Fax: +978-250-3373
europe@hittite.com

France, Italy & Benelux
Hittite Microwave Deutschland GmbH
Phone: +44-7811-267418
Fax: +978-250-3373
europe@hittite.com

Northern Europe
Hittite Microwave Nordic AB
Phone: +46-761-763969
nordic@hittite.com

Central & Eastern Europe
Hittite Microwave Deutschland GmbH
Phone: +49-8031-97654
Fax: +49-8031-98883
germany@hittite.com

Africa
Hittite Microwave Egypt
Phone: +202-275-46812
Fax: 978-250-3373
egypt@hittite.com

Asia & Pacific

Australia & New Zealand
Hittite Microwave Corporation
Phone: 978-250-3343
Fax: 978-250-3373
ausnz@hittite.com

India
Hittite Microwave India
Phone: +91-40-44311254
Fax: +91-40-44311100
india@hittite.com

Republic of Korea
Hittite Microwave Asia Co., Limited
Phone: +82-2559-0638
Fax: +82-2559-0639
korea@hittite.com

Peoples Republic of China
Hittite Microwave Co., Limited
Shanghai Office
Phone: +86-21-6209-8809
Fax: +86-21-6209-6730
china@hittite.com

Shenzhen Office
Phone: +86-755-3322-2116
Fax: +86-755-3322-2117
shenzhen@hittite.com

Beijing Office
Phone: +86-10-6485 9219
Fax: +86-10-6485 0377
beijing@hittite.com

Japan
Hittite KK
Phone: +81-3-5652-5772
Fax: +81-3-5652-6694
japan@hittite.com

Sales Representatives

Americas

Brazil;
Vermont Rep. Com. Ltda
+55 11 3726-6655

Canada;
Repwave
Calgary, Ottawa & Montreal:
+613-270-9811
Toronto:
+647-883-7360
Vancouver:
+604-929-8541

Mexico
Quad State Sales and Marketing
918-499-1711

Central & South America
Hittite Microwave Corporation
978-250-3343 x1250

USA North East & Mid-Atlantic;

CT, MA, ME, NH,
So. NJ, RI & VT:
Microwave Marketing Specialist
978-392-0110

Western NY:
Zimmerman Sales
585-381-3186

So. CT, Metro LI & No. NJ:
Comp Tech
973-832-4545

Eastern PA & So. NJ
Omega Electronic Sales, Inc.
215-244-4000

Western PA
Schillinger Associates, Inc.
765-457-7241

DC, DE, MD, VA & WV:
Vincent Pirro Electronics
410-489-9554

USA Mid-West;

IA
Essig & Associates
319-363-8703

AK, KS, LA, W. MO, OK, TX:
Quad State Sales & Marketing
918-499-1711

IL & WI:
TEQ Sales
847-742-3767

IN, KY, MI & OH:
Schillinger Associates, Inc.
765-457-7241

NE:
HMC Central (North) - North America
312-485-8730

MN, ND, SD & W. WI:
Matrix Design Technology
952-400-1070

USA South East;

AL, FL, GA, MS, NC, SC & TN:
Precision Marketing Inc.
954-752-1700

USA South West;

AZ & NM:
Saguaro Technical Sales, Inc.
480-947-3724

AR:
HMC Central (South) - North America
817-727-7146

USA West;

CO, ID, MT, UT & WY:
Innovation Sales
303-652-3030

No. CA & NV:
Custom & Wireless Sales
408-371-0222

So. CA:
Acetec
858-784-0900

OR & WA:
Sea-Port Technical Sales
425-702-8300

Europe, Mid-East & Africa

Germany, Austria, Poland, Switzerland
MEV Elektronik Service GmbH
49 5424 2340-28

Czech Republic, Estonia, Hungary, Latvia, Lithuania, Slovakia:
Hittite Microwave Deutschland GmbH
+49 8031-97654

Belgium, Luxemburg:
Nijkerk Electronics N.V.
+32 3 544 70 66

Bosnia Herzegovina, Bulgaria, Croatia, Macedonia, Romania, Serbia Montenegro & Slovenia
IC Electronika
+386(0) 1 568-01-18

Denmark
Acte A/S
+45 46 900 400

Netherlands:
Nijkerk Electronics B.V.
+31 20 504 14 24

Norway & Sweden:
Hittite Microwave Nordic AB
+46-761-763969

Finland:
LKC OY
+358-400-460-646France:

France:
L-TEQ Microwave
+33-1-3007-7780

Greece:
Hittite Microwave Europe Limited
+44-7811-267418

United Kingdom & Ireland:
Firefly Technology Ltd.
+44-1256-884980

Italy:
Special-Ind SPA
+39-02-6074741

Norway:
Bredengen AS
+47-2100-9100

Russia
Radiant-Elcom Ltd.
+7(495) 725-0404

Spain & Portugal:
Altaix Electronica S.A.L
+34-91-636-39-39

South Africa:
RF Design Laboratory CC
+27-21-555-8400

Turkey:
EMPA Electronics
+90 (212) 465-71-99

Asia & South Pacific

Australia & New Zealand:
Braemac
+61-8-8275-0100

China & Hong Kong:
Gateway Tech Co., Ltd.
+0755-8608-1010

Secom Telecom Co., Ltd.
+86-755-25155888

Wai Tat Electronics Ltd.
+852-2799-7393

India:
Syratron
+91-802-5591107/5591031

Indonesia, Malaysia, Philippines & Singapore
MEDs Technologies, Pte., Ltd.
+65-6453-8313

Japan:
Daito Electron Co., Ltd
+81-3-3237-1471

Rikei Corporation *(only FO & HSL)*
+81-3-3345-2150

Korea:
EZ Hightech
+82-031-382-6500

JS Commtech
+82-2-574-6100

Makus
82-2-3490-9526

Taiwan R.O.C.:
Bandtek International Co., Ltd.
+886-2-2657-2615

Instrumentation Sales Representatives

North America

CT, MA, ME, NH, RI & VT:
PAT Associates
401-783-9598

NJ, NY & E.PA:
Tera Technologies
888-449-2799

AZ, CO, ID, MO, NM, UT & WY:
Technologies West RMS
602-312-3789

CA & NV:
Tritek Solutions
949-609-0560

OR & WA:
Tritek Northwest
949-609-0560

Europe

Belgium, Luxembourg & Netherlands:
AR Benelux B.V.
+31-172-423-000

Finland, Lithuania, Latvia & Estonia:
Caltest Oy
358 9 530 607 0

Greece:
Vector Technologies, LTD
+30-210-68-58-008

Italy:
Giakova srl
+39-023-3512100

Russian Federation:
Radiant-Elcom Ltd.
+7(495) 725-0404

Spain:
AFC Ingenieros, S.A.
+34 91 365 44 05

Sweden
RF Partner AB
+46-31-475100

Turkey:
Spark Olcum Teknolojileri Ltd. Sti
+90 (312) 466 821

United Kingdom:
MCS Test Equipment LTD
08453 62 63 65

Asia

China:
WAT-COM Technologies
86-755-86233486

Taiwan R.O.C.:
T&E Communication
886-2-82211258

Japan:
Farad
+82-3-5261-3091

© 2012, Hittite Microwave Corporation, All Rights Reserved.

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

Boston • Cork • Hyderabad • London • Munich • Seoul • Shanghai • Stockholm • Tokyo