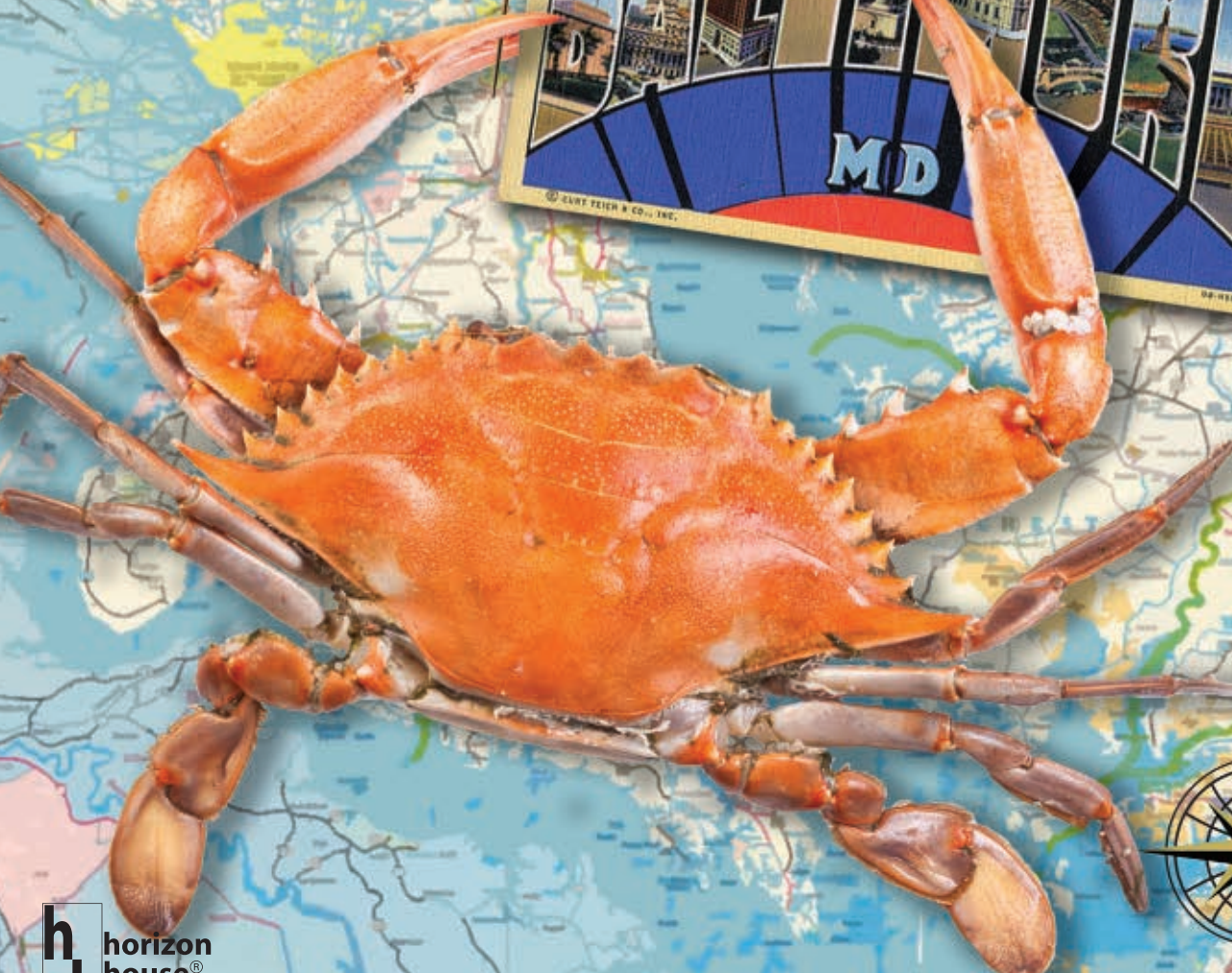


Microwave Journal



I-TEL

FSY



K&L
MICROWAVE

LORCH
MICROWAVE



EWT



Founded in 1958

mwjournal.com

MTT-S IMS Show Issue

THE FUTURE OF NOISE



Noisecom's cutting edge technology will lead you down the road to success with our innovative and high-speed solutions.

As a global provider of noise generators, modules, diodes and specialized test solutions we are ready to meet your present needs, as well as address your future applications.

For more information visit: www.noisecom.com or call +1 973-386-9696.

- RF & Microwave AWGN
- Digital Noise Generation
- Satellite Communications (BER, Eb/No)
- Wireless (WiMAX & LTE)
- >60 GHz Noise Figure
- Serial Data Compliance (Jitter, Rj)
- Wireless HD Testing
- Receiver & Antenna Calibration



BROADBAND GaN POWER AMPLIFIERS

*with Frequency ranges in excess of 10 octaves
3 to 10 W*



FEATURES:

- Single bias, 30V
- Excellent gain flatness over very wide bandwidths
- Withstands high baseplate temperatures or surges in RF or DC power without compromising reliability
- Various models available that operate from 30 MHz to 4 GHz
- Built-in over/reverse voltage protection
- Temperature and over-current protection

MODEL NUMBER	FREQUENCY RANGE (GHz)	GAIN (dB, Min.)	GAIN FLATNESS (\pm dB, Max.)	NOISE FIGURE (dB, Max.)	VSWR IN/OUT	P1dB (dBm, Min.)	Psat (dBm, Min.)	NOMINAL PEAK CURRENT @ 30V (mA)
AMFG-3F-00030300-60-33P	0.03-3	40	2	6	2:2.2	33	35.5	750
AMFG-3F-00030400-60-32P	0.03-4	40	2	6	2:2	32	35	750
AMFG-3F-00040250-60-33P	0.04-2.5	40	2	6	2:2.2	33	35.5	670
AMFG-3F-00050100-50-34P	0.5-1	40	1.5	5	1.8:1.8	34	37	750
AMFG-3F-00230025-30-37P	0.23-0.25	50	1	3	1.5:2	37	40	250
AMFG-3F-00700380-60-35P	0.7-3.8	40	2	6	2.5:2.5	35	39	1500
AMFG-3F-00800220-60-35P	0.8-2.2	40	1.5	6	2:2	35	38	900
AMFG-2F-01000300-60-35P	1-3	40	2	6	2:2.2	35	39	1500

Note: Psat is defined as the output power where a minimum of 3 dB gain compression takes place.

For additional information, please contact our Sales Department
at (631) 439-9220 or e-mail components@miteq.com



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

www.miteq.com

See us at MTT-S Booth 1909





POWER/ SPLITTERS COMBINERS

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

THE INDUSTRY'S LARGEST SELECTION Mini-Circuits offers thousands of power splitters/combiners for applications from **2 kHz to 18 GHz** and with power handling as high as 300 watts. Choose from coaxial, flat-pack, and surface-mount housings, for 50 Ω and 75 Ω applications. The industry's largest selection includes 2-way through 48-way power splitters/combiners in 0°, 90°, and 180° configurations, with outstanding performance in terms of insertion loss, VSWR, amplitude unbalance, and phase unbalance. All models are characterized with detailed data and performance curves, available at the touch of a button using Mini-Circuits advanced Yoni2 search engine. These **low-cost, off-the-shelf power splitters/combiners** are available immediately, and backed by Mini-Circuits 1 year guarantee. But if your application calls for a custom unit, our development team will meet or exceed your requirements quickly and cost-effectively. Contact Mini-Circuits today, for the industry's largest selection of power splitters/combiners.

Mini-Circuits...Your partners for success since 1969

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

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

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

 **Yoni2®**
U.S. patent 7739260

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

IF/RF MICROWAVE COMPONENTS

See us at MTT-S Booth 1031

448 rev E

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 MTT-S Booth 4014



INNOVATION



We provide the innovation to help your ideas grow.

Technical expertise and manufacturing savvy have made K&L a pioneer in the filter industry.



Technical Expertise

K&L maintains a large staff of design and application engineers with access to an extensive design library and a variety of software tools for approximation, synthesis, realization, analysis, and simulation. Two applied R&D groups focus on developing advanced passive and active solutions for customer requirements.



Manufacturing Savvy

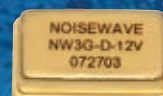
Numerous CNC machining stations are networked with CAD/CAM computing stations, allowing efficient transfer of data from one process area to the next. A state-of-the-art plating facility, temperature chambers, vibration and leak testing equipment, laser-welding and laser-labeling devices, dedicated low PIM and millimeter wave test stations, and 150 network analyzers support efficient flow of product throughout the company to meet delivery deadlines.

K&L Microwave, Inc. • 2250 Northwood Drive • Salisbury • MD • 21801 • P: 410-749-2424
F: 443-260-2268 • www.klmicrowave.com • www.klfilterwizard.com • sales@klmicrowave.com

See us at MTT-S Booth 902



New Wave in Noise



NoiseWave

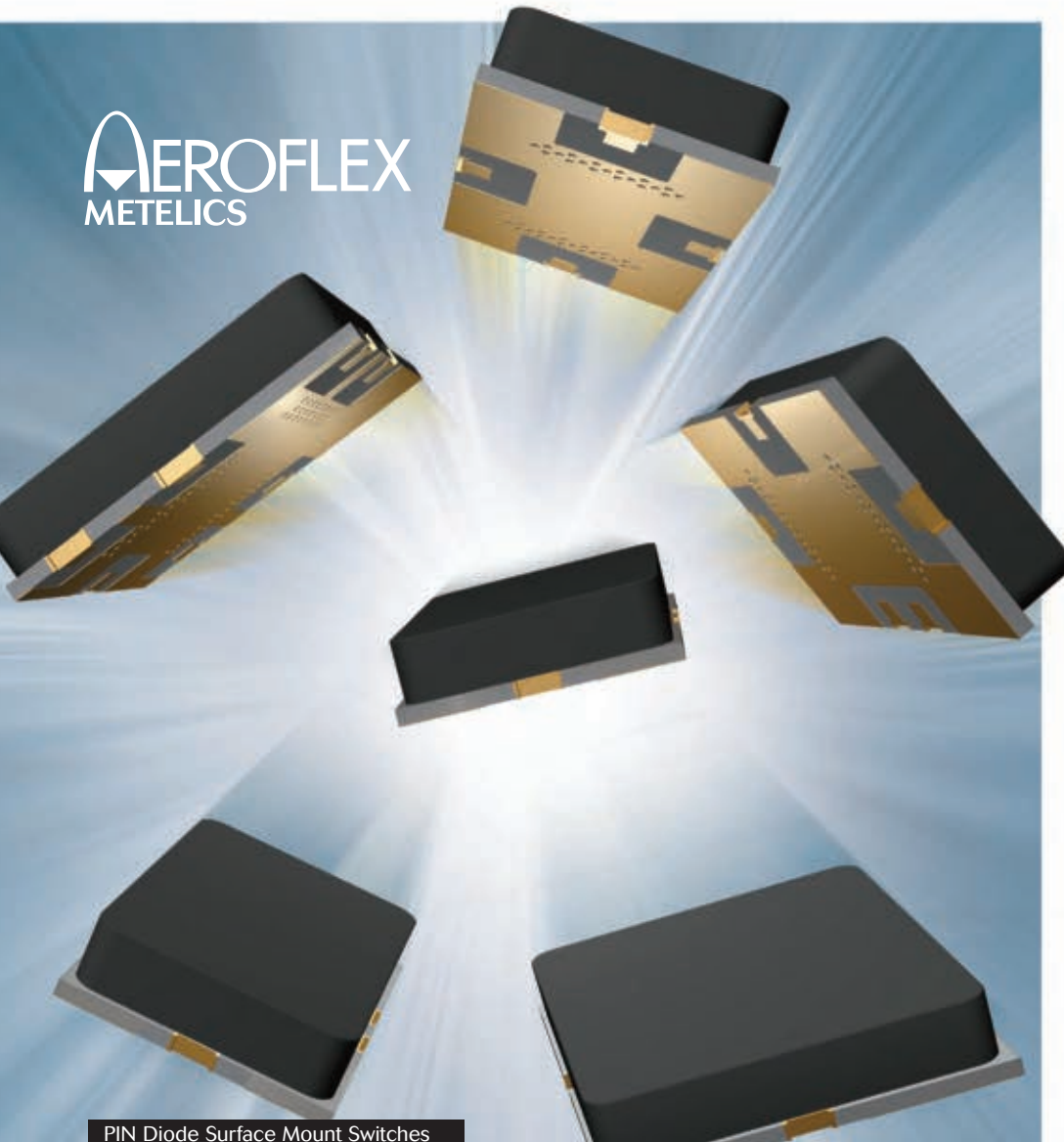
your supplier of high performance, precise equipment for AWGN



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

See us at MTT-S Booth 837

Power up with PIN diode switches and replace those sensitive MMICs



New, surface mount PIN diode switches from Aeroflex / Metelics are the preferred alternative to lower power QFN packaged MMICs. These SP2TT-R and symmetrical SP2T and SP3T switches provide:

- 158 W C.W. incident power handling @ +25° C
- 630 W @ 10 μ S, 1% duty incident power handling @ +25° C
- 0.2 dB insertion loss
- 57 dB isolation
- Class 1C HBM ESD rating

Compare this superior performance to the average QFN MMIC switch, which offers just 20 W C.W. or 100 W peak input power, and see how your military radio, WiMAX, IED and MRI designs excel.

These devices are RoHS compliant. RF and PIN diode driver evaluation boards are readily available.

Call 888-641-7364 or visit our website for datasheets, quotes, and samples:

www.aeroflex.com/metelicsMJ

See us at MTT-S Booth 2212

PIN Diode Surface Mount Switches

Part Number	Configuration	DC Power	F (MHz)*	Loss (dB)	VSWR	Isolation (dB)	C.W. Incident Power (dBm)
MSW2000-200	SP2TT-R Switch	+V Only	20-1000	0.2	1.2:1	57	+ 51
MSW2001-200	SP2TT-R Switch	+V Only	200-4000	0.3	1.3:1	45	+ 51
MSW2002-200	SP2TT-R Switch	+V Only	2000-6000	0.4	1.5:1	40	+ 51
MSW2022-200	SP2TT-R Switch	+V & -V	10-1000	0.2	1.2:1	52	+ 52
MSW2050-205	SP2TT-R Switch	+V Only	20-1000	0.2	1.2:1	52	+ 52
MSW2051-205	SP2TT-R Switch	+V Only	200-4000	0.3	1.3:1	40	+ 52
MSW2030-203	Symmetrical SP2T	+V Only	20-1000	0.2	1.2:1	55	+ 51
MSW2031-203	Symmetrical SP2T	+V Only	200-4000	0.4	1.3:1	45	+ 51
MSW2032-203	Symmetrical SP2T	+V Only	2000-6000	0.5	1.5:1	40	+ 51
MSW2040-204	Symmetrical SP2T	+V Only	20-1000	0.2	1.2:1	54	+ 52
MSW2041-204	Symmetrical SP2T	+V Only	200-4000	0.3	1.3:1	44	+ 52
MSW2060-206	Symmetrical SP2T	+V & -V	20-1000	0.2	1.2:1	55	+ 51
MSW2061-206	Symmetrical SP2T	+V & -V	400-4000	0.4	1.3:1	45	+ 51
MSW2062-206	Symmetrical SP2T	+V & -V	2000-6000	0.5	1.5:1	40	+ 51
MSW3100-310	Symmetrical SP3T	+V Only	20-1000	0.3	1.2:1	57	+ 51
MSW3101-310	Symmetrical SP3T	+V Only	200-4000	0.5	1.4:1	43	+ 51
MSW3200-310	Symmetrical SP3T	+V & -V	20-1000	0.3	1.2:1	57	+ 51
MSW3201-310	Symmetrical SP3T	+V & -V	400-4000	0.5	1.4:1	43	+ 51

* 20-1,000 MHz specs at 500 MHz, 400 - 4,000 MHz specs at 2000 MHz, 2000 - 6,000 Specs at 4,000 MHz

AEROFLEX
A passion for performance.



MAY 2011 VOL. 54 • NO. 5

IEEE MTT-S International Microwave Symposium & Exhibition

24 **Trending the Conference**

David Vye, Microwave Journal Editor

Overview of *Microwave Journal's* coverage of the 2011 IEEE MTT-S International Microwave Symposium and Exhibition

28 **Made in Maryland: Filter Lore from Gaithersburg to the Eastern Shore**

David Vye, Microwave Journal Editor

Reflections of two entrepreneurs who launched successful businesses in Maryland and were largely responsible for developing the region into a hotbed of filter companies

56 **IMS 2011 General Chair's Message**

Jeffrey M. Pond, IMS 2011 General Chairman

60 **RFIC 2011 General Chair's Message**

David Ngo, RFIC 2011 General Chairman

62 **77th ARFTG Microwave Measurement Conference**

Mohamed Sayed, ARFTG Conference Chair

64 **IMS 2011 MicroApps: A Perfect Match**

Rafi Hershtig and Tim Dolan, 2011 MicroApps Co-Chairmen

Introduction to a forum designed for participating exhibitors to present the technology and capabilities behind their products

66 **Women in Microwaves (WIM) Reception**

Sherry Hess, WIM Organizer

Insight from a second year veteran on the Women in Microwaves and invitation to participate in this year's WIM Reception

70 **Opportunities and Challenges: RF Industry in 2011**

Greg Peters, Agilent Technologies Inc.

Opportunities and challenges that the RF industry will face in 2011 from a test and measurement perspective

74 **Microwave Technology at the NRL**

Jeffrey M. Pond, Naval Research Laboratory and IMS General Chair

The Naval Research Laboratory's contributions to microwave technology and outlook on future developments

78 **Twitter Together at MTT-S IMS**

Tips on social media involvement around the show using Twitter and other useful group apps

81 **MTT-Stories**

A graphic novel depicting the lighter side of Microwave Week and its characters

88 **2011 IMS Exhibitors**

Alphabetical listing of companies participating in the Microwave Week exhibition and their respective booth numbers



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 that part of the electronics industry, including governmental and university installation, that deal with VHF through light frequencies. 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.

©2011 by Horizon House Publications Inc.

Posted under Canadian international publications mail agreement #PM40063731



EM speed that will turbocharge your design creativity.

Stop waiting and wishing for an EM tool that keeps pace with your own creative ideas. AXIEM is capable of solving big problems fast — typically 10x faster than current alternatives for designs of 10K unknowns or more. And now that it handles antennas, too, your creativity will know no bounds. For the most accurate EM results in minutes rather than hours, go with AXIEM. Grab a test copy today at www.awrcorp.com/AXIEM
See us at MTT-S Booth 1618



Stop waiting and start designing™

AXIEM®
3D PLANAR EM

SPECIAL REPORT

124 Passive Intermodulation (PIM) Testing Moves to the Base Station

Rick Hartman, Kaelus Inc.

Overview of passive intermodulation including testing and analysis

TECHNICAL FEATURES

132 Methods for Characterizing the Dielectric Constant of Microwave PCB Laminates

John Coonrod, Rogers Corp.

Overview of the common test methods used to determine ϵ_r for microwave laminates and how it relates to design

146 Analytical Design of an Inverse Class F Power Amplifier for Linear Amplification

Yingjie Xu, Jingqi Wang and Xiaowei Zhu, Southeast University

Presentation of an analytical design approach for a highly efficient inverse Class F power amplifier

158 Design of a Metamaterial Bandpass Filter Using the ZOR of a Modified Circular Mushroom Structure

Geonho Jang and Sungtek Kahng, University of Incheon

Design of a new bandpass filter based on the modified circular mushroom metamaterial structure

168 A HEMT Large-signal Model with Improved Transconductance and Gate Capacitance Peaking Characteristics

Lin-Sheng Liu, University of Electronic Science and Technology of China

Presentation of an improved large-signal device model of HEMTs amenable for use in commercial nonlinear simulators

182 Design of a Wide Stopband Bandpass Filter with Source-load Coupling

Zhong Yin Xiao, Shan Gao, De Chen Ma and Liang Liang Xiang, Shanghai University

Presentation of a microstrip bandpass filter for wireless LAN applications

188 Fast Calculation of Transimpedance Gain and Equivalent Input Noise Current Density for High-speed Optical Preamplifier Design

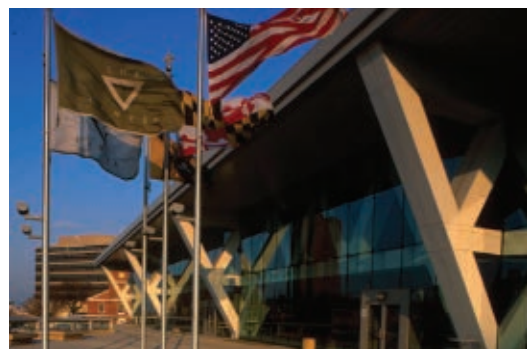
Jianjun Gao, East China Normal University

Development of analytical expressions for high-speed optical transimpedance preamplifier design

206 Multipactor Discharge in Coaxial Components

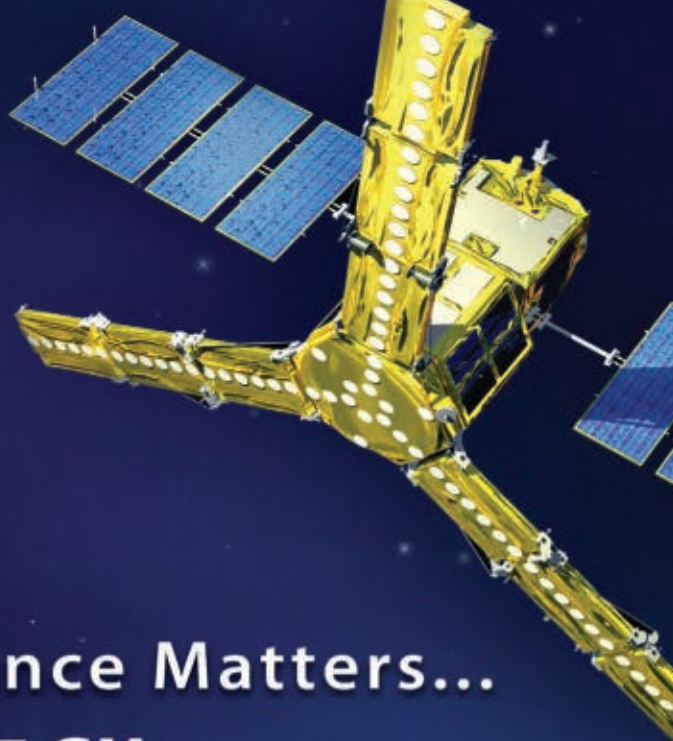
Rudy Fuks, Astrolab Inc.

A review of multipactor and development of coaxial microwave components capable of high peak power handling for space applications



Photos courtesy of Visit Baltimore

See us at
IMS MTT-S
Booth 2309



When Performance Matters... **DC to 27 GHz**



EPSMA™

Enhanced Performance

Introducing our latest line of SMA connectors:

The EPSMA™ (Enhanced Performance) series of the Standard SMA product line provides mode free performance to 27 GHz. In addition, these connectors are tuned to provide ultra low VSWR to 27 GHz (typically 1.15:1). The current product offering consists of field replaceable styles with industry standard flange configurations and pin sizes.

Features:

- Frequency range: **DC to 27 GHz**
- Low VSWR to 27 GHz (1.15:1 max to 27 GHz)
- 2 Hole and 4 Hole flange field replaceable configurations
- Low RF leakage (less than 90 dB)
- Interface conforms to MIL-STD 348
- Common configurations in stock

Tensolite JERRIK ECS GTI OMI

1.866.282.4708

www.CarlisleIT.com

rf@CarlisleIT.com

CARLISLE
INTERCONNECT TECHNOLOGIES



APPLICATION NOTE

222 Considerations for Accurately Measuring Pulsed Active Devices

Hiroiyuki Maehara, Agilent Technologies Inc.

Considerations and challenges for accurately measuring pulsed active devices that are power dependent

PRODUCT FEATURES

230 ADS 2011 Ushers in a New Era in RF/Microwave Design

Agilent Technologies Inc.

New release of ADS 2011 highlighting its new capabilities

238 New Network Analyzer Generation Sets the Pace

Rohde & Schwarz

Introduction to a family of network analyzers featuring wide dynamic range, low trace noise and high output power

246 Second Generation RF Linearizer Targets 4G Small Cell Deployments

Scintera

Introduction to a commercially available solution to cost-effectively linearize PAs from 50 W down to 250 mW

TECH BRIEFS

252 Ultra Low Noise, High IP3 Monolithic Amplifier

Mini-Circuits

Introduction of an ultra low noise MMIC amplifier covering 0.7 to 1.6 GHz

254 High Speed Analog-to-Digital Converter Family

Hittite Microwave Corp.

Introduction of a high speed ADC product line that exhibits ultra-low power dissipation and cost efficiency while maintaining high performance

256 600 W UHF Power Transistor

NXP Semiconductors

Introduction of a UHF 600 W RF power transistor for broadcast transmitters and industrial applications

DEPARTMENTS

19... Mark Your Calendar
20... Coming Events
99... Defense News
103... International Report
107... Commercial Market
110... Around the Circuit

258... New Products
284... The Book End
286... Ad Index
288... Sales Reps
290... MWJ Puzzler

STAFF

PUBLISHER: CARL SHEFFRES

EDITOR: DAVID VYE

MANAGING EDITOR: JENNIFER DIMARCO

TECHNICAL EDITOR: PATRICK HINDLE

ASSOCIATE TECHNICAL EDITOR: DAN MASSÉ

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

LEAD DESIGNER & PRODUCTION COORDINATOR:

JANICE LEVENSON

GRAPHIC DESIGNER: SACHIKO STIGLITZ

EUROPE

INTERNATIONAL EDITOR: RICHARD MUMFORD

OFFICE MANAGER: NINA PLESU

CORPORATE STAFF

CEO: WILLIAM M. BAZZY

PRESIDENT: IVAR BAZZY

VICE PRESIDENT: JARED BAZZY

EDITORIAL REVIEW BOARD

Dr. I.J. Bahl	Dr. J.C. Lin
D.K. Barton	Dr. S. Maas
F.M. Bashore	Dr. R.J. Mailloux
Dr. E.F. Belohoubek	S. March
Dr. C.R. Boyd	Dr. G.L. Matthaei
N.R. Dietrich	Dr. D.N. McQuiddy
Dr. Z. Galani	Dr. J.M. Osepchuk
Dr. F.E. Gardiol	Dr. J. Rautio
G. Goldberg	Dr. U. Rohde
M. Goldfarb	Dr. G.F. Ross
Dr. P. Goldsmith	M. Schindler
Dr. M.A.K. Hamid	Dr. P. Staecker
J.L. Heaton	F. Sullivan
Dr. G. Heiter	D. Swanson
N. Herscovici	Dr. R.J. Trew
Dr. W.E. Hord	G.D. Vendelin
H. Howe, Jr.	C. Wheatley
Dr. T. Itoh	Dr. J. Wiltse
Dr. J. Lasker	Prof. K. Wu
Dr. L. Lewin	

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.mwjjournal.com

Printed in the USA

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

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



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

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 4201-63
Digital Attenuator



- /// 0.4-6.0 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

3-Port Short/Open/Load
Model 1561



- /// Specifically designed to simplify wireless test Setups
- /// dc to 2 GHz
- /// TNC female connectors
- /// VSWR: 1:25 maximum

Aeroflex / Weinschel has been pioneering developments in microwave and RF technologies for more than 57 years. Today part of Aeroflex, we are continuing to set new standards in component and sub-system 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/weinschelMJ

See us at MTT-S Booth 2212

AEROFLEX
A passion for performance.

The latest industry news, product updates, resources and web exclusives from the editors of *Microwave Journal*

Free Webinars

Innovations in EDA Series Presented by Agilent Technologies Direct Filter Synthesis

This webcast looks at direct filter synthesis derived from user-specified input. Direct synthesis eliminates reliance on optimization for more optimal performance.

Available for on demand viewing after 5/5/11
Sponsored by **Agilent Technologies Inc.**

RF/Microwave Training Series Presented by Besser Associates Mixers and Frequency Converters

This webinar looks at various mixer types, design considerations and key specifications such as conversion loss, isolation, noise figure and spurious outputs.

Live webcast: 5/17/11, 11:00 AM EDT
Sponsored by **Mini-Circuits**

Technical Education Series Presented by COMSOL RF and Microwave Heating

This webinar is meant for anyone interested in simulation of RF and microwave heating in antennas, circuit boards, living tissue, or any device that has a combination of lossy dielectric and metallic domains.

Live webcast: 5/19/11, 2:00 PM EDT
Sponsored by **COMSOL**

Web Simulcast: Nonlinear Characterization Expert Forum at MTT-S IMS MicroApps

June 8, 2011, 12:00 – 1:30 PM

This live forum and webcast features experts in RF nonlinear device measurement and characterization discussing trends in nonlinear device characterization. An open panel session will follow with questions from both the live and online audience.

To view live webcast online, register at www.mwjjournal.com/ims_2011_microapps_experts

Executive Interview

Described as a microwave pioneer, **Professor J. David Rhodes**, Engineering Emeritus Professor at the University of Leeds, UK, explains founding Filtronic plc, being awarded the OBE and CBE by the Queen and his role as 2011 MTT-S IMS plenary speaker.



IMS Online Show Coverage

Catch our exclusive conference information, news, social networking, photos, videos, and more at MWJOURNAL.COM/IMS2011, proud sponsor of the IMS 2011 Cyber Café.

Online Technical Papers

Optimizing High Performance RF Components for LTE and LTE Advanced Base Stations

Randy Cochran, Phil Knights, Jarek Lucek, NXP

Microwave Applicator with Conveyor Belt System

Application Note, Presented by COMSOL

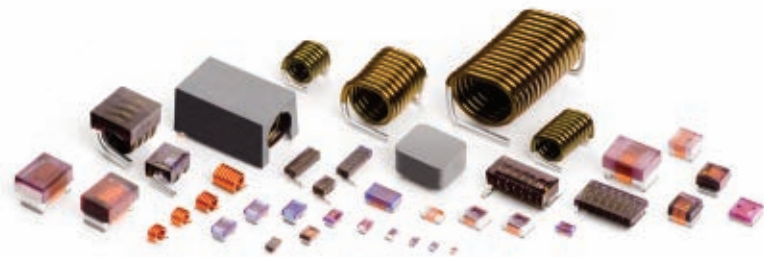
PNA-X Nonlinear Vector Network Analyzer and X-Parameters in Power Amplifier Design

Loren Betts, Agilent Technologies Inc.

Taking Mobile to Rural Africa: The Vital Role of Hybrid Satellite—Microwave Backhaul

White Paper, Intelsat

Why Coilcraft wirewound chip inductors are your #1 choice



Higher Q Compared to non-wirewounds, our chip inductors usually have Qs that are 50 to 150% higher.

Lower DCR Put up to 3 times more current through our chip inductors thanks to their low DC resistance.

Higher SRF The solenoid winding of our inductors gives them a much higher SRF than multilayer parts.

Tighter tolerance Precision manufacturing lets us consistently make parts with $\pm 2\%$ inductance tolerance. Many popular values also come in $\pm 1\%$.

Better support With our engineer-friendly web site, interactive design tools and generous free samples, Coilcraft is just plain easier to do business with.

Visit **www.coilcraft.com** for information on all our high performance wirewound inductors.

See us at MTT-S Booth 2402



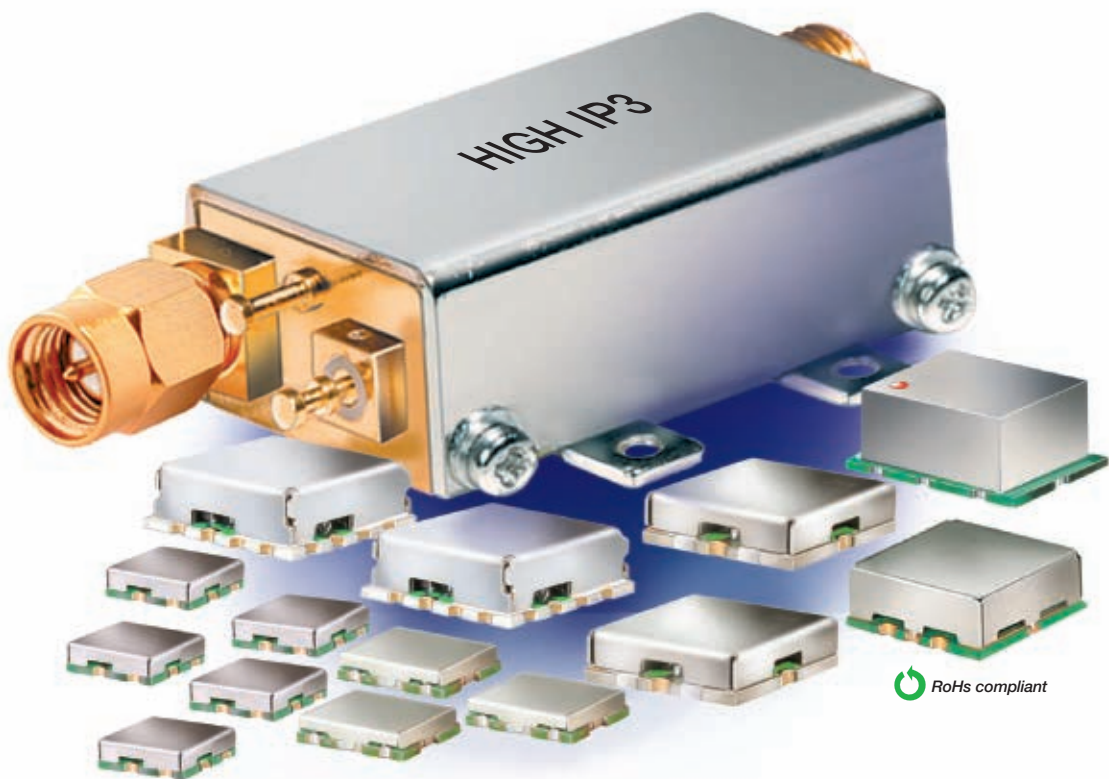
WWW.COILCRAFT.COM



Constant Impedance

VVAs

10 MHz to 7 GHz



\$3⁹⁵
from ea. qty. 25

Voltage Variable Attenuators (VVAs) deliver as high as 40 dB attenuation control over the 10 MHz through 7.0 GHz range. Offered in both 50 and 75 Ω models these surface-mount and coaxial low-cost VVAs require no external components and maintain a good impedance match over the entire frequency and attenuation range, typically 20 dB return loss at input and output ports. These high performance units offer insertion loss as low as 1.5 dB, typical IP3 performance as high as +56 dBm, and minimal phase variation low as 7°.

Mini-Circuits VVAs are enclosed in shielded surface-mount cases as small as 0.3" x 0.3" x 0.1". Coaxial models are available with unibody case with SMA connectors. Applications include automatic-level-control (ALC) circuits, gain and power level control, and leveling in feedforward amplifiers. Visit the Mini-Circuits website at www.minicircuits.com for comprehensive performance data, circuit layouts, environmental specifications and real-time price and availability.

Mini-Circuits...Your partners for success since 1969

Mini-Circuits®
ISO 9001 ISO 14001 AS9100 CERTIFIED

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



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

IF/RF MICROWAVE COMPONENTS

See us at MTT-S Booth 1031



SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
29	30	31	1	2 Innovations in EDA Webcast: LTE Agilent Technologies	3	4
			MIE 2011 2011 National Conference on Microwave and Millimeter Wave in China 2011 Microwave Industry Exhibition in China Qingdao, Shandong, China			
5	6 	7	8	9	10	11
<div>  IEEE IMS2011 Baltimore  </div>						
IEEE Radio Frequency Integrated Circuits Symposium			Nonlinear Characterization Expert Forum MicroApps		ARFTG 2011	
12	13 Innovations in VSA Webcast Agilent Technologies	14	15	16	17	18
		European Test and Telemetry Conference Toulouse, France				
19	20	21 MWJ Besser Webinar: Power Amplifier Design Sponsored by:  Tektronix	22	23	24	25
26	27	28 Strategy Analytics Webinar: Gallium Nitride Sponsored by: 	29	30	1	2
		JSDE/ION Joint Navigation Conference Colorado Springs, CO				

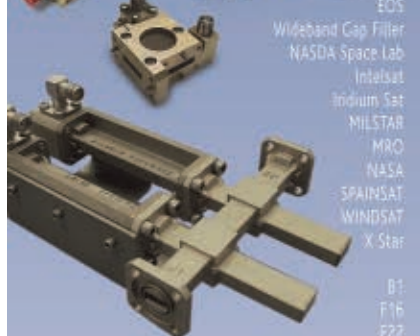
Go to: www.mwjjournal.com/events

MISSION CAPABLE



SPACE to DEEP SEA

**MILITARY, SPACE QUALIFIED,
HOMELAND SECURITY AND
COMMERCIAL PROGRAMS**



From 88 MHz to 65 GHz
Quality Passive Components
Waveguide, Coaxial & Stripline
Duplexers, Combiners, Terminations
Integrated & Rack Mount Assemblies
Couplers, Filters, Power Dividers
Isolators, Circulators, Drop-Ins
ISO-Adapters, ISO-Filters
HD Radio Circulators

AEHF
ASTROLINK
EOS
Wideband Cap Filter
NASA Space Lab
IntelSat
Indium Set
MILSTAR
MRO
NASA
SPAINSAT
WINDSAT
X-Star

B1
F16
F22
F35
C130
Tumult Hawk
E2C
E2D
AEGIS
AWACS
Combat Talon
J-Stars
Trac 170
Mini Mutas
VSR-EQ36
F563 Radar
Rescue 21
Deepwater



CHANNEL MICROWAVE
www.channelmicrowave.com
sales@channelmicrowave.com
Camarillo, California
Phone (805) 482-7280

smiths
bringing technology to life



COMING EVENTS

AUGUST

EMC 2011

**IEEE INTERNATIONAL SYMPOSIUM ON
ELECTROMAGNETIC COMPATIBILITY**
August 14-19, 2011 • Long Beach, CA
www.emc2011.org

AUVSI UNMANNED SYSTEMS N. AMERICA 2011

August 16-19, 2011 • Washington DC
http://symposium.auvsi.org/auvsi11/public/
enter.aspx

SEPTEMBER

ION GNSS 2011

September 20-23, 2011 • Portland, OR
www.ion.org



OCTOBER

EuMW 2011

EUROPEAN MICROWAVE WEEK
October 9-14, 2011 • Manchester, UK
www.eumweek.com

7TH ANNUAL COMSOL CONFERENCE

October 13-15, 2011 • Boston, MA
www.comsol.com/conference2011/usa/

MICROWAVE UPDATE (MUD) 2011

October 13-16, 2011 • Enfield, CT
www.microwaveupdate.org

AMTA 2011

**33RD ANNUAL SYMPOSIUM OF THE ANTENNA
MEASUREMENT TECHNIQUES ASSOCIATION**
October 16-21, 2011 • Englewood, CO
www.amta2011.org

4G WORLD 2011

October 24-27, 2011 • Chicago, IL
www.4gworld.com

RADAR 2011

INTERNATIONAL CONFERENCE ON RADAR
October 24-27, 2011 • Chengdu, China
www.radar2011.org

NOVEMBER

COMCAS 2011

**INTERNATIONAL IEEE CONFERENCE ON
MICROWAVES, COMMUNICATIONS, ANTENNAS AND
ELECTRONIC SYSTEMS**
November 7-9, 2011 • Tel Aviv, Israel
www.comcas.org

MILCOM 2011

November 7-10, 2011 • Baltimore, MD
www.milcom.org

DECEMBER

APMC 2011

ASIA PACIFIC MICROWAVE CONFERENCE
December 5-8, 2011 • Melbourne, Australia
www.apmc2011.com

CALL FOR PAPERS

IEEE COMCAS 2011

Deadline: June 15, 2011

APMC 2011

Deadline: June 24, 2011

MILCOM 2011

Deadline: August 12, 2011

ONLINE: COMING SOON

For complete coverage of the IMS 2011
conference, event news, exhibitor product
information and special reports from the
editors of Microwave Journal, visit www.mwjjournal.com/IMS2011.

www.mwjjournal.com/IMS2011

MAY

ASIA-PACIFIC EMC SYMPOSIUM

May 16-19, 2011 • Jeju Island, Korea
www.apemc2011.org



JUNE

MIE 2011

**2011 NATIONAL CONFERENCE ON MICROWAVE
AND MILLIMETER WAVE IN CHINA**
**2011 MICROWAVE INDUSTRY EXHIBITION IN
CHINA**

June 1-4, 2011 • Qingdao, Shandong, China
www.cnmw.org

RFIC 2011

**IEEE RADIO FREQUENCY INTEGRATED CIRCUITS
SYMPOSIUM**
June 5-7, 2011 • Baltimore, MD
www.rfic2011.org

IMS 2011

**IEEE MTT-S INTERNATIONAL MICROWAVE
SYMPOSIUM**
June 5-10, 2011 • Baltimore, MD
www.ims2011.org

ARFTG 2011

**77TH ARFTG MICROWAVE MEASUREMENT
CONFERENCE**
June 10, 2011 • Baltimore, MD
www.arftg.org

JNC 2011

JOINT NAVIGATION CONFERENCE
June 28-30, 2011 • Colorado Springs, CO
www.jointnavigation.org

JULY

AP-S/USNC/URSI 2011

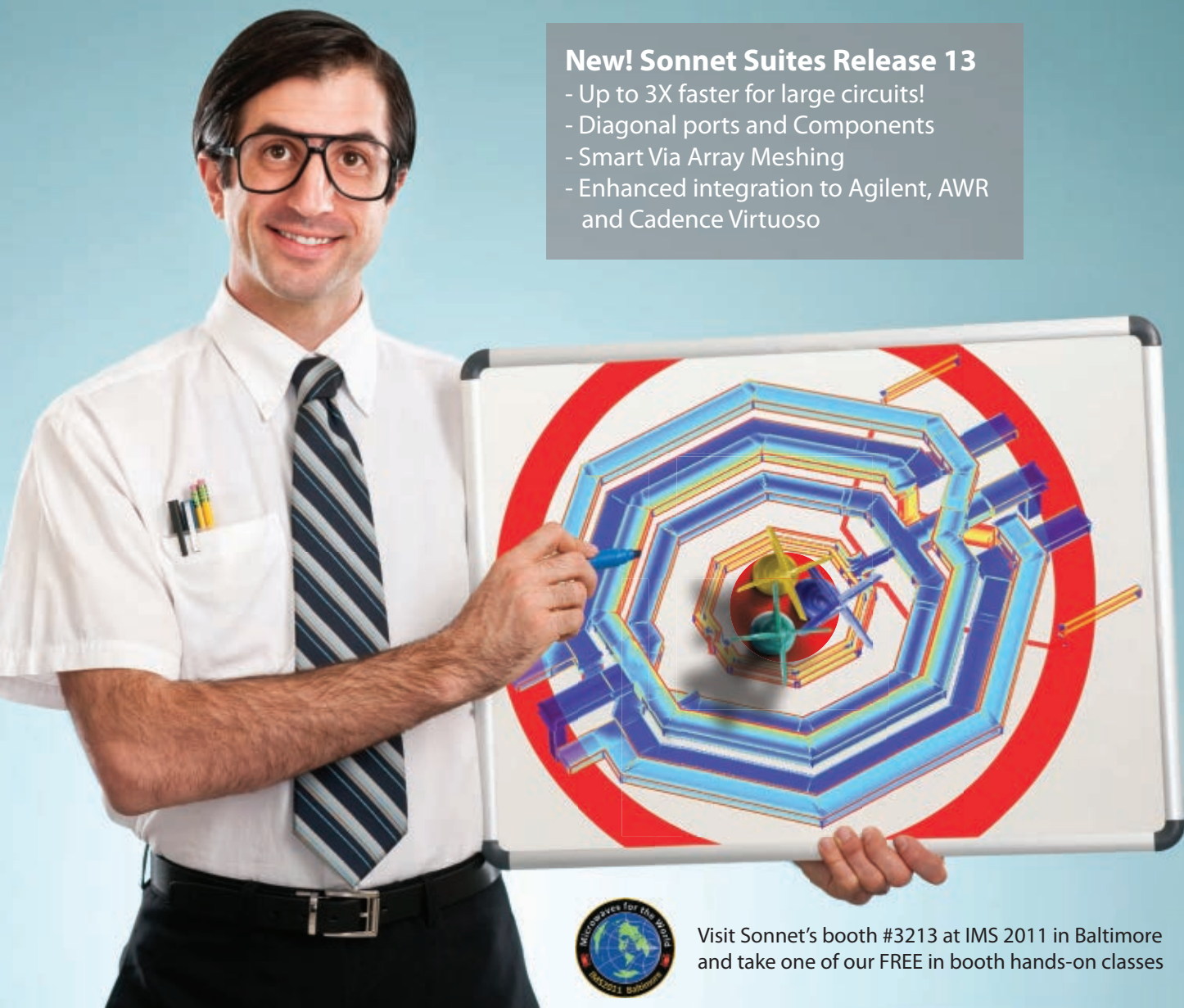
**IEEE INTERNATIONAL SYMPOSIUM ON ANTENNAS
AND PROPAGATION AND USNC/URSI NATIONAL
RADIO SCIENCE MEETING**
July 3-8, 2011 • Spokane, WA
www.apsursi2011.org

Work smarter.

Sonnet® gives you the accuracy to keep your projects on target.

New! Sonnet Suites Release 13

- Up to 3X faster for large circuits!
- Diagonal ports and Components
- Smart Via Array Meshing
- Enhanced integration to Agilent, AWR and Cadence Virtuoso



Visit Sonnet's booth #3213 at IMS 2011 in Baltimore and take one of our FREE in booth hands-on classes

Really accurate full wave 3D Electromagnetic software for really smart people--high frequency designers. While we can't raise your IQ, we can raise your success rate on high frequency designs.

Smart engineers demand smart software. Sonnet gives you unmatched accuracy as a standalone tool, or within your preferred microwave EDA design framework.



Download a free QR barcode app on your smartphone.



High Frequency Electromagnetic Software

Call, click or scan for IMS Class Schedule

(877) 7-SONNET

www.sonnetsoftware.com/ims

© 2011 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 and the AWR logo is a trademark of Applied Wave Research, Inc.
Cadence and Virtuoso are registered trademarks and the Cadence logo is a trademark of Cadence Design Systems, Inc.



You Have Our Undivided **ATTENTION**

Military • Commercial Wireless • Space

No matter what your application, Eastern Wireless TeleComm understands just how much is on the line with each and every product we make. That is why you will have our undivided attention while we continually provide the highest quality filter products, design support, and service to you each and every time. Where Performance Counts, Count on EWT.





Specializing in custom design &
manufacturing of RF and Microwave filters
and filter based products to 50 GHz.

Bandpass • Bandreject • Highpass • Lowpass
Transmit • Receive • Duplexers • Multiplexers

Eastern Wireless TeleComm, Inc.
Tel: 410.749.3800 Fax: 410.749.4852
sales@ewtfilters.com



TRENDING THE CONFERENCE



Around this time of year, i.e. MTT-S IMS season, I often find myself on one side or the other of the following question – “So, what’s new in the industry.” In actuality, the big picture does not really change much; communication systems (their devices and supporting infrastructure) are increasingly ubiquitous and defense systems are continually evolving in response to a complex and dangerous world.

If you Google “The more things change, the more they stay the same,” you will learn that the phrase is attributed to Jean Baptiste Alphonse Karr (or as he put it ‘plus ça change, plus c’est la même chose’). For Karr, turbulent changes did not affect reality on any deeper level other than to reinforce the status quo. So what is our status quo? I would say this year’s technology is expected to do more than it did last year... only for less money. And I am sure to be saying the same thing next year.

The meaningful part of the question “what’s new” is more about specifics; as in “What will be the improved power added efficiency with that low loss switch?” or “What is the state of the art in dynamic range for a spectrum analyzer?” and are either worth the extra cost. In addition to finding out about the latest research and technical advances, a good number of microwave professionals are equally interested in new products, market trends, applications, mergers and acquisitions,

appointments, and who won what contract or got promoted. It is wise to take an interest in such developments. Technology makes our business possible and vice versa.

I have come to believe that one of the most valuable functions of IMS and the exhibition is to provide answers to the “what’s new” question, on all fronts. The technical program provides part of the answer in its organized workshops, panels and sessions. The remaining part is found in the exhibition hall, which is more akin to parallel processing or should I say, connecting to ‘the cloud.’ Information overload is inevitable.

Anticipating a large captive audience and the media spotlight, exhibitors usually schedule their major product releases right around this show. Absorbing all the “what’s new” information from over 500 exhibitors, on top of the technical program is a daunting if not impossible task. Our goal for this month’s IMS show issue editorial, as well as our series of show related electronic newsletters, exhibitor preview and dedicated IMS online show coverage is to provide readers with enough advance coverage to help them sort through all this information and prioritize that which is most important before heading to Baltimore.

For this issue, my predecessor Harlan Howe used to scribe his annual “Attending the Conference.” Playing off that title, we have solicited content that looks at industry trends heading into the conference. Trends are mapped

with data points over time. And so we begin with our cover story based on the reflections of two well-known entrepreneurs who launched very successful microwave businesses in Maryland and were largely responsible for developing the region into a hotbed of filter companies.

Our show coverage also includes a welcome from this year’s conference chairs (IMS, RFIC and ARFTG) as well as pre-conference perspectives from industry and defense research – Opportunities and Challenges in 2011 by Greg Peters of Agilent and Microwave Technology Development at the Naval Research Lab by Jeff Pond of NRL.

IMS is made up of many events within the event and so we have asked the organizers of this year’s MicroApps and the ‘Women in Engineering Reception’ to provide a preview. Speaking of MicroApps, the *Journal* is pleased to be co-organizing the MicroApps marquee event and keynote, an expert panel on nonlinear device characterization featuring an open forum with presenters from Agilent, Anritsu, Rohde & Schwarz/NMDG and Tektronix/Mesuro. Advances in measurement equipment and nonlinear modeling promise to make this event educational and lively. The *Journal* will cover the action via a live webcast so that even those not attending IMS will be able to watch and participate in the Q&A.

DAVID VYE

Editor, Microwave Journal

In the field, every measurement counts.



So does every minute you save.

Making complex measurements simple and reliable is what Agilent handheld spectrum analyzers (HSA) are all about—rain or shine, day or night. Automated functions reduce human error and save time. Agilent's new N9342C 7 GHz HSA even stores multiple test routines so repetitive tasks can be quickly executed. MIL-rugged, superb ergonomics and feature-rich. That's field ready. That's Agilent.

Handheld Spectrum Analyzers	N9340B	NEW N9342C
Frequency range	100 kHz – 3 GHz	100 kHz – 7 GHz
Task planner and internal GPS	No	Yes
Weight	7.7 lbs	8.1 lbs
Dimensions	12.5" x 8.15" x 2.7"	12.5" x 8.15" x 2.7"

© 2010 Agilent Technologies, Inc.
* With purchase of an N9340B or N9342C HSA.
Promotion ends May 31, 2011.

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

**Buy from an
Authorized Distributor**
www.agilent.com/find/distributors

**FREE spare battery, battery charger
and 12 V adapter with purchase***
Learn more at www.agilent.com/find/AgilentHSAoffer



Agilent Technologies

See us at MTT-S Booth 813



you asked
Multi-function MMICs move designs along
we delivered

Endwave GaAs PHEMT upconverter MMICs offer designers more functions per sq mm than ever before. We have combined LO multiplication with innovative VVA-based RF gain adjustability and a mixer. Our two workhorse models offer QFN solutions through 24 GHz. These devices feature nominal conversion gain, precise gain adjustability, and integrated ESD protection.

Check a few things off your list with an Endwave multi-function upconverter.

	EWU1509YF UPCONVERTER	EWU1809YF UPCONVERTER
Frequency (GHz)	10 to 15.4	17.5 to 24
IF Bandwidth (GHz)	DC to 5	DC to 5
Conversion Gain (dB)	+16	+11
RF Gain Adjustability (dB)	27	22
Output IP3 (dBm)	+28	+26
LOx2 Leakage (dBm)	0	-10
Power Consumption	385 mA @ 4.5 V	460 mA @ 4.5 V
Package	32 lead 5x5 SMT QFN	32 lead 5x5 SMT QFN

Endwave. Plug us in.

www.endwave.com



For your guide to exhibiting companies and new products, we feature the complete exhibitor listing with an index to their ad location in the issue and the new products section is exclusively dedicated to items you will find at the show. The exhibitor listing, new product section and advertisements placed throughout this issue undoubtedly represent the most comprehensive pre-show snapshot of who's introducing "what's new."

With the IMS technical program available online and printed in the conference guide, it would be redundant to publish the schedule in this issue. The same is true for a guide to tourist spots and restaurants in the host city, where the Internet can provide a more comprehensive list. Removing these items has created space for us to do what we do best—deliver show and industry related content and perspective. I hope you find this month's special editorial insightful, informative and even entertaining (check out the animated MTT-Stories). We began implementing these changes a few years ago, and I am confident that it has been a worthwhile disruption to the status quo.

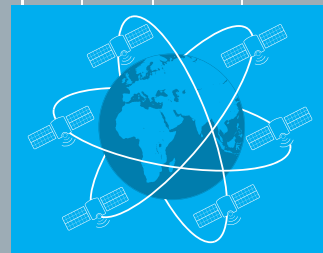
As engineers, you make your livelihood from being inventive. You should expect no less from your reading material. How we access and absorb information was forever changed by the Internet. We at the *Journal* are constantly thinking of new ways to utilize all forms of media; each has a particular strength. So look for our IMS related newsletters in your e-mail, visit our website for online show coverage and take the next three weeks to leisurely read your show issue, hopefully cover to cover. Then you will be better prepared to discover what is most significant to you from among all the "what's new." As Robert Gallagher said, "Change is inevitable - except from a vending machine." You might as well be ready for it. Safe travels and I will see you in Baltimore. ■

GPS/Galileo simulation easier than ever.

The R&S®SMBV100A vector signal generator with GNSS software options

Expensive, inflexible simulation of GNSS scenarios is a thing of the past. Now you can easily test your satellite receivers under realistic signal conditions – with the new software options for the R&S®SMBV100A vector signal generator.

- Realtime scenarios with up to 12 GPS and/or Galileo satellites
 - Unlimited simulation time
 - Realistic signal modeling with moving profiles, multipath propagation, dynamic power control and atmospheric modeling
 - Support of A-GPS and all relevant communications and broadcasting standards such as LTE, HSPA+, GSM/EDGE, HD radio™, and FM stereo.
- A single generator for testing all major standards



To find out more, go to
www.rohde-schwarz.com/ad/smbv-gnss/mwj
See us at MTT-S Booth 2115



ROHDE & SCHWARZ



MADE IN MARYLAND: FILTER LORE FROM GAITHERSBURG TO THE EASTERN SHORE

Starting in the early 1960s, Maryland has been home to numerous custom microwave filter houses. Originally founded as small, family-oriented companies by hardworking and ambitious entrepreneurs, these start-ups saw opportunity and were hungry to seize it. Possessing the agility and inventiveness that is the hallmark of all fledgling companies that succeed in business, many of these organizations went on to become among the most famous names in the RF/microwave industry.

To get their products designed into the defense and telecommunication systems of the day, they would have to push the state-of-the-art in performance, size and cost. These young filter houses became incubators for creative filter design. Their ability to develop and, most importantly, deliver products on time and on budget surpassed the efforts of the internal filter departments of the large defense contractors that eventually became their customers.

Grooming and retaining engineering talent was critical to these smaller companies in achieving technical prowess and transforming their filter building formulas into a competitive advantage. In contrast, large defense contractors were forced to frequently re-

plenish their expertise with less experienced employees as leading engineers followed career paths that went "up" into management or went "out" to join some promising start-up.

With a sharp and motivated worker and an environment offering the right nurturing and support, the art of filter tuning and design was developed, enhanced and passed down to the next generation. Success required one or more knowledgeable gurus, a tight group of self-motivated learners and a driven business leader with enough 'can-do' attitude to convince customers and his own team that they could achieve new heights in filter technology. These are some of the insights shared during a dinner conversation between *Microwave Journal* and two such entrepreneurs from Maryland's rich filter history and the sons who are carrying on their legacy.

MEET THE BERNSTEINS AND THE ASSURIANS

Dick Bernstein is the legendary founder of K&L Microwave. Bernstein studied engineering at the Virginia Military Institute and earned his undergraduate degree from Salisbury State University after having gone to work as a Lead

Designer for I-Tel, a filters, diplexers and multiplexers shop founded by Richard Wainwright and his wife, Virginia, in Kensington, MD. Within three years, Bernstein outgrew the opportunities available at I-Tel and followed a career path to Texscan in 1967. Texscan was a solid-state sweep generator



Kevin and Dick Bernstein

manufacturer in Indianapolis, IN; a spin-off from a California company called Telonic, founded by two other (un-related) Wainwrights, Claire and his wife, Barbara.

In 1970, Bernstein returned to Salisbury, MD to set up his own company, named after his children Kevin and Lisa. At its helm, Bernstein grew K&L into one of the most recognized companies in our industry before selling it to Dover Corp. in 1983. Bernstein stayed on at K&L until 1989. The

David Vye

Editor, *Microwave Journal*

SPDT & DPDT WAVEGUIDE SWITCHES

RLC has the standard and custom design solutions you're looking for.

RLC Electronics' electromechanical waveguide switches offer a compact design utilizing a proprietary non-contacting actuator mechanism that requires low current. Precision machined parts insure optimum electrical performance over the entire waveguide band.

- Frequencies from 7.05 to 40 GHz
- Standard Waveguide Sizes
- Low VSWR
- Failsafe, Latching, Manual Override or Manual
- Switching Times As Fast As 25 Milliseconds
- 5, 12 or 28v DC Coil
- Indicator and TTL Options
- High Isolation
- Environmentally Conforms to MIL-DTL-3928
- Low Insertion Loss

For more detailed information on SPDT & DPDT Waveguide Switches, visit our web site.



RLC ELECTRONICS, INC.

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

ISO 9001:2000 CERTIFIED

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



See us at MTT-S Booth 739



eternal entrepreneur left to start BAI Aerosystems, acquired Lorch Microwave in 1994 and moved that company up to Maryland. BAI Aerosystems was sold to L-3 Communications in 2004; Lorch was sold to Smiths Interconnect in 2006. His son Kevin Bernstein is the company President.

Manny Assurian has also established a global reputation as a leading businessman among the custom filter manufacturing community and their clients. In 1967, Assurian was fresh out of college from the Capitol Institute of Technology when he joined I-Tel as an engineer shortly after Bernstein's departure. As often happens at small companies, Assurian cut his teeth by doing a little bit of everything (assembly, machine shop, tuning, etc.). In the 1970s, I-Tel changed its name to Cir-Q-Tel (see call-out box for details). During this period, Assurian's responsibilities grew until he was serving as company President and running the business for Wainwright. Leveraging his experience, Assurian left Cir-Q-Tel to launch Reactel in January of 1979 along with former colleague, Don Claycomb.

Assurian grew his two man operation, originally located in less than 1000 square feet of manufacturing space, into a leader in the design and manufacture of high performance custom RF and microwave filters, multiplexers and multifunction assemblies. Today the company operates in a 15,000 square foot state-of-the-art facility located in Gaithersburg. Manny's son Jim Assurian is currently the Director of Business Development at Reactel.



Jim and Manny Assurian

Itel was a San Francisco-based equipment leasing company founded in 1967. Through creative financial arrangements and investments, Itel was able to lease IBM mainframes to customers at costs below what customers would have paid IBM, making them second only to IBM in revenues from IBM mainframe leasing. Unfortunately, the name they chose for their company already belonged to a tiny microwave company in Kensington, MD. This led the much larger Itel of San Francisco to sue I-Tel of Kensington over the use of the company name.

Virginia Wainwright, who handled the business side of I-Tel went to New York and hired the most prestigious lawyers she could find. In court, the judge ruled in her favor. Recognizing the considerable costs associated with re-branding the larger company, Virginia was able to negotiate an attractive financial compensation in exchange for renaming her company. Meanwhile, Dick Wainwright envisioned a future market for drop-in circulators and thus developed such a component. The company's new name, Cir-Q-Tel was chosen to reflect its re-direction in product focus.

STEAK AND SHOP TALK

We met in a Washington, DC restaurant, where everyone had travelled to attend the Satellite 2011 show. The Bernsteins had just returned from Dubai, where they were visiting an armaments show. Dick is currently the CEO of LWRC International, a company that designs and manufactures what the company claims to be 'the finest evolution of the M4/M16 rifles and carbines since the weapon's introduction.' Using the latest technology and materials, Bernstein's new company is able to produce rifles that operate cleaner, cooler and more reliably without sacrificing accuracy. Asked if his experience in the filter business has been applicable to his current endeavor, Bernstein replied, "Everything

we've done has been a stepping stone in all our ventures."

MWJ: So, why start a filter company in Salisbury, MD?

Dick Bernstein: I thought I would start the business close to my family and Salisbury had an airport. Then UPS and FedEx came along; so today, location is much less important. I tell people that unless you're in the next town over, it doesn't matter where you are. I'm as close to my customers in France as I would be if I were in Philadelphia or some other place. In my early ads we said, 'just below Baltimore' although it was over 100 miles away.

I grew up on the shore where my parents had a garment factory, so I knew the people in that industry. They were very loyal, fast learners, steady and dependable workers, which leads me to a story about one of the things I brought to the industry.

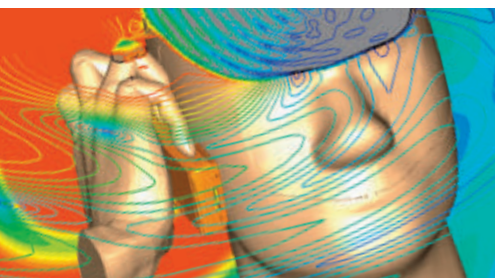
I had left the shore unable to get a job there after college and took a job [at I-Tel] on the western shore in Kensington [Maryland], followed by a few years at Texscan [Indianapolis, IN]. Texscan was making solid-state sweep generators, competing head on with Telonic, which made the old wobbleator and oscillator type sweep generators. So they needed someone to handle components, and that's how they came to hire me.

Both I-Tel and Texscan made high mix products; those are low volume, very custom parts. In Washington, DC, I was training people that were part of a very transient labor supply. Somebody across the street would offer an employee 25 cents an hour more and they would leave. But in Indianapolis, we didn't have that problem. We were getting very loyal people. They were unskilled, basically off the farm, but very trainable people. They reminded me of the people on the eastern shore. In the early 1970s, defense spending was winding down and engineers were losing jobs and driving taxi cabs. Texscan was cutting back, so I thought it was a good opportunity

AT THE FRONTIERS OF SIMULATION

CST STUDIO SUITE 2011

Explore the EM simulation universe



→ Get equipped with leading edge EM technology. CST's tools enable you to characterize, design and optimize electromagnetic devices all before going into the lab or measurement chamber. This can help save substantial costs especially for new or cutting edge products, and also reduce design risk and improve overall performance and profitability.

Involved in mobile phone development? You can read about how CST technology was used to simulate this handset's antenna performance at www.cst.com/handset. If you're more interested in filters, couplers, planar and multi-layer structures, we've a wide variety of worked application examples live on our website at www.cst.com/apps

The extensive range of tools integrated in CST STUDIO SUITE enables numerous applications to be analyzed without leaving the familiar CST design environment. This complete technology approach enables unprecedented simulation reliability and additional security through cross verification.

→ Grab the latest in simulation technology. Choose the accuracy and speed offered by CST STUDIO SUITE.

See us at MTT-S Booth 1423



CHANGING THE STANDARDS

GaN Pallet Type Power Amplifiers

“Based on internally matched
GaN-on-SiC device
and Doherty technology”

Excellent for **LTE RRH**
and Telecom Applications

- ✓ 45% Efficiency
(When interlocked with DPD)
- ✓ 40-50dB Gain
- ✓ 8, 10, 16, 25, 30, 40, 60, 80W
- ✓ 80-200MHz Bandwidth
- ✓ 800MHz, 2100MHz,
2300MHz, 2600MHz, 3600MHz
- ✓ Small Size
- ✓ Custom-Design Available



* Metric ruler

Visit Us At The **MTT 2011** Booth 4206



RF is our business and passion

Worldwide
Tel) 82-31-250-5011 / Fax) 82-31-250-5088
E-mail) rfsales@rfhic.com

USA Office
Tel) 919-710-1645
E-mail) samkim@rfhic.com

RFHIC
www.rfhic.com



to come back to the eastern shore and start a business (Note: I-Tel and Texscan are now part of Trilithic).

So when I came back, I went to Salisbury because I knew the people [garment workers] that were available there. They were also trainable and loyal. Now in Kensington, we had high turnover. I-Tel did not believe in trying to hang on to people. You would learn and you would either get too smart, or need too much money and you were dispensable. But I believed in having continuity.

In the garment industry, what I learned is that the operator used every part of the body, their knee, their elbow, whatever it takes to run the equipment, workers are very efficient. When I went to work at I-Tel, I was amazed by how inefficient the electronic industry really was. After all, the material costs are only a small percentage of the total product and the rest of it is mostly labor. We usually had to rebuild the product two or three times to get it right, so I created some mechanization for the workers, such as hot plates to solder on and automatic wire cutters, and stuff like that. We also moved away from individually made parts and more toward a mass-production type of line with one person working on one aspect of the component and passing it along to the next person, assembly line fashion and that really improved the quality and efficiency right away.

The reason we were able to grow this industry is that we didn't try to teach somebody how to tune and build a microwave filter; we taught them how to do one part of it. They would learn that and then they moved on to something else. We broke up the product assembly so that each aspect of the product's construction became a simple task for entry level people to achieve and feel good about.

My competition at the time advertised in the paper for skilled technicians or specialized microwave machinists and was forced to pay higher wages. In the same paper, Frank Perdue would be advertising for chicken pluckers and

gizzard trimmers. The same person who would apply at his [Perdue's] place then would come over to apply at my place. That was the choice people had in those days; they could either pluck chickens or tune filters, and I had a cleaner operation than Perdue.

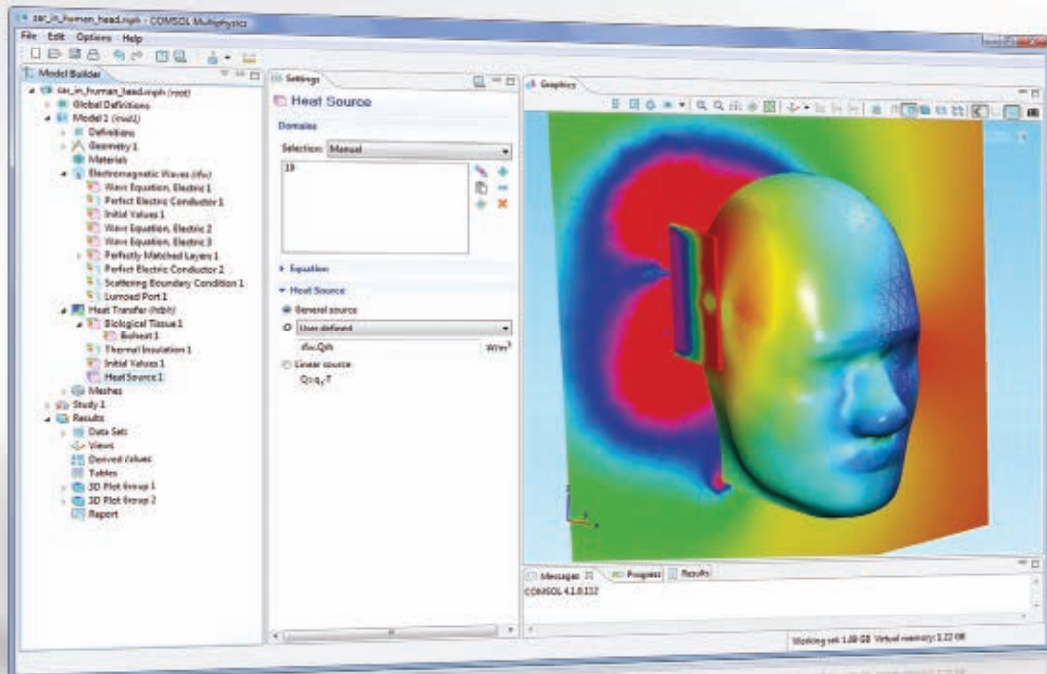
Charlie Schaub was one of my first employees. By the time I left K&L he became the President. Bob Livingston, who I hired as an accountant in 1982, is now the CEO of Dover Corp., which is now a \$7 B company. Bob went to Salisbury University, and he worked for a company in Washington and then he came back, bought a restaurant and was a cook around the time I was looking for somebody to work in accounting. So when I talk about growth in Salisbury, there are lots of people who demonstrate that. Many of them were able to go far beyond what I was able to teach them.

THE 'SHOE BOX' AD

Every entrepreneur knows that launching a company and winning initial business is not necessarily a pretty or clean endeavor. Dick recalled for us the tale of how a clever, yet somewhat over-reaching marketing campaign provided both customer and vendor with the confidence to move forward together on the development of a new filter type, helping to secure a much needed contract in K&L Microwave's early days.

Mike Hallman, Microwave Journal: *I was at K&L, working for Charlie Schaub as an intern when I heard some folklore of how you went to banks with broom handles cut up and painted black to look like filters. Is that stuff true?*

Dick Bernstein: The broom part is not really correct, but I can tell you a story about that. Back in the 1970s, the market needed a tunable notch filter and there were none. Telonic was making these tunable bandpass filters and there were some engineering companies that made some other special filters, but nobody had made anything like what the market was looking for.



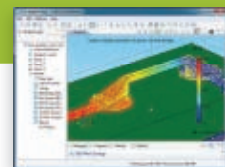
Absorbed Radiation (SAR value) in a Human Head.

Capture the Concept.

With COMSOL Multiphysics® you are empowered to build the 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. This multiphysics approach delivers results—tangible results that save precious development time and spark innovation.

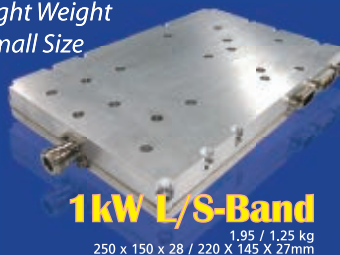
Watch Tutorial

Currents, Fields and Waves Simulation
www.comsol.com/showcase/em



GaN L-Band / S-Band 1kW Power Amplifiers

- ✓ GaN HEMT
- ✓ 50 Ω Input / Output Impedance
- ✓ High Efficiency
- ✓ High Reliability
- ✓ Easy Integration for High Power Amplifier
- ✓ High Breakdown Voltage
- ✓ Wide Bandwidth
- ✓ Light Weight
- ✓ Small Size



1kW L/S-Band

1.95 / 1.25 kg
250 x 150 x 28 / 220 X 145 X 27mm

E-pHEMT MMIC

P1dB 19dBm~36dBm

- ✓ Transient and ESD protected
- ✓ Low current consumption
- ✓ Extremely low distortion



Perfect for :

- Digital TV Multi-Tuner
- Optical Node, RFoG
- TV Set-Top Box, Cable Modem
- CATV Booster, Trunk Amplifier
- LTE, WiMAX, WCDMA

Visit Us At The **MTT 2011** Booth 4206



RF is our business and passion

Worldwide
Tel) 82-31-250-5011 / Fax) 82-31-250-5088
E-mail) rfsales@rfhic.com

USA Office
Tel) 919-710-1645
E-mail) samkim@rfhic.com

RFHIC
www.rfhic.com



I had designed tunable band-pass filters as well, so I knew pretty much what the construction was. Texscan began sending me a requirement for a tunable notch filter that they were going to bid on, but they really didn't have interest in developing it themselves. And so they ran it by me thinking it might be something I'd be interested in. This was for Harris Corp. down in Melbourne, FL, and it was all related to a program in Germany.

At the time, we [US Government] had antennas on the border of West Germany and Czechoslovakia and whatever other borders we were listening in on. In Germany, there were these high power television stations that were interfering with the ability of our listening equipment to find out what was going on over the border. So I got this requirement from Texscan for a notch band filter to block the high power television signal. I responded "no bid" because I didn't really know how to make them.

Well, after being in business for about seven or eight months and nearly starving to death, I decided to run an advertisement in a microwave magazine for a filter based on the same specifications that I was getting from Harris. I created an ad that basically reproduced the requirements for a tunable notch filter with this frequency, performance, etc. I called it the shoe box ad. It was actually a block of wood that I painted black, I took the knob off my TV set and pasted it on as a tuner dial and stuck N-connectors on the side of it with glue and took some fuzzy pictures of it.

Well, I got another requirement from Harris and once again I 'no bid' it, since it was just a marketing gimmick; a way to say 'we do these things' to differentiate ourselves from all the other microwave guys. But the buyer calls me and asks, 'why don't you bid this,' to which I said we don't make that frequency. He replied, 'well it's pretty CLOSE to what you're advertising in this magazine. Do you mind coming down here and making a presentation to our engineers? What we

really want is what you've been advertising.'

So on the airplane heading down I literally sketched up how I would design this tunable notch filter on yellow lined paper. I arrived and three or four other engineers were already there to do a presentation. I remember there were guys from TRW and others from Hughes and they all went in and did their presentations. I went in with my yellow pad. There was a blackboard in the room and I drew up how I was going to do this thing. So they called us all back about an hour later to say they made their decision 'and gentleman, we're going to give the award to K&L Microwave.'

I said to the guy, 'well I'm delighted to get this order but I thought these other guys [from TRW and Hughes] would be far more advanced,' and the buyer said, 'well Mr. Bernstein, this is a critical program for Harris Corp. and we can't afford to wait and you've already got it made, we've seen the advertising.' That's the power of advertising!

AN ANGEL VISITS K&L

Dick Bernstein: We were just starting the business when I bid on a requirement from GTE Sylvania in Syracuse. GTE said that I was the only vendor who was fully compliant on the ten or so different items in the proposal. There were some high power stuff and some tiny stuff, but I quoted 100 percent that I could do everything they wanted in the proposal. And they called me up and told me they liked my quote but that they wanted to come out for a pre-award survey [similar to a source inspection]. At the time, I had rented this building for \$75 a month; it had no heat, no air conditioning and one door. Today they would put you in jail for trying to operate out of a building like that.

Let me give you an idea of my operations back then. On weekends I would borrow Wavetek test equipment from Herb Weinstein, who was with Eastern Instrumentation, meeting him at the bay

AMPLIFIERS FROM STOCK!



- **Ultra High Performance!**
- **Ultra-Wide Bandwidths!**
- **Models to 40 Ghz!**
- **3 Year Warranty!**

Drop-In ?



- **Operating Temperature:
-55° to +85° C**
- **Reverse Polarity Protected**
- **Internal Voltage Regulator**
- **Smallest Housing**
- **RoHS Compliant**

Just Remove Connectors!

Delivery from stock to 7 days!

For the full list ➡ Visit www.bnzttech.com/fastamps

Model	Frequency Range (GHz)		Noise Figure (dB) Max.	Gain (dB) Min.	Output P1dB (dBm) Min.	Gain Flatness (± dB) Max.	VSWR In / Out	Price Domestic, U.S.
	Start	Stop						
BZP540A	0.5	40	5.5	25	8	2.5	2.5:1	\$985
BZ2640A	26	40	4.5	25	8	2.0	2.5:1	\$985
BZ1826A	18	26	2.5	28	8	1.0	2.0:1	\$875
BZP518A	0.5	18	2.7	30	10	1.8	2.5:1	\$985
BZ0618B	6	18	1.8	30	10	1.5	2.0:1	\$985
BZ0412B	4	12	1.6	28	10	1.5	2.0:1	\$785
BZP506A	0.5	6	1.4	25	10	1.3	2.0:1	\$875
BZP504F	0.5	4	1.3	30	17	1.0	2.0:1	\$985
BZ0204F	2	4	1.0	30	17	0.5	2.0:1	\$685
BZ0102F	1	2	1.0	30	17	0.5	2.0:1	\$685

Contact us for a quote with YOUR custom specifications.

See us at MTT-S Booth 4518



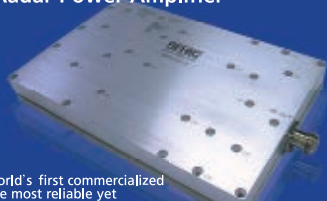
Ph: +1 (631) 444-8827
 Fax: +1 (631) 444-8825
 E-Mail: info@bnzttech.com
 Web: www.bnzttech.com
 Made in USA



DO you have the **future** working for you?

*"Come see live demonstrations
of the next generation of
power amplifier solutions
at **MTT (Booth 4206)**"*

On Tuesday the 7th,
our GaN S-Band
1 kW Radar Power Amplifier



• The world's first commercialized
and the most reliable yet
cost effective solid state replacement for tube.

On Wednesday the 8th,
The world's first mass-produced
GaN RRH Power Amplifier



• 50W, 65MHz, & 40% eff.

On Thursday the 9th,
our GaN Hybrid Power Amplifiers



• Low Cost
• Mass Produced
• High Efficiency

To see its actual performance.

Visit Us

IEEE MTT-S 2011

International Microwave symposium
Baltimore Convention Center
Booth # 4206



RF is our business and passion

Worldwide
Tel) 82-31-250-5011 / Fax) 82-31-250-5088
E-mail) rfsales@rfhic.com

USA Office
Tel) 919-710-1645
E-mail) samkim@rfhic.com

RFHC
www.rfhic.com



bridge on Saturday mornings, returning it on Sunday nights. This way I was able to tune filters on the weekend and it didn't cost me anything. That's how poor I was.

So the guy [from GTE] came in and I had my family members sitting around at tables [workstations] in the back, looking like they knew what they were doing. And we sat up front and talked. I had made up this control manual that showed how I was going to run the company. He looked through that and said it looked good, and then he said, 'let me see the rest of your factory.' Well the factory was essentially 1200 square feet of empty warehouse. But what I had done was put lines on the floor, marking off different spaces with tape. 'This is where my stock room is going to be and this will be my assembly room—all marked with yellow tape on the floor, and this is my test station, my QC, this is where we're going to do the machining, etc.'

And so we walked across this literally empty space where the floor was marked into these areas. He must have thought I was crazy. That might have taken 20 minutes to walk around and then we went back up to the front desk and he said, 'Mr. Bernstein, this is a very, very big contract and an important contract for GTE. I don't think we can award this contract to you. I don't see much that you're doing here.'

Well, he must have seen my jaw drop, because he then said, 'On the other hand, Mr. Bernstein, I don't see anything that you're doing wrong. So I'm going to recommend that we approve you for this contract, but I'm going to come back in six months and I want to see this machine shop there and that stock room there.' And so I've told people to this day, that everyday I went to the building, I operated as though he was going to come back to make sure that I did what I said I was going to do. And that's been the basic principle behind our success. He never came back, but he didn't need to. And we had many other good breaks.

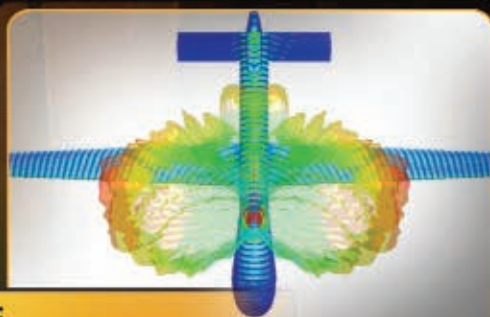
BASEMENT BEGINNINGS

While Bernstein created K&L by leveraging his experience at I-Tel and Texscan with his awareness of an untapped but trainable labor pool in Salisbury and the belief that the electronics industry could operate more efficiently, Manny Assurian leveraged his experience of running a small business with an opportunity to get his hands on the equipment needed to launch his own venture.

Manny Assurian: I had an employment contract with Cir-Q-Tel that prevented me from competing with them directly for one year. Well, I had found this guy who was selling his company. He wanted to retire and he had enough of the necessary equipment in his basement to start a filter company, but this wasn't a filter company. So I went and talked to him and saw that he had lathes, a small mill and some test equipment. I thought—this would be perfect to do filters. So I bought all the equipment in his basement and for one year I started advertising in a local telephone book that I would do any small machining job, build cables, or anything electronic—just to survive until I could get back into the filter business.

Jim Assurian: The business Manny bought was making harnesses and boxes for the weather bureau and this gave Reactel a product to sell while they [Manny and Don] geared up for filters in 1980. I remember moving the equipment and materials from his place to our first windowless warehouse in Rockville. We bought his business because he had the rudimentary equipment that could be used to make filters (some electronic test equipment, some machine shop equipment and some assembly equipment). By no means was it the best, but it would do. Looking back on that equipment, it is laughable, but it got the job done (we do not throw anything out, it is all gathering dust in our current facility).

Manny Assurian: He was building a lot of components for



HFSS-IE

- 3D Method of Moments - Ideal for radiation and scattering studies
- Industry-standard HFSS user interface
- Automatic and adaptive mesh generation
- Ability to link HFSS and HFSS-IE projects



HIGH-PERFORMANCE COMPUTING

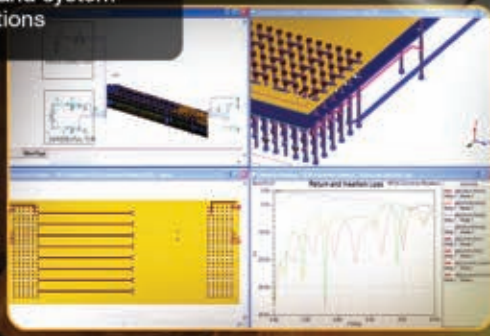
- Distributed Solve for fast, parallel parametric analysis
- HFSS HPC for large scale, 3D EM field simulation
- Multiprocessing for faster simulation throughput

HFSS®

THE GOLD STANDARD FOR
3D FULL-WAVE ELECTROMAGNETIC
FIELD SIMULATION

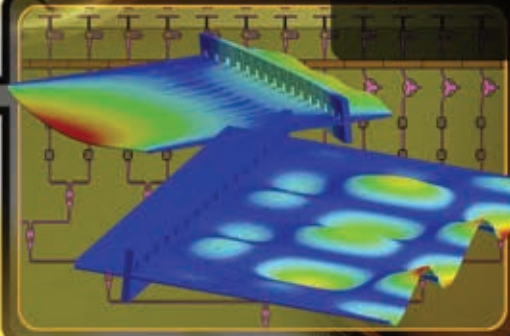
ECAD INTERFACE

- Planar (layout based) front-end for HFSS
- Links to popular EDA layout for package and board simulations
- Add HFSS accuracy to circuit and system simulations



MULTIPHYSICS

- Direct links to ANSYS Mechanical
 - Thermal
 - Stress
 - Vibration
- Coupled EM-Mechanical analysis



HFSS™, the gold-standard simulation tool for 3D full-wave electromagnetic field simulation, has raised the bar! New high-performance computing (HPC) and HFSS-IE capabilities allow you to perform parametric studies and solve large-scale simulations fast. The new ECAD interface delivers the accuracy and power of HFSS directly from the layout based Ansoft Designer® interface creating an ideal platform for signal integrity analysis. New links with ANSYS® Mechanical provide a full-featured environment for multiphysics studies. HFSS can help you raise the bar on your RF, microwave and high-speed electronics competitors.



ANSYS Product Suite

ansoft.com



certain radar markets, but they were older systems like World War II and weather radar vintage. So in 1979, we did those wire harnesses for NOAA – National Weather Service, because the equipment that we now owned and the sample materials he had sold me were for that market. He also introduced me to his contacts there, so there

was some existing business, but we basically did whatever work we could find.

Then as the one year non-compete approached, I started advertising for microwave components such as semi-rigid cables, and I got a call from a company in Virginia. I think it was Atlantic Microwave. They needed a lot of semi-

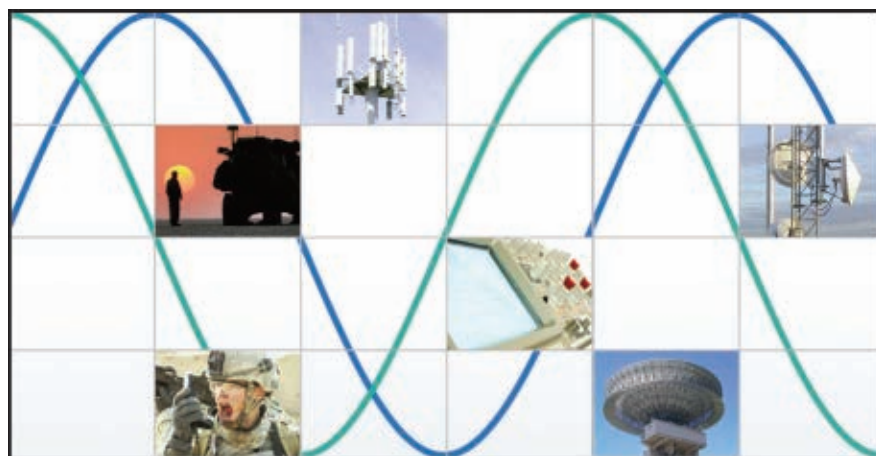
rigid cable and asked if I could make it. So I said 'of course I could, I'm an expert!', although I had never made a cable in my life.

I went to visit them and they showed me their boards and the drawings for the cables they needed and then I noticed that they were using K&L filters. It's almost one year after leaving I-Tel. I mentioned something about the filters in his design and I told him, 'I can make those.' This guy said, 'nah, nah, nah, you can't make these. These are very sophisticated filters.' So I told him to 'give me the most difficult filter that you have and I'll make you a set.' I went back [to Reactel], and at the time I didn't have any test equipment that went up to that frequency. So I went to a junk house and bought a Texscan sweep generator and made this filter to the spec.

I took it to him and we hooked it up and he was impressed how well it worked. So I told him I could do the rest of them too and I got the job, which included all the K&L filters and all the semi-rigid cables that went with it. And that's how I got back into filters, but this time with my own business. After the year was up, I placed my first advertising in MSN, *Microwave System News* and it said "Manny's back," call this number. Oh boy, and the calls I got. By 1980, we were back in the filter business and what is considered our first "official" job was a nine unit order from COMSAT totaling \$1086.00.

K&L GROWS AND IS ACQUIRED

Dick Bernstein: We started our business in 1971, when there was a recession going on. Most companies were cutting back and dropping their advertising dollars. I was running a brand new company, and perhaps I didn't know any better, but I kept advertising and would go out on the road to meet customers. When things eventually turned around, who did these companies remember? It was the last guy they heard from. So K&L was able to get ahead of our competitors. K&L's growth tracked the



High Precision Oscillators

Featured Products

OCXOs

	PRODUCT SERIES	OUTPUT	SUPPLY VOLTAGE	TEMP.	FREQUENCY RANGE (MHz)	POWER (dBm)	MAXIMUM STABILITY	OPERATING TEMPERATURE	PHASE NOISE FLOOR (dB/Hz)
Ultra Stable OCXOs	VFOV100	CMOS/SINE	3.3V 5.0V 12.0V	0°C	5MHz - 120MHz	1.0W	±10ppb	-40°C to +85°C	-155
	VFOV110	CMOS/SINE	5.0V 12.0V	0°C	25MHz - 135MHz	1.2W	±200ppb	-40°C to +85°C	-174
	VFOV200	CMOS/SINE	3.3V 5.0V 12.0V	0°C	5MHz - 250MHz	1.0W	±2ppb	-40°C to +85°C	-180
	VFOV300	CMOS/SINE	5.0V 12.0V	0°C	5MHz - 100MHz	1.25W	±0.5ppb	-30°C to +70°C	-185
Mini-Miniature, Ultra Low Power OCXOs	VFOV400	CMOS/SINE	3.3V 5.0V	0°C	5MHz - 250MHz	0.12W	±5ppb	-40°C to +85°C	-185
	VFOV500	CMOS/TTL	3.3V 5.0V	0°C	30MHz - 120MHz	0.12W	±20ppb	-40°C to +85°C	-160
Small Low Power OCXOs	VFOV600	HCMOS/TTL	3.3V 5.0V	0°C	10MHz - 100MHz	0.6W	±100ppb	-30°C to +70°C	-175
	VFOV850	HCMOS	3.3V 5.0V	0°C	10MHz - 100MHz	0.6W	±10ppb	-40°C to +85°C	-185

Please visit <http://www.valpeyfisher.com/MWJ0511.html> for our full line of High Precision Oscillators.



IEEE IMS2011 Baltimore
Booth #1633



Scan QR code with your smart phone

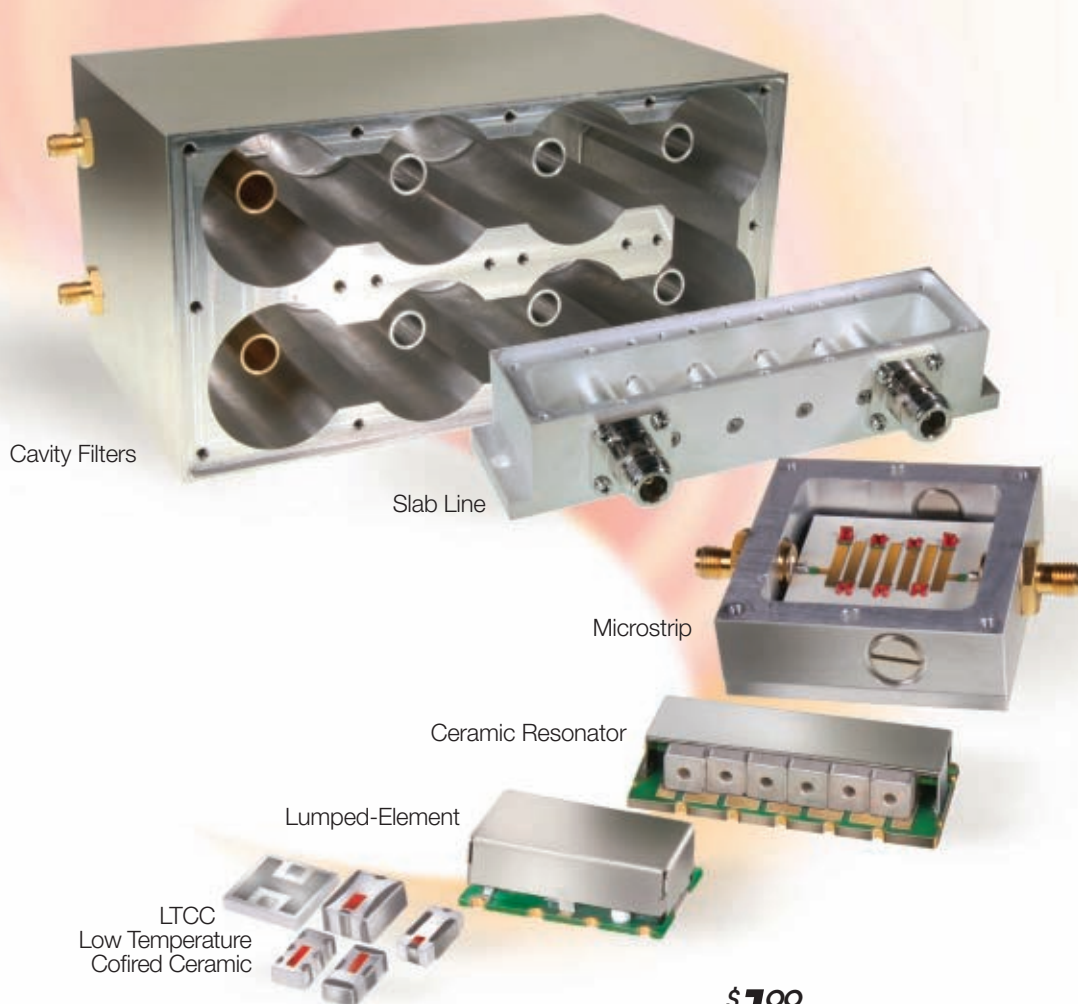


Valpey Fisher Corporation

75 South Street, Hopkinton, MA 01748 • 800-682-6737 • www.valpeyfisher.com • sales@valpeyfisher.com

FILTER SOLUTIONS

DC to 15 GHz



Over 300 Models *IN STOCK* ... Immediate Delivery! from **\$199** ea. 10-49

Different needs demand different technologies, and the Mini-Circuits RF/microwave filter lineup delivers. Over 300 proven solutions, from DC to 15 GHz, are standing by, ready to ship. High-pass or low-pass, band-pass or band-stop, in coaxial, surface-mount, or plug-in packages. Across the board, our filters achieve low insertion loss and low VSWR in the passband and high attenuation in the rejection band. Just go to minicircuits.com for more information. If you need a specific performance and want to search our entire model database, including engineering models, click on Yoni2, our exclusive search engine.

In Yoni2, you can enter the response type, connection option, frequency, insertion loss, or any other specifications you have. If a model cannot be found, we understand the sense of urgency. So contact us, and our engineers will find a quick, cost-effective, custom solution and deliver simulation results within a few days.

Yoni2® The Design Engineers Search Engine...
U.S. patent 7739260 finds the model you need, Instantly.

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

Mini-Circuits®
ISO 9001 ISO 14001 AS9100 CERTIFIED

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661 • For detailed performance specs & shopping online see

minicircuits.com

IF/RF MICROWAVE COMPONENTS

See us at MTT-S Booth 1031

484 Rev. Orig.



industry and general economic ups and downs over the years, but we really outpaced everyone else in our level of growth.

When I started K&L, I was the engineer. But after awhile, I realized I could hire engineers who were a lot smarter than me. I wanted to stay close to the market and so I'd hire the right engineers. That way,

I could shift my focus and run the business as a business. To do that, I brought in the people I needed to help me satisfy the customer requirements and that's how we were able to grow.

At K&L, I liked to think of ourselves as being on the leading edge of technology, not the bleeding edge of technology, meaning

that we were not trying to create new markets. We were trying to understand new markets and adapt to them. One of the reasons we looked to be part of a bigger company was to have somebody that could help us with the broader vision. And Dover as a parent company made a lot of sense for us.

Dover is a great company. The deal we made with them allowed us to continue with what we were already doing and wanted to accomplish. We were approached by several large microwave companies. The reason I liked Dover is that they weren't in the microwave business. That told me that they needed our people to continue to grow what we had already started. And that made our people feel more secure.

K&L SPROUTS SEVERAL START-UPS: SALISBURY ENGINEERING AND FILTRONIC COMTEK

MWJ: Tell us about Wayne Barbely and Salisbury Engineering.

Dick Bernstein: Wayne Barbely was working at Wallops Island [Command and Data Acquisition Station] out of NOAA. Wayne was a very good engineer. At the time we were building varactor tuned filters and we had hired Wayne and another engineer to work on these. Back then we had to get our production out of the way to meet our payroll and cash flow. So the way I worked the company was to take the first two or three days of the week and have everyone working on achieving that goal. Then after that, engineers could work on new projects and developing stuff. We needed Wayne to get stuff out the door. He didn't like that approach, so eventually he left and started Salisbury Engineering. Wayne wanted to get into what we were doing, but in his own way. So Salisbury Engineering was founded; that was in 1983. We had other people who had left to start businesses in California, but he was the first person to leave K&L to start something new in Maryland.

Wayne ran a different type of company than I did. I think there

Microwave components from Herley General Microwave

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 free 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



Proven Microwave Performance

www.herley.com

Herley New York • 227A Michael Drive, Syosset, NY 11791
Telephone: 516-802-0900 • FAX: 516-802-0897 • E-mail: sales.newyork@herley.com

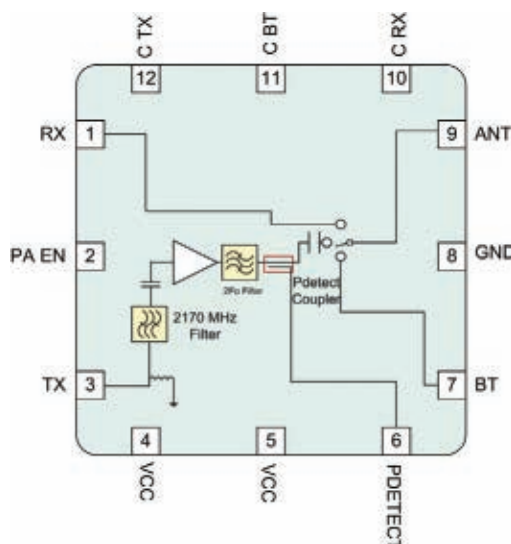


RFMD's line of high-efficiency 2.5 GHz front end modules (FEMs) offer higher linear output power and high levels of integration for reduced component count. These FEMS are optimized for a wide range of high-performance WiFi applications including mobile devices, consumer electronics, SmartEnergy, and much more. These front end products are specifically designed to address the need for aggressive size reduction in a typical 802.11b/g/n front end design and offer a reduced footprint and minimized component count outside of the core chipset.

SPECIFICATIONS

Part Number	Architecture	Freq (GHz)	Gain (dB)	Avg P _{OUT} (dBm)	EVM %	V _{CC} (V)	Current at P _{OUT} (mA)	Package Style	RoHS Comp Pb Free
RF5365/75	2.4 GHz FEM, PA, SP3T SW, and P _{DET}	2.4 to 2.5	27	18	3.0	3.0 to 4.8	170	QFN 2.5 x 2.5	Y
RF5385/95	2.4 GHz FEM, PA, SP3T SW, and P _{DET}	2.4 to 2.5	27	20	3.0	3.0 to 4.8	190	QFN 2.5 x 2.5	Y

Order RFMD products online at www.rfmd.com/MWJ0511.



RF5365/RF5375 (mirror image)

- PA, LPF, SP3T
- 18 dBm at 3.0%
- 2.5 x 2.5 x 0.5 mm

RF5385/RF5395 (mirror image)

- High Power PA, SP3T
- 20 dBm at 3.0%
- 2.5 x 2.5 x 0.5 mm

For sales or technical support, contact your authorized local sales representative (see www.rfmd.com/globalsales).

Register to receive RFMD's latest product releases with our Email Component Alerts at www.rfmd.com/emailalert.

7628 Thorndike Rd., Greensboro, NC 27409-9421 USA • Phone 336.664.1233



These products comply with RFMD's green packaging standards.

RFMD® is a trademark of RFMD, LLC. All other trade names, trademarks and registered trademarks are the property of their respective owners. ©2011 RFMD.

See us at MTT-S Booth 1402



are essentially two types of companies. I try to grow the business and in doing that I bring up other people and eventually they replace me and that's how we grow. This was something I recognized was missing when I worked for Wainwright, which meant I could only go so far at I-Tel. Manny saw that as well, which is why he even-

tually left. The only way you can grow is to leave, unless you are happy with your position in that company. Likewise, Wayne wasn't happy with our approach at K&L and left to do things his way. Salisbury's approach was for management to maintain strong control of sales and engineering. This worked well for Wayne.

MWJ: *Well, there are a lot of companies in our industry that are happy with being a certain size. They make good profit year after year and they don't want to mess up the formula.*

Dick Bernstein: That's true, and it works for some people. I prefer to have the challenges that come with trying to grow a business than the challenges of trying to maintain a certain size. In the end, Salisbury's strategy worked for them.

Carl Sheffres, Microwave Journal: *Wayne told me he never wanted it to get too big. He figured out what he needed to do to make about the same amount of money every year.*

According to public record, Salisbury Engineering earned approximately \$4 M in 2004, the year they were acquired by Spectrum Control.

MWJ: *Spectrum bought two companies with Maryland produced filter roots: Salisbury Engineering in Salisbury and FSY in Columbia. And API Technologies just acquired Spectrum Control for about \$270 M. But going back to the topic of K&L spin-offs, how did Comtek come about?*

Dick Bernstein: Dr. David Chambers worked for Professor Rhodes of Filtronic in the UK. Rhodes was a pure genius who approached everything from a theoretical perspective, including business. He would visit me at the shows and congratulate me. He would ask 'how do you guys do this stuff.' That is, being so well known in the filter business without many engineers or PhDs. I told him that our approach is based on the belief that ultimately, the low cost producer was going to win. The competition was no longer just across the street or across the state but all over the world, and our job was to take customers orders and deliver the product in the shortest time possible at the lowest possible cost. Well, Professor Rhodes had a different philosophy. He was able to go beyond the filter and integrate these complete systems.



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




www.pivotone.com

We are ready to work with you!

Pivotone specializes in designing, manufacturing and selling RF & microwave components, device and module products for communication systems.

See us at MTT-S Booth 941

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



**Learn more about
J. David Rhodes,
Engineering Emeritus Professor
University of Leeds, UK
Visit www.mwjjournal.com to read this
in-depth interview.**



In the mid-1980s David Chambers joined K&L as our Senior Engineer and helped take us to the next level. He's what I call an engineers' engineer. All of a sudden my other engineers could learn from him. We had been using University of Maryland professors to come in and teach some microwave networks theory, but when he (Chambers) came on board everyone gravitated toward him. He became their mentor.

And Dave used to tell me that it was amazing what we were able to accomplish with so few engineers, which he meant to be a compliment. And I would kid him back by saying that's why we had been so successful. But he understood where I was coming from, and he did help us get to the next level, handling the more sophisticated stuff as our market grew from production oriented to more engineering oriented. And this was from 1983 through the early 1990s. David stayed with me through that period of time, and then when I left the company there was a change in management.

THE COMMERCIAL WIRELESS EXPLOSION

Kevin Bernstein: You have to understand what was happening at the time. K&L was positioned squarely in the defense market and we would see these requirements for ridiculous quantities at ridiculously low prices and our natural reaction was 'impossible.' Rhodes understood what was happening and believed in it. Prices were just dropping. Things we would sell for \$800 to \$1,000, people were demanding \$300 or \$400. We would tell them no way, but they would tell us they were getting it from a new type of supplier.

Dick Bernstein: At that time our business was 90 percent defense, small quantity high mix of products. The cellular business represented high quantity, low mix products. And that was something we didn't see coming. It was a more sophisticated kind of product. Filtronics filled that void; they



We've condensed
all the power,
performance
and function of
our rack-mounted
amplifier systems
into a highly
compact package



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.

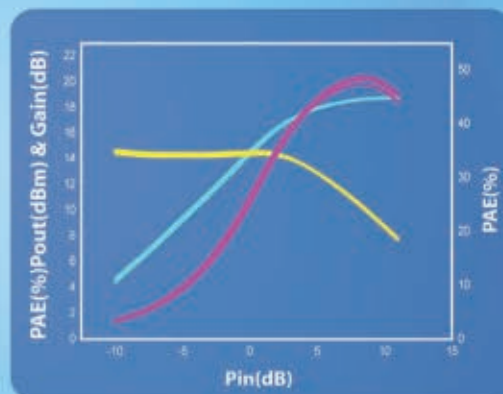
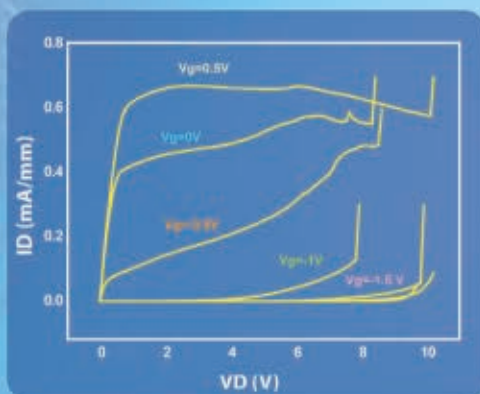
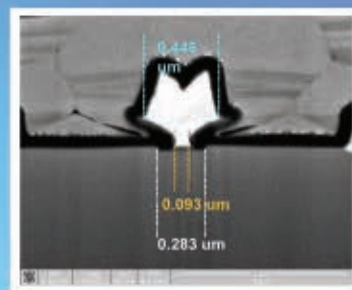


105 Baylis Road, Melville, NY 11747 • Tel: (631) 777-8900
Fax: (631) 777-8877 • www.comtechpst.com

0.1 μ m GaAs pHEMT Technology

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

- 0.1 μ m gate length of pHEMT technology
- 10V off-state BV for power application
- Single recess for high performance
- 500 mW/mm output power of 3.5 V @ 29 GHz
- 450 pF/mm capacitor for design flexibility



Comparison of WIN's millimeter wave pHEMT technologies

	PP-15	PL-15	MP-15	PP-10
V_{to} (V)	-1.2	-0.7	-0.8	-0.9
I_{dss} (mA/mm)	500	260	400	460
I_{dmax} (mA/mm)	650	500	600	660
GM (mS/mm)	495	550	700	700
VGD (V)	10	9	12	10.5
f_T (GHz)	85	95	105	128
F_{max} (GHz)	180	160	180	180
P_{1dB} (mW/mm)	670 (5V)	242 (3V)	--	380 (3.5V)
P_{sat} (mW/mm)	820 (5V)	312 (3V)	--	500 (3.5V)
Gain (dB)	11	12.6	--	14.6
PAE (%)	50	39	--	47

See us at MTT-S Booth 810

GaN Transistors
from
M/A-COM Tech

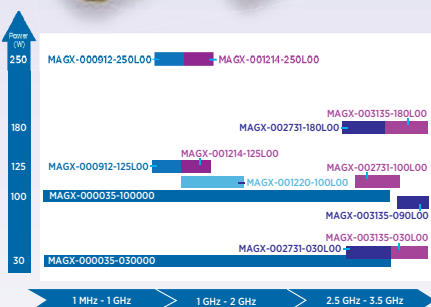
THE ULTIMATE POWER ZONE



S-band and L-band
radar



S-band and L-band
radar



GAN TRANSISTORS

Broadening our leadership in high power semiconductors

M/A-COM Tech GaN on Silicon Carbide high power devices target applications from HR communications to L- and S- band radar. Our products exhibit excellent RF performance over multiple octave bandwidths.

To learn about all our products and capabilities, visit
macomtech.com



were focused on that kind of market.

Kevin Bernstein: When you look at how Comtek started in Salisbury, it was really a combination of some personalities, and market changes. Rhodes knew it was time to invest in the commercial business and David lived in Salisbury, and he was a visionary and knew where the business was headed. Rhodes also knew which way it was heading. For practical guys like us, we would say there's no way that's going to happen.

Jim Assurian: I couldn't believe how big they were, they were huge. At the time, we were both using the same silver plater. Reactel would have a hot job and I'd drop off a handful of units when this truck from Filtronic Comtek would back in. They began unloading pallets, while I've got a box of about five cavity filters that I needed right away and I was going to wait for them to be plated. It was a go-go time for those guys.

Kevin Bernstein: Same for us. They would get some parts machined at the same machine shop that we used. I'd go in there and they would have all the machines dedicated to Comtek and they weren't interested in doing our stuff. I was having trouble using our own machine shop. It came about because they had a vision of the market that wasn't understood at the traditional defense businesses.

In 1994, demand for the company's filters used in cellular base stations was booming. Filtronic Comtek, a division of Filtronic Comtek PLC England, had 110 employees on the Eastern Shore and expected to add another 200 after the construction of their 62,500-square-foot, \$4 M headquarters and manufacturing center in Salisbury.

Dick Bernstein: Professor Rhodes bought one or two companies, he bought a circulator company, had a company up in Scotland, a foundry that made

their integrated circuits, and they were publicly financed in the UK. I remember meeting some of the board members; they didn't have much tolerance for losing money. But they had fantastic growth.

Manny Assurian: At that time [early 1990s] the commercial market really took off. They were selling stuff for much less and we would scratch our heads trying to figure out how they did that. And that's when I came up with the idea to see if I could get my labor costs down since the most money that you spend on a filter is the manual labor for tuning. So I figured if I can get it to the point where anybody could come in here and learn this skill in a week, I could get lower wage earners. So we developed a methodology to tune filters and I was able to reduce my labor costs.

Dick Bernstein: In the defense market the customer pays for the R&D, so you get a higher mark up because your costs are higher. In the commercial business you have to go with the 1000 piece price that is set by the market. So you're taking all the development cost on your chin and you're at risk. And what happens when they do that? Well, take a look at everything that's going on in the commercial business. Where is it being done today? It's being done offshore and they're chasing lower labor dollars constantly. So that's what happened to Comtek. Eventually it went off to China, because that's the big market. And you have to be in China today to satisfy that cellular business.

Manny Assurian: Even K&L went to China [under Motorola's insistence], but they didn't do very well. But then it was all based on Motorola business. Later, I was congratulating K&L at one of the shows and they told me that they had to shut it down. Although they were making the parts there, they needed them at a Chinese price. The price had dropped from \$400 a unit down to \$150 a piece. And there was no way they could do that, so they had to shut it down.

POWER



M/A-COM TECH AMPLIFIERS

Supporting the demanding requirements of military, consumer and industrial applications.

Part Number	Frequency (GHz)	Gain (dB)	P1dB (dBm)	IP3 (dBm)	NF (dB)	Supply Voltage	Package Style
Power Amps							
MAAP-008923	2.5 - 5.0	33.0	30.0	44.0	—	+6/-1.0	5 mm PQFN
MAAP-008924	10.0 - 13.3	27.0	31.0	43.0	—	+6/-1.0	5 mm PQFN
XPT039-QJ	5.6 - 7.1	16.5	34.5	49.0	—	+7/-1.0	6 mm PQFN
XPT050-QJ	7.1 - 8.5	15.0	33.5	48.0	—	+6/-1.0	6 mm PQFN
XD1008-BD	0.003 - 40	15	22.5	38.0	3.0	+7/-2.5	Die
Driver Amps							
MAAM-009286	250 - 4000	15.5	27.0	42.0	3.5	+5.0	SOT-89
MAAM-009560	250 - 4000	14.5	28.5	40.0	2.7	+5.0	SOT-89
MAAM-009563	250 - 3000	19.5	31.0	47.0	6.25	+5.0	SOIC-8EP
XB1007-QT	4.0 - 11.0	23.0	19.0	31.0	4.0	+4.0	3 mm QFN
XB1008-QT	10.0 - 21.0	17.0	18.0	32.0	4.5	+4.0	3 mm QFN

M/A-COM Tech provides one of the broadest portfolios of power and driver amplifiers in the industry. Designed for general purpose, infrastructure, point-to-point radio, defense, CATV, optical and other high performance RF and microwave systems, our amplifiers deliver optimum performance and rugged reliability.

M/A-COM Tech amplifiers feature:

- Operating bandwidths: 200 MHz to 40 GHz
- Output power: 0.1 - 12 Watts
- High linearity: OPI3 up to 45 dBm
- High reliability: MTTF \geq 1 million hours
- 3.0, 5.0 and 7.0 volt operation
- RoHS compliability

To learn about all our products and capabilities, visit macomtech.com

Power Amps and Drivers Amps from M/A-COM Tech

POWER

defense

broadband/CATV

communications

Part Number	Frequency (GHz)	Gain (dB)	P1dB (dBm)	IP3 (dBm)	NF (dB)	Supply Voltage	Package Style
Power Amps							
MAAP-008923	2.5 - 5.0	33.0	30.0	44.0	—	+6/-1.0	5 mm PQFN
MAAP-008924	10.0 - 13.3	27.0	31.0	43.0	—	+6/-1.0	5 mm PQFN
XP1039-QJ	5.6 - 7.1	16.5	34.5	49.0	—	+7/-1.0	6 mm PQFN
XP1050-QJ	7.1 - 8.5	15.0	33.5	48.0	—	+6/-1.0	6 mm PQFN
XD1008-8D	0.003 - 40	15	22.5	38.0	3.0	+7/-2.5	Die
Driver Amps							
MAAM-009286	250 - 4000	15.5	27.0	42.0	3.5	+5.0	SOT-89
MAAM-009560	250 - 4000	14.5	28.5	40.0	2.7	+5.0	SOT-89
MAAM-009563	250 - 3000	19.5	31.0	47.0	6.25	+5.0	SOIC-8EP
XB1007-QT	4.0 - 11.0	23.0	19.0	31.0	4.0	+4.0	3 mm QFN
XB1008-QT	10.0 - 21.0	17.0	18.0	32.0	4.5	+4.0	3 mm QFN

AMPLIFIERS

Supporting the demanding requirements of military, consumer and industrial applications

M/A-COM Tech high performance RF and microwave amplifiers deliver optimum performance and rugged reliability.

To learn about all our products and capabilities, visit macomtech.com



LORCH MICROWAVE

MWJ: So Dick, you mentioned leaving K&L, which eventually got you connected with Lorch. What's the story behind Joe Lorch and Lorch Microwave? What got you interested in purchasing them and returning to the filter business?

Kevin Bernstein: Joe came out of Empire Devices and started Lorch Electronics in the mid 1960s.

Manny Assurian: They didn't make filters; they were doing lots of combiners and loads.

Kevin Bernstein: Well, Joe did whatever was interesting to Joe. What I saw there were lots of mixers and phase shifters, IQ modulators, some filters but transformers as well. Early Lorch catalogs had everything under the sun. Joe sold the company around 1983 or 1984 to Vernitron, who moved it from New Jersey to the St. Petersburg [Florida] area and the company kept getting smaller and smaller and then they eventually sold it to Dad. That's when we moved it back up to Salisbury and we changed its focus to filters.

Dick Bernstein: I left K&L in the early 1990s and at that time my turn-over rate for people was extremely low. And when the new management came in, they began to cut back and replace people, so there were a lot of people on the street that had filter knowledge.

When I left K&L, I actually started a new company called BAI Aerosystems [BAI was later acquired by L-3 Communications in 2004]. We made Unmanned Aerial Vehicles (UAV) or drones. This company that I had just acquired only made airframes. They weren't making autopilots or guidance systems or anything like that. I thought we could make transmitters and receivers for a complete UAV guidance system using people who had knowledge in telemetry. So we started hiring these people who were out on the street. The job market was soft but their background [filter experience] was strong.

Meanwhile, K&L was laying off

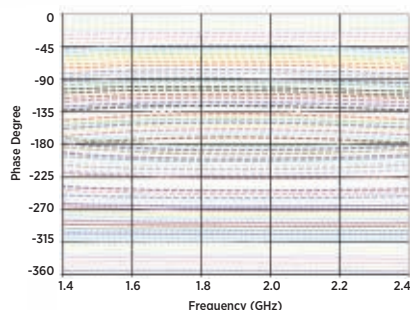
and people were looking for jobs, and I was approached by a business group to look at Lorch Microwave. They needed someone with knowledge of the products to step in and help them fulfill their contracts.

Lorch Electronics in Florida had taken this product line, and was struggling due to lack of continuity of key personnel from the original company in New Jersey. They tried many manufacturing models, including off-shore manufacturing, but they were unable to consistently maintain the expected quality levels. To this day, in microwaves you can't rely on the last build, because there are always some subtle differences in components. You need that guy (the technician) with the knowledge to figure out what the differences are in order to tweak it properly. I said I could acquire Lorch, but that I would have to move them to Salisbury where we were familiar with the available talent.

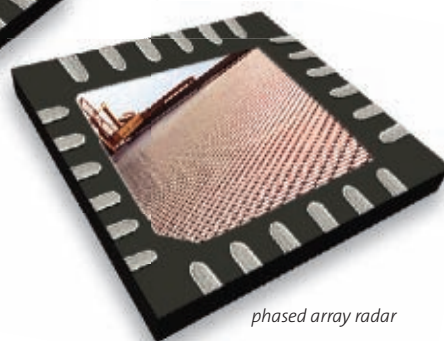
I looked at it, they made me a sweetheart deal, and so I acquired the company and moved it to Salisbury. We turned it into a great little company because I needed those products for the airplane business. It was there to support the electronic side of the airplane business. My non-compete with K&L was for five years. Lorch was acquired in 1994 and I had left K&L in 1989, so five years later I was able to acquire them and re-enter the filter business but with a different focus and objective. We relocated Lorch to Salisbury with about 10 employees.

Lorch Microwave is now part of Smiths Interconnect, which designs and manufactures RF components for the wireless telecommunications, aerospace, defense, space, medical, rail, test and industrial markets. From the Bernsteins' perspective, Smiths has been a great parent as the business has been able to maintain its traditional management philosophies, yet has the strength and support of a much larger global organization.

MORE ACCURACY



high gain antenna



phased array radar

M/A-COM TECH PHASE SHIFTERS

Extending our leadership in high accuracy semiconductors

Part Number	Frequency (GHz)	Function (dB)	Phase Range (degree)	Insertion Loss (dB)	RMS Phase Error (degree)	Gain Vibration (dB)
MAPS-010143	1.4 - 2.4	4-bit	22.5 - 360	3.2	2	± 0.5
MAPS-010144	2.3 - 3.8	4-bit	22.5 - 360	3.5	3	± 0.6
MAPS-010145	3.5 - 6.0	4-bit	22.5 - 360	4.5	3	± 0.7
MAPS-010146	8.0 - 12.0	4-bit	22.5 - 360	4.5	3	± 0.8
MAPS-010163	1.4 - 2.4	6-bit	5.625 - 360	5.0	5.2	± 0.8
MAPS-010164	2.3 - 3.8	6-bit	5.625 - 360	5.0	3	± 0.8
MAPS-010165	3.5 - 6.0	6-bit	5.625 - 360	5.5	3	± 0.8
MAPS-010166	8.0 - 12.0	6-bit	5.625 - 360	5.0	3	± 0.8

M/A-COM Technology Solutions digital phase shifters are fabricated using GaAs pHEMT technology. Our phase shifters provide a comprehensive set of solutions for active antennas, such as phased array for communications and radar.

M/A-COM Tech phase shifters feature:

- Integral CMOS driver
- Serial or parallel control
- Low DC power consumption
- Minimal attenuation variation over phase shift range
- 50 ohms impedance
- RoHS compliant 4 mm PQFN package

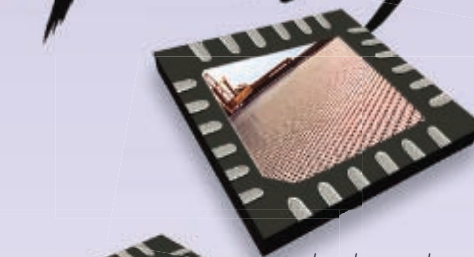
To learn about all our products and capabilities, visit macomtech.com

©2011 M/A-COM Technology Solutions Inc.

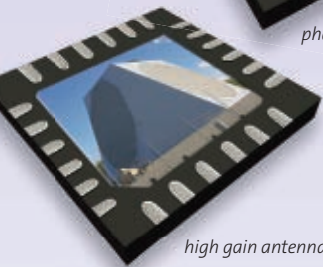
MACOM
Technology Solutions
THE FIRST NAME IN MICROWAVE

Phase Shifters from M/A-COM Tech

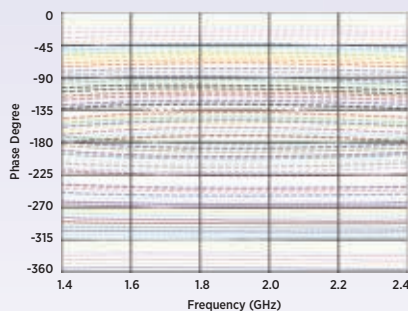
MORE ACCURACY



phased array radar



high gain antenna



6-bit L-band Phase Shifter: all phase states

PHASE SHIFTERS

Extending our leadership in high accuracy semiconductors

M/A-COM Tech phase shifters provide a comprehensive set of solutions for active antennas, such as phased array for communications and radar.

To learn about all our products and capabilities, visit
macomtech.com



THE MARYLAND FILTER LEGACY

Kevin Bernstein: In Salisbury, the two big spin-offs were Salisbury Engineering and Comtek, but there were all kinds of permutations after that. You had people that were at K&L that went to Comtek, and then we brought Lorch into Salisbury, so people were going from K&L to Lorch. People like Gary Ennis left K&L and Lee Mason left Filtronic and started ClearComm in 1997. ClearComm saw a niche in the market among the 2nd and 3rd tier carriers for orders of less than 1,000 parts that K&L or Comtek weren't interested in supplying. So they started knocking on doors and were able to establish a business there.

There was also RelComm. That's the company that John Tinkler started after he left K&L. In 1993, K&L acquired the switch line from Transco in Camarillo, CA. RelComm Technologies was established in April 1994 in Salisbury. RelComm designs and manufactures custom (design enhanced application specific) RF coaxial relays for telecom infrastructure, MILCOM systems as well as test instruments. In 1996 Dow-Key was acquired by K&L Microwave/Transco under the umbrella of Dover Technologies. Dover felt that Dow-Key had the stronger position in the switch market and all production was moved to Ventura, CA.

There is also Eastern Wireless Telecom (EWT) that was spun off from Lorch in 2000 by my cousins, Kerry and Bryan Bernstein. EWT specializes in custom filters and filter based products for military, commercial, wireless and space applications. All those people worked at K&L at some point. Cir-Q-Tel and Reactel also spawned their share of spin-offs.

Manny Assurian: In 1983, three people (Bill Forrestel, Roland Siushansian and John Yania) who I hired during my time at Cir-Q-Tel (and two of whom worked for us a little at Reactel) left to start FSJ Microwave as a company that designed and manufactured filters and multiplexers. Neither Bill,

John or Roland were involved in electronics at all when I first hired them at Cir-Q-Tel, but eventually they all moved through the ranks to the point that they decided to go out on their own. FSJ eventually got bought by Spectrum Microwave (Siushansian is retired, Yania still works for Spectrum as a Business Development Manager, and Forrestel now works for Aeroflex Weinschel in Frederick, MD as the Director of Subsystems Engineering). While one could debate whether FSJ was truly a spin-off from Reactel, our first "official" spin-off was ES Microwave.

Spectrum Microwave originally evolved under the direction of Spectrum Control's CEO Richard Southworth, leveraging their expertise in RF and microwave ceramic filter and antenna technologies. The division's initial strategic acquisitions in 2002 were FSJ Microwave and Salisbury Engineering; both companies were leaders in their own right. In July 2002 Spectrum paid \$6.5 M to pick up FSJ Microwave Inc. At the time it was purchased the production and R&D facilities in Columbia, MD totaled 45,000 square feet.

My nephew Sargon Assurian and a technician we had at Reactel left to start Eastern Multiplexers in 1991. In 1996, that same nephew left EM and together we started ES Microwave. ES Microwave concentrates mainly on suspended substrate filters, multiplexers and switched filter banks.

MARKET DRIVERS TODAY

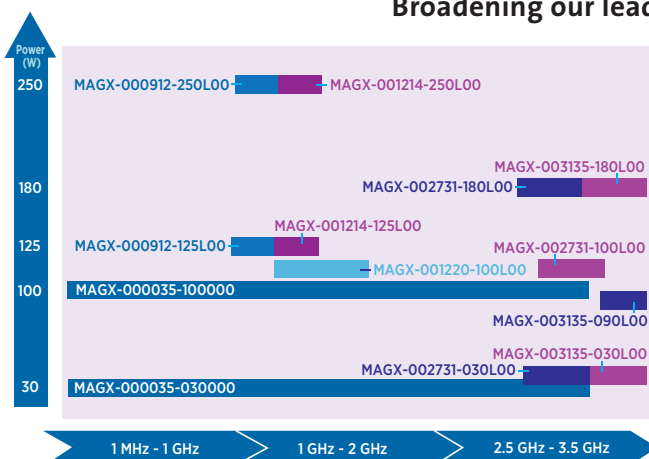
MWJ: *It seems that certain events come along over time and propel the industry forward, such as radar in World War II, the Cold War, Vietnam War, weather radar, NASA, commercial telecom and wireless communications. And that pushes the need for smaller, lighter and less expensive solutions. So looking at where we are today, what do you see pushing the industry forward?*

Dick Bernstein: When this country was building its [telecom-



M/A-COM TECH GAN TRANSISTORS

Broadening our leadership in high power semiconductors



Leveraging our rich heritage of providing standard and custom solutions for demanding requirements, M/A-COM Technology Solutions GaN on Silicon Carbide high power devices target a wide spectrum of applications from HF communications through L- and S-band radar. Our GaN transistors and higher level pallet amplifiers are powered by a leading-edge proprietary 0.5 micron HEMT design and exhibit excellent RF performance over multiple octave bandwidths.

M/A-COM Tech GaN products feature:

- Superior efficiency; excellent thermal properties
- High breakdown voltage with excellent load mismatch tolerance
- Small, compact form factor

To learn about all our products and capabilities, visit macomtech.com



munications] infrastructure, they were digging trenches and laying cables underneath the ocean. Now anybody in Indonesia or Somalia has a cell phone and they need their own infrastructure. That's where the future market is going to be. That's what Professor Rhodes did so well, and so he set his company up as an integrator

and created a new type of filter company. But the cost needs to be so cheap today compared to what it was, and that is where the challenges are. I also think you're going to see the next big opportunity in automotive, where you'll have tracking and cars will be another mobile wireless device and people will get their e-mails on the

dashboard and have full access to the Internet.

MWJ: *Hopefully the driver is watching the road. But, what you are describing sounds like a high volume, cost driven market. Has Maryland become the center of the universe for custom microwave parts and does chasing that business restrict growth for such companies?*

Kevin Bernstein: It doesn't restrict our growth when it comes to the defense market, but it definitely restricts our growth in telecommunications. And the two markets don't really converge; we don't see custom parts working their way into high volume markets.

MWJ: *It seemed like years ago, businesses could cycle back and forth between the defense or commercial markets based on whichever one was stronger at a given time. Eventually companies seemed to have settled into serving one or the other markets.*

If those markets don't converge, do you ever see custom shops shifting back from defense to commercial markets in the future?

Jim Assurian: You can't put a square peg into a round hole. We may not have a period of phenomenal growth like a high volume, commercial based business would, but few of those guys are making money these days. We have steady growth. We have been around for 32 years and have seen all business cycles and we're still here. People will always need what we provide. We also don't have a problem with a part becoming obsolete. We have buyers come up to us with old catalogs and we're able to supply them with old parts because we have all the old drawings, the bill of materials and the know-how.

People do come up to us and ask, 'what new things are we presenting to the market?' But we're more driven by the market. We respond to market needs, such as making a smaller filter or using a different type of connector. Someone comes to us with a unique requirement and we're going to develop something explicitly for him, but he's going to

TCX



T1215

Frequency 10 - 800 MHz
Attributes Hermetic Pkg.
 High Shock & Vibration
Best Stability ± 0.3 ppm
Output CMOS, Cl. Sine, LVPECL
Size 9.0 x 7.0 x 2.8 mm
 0.35 x 0.28 x 0.11 in., SMT



T75

Frequency 10 - 50 MHz
Attributes Tight Stability
 High Shock & Vibration
Best Stability ± 0.3 ppm
Output CMOS, Clipped Sine
Size 7.0 x 5.0 x 2.5 mm
 0.28 x 0.20 x 0.10 in., SMT



T53

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

Innovation On Display.

Greenray's comprehensive range of TCXO products are designed for communications, instrumentation, and military applications, and feature temperature stability performance of 1ppm or less, from 1Hz to 1GHz.

Greenray TCXOs are available in a variety of packages, including miniature DIP, ceramic, SMT, MIL spec, as well as industry-standard sizes.

Greenray's stringent materials, assembly, test and quality assurance protocols satisfy the rigorous requirements of defense contractors and commercial customers alike.

Visit us at the IMS2011 MTT-S Show and see what 50 years of engineering excellence can do for you.

Booth #3712



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

New Product Releases



Long Life Switch

- *DC to 26.5 GHz
- *SMA Connectors

*Operating Life: **5,000,000** cycles
 *Operating Temperature: -25C to +65C ambient



High Power Switch

- *DC to 5 GHz
- *Peak Power: 50 kw

*Operating Life: 1,000,000 cycles
 *Operating Temperature: -35C to +85C ambient
 *Average RF Power up to 3 kw
 *SC Connectors



Switch Matrices

- *Modular Design

*Common Control and Command Protocol
 *Flexible system architecture
 *Compact physical format

Standard Product Configuration



SPDT



Multi Position



Transfer

Operating Modes

- *Status Indicator
- *Logic Interface
- *Failsafe Option
- *Latching Option

Ducommun Technologies

Products to Solutions

Servicing all RF to Microwave Needs

Ducommun Technologies RF Product Group has over forty years of design and manufacturing experience with coaxial switches and switch matrices. Our broad suite of products, support critical applications across multiple markets including defense, testing equipment, avionics, communications, industrial and medical applications.

To discuss you applications, contact our RF coaxial switch engineers at (310) 513-7256.

Come visit us at the Microwave for the World IMS2011 convention from June 5-11 at booth 404 for further service and product inquiries.



Available Options

- *Frequency Range: DC to 40 GHz
- *Temperature Range: -25C to +65C
- Ruggedized: -55C to +125C
- *Switching time: 15 ms (typical)
- *High power option

RF Connector Options

- *SMA
- *K
- *BNC
- *SC
- *Other options available
- *3.5 mm
- *TNC
- *N
- *Mini SMB

Ducommun Technologies

www.ducommun.com/mmwave
rfsales@ducommun.com : (310) 847-2859



be the only guy who needs that part and he'll be the only guy we sell that part to and he'll come back to us for as long as he needs that part. That's the custom business. Therefore, I think there's always going to be the need for the custom guys.

Manny Assurian: Just the other day I got a call from a buyer. They wanted to know if a certain part was

still available. I told him of course it is. I understand why he would ask this question. If you look around, a lot of these companies have disappeared. Maybe because we make these simple boxes, although they are not simple inside, but we are reacting to what our customers tell us they need. So our customers, the system integrators may see larger

trends, but it's hard to decipher what direction the market is headed or what the next big thing will be based on our vantage point.

Kevin Bernstein: In the commercial telecom products, every OEM has the same electrical requirements, but people approach the problem in their own way, integrating different parts, optimizing the amplifier or the filter depending on their strengths and expertise. They all have their own formulas and there are infinite ways to address a need. And even with so-called standard parts, there still seems to be the need for a nearly limitless number of components built to infinite configurations, combinations of frequency bandwidths, connector types, etc. So that represents a relatively small but steady market and we're happy to fill that niche.

When customers talk about obsolescence, there's no such thing for us. We can make the same parts that we made 40 years ago. No problem.

YOU CAN'T TUNE A FISH

What Bernstein started in 1971 with K&L Microwave, today represents a community of more than 1,800 workers in Salisbury. In recognition, he has been awarded honorary doctorates from both the University of Maryland and Salisbury State University. Along with Manny Assurian, who extended the state's filter expertise with Reactel and the handful of spin-offs that he has inspired, these entrepreneurs are responsible for some remarkable accomplishments. Thanks to K&L Microwave's impact on the region, the industrial base of Maryland's Eastern Shore now contributes more than \$200 M aggregately to the local economy. To mix metaphors – You can give a man a fish and he will eat for a day, but teach him how to tune a filter and he just might be able to buy fish for a lifetime. ■

11:48 AM
Why not try a different approach before you head to lunch?

10:05 AM
Your first board is ready to test.

9:00 AM
Your circuit design is done and you're ready to make a prototype.

1:03 PM
Your second board is ready to test.

3:14 PM
After a few tweaks, you're ready to make your finished board.

4:09 PM
Your finished board is ready to go.

5:00 PM
Nice work. You just shaved weeks off your development schedule.

All in a day's work

ProtoMat® Benchtop PCB Prototyping Machine

What would your day look like tomorrow if you could cut yourself free from the board house and produce true, industrial quality microwave circuits on any substrate right at your desk? LPKF's ProtoMat benchtop prototyping systems are helping thousands of microwave engineers around the world take their development time from days and weeks to minutes and hours. In today's race to market, it's like having a time machine.

www.lpkfusa.com/pcb
1-800-345-LPKF

"You can't beat an LPKF system for prototyping. We do up to three iterations of a design within a day."

Leonard Weber
Agilent

LPKF®
Laser & Electronics

Best
of the...

JS Series Amplifiers



Features:

- Various Bandwidth
- Super Low Noise
- Small Footprint
- MIL883 Screening
- Quick Delivery

Model Numbers	Frequency Range (GHz)	Gain (dB, Min.)	Gain Variation (\pm dB, Max)	Noise Figure (dB, Max.)	VSWR IN/OUT	Power Out @ 1 dB Comp (dBm, Min.)	DC Power @ +15 V (mA, Nom.)
JS2-00100800-13-8P	.1 - 8	23	1.7	1.3*	2.3:1	8	175
JS4-00101000-21-10P	.1 - 10	31	1.6	2.1*	2.5:1	10	200
JS4-00101200-22-10P	.1 - 12	31	1.7	2.2*	2.5:1	10	200
JS4-00101500-23-10P	.1 - 15	30	1.8	2.3*	2.5:1	10	200
JS4-00101800-24-10P	.1 - 18	29	1.8	2.4*	2.5:1	10	200
JS4-00102000-25-10P	.1 - 20	29	2.0	2.5*	2.5:1	10	200
JS4-00102600-30-10P	.1 - 26	28	2.5	3*	2.5:1	10	200
JS4-00104000-54-5P	.1 - 40	30	3.0	5.4*	2.5:1	5	200
JS2-01000200-06-10P	1 - 2	34	1.2	0.65	2.0:1	10	225
JS2-02000400-05-10P	2 - 4	34	1.2	0.55	2.0:1	10	225
JS3-04000800-08-10P	4 - 8	35	1.2	0.8	2.0:1	10	195
JS3-04002000-19-8P	4 - 20	31	1.7	1.9	2.2:1	8	195
JS3-05001000-15-15P	5 - 10	28	1.3	1.5	2.0:1	15	200
JS4-06001800-15-10P	6 - 18	34	1.8	1.55	2.2:1	10	200
JS4-08001800-15-10P	8 - 18	34	1.6	1.55	2.0:1	10	200
JS3-12001800-14-5P	12 - 18	27	1.5	1.4	2.0:1	5	200
JS4-12002600-24-10P	12 - 26	33	2.5	2.4	2.3:1	10	200
JS3-18002200-15-10P	18 - 22	26	1.3	1.5	2.0:1	10	150
JS4-18002600-22-10P	18 - 26	35	1.5	2.2	2.0:1	10	200
JS3-18004000-40-15P	18 - 40	32	2.7	4	2.6:1	15	400**
JS4-18004000-30-5P	18 - 40	23	2.5	3	2.5:1	5	200
JS42-18004000-31-8P	18 - 40	35	3.5	3.1	2.5:1	8	300
JS1-26004000-100-19P	26 - 40	17	2.5	10	2.5:1	19	400**
JS4-26004000-30-8P	26 - 40	23	2.5	3	2.5:1	8	200
JS42-26004000-31-8P	26 - 40	37	3.5	3.1	2.5:1	8	300
JS2-01200140-04-10P	1.2 - 1.4	34	0.7	0.45	1.8:1	10	225
JS3-17901920-14-10P	17.9 - 19.2	27	1.0	1.4	2.0:1	10	150
JS3-19202020-14-10P	19.2 - 20.2	27	1.0	1.4	2.0:1	10	150
JS3-20202120-14-10P	20.2 - 21.2	27	1.0	1.4	2.0:1	10	150
JS3-21002200-14-10P	21 - 22	27	1.0	1.45	2.0:1	10	150

*Above 800 MHz.

** Dual Voltage, -8V @50 mA.

For additional information or technical support,
please contact our Sales Department at
(631) 439-9220 or e-mail components@miteq.com



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

www.miteq.com

See us at MTT-S Booth 1909



IMS 2011 GENERAL CHAIR'S MESSAGE



The 2011 IEEE MTT-S International Microwave Symposium is in Baltimore this year with the venue being the Convention Center and hotels surrounding the beautiful Inner Harbor. The theme for IMS 2011 is *Microwaves for the World* with our emphasis on bringing together world experts who will be showcasing how our science, technology and profession have globally benefited mankind.

Since Baltimore last hosted the IMS in 1998, the Inner Harbor area revitalization has continued. The Convention Center is centrally located just a block from the Inner Harbor, assuring attendees of quick and easy pedestrian access to a multitude of restaurants, attractions and official IMS 2011 hotels.

In addition to Microwave Week's technical programs and exhibition, the main IMS events will be Monday evening's Plenary Session and Welcome Reception, Wednesday evening's Awards Banquet, and Thursday evening's Crab Feast. The Crab Feast is a

unique feature of IMS when it comes to Baltimore and should not be missed; however, space is limited, so buy your tickets early.

TECHNICAL PROGRAMS

Microwave Week is June 5th through June 10th this year. In addition to the International Microwave Symposium (www.ims2011.org) you will be able to participate in the Radio Frequency Integrated Circuit Symposium (www.rfic2011.org) and the 77th Automatic Radio Frequency Techniques Group Conference (www.arftg.org).

IMS 2011 is honored to have Professor J. David Rhodes deliver this year's Monday evening IMS Plenary Address, *Migration of 4G LTE into Existing Cellular Networks*, at 5:30 PM June 6th in the fourth floor Ballroom of the Baltimore Convention Center.

The IMS 2011 Technical Program Committee, under the leadership of Ramesh Gupta, Technical Program Chair, has assembled an outstanding international program. This year's Microwave Week

combined technical program consists of over 1000 technical presentations. IMS has many Special and Focus Sessions that highlight both the diversity and global reach of our profession. We have something for everyone, from emerging areas like RF Nanotechnologies to applied, life-saving, applications such as high-field-strength MRI. There are Workshops and Short Courses designed to educate and enlighten you in new areas of your profession. IMS is where it is at for continuing education as well as networking with colleagues from around the world. We also think you will be intrigued and fascinated by all of the student activities during Microwave Week. These future leaders of our profession and industry will be in Baltimore for Microwave Week.

EXHIBITION

The world's largest microwave industry exhibition is collocated

JEFFREY M. POND
IMS 2011
General Chairman



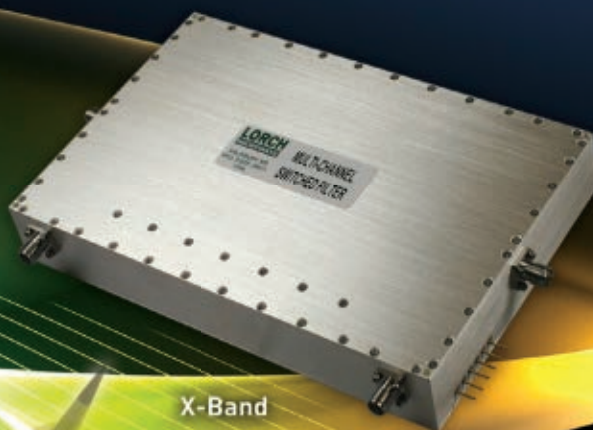
High Performance RF and Microwave Filters

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.



X-Band



Low Profile



High Power



LORCH
MICROWAVE

Salisbury, MD 21802 • USA • 800.780.2169 • 410.860.5100
Brackenholve Y08 6EL, UK • Tel/Fax +44 (0) 1757 633 755
www.lorch.com
See us at MTT-S Booth 1512

smiths
bringing technology to life



with IMS 2011. As I write this we are nearing 900 booths from nearly 550 exhibitors. Microwave Week is where you can quickly and easily connect with all the leading vendors of hardware, software and services within the microwave industry. In addition, we have an intriguing Historical Exhibit, which showcases both the evolution of our technology and its revolutionary impact on the world.

MicroApps continues to expand and improve with 56 different presentations on readily available state-of-the-art instrumentation, software and services. A new MicroApps feature for 2011 is a Panel Session on nonlinear measurements at noon on Wednesday. Please stop by the MicroApps Theater, prominently located on the exhibit floor, to learn from the experts.

Exhibition hours are Tuesday, June 7th 9:00 AM to 5:00 PM, Wednesday, June 8th 9:00 AM to 6:00 PM, and Thursday, June 9th 9:00 AM to 3:00 PM. On Wednesday, there will be the Industry Hosted Cocktail Reception on the exhibit floor starting at 5:15 PM.

VISITING BALTIMORE

Baltimore-Washington International Airport (BWI) is the most convenient airport for accessing Baltimore. We suggest the Light Rail line, which for less than \$2 will take you from BWI to the Convention Center and Hilton in about 20 minutes. Official IMS

2011 hotels are all within a short walk.

Baltimore in early June has an amiable climate and is a wonderful place to bring family and friends. We will have a family friendly hospitality suite in the Hilton and are putting together an innovative guest program featuring self-guided tours with packages of discount tickets, in addition to a few formal tours.

With Baltimore being centrally located on the east coast, you do not have to go far to find the culturally and historically rich cities of Washington, DC, Annapolis, MD, and Philadelphia, PA. Nearby are the beautiful sand beaches of the Mid-Atlantic oceanfront, the vistas and hiking trails of the Appalachian Mountains, the Chesapeake Bay for sailing, world-class golf courses, miles of equestrian trails, and many quaint villages with antique shops and bed-and-breakfast inns.

Now you know why our logo illustrates our slogan: *IMS 2011 in Baltimore: A Perfect Match*. So grab your camera, and with your family and friends, join us at IMS 2011 in Baltimore beginning June 5th to reinvigorate your career, your mind and your life. Heck, you might even bring your supervisor; it would probably do him good to focus on engineering again.

We encourage you to visit the IMS 2011 website (www.ims2011.org) to obtain further information and details that will help you enjoy your visit. On behalf of our Steering Committee, see you soon at IMS 2011! ■

MEASURING PHASE NOISE is:

✓ INTUITIVE ✓ PORTABLE ✓ ACCURATE ✓ FAST!

MTT-S BOOTH
2419

The HA7000 Series Analyzer interface operates on any standard PC



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 are 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, visit <http://goo.gl/sqwjjg> or call us at 215-723-8181.

Come See Us at MTTs 2011, Baltimore, MD, June 7-9, Booth 1103



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





RFIC 2011 GENERAL CHAIR'S MESSAGE



Welcome to the 2011 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium, which will take place in Baltimore, MD (www.RFIC2011.org), 5-7 June 2011. Our Symposium, held in conjunction with the IEEE MTT-S International Microwave Symposium, opens Microwave Week 2011, the largest worldwide RF/microwave meeting of the year.

The 2011 RFIC Symposium continues to build upon its heritage as one of the foremost IEEE technical conferences, increasing each year its impact and reputation of excellence. By bringing focus to the technical accomplishments in RF circuits, systems and devices, the RFIC Symposium has become essential to both the academic and the industrial communities. This year's exciting technical program will showcase the latest innovations in RF integrated circuit design with sessions that cover a broad spectrum of topics from cellular and wireless-connectivity system ICs, broadband wireless communications, digitally enhanced RF circuits, silicon millimeter-wave ICs, and RF device technology, modeling, and characterization. Applications highlighted by the technology include mobile phones, wireless communication systems, broadband access modems, radar systems and intelligent transport systems.

Running in conjunction with the International Microwave Symposium and Exhibition, RFIC Symposium adds to the excitement of Microwave Week with three days

focused exclusively on RFIC technology and innovation.

The 2011 RFIC Symposium will start on Sunday with half-day and full-day workshops covering a wide array of topics. Some of the topics include: New Architectures for Digitized Receivers, RFIC for Bio-Medical Applications, Imaging at mm-Wave and Beyond, Cognitive Radios and Spectrum Sensing, Advancements in Linear Power Amplifiers, Efficiency Enhancement Techniques for Power Amplifiers and Transmitters, Advancements and Challenges Toward Radio-in-package and Radio-on-chip, Re-configurability Requirements for Multi-standard, Low-power Operation, and EMI compliant product design practices.

The conference also includes a Plenary Session, which is held on Sunday evening. Keynote addresses will be given by two renowned leaders from the wireless industry. Both of them will share their views and insights on the direction and challenges that the RF IC design community is facing. The first speaker is the Chief Technical Officer and Co-Founder of Telegent Systems, Dr. Samuel Sheng, who will discuss "RF Co-existence—Challenges and Opportunities." The second speaker is Ron Ruebusch, Vice President of R&D of Wireless Semiconductor Division of Avago Technologies. He will discuss "3G to 4G Transition—Challenges and Opportunities." In addition to the keynote addresses, the conference holds a student paper competition to en-

courage the publication of innovative research from university students. Consequently, best student paper awards are presented in the Plenary Session to acknowledge these contributions. The highly anticipated RFIC Reception will follow immediately after the Plenary Session, providing a relaxing time for all to mingle with old friends and catch up on the latest news.

On Monday and Tuesday, the conference will feature lunchtime panel sessions that traditionally draw strong debate between panel members as well as stimulating interaction between attendees and panelists. The Monday panel session is entitled "Software Defined Radios—Facts and Fantasies," while the Tuesday panel session is entitled "What is the limit of multi-radio integration... or rather, is it 'disintegration'?" Please be sure to attend these lively and entertaining forums.

Technical papers will be presented during oral sessions throughout Monday and Tuesday. There will be a total of 130 papers presented in 23 technical focused sessions. The technical program will conclude with the Interactive Forum session on Tuesday afternoon, which will feature 31 poster papers and the chance to speak directly with authors regarding their work.

On behalf of the RFIC Steering Committee, I look forward to seeing you at the 2011 RFIC Symposium in Baltimore. ■

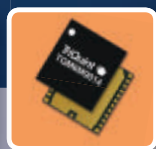
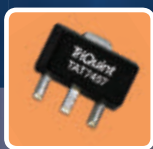
DAVID NGO
RFIC 2011 General Chairman



BOOST YOUR RF PERFORMANCE

Choose TriQuint's Innovative RF Solutions

**Connect with TriQuint at the
2011 MTT-S IMS, Booth# 2218.**



TriQuint's quest to improve performance and lower overall costs has led to new innovations:

- Achievements in GaN performance are enabling new amplifiers, switches and modules for communications, radar & EW
- Greater efficiency & protection from ESD / RF overdrive / DC overvoltage are integrated into new base station RFICs
- Exceptional performance through lower power dissipation / high linearity are realized in new microwave radio amplifiers
- High-efficiency optical modulator drivers for 40 & 100 Gb/s networks provide class-leading performance in high-speed, high-bandwidth applications

For innovative solutions that simplify RF connectivity,
Choose TriQuint.

Connecting the Digital World to the Global Network®

Phone: +1.503.615.9000 • Fax: +1.503.615.8900 • info-sales@tqs.com • www.triquint.com

TriQuint 
SEMICONDUCTOR



77TH ARFTG MICROWAVE MEASUREMENT CONFERENCE



The 77th Automatic RF Techniques Group (ARFTG) Microwave Measurement Conference is being held at the Baltimore Hilton on Friday, June 10th, 2011. 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 measurement and test community. The conference theme is "Design and Measurement of Microwave Systems" with papers focusing on linear and nonlinear measurement systems, on-wafer methods and uncertainty analysis, and broadband and mm-wave techniques.

The conference will open with an invited talk on modular measurement systems by Jin Bains, R&D HW Director of RF Products at National Instruments. This talk will consider the increasing adoption of chassis-based instrumentation (PXI, LXI, and, to a certain extent USB) with an integrated software platform. While that structure is discussed most often in the sense of manufacturing applications, it may also apply to more flexibility-oriented R&D environments. The audience is intended to be those interested in an area of recent change/development in the RF/microwave measurement area.

One of the major progressions in RF/microwave test recently has been the ability to make fast, flexible and accurate measurements using SW-based modular test products. This is a trend that has gained momentum and is continuing to accelerate. It can be very difficult to solve the ever-changing needs of the wireless industry with traditional test products that are often expensive, fairly large and usually rigid. Advances in RF technologies and processes have enabled the development of smaller form-factor, lower cost modular products to match the performance and features of more traditional test products. Modular systems can take full advantage of multi-core processors and leverage the latest FPGA technologies to allow for the greatest measurement flexibility and timing control. The expandability of modular systems allows for synchronized, phase-coherent measurements on systems comprising multiple sources or receivers.

The Nonlinear Vector Network Analyzer (NVNA) Users' Forum, 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 el-

ements, will be meeting Thursday evening. Attendees of the conference are invited to attend.

Also, be sure to check out the three joint ARFTG/IMS workshops: "WMC: Practical Compression, IMD, Load Pull and Behavioral Modeling Measurements"; "WMD: Laboratory Class: Wafer-level S-parameter Calibration Techniques"; and "WFC: The Design Flow of Microwave Power Amplifiers: Challenges and Future Trends."

An important part of all ARFTG conferences is the opportunity to interact with colleagues, experts and vendors in the RF and microwave test and measurement community. Starting with the continental breakfast in the exhibition area, continuing through the two interactive forum sessions, the exhibition and luncheon, there will be ample opportunity for discussion with others facing similar challenges.

Full details of the technical program are available at: www.arftg.org/conferences/arftg77/77th_ARFTG_Technical_Agenda.pdf.

ARFTG Conference registration is available through the IMS website at: www.ims2011.org. ■

MOHAMED SAYED
ARFTG Conference Chair

Have you heard?

Oscilloscopes from the T&M expert

Fast and efficient, easy to use, precise results. Our newest product line comes in three performance classes and a total of five bandwidths. Take a look.

R&S®RTO: high performance up to 2 GHz

The R&S®RTO oscilloscopes detect and analyze faster than conventional scopes. The digital trigger system delivers exceptional accuracy, and the intelligent operating concept and touchscreen make it fun to use.

R&S®RTM: mid-range scopes with 500 MHz bandwidth

The solid features and outstanding price/performance ratio of the R&S®RTM make it the ideal solution for everyday measurements.

HAMEG: basic oscilloscopes up to 350 MHz

Our subsidiary HAMEG Instruments develops powerful, cost-effective products for smaller budgets, since 2009 including digital instruments up to 350 MHz.

For details go to www.scope-of-the-art.com/ad/all/mwj

See us at MTT-S Booth 2115

scope-
of-the-
art.com



ROHDE & SCHWARZ



IMS 2011 MicroApps: A PERFECT MATCH

The Microwave Application & Product Seminars (MicroApps) portion of IMS 2011 is a series of brief technical presentations featuring new technologies and special capabilities of exhibiting organizations. The talks will be approximately 20 minutes in length and open to all conference and exhibit attendees without additional charge. MicroApps is distinct from the IEEE technical sessions, but complementary in its application-centric treatment of a variety of engineering topics of interest to the microwave community. The seminar series will be held in Booth #413 from June 7 to 9, starting at 9:30 AM on Tuesday and Wednesday and at 9:10 AM on Thursday. Attendees will receive a free CD-ROM collection of all three days of presentations.

The MicroApps program serves as a forum for exhibitors to describe state-of-the-art products and processes, including noteworthy components, emerging technologies, and novel techniques for manufacturing and design. Organizationally, presentations have been divided into seven topic categories:

- 3G/4G
- CAD
- Calibration, Testing and Measurements
- Manufacturing and Processes

- Materials and Components
- Semiconductors and Modeling
- Terahertz Devices

The 2011 program offers 55 presentations on recent hardware and software developments from roughly 25 organizations around the globe. Along with North America, Europe is particularly well represented this year. Multiple first-time presenters help substantiate that Baltimore is fulfilling the hope and promise expressed by "A Perfect Match" as theme.

This year's highlights include an emerging technology panel session and a keynote presentation by industry leader John Ocampo, both on Wednesday.

- **Expert Panel – Nonlinear Characterization:** This panel discussion of nonlinear measurements will cover the latest advances in device characterization and simulation. The session will be held on Wednesday from 12:00 until 1:30 PM during the technical session lunch break. This session is organized by *Microwave Journal* and will be featured in a simultaneous webcast for audiences not attending IMS. Both live and web-based audiences will be able to participate in the Q&A following the invited speaker presentations. The event will also be video recorded by IEEE.TV. The



session will be available for viewing on both the MWJ and IEEE.TV websites. This event is sponsored by the leaders in RF/microwave nonlinear test equipment—Agilent, Anritsu, Rohde & Schwarz/NMDG and Tektronix/Mesuro.

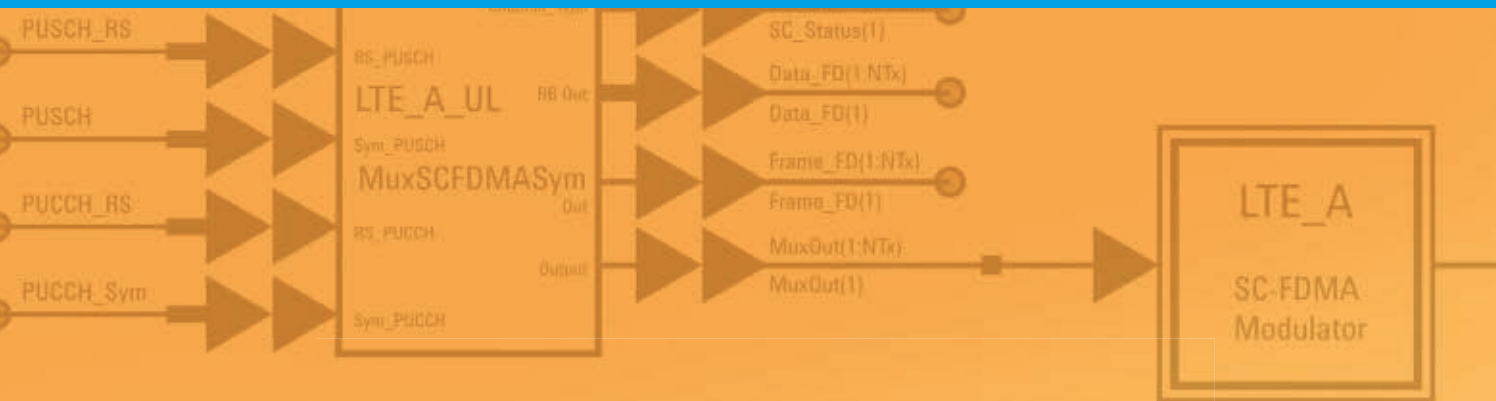
- **Industry Keynote Address – "What Makes Successful Mergers?":** This year's keynote speaker will be John Ocampo, Chairman of the Board of M/A-COM Technology Solutions. The talk begins on Wednesday at 5:00 PM during the "open exhibition" reception hour. The session will be videotaped by IEEE.TV and available on the IEEE.TV website for future viewing.

Agilent Technologies is this year's MicroApps sponsor, and the presentation CD will be available for free, thanks to the sponsorship of AWR. MicroApps will be conveniently located in the midst of the exhibits at Booth #413. The complete and up-to-date MicroApps session schedule can be found in the IMS 2011 program book or online.

Join us for MicroApps at Booth #413. We look forward to seeing you there! ■

**RAFI HERSHTIG AND
TIM DOLAN**

2011 MicroApps Co-Chairmen



Equip yourself to meet the challenges of LTE-Advanced.



Accelerate your drive to the forefront. Be first to market with up-to-date Agilent LTE-Advanced resources, expertise and test tools.

That's thinking ahead. That's Agilent.

The LTE-Advanced Portfolio

Design libraries for LTE-A physical layer

Generate LTE-A signals to today's standards and beyond

Analyze multiple LTE-A signals simultaneously

Download an in-depth LTE-A App Note

Visit www.agilent.com/find/LTEAInsight





WOMEN IN MICROWAVES (WIM) RECEPTION



IMS 2011 will mark my second year organizing the WIM Reception, and the second time I actually attend this event. Now, I have been going to IMS since the mid-1990s, but I had not heard of this event prior to last year. Why is that? Well, for starters the “technical” side of the show and the “exhibition” side are like magnets with the same polarization. They repel each other. Perhaps I am exaggerating a little with this analogy, but there seems to be some truth in the statement. The technical/committee side of IMS organizes the conference, and many believe the focus should largely be on the conference attendees and not the many thousands of exhibitors who also attend IMS. Let’s take a closer look.

Given that I hold a BSEE degree from Carnegie Mellon University—one of only eight women who graduated in a class of 150 in 1988—why would I not have been previously invited to attend the “women in microwave engineer-

ing” or WIM Reception? Why had I not heard of it? Certainly, since such a small percentage of engineers in the RF and microwave realm are women to begin with, it appears even more difficult to get the word out about this reception.

After learning about this event, I quickly spoke up and got to work making sure more and more women, regardless of their IMS registration, became aware of the WIM Reception. I knew we had to be aggressive with our outreach in order to increase awareness of our group and to fully promote the many benefits and opportunities that the RF and microwave industry offers women.

Last year, I am happy to share, we had women from all facets of IMS, regardless of their registration status, attend the event:

- Technologists like Kiki Ikossi of DTRA and Amanda Hereida of Aethercomm
- Exhibitors like Jeannette Wilson of Freescale and Katherine Van Diepen of Anritsu

- Editors like Kate Remley from *IEEE Microwave* and Christina Nickolas of *Electronic Products*
- Educators like Zoya Popovic of UC Boulder and Rashaunda Henderson of UT Dallas
- And *Microwave Journal’s* staff of women too: Jenn DiMarco, newly promoted Managing Editor of *Microwave Journal* and Kristen Anderson, Marketing and Event Coordinator for *Microwave Journal*

Overall, we had more than 75 people (men and women) attend the WIM Reception during IMS 2010, which was more than double the year prior participation. For WIM 2011, I hope to exceed last year’s attendance and surpass 100 as there are easily a few hundred women who attend some aspect of IMS.

With such a small percentage of women pursuing engineering even today, we have to find novel

SHERRY HESS
WIM Organizer

From Core Components to Integrated Solutions

COBHAM

The most important thing we build is trust



Photo courtesy of U.S. DoD

Product Technologies include:

- MMIC
- Filters
- Multipliers
- Amplifiers
- Control Systems
- Integrated Microwave Assemblies
- High Performance Antennas
- Composites and Radomes
- Precision Positioners
- RF Front-End Subsystems

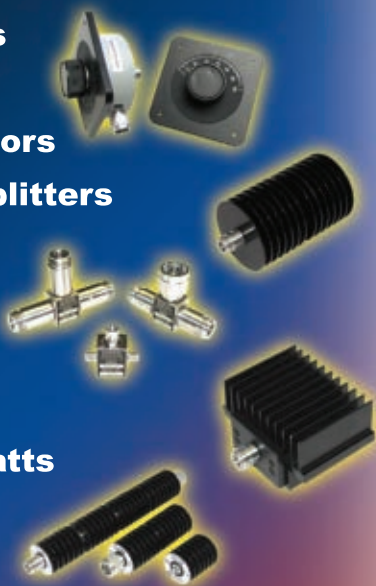
For further information on Cobham capabilities, please contact us at sensorsales@cobham.com

See us at MTT-S Booth 1024

www.cobham.com

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



www.WeinschelAssociates.com

A Tradition of Quality

A Commitment to Customer Service



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

See us at MTT-S Booth 428

**Resistors • RF Loads • Attenuators • Splitters • Couplers
Dividers • Filters • Thermal Management • Customs**

For ANY RF & Microwave application



IMS is your optimal source for passive components!

Chip Attenuators- DC-40GHz IAX Series, V-Series & A-Series

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



A/N Power Resistors & Terminations N-Series

- Power Ratings to 380W
- Characterized to 40GHz
- 8 Sizes- 0505 to 3725
- Values to 10Ω to 2KΩ
- Solder, Epoxy or Wirebond Terminals
- 4 Weeks Max Lead Time!



**Get Samples and See More at www.ims-resistors.com!
Visit us at IMS2011 in Baltimore! Booth 2106**



ways to stay connected to the ones who have already chosen "RF and microwave" as their path, and work together to uncover ways to bring even more females into this domain of engineering.

It is definitely a struggle to make engineering appear more inspiring for either gender, whether male or female, but it cannot hurt for all of us—as engineers—to stretch a little bit outside of our comfort zone and talk about our profession. Our field of RF and microwave literally brought us the wireless revolution. I mean the 24/7 access to everything, anywhere and in any way.

Naturally, with so much content and information out there fighting for our attention, we have to raise our collective voice and cut through the information clutter with our message about how great the RF and microwave engineering discipline is. As a simple tip, the next time someone asks, "How does my smartphone know which way I'm holding it and self-adjust?" Maybe we should answer it with an "oh, if you were an engineer, you would know." Or when someone says, "What did we do before GPS?," maybe we should answer, "we spent hours driving around, wasting gas, lost in the car; but now thanks to engineers, we always know exactly where we are."

Remember this and spread the word:

- WIM (Women in Microwave Engineering) Reception - IMS 2011
- Tuesday evening, June 7, 2011, 6-8 PM
- Hilton Lobby Bar, Hilton Convention Center Hotel, Baltimore, MD

Reserve your spot at the reception, e-mail RSVP to wim@ims2011.org or for all of you out there using a GPS on your smartphone, enter 401 W Pratt Street, Baltimore, MD 21201 then touch "go." And remember to say "thanks" to our collective group of engineers who made it possible to do so in the first place! ■

RFfortless components



reflections in their tracks!



SV Microwave's heritage as a leading supplier of Mil-Spec attenuators and terminations is changing the game in RFfortless components.

The RFfortless line includes connector series SMP, SMPM, and SMPS as well as the larger line sizes BMA, BZ, and BMZ. Terminations are available in power handling values from $\frac{1}{4}$ watt up to 5 watts and attenuation values from .5 dB through 20 dB.

These components are space qualified and already fly on satellite programs. Custom configurations are available with minimum quantities as low as 25 pieces.

See us at MTT-S Booth 2409

LOW VSWR
ZONE
AHEAD



Amphenol
SV MICROWAVE
www.svmicrowave.com





OPPORTUNITIES AND CHALLENGES: RF INDUSTRY IN 2011



Based on the indicators we have been watching, the RF industry seems to have completed another economic cycle. When the cycle hit bottom in Spring 2009, no one would have dared to predict a rapid recovery that equaled or exceeded 2008 business levels.

Today, the industry faces new questions about additional capacity expansion and the impact of Long Term Evolution (LTE). It is also battling challenges with defense budgets in mature economies. Against that backdrop, let us examine a few important industry drivers and see if we can detect patterns and opportunities:

Wireless: Wireless communications in all forms is now being driven by “edge of the network” opportunities. These include the increasing penetration of mobile communications around the world, especially in emerging economies and in applications that rely on wireless networks coupled to sensor networks to measure the real world. The number of edge-of-the-network devices of all types is increasing at a geometric rate and will soon exceed 10 billion devices.

Aerospace/Defense: This is

a tale of two worlds, one emerging and one maturing. Emerging economies are rapidly growing their defense spending while mature economies are struggling to maintain their existing force, components and infrastructure. Even with these differences, both worlds share a common theme: achieve lower costs across the board.

Research: With government budgets under pressure, research funding will become a target of cuts. Overall growth in research spending is centered on life sciences, food safety and medical applications. One consequence: Spending on electronics research is increasingly focused on supporting these initiatives.

The Cloud: While “the cloud” seems to be drifting through the hype phase, this infrastructure approach has the potential to deliver many useful benefits. The path from here to there contains both opportunities and challenges. The key challenges include security and availability, both of which will require large cycles of investment and deployment.

Going Green: This multi-decade trend will transform energy supply and demand. However,

the same issues that apply to the trends above also apply here—lower costs, security—and those challenges are compounded by the need to control the grid remotely.

Looking at these trends through the lens of test and measurement (T&M), five conclusions come into focus:

Edge devices become smarter and cheaper. Increasingly, edge-of-the-network devices are a blend of electronics and a real-world sensor (e.g., gas detection, separations, pressure, etc.). The electronics are in service to the sensor and network as well as the analysis that turns data into insight. Electronics must be low-cost, reliable and generally invisible. RF design, characterization, test and maintenance of these solutions must be appropriate to the role electronics plays.

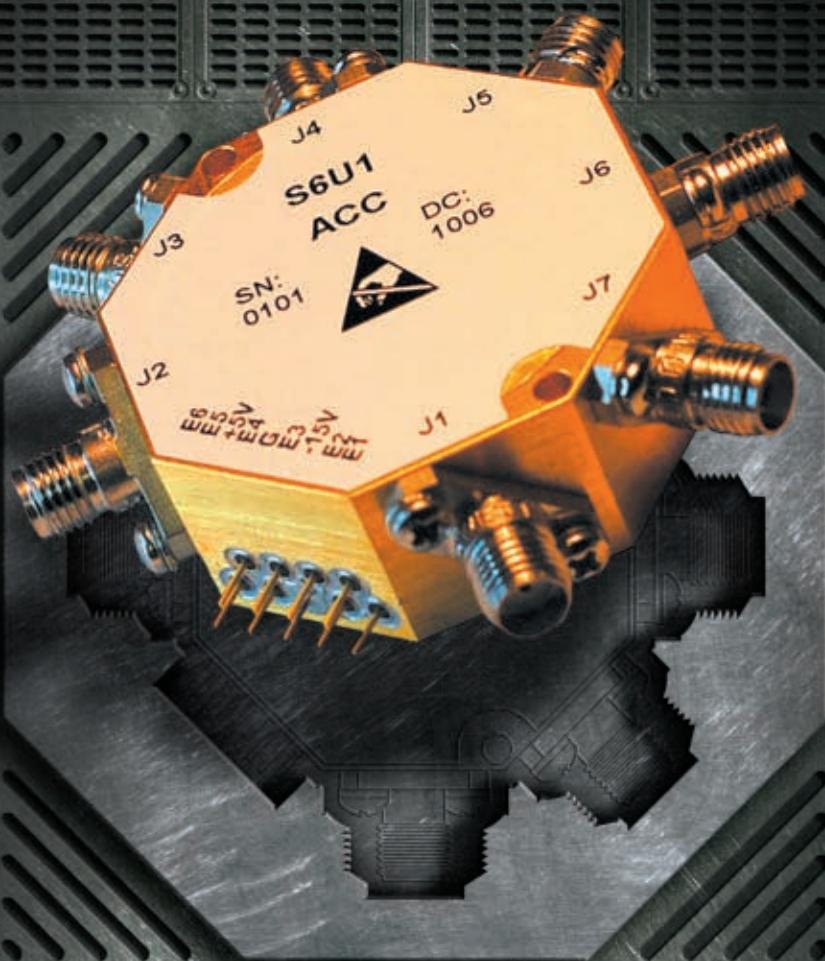
It is all about cost of test. Whether in high-volume wireless manufacturing or in high-mix/low-volume applications, total cost of test will be the key driver. That cost includes much more than in-

GREG PETERS

*Agilent Technologies Inc.
Santa Clara, CA*

Not everyone needs ruggedized switches. But you're not everyone.

AEROFLEX
CONTROL COMPONENTS



Aeroflex Control Components gives you the battle-tested pin diode and GaAs FET switch design and manufacturing experience you need. Proven in some of the most demanding programs in force protection and platforms such as Predator, MRAP, F-16, AEGIS, THAAD and dozens more, our switches and matrices are built to last and come in any number of throws.

- Frequency up to 40 GHz
- Isolation up to 120 dB
- Power to 150W CW
- Switching as fast as 10 nSec

A library of standard and custom configurations are available to help you design the best jamming or transmitting system you can imagine—with over **2,700 catalog switches available in 30 days** or less. Call or visit our website for details.

732-460-0212

www.aeroflex.com/ACCMJ
See us at MTT-S Booth 2212

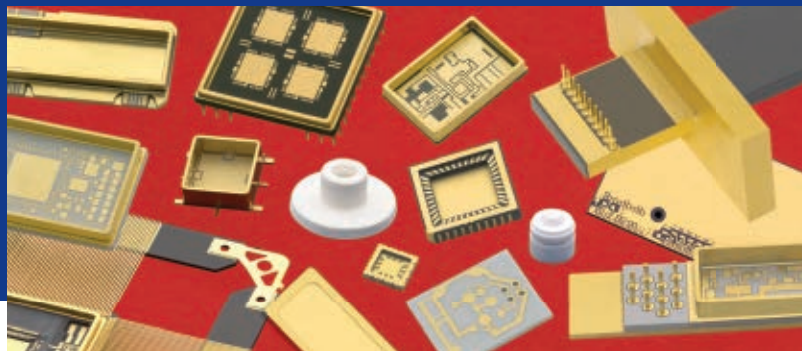


AEROFLEX
A passion for performance.



AdTech Ceramics

Your ceramic source for high reliability Microelectronic applications.



TECHNOLOGY

- Alumina (HTCC)
- Multilayer Aluminum Nitride
- Thin Film HD Alumina
- Pt Co-fire
- Chemical Milling
- Brazed Assemblies
- Injection Molding

APPLICATIONS

- Medical
- Military
- Optoelectronic
- High Frequency
- High Reliability Commercial
- High Temperature Electronics
- Step Etched Lids & Lead Frames

EXPERTISE

- Microwave Modeling and Design
- Developmental Partnerships
- 30+ years of MLC Manufacturing
- 15+ years of AIN Multilayer technology
- ITAR Compliant
- DFARS 252.225-7014 (Alternate 1) Compliant
- ISO 9001:2008 Certified



Advanced Technical Ceramics Company

511 Manufacturers Rd. | Chattanooga, TN 37405
tel (423) 755-5400 | fax (423) 755-5438
www.AdTechCeramics.com



ITAR Compliant

Associated Companies



www.greenrayindustries.com



www.statek.com

Meeting your advanced ceramic needs with experience, communication and technology.

See us at MTT-S Booth 3713

Custom Antenna Solutions

Low observable antenna achieves exceptional low angle radiation for UAVs

An antenna delivering 3dB beamwidth horizon to 55° elevation with less than 3dB azimuth variation in a compact, rugged package? That's the challenge we met for a UAV application with our low observable antenna. As the industry's only true vertically integrated antenna solutions provider, we'll develop your antenna from concept through manufacturing... completely in-house. This means more flexibility in our design approach, greater quality control and shorter lead times for prototypes and production volumes.

**To find out more,
call 888.267.1195
or visit SpecEMC.com.**



SPECTRUM
Advanced Specialty
PRODUCTS
A Spectrum Control Business

See us at MTT-S Booth 1415



strumentation: the costs of fixturing, software, service cycles and repair must all be added to the total cost envelope.

"Multi-discipline" is the key concept. Today's leading researchers are applying electronics to solve a wider variety of problems than ever before—and all facets of electronics will be used. As with edge-of-the-network devices, researchers are experts in their own domain and use electronics as a means to an end. Software, bench tools and measurement accessories must be designed to enable the researcher to modify the equipment to their specialized purposes. RF/MW plays a key role here in both communications/control as well as stimulus/response in certain applications.

The Cloud = Performance. Here is where the electronics industry really shines. Continuing contributions from semiconductors, channel designs—copper, optical or wireless—between subsystems and software will improve the performance, reliability and security of the core of the Internet. High speed digital is all about excellent microwave design at the physical level. Understanding surface roughness of copper traces is an excellent example of this trend.

Green = Green, as in money. The electronic industry is again at the core of the green revolution and will play a major role in reducing costs and improving performance. Smart meters are just the start of this revolution and RF again plays a key role in enabling distributed energy generation, utilization and management.

Is this a bright and rosy future? No—growth in any of these areas can be dampened by uncertainty in the global economy—and the certainty of more shocks and future downturns. Even so, today's trends offer significant opportunities for T&M vendors to add value to a wide variety of companies around the world. For our industry, the key to success is not just watching or pursuing these trends but harnessing them to our advantage. ■



WE MAKE HARDWARE THAT SAVES LIVES.



PRODUCTS

High Power RF Amplifiers
High Power RF Subsystems
High Power RF Systems

SPECIFICATIONS

DC - 40+ GHz
Power levels to 10,000+ watts
MIC and Hybrid Construction
AS9100 Certification

PLATFORMS

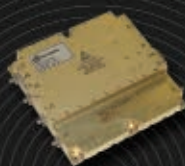
Abrahms Main Battle Tank
Stryker Combat Vehicle
Humvee
Bradley Fighting Vehicle
Black Hawk Helicopter
Joint Strike Fighter
AV8B Harrier
F15 Eagle
F16 Fighting Falcon
F18 Super Hornet
F35 Joint Strike Fighter

SYSTEMS & ENVIRONMENTS

Electronic Warfare
RADAR
Communication Systems
Pulsed or CW
Airborne
Land, Sea and Space



RF
Amplifiers



RF
Subsystems



RF
Systems

www.aethercomm.com

See us at MTT-S Booth 3304





MICROWAVE TECHNOLOGY AT THE NRL



The Naval Research Laboratory (NRL) has a long and distinguished history of making important contributions to the development of microwave technology. The inspiration for NRL originally came from Thomas Edison, who, in 1915, stated, "The Government should maintain a great research laboratory... in this could be developed... all the technique of military and naval progression without any vast expense." War delayed construction of NRL until 1920; it was completed in 1923. Although NRL has long maintained extensive research programs in all areas of the physical sciences, its significant contributions in the microwave area began almost immediately with the development of radar. First came the ability to determine range and bearing of ships in 1922 and aircraft in 1930. Subsequent important radar inventions included the duplexer, the plan positions indicator and the monopulse receiver.

Other NRL microwave-related contributions include the TIMATION satellites (the subject of a talk at Tuesday's IMS 2011 session "Historical Perspectives on Microwave Development in

the Baltimore-Washington Area") and atomic clocks that led to our current GPS satellites, as well as numerous communications, electronic warfare and radar systems.

While the above examples highlight the system level R&D that NRL is well known for, basic materials research has also played a significant role. For example, at NRL in the 1970s, a focused effort resulted in a method of growing high-purity single crystals of semi-insulating gallium arsenide, the basis for the revolution in microwave semiconductor devices that followed. NRL began making GaN microwave transistors back in the early to mid 1990s and has continued its own in-house R&D program while also being at the forefront in helping to establish the reliability of this technology by working closely with industry. High-power, high-frequency vacuum electronics has been greatly advanced by NRL developments including: rare-earth-iron-boron permanent magnet materials, the Controlled Porosity Dispenser cathode, and gyro-based devices that culminated in 1999's WARLOC 10 kW average power over 94 GHz gyro-klystron.

While NRL has made and continues to make important contributions to the development of microwave materials, devices, components and systems, it is extremely difficult to look ahead and predict which of the many on-going programs may be looked back upon in the future with the same game changing recognition. One of my colleagues keeps Albert Einstein's quote "If we knew what we were doing, it wouldn't be called research, would it?" prominently at his desk. And while many of us can extrapolate today's technology to faster, higher frequency, lower power consumption, etc., I think that quote does summarize the difficulty of predicting breakthroughs. Nevertheless, there is a lot of ongoing microwave materials and device research at NRL that is likely to result in next generation capabilities. In particular, new atomic layer deposition techniques, in conjunction with both wide band-gap and narrow band-gap materials, will lead to complementary circuit capabilities in both of these semiconductor

JEFFREY M. POND

*Naval Research Laboratory and
IMS General Chair, Washington, DC*



Control Devices

*Up to W Band

- *Switches, Attenuator, Phase & Shifters
- *Coaxial/Waveguide/PIN Switches



Antennas

*Up to W Band

- *Rectangular & Circular Horns
- *Patch array antennas



Ferrite Devices

*X to W Band

- * Isolators & Circulators
- *Full/Narrow Band Configuration



Amplifiers

*8 to 110 GHz

- *Full Waveguide Band Amplifier series
- *Regular integrated single power supply
- *LNA/PA/General Purpose
- *Combined HPA Module



Doppler Sensors

*K, KA, E, & W Band

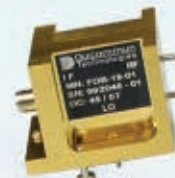
- *Speed Direction & Range Measurements
- *Compact Transceiver Module with Antenna



Passive Components

*DC to 110 GHz

- *Coupler, Filter, Dividers, Adapter & Diplexer
- *Instrumentation Grade
- *Waveguide Section



Frequency Converters

*Up to W Band

- *Detector, Mixer, & Multiplier
- *Balanced, IQ, Harmonic, External & Biased
- *SSB Modulators

Ducommun Technologies

Products to Solutions

Servicing all RF to Millimeter Wave Needs

Ducommun RF Product offers design and manufacturing experience of Millimeter Wave Components, Sub-Systems & Integrated Solutions. Our broad suites of products support critical applications across multiple markets. Our vision is to drive innovative solutions & services to the Aerospace, Defence, & High Technology Markets.

To discuss your application, contact our RF Millimeter Wave Engineers at (310) 513-7256.

Come visit us at the Mircowave for the World IMS2011 convention from June 5-11 at booth 404 for further service and product inquiries.



Ducommun Technologies

www.ducommun.com/mmwave
rfsales@ducommun.com : (310) 847-2859



systems. This will push the digital realm much closer to the antenna at higher frequencies on both the transmitter and receiver side. For the narrow band-gap semiconductors one of the big challenges in realizing complementary circuitry will be to raise the hole mobility.

The last few years have seen tremendous interest and investment in carbon-based electronics in the form of both carbon nanotubes as well as graphene. While the electronic properties of these materials are intriguing for microwave applications, there is still much research to be done before conventional semiconductor materials are likely, if ever, to be replaced. Not only do these materials have unique electronic properties, they possess mechanical properties that may prove very useful in future microwave devices and components. This could involve everything from packaging to acoustic wave resonators for high-Q micro-miniature filters. At NRL we have several programs that are developing the electronic and mechanical properties of carbon-based materials for microwave applications.

Another area where NRL has been advancing microwave component technology has been in the area of tunable and recon-

figurable filters. While the world in general is beginning to understand how crowded the spectrum is becoming, the Navy has been facing this problem much longer since almost all Navy platforms, ship or airplane, are very compact structures considering all of the equipment they carry that involves transmitting and receiving. Co-site interference is a problem the Navy has been dealing with for a long time and has led to a push to develop new filter architectures that address these concerns. These technologies are likely to be recognized, appreciated and adopted by the commercial providers as these spectrum issues become prevalent in their domain.

NRL is the government center of excellence in vacuum electronics and continues to lead in developing the design tools that enable higher frequency and higher power vacuum electronics oscillators and amplifiers for millimeter-wave frequencies. NRL CAD software is commonly used by industry to design current and next generation vacuum electronics. In addition, NRL has R&D efforts in multiple and sheet beam technologies and advanced cathodes that should result in much greater powers and frequencies in the next few years.

Of course there continue to be active programs in next generation radar, electronic warfare, and communications systems within NRL's Radar, Tactical Electronic Warfare, and Information Technology Divisions, as well as NRL's Naval Center for Space Technology. While the details of such programs usually do not become known until decades later, the same level of talent, ingenuity and perseverance that led to NRL's earliest contributions in radar are hard at work to ensure that the Navy and the country are well served and protected in the future.

Irrespective of which of these R&D efforts bears the greatest return, or if it is one I have not mentioned, NRL will remain a center of microwave R&D. NRL has a special R&D environment where engineers, materials scientists and physicists all work closely together to address the materials, device, component and system challenges that confront Naval radar, communications and electronic warfare systems. ■

To learn how microwave and millimeter-wave systems are being used in material processing at the Naval Research Laboratory, go to www.mwjjournal.com/nrl_materials_2011—an MWJ online exclusive by A. Fliflet and M.A. Imam, NRL.

fastRise™ prepreg and Speedboard® C may look a lot alike, but their loss properties are another story.

Material	Composition	Reinforcement	Part Number	10 GHz		40 GHz	
				Dk	Df	Dk	Df
<i>fastRise</i> ™	PTFE, Thermoset	None	FR-26-0025-60	2.57	0.0014		
			FR-27-0035-66	2.67	0.0015		
			FR-27-0045-35	2.73	0.0014	2.70	0.0017
Speedboard® C	PTFE, Thermoset	None		2.56	0.0038	2.67	0.0053

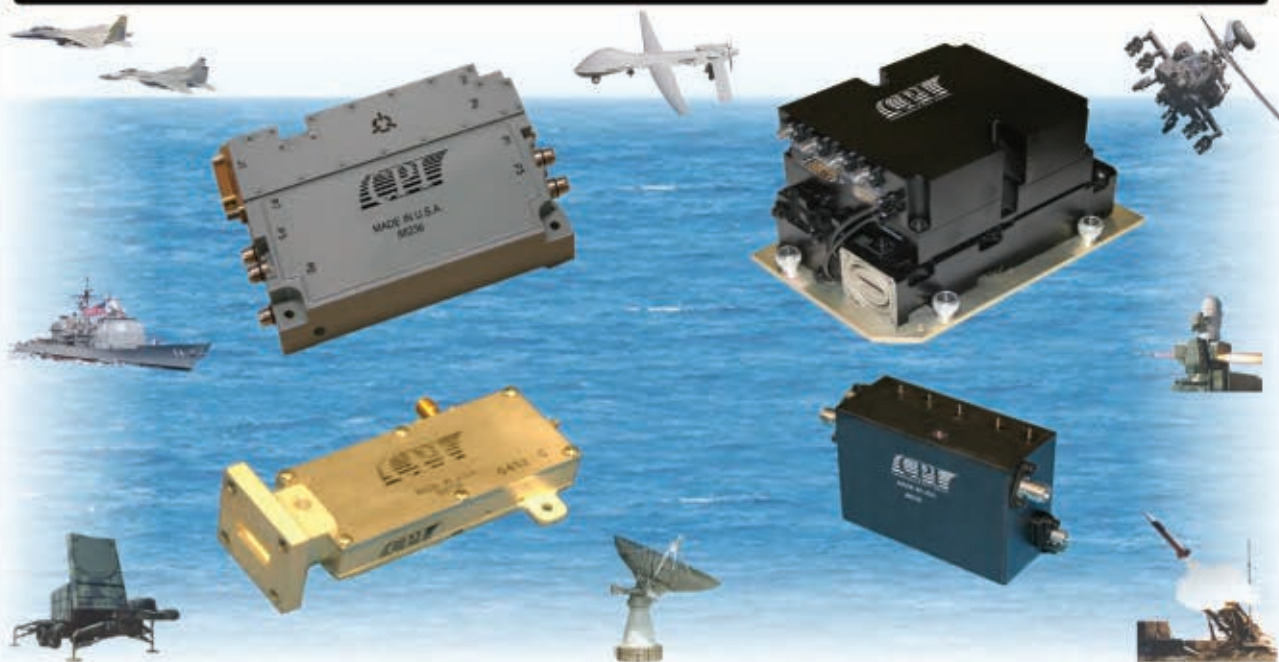
fastRise™ is a trademark of Taconic. Speedboard® C is a registered trademark of W. L. Gore & Associates.

Listed values are from Gore™ Speedboard® C Prepreg Material Properties data sheet, 03/04.

800-833-1805 • www.taconic-add.com

TACONIC
Finding a better way

Integrated Microwave Assemblies



Advanced Technology - Extensive Experience - Superior Performance



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



TWITTER TOGETHER AT MTT-S IMS



With all the hype about social media, there is still only a limited microwave audience on Twitter, LinkedIn and Facebook. Let's change that this year and expand the small but growing group of Twitter users involved in the MTT-S IMS show.

At last year's symposium, a handful of companies shared their experiences Twittering about their latest product releases, news, social events and happenings on the show floor. Some of the companies that can be found on Twitter include Agilent, Anritsu, AWR, R&S, Reactel, Skyworks, EM Research, Z-Communications, RFMD, Freescale, Resnet Microwave, ADI, Phase Matrix, TriQuint, CST, Tektronix and NXP. Last year, a search feed displayed all Symposium related Tweets on our Online Show Daily website (the official IMS Cyber Café homepage), and IMS attendees could follow these companies from our website or on their mobile phones. We will be doing the same thing this year.

Try using Twitter to note interesting sessions, new products, social events, good giveaways, interesting demos on the show floor, good restaurants and bars. If everyone does a couple of Tweets a day about their favorite (or not so favorite) things that they find

around town, everyone will know where the good restaurants and watering holes are located. It will also allow everyone to know in real time the exciting activities that are going on at the show or after hours. There has been some Twittering about the show already so keep the pre-show, during the show and post-show Tweets going.

Taking Twitter a step further and finding your friends and others locally, try Foursquare. This app allows you to "check in" at various locations so your group of friends knows exactly where you are and can meet up with you if they are in the area.

The next big thing could be group messaging. There are many new apps being produced that solve the problem of having private conversations with a small group of friends. While many people use SMS, it is very difficult to message more than one person at a time, making group discussions almost impossible. Using group messaging, the timeline of discussions is visible to only those in the discussion. If someone is added, they immediately receive the discussion string. While e-mail can be used, it is not as immediate and threading not as clean.

Some new apps that address this issue are Beluga, Yobongo,

GroupMe, Fast Society and Disco, which was bought by Google. These apps avoid text messaging fees for the most part as the string is only considered a single message and not individual messages from each person.

The social media market is fast moving and there are new apps releasing all the time, so it is difficult to keep up with everything that is going on. Just try some of the different apps from time to time and see how they work for you and your friends. Talk about them and share experiences – you will learn quickly which ones work for you.

Join in the real time social media scene by using the Hashtag **#IMS2011** in your Tweets so everyone can follow the action [# indicates the word is a Hashtag (developed by Hashtags.org) and allows people to follow that keyword easily].

Visit the *Microwave Journal* website for the Twitter feed on the MTT-S IMS show page at www.mwjjournal.com/IMS2011 and trace the MWJ staff on Twitter by following David Vye @mwjournal, Pat Hindle @pathindle and Kristen Anderson @KAatMWJ. ■

PAT HINDLE AND KRISTEN ANDERSON
MWJ Staff

Tactical Advantage.

When Reliability Counts.

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

The rock solid performance of Rogers' microwave materials deliver the high performance and high-reliability demanded by the most mission-critical applications. Can you afford to use anything less?

To learn more about Rogers' aerospace and defense microwave material solutions, visit us at:

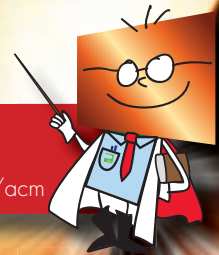
www.rogerscorp.com/military



Photos used by permission from Northrop Grumman Corporation.

Read Our New
ROG Blog

www.rogerscorp.com/acm



Features

Benefits

RT/duroid® 6202PR	Reduced planar resistor variation	Lower manufacturing costs due to decreased tuning
	Low thermal coefficient of dielectric constant	Stable electrical performance versus temperature
	Low coefficient of thermal expansion	High reliability in complex multilayer designs
RT/duroid® 5880LZ	Dielectric constant of 1.96	Lowest dielectric constant microwave PCB material
	Low z-axis coefficient of thermal expansion	Plated through hole capable
	Light weight	Advantage for airborne applications
RT/duroid® 6035HTC	Highest thermal conductivity (1.44 W/mk) for 3.5Dk printed circuit board laminates	Excellent power handling capability
	Low loss 0.0013	Excellent high frequency performance
	Low profile, thermally stable copper options	Lower insertion loss, and performance reliability in high temperature applications

Visit Us At
Booth #2515
June 7-9, 2011



The world runs better with Rogers.®



ROGERS
CORPORATION

Advanced Circuit Materials

A PROUD MARYLAND BUSINESS FOR OVER 30 YEARS

Reactel, Incorporated



FILTERS

Crab Cakes & Football That's what Maryland does!

Learn more at www.reactel.com/mtts2011

It is no secret that Maryland is best known for their Crab Cakes.

Reactel would like to celebrate the IMS MTT-S Show's presence in Baltimore, Maryland by offering a fabulous Crab Cake giveaway.

Please stop by Booth #3915 to enter for your chance to win a

Celebrate Crab Cakes and Filters Gift Package

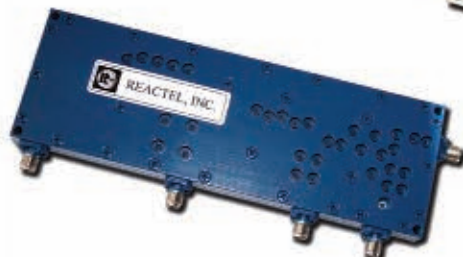
featuring gigantic Crab Cakes from the famous
G & M Restaurant in Linthicum, Maryland.

G & M has been voted best Crab Cake in Baltimore 5 times.

A less well known secret is that Maryland is home to nearly a dozen RF & Microwave Filter Manufacturers.

Reactel is a proud Maryland company offering RF & Microwave Filters, Multiplexers and Multifunction Assemblies for Military, Space, Commercial and Industrial applications.

While at our booth, we also invite you to visit with our Engineers to discuss your requirements, see some of our latest offerings and pick up a copy of our newest catalog.



8031 Cessna Avenue • Gaithersburg, Maryland 20879 • Phone: (301) 519-3660 • Fax: (301) 519-2447
For general inquiries, please email reactel@reactel.com • <http://twitter.com/reacteljim>
Go online to www.reactel.com to download your Reactel catalog today.
See us at MTT-S Booth 3915

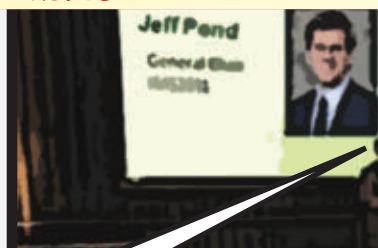


FROM ACROSS THE GLOBE, MICROWAVE PROFESSIONALS BOARD PLANES BOUND FOR IMS 2011. ONE DESTINATION, COUNTLESS AGENDAS.

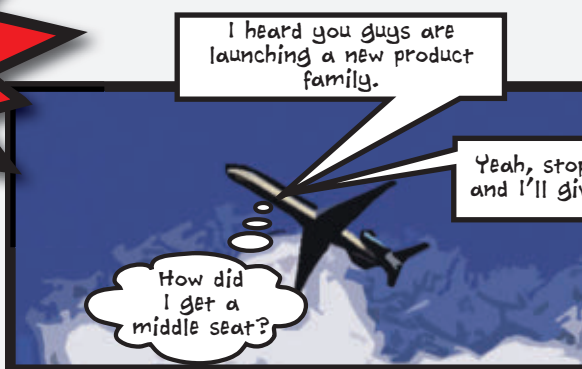


How do I know that guy in 18c?

GENERAL CHAIR, JEFF POND ADDRESSES IMS ATTENDEES AT THE PLENARY SESSION WITH OPENING REMARKS AND AN INTRODUCTION OF KEYNOTE SPEAKER, PROFESSOR J. DAVID RHODES.



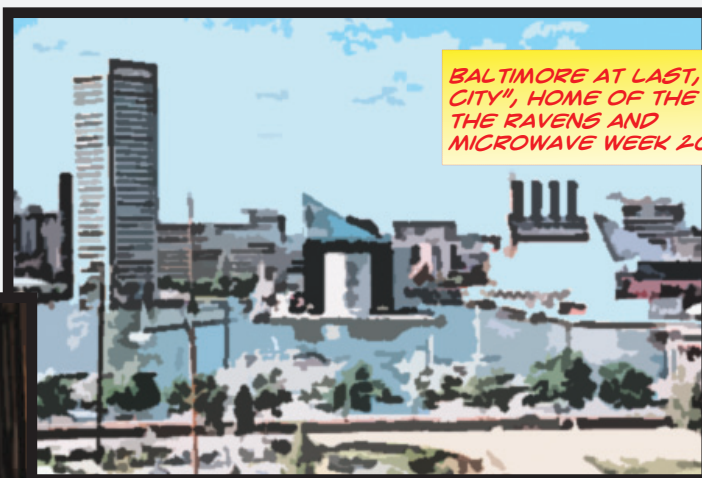
Professor Rhodes founded Filtronic over 30 years ago and grew it into an international microwave company. Today, he will speak about the migration of W-CDMA and 4G LTE into existing cellular bands.



I heard you guys are launching a new product family.

Yeah, stop by our booth and I'll give you a demo.

How did I get a middle seat?



BALTIMORE AT LAST, "CHARM CITY", HOME OF THE ORIOLES, THE RAVENS AND MICROWAVE WEEK 2011.

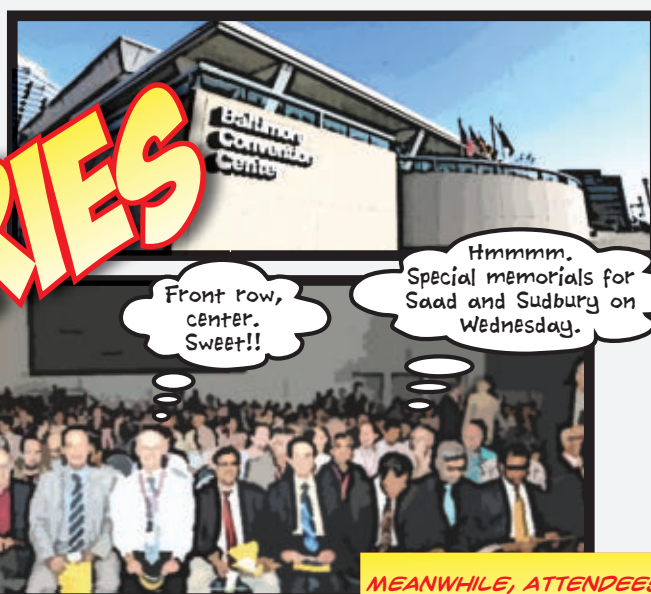
MTT-STORIES

AS MICROWAVE WEEK PROGRESSES, IMS, RFIC AND ARFTG ATTENDEES GET DOWN TO BUSINESS AT THE TECHNICAL, PANEL AND RUMP SESSIONS AS WELL AS THE WORKSHOPS.



Welcome to this technical session on Compact Reconfigurable and Tunable Filters.

Why am I thinking about Crab Cakes?



Front row, center. Sweet!!

Hmmmm. Special memorials for Saad and Sudbury on Wednesday.

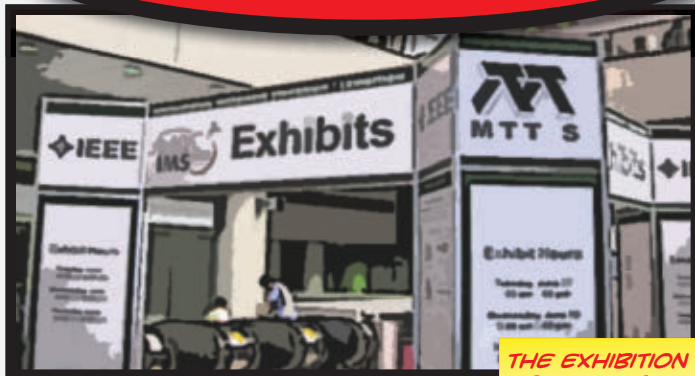
MEANWHILE, ATTENDEES DIRECTLY ENGAGE AUTHORS AT THE POSTER SESSIONS.



I could introduce you to my professor at the student reception.

STUDENT WORK IS HIGHLIGHTED IN BOTH THE STUDENT PAPER COMPETITION AND DESIGN COMPETITION.

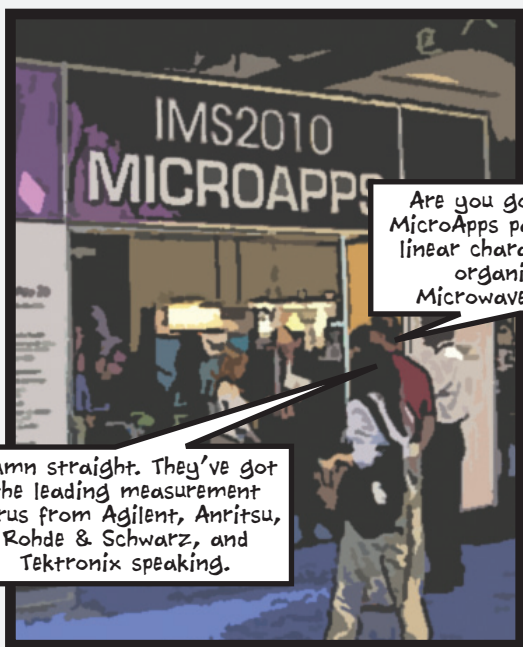
ON TUESDAY MORNING, THE MICROWAVE EXHIBITION STARTS. TO PARAPHRASE CALVIN COOLIDGE, "THE BUSINESS OF MICROWAVES IS ... BUSINESS"



THE EXHIBITION FLOOR BUSTLES WITH ACTIVITY AS OVER 500 EXHIBITING COMPANIES SHOW OFF THEIR LATEST PRODUCTS.

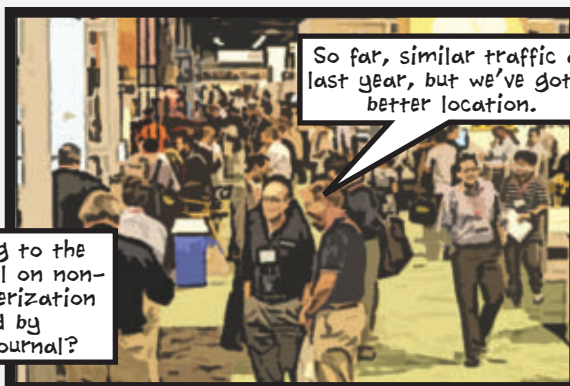


Where's that cyber café?



Are you going to the MicroApps panel on non-linear characterization organized by Microwave Journal?

Damn straight. They've got the leading measurement gurus from Agilent, Anritsu, Rohde & Schwarz, and Tektronix speaking.



So far, similar traffic as last year, but we've got a better location.



Actually, I do speak Japanese: "Sonnet kara no go aisatsu."

AGILENT TEAMS UP WITH AURIGA, CASCADE, ELECTRO-RENT, ETS-LINDGREN, EMS-CAN, IN-PHASE TECH, MAURY, MODELITHICS, NSI, T-TECH, WIN AND JAZZ SEMI AT AGILENT AVENUE, BOOTH 813.

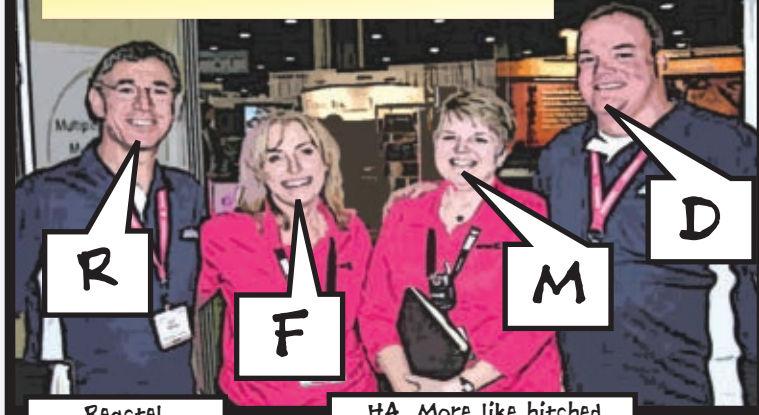


I should be tweeting about this.

SOME OF THE MOST IMPORTANT NETWORKING OPPORTUNITIES AND BUSINESS DECISIONS HAPPEN IN THE MOST UNLIKELY PLACES...

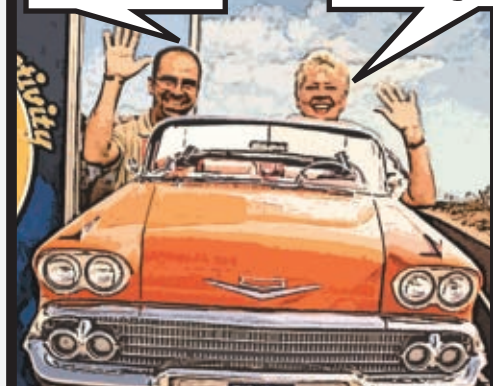


WHILE SOME EXHIBITORS HAM IT UP WITH MICROWAVE JOURNAL EDITORS AND THEIR VIDEO CAMERAS...

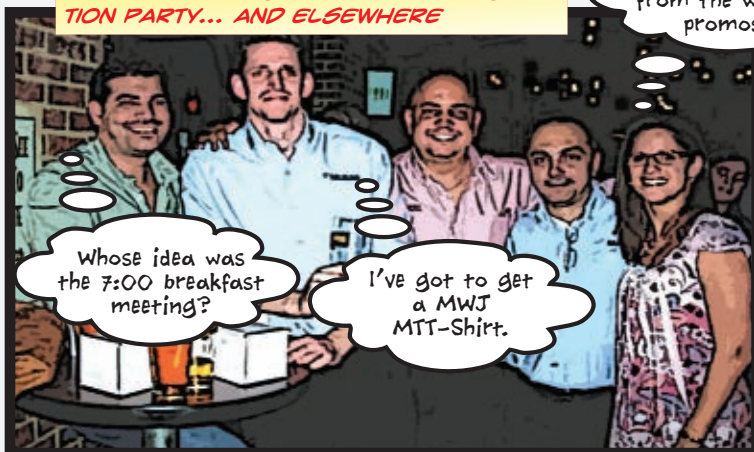


Reactel is local. Of course we drove.

HA. More like hitched a ride in the Triquint Chevy, Jimmy.



AND THE MICROWAVE MARKETING ELITE, GATHER TO NETWORK AT THE MICROWAVE JOURNAL CUSTOMER APPRECIATION PARTY... AND ELSEWHERE



Whose idea was the 7:00 breakfast meeting?

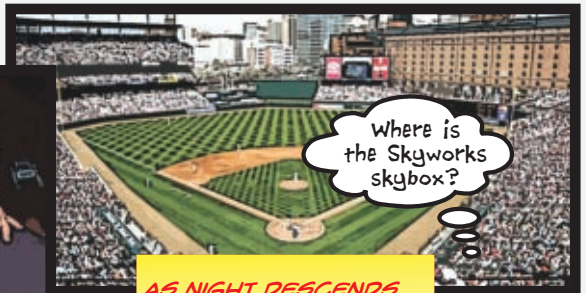
I've got to get a MWJ MTT-Shirt.

Isn't that the guy from the webinar promos?

BETSY HUSTLES RF/MICROWAVE ENGINEERS AT POOL IN THE COMPONENT DISTRIBUTORS BOOTH.



OK, if I make this shot, you'll place an order.



Where is the Skyworks skybox?

AS NIGHT DESCENDS ON THE EXHIBITION, SOME HEAD OVER TO CAMDEN YARDS.

So Dane, another successful AWR shindig?



I'd say so. This event ROCKS every year. Here's to our lucky 7th annual customer appreciation party.



My feet kill!!! I've been standing for 12 hours straight.

ON DAY 3, THE EXPO CROWD BEGINS TO DEPART.

Call me next week for a follow-up meeting with my engineers.

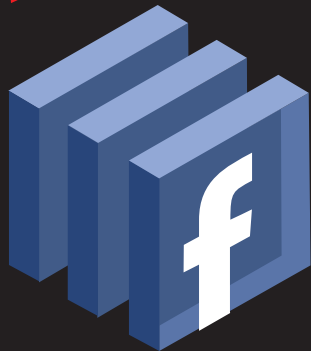
Every year I question whether it's worth the effort and every year the show delivers.

You talking about this year's K&L bag?



AS THE SUN SETS ON MICROWAVE WEEK, EXHAUSTED ENGINEERS AND BUSINESS PROFESSIONALS HEAD HOME WITH LOADS OF PRODUCT INFORMATION, BUSINESS CONTACTS, ACTION ITEMS, AND PLANS FOR NEXT YEAR.

BE FEATURED IN OUR 2011 IMS-WRAP UP



1.

CAPTURE THOSE SPECIAL
IMS 2011 MOMENTS WITH
YOUR CAMERA OR PHONE



2.

"LIKE" MICROWAVE JOURNAL'S FACEBOOK PAGE
@ FACEBOOK.COM/MICROWAVEJOURNAL

3.

POST YOUR PICTURES
TO OUR WALL (WITH OR
WITHOUT CAPTIONS)



4.

VISIT AND COMMENT ON THIS
YEAR'S CROP OF IMAGES. HELP
OUR EDITORS SELECT SCENES
FOR OUR IMS 2011 WRAP-UP

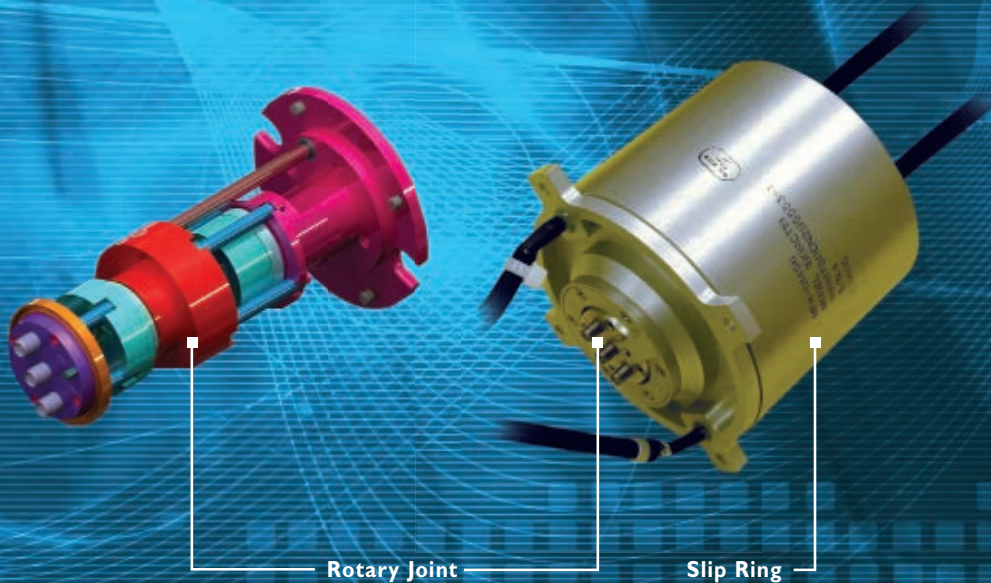


Frequency Matters.

COMING IN OUR AUGUST ISSUE

Follow us at: <http://www.facebook.com/MicrowaveJournal>

Channel surfing.



Multichannel Coax Rotary Joint / Slip Ring Assembly

Up to 30 channels.

Use MDL's rotary joint to transfer 3 RF signals and a 30-channel slip ring for flawless DC transmission. We make and assemble both components, so you'll save labor and testing costs. And you're assured of the highest quality and reliability from the leader in high quality cast components and waveguide packages.

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 do a little surfing of your own and visit us at mdllab.com.

RF Rotary Joint

Two Channels: 14.4 – 15.4 Ghz
One Channel: 9.7 – 15.4 Ghz
VSWR: <2.0:1
I.L.: <2.0dB
Isolation: >60 dB

Slip Ring Assembly

Isolated Contacts: 30
Voltage: 20-300 Volts
Current: .1 - 5 Amps

WAVEGUIDE CAST BENDS & TWISTS
WAVEGUIDE FEED ASSEMBLIES
MONOPULSE COMPARATORS
ROTARY JOINTS
MICROWAVE FILTERS
ROTARY SWITCHES
WAVEGUIDE TO COAX ADAPTERS
WAVEGUIDE PRESSURE WINDOWS
COMMERCIAL WAVEGUIDE ASSEMBLIES



IEEE

IMS2011 Baltimore



Visit MDL at Booth #2519



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



**At the heart of the
next generation air and
missile defense radars.**





Map of Baltimore area provided courtesy of CTT, Inc. Stop by CTT's Booth 2302

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.

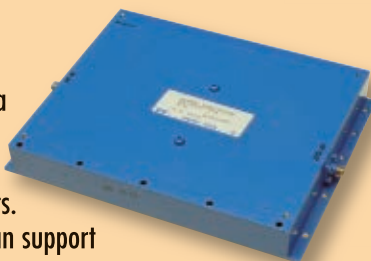
CTT has delivered production quantities of amplifiers with power levels of 10, 20, 40, 80, and 100 Watts – and higher – for a variety of radar applications.

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

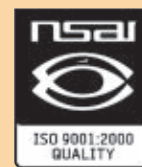
More than twenty-five years ago CTT, Inc. made a strong commitment to serve the defense electronics market with a simple goal: quality, performance, reliability, service and on-time delivery of our products.

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



Microwave Technology Leadership

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



USA-based thin-film microwave production facility

241 East Java Drive • Sunnyvale • California 94089
Phone: 408-541-0596 • Fax: 408-541-0794
www.cttinc.com • E-mail: sales@cttinc.com

CTT INC.

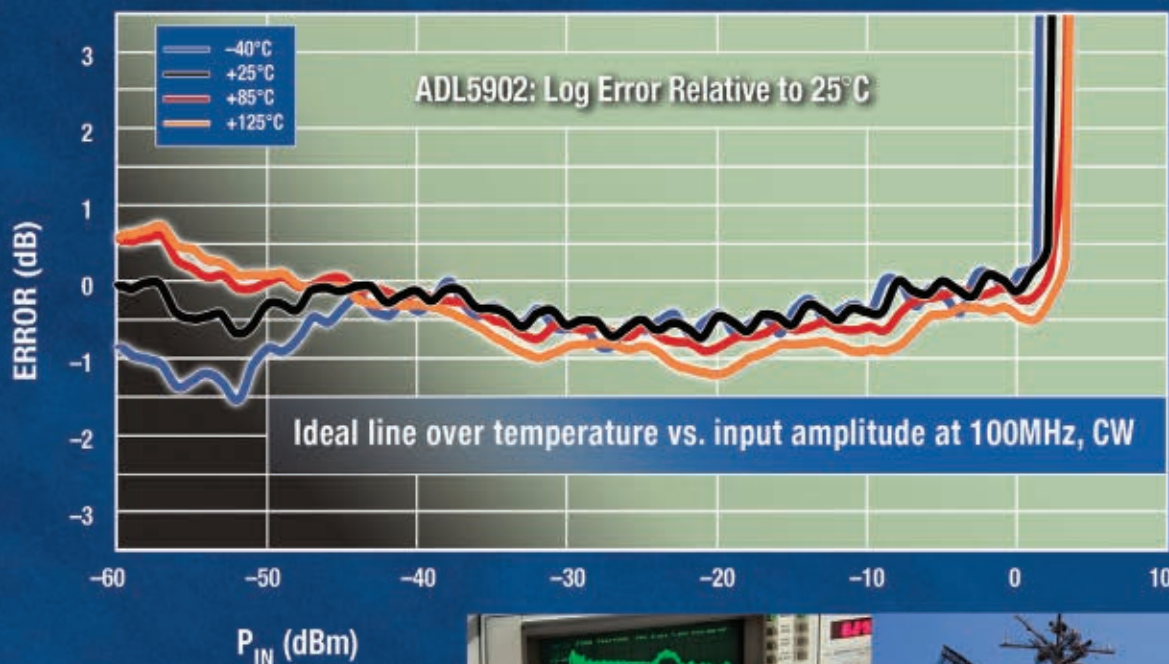


2011 IMS EXHIBITORS

The following list is complete as of April 8, 2011. Exhibitors in bold have an ad in this issue.

2COMU	1929	B&Z Technologies	4518	Diablo Industries Thin Film	4115
3G Metalworx Inc.	4012	Barry Industries Inc.	726	Diamond Antenna & Microwave Corp.	3511
A-Alpha Waveguide Co.	2510	Batten & Allen Ltd.	4510	Dielectric Laboratories Inc.	1006
A.J. Tuck Co.	424	Besser Associates Inc.	1707	Diemat Inc.	3612
A.T. Wall Co.	429	Bliley Technologies Inc.	4515	DiTom Microwave Inc.	702
Accumet Engineering Corp.	337	Bowei Integrated Circuits Co. Ltd.	643	Dorado International Corp.	706
Acewavetech Co. Ltd.	4405	Brush Ceramic Products	4111	Dow Key Microwave Corp.	907
Actipass Co. Ltd.	1038	CW Swift	3714	Ducommun Technologies Inc.	404
Active Spectrum Inc.	347	C-Tech	505	DuPont Electronic Technologies	4010
Advanced Mobile Tecnology	4707	CAD Design Software	3509	Dyconex AG	744
AdTech Ceramics	3713	Cambridge University Press	3203	Dynaware Inc.	2511
Advance Reproductions Corp.	4410	CAP Wireless Inc.	3210	Dyne Tech Co. LTD	5118
Advanced Test Equipment Rentals	3802	CapeSym Inc.	306	e2v aerospace and defense Inc.	4702
AEM Inc.	4907	Carlisle Interconnect Technologies	2309	EADS North America	3706
Aeroflex Inc.	2212	Cascade Microtech Inc.	911	Eastern-Optx	1050
Aethercomm Inc.	3304	Centellax Inc.	312	Eclipse Microwave Inc.	703
Agilent Technologies	813	Centerline Technologies LLC	4502	<i>EE-Evaluation Engineering</i>	5214
AI Technology Inc.	538	Century Seals Inc.	3705	Egide	4612
AKON Inc.	307	Cernex	3207	Elcom Technologies Inc.	4506
Aldetec Inc.	425	Channel Microwave	1514	Electro Rent Corp.	528
Aliner Industries Inc.	4412	Charter Engineering Inc.	4809	ElectroMagneticWorks Inc.	338
Allwin Technology Inc.	645	Chengdu BoCen Microwave Tech. Co.	4606	Elisra Electronic Systems Ltd.	3504
AMCAD Engineering	714	Chin Nan Precision Electronics Co. Ltd.	641	EM Research Inc.	1149
Amcom Communications Inc.	3503	Ciao Wireless Inc.	3609	EM Software & Systems - FEKO	936
American Microwave Corp.	4319	Cirexx International Inc.	4009	Emerson & Cuming Microwave	3507
American Standard Circuits Inc.	3809	Cirtek Electronics Corp.	944	Emerson Connectivity Solutions	517
Ametek HCC Industries	3710	Coham	1024	Emicon Corp.	3811
AML Communications Inc.	2024	Coherent Logix	4306	Empower RF Systems	947, 1047
Amplifier Solutions	4205	Coilcraft Inc.	2402	Empowering Systems Inc.	5205
AmpliTech Inc.	2303	Coining Inc.	4404	EMSCAN	1010
ANADIGICS	1144	Coleman Cable Systems Inc.	804	Endwave Corp.	1904
Analog Devices Inc.	820	Coleman Microwave Co.	840	ENS Microwave LLC	343
Anapico Ltd.	2323	COM DEV Ltd.	334	Epoch Microelectronics Inc.	649
Anaren Inc.	928	Communication Power Corp. (CPC)	5011	Epoxy Technology Inc.	352
Anatech Electronics	4507	Communications & Power Industries ..	2411	ET Industries	4106
Anoison Electronics	631	Compex Corp.	3803	ETL Systems	3303
Anritsu Co.	1818	Component Distributors Inc.	1623	ETS-Lindgren	817
ANSYS Inc.	1020	Connecticut Microwave Corp.	850	EuMW 2011/Horizon House Publ. Ltd.	3411
Antenna Research Associates Inc.-ARA ..	5119	Connectronics Inc.	639	EZ Form Cable Corp.	2124
APA Wireless Technologies	317	Constant Wave	1052	F&K Delvotec Inc.	1804
API Technologies	446	Continental Resources Inc.	5109	Farran Technology Ltd.	1515
APMC 2011	447	Corning Gilbert Inc.	1902	Ferrite Co. The	1136
Applied Thin-Film Products	3514	CORWIL Technology Corp.	648	Ferro-Ceramic Grinding	745
AR RF/Microwave Instrumentation	1103	CPS Technologies	4413	Filtel Microwave Inc.	322
ARC Technologies Inc.	1140	Crane Aerospace & Electronics	1822	Flann Microwave	426
Arlon Tech. Enabling Innovation	4613	Crane Polyflon	2023	Flexco Microwave Inc.	640
Artech House	3412	Cree Inc.	1925	Florida RF Labs/EMC Technology	1612
ASB Inc.	1143	Cristek Interconnects Inc.	506	Focus Microwaves Inc.	2119
Ascent Circuits Pvt Ltd	4103	Crystek Corp.	325	Fotofab	834
Aselsan	344	CST of America Inc.	1423	Freescale Semiconductor	1028
Assemblies Inc.	2204	CTT Inc.	2302	Frontlynk Technologies Inc.	3512
Astrolab Inc.	931	Cuming Microwave Corp	3209	FTG Corp.	633
Auriga Microwave	912	Custom Cable Assemblies Inc.	3812	G-Way Microwave	3912
Aurora Software & Testing SL	329	Custom Interconnects	445	Geib Refining Corp.	748
Avago Technologies	1602	Custom Microwave Components Inc.	735	Gerotron Communication GmbH	340
Avalon Test Equipment Rentals & Repairs ..	4604	Custom MMIC Design Services Inc.	650	GGB Industries Inc.	2004
AVX Corp.	3405	D.L.S. Electronic Systems Inc.	437	Giga-Tronics Inc.	1409
AWR Corp.	1618	Daa-Sheen Technology Co. Ltd.	3602	GigaLane Co. Ltd.	3709
Axiom Test Equipment Inc.	341	dBm	933	Global Communication Semiconductors ...	2504
		<i>Defense Tech Briefs</i>	750	GNI Microwave Co. Ltd.	637
		DELFMEMS	632	Gowanda Electronics	730
		Delta Electronics Mfg. Corp.	3814	Greenray Industries Inc.	3712
		Delta Microwave	731	GuangShun Electronic Tech. Research Inst.	4110
		Delta Workshop Technologies Inc.	1044	H Rollet	3613
		DeWeyl Tool Co. Inc.	4802	Harbour Industries Inc.	3813

Any complex modulated signal in; accurate signal power measurement out.



In RF, ADI makes the difference.

New TruPwr™ RMS detectors:



ADL5902

Accurate rms-to-dc conversion from 50 MHz to 9 GHz. Single-ended dynamic range of 65 dB. Best-in-class temperature stability of ± 0.3 dB. Linear-in-dB output.



ADL5505

For use in 450 MHz to 6 GHz Rx and Tx designs; 35 dB input power dynamic range, inclusive of crest factor. Excellent temperature stability.

TruPwr™ RMS Detectors Simplify RF Designs. The proliferation of high crest factor signals in broadband RF designs complicates the task of power measurement. RMS detectors from Analog Devices solve this problem, delivering accurate, repeatable measurement results that are independent of signal type. Analog Devices' TruPwr RMS detector portfolio offers best-in-class temperature stability over the widest temperature range and across the widest dynamic range. Input frequencies up to 9 GHz can be measured while maintaining frequency versatility without the need for a balun, or any other form of external input tuning, thereby simplifying designs and reducing component count and cost. With the industry's broadest portfolio of high performance RF detectors, ADI can meet any RF power measurement challenge. Learn more at www.analog.com/TruPwr.

See us at MTT-S Booth 820

Trust Us
with Your
Assembly & Test
And...

GET
THE
EDGE



SemiGen

See our production line in action at:
SemiGen.net



ISO 9001:2008
REGISTERED

ITAR
REGISTERED

HEI Inc.....	547	M/A-COM Technology Solutions.....	1418
Herley Industries	919	M2 Global Technology Ltd.	2509
Herotek Inc.	940	Mag Layers USA Inc.....	550
Hesse & Knipps Inc.....	3410	Marcel Electronics International	5113
<i>High Frequency Electronics.....</i>	<i>1705</i>	Massachusetts Bay Technologies	4303
Hirose Electric Co. Ltd.	5209	Materion	4111
Historical Booth.....	5419	MathWorks.....	4304
Hittite Microwave Corp.	2009	Maury Microwave Corp.	1016
Holzworth Instrumentation Inc.....	2419	McGraw-Hill Professional.....	3506
Huada Intl. Electronics & Tech. Co. Ltd.....	4109	MECA Electronics Inc.	4014
Hughes Circuits Inc.....	444	Mega Circuit Inc.....	524
HXI LLC.....	5019	MegaPhase	4202
IBM Corp.....	5114	Meggitt Safety Systems Inc.....	918
<i>IEEE Microwave Magazine</i>	<i>3502</i>	Mentor Graphics Corp.	605
IHP GmbH.....	3605	Mersen.....	4909
IMST GmbH	2224	MESL Microwave Ltd.	743
IMT.....	3903	Metropole Products Inc.	803
In-Phase Technologies Inc.....	711	Mician GmbH.....	740
Infinite Graphics	5315	Micreo Ltd.	4007
INGUN Pruefmittelbau GmbH	3804	Micro Communications Inc.....	644
Innertron Inc.	4407	Micro Electronic Tech. Development.....	441
Instek America Corp.....	3913	Micro Lambda Wireless Inc.	2502
Instruments For Industry (IFI).....	4504	Micro Tool Inc.....	849
Integra Technologies Inc.....	4015	Micro-Coax Inc.	3404
Integrand Software Inc.	3305	Micro-Mode Products Inc.	435
Intercept Technology Inc.....	332	MicroApps	413
International Manufacturing Services ...	2106	MicroFab Inc.	4503
Ion Beam Milling Inc.....	3307	Micronetics Inc.....	525, 625
IROM Tech. Inc.	549	Microphase Corp.	529
Isola	2104	Microsemi Corp.	722
ISOTEC Corp.....	4409	Microtech Inc.	2125
ITF Co. Ltd.....	833	Microwave Applications Group	326
iTherm Technologies	5318	Microwave Circuits.....	704
ITT Corp.-Microwave Systems	2007	Microwave Communications Labs Inc.....	610
IW Insulated Wire Microwave Products	407	Microwave Development Labs Inc.	2519
Jersey Microwave LLC	630	Microwave Dynamics	802
JFW Industries Inc.....	2002	Microwave Engineering Europe.....	546
Johanson Manufacturing Corp.....	439	Microwave Journal	3414
Johanson Technology Inc.....	1609	Microwave Packaging Technology Inc.....	3611
John Wiley & Sons.....	807	<i>Microwave Product Digest</i>	<i>617</i>
Johnstech International	4402	Microwave Technology Inc.....	1046
JOL Electronics Inc.	3909	Microwavefilters S.R.L.....	533
Jye Bao Co. Ltd.....	3606	MIG-Microwave Innovation Group	1605
K&L Microwave Inc.	902	Millennium Microwave Inc.....	3403
Kaben Wireless Silicon Inc.	4807	Millitech Inc.....	1610
Kaelus	1509	Mini-Circuits.....	1031
KCB Solutions.....	3911	Mini-Systems Inc.	935
Kemac Technology Inc.	806	MITEQ Inc.	1909
Keragis Corp.....	705	Mitsubishi Electric & Electronics.....	510
KJ Comtech	4305	Modelithics Inc.....	713
KMIC Technology Inc.	3905	Modular Components National Inc.....	2107
Krytar Inc.	1712	Molex RF/Microwave Business Unit	2102
KVG Quartz Crystal Technology GmbH	5107	Momentive Performance Materials	4618
Kyocera America Inc.	628	Mosis	950
L-3 Communications	502, 602	MPDevice Co. Ltd.....	736
LadyBug Technologies LLC	737	MtronPTI	1152
Lake Shore Cryotronics Inc.....	3603	Murata Electronics	1607
Lanjan Electronics.....	3805	Mustang Industrial Corp.....	749
Lark Engineering Co.	1535	Nanjing Jiexi Technologies Co. Ltd.....	4918
Laser Process Mfg.	747	National Instruments	2420
Laser Processing Technology Inc.	4915	National Reconnaissance Office	844
Laser Services	2123	NAVICP	5218
LCF Enterprise.....	406	NDK	710
Leader Tech. Inc.	346	Netcom Inc.....	1729
Liberty Test Equipment.....	848	Networks International Corp. (NIC).....	733
Linearizer Technology Inc.	530	Nitronex Corp.	945
Lintek Pty Ltd.....	4006	Noise XT.....	1049
Litron Inc.....	443	NoiseWave Corp.....	837
LNX Corp.	1147	Norden Millimeter Inc.	635
Logus Microwave Corp.	328	Northrop Grumman.....	304
Lorch Microwave	1512	NSI	1110
LPKF Laser & Electronics	2202	NTT Advanced Technology	4406



HIGH POWER

100 MHz
to 20 GHz



**For Military/Radar
Applications.**

Isolators/Circulators

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



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

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

The following models are examples of our High Power units

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

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

sales@utemicrowave.com

See us at MTT-S Booth 1040

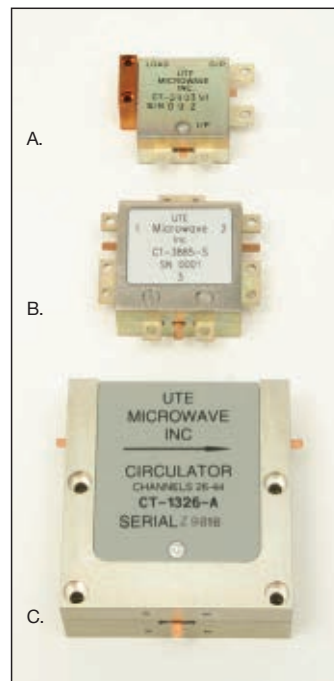
As one of the leading suppliers of ferrite components in the industry, UTE Microwave has pioneered innovative designs, quality craftsmanship and exceptionally high quality products. Custom designs, standards...many of them off-the-shelf, are the result of over 35 years of experience in the industry.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

HIGH POWER Drop-in Series

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

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

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



FEATURES:

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



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

Contact us for more information on our extensive product line and current catalog. We accept Visa, MC, Amex



Nuhertz Technologies LLC	4114
Nuvotronics	1802
NuWaves Engineering	545
NXP Semiconductors	420
OEwaves Inc.	324
OMMIC	4104
ON Semiconductor	548
OPHIR RF Inc.	4002
Orient Microwave Corp.	1732
Paciwave Inc.	3510
Paricon Technologies Corp.	436
Partron Co. Ltd.	836

Pascall Electronics Ltd.	450
Passive Plus Inc.	2404
Penton Electronics Group.	5009
Peregrine Semiconductor Corp.	1626
PHARAD LLC.	1037
Phase Matrix Inc.	4418
Photo Sciences Inc.	1803
Photofabrication Eng. Inc.	4302
Piconics Inc.	3306
Pivotone Communication Tech. Inc.	941
Planar	433
Planar Monolithics Industries Inc.	2304

Plansee Thermal Management Solutions	434
Plextek Ltd.	2122
Pole/Zero Corp.	906
Polyfet RF Devices	3407
Ponn Machine Cutting Co.	4716
Power Module Technology	4715
Precision Connector Inc.	4818
Precision Manufacturing Group	4415
Presto Engineering Inc.	5213
Procast/John List Corp.	3703
Prototron Circuits	4102
Q Microwave Inc.	315
Q3 Laboratory	4602
Quest Microwave Inc.	1713
Questech Services Corp.	4605
Quik-Pak; Gel-Pak	4514
QuinStar Technology Inc.	310
QWED Sp. z o.o.	438
R&D Circuits	448
R&D Microwaves LLC	5410
R&K Co. Ltd.	540
Radant MEMS Inc.	937
Reactel Inc.	3915
Reinhardt Microtech AG	622
RelComm Technologies Inc.	2005
Remcom Inc.	629
Remtec Inc.	3607
Renaissance Electronics Corp.	5018
Resin Systems Corp.	1036
Response Microwave Inc.	4414
Restor Metrology	4204
RF Depot Inc.	707
RF Globalnet	2025
RF Industries	4615
RF Logic	4819
RF Morecom	4815
RFcore Co. Ltd.	634, 534
RFHIC Corp.	4206
RFMD	1402
RFMW Ltd.	2507
RFS Ferrocom Ferrite Division	4307
RH Laboratories Inc.	604
Richardson RFPD	728
RIV Inc. - Precision Printing Screens	746
RJR Polymers Inc.	718
RLC Electronics Inc.	739
Rockwell Collins	4403
Rogers Corp.	2515
Rohde & Schwarz	2115
Rosenberger North America LLC	1411
RT Logic	838
Sainty-Tech Communications Ltd.	336
San-tron Inc.	4616
Sangshin Elecom Co. Ltd.	4004
Sawnics Inc.	3406
Schmid & Partner Engineering AG	3204
Scientific Microwave Corp.	3202
Scintera Inc.	402
SEL	831
Semi Dice Inc.	805
SemiGen	348
SGMC Microwave	3806
Shadow Technologies Inc.	3604
Shanghai Huaxiang Computer Comm. Eng.	543
Shenzhen Huayang Tech. Development Co.	647
Shenzhen Yulongtong Electron Co. Ltd. ...	646
Shin-Etsu Chemical Co. Ltd.	4520
Sierra Circuits Inc.	638
Signatone	1631
Silicon Cert Laboratories	1043
Sinclair Manufacturing Co.	539
SIPAT Co.	544

OSCILLATORS ▶ HIGH-SPEED CLOCKS

Phase Locked, Digitally Tuned, Voltage Controlled

UP TO 50 GHz

VOLTAGE-CONTROLLED OSCILLATORS

- Low Phase Noise
- Fundamental Si Bipolar Outputs to 15 GHz
- Narrow band to octave band

HIGH-SPEED CLOCKS

- 40 Gb/s and 100 Gb/s Applications
- Jitter at 40 GHz: 50 KHz - 80 MHz < 50 fsec
- Single-Ended or Differential Output
- Slew Rate: > 25 V/ns

PHASE-LOCKED OSCILLATORS

- Low Phase Noise
- Internal/External Ref. 10 MHz/100 MHz
- Harmonics < -30 dBc
- Spurious < -65 dBc

Contact us about Custom sub-assemblies

Phase Matrix, Inc.™
www.phasematrix.com
877-447-2736 or 408-428-1000

SELECTION SUPPORT SERVICE

When you need it most

All are key when purchasing high performance microwave transmission lines. Currently a **SELECTION** of IW products are employed on the Navy's latest platforms in a variety of systems including the AIMS ATC/IFF radar, PHALANX close in defense system, HDR and MILSTAR.

IW's **SUPPORT** for these systems includes a wide range of flexible microwave cable assemblies. Extremely low loss cables are optimized for operation up to 11 GHz, 18 GHz, 26.5 GHz, 40 GHz, 50 GHz, and 65 GHz. These cables are available with optional internal and external ruggedization and a selection of jacket materials to meet specific environmental requirements. IW supports these cables with a wide selection of connectors including SMA, TNC, N, SC, 1.65mm, 2.4mm, 3.5mm, and 7mm.

IW's **SERVICE** is second to none. Most quotes are provided within 24 hours. Additionally, your calls are handled personally, not through voice mail!

ISO 9001:2008 CERTIFIED





Skyworks Solutions Inc.	1428
Smith Interconnect	1510
Sonnet Software Inc.	3213
SOURIAU PA&E	738
Southwest Microwave Inc.	824
Spanawave Corp	847
Spectra - Mat Inc.	4607
Spectracom Corp.	535
Spectrum Microwave Inc.	1415
Spinner Atlanta	431
SRI Connector Gage Company	531
SSI Cable Corp.	934

State Of The Art Inc.	1805
Statak Corp.	3711
Stellar Industries Corp.	319
Stellar Microelectronics	1145
StratEdge Corp.....	618
Sumitomo Electric Device Innovations ...	620
SV Microwave Inc.	2409
Synergy Microwave Corp.	507, 607
SynQor Inc.	4609
T-Tech Inc.	717
Taconic	3914
Tahoe RF Semiconductor Inc.	504

Tai-Saw Technology Co. Ltd.	1045
TDK-Lambda Americas	2223
TE Connectivity.....	841
Tecdia Inc.	2027
Tech-X Corp.	541
Techmaster Electronics Inc.....	4005
Tektronix Inc.	1432
Telcon Co. Ltd.	4011
Teledyne Storm Products	2021
Teledyne Technologies Inc.	1812
Telegartner Inc.	2121
Temp-Flex Cable Inc.	5007
Test Equipment Repair Corp.	3906
TestEquity LLC	835
Thales Components Corp.....	1138
THINFILMS Inc.	331
Times Microwave Systems	3310
TMD Technologies Ltd.....	536
Torrey Hills Technologies LLC.....	4611
Toshiba America Electronic Cmpts.	2306
TotalTemp Technologies Inc.....	1730
TowerJazz	715
TRAK Microwave Corp.	1614
Transcom Inc.	3810
Tresky Corp.	3702
Trilithic Inc.	938
TriQuint Semiconductor	2218
TRM Microwave.....	3902
Tronser Inc.....	839
TRU Corp. Inc.	302
TTE Inc.	302
UltraSource Inc.....	1435
UMS (United Monolithic Semiconductors) ..	1709
University Booth.....	4209
UTE Microwave Inc.	1040
Vacuum Engineering & Materials Co. Inc. ..	3910
Valpey Fisher Corp.	1633
Vectron International	1002
Verspecht-Teyssier-Degroote	318
VIDA Products Inc.	440
VidaRF	314
Virginia Diodes Inc.	4411
Vishay Intertechnology Inc.....	4509
Voltronics Corp.	1005
VTI Instruments Corp.	909
Vubiq Inc.....	5015
W.L. Gore & Associates	320
Wavenics Inc.	636
Webcom Communications/Antenna Sys.....	333
Weinschel Associates	428
Wenzel Associates Inc.	3409
Werlatone Inc.	3402
West Bond Inc.	3614
WEVERCOMM Co. Ltd.	3610
Williams Advanced Materials	4111
WIN Semiconductor Corp.	810
Winchester Electronics	4709
WIPL-D D.O.O	734
<i>Wireless Design & Development</i>	4203
Wireless Telecom Group	2019
X5 Systems Inc.	330
Xi'an Forstar S&T Co. Ltd.	845
XMA Corp.	350
Xyztec	3704
Yantel Corp.	4003
Yokowo Co. Ltd.	949
Z-Communications Inc.	313
Zeeteq Electronics Ltd.....	1041

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

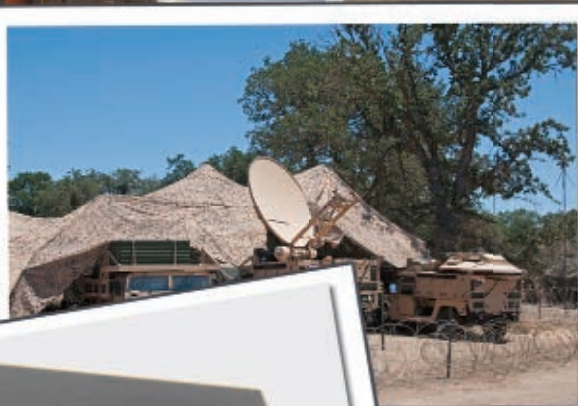
TRAK

Dependable **RF Solutions**



- **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 MTT-S Booth 2002

Complex problems require **Balanced Solutions...**

Auriga Microwave designs and manufactures
Balanced Solutions that overcome historical and
perplexing design and performance limitations.

By creatively optimizing efficiency, linearity and size, our
customers receive a balanced solution that meets or exceeds
their specifications based on performance, time and money.



**Visit Auriga Microwave at
IMS-MTT 2011, Booth #912**

Microwave Design

Auriga designs, manufactures and delivers balanced solutions. Our customers turn to us when efficiency, linearity and size need to be optimized, especially when time-to-market is critical or internal expertise is unavailable. Team with Auriga to leverage our 80 years of combined modeling and design experience, and expertise with the industry's most sophisticated technology in high-powered RF and microwave devices.

Pulsed IV/RF System

Auriga delivers unprecedented testing capabilities in one small package. Our third-generation AU4750 is a standalone bench-top solution for capturing pulsed IV/RF data for pulsed DC device modeling. It may be fully integrated with a PNA for pulsed s-parameters measurements. Use Auriga's AU4750 and see how self-heating and trap-effects affect your device down to measurement widths of 200 ns.

Custom ATE

Auriga's third-generation custom test system enables a paradigm shift. Our turn-key, fully-automated, component test systems provide 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.

Bias Tees

Auriga bias tees perform where no other bias tee can. Our bias tees cover RF frequency ranges from 0.1 to 26.5 GHz in multiple frequency-band configurations and are targeted at wideband, high-power applications. Highest-grade materials are used to minimize loss and optimize heat dissipation. Heavy-duty construction make these ideal for laboratory and rugged environments.



www.aurigamicrowave.com/mtts11

RF Amplifiers and Sub-Assemblies for Every Application

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

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

ISO 9001:2000
and AS9100B
CERTIFIED

OCTAVE BAND LOW NOISE AMPLIFIERS

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

NARROW BAND LOW NOISE AND MEDIUM POWER AMPLIFIERS

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

ULTRA-BROADBAND & MULTI-OCTAVE BAND AMPLIFIERS

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

LIMITING AMPLIFIERS

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

AMPLIFIERS WITH INTEGRATED GAIN ATTENUATION

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

LOW FREQUENCY AMPLIFIERS

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

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

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

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

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

See us at MTT-S Booth 3609





Cobra Judy Replacement Team Completes Radar Delivery Milestone

Raytheon Co. and Northrop Grumman Corp. recently completed a significant milestone for the Cobra Judy Replacement program. The CJR S-band active phased-array antenna was successfully delivered to the CJR integration site at Kiewit Offshore Services, Corpus Christi, TX, completing the development phase of the program.

The mission of the CJR program is to provide the government with long-loiter ballistic missile data collection

"This radar suite will provide an integral sea-based treaty verification capability to the US and its allies."

capability. Its dual-band radar suite consists of X-band and S-band phased-array sensors, a common radar suite controller, and other related mission equipment. The program now progresses to full dual-band radar integration and testing.

"This delivery represents a tremendous step forward for the CJR program and the entire industry team," said Raytheon Integrated Defense Systems' Patrick "Kevin" Peppe, Vice President of Seapower Capability Systems. "This sophisticated radar suite will provide an integral sea-based treaty verification capability to the United States and its allies."

Northrop Grumman GaN-based Modules Set New Standard for High Power Operation

Northrop Grumman Corp. has set a new standard for its gallium nitride-based high power transmit/receive (T/R) modules by reliably operating them for more than 180 days during continuous high power testing. In a rigorous evaluation conducted by the company's Advanced Concepts and Technology Division, the T/R modules were tested by using high-stressing operational long-pulse waveforms, which operated on the modules nonstop for more than six months. These waveforms were designed to simulate the electronic activities of actual radar functions, in a relevant environment allowing Northrop Grumman engineers to understand how well they would perform in tactical operation.

The successful tests prove that the next generation of active electronically scanned arrays (AESA) is capable of reliable operation while producing much greater radar sensitivity, at higher efficiency and lower cost. With this new threshold established, the T/R modules can serve as critical technology elements for a wide range of future applications.

"By successfully employing the latest advances in high power semiconductor technology in a functioning T/R module, we have demonstrated the great performance and reliability of our design approach," said Steve McCoy, Vice President of the Advanced Concepts business unit within the company's Electronic Systems sector. "This new level of maturity also supports technology readiness for the next generation of Northrop Grumman's high performance, low cost AESA radars, and opportunities for cost reduction and performance upgrades to our current AESA product line."

By successfully employing the latest advances...we have demonstrated the great performance and reliability of our approach."

Harris Corp. Introduces First Unfurlable, High Frequency Ka-band Space Antenna

Harris Corp. introduced an unfurlable space antenna designed to support emerging requirements for high-throughput Ka-band satellites. The new Harris Ka-band antenna greatly increases the gain and potential spot beams currently available to spacecraft manufacturers and service providers. The increased frequency reuse provided by the additional spot beams enables higher data rates required by providers of bandwidth-hungry services such as satellite Internet, HDTV and 3D TV, and by businesses that transfer large amounts of data between remote locations, such as oil and gas companies and maritime users.

The antenna features flight-proven design elements that have been refined during development and production for US government and commercial programs, including the application of reflective mesh, surface-shaping technology and thermally stable materials. The antenna's architecture leverages Harris' robust radial rib structure reflector design, 40 of which are currently in operation. The projected aperture ranges from 3.5 meters to 8 meters in diameter, with a compact stowed configuration suitable for most launch vehicles. During launch, the Harris reflectors are stowed onboard the satellite much like an umbrella. Once in orbit, controllers execute a series of maneuvers, and then send commands to deploy an articulating boom and unfurl the reflector.

"This new Ka-band product is a natural extension of our existing offerings for larger apertures, and continues our 35-year legacy of providing high performance antenna solutions with unmatched performance," said Sheldon Fox, Group President, Harris Government Communications Systems. "The Harris solution supports the ever-increasing global demand for higher bandwidth capacity."

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



Lockheed Martin Awarded \$43.3 M Contract for Concept Definition of Standard Missile-3 Block IIB

Lockheed Martin announced that the US Missile Defense Agency has awarded it a \$43.3 M contract for concept definition and program planning for the Standard Missile-3 Block IIB (SM-3 IIB). The new missile, formerly known as

"This represents a unique opportunity to develop and field a critical addition to our nation's missile defense capability..."

the Next Generation Aegis Missile, will provide early intercept capability against intermediate- and long-range ballistic missile threats. It will be a key element of the fourth phase of the Phased Adaptive Approach, which will provide enhanced capabilities against threats on a global basis. The missile will be

integrated into the Aegis Weapon System, with the Aegis BMD 5.1 Fire Control and the MK 41 Vertical Launching System, as part of the land-based Aegis Ashore capability.

"This represents a unique opportunity to develop and field a critical addition to our nation's missile defense capability, one that complements existing systems," said Doug Graham, Vice President of Advanced Programs, Strategic

and Missile Defense Systems, Lockheed Martin Space Systems Co. "Working in partnership with the Missile Defense Agency and the US Navy, Lockheed Martin will leverage extensive missile defense interceptor and weapon system integration expertise to deliver a new interceptor that addresses emerging ballistic missile threats, with the flexibility to operate across the globe."

Raytheon Awarded \$42 M for Next Generation Standard Missile-3 Interceptor

Raytheon Co. was awarded \$42 M for the initial concept development and program planning for the Standard Missile-3 Block IIB, which is the Missile Defense Agency's next-generation Aegis missile.

"Raytheon is the lowest-risk, lowest-cost, most-technically capable provider of missile defense solutions," said Frank Wyatt, Vice President of Raytheon's Air and Missile Defense Systems product line. "SM-3 has successfully defeated 18 incoming ballistic missile threats in realistic test scenarios; it's in a class by itself. Spiral development of the Standard Missile program is the right choice for developing and delivering this capability for the country."

Raytheon's Standard Missile-3 family is a core element of the administration's Phased Adaptive Approach for missile defense. Raytheon engineers have decades of experience in radars, airborne and space-based sensors, interceptors and kill vehicles.

A Clean Sweep

If your RADAR, EW, or SIGINT system requires the cleanest signals, ITT Microwave Systems has the solutions. We deliver premium RF and digital subsystems by integrating our proprietary technologies within densely populated custom and standard packages. Our expertise is in frequencies through 20 GHz and includes FPGA-based Direct Digital Synthesis (DDS) LO synthesizers and waveform generators, as well as software controlled, wideband RF/digital tuners and upconverters.

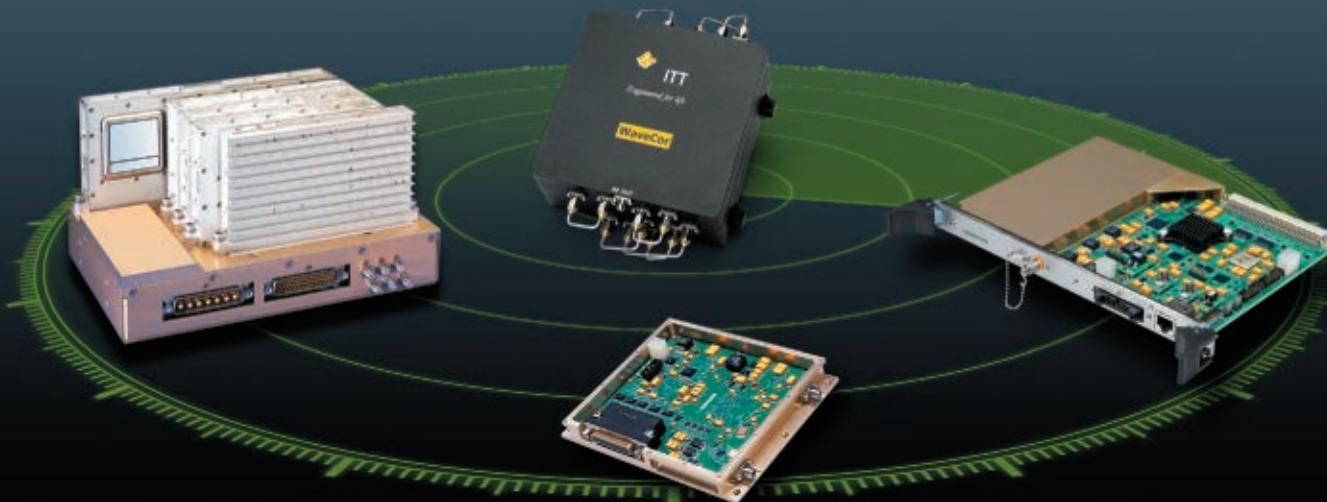
Visit our website for more information.



ITT

Engineered for life

ITT Microwave Systems
978-441-0200
ittmicrowave.com



See us at MTT-S Booth 2007

narda today

The Engineer's **Choice**



For IMAs Narda offers technically superior IMA products using its new proprietary microwave multilayer circuits (MMC) technology with digital signal processing. These IMA products allow for extremely compact, densely populated modules, consistent with SWaP goals. Embedded microprocessors and FPGA devices make possible adaptive adjustments that compensate for system dynamics and environmental extremes.

For RF & Microwave Components

Narda is recognized as the number one source for in-stock catalog RF and microwave components, including Couplers, Power Dividers, Attenuators, Terminations, Phase Shifters, Detectors, Adapters, Electro-Mechanical and PIN Diode based control products.

For RF Safety Solutions Narda holds 95% of all patents for EMF measurement worldwide. This division specializes in personal and field measurement instruments and RF safety training and education.



Visit Us At Booth 502

narda

an **L3** communications company

435 Moreland Road, Hauppauge, NY 11788
Tel: 631.231.1700 • Fax: 631.231.1711
e-mail: nardaeast@L-3com.com

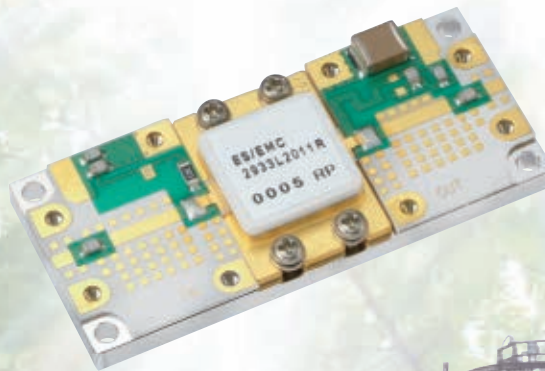
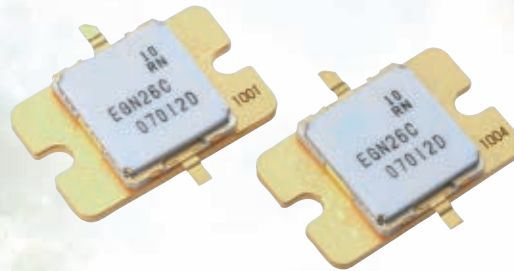
www.nardamicrowave.com/east

Engineering, without compromise since 1954.

GaN HEMT

High Volume Production

1,000,000 devices shipped



High Efficiency,
High Power, Wide Band
High Reliability

See us at MTT-S Booth 620

 **SUMITOMO ELECTRIC**

Ingenious Dynamics

http://global-sei.com/Electro-optic/index_e.html

Phone / Japan : +81 45 851 1468

USA : +1 408 232 9500

Europe : +44 (0) 20 89538118

Asia : +852 25760080



PERSEUS Project to Develop and Test European Maritime Surveillance System

The Protection of European BoRders and Seas through the IntElligent Use of Surveillance (PERSEUS) project, led by Indra, has been instigated to provide protection of the European seas and borders with the smart use of technologies. The project, with a budget of €43.7 M and an execution period of four years, is one of the most significant initiatives within the 7th Framework Programme of the EC and will be the flagship of R&D in the maritime security segment.

PERSEUS addresses the call for an integrated European system for maritime border control. Its purpose is to build and demonstrate an EU maritime surveillance system integrating existing national and communitarian installations and enhancing them with innovative technologies. By means of two large scale demonstrations the project will prove its feasibility and will set the standards and grounds for the future development of EU maritime surveillance systems.

Indra will undertake the coordination of the consortium comprising 29 partners from 12 EU member countries. Collaboration with non European countries and international agencies such as NATO or the International Maritime Organisation (IMO) is also envisaged. The new maritime surveillance system is expected to increase the effectiveness of the current systems by creating a common maritime information sharing environment for the benefit of the network, including National Coordination Centres, Frontex and the European Maritime Safety Agency (EMSA).

PERSEUS will incorporate technological innovations regarding detection and analysis applied to maritime security, particularly for the detection of low flying targets and small vessels. Multiple sensors and sources of information will be incorporated into the system, which will also employ technologies and capabilities under development by other EU projects, including other segments such as Space.

FP7 Programme Update

The PERSEUS Project is part of the 7th Framework Programme. The Project, which is set to end on 31 December 2014, will contribute to Europe's efforts to monitor illegal migration and combat related crime and goods smuggling by proposing a large scale demonstration of an EU Maritime surveillance System of Systems. To discover the project's objectives, participants, funding, etc., visit: www.mwjjournal.com/FP7MAY2011.

V3DIM Project to Develop 3D SiP Solutions in Millimetre-wave Range

The German V3DIM (standing for design for vertical 3D system integration in millimetre-wave applications) research project aims to lay the foundations for establishing the design requirements to develop innova-

tive, highly integrated 3D System-in-Package (SiP) solutions for systems in the 40 to 100 GHz range.

Five partners from industry, science and research have joined forces in the project funded by the German Federal Ministry of Education and Research (BMBF) to explore how innovative 3D integration technologies can be exploited in chip and package manufacture. In their quest, special attention will be paid to miniaturization, performance (including power loss, signal integrity, noise and cost), energy efficiency and reliability.

The five project partners are Fraunhofer Institutes in Dresden, Munich and Berlin lead-managed by the Dresden Institute for Integrated Circuits, SYMEO GmbH, Siemens AG, the Institute of Technical Electronics at the University of Erlangen-Nuremberg, and the project manager, Infineon Technologies AG.

The project is scheduled for completion at the end of August 2013. The five partners will devise new design methods, models and SiP technology components to meet the special challenges of vertical 3D system integration in the sphere of millimetre-wave applications.

V3DIM's overall project cost amounts to €6.8 M, with approximately 40 percent being funded by the three industry project partners. In addition, the project will receive BMBF support of about €4.1 M over a three-year term under the Information and Communications Technology 2020 (ICT 2020) programme as part of the German Federal Government's High-Tech Strategy. The V3DIM project also collaborates closely with the European CATRENE 3DIM3v project, which works on complementary aspects of vertical 3D system integration.

*... special attention
will be paid to
miniaturization,
performance...
energy efficiency and
reliability.*

Alcatel-Lucent Bell Labs, Thales and CEA-Leti Join Forces in III-V Lab

CEA-Leti has joined the III-V Lab in a move to strengthen the industrial research capabilities of the R&D centre, which is Europe's most advanced in the field of III-V semiconductors. CEA-Leti joins Alcatel-Lucent Bell Labs and Thales, which established the III-V Lab, south of Paris, France, in 2004.

Since then the lab has enabled the rapid development of a common platform for dual-use optoelectronic and microelectronic technology for markets addressed by the two groups such as telecom, space, defence and security. CEA-Leti will significantly broaden the scope of the lab's targeted applications by combining its IP and expertise in silicon, microelectronics and microsystems, and in heterogeneous integration.

The new public-private partnership will combine III-V

“The new III-V Lab will be a strong source of value creation.”

cians and doctoral candidates.

“This innovative joint venture is a unique model of partnership for joining competences, technologies and ambitions, and it will enable the partners to accomplish things they couldn’t do alone,” said Leti CEO Laurent Malier. “Each of us brings very specific and complementary expertise to our pursuit of common goals. Moreover, each partner can capitalize on the developments and transfer new technologies to our customers. The new III-V Lab will be a strong source of value creation.”

Newtec Joins Asia-Pacific Satellite Communications Council

Newtec has marked ten years in Asia by joining the Asia-Pacific Satellite Communications Council (APSCC) as a member. APSCC is a non-profit international organization representing all sectors of satellite and space related industries, including private companies, government ministries and agencies, and academic and research entities. Its overall

semiconductor and silicon technologies, opening up new research perspectives and dynamics. The enlarged III-V Lab will include more than 130 researchers, techni-

objective is to promote communications and broadcasting via satellite as well as outer space activities in the Asia-Pacific, for the socio-economic and cultural development of the region.

Yutaka Nagai, President of APSCC, said, “APSCC is delighted to welcome Newtec into the organisation. Newtec is a progressive, exciting, innovative company and technology leader in the satellite industry. We look forward to their contribution to APSCC activities.”

After a decade of activity in the Asian region, Newtec is now ready to become more firmly established in the region. The company has recently augmented and re-organised its team in Asia and has offices in Singapore and Beijing in order to direct more focus towards its products and solutions in the region. Joining the APSCC is the next logical step for further progression in the region.

Serge Van Herck, CEO of Newtec, commented, “This was the right time for Newtec to join APSCC. We have built a firm foundation in the Far East and we now want to build upon this to strengthen our presence in the region. Newtec’s involvement with APSCC will enable us to build new relationships and gain further knowledge of the satellite and space industry in the region. We are proud to be members of such an organisation.”

“Newtec’s involvement with APSCC will enable us to build new relationships...”

Bring Realistic and Fully Repeatable Air Interface Conditions into Your Lab EB Prosim Radio Channel Emulators



Expertise in Radio Channel Emulation since 1995 for

**DEVICE MANUFACTURERS
AEROSPACE & DEFENSE**

**RADIO NETWORK MANUFACTURERS
CHIPSET DEVELOPERS**

**OPERATORS
RESEARCH**

EB (Elektrobit) Tutkijantie 8, 90590 Oulu, Finland Tel. +358 40 344 2000 Fax +358 8 343 032
email: rcpsales@elektrobit.com website: www.elektrobit.com/ebprosim

HI-REL LIMITERS

**BLOCK HIGH LEVEL RF INTERFERENCE ...
PROTECT YOUR LOW NOISE RECEIVERS.**



10 MHz to 7 GHz from \$9.95 10-49

Need to protect a low-noise receiver that will be operating in a hostile environment? These limiters offer excellent protection against ESD, power surges and unwanted high-level signals--without the tradeoff of high insertion loss. And these limiters react nearly instantaneously (2 ns response time, 10 ns recovery time) and work over a very broad band.

With an insertion loss of only 0.23 dB typical, these hi-rel, wide-band limiters provide protection against high level signals from +12 dBm to +30 dBm input. The power out of the limiter is +11.5 dBm, typical. Thus protecting

the sensitive devices connected to the limiter output. The surface mount RLM series is housed in a miniature plastic case, 0.25" x 0.31" x 0.17". While the VLM SMA connectorized series is housed in a rugged, patented unibody package for easy connection to sensitive devices following the limiter.

Data sheets, performance curves, measurement data, and environmental specifications are available on our website, minicircuits.com. So why wait, order on our website and get delivery as quickly as the next day.

Unibody patent 6,943,646  RoHS compliant.

Mini-Circuits...Your partners for success since 1969

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

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

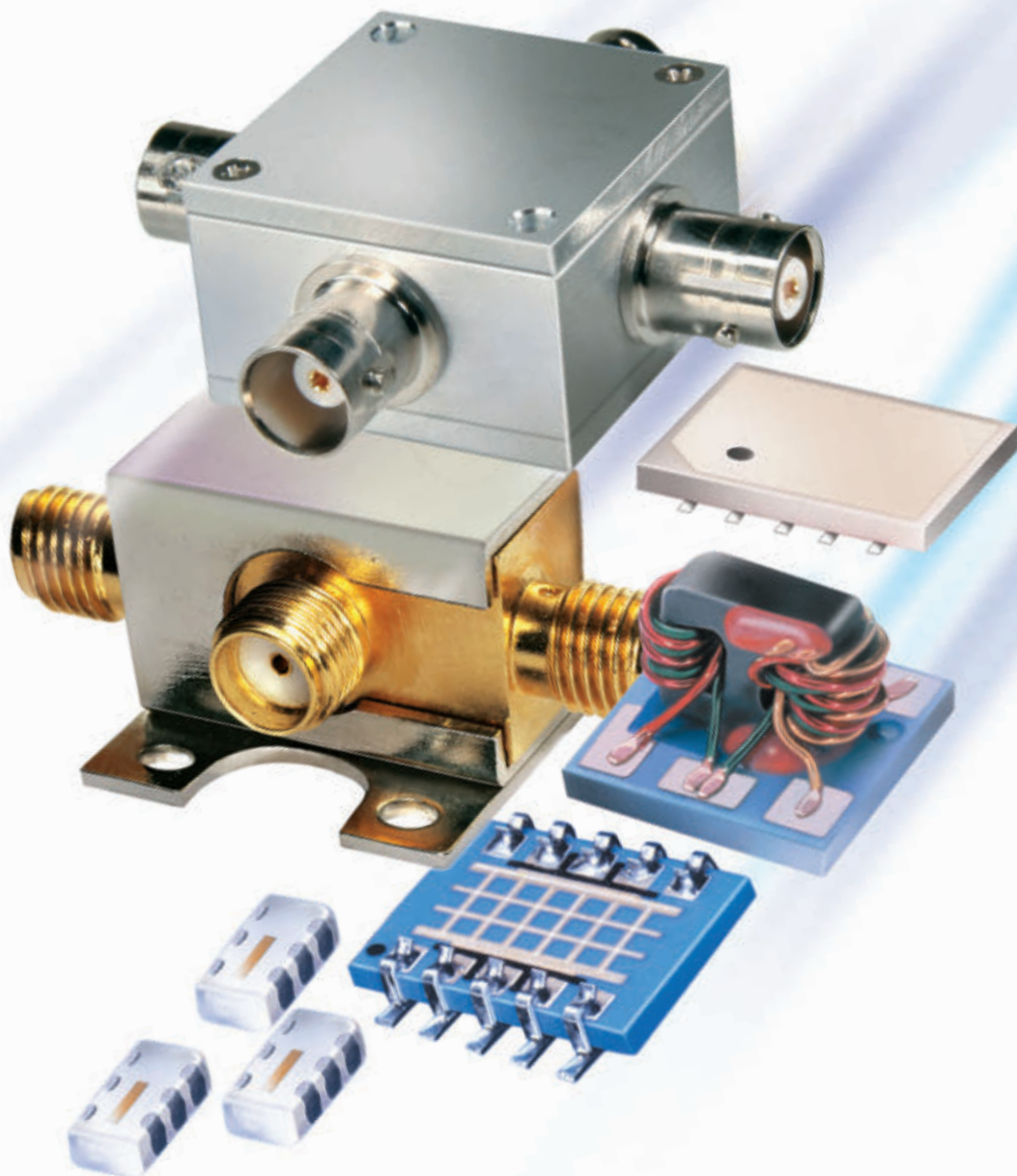


The Design Engineers Search Engine finds the model you need, Instantly • For detailed performance specs & shopping online see minicircuits.com

IF/RF MICROWAVE COMPONENTS

See us at MTT-S Booth 1031

480 rev org



Directional/Bi-Directional LTCC COUPLER FAMILY



IN STOCK \$ **169**
From ea. Qty. 1000

Mini-Circuits LTCC coupler family offers versatile, low cost solutions for your **5 kHz to 6 GHz** needs with rugged connectorized models from .74"x.50" to surface mount couplers from .12"x.06", the smallest in the world! Choose from our 50 & 75 Ω directional and bi-directional couplers with coupling ranging from 6-22 dB and with capability to pass DC. Mini-Circuits offers the world's most highly evolved LTCC

technology delivering both minimal insertion loss and high directivity with models handling up to 65 W. All of our couplers are ESD compliant and available as RoHS compliant. For full product details and specifications for all our couplers, go to Mini-Circuits web site and select the best couplers for your commercial, industrial and military requirements.

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

Mini-Circuits®
ISO 9001 ISO 14001 AS9100 CERTIFIED

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



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

IF/RF MICROWAVE COMPONENTS

See us at MTT-S Booth 1031

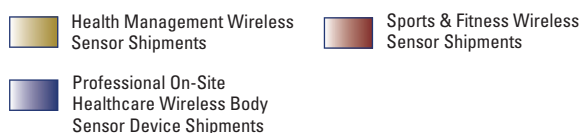
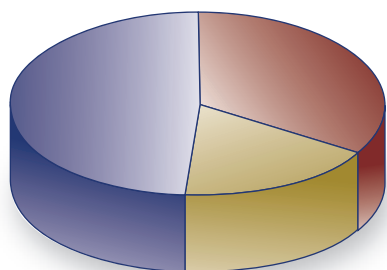
396 rev M



Half-billion Dollar Market at Risk, Due to Delays in Bluetooth Low Energy Standard Adoption

Bluetooth Low Energy (BLE) has the potential to power a range of new applications collecting and sharing personal fitness and health management data, but delays in product deliveries to markets over the past 12 months have some application developers looking to rival technologies and protocols. The Bluetooth SIG did not formally adopt the Bluetooth Core Specification Version 4.0 which encompasses Bluetooth Low Energy technology until July 2010 – more than six months later than many in the industry had expected.

**Wireless Sensor Shipments by Market Segment
World Markets, Forecast: 2016**



Source: ABI Research

With the huge potential of the Bluetooth Low Energy technology, the wait for adoption by the Bluetooth SIG has put a brake on many wireless health and sports devices' market launches. Where it has not halted product development it has fostered adoption of rival traditional Bluetooth and proprietary offerings in the market. In addition, application developers have looked to build offerings around smartphone handsets' current sensor and data collection capabilities. However, ABI Research believes that Bluetooth Low Energy remains of key importance to the proliferation and adoption of wearable wireless-enabled sports and health sensors.

ABI Research's "Wireless Healthcare and Fitness Market Data" provides forecast data for a number of significant types of wireless equipment in a healthcare environment including Wi-Fi access points and Wi-Fi RTLS appliances. It includes examination of remote patient monitoring, telehealth and telepresence, and contains data about "body area networks."

This product is included in the firm's Wireless Health-

care Research Service, which also includes Research Reports, a home security Survey, ABI Insights, and analyst inquiry support.

Median Pricing for 200 mm Production CMOS Wafers Increases at the Same Rate as 300 mm Wafers QoQ

The Global Semiconductor Alliance (GSA), the voice of the global semiconductor industry, announced the results of its quarterly Wafer Fabrication and Back-end Pricing Survey, analyzing prices paid per wafer and mask set and for outsourced assembly services by fabless semiconductor companies and integrated device manufacturers (IDM). The results of the Q1 2011 Wafer Fabrication and Back-end Pricing Survey include:

- Median pricing for both 200 and 300 mm production CMOS wafers increased by about 5 percent quarter-over-quarter (QoQ).
- After decreasing for two consecutive quarters, survey participants reported a sequential increase in the median mask set cost for 200 mm CMOS wafers. Participants indicated that the median cost increased 21 percent QoQ and 20 percent YoY.
- The median cost for QFN packages with ≤ 64 leads increased 3 percent QoQ.
- 90 percent of survey participants are getting the capacity they need, with the "Yes" percentage increasing by 13 percentage points QoQ.

The survey results provide detailed insight into wafer and mask costs using factors such as development stage, process geometry, number of metal layers, number of poly layers and epitaxial/non-epitaxial processes. Subscribers can also search assembly costs by such factors as package family, leads, units per week and substrate cost. These results are published in GSA's quarterly Wafer Fabrication and Back-end Pricing Report which includes a written analysis of the survey results, a downloadable MS Access database of all aggregated results, and interactive online results showing rolling average and median prices for four consecutive quarters by varying factors.

Note: The Q1 2011 results represent purchases made/received between 10/1/2010 to 12/31/2010.

MEMs Market to Approach Five Billion Shipped in 2016

MEMS (Micro-electromechanical Systems) are starting to be the "Swiss Army Knives" of modern consumer electronics: they can take the form of (or be incorporated in) accelerometers, gyroscopes, magnetometers, altimeters, screens, projectors and microphones. New data from ABI Research indicates that strong growth in the MEMS market over the next



five years will result in nearly five billion MEMS being shipped during 2016.

MEMS are found in smartphones, netbooks, media tablets, eReaders, games consoles and handheld gaming platforms, where some of them assist with navigation, dead reckoning, image stabilization and augmented reality. (Often, more than one MEMS will reside in any given consumer device.) Still others will underpin new forms of display that use far less power than today's screen technologies (although initially at greater cost).

"Initially, smartphones will provide the greatest boost to uptake," notes Practice Director Peter Cooney, "but if OEMs embrace MEMS displays, they may deliver the strongest overall growth in revenue over time. ABI Research's MEMS market forecasts depend on device shipments growing as expected. At this point however, we are confident about the prospects for CE devices market growth."

The MEMS market is currently split between seven quite specialized major vendors – STMicroelectronics, Asahi Kasei, InvenSense, Bosch, Knowles, Kionix, Freescale Semiconductor – and a number of smaller ones.

"Over time, competition in the MEMS market will result in falling ASPs," says Cooney. "Two of the larger vendors, Bosch and STMicroelectronics, have more diversified product offerings, taking shares across a number of appli-

cations. This positions them well to prosper as market conditions change, while other vendors continue to specialize. There is still room for new vendors with new products, however."

Dual Platform 4G Strategy Rewards Mobile Network Operators, Chip and Device Makers

There is no question that in the long term LTE will become the mainstay 4G network technology, although its universal use is still in the future. Until then, says ABI Research, some service providers will benefit from a dual-platform strategy based on both LTE and WiMAX.

Who stands to benefit? Some operators, such as Sprint and Clearwire, KDDI and UQ Communications, and KT, will use both technologies for some time. Multi-standard base stations now being deployed support several generations of technologies as well as both 4G standards. There will also be multi-mode 4G chipsets in devices. New data on these and other 4G topics are presented in ABI Research's "4G Subscriber, Device, and Networks Market Data" which contains regional and selected country-level segmentation for the mobile WiMAX and LTE markets. It is part of the firm's 4G Research Service.

RFS Ferrocom Isolators Deliver Exceptional Electrical Performance

Extremely low insertion loss

Enables high-quality cellular services

Low inter-modulation

Increases capacity and improves clarity

Superior power handling

Supports multiple carriers

Connector or tab interface

Simplifies manufacturing integration

Tested for extreme temperatures

Ensures functionality in all conditions

Available for many frequency bands

Provides flexibility for emerging technologies



NEW! IZA Series Isolator



NEW! ICA Series Isolator

A Worldwide Leader in Ferrite Devices

RFS Ferrocom designs and manufactures a broad range of ferrite devices that are unequalled in performance, quality and reliability. We offer more than 2000 designs covering the 80 MHz to 40 GHz range as well as a highly skilled engineering staff that is ready to develop isolators and circulators to your specifications.

In keeping with our commitment to quality, our facility is registered to the ISO-9001/2008 quality standard and fully compliant with MIL-I-45208A.

Technical Information:

Tam Nguyen
tam.d.nguyen@rfsworld.com

Sales Information:

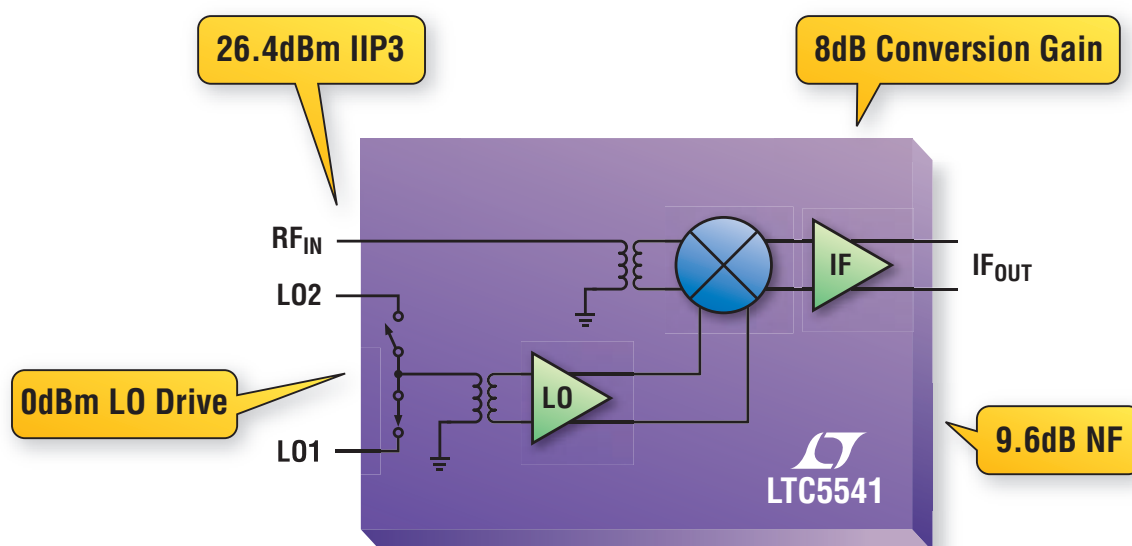
Christina Alvarado
christina.alvarado@rfsworld.com

RADIO FREQUENCY SYSTEMS
FERROCOM FERRITE DIVISION



Visit us at IMS2011 Booth 4307
www.rfsworld.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 @ 5dB 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



L[®], 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.





AROUND THE CIRCUIT

Jennifer DiMarco, Staff Editor

INDUSTRY NEWS

Texas Instruments has signed a definitive agreement to purchase **National Semiconductor** in an all-cash transaction of about \$6.5 B. This merger will unite two industry leaders who have a common commitment to solving analog needs. Both companies will operate independently pending close of the acquisition that is expected to take six to nine months.

API Technologies Corp., a provider of secure communications, electronic components and subsystems, and contract manufacturing services to the global defense and aerospace industries, and **Spectrum Control Inc.**, a designer and manufacturer of custom solutions for the defense, aerospace, industrial and medical industries headquartered in Fairview, PA, announced that they have entered into a definitive merger agreement providing for the cash acquisition of Spectrum by API. Upon closing of the transaction, Spectrum will operate as a wholly owned subsidiary of API. Pursuant to the terms of the definitive agreement, API will acquire 100 percent of the issued and outstanding equity of Spectrum for \$20.00 per share for a total purchase price of approximately \$270 M.

AML Communications Inc. announced that it had signed a definitive agreement and plan of merger with **Microsemi Corp.** and a wholly-owned subsidiary of Microsemi. Microsemi shall acquire AML for \$2.50 per share in cash, subject to the terms and conditions of the Microsemi Merger Agreement. The transaction is subject to customary closing conditions, including the approval of AML Communications' stockholders, and is expected to close around the end of June, 2011.

Ducommun Inc. announced that it has entered into a definitive agreement to acquire all outstanding stock of **LaBarge Inc.** LaBarge, with revenue of \$324 M for the 12 months ended January 2, 2011, is a supplier of electronics manufacturing services (EMS) operating across many high-growth industries. The acquisition will nearly double Ducommun's revenue base, improve the company's position as a Tier 2 leader in both aerostructures and electronics, and bring access to new customers and markets. Pursuant to the terms of the definitive agreement, Ducommun will acquire all issued and outstanding shares of LaBarge at \$19.25 per share in cash for a total purchase price of approximately \$340 M, including the assumption of LaBarge's outstanding debt (\$30 M as of January 2, 2011).

Alpine Investors, a middle-market private equity firm based in San Francisco, CA, announced that it has acquired **Linx Technologies**, a provider of cost-effective wireless modules, antennas, connectors and wireless design services. Linx enables Wireless Made Simple® by

providing design engineers with robust easy to implement wireless control and data modules and components. As part of the transaction, Alpine has announced Tolga Latif, an executive-in-residence with Alpine, as the new President and CEO of Linx. Latif brings marketing, sales and product development experience from various leadership roles at Danaher Corp. The financial terms of the transaction were not disclosed.

Cornell Dubilier Marketing Inc. has sold its KVX mica product line to **Custom Electronics**. Custom Electronics will support all Cornell Dubilier customers for this capacitor line moving forward.

AWR® Corp. announced that it plans to open its third direct sales and support office in Asia with a Shanghai, China location. The announcement aligns with the end of AWR's fiscal year and in particular one that has seen double-digit growth in AWR sales for the Asia-Pacific sub-region of Japan, China and Korea versus the year prior.

United Monolithic Semiconductors' (UMS) BES MMIC Schottky diode process has been successfully Space Evaluated and is now part of the European Preferred Part List established by ESA/ESCIES. Due to its very high cut-off frequency (>3 THz), BES is the preferred process for the design of MMICs, mixers, multipliers and switches at very high frequencies.

In order to provide RF test and measurement technology from a single source, **HUBER+SUHNER** and **SPINNER** have agreed to provide each other with parts of their measurement technology product range. HUBER+SUHNER will add SPINNER calibration components to its product range, and, in return, SPINNER will sell the established SUCOFLEX® and SUCOTEST® measurement cables. The extent of the collaboration is underlined by a joint internet site—www.rfmeasuring.com—where more information can be found.

After several years of intensive technical development, **Protium Technologies Inc.** is shipping the P6010 tuner, an advanced yet inexpensive component from the company's growing SIGINT receiver product line. The SDR/FPGA-based modular design covers the 20 to 6000 MHz frequency range in a small brick package specifically designed for cost-sensitive tactical applications.

RF Micro Devices Inc. (RFMD) announced it has teamed with **Atmel Corp.**, a leader in microcontroller and touch solutions, to deliver ZigBee® solutions for a broad range of smart energy applications.

Tahoe RF Semiconductor has achieved another first pass success with the delivery of a highly integrated Specialty GPS Receiver IC with exceptional performance in a small

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



POWER DIVIDERS

& COMBINERS

Features

- > Excellent Performance
- > Wide Bandwidth
- > Up to 100 Watts Power

Applications:

**Signal Splitting &
Low Power Combining**

Bandwidth:

2-way: 0.01 to 1000 MHz

3-way: 1 to 2300 MHz

4-way: 1 to 3600 MHz

5-way: 0.5 to 300 MHz

6-way: 1 to 500 MHz

8-way: 0.01 to 1000 MHz

10-way: 1 to 200 MHz

12-way: 2 to 1000 MHz

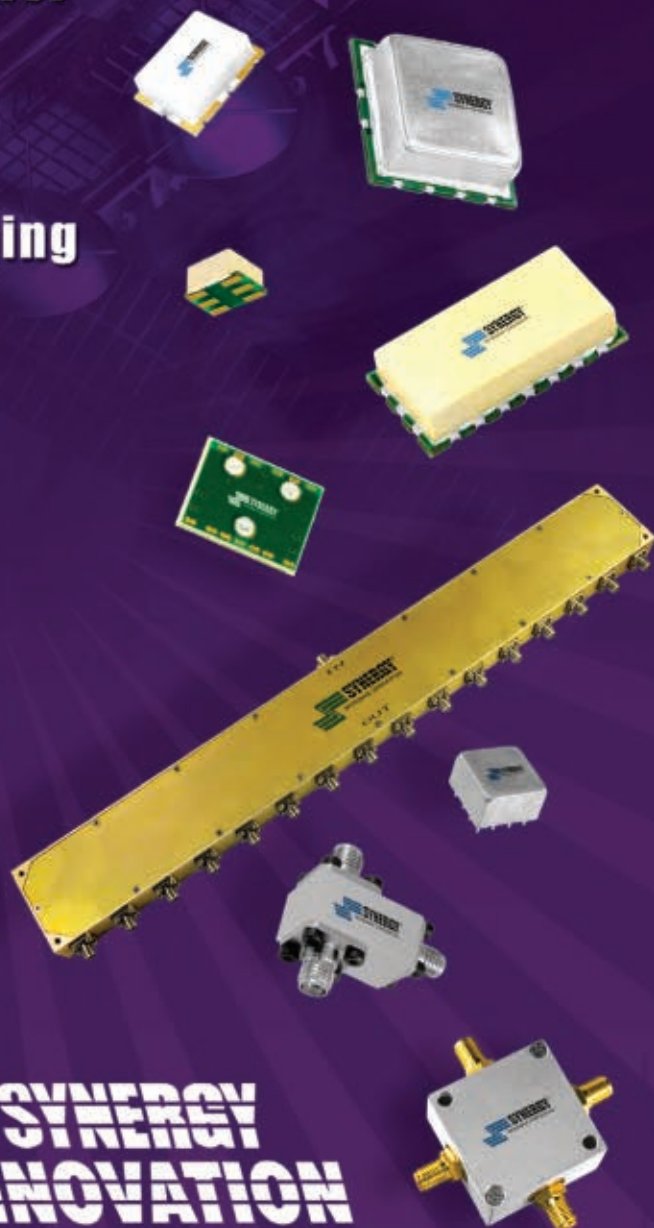
16-way: 10 to 1000 MHz

Visit Us!

**Booth#
507 & 607**

June 5 to 10, 2011

IEEE-MTTs Baltimore, Maryland



**When There's SYNERGY
There's INNOVATION**



For additional information, contact Synergy's sales and application team.
201 McLean Boulevard, Paterson, NJ 07504 | Phone: (973) 881-8800
Fax: (973) 881-8361 | E-mail: sales@synergymwave.com

Visit Our Website At WWW.SYNERGYMWAVE.COM

AROUND THE CIRCUIT

plastic molded package. The company has successfully delivered an M-code GPS Receiver IC to **ITT Corp.** to enhance its SINCGARS radio solution with position, navigation and timing capability.

Agilent Technologies Inc. announced shipment of the latest release of its flagship RF and microwave design and simulation platform, Advanced Design System 2011. As the industry's most comprehensive multi-technology design platform, ADS 2011 represents a significant breakthrough in electronic design automation. Agilent also announced that its work with GaAs/GaN and RF SiGe/BiCMOS/CMOS foundries and relevant SMD component vendors has resulted in their support for ADS 2011. During the past six months, the majority of existing ADS process design kits and libraries have been upgraded and verified on early access releases. These upgraded kits and libraries will be made publicly available to foundry and component vendor customers in the coming days, enabling them to take advantage of new capabilities in ADS 2011.

Accel-RF Corp. announced the successful shipment and installation of two advanced semiconductor reliability test systems to customers in Asia. The systems were delivered in Q4 of 2010 with installation completed in early January 2011. Shipped to both government research and commercial entities, these systems will be instrumental in the

development of compound semiconductor device performance characterization in Asia.

LPKF headquarters located in Germany recently invested 5 M Euros into purchasing a neighboring building, giving an additional 32,000 square feet for product development and production. With the new space, LPKF will combine its research and development departments and will use the existing building for manufacturing laser systems. The new building is currently under renovation, joining it to the company's existing complex and will be completed by June 2011.

Tektronix Inc. announced plans to expand its presence in the San Francisco Bay Area by opening an RF Design Center in Santa Rosa, CA. This announcement comes on the heels of the opening of a new technology and service center in Santa Clara, CA. The new RF Design Center is intended to expand Tektronix' efforts to develop next-generation RF and microwave test capabilities to better serve customers. By adding this new center in a desirable and highly livable community, Tektronix will have more options for attracting world-class technical talent to accelerate time to market. The company confirmed intentions to hire approximately 15 local RF design engineers and researchers during the initial ramp up phase.

RF Micro Devices Inc. (RFMD) announced it is proudly celebrating its 20th anniversary with commemorative events planned at company locations throughout the year. RF Micro Devices was incorporated on February 27,

AGILE RF SYNTHESIZER MODULES BROADBAND • STABLE • COHERENT • COMPACT

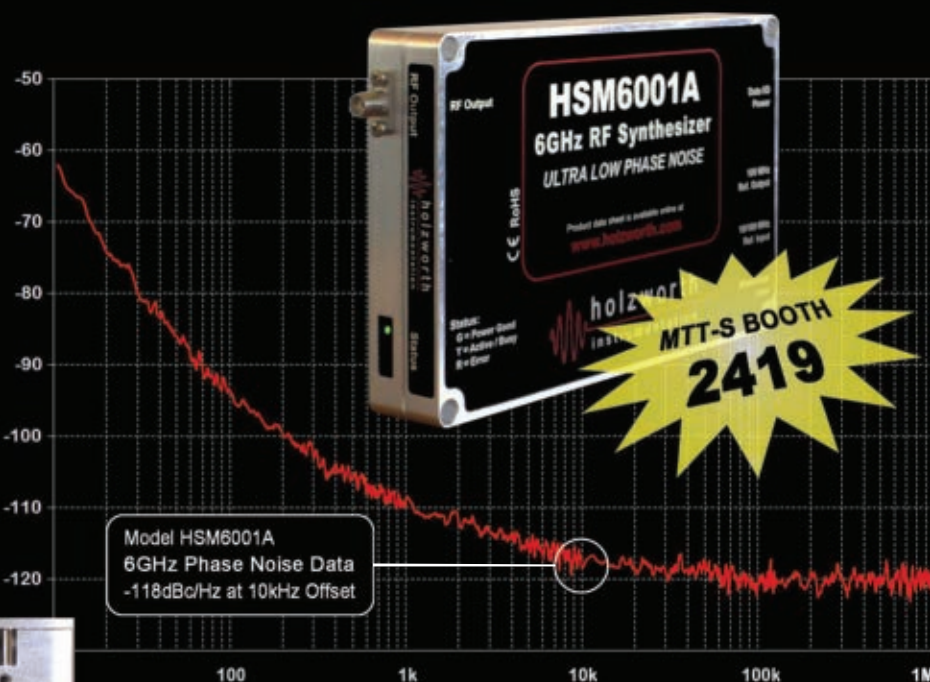
HSM Series

Holworth's proprietary NON-PLL, hybrid digital-analog architectures are the most stable and the only phase coherent sources available in their class:

- +13dBm to -80dBm (± 0.15 dB accuracy)
- <10 μ s SWITCHING SPEEDS (100% settled)
- PHASE CONTINUOUS SWITCHING
- 5 MODELS for OPTIMAL PRICING
 - ▶ HSM1001A: 250kHz - 1GHz
 - ▶ HSM2001A: 250kHz - 2GHz
 - ▶ HSM3001A: 250kHz - 3GHz
 - ▶ HSM4001A: 250kHz - 4GHz
 - ▶ HSM6001A: 250kHz - 6.5GHz



OPTION SYS1: 0.57in (14.5mm) high



MTT-S BOOTH
2419


SKYWORKS®

Discrete and Integrated RF Solutions

Skyworks broad product portfolio supports a wide variety of markets, including:



Cellular and Broadband Communications

Semiconductor and ceramic solutions for wireless communications infrastructure systems, including cellular base stations, LTE access points, land-mobile radio systems, point-to-point radio links and more. Also, highly integrated PA and FEM solutions with embedded mobile connectivity for GSM, GPRS, EDGE and WCDMA, CDMA, and LTE air interfaces.



Wireless Energy Management

Unique front-end solutions for automated metering infrastructure (AMI), security, medical, and home/industrial automation. Products address all major ISM bands and ZigBee® / IEEE 802.15.4 standards.



Wireless Data Communications (WLAN)

High-performance RF switching and amplification solutions that enable design flexibility for all 802.11a,b,g,n WLAN applications.



Military/Microwave

Amplifiers, switches, diodes, ceramic filters and resonators for defense and homeland security systems including radio communications, radars, electronic surveillance, electronic countermeasures and more. Screenings equivalent to JANS level of MIL-PRF-19500 and Class K of MIL-PRF-38534.

**Amplifiers • Low Noise Amplifiers • Front-End Modules • Antenna Switch Modules
Discrete RF Switches • Mixers/Demodulators • RF Diodes • PLLs • Synthesizers
VCOs • Digital Attenuators • Couplers • Hybrids • Power Dividers • RF Ceramics**

Visit us at IEEE MTT-S IMS2011 Booth 1428

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

RF Cable Assemblies

from the RF connector experts

RF
Cable Assembly

Division of RF Industries

www.rfindustries.com

800-233-1728, 858-549-6340



Visit us at IMS2011 Baltimore, June 7-9, Booth #4615

Handle cable assemblies first hand, including Fibre Optic.

IMS 2011
Booth 849

Microtool, Inc.

913-492-1588

www.microtoolinc.com

K-100 Glass Bead Installation Available

Specializing in precision machining for the millimeter wave industry.

Precision Finishing Dept.



ITAR Registered Vendor

CAGE CODE PROVIDED UPON REQUEST



Aluminum • Brass • Copper • Plastic • Rexolite • Stainless Steels

AROUND THE CIRCUIT

1991, and held its initial public offering on June 3, 1997. From its earliest days, RFMD has been an innovator in the semiconductor industry. RFMD was a pioneer in the commercialization of RF components using gallium arsenide (GaAs) compound semiconductor technology, and today RFMD is a leading manufacturer of GaAs technology. In the 1990's RFMD was a primary contributor to the rapid growth in the cellular handset market, and in 2000 RFMD was identified by *Fortune* magazine as the second-fastest growing company in America. In 2004, RFMD became the first semiconductor company to ship one billion cellular power amplifiers, and today RFMD routinely ships greater than three million RF components per day.

Mini-Circuits was recently presented with the 2011 RF-Crystals Co-Supplier of the Year Award by Clay Jones, Chairman, President and CEO, during the company's Annual Supplier Conference. The Supplier of the Year award is an acknowledgment of significant contributions made during the year by suppliers and is based upon quality, delivery, total cost of ownership, lead time and customer service.

TriQuint Semiconductor Inc. announced it has received ZTE Corp.'s "Supplier of the Year" award for 2010. ZTE is a leading Chinese manufacturer of wireless communication system equipment and annually recognizes top suppliers who exhibit superior quality, delivery, cost and service performance. TriQuint has achieved top supplier recognition for the fourth consecutive year and is ZTE's largest provider of power amplifiers for mobile devices.

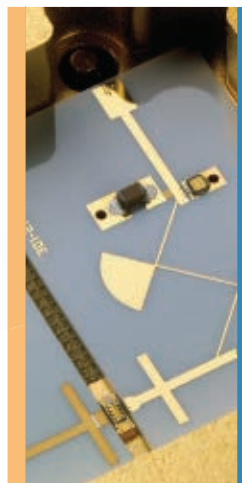
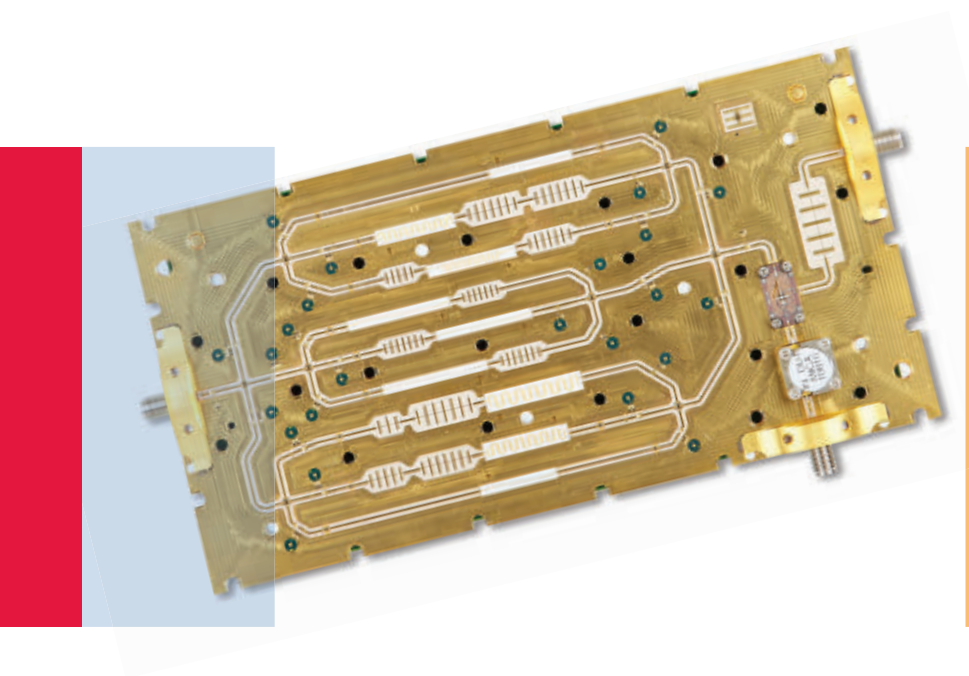
TRU Corp., a provider of RF and microwave cable assemblies and interconnects, was listed as the 34th largest women-led company in Massachusetts by *Boston Business Journal* in the December 2010 publication. The ranking was compiled based upon 2009 revenue.

CONTRACTS

Cobham has received a five-year, US \$45 M long-term agreement from **Pratt & Whitney**, a United Technologies Corp. company, to manufacture advanced composite products for multiple military aircraft engine applications. Cobham will produce advanced, medium and high temperature composite structures for both the F135 and F119 engines at the company's state-of-the-art production facilities in San Diego, CA and Suffolk, VA.

An innovative combination of **DragonWave** high capacity packet microwave backhaul and backbone networking solutions will enable **KeyOn Communications Holdings Inc.** to bring unprecedented services to rural communities across Nevada. The Horizon Compact and Horizon Duo high-capacity packet microwave solutions from DragonWave are being deployed to anchor the "middle mile" network components for KeyOn's stimulus-funded 4G wireless network service rollout to rural homes, businesses and critical community facilities such as healthcare providers.

Custom RF and microwave modules. With a new name.



Maxtek is now Tektronix Component Solutions, offering a variety of services—including customization, design, assembly and test—for RF and microwave components and modules.

- DROs
- Switched filter banks
- Custom integrated microwave assemblies

Applying more than 40 years of engineering, manufacturing and test expertise, Tektronix Component Solutions creates and customizes modules to support RF and microwave applications requiring high performance, reliability and quality.

Performance. Reliability. Quality.

For more information:

800.462.9835

components@tektronix.com

component-solutions.tektronix.com/mwjjournal/

RF and Microwave Capabilities

- Circuit and mechanical design
- Simulation
- Component engineering
- Assembly
- Electrical and environmental test

Industry Experience

- Defense and aerospace
- High-speed communications
- Medical imaging
- Instrumentation

© 2011 Tektronix Component Solutions. All rights reserved. Tektronix Component Solutions services and products are covered by U.S. and foreign patents, issued and pending. TEKTRONIX COMPONENT SOLUTIONS and the Tektronix Component Solutions logo are registered trademarks.

Tektronix®
Component Solutions

See us at MTT-S Booth 1432

AKON

DEDICATED TO EXCELLENCE

VISIT US AT THE IEEE-MTT-S SYMPOSIUM
BALTIMORE
BOOTH 307

Components



Filters and Switches



Log Components



Higher Performance

Subsystems

08-20 GHz Prechannelized
Dual Conversion IF BW
2-6 GHz Selectable IF Tuner



Four Channel 05-18
GHz ESM System
Converter



2135 Ringwood Avenue, San Jose, CA 95131
(408) 432-8039, (408) 432-1089 fax
www.akoninc.com

AROUND THE CIRCUIT

PERSONNEL

ANADIGICS Inc. announced the resignation of President and Chief Executive Officer **Mario Rivas** and Senior Vice President **Greg White**. The company also announced that its first quarter 2011 revenue guidance remains on track with previous revenue guidance of \$42 to \$44 M. **Ron Michels**, who was the SVP, Chief Technology and Strategy Officer, will assume the responsibilities of the CEO, **Tom Shields**, who currently serves as EVP and CFO, will assume the additional post of COO, and **John Van Sadlers**, who was the VP Advanced Technology, will serve as SVP RF Products.



▲ David M. Kirk

Murata Electronics North America announced the appointment of **David M. Kirk** as President, Chief Executive Officer (CEO) and a Director of MENA effective April 1, 2011. Kirk brings to the new role more than 27 years of engineering, marketing and management experience in the electronics industry. Before joining Murata Electronics North America Inc., Kirk held the position of President, CEO and a Director of RF Monolithics Inc. Prior to that, he spent 14 years with Murata Electronics North America where he held positions ranging from product management of various product lines to Director of Marketing for North America. Kirk succeeds Satoshi Sonoda, who will continue his assignment in MENA for a couple of months, to facilitate the transition of his responsibilities to Kirk.



▲ Hiroyuki Hojo

Fujitsu Semiconductor America Inc. (FSA) announced that **Hiroyuki Hojo** has been named President and Chief Executive Officer effective April 1, 2011. He replaces Shinichi "James" Machida, who will return to Fujitsu Semiconductor Ltd. (FSL) in Japan as Corporate Vice President in June. Hojo joined the Fujitsu organization in September 2000. Before being assigned to FSA, he was Corporate Senior Executive Vice President and member of the board of directors of FSL and FSA. From April 2009 through March 2010, Hojo was FML's Corporate Senior Vice President and, from March 2008 through April 2009, was FML's Corporate Vice President. In these positions, Hojo directed the management of the company's planning and sales divisions, developing and implementing corporate strategies to promote Fujitsu's semiconductor business.



▲ Robert Dennehy

M/A-COM Technology Solutions announced that **Robert Dennehy** is appointed Vice President of Operations, reporting to Bob Donahue, Chief Operations Officer. Dennehy will oversee M/A-COM Tech's global manufacturing operations. He will also work with his team to establish long-term goals and strategic planning for the company's

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

See us at MTT-S Booth 2021



**TELEDYNE
STORM PRODUCTS**

A Teledyne Technologies Company

888-347-8676

www.teledynestorm.com/mj0511



QCJ5

Del Mar
Electronics Show
May 4-5 Booth 327
IMS 2011 June 7-9
Booth 717 Agilent Ave.

Prototyping Simplified

- Front Panel Control
- 4-Zone Vacuum Table
- More Tool Positions
- Greater Z-Axis Travel
- Automatic Depth Control

Made in U.S.A.

T | TECH

Quick Circuit Prototyping Systems

www.t-tech.com • 800-370-1530 • sales@t-tech.com

EMI FILTERS

Syfer has an unrivalled range of EMI filter products, and a commitment to product innovation.

Like the surface mount Pi filters; where we offer the highest capacitance and voltage in the market.

We consider flexibility to be the key, not only with new ranges being continually developed, but also with custom solutions.

INNOVATIVE, WORLD-CLASS
CERAMIC COMPONENTS



www.syfer.com

Screw-In EMI filters

EMI Power filters

X2Y IPcs



▲ John P. DiStasio

Crane Aerospace & Electronics, a segment of Crane Co., has announced the appointment of **John P. DiStasio**, Senior Director of Business Development for Microwave Solutions for the Electronics Group. DiStasio will lead the Microwave Solutions business development team, which includes sites in Beverly, MA, Chandler, AZ, West Caldwell, NJ and San Jose, Costa Rica. DiStasio comes to Crane Aerospace & Electronics with an extensive background in the microwave industry. He joins us from Cobham – M/A-COM Inc., where he held the position of Director of Field Sales. At Cobham, DiStasio managed the worldwide field sales organization for several years.



▲ Tony Drake

MFG Galileo Composites announced that **Tony Drake** has been assigned general management responsibility for the company's manufacturing operations in Opp, AL and Adelanto, CA. Drake was promoted to General Manager of sister company MFG West in February 2010, where he had served as Research and Development Engineer since 2008.

Drake brings experience in the design and production of composite radomes, as well as more than 20 years of professional experience with composites molding, composite marketing, product development, applied composites design, and research and development.

AROUND THE CIRCUIT

global growth strategy. Dennehy has a long and successful track record with the company. He began as a Test Engineer in 1993 and most recently has been serving as Managing Director of the Infrastructure Group in Cork, Ireland.

KOR Electronics has appointed **David Edwards** and **Chris Michalski** to key leadership roles aimed at extending the company's intelligence-related business for both the defense and intelligence communities. Edwards and Michalski will focus on identifying new business opportunities and developing strategies and products/systems to grow KOR's ISR market position. Edwards as Vice President, ISR Systems, and Michalski as Technical Director, ISR Systems, both join KOR having both spent greater than 30 years at Northrop Grumman ESL.

Auriga Microwave announced the appointment of **Moosa E. Moosa** in the newly created position of Chief Financial Officer. Previously, he served as a part-time financial consultant to the company. He has more than 30 years of extensive and broad business experience as a proactive, business-oriented financial leader and key member of senior leadership teams. His financial and operational experience includes almost 20 years as a CFO of various technology-based and manufacturing companies, including 10 years as CFO of publicly-traded companies. Moosa has a successful track record of growing companies into new markets and repositioning them during changing environments.



A new breed

They look subtly different, but their behavior is incredibly unique. eSeries connectors have been re-engineered for performance and durability and to be the perfect mate for T-Flex™ cable. Interfaces have evolved, materials have been perfectly matched, and extended ferrules and positive cable stops have been added for ruggedness and easy assembly. They're your answer to a history of semi-rigid dependence and your high performance solution for advanced systems. eSeries Type Ns work through 18 GHz, eSMAs offer VSWR of 1.22 through 20 GHz, and eSeries 7/16s deliver typical PIM performance of -165 dBc. eSeries TNCs are also available as are several standard straight and right angle plugs and jacks. Learn more about this advanced species—watch the eSeries video at **Santron.com**.



Always Thinking

See us at MTT-S Booth 4616

AROUND THE CIRCUIT

Buyers Bridge Co. announced that **Phillip Wu** has joined the company as Vendor Management Engineer. With highly specialized knowledge in procurement, quality systems and international trade, Wu joins Buyers Bridge's team in Taiwan, Republic of China at an important time in its development and will facilitate the expansion of outsourced supply chain management services. In this assignment, Wu is responsible for directing Buyers Bridge's fee based sourcing programs. Wu has broad experience in apparel, consumer products, industrial hardware and electronic contract manufacturing (ECM). Most recently Wu was employed by Dynamic Flex, an electronics manufacturer in Taiwan.



▲ Jenn DiMarco

Jenn DiMarco has recently been promoted to *Microwave Journal* Managing Editor. In her previous role as Staff Editor, DiMarco has worked closely with the industry's marcom professionals, Product Managers and media relations to publish their press releases and product information in *Microwave Journal* magazine, online media and newsletters. Readers are likely more familiar with her work compiling the 'Around the Circuit', 'New Products' and 'Mark your Calendar' features every month as well as the news and editorial that appears in the publication's family of *Microwave Flash* and *Show Daily* newsletters. DiMarco takes

over the production of the print and online versions of *Microwave Journal*, in addition to the newsletters. DiMarco received a Bachelor of Science degree in Marketing in 1998 from Johnson & Wales University, Providence, RI.

REP APPOINTMENTS

AWR® Corp. announced that it has signed an agreement with **CapeSym** that names AWR as the global and exclusive reseller of CapeSym's SYMMIC software package for thermal analysis of microwave integrated circuits (MMIC). Marketed as AWR Connected™ for CapeSym SYMMIC, the product offering allows high power RF designers to perform thermal analysis on MMICs designed within AWR's Microwave Office™ software.

Reactel Inc., a manufacturer of RF and microwave filters, multiplexers and multifunction assemblies to the military, commercial, industrial and medical industries, announced the appointment of **WLM Components** as the company's exclusive representative in upstate New York. For more information about WLM Components, please contact Bill Morin at (978) 390-5545 or billmorin@wlmcomponents.com.

Star Microwave Inc., a provider of technology solutions for the growing requirements for catalog and specialized designs of high power drop-in and connectorized isolators and circulators, for the US and international markets, has announced the expansion of regional sales representatives with the appointment of E-Squared Marketing Inc., Kings Park, NY, phone: (631) 544-4788; and Associated Tech-

All Roads Lead to Adapter City
www.AdapterCity.com



Design it Fast

The collage features various electronic components including resistors, capacitors, and integrated circuits. A circuit board with a green PCB and various components is shown. A silver computer mouse is positioned in the lower right. A screenshot of the RichardsonRFPD website is displayed in the center, showing a navigation menu with options like 'What's Hot', 'Online Shopping', 'Featured Products', 'Design Resource Center', and 'Welcome'. The website also highlights 'Design it Fast' and 'On the NEW'.

on the
NEW
www.richardsonrfpd.com

Engineer-Focused Navigation™ system
provides quick, easy access to:

- New Products
- Block Diagrams
- Design Kits
- Calculators & Converters
- Parametric Comparisons
- Application Design Assistance
- Related Applications, Industries & Services



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

RichardsonRFPD
An Arrow Company

See us at MTT-S Booth 728

AROUND THE CIRCUIT

nical Sales, of Tustin, CA, phone: (877) 287-1737, Web: www.ats1rep.com. **E-Squared Marketing Inc.** will represent the company in New York and northern New Jersey. **Associated Technical Sales** will represent the company in southern California areas.

WEBSITES

Richardson RFPD Inc. announced the launch of a new "microsite" to help design engineers incorporate **Free-scale's** rugged 50 V LDMOS technology into either new or existing designs. The microsite contains a broad array of technical support material, such as white papers, reference designs and links to ADS/AWR models. Please visit the new microsite at www.rell.com/ruggedldmos.

EM Research Inc. has unveiled a new website design, marking the company's 20th year in business. The new website features a fresh, sophisticated look and provides customers with the ability to sort and customize individual products to meet their specific requirements. With the new website, customers are able to tailor electrical specifications for individual packages. One of the more exciting additions to the new website is the ability to search for a specific product based on the frequency and package type of interest, rather than a list of products. For more information, visit: www.emresearch.com.

Lunch with Strategy Analytics at IMS 2011

Join Strategy Analytics for lunch to hear their experts discuss forecasts, enabling trends and opportunities from both commercial and defense industry segments that will shape the future use of semiconductor technologies including InP, GaAs, GaN and Si and SiGe. Hear key insights on topics such as:

- The impact of budget constraints on future defense technology investment
- Trends for future wireless terminals
- Implementing next generation wireless and wired infrastructure rollout
- Complementary strengths or competing technologies; where do the different semiconductor technologies stand?

Date: Tuesday, 7th June, 2011

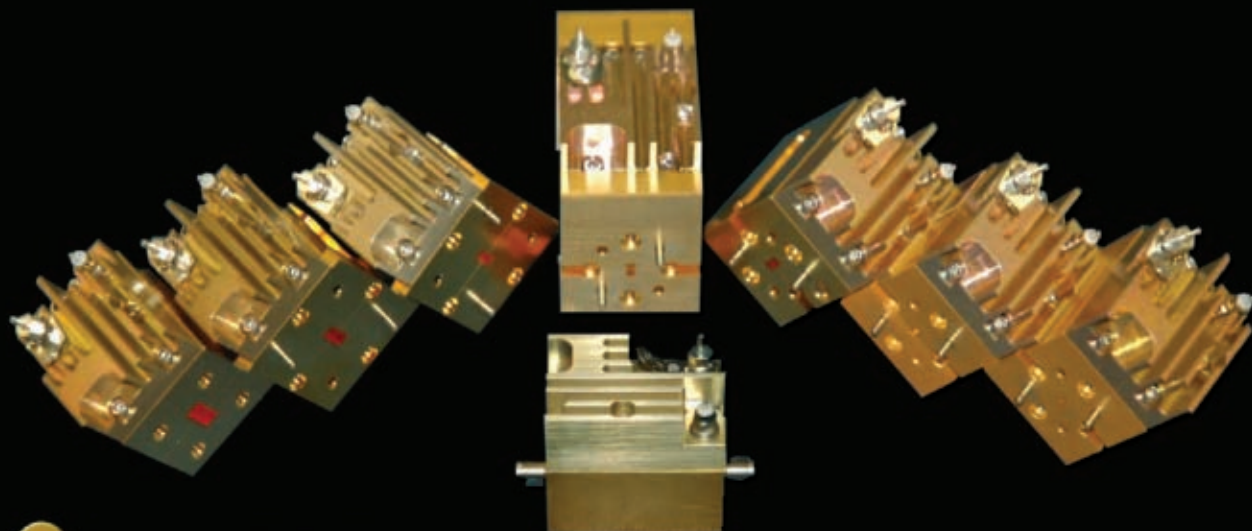
Time: 12:00 PM Registration

12:15 - 1:15 PM Presentation (45 minutes)
plus Q&A

Active Multiplier Chain

Available from 20-320 GHz

Download Datasheet at www.millitech.com/MultiplierAMC.htm



millitech®

Come see us at MTTTS Booth 1610

The Industry Leader

www.millitech.com

 WORLD'S WIDEST SELECTION

VCOs



10 to 6840 MHz from **\$11⁹⁵** ea. (qty. 5)

Want a miniature surface mount, shielded plug-in, or rugged coaxial voltage controlled oscillator with the right stuff for your project? Contact Mini-Circuits! From custom designs to standard catalog models ***always in stock***, we'll supply extra robust, 100% tested VCO solutions you need at a price you can afford. Choose from narrow to broad to octave band widths. Select linear tuning, low phase noise, and 5V models optimized for PLLs and synthesizers. And pick from an innovative array of miniature SM packages as small as 0.370" square for a variety of designs and applications. You can quickly find the model you need using "The YON12 Search Engine" at the Mini-Circuits web site. Just enter your specifications into YON12...click...and immediately

start evaluating suggested VCO solutions using the *actual measured performance data* displayed. But perhaps you need a custom design. Not a problem! Contact us for our lightning fast response, low prices, and quick turnaround. Give the competition *real competition*... specify Mini-Circuits VCOs!

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

 Agilent Technologies

For high reliability, all Mini-Circuits VCOs are tested with the Agilent E5052B Signal Source Analyzer.
www.agilent.com/find/ssa



 **Mini-Circuits®**
ISO 9001 ISO 14001 AS 9100 CERTIFIED

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



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

IF/RF MICROWAVE COMPONENTS

See us at MTT-S Booth 1031

359 rev Q

PASSIVE INTERMODULATION (PIM) TESTING MOVES TO THE BASE STATION

Passive intermodulation (PIM) has been recognized as a potential problem in communications systems for nearly 50 years. The phenomenon occurs when two or more signals encounter a nonlinear junction and “child” frequencies are generated that are mathematically related to the “parent” signals. With the advent of cellular communications, PIM began to rise in prominence as a concern, due to the quality of service impact these unintended signals could have by interfering or blocking the uplink (receive) channels of the base station.

As the network technology progressed from 2G to 3G and now 4G, we have gone from wondering what would be the “killer app” that would justify the investments being made in spectrum, infrastructure and technology to now struggling with delivering sufficient bandwidth and capacity to gratify the consumers’ appetite for data intensive applications that are delivered faster and more reliably. And consumers do not just want this, they expect it.

As a result, controlling or eliminating any interfering signals that impair data rates and signal quality is a must in optimizing network performance. Because PIM is a measure of nonlinearity in the system and is highly sensitive in detecting inadequate construction quality, it has become the preferred performance metric at the base station.

A BRIEF HISTORY

In the early days of commercial telecommunications, manufacturers of RF components used in the high power path of the base station were loosely required to verify PIM per-

formance. Some companies “verified by design,” some through first article testing, some through sample testing and some of the more enterprising companies did 100 percent acceptance testing. Those companies doing testing would cobble together signal generators, amplifiers, a spectrum analyzer and a bench full of filters to realize their test bench.

Summitek introduced its first PIM analyzer in September 1996 and brought standardization to the industry and PIM testing. In this same time period, The International Electrotechnical Commission (IEC), Technical Committee 46, formed a working group tasked with defining recommended test methods for PIM. The first edition of IEC 62037 specification was released in 1999. Although this specification covered only “RF connectors, connector cable assemblies and cables,” it was widely adopted as the recommended test method for all components. In its simplest terms, it proposed testing PIM at 2×43 dBm (20 W).

The follow-up specification that defines test methods and procedures for a larger variety of components, antennas, filters, cables, connectors and cable assemblies, has been in process for the last ten years and is nearing formal release. This version expands upon the test methods and specifically recommends the need for dynamic testing, where the device under test is mechanically stressed (tapped or flexed, as appropriate).

In 2005, as high data rate networks were becoming a focus, Telstra, in Australia, realized the importance of “clean” infrastructure and

RICK HARTMAN
Kaelus Inc., Thousand Oaks, CA

Rosenberger



Well connected

Rosenberger Coaxial Connectors and Cable Assemblies

play a key role in many high-tech-applications – such as telecommunications, radio base stations, automotive electronics, test & measurement applications, aerospace engineering, modern data networks, medical electronics etc.

Our comprehensive product range covers RF-coaxial connectors, automotive connectors, adaptors or test & measurement products such as high-precision connectors, calibration kits, test cables and many more.

New:

- Multiport coax connections – for semiconductor test equipment applications
- Passive intermodulation analyzers – rack and portable types, site analyzers.

Exploring new directions

North America:

Rosenberger of North America, LLC

P.O.Box 309 · 309 Colonial Drive · USA – Akron, PA 17501

Phone: +1-717-290-8000 · Fax: +1-717-399-9885

info@rosenbergerna.com · www.rosenbergerna.com

Europe:

Rosenberger Hochfrequenztechnik GmbH & Co. KG

P.O.Box 1260

D-84526 Tittmoning

Phone: +49-8684-18-0 · Fax: +49-8684-18-499

info@rosenberger.de · www.rosenberger.com

See us at MTT-S Booth 1411

10 MHz to 67 GHz Components



Directional Couplers



Power Dividers



Antenna Beamformers



90°/180° Hybrids



QPSK Modulators



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

engaged Triaxx to develop a rugged, field suitable PIM unit. Telstra was the first network operator to require that PIM be measured and confirmed to be within acceptable levels as a requirement in site certification. It is important to note that PIM does not replace the need for return loss verification. It is a complementary test that identifies a set of problems that might go undetected with a return loss measurement. Summitek teamed with Triaxx in 2007 to introduce the first 2×20 W portable PIM (PPIM) unit in the United States. PIM testing at the base station to verify construction quality is now a widely accepted requirement by nearly every network operator in the US.

THE TEST PROCESS

Conceptually, PIM testing at the base station is simple. The jumper cable is disconnected at the BTS input, the PPIM unit is attached in its place, the two high power signals are turned on and the resultant IM (typically the third-order product, IM3, because it has the highest signal strength) is monitored.

If the IM level is within performance limits, then dynamically testing of the infrastructure needs to be started. Contrary to the belief of some that a pass in a static test is sufficient for certification, a site cannot be certified unless it can maintain acceptable PIM performance under mechanical stress. This is the standard procedure for every network operator, which is consistent with the emerging specification from the IEC.

Dynamic testing involves tapping all connector interfaces, all filters (diplexers and tower mounted amplifiers) and the back of the antennas. This should not be destructive in force, but sufficient to move any minor mechanical discontinuities that might exist in the component. Additionally, jumper cable assemblies should be gently flexed.

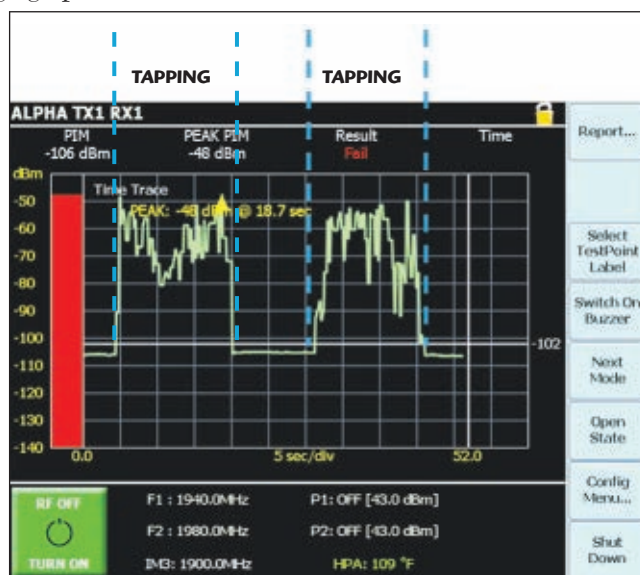
A word of cau-

tion about transmitting two high power signals through the antenna: in most cases, if an operator wants to stay within their licensed band, they cannot get enough separation between the two test frequencies to have the IM3 frequency land within the receive (uplink) band. Consequently, they will need to transmit outside their licensed band. Summitek recommends that the carriers be placed at guard band frequencies to minimize the chance that they will interfere with another operator. This should always be done with a good neighbor policy in mind.

It is not recommended to transmit swept frequency signals through the antenna and into the air. A swept frequency test at 2×20 W (43 dBm) will almost guarantee that it will interfere with at least one other operator. If a swept frequency measurement is desired, then the antenna should be replaced with a low IM termination to eliminate the possibility of interference.

Locating the Source of PIM

As mentioned above, whether the line being tested passes PIM with a static test or not, it is a requirement to dynamically test all components and interconnects to certify that there are no unacceptably high PIM sources that are hidden under static conditions. It becomes evident in a hurry where the PIM source is if, when tapped or flexed, the PIM goes up or down measurably (more than several dB), as shown in **Figure 1**.

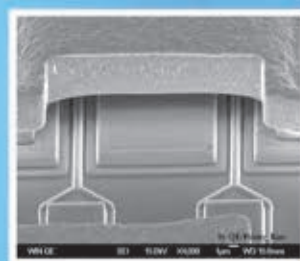
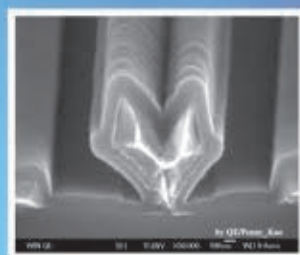
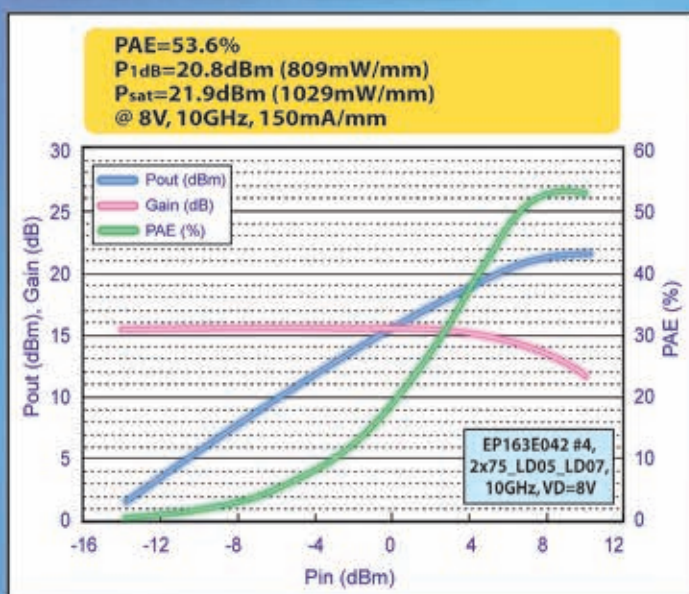


▲ Fig. 1 Dynamic PIM testing showing PIM rising above limits while being tapped but acceptable when static.

High Voltage 8V Ku-Band 0.25 μ m Power pHEMT

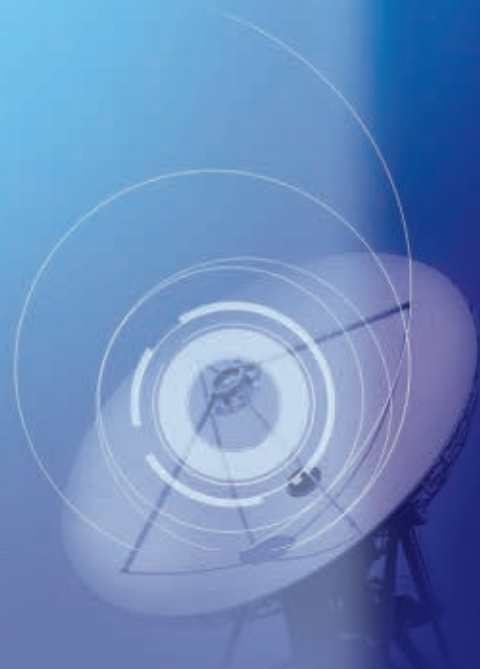
- Stepper based 0.25 μ m gate length
- 8V operation / 70 GHz Ft
- 1 W/mm saturated power density
- BCB encapsulation for repeatable packaged performance

PP25-21 Power Performance



Comparison Table for 0.1 μ m, 0.15 μ m, 0.25 μ m and 0.5 μ m pHEMT

	PP10	PP15	PP25-21	PP50-11
V _{to} (V)	-0.9	-1.2	-1.2	-1.4
I _{dss} (mA/mm)	450	500	345	350
I _{dmax} (mA/mm)	720	650	460	480
GM (mS/mm)	750	495	380	310
VDG (V)	9	10	19.2	20
f _t (GHz)	130	85	65~72	32
F _{max} (GHz)	175	180	160	85
P _{1dB} (mW/mm)	533.25 (3.5V)	670 (5V)	809 (8V)	587 (8V)
P _{sat} (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



FROM 500 MHz TO 110 GHz
SIMPLE OR COMPLEX

WE MANUFACTURE THE
COMPONENTS YOU NEED

AMPLIFIERS



FREQUENCY MULTIPLIERS



FREQUENCY CONVERTERS



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

Several suppliers have developed a range-to-fault (RTF) technology that includes the additional hardware and signal processing software to generate time domain plots similar to those generated in network analysis distance-to-fault. RTF technology is an analysis tool developed to enhance, not replace, standard fixed tone PIM testing.

The most effective way to use RTF analysis is to systematically remove the largest magnitude PIM source identified on the line. Repeat the analysis and continue removing the largest PIM source found until all significant static PIM sources have been removed. Regardless of its location on the line, the distance to the largest PIM source will be predicted most accurately by the algorithm. Each time a PIM source is repaired, the accuracy for locating the next largest PIM source will improve.

As initially stated, RTF analysis is not a replacement for dynamic PIM testing. RTF analysis will enhance site testing and potentially speed the removal of static PIM sources at the cell site. The analysis alone, however, should not be used to certify construction quality because:

- Knowing the range to a fault provides a helpful starting point, but does not ensure there are no other hidden PIM sources within the RF feed system
- The absolute value of the RTF PIM magnitude may not be accurate due to distortion brought about by frequency sensitive group delay in RF devices, such as surge arrestors, filters and TMAs. Furthermore, the windowing function used in the transform can affect the magnitude of the data in the time domain.
- "Ghost" PIM sources can be created as a product of the mathematics and/or by impedance mismatches in the system, that reflect PIM generated at different locations on the line

What Transmit Power Should Be Used?

Two, four, 20, 40 W, or more? This is an often asked question. The IEC PIM standard committee confronted this question many years ago and recommended a test power of 20 W (43 dBm) per carrier. Consequently, this

has become the industry standard—nearly all manufacturers specify and verify their products based on the third-order IM level, when measured with 2×43 dBm carrier powers.

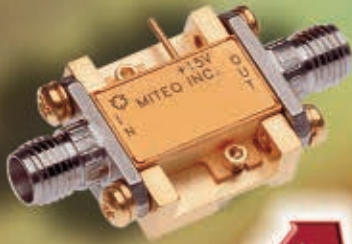
What conditions would have to exist for the benefit of testing at higher power levels?

- 1) The PIM power level would have to increase in a nonlinear manner, relative to the carrier power.
- 2) Or, the higher power would have to excite a PIM source not excited at lower power levels.

If either of the above were true, there would be a dilemma as to when to stop increasing the test power, because there would always be a level of uncertainty. Fortunately, based upon more than 15 years of real world experience, as well as theoretical analysis confirmed by experimentation, neither of the above is true.

Theoretically, the IM3 increases by 3 dB for every 1 dB increase in the carrier power. Although it is known from experience that the relationship is rarely 3 dB/dB in passive components, it is indeed linear. The slope will vary depending upon the characteristics of the PIM source, but it is always linear. To demonstrate, three different devices were measured with carrier powers from 33 dBm (2 W) up to 46 dBm (40 W) in 1 dB increments. The devices under test are a jumper cable built on site at a base station, a jumper cable built in the factory and a resistive termination (high PIM source). The test results are plotted in **Figure 2**. Overlaid on each plot of the raw data is a best fit line. As can be seen, in all cases, the PIM is linear with power and testing at higher power does not result in the illumination of a PIM source that is not already excited at lower power—even all the way down to 2 W.

But what about the second condition postulated above; will testing at higher power cause an intermittent PIM source to show up that might not be seen at lower power? The answer is—possibly. But this is exactly why PIM testing must always be a dynamic test. Each component being manufactured in the factory and every joint and component comprising the base station infrastructure must be subjected to mechanical stress such as a tapping on connectors, tuning screws of filters, backplanes of antennas, etc.,



AFS SERIES... More Than Just Low Noise

AMPLIFIERS

- OPTIONS:**
- Cryogenic
 - TTL Controlled
 - Detected Output
 - Limiting
 - High Dynamic Range
 - Military Versions
 - Variable Gain
 - Equalized Gain
 - Space Qualified
 - Limiter Input
 - Built-in Test

Model Number	Frequency Range (GHz)	Gain (Min./Max.) (dB)	Gain Flatness (\pm dB)	Noise Figure (dB, Max.)	VSWR Input (Max.)	VSWR Output (Max.)	Output Power @ 1 dB Comp. (dBm, Min.)	Nom. DC Power (+15 V, mA)
OCTAVE BAND AMPLIFIERS								
AFS3-00120025-09-10P-4	0.12-25	38	0.50	0.9	2.0:1	2.0:1	+10	125
AFS3-00250050-08-10P-4	0.25-0.5	38	0.50	0.8	2.0:1	2.0:1	+10	125
AFS3-00500100-06-10P-6	0.5-1	38	0.75	0.6	2.0:1	1.5:1	+10	150
AFS3-01000200-05-10P-6	1-2	38	1.00	0.5	2.0:1	2.0:1	+10	150
AFS3-01200240-06-10P-6	1.2-2.4	34	1.00	0.6	2.0:1	2.0:1	+10	150
AFS3-02000400-06-10P-4	2-4	32	1.00	0.6	2.0:1	2.0:1	+10	125
AFS3-02600520-10-10P-4	2.6-5.2	28	1.00	1.0	2.0:1	2.0:1	+10	125
AFS3-04000800-07-10P-4	4-8	32	1.00	0.7	2.0:1	2.0:1	+10	125
AFS3-08001200-09-10P-4	8-12	28	1.00	0.9	2.0:1	2.0:1	+10	125
AFS3-08001600-15-8P-4	8-16	28	1.00	1.5	2.0:1	2.0:1	+8	100
AFS4-12001800-18-10P-4	12-18	28	1.50	1.8	2.0:1	2.0:1	+10	125
AFS4-12002400-30-10P-4	12-24	24	2.00	3.0	2.0:1	2.0:1	+10	85
AFS3-18002650-30-8P-4	18-26.5	18	1.75	3.0	2.2:1	2.2:1	+8	125
MULTIOCTAVE BAND AMPLIFIERS								
AFS3-00300140-09-10P-4	0.3-1.4	38	1.00	0.9	2.0:1	2.0:1	+10	125
AFS2-00400350-12-10P-4	0.4-3.5	22	1.50	1.2	2.0:1	2.0:1	+10	80
AFS3-00500200-08-15P-4	0.5-2	38	1.00	0.8	2.0:1	2.0:1	+15	125
AFS3-01000400-10-10P-4	1-4	30	1.50	1.0	2.0:1	2.0:1	+10	125
AFS3-02000800-09-10P-4	2-8	26	1.00	0.9	2.0:1	2.0:1	+10	125
AFS4-02001800-24-10P-4	2-18	35	2.00	2.4	2.5:1	2.5:1	+10	175
AFS4-06001800-22-10P-4	6-18	25	2.00	2.2	2.0:1	2.0:1	+10	125
AFS4-08001800-22-10P-4	8-18	28	2.00	2.2	2.0:1	2.0:1	+10	125
ULTRA WIDEBAND AMPLIFIERS								
AFS3-00100100-09-10P-4	0.1-1	38	1.00	0.9	2.0:1	2.0:1	+10	125
AFS3-00100200-10-15P-4	0.1-2	38	1.00	1.0	2.0:1	2.0:1	+15	150
AFS1-00040200-12-10P-4	0.04-2	15	1.50	1.2	2.0:1	2.0:1	+10	50
AFS3-00100300-12-10P-4	0.1-3	32	1.00	1.2	2.0:1	2.0:1	+10	125
AFS3-00100400-13-10P-4	0.1-4	30	1.00	1.3	2.0:1	2.0:1	+10	125
AFS3-00100600-13-10P-4	0.1-6	30	1.25	1.3	2.0:1	2.0:1	+10	125
AFS3-00100800-14-10P-4	0.1-8	28	1.50	1.4	2.0:1	2.0:1	+10	125
AFS4-00101200-22-10P-4	0.1-12	34	1.50	2.2	2.0:1	2.0:1	+10	150
AFS4-00101400-23-10P-4	0.1-14	24	2.00	2.3	2.5:1	2.5:1	+10	200
AFS4-00101800-25-S-4	0.1-18	25	2.00	2.5	2.5:1	2.5:1	+10	175
AFS4-00102000-30-10P-4	0.1-20	20	2.50	3.0	2.5:1	2.5:1	+10	125
AFS4-00102650-42-8P-4	0.1-26.5	24	2.50	4.2	2.5:1	2.5:1	+8	135

Note: Noise figure increases below 500 MHz.

This is only a small sample of our extensive list of standard catalog items. Please contact our Sales Department at (631) 439-9220 or e-mail components@miteq.com for additional information or to discuss your custom requirements.



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

www.miteq.com

See us at MTT-S Booth 1909



Application of Agilent Technologies' PNA-X Nonlinear Vector Network Analyzer and X-Parameters in Power Amplifier Design

By Loren Betts, Agilent Technologies and Dylan T. Bepalko and Slim Boumaiza, University of Waterloo, Canada

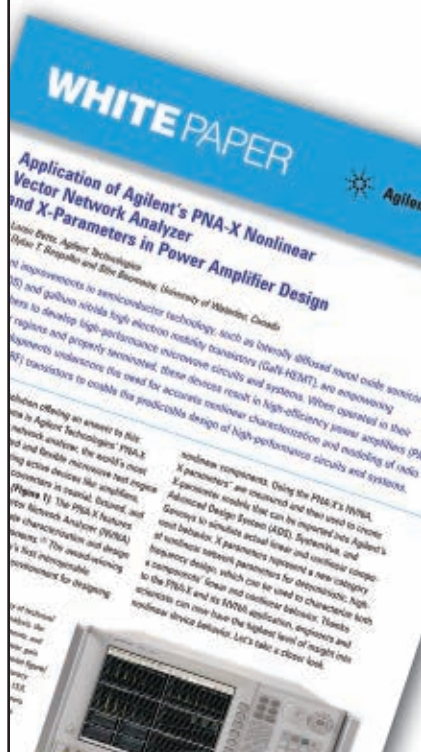
Recent improvements in semiconductor technology are empowering researchers to develop high-performance microwave circuits and systems. When operated in their nonlinear regions and properly terminated, these devices result in high-efficiency power amplifiers. Such developments underscore the need for accurate nonlinear characterization and modeling of Radio Frequency transistors. This FREE white paper examines how engineers are using the PNA-X's NVNA and X-parameters* to develop the next generation of wireless devices.

Download the PDF at:
<http://www.agilent.com/find/pnaxapps>



Agilent Technologies

* "X-parameters" is a registered trademark of Agilent Technologies. The X-parameter format and underlying equations are open and documented. For more information, visit <http://www.agilent.com/find/eesof-x-parameters-info>



and light flexing of cable assemblies. If the component or site is not dynamically tested, the results are invalid.

So, if testing at higher power is not of benefit and PIM is a straight line, why not test at lower powers and adjust the PIM specification to compensate for the lower power? If feasible, this has the added benefit of reducing the potential RF hazard to test personnel. Testing at lower power levels may be acceptable in some cases—particularly for pretest components—but currently site certification of the base station infrastructure is always done with 2×20 W.

Testing Antennas Before Installation

Base station antennas have become increasingly complex as demands for network optimization require greater flexibility and versatility. What began as a simple array of linearly polarized dipoles has evolved into highly complex electrical and mechanical structures that support multiple bands, multiple polarizations and remotely variable radiation patterns. Now the advent of antennas that integrate the radio and the radiating elements is happening.

The complexity of these antennas means that there is a greater opportunity for mechanical failure during the transportation process. Consequently, it has become common practice to test and verify the PIM performance of the antenna prior to installation.

Accurate characterization of the antenna prior to installation requires keen awareness of the surrounding environment and the potential for creating PIM from external sources. Ideally, the antenna should be situated on a non-metallic structure at least one to two feet above the ground pointing straight up into the sky, as shown in **Figure 3**. The area around the antenna must be clear of any metallic structures (fences, fork lifts and

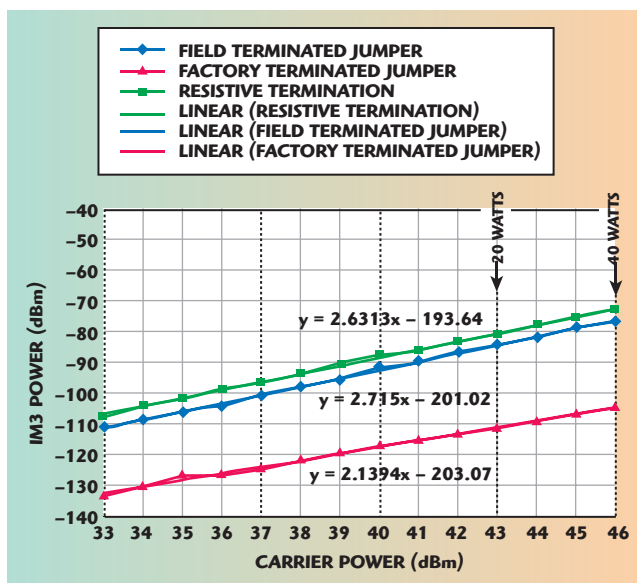


Fig. 2 IM3 power vs. carrier power for three different devices under test.



Fig. 3 Test set-up for antenna PIM measurement.

towers) that might cause PIM. The antennas cannot be tested inside a warehouse unless tested inside an anechoic chamber.

CONCLUSION

Passive intermodulation has long been recognized as a potential impairment to the performance of telecommunications systems and was formalized as a quality metric by the IEC in 1999. Modern telecommunications systems are more dependent than ever on a "transparent" RF infrastructure to achieve their performance objectives. Realizing these goals is directly dependent upon the quality of construction of the components used in building the sites, and the quality of the interconnections that join them together. The most sensitive and effective parameter for determining construction quality is PIM. Consequently, PIM testing has become an essential part of the site certification process. ■

Rick Hartman is President of North American operations at Kaelus Inc. (formerly Summittek Instruments).

Application of Agilent's PNA-X Nonlinear Vector Network Analyzer and X-Parameters in Power Amplifier Design

By Loren Betts, Agilent Technologies
and Dylan T. Bespalko and Slim Boumaiza, University of Waterloo, Canada

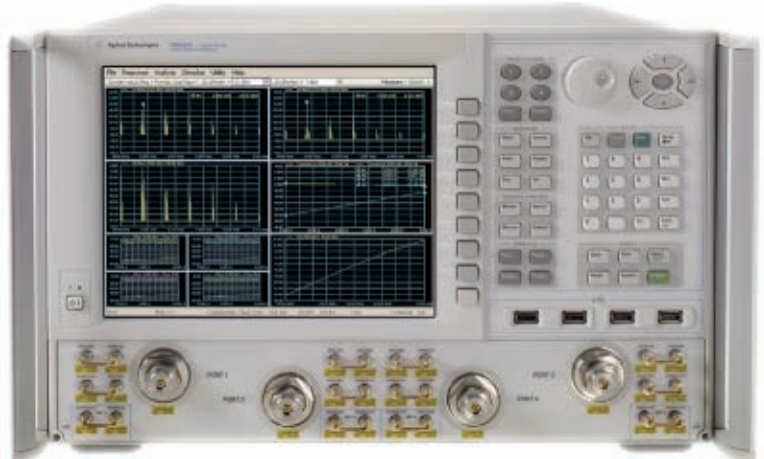
Recent improvements in semiconductor technology, such as laterally diffused metal oxide semiconductor (LDMOS) and gallium nitride high electron mobility transistors (GaN-HEMT), are empowering researchers to develop high-performance microwave circuits and systems. When operated in their nonlinear regions and properly terminated, these devices result in high-efficiency power amplifiers (PA).^[1] Such developments underscore the need for accurate nonlinear characterization and modeling of radio frequency (RF) transistors to enable the predictable design of high-performance circuits and systems.

One solution offering an answer to this dilemma is Agilent Technologies' PNA-X vector network analyzer, the world's most integrated and flexible microwave test engine for accurately measuring active devices like amplifiers, mixers, and frequency converters in coaxial, fixtured, and on-wafer environments (**Figure 1**). The PNA-X features an optional Nonlinear Vector Network Analyzer (NVNA) application for fast, accurate characterization and design of active devices and components.^[2] The award-winning Agilent NVNA is the industry's first interoperable measurement and simulation environment for designing

nonlinear components. Using the PNA-X's NVNA, X-parameters* are measured and then used to create X-parameter models that can be imported into Agilent's Advanced Design System (ADS), SystemVue, and Genesys to simulate actual linear and nonlinear component behavior. X-parameters represent a new category of nonlinear network parameters for deterministic, high-frequency design, which can be used to characterize both a components' linear and nonlinear behavior. Thanks to the PNA-X and its NVNA application, engineers and scientists can now have the highest level of insight into nonlinear device behavior. Let's take a closer look.

Figure 1. Built on Agilent's 40-year legacy of technical leadership and innovation in RF network analysis, the PNA-X provides excellent passive measurements, and a variety of active measurements (e.g., nonlinear, gain compression, intermodulation distortion, and noise figure) with an unsurpassed combination of speed, accuracy and flexibility. Available in five frequency ranges: 13.5, 26.5, 43.5, 50, and 67 GHz, it enables today's engineers to realize higher levels of test integration, as well as reduced setup time, measurement complexity, time to make measurements, and test costs.

*"X-parameters" is a registered trademark of Agilent Technologies. The X-parameter format and underlying equations are open and documented. For more information, visit: <http://www.agilent.com/find/eesof-x-parameters-info>.



Wanted: Nonlinear Characterization

When driven with a stimulus that places a component in a nonlinear operating region, the component may generate distorted input and output currents and voltages (or traveling waves) that include multiple spectral components.

While device characterization provides accurate performance information under a given set of operating conditions, extracting a measurement-based simulation model of the transistor offers all-encompassing design insight and flexibility. Two alternative nonlinear device modeling approaches that have been investigated include compact and behavioral models.

Compact models are analytical models generated from device measurement data and are suitable for use in computer-aided design (CAD) simulations for circuit-level design. They are less amenable to system-level simulation where the design may consist of many circuit-level models and where the stimulus involved consists of complex modulated signals. Moreover, they are not always reliable for high powers and non-linear circuit design because they usually lead to intolerable disparities between predicted and measured

performance. As a result, microwave circuit engineers—particularly PA designers—have been forced to choose between sometimes inaccurate and simulation-friendly compact models or an explicit measurement-based load-pull technique that does not support a robust simulation. This “broken link” in the design chain dramatically increases the cost and development time required. Bringing accurate device behavioral models into the simulation environment will empower circuit and system designers to develop advanced circuit topologies and system architectures in a systematic manner.

The X-parameter model is a sophisticated behavioral model that describes the linear and non-linear behavior of the component by describing the relationship between the input-output frequency spectrum on a multi-port device for a given large-signal operation condition.^[3-6] The recent integration of X-parameter modeling with load-pull measurements allows PA designers to develop measurement-based behavior models of unmatched devices that can be imported into ADS.^[7-8]

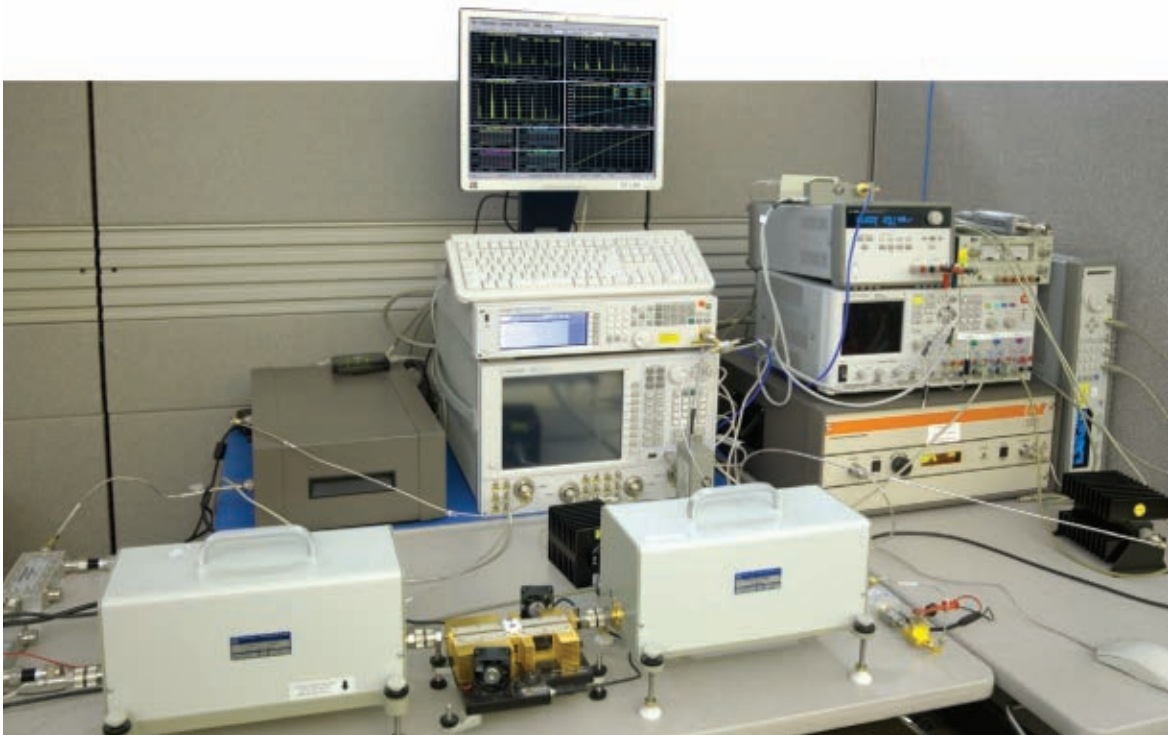


Figure 2. The PNA-X with NVNA X-parameter high-power load-pull measurement configuration.

Understanding the X-parameter measurement system

As an example of how to utilize a measurement-based X-parameter model, consider the design of a Class AB 45-Watt GaN amplifier, developed entirely inside the circuit simulator. The measurement system utilized in this example is shown in **Figure 2**. This setup is used to construct the X-parameters of a power transistor. It consists of the PNA-X with the NVNA firmware Option 510 (base NVNA firmware), Option 514 (X-parameters), and Option 520 (load-dependent X-parameter extension). The Agilent U9391C phase reference is also utilized to provide the cross-frequency phase calibration information that is critical to identify the X-parameter coefficients.

In addition to the NVNA, external hardware may be required to measure the X-parameters of a high-power unmatched transistor.^[9] Internal signal-routing switches in the PNA-X allow connection of other test equipment to the device-under-test (DUT) via the network analyzer’s test-port connectors (see **Figure 3** below).

Fundamental frequency	1.2 GHz
Harmonics	3
Gain	15 to 20 dB
Output power	45 Watts
Impedance	Unmatched
Bias	Gate (<5 Volts, <100 mA) Drain (<30 Volts, <3 Amps)

Table 1. General transistor measurement characteristics

To determine the required hardware, the component’s general characteristics should be identified (for example, frequency, input power, output power, and DC bias). For the following analysis, the general requirements are listed in **Table 1**.

Since the transistor’s output power (approximately 46 dBm) exceeds the maximum input power rating at the PNA-X test ports (typically 30 dBm, or 40 dBm with Option H85), external high power couplers must be connected to the front panel jumpers of the PNA-X to bypass the internal couplers. The external couplers utilized should cover the frequency range of the measurements (1.2 to 3.6 GHz) and handle up to 45 Watts of average power.

Because the transistor under test has a rated small signal gain of 15 to 20 dB, with a typical output power of about 46 dBm, it may require an input stimulus (large-drive) of about 30 dBm (1 Watt) to drive it to saturation. The measurement data is collected with the transistor driven by a pulsed RF signal (carrier frequency = 1.2 GHz, pulse width = 400 μ s, and duty cycle = 1%). The NVNA X-parameter measurements, conducted with an input power of 10 dBm to 32 dBm, includes up to the first three harmonics. The X-parameter measurements (refer to the Appendix, “*The NVNA X-Parameter Measurement Sequence*” on page 13) require an additional measurement signal with a frequency up to the 3rd harmonic and therefore, a broadband pre-amplifier that covers up to three times the test frequency (1.2 GHz).

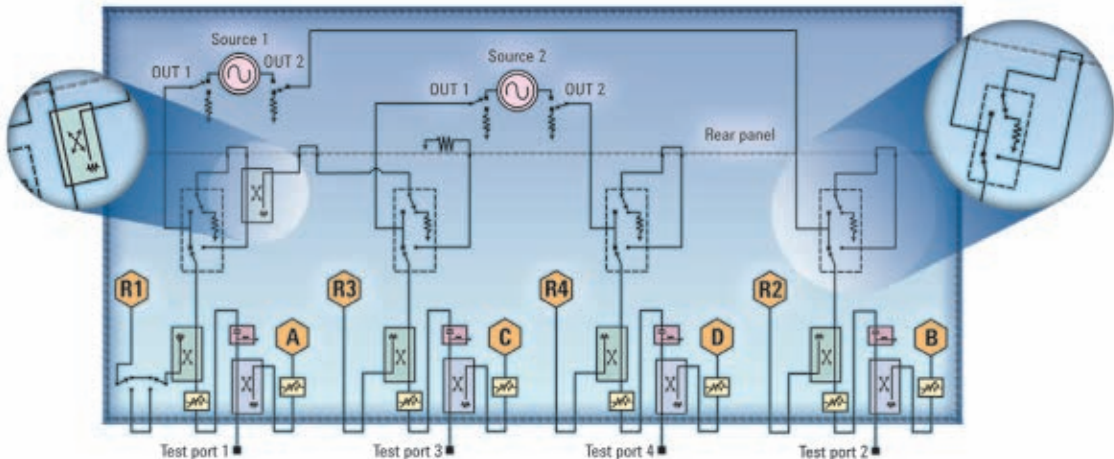


Figure 3. Internal signal-routing switches in the PNA-X provide increased flexibility for adding signal conditioning hardware or additional test equipment for single connection measurements. They also enable alternate measurement paths, re-routing of signal paths and the addition of amplifiers, filters, and attenuators to optimize system setup.

The X-parameter measurements also require an RF stimulus to be applied to the output port while the large drive signal is simultaneously provided to the input. This reverse stimulus signal must be approximately 20 dBc below the saturated output power of the transistor. Therefore, the expected saturated output power (approximately 46 dBm) requires a measurement signal on the drain of 26 dBm. If there is any additional attenuation between the drain and the second source of the PNA-X, additional power will be required. In this case, a 60-Watt driver was chosen that operates over the measurement bandwidth.

The input impedance of the unmatched transistor may be different than 50 Ohms. Consequently, obtaining the required input power at the gate of the transistor requires a source tuner. Additionally, a load-dependent X-parameter model requires a load tuner on the drain. Fundamental frequency source-pull is not required during X-parameter model extraction, since a power sweep is performed over a range of input powers at the fixed optimum input impedance (as provided by the source tuner). This measurement process is equivalent to keeping the source power fixed, while sweeping the source impedance provided to the transistor. The tuners also need to cover the bandwidth of the stimulus (up to 3.6 GHz) during the X-parameter measurements because the measurement stimulus must pass through the tuners before reaching the transistor.

Since the X-parameter extraction procedure performs phase-swept measurements at the harmonic frequencies, any variations of the harmonic source and load impedances are implicitly defined inside the X-parameter model. Therefore, independent control of the harmonic impedances may not be necessary for the X-parameter model extraction of the given nonlinear device. As a result, fundamental frequency tuners were chosen and must provide a gamma high enough to match the potential low impedance of the transistor.

The impedance tuners must be characterized using the tuner software and PNA-X before X-parameter measurements are performed. This characterization process provides a pre-computed configurable input impedance and an S-parameter model of the tuner.

The S-parameter data is used to de-embed the tuners from the measured results so that the measurement is done at the transistor reference plane. Note that the tuner characterization is performed with a 50-Ohm impedance supplied by the PNA-X at both measurement ports. Based on this calibration, the tuner then provides an impedance transformation from 50 Ohm to an impedance designated by the user, under the assumption that a matched device is presented to the 50-Ohm port of the tuner. If this condition is not satisfied, such as when a poorly matched driver amplifier is connected, the calibration of the tuner is no longer valid and the mismatch of the driver must be characterized and taken into account.

A test fixture connects the transistor to the X-parameter measurement system. It consists of a 50-Ohm microstrip transmission line with the equivalent width of the packaging leads of the transistor so that the insertion loss between the transistor port and the impedance tuner is minimized. This ensures that a transistor without standard measurement connectors can be connected to the impedance tuners without jeopardizing the configurable impedance range of the tuners. Furthermore, this fixture can be calibrated using the PNA-X and the measurements can be de-embedded through the fixture to the package of the DUT.

For the chosen transistor characteristics, a gate voltage of less than 5 Volts (at less than 100 mA) and drain voltage less than 30 Volts (at less than 3 A) is anticipated. External high power bias networks were placed, before the tuners, on the gate and drain sides of the component to apply the necessary voltage and current coupled on the RF ports of the transistor.

Couplers	Mini-Circuits ZGDC10-362HP+
Input pre-amplifier	AR 5S1G4
Output pre-amplifier	AR 60S1G4
Tuners	Maury Microwave MT982
DC supply	Agilent N6705A (with N6752A (gate) and N6754A (drain) modules)

Table 2. External hardware used for the measurements

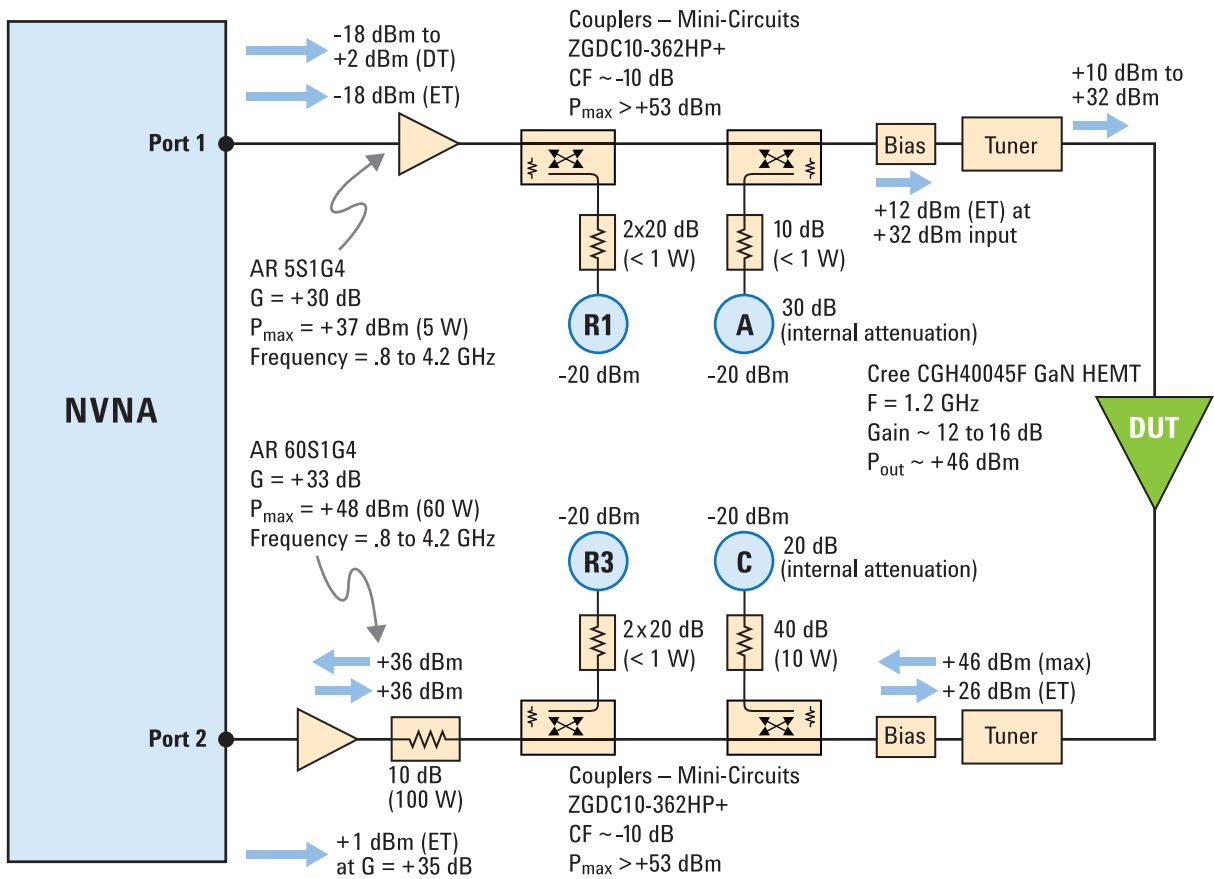


Figure 4. The NVNA power budget.

Table 2 lists the external hardware chosen for the measurements. Before measurements are performed, a power budget must be completed (**See Figure 4**). This is done to ensure instrumentation is not damaged and all system components are operating in their linear range (e.g., no pre-amplifier compression or PNA-X receiver compression at peak powers).

The first step in the power budget is to determine the stimulus/response powers presented at the transistor ports and measurement receivers based on the component's specifications. Next, the required external components can be chosen to satisfy the high-power and receiver linearity requirements. Care should be taken when choosing the pre-amplifier that provides the

forward and reverse RF stimulus. If the pre-amplifiers are saturated by the large-drive signal level (which determines the large-signal operating point of the X-parameter model extraction), then adding the extraction signal will result in an invalid model extraction. Therefore, the X-parameters will appear to be incorrect at the higher drive level powers. This is generally seen during a power sweep when there is a divergence between the simulated (X-parameters) and measured results at the higher input power levels. The maximum RF power at the receiver should be limited to -20 dBm for best receiver linearity. Appropriate external and internal attenuation is chosen to meet this requirement based on the power budget shown in **Figure 4**.

Calibration

Once the power budget is computed and the necessary instrumentation is connected, the PNA-X's NVNA can be calibrated. The NVNA calibration consists of three steps: vector calibration using a vector calibration kit or ECal, amplitude calibration using a power sensor and cross-frequency phase calibration using a phase reference.

The pre-amplifiers behind the couplers are often removed during calibration and then inserted back into the measurement system after the calibration procedure is complete. This does not invalidate the calibration since an eight-term error model is utilized in the NVNA. However, adding the pre-amplifiers may affect the tuner characterization. Consequently, the source and load impedances behind the tuners should be measured with the NVNA and must be accounted for to ensure that the impedance presented to the component by the tuners corresponds with the predicted impedance in the tuner characterization file. This process is usually part of the tuner software.

X-parameter verification

When it comes to X-parameter verification, one of the first things to confirm is that the measured X-parameter model is valid in the expected stimulus/response range. This is accomplished by comparing simulated performance using the X-parameter model against the measured performance of the actual component. If the actual measured performance is the same as the simulated one, then the X-parameter model is valid.

When comparing simulated versus measured performance, it is critical that the source and load impedance terminations at the fundamental and harmonic frequencies in the simulation match the impedances that are used during the measurement. The impedances chosen were not the same as those used to create the X-parameter model. As discussed in the previous section and in the Appendix, “*The NVNA X-Parameter Measurement Sequence*,” the component behavior versus harmonic source and load impedances is implicitly defined in the X-parameter model and identified during the application of the measurement signal. At the fundamental

frequency, the application of physical impedance from a tuner was used to generate load-dependent X-parameters. Therefore, the X-parameter model is valid over a full gamma at the harmonic source and load impedances, and valid over the fundamental frequency load ‘grid’ conditions presented by the tuner. The impedances are shown in the simulation network depicted in **Figure 5**. **Figure 6** illustrates a comparison between the measured and simulated delivered power and thus, validates the behavior of the model.

Designing the power amplifier

To design a Class AB 45-Watt GaN amplifier, the Cree CGH40045F GaN-HEMT transistor was employed. **Table 3** contains a performance overview of the transistor taken from its datasheet.

A design frequency of 1.2 GHz was chosen so that a third-order X-parameter model could be generated using the X-parameter extraction setup described in **Figure 4**, page 5. Before the X-parameters are extracted, the DC quiescent point must be set. A Class AB operation was chosen for the targeted PA. Corresponding supply voltages are listed in **Table 4**.

Frequency	Up to 4 GHz
Gain (small signal)	15 to 20 dB
Psat (typical)	45 Watts
Drain efficiency (typical)	55%

Table 3. Cree CGH40045F transistor specifications

Frequency	1.2 GHz
VGS	-2.87 V
VDS	28.0 V
IDS ₀	400 mA

Table 4. Class AB bias conditions for X-parameter model extraction

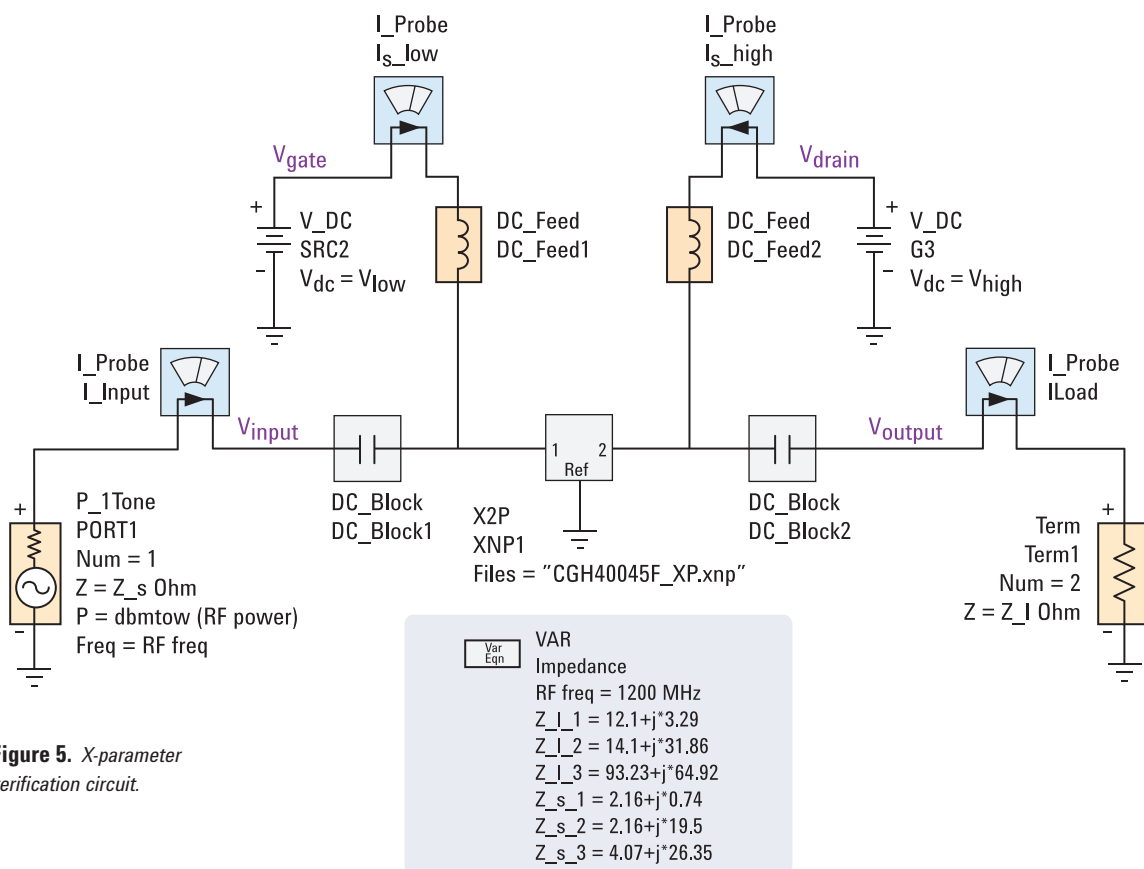


Figure 5. X-parameter verification circuit.

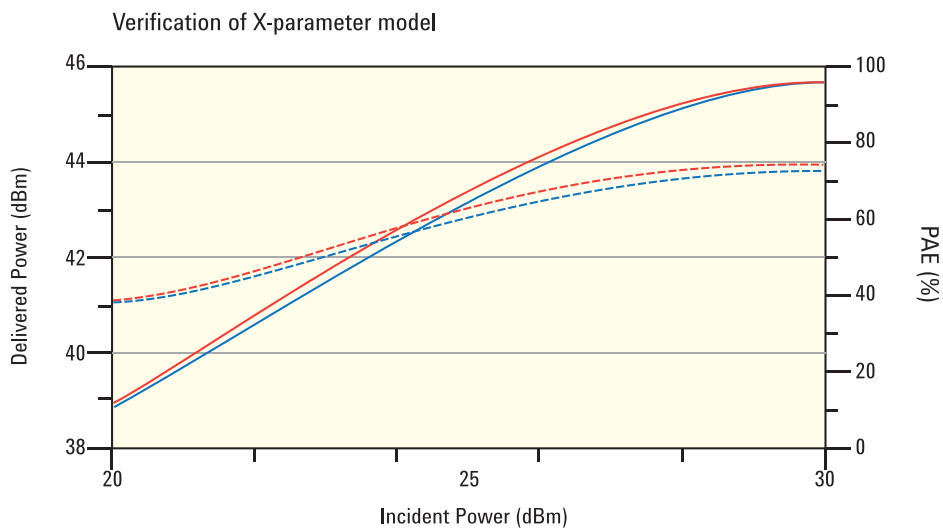


Figure 6. X-parameter verification results.

Source/load-pull X-parameter simulations

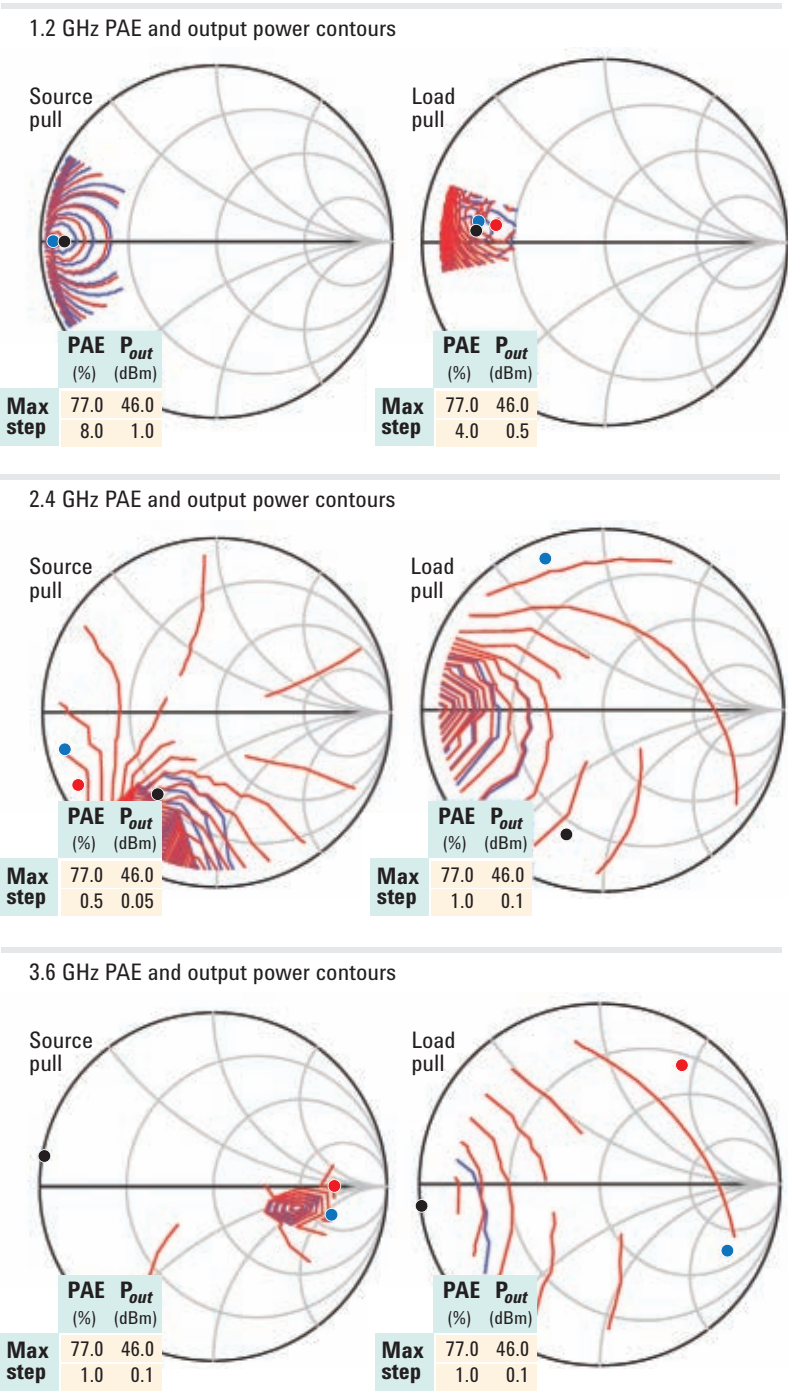
Source and load-pull simulations were conducted based on the measured X-parameter model to determine the optimal impedance matching conditions. The X-parameter model provides an implicit prediction of the harmonic source and load impedance variations. The simulated source and load-pull contours for the first three harmonics are presented in **Figure 5**. In this case, a compromise was struck between maximizing output

power and maximizing power-added-efficiency (PAE) to ensure that suitable output power, greater than 45 dBm, would be obtainable. Given this trade-off, the results in **Figure 7** demonstrate the maximum PAE and output power that can be achieved with harmonic matching networks that have explicit control over the 2nd and 3rd harmonic impedance at the source and the load of the transistor.

Figure 7. Source and load-pull simulated contours of the first three harmonics.

Legend

—	Power added efficiency contours
—	Output power contours
●	Maximum power added efficiency impedance condition
●	Maximum output power impedance condition
●	Matching network impedance condition



Matching networks and simulation results

The matching networks for the PA were designed using a variable-width, sequential transmission line topology and were simulated using the RF-ADS harmonic balance simulator, followed by electromagnetic (EM) simulations that were run in Momentum-ADS. This type of matching network guarantees optimal matching at the fundamental frequency; however, it provides limited control over the source and load impedance that is presented to the device at the harmonic frequencies. Therefore, this simple matching network cannot provide the maximum efficiency predicted in the harmonic source/load-pull simulations of **Figure 7**. Instead, a more sophisticated harmonic matching network would be required.

Since the purpose of this article is to demonstrate the application of X-parameters modeling technology in PA design it was beneficial to use a simple matching network topology to minimize fabrication related errors. Furthermore, the size of the input and output tab of the transistor ($0.22'' \times 0.25''$) behaves as a capacitance that effectively short-circuits the third harmonic impedance

on the gate and drain. For these practical reasons, it was impossible to design a matching network that has the same harmonic impedances as the simulated source and load-pull analysis.

The matching networks shown in **Figure 8** below include integrated microstrip bias networks that are constructed from a bank of capacitors, and a quarter-wavelength transmission line, which ensure that RF leakage does not occur through the bias network. The source and load impedance presented by the matching networks are listed in **Table 5** and are indicated by the black dots in **Figure 7**.

Frequency	Source impedance (Ω)	Load impedance (Ω)
1.2 GHz	$3.03 - j0.07$	$8.85 + j2.42$
2.4 GHz	$16.5 - j23.4$	$12.7 + j36.1$
3.6 GHz	$0.08 + j4.53$	$0.20 + j2.85$

Table 5. Matching conditions provided by the impedance matching networks

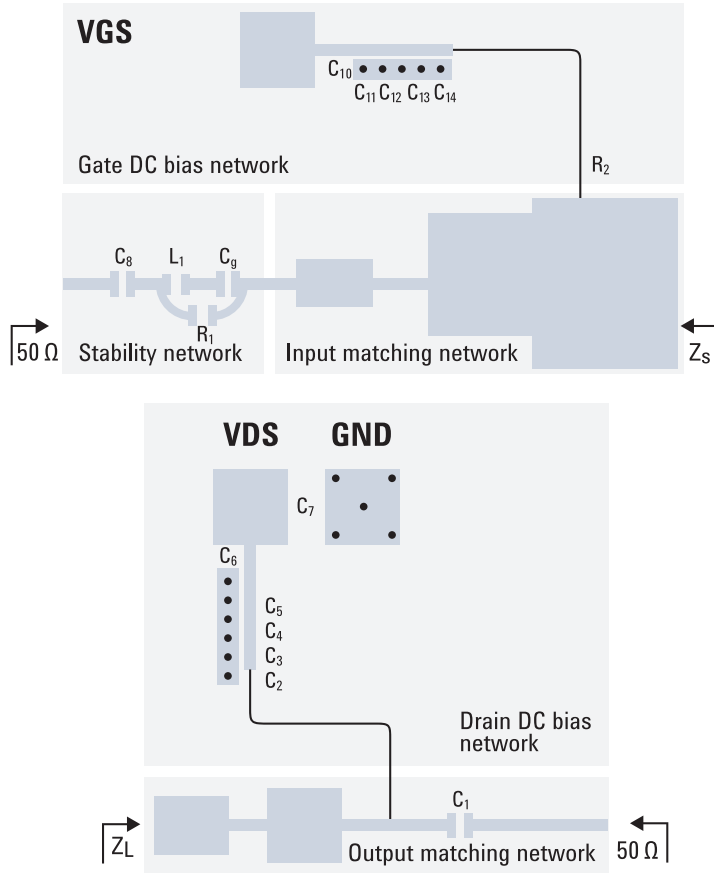


Figure 8. Input and output matching network design.

To predict the effects of connecting the input and output matching networks to the transistor ports, a PA simulation design was created by combining the matching networks (as a Momentum-ADS component) and the X-parameter model inside a single simulation. From this simulation, the overall performance of the PA was simulated at the reference plane outside of the matching networks as shown in **Figure 9**. The final simulation results of the PA are listed in **Table 6**

Figure of merit	Value
Input power	30 dBm
Drain efficiency	64.1%
PAE	62.3%
Output power	45.3 dBm

Table 6 Power amplifier simulation results

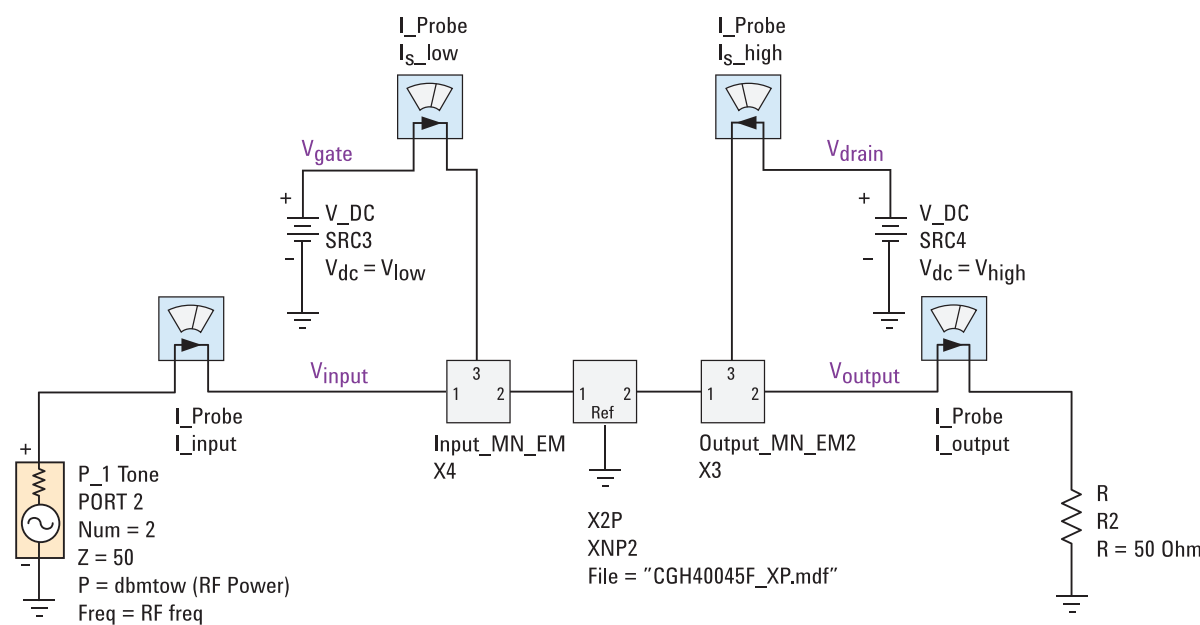


Figure 9. Power amplifier simulation schematic.

Comparing the results

The PA was fabricated (**Figure 10**) and measured using the NVNA. **Table 7** compares the simulated results to the measurement results at a fixed input power at 30 dBm.

The measurements show excellent correlation with the simulation results and demonstrate that the X-parameter model prediction is accurate to within 1% of the measured drain efficiency and 0.4 dB of the measured output power. Consequently, the measurement results prove that the X-parameter model is a viable solution for modeling high-power unmatched nonlinear devices.

Figure of merit	Simulation results	Measurement results
Input power	30 dBm	30 dBm
Drain efficiency	64.1%	64.6 %
PAE	62.3%	62.6 %
Output power	45.3 dBm	44.93 dBm

Table 7. Power amplifier measurements versus simulation results

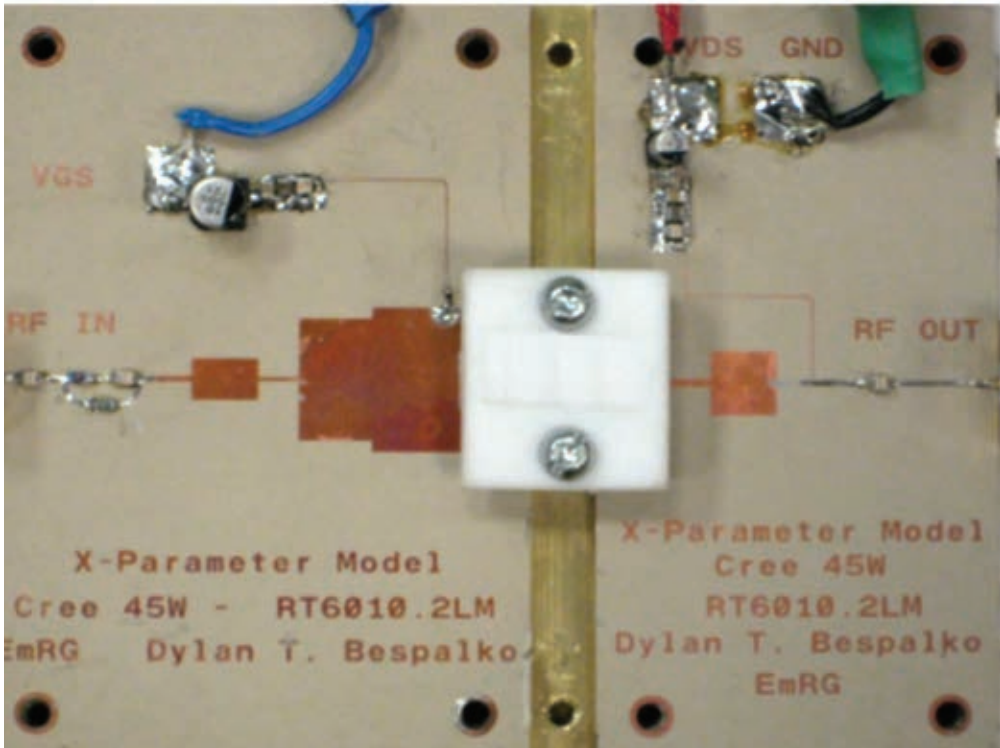


Figure 10. A 45-Watt Class AB power amplifier.

Conclusion

Traditionally, barriers have existed between device characterization and modeling and microwave circuit design. Luckily, a new approach to bridging this gap has now been proposed that can be extremely helpful in streamlining the high-power amplifier design process.

Using the example of a Class AB 45-Watt GaN amplifier, the first step of this process combines load-pull characterization with the advantages of Agilent's NVNA application for the PNA-X network analyzer to generate an X-parameter model of an unmatched 45-Watt GaN device that is imported into the ADS simulation software. The resulting model is used to identify adequate source and load matching networks to be presented to the transistor. In this article, the design was simulated using the RF-ADS harmonic-balance analysis and the ADS dynamic link with the accurate EM simulator Momentum, to accurately synthesize the biasing and matching networks. When compared to the simulation results, the measurement results for the fabricated PA prototype were in excellent agreement. Consequently, this example demonstrates the true power of bringing accurate device behavioral models into the simulation environment to systematically develop advanced circuit topologies and system architectures.

References

- [1] S. Cripps, *"RF Power Amplifiers for Wireless Communications, Second Edition,"* Artech House Publishers, 2006.
- [2] L. Betts, *"Nonlinear Vector Network Analyzer Applications,"* Microwave Journal, March 2009.
- [3] D. Vye, *"X-Parameters Fundamentally Changing Nonlinear Microwave Design,"* Microwave Journal, March 2010.
- [4] J. Verspecht, D.E. Root, *"PolyHarmonic Distortion Modeling,"* IEEE Microwave Magazine, (2006).
- [5] *"Agilent Nonlinear Vector Network Analyzer (NVNA),"* Agilent Technologies, Brochure 5989-8575EN.
- [6] www.agilent.com/find/nvna
- [7] G. Simpson, J. Horn, D. Gunyan, and D.E. Root, *"Load-Pull + NVNA = Enhanced X-Parameters for PA Designs with High Mismatch and Technology-Independent Large-Signal Device Models,"* ARFTG Microwave Measurement Symposium, 2008.
- [8] J. Horn, D.E. Root, G. Simpson, *"GaN Device Modeling with X-Parameters,"* CSICS, 2010.
- [9] *"High Power Amplifier Measurements Using Agilent's Nonlinear Vector Network Analyzer,"* Agilent Technologies, Application Note 1408-19.

Appendix

The NVNA X-Parameter Measurement Sequence

Linear scattering parameters (S-parameters) describe the linear behavior of a component and can be used to design predictable linear systems (**Figure A**). They relate the incident independent 'a' waves to the reflected dependent 'b' waves at the component input and output ports. For a two-port component, the S-parameter can be written as two independent equations with four unknowns (S_{11} , S_{21} , S_{12} , and S_{22}). A vector network analyzer (VNA) is utilized to measure the 'a' and 'b' waves at the component to determine a solution for the S-parameters. This is typically done by performing a forward and reverse stimulus sweep on the component, which provides a set of four independent equations for the four unknowns. The S-parameters, by definition, cannot change versus the stimulus drive direction when determining the solution. This is often the

case for a component that exhibits nonlinear behavior.

When measuring a component that exhibits nonlinear behavior, the definition of the linear scattering model is no longer valid. Examples of nonlinear component behavior are multiple input and output frequencies (harmonics) generated by the component, or changes in the linear scattering parameters as previously discussed. A new model must be generated that accurately encompasses both the linear and nonlinear characteristics of the component.

Figure B shows an example realization of this model consisting of scattering coefficients called X-parameters. Like S-parameters, X-parameters relate the incident independent 'a' waves to the reflected dependent 'b' waves, but across the full linear and nonlinear component behavior.

Figure A. Scattering parameters—linear systems S-parameters.

Definitions

- i = Output port index
- j = Output frequency index
- k = Input port frequency
- l = Input frequency index

$$b_i = \sum_k S_{ik} \cdot a_k$$

$$b_1 = S_{11} a_1 + S_{12} a_2$$

$$b_2 = S_{21} a_1 + S_{22} a_2$$

$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$$

$$\begin{bmatrix} b_1^{fwd} & b_1^{rev} \\ b_2^{fwd} & b_2^{rev} \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \begin{bmatrix} a_1^{fwd} & a_1^{rev} \\ a_2^{fwd} & a_2^{rev} \end{bmatrix}$$

$$\begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} = \begin{bmatrix} b_1^{fwd} & b_1^{rev} \\ b_2^{fwd} & b_2^{rev} \end{bmatrix} \begin{bmatrix} a_1^{fwd} & a_1^{rev} \\ a_2^{fwd} & a_2^{rev} \end{bmatrix}^{-1}$$

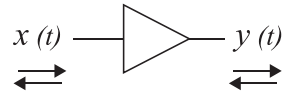


Figure B. Scattering parameters—nonlinear systems X-parameters.

Definitions

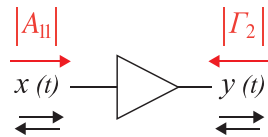
- i = Output port index
- j = Output frequency index
- k = Input port frequency
- l = Input frequency index

- $|A_{11}|$ = Large signal drive to the amplifier input port (port #1) at the fundamental frequency (#1)
- $|F_2|$ = Load dependent X-parameters with variable gamma at port #2

$$b_{ij} = X_{ij}^{(F)}(DC, |A_{11}|, F_2) P^j + \sum_{k,l \neq (1,1)} (X_{ij,kl}^{(S)}(DC, |A_{11}|, F_2) P^{j-l} \cdot a_{kl} + X_{ij,kl}^{(T)}(DC, |A_{11}|, F_2) P^{j+l} \cdot a_{kl}^*)$$

For example: $X_{21,21}^T$

Means: Output port = 2
Output frequency = 1 (fundamental)
Input port = 2
Input frequency = 1 (fundamental)



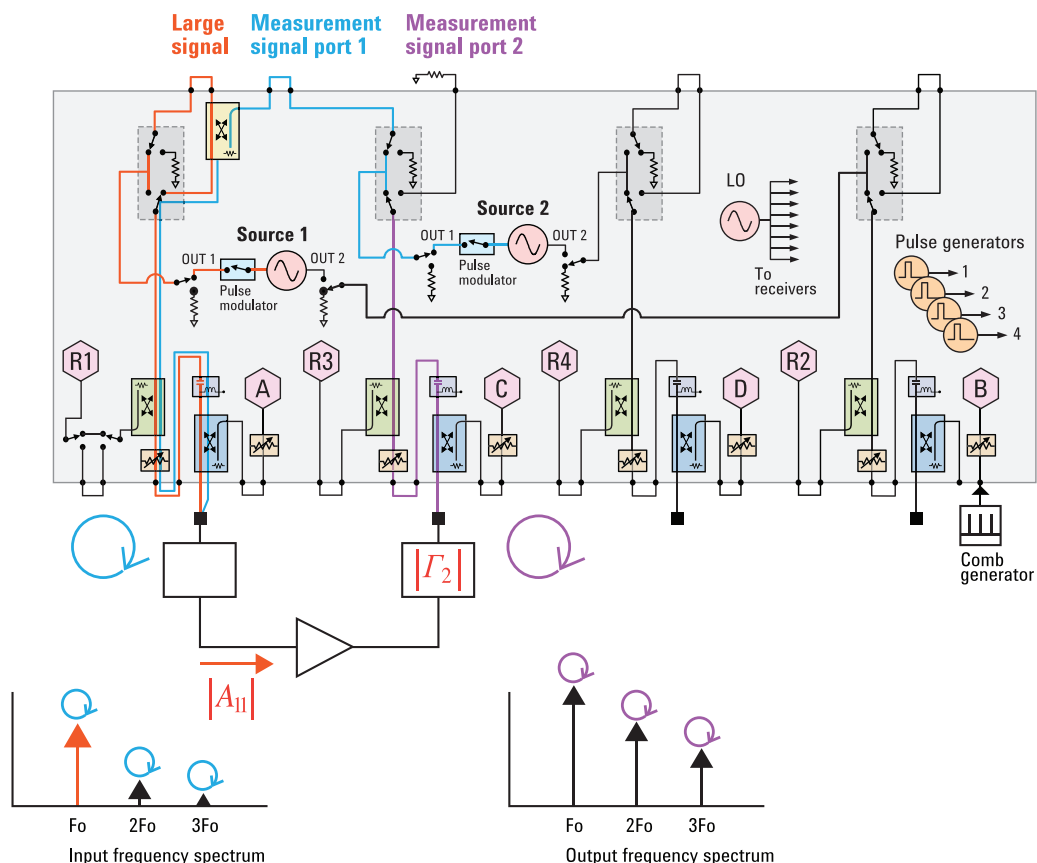


Figure C. The sequence used by the Agilent PNA-X with NVNA application to measure X-parameters.

As an example, consider that an amplifier is stimulated with a large-drive signal from one source on its input port that sets a specific large-signal-operation-point (LSOP). The X-parameters are measured utilizing a second source. The input power of the large-drive signal is then swept across the linear and nonlinear range of the component. At each input power point, a set of X-parameters is generated that are mathematically and analytically correct over the full linear and nonlinear range of the component.

The Agilent PNA-X network analyzer with the NVNA software application is used to measure the X-parameters following the sequence illustrated in **Figure C**. To simplify the analysis, the input large signal is assumed to be set at a single frequency and power level. During the measurement process, the following steps are taken:

Step 1:

A large drive signal is applied only to the PNA-X's port 1.

Step 2:

Simultaneously with the large signal on port 1, the measurement signal is applied to port 1 sequentially to all fundamental and harmonic frequencies. At each frequency, the phase is rotated at steps around 360 degrees.

Step 3:

Simultaneously with the large signal on port 1, the measurement signal is applied to the PNA-X's port 2 sequentially to all fundamental and harmonic frequencies. At each frequency, the phase is rotated at steps around 360 degrees.

The 'a' and 'b' waves are measured at each stimulus change (e.g., port, frequency and phase) in the large drive and measurements signals. Once all the sequences are complete, the resulting waves are utilized to identify the X-parameters.

Authors

Loren Betts, Ph.D. is currently a research scientist and senior engineer at Agilent Technologies focusing on complex stimulus/response measurements and modeling of nonlinear components utilizing vector network analyzers. He co-developed the pulse measurement detection algorithms utilized in current Agilent PNA and PNA-X VNAs. Loren holds a B.Sc. degree in computer engineering and M.Sc. and Ph.D. degrees in electrical engineering. His Ph.D. research focused on the PNA-X NVNA.

Dylan T. Besspalko is a Ph.D. student at the University of Waterloo, ON, Canada, (B.Sc. Electrical Engineering '07 University of Calgary) and is a member of the Emerging System Research Group. His research is devoted to measurement-based characterization and modeling of high-power nonlinear devices for applications in the development of sophisticated multi-standard RF front-end design.

Slim Boumaiza is an associate professor with the Department of Electrical and Computer Engineering, University of Waterloo, Waterloo, ON, Canada, where he is leading the Emerging Radio System Research Group that is conducting multidisciplinary research activities in the general areas of design of RF/micro-wave and millimeter components and systems for wireless communications. His specific current research interests include RF/DSP mixed design of intelligent RF transmitter; design, characterization, modeling and linearization of high efficiency power RF amplifiers, reconfigurable and software defined transceivers.

The authors would like to thank the following vendors for use of their equipment: AR RF/Microwave Instrumentation, Maury Microwave Corporation, and Mini-Circuits.

Nonlinear Reference Website

Get the latest nonlinear reference information, download a free copy of “High Power Amplifier Measurements Using Agilent’s Nonlinear Vector Network Analyzer,” (App Note 1408-19), and find pertinent X-parameter and nonlinear technical papers at: www.agilent.com/find/nonlinear

To learn more about Agilent’s NVNA, go to: www.agilent.com/find/agilentnvna

For more information on Agilent Technologies' products, applications or services, please contact your local Agilent office. The complete list is available at:

www.agilent.com/find/contactus

Americas

Canada	(877) 894 4414
Brazil	(11) 4197 3500
Mexico	01800 5064 800
United States	(800) 829 4444

Asia Pacific

Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 112 929
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Other AP Countries	(65) 375 8100

Europe & Middle East

Belgium	32 (0) 2 404 93 40
Denmark	45 70 13 15 15
Finland	358 (0) 10 855 2100
France	0825 010 700*
	*0.125 €/minute
Germany	49 (0) 7031 464 6333
Ireland	1890 924 204
Israel	972-3-9288-504/544
Italy	39 02 92 60 8484
Netherlands	31 (0) 20 547 2111
Spain	34 (91) 631 3300
Sweden	0200-88 22 55
United Kingdom	44 (0) 118 9276201

For other unlisted Countries:

www.agilent.com/find/contactus

Revised: October 14, 2010

Product specifications and descriptions in this document subject to change without notice.

© Agilent Technologies, Inc. 2011

Printed in USA, May 1, 2011

5990-7768EN



Agilent Technologies

**Verifying EMC performance is one thing.
Diagnosing the cause of EMI is quite another.**



When you find a device out of EMI compliance, now you can also understand why. Because the new Agilent receiver is also an X-Series signal analyzer, loaded with diagnostics to show what's happening. **That's thinking ahead. That's Agilent.**

Agilent N9038A MXE EMI Receiver

CISPR 16-1-1 2010 compliant

Built-in X-Series analyzer runs applications

Intuitive interface and graphical displays

Upgradable for long-term flexibility

Download Competitive Comparison and App Notes: Reduce Verification Time with Fast Scanning and Integrated Tools for Faster EMC Verification and EMI Troubleshooting.
www.agilent.com/find/AgilentEMIreceiver



METHODS FOR CHARACTERIZING THE DIELECTRIC CONSTANT OF MICROWAVE PCB LAMINATES

Copper clad laminates used in the microwave Printed Circuit Board (PCB) industry have many properties of concern. The dielectric constant (relative permittivity or ϵ_r) is one of the most critical. Many design engineers have made the assumption that this property is a rigid value; however, often that is not the case. The suppliers of copper clad laminates give the ϵ_r value on the product datasheet with accompanying information regarding the test method and testing frequency. One confounding issue is that the ϵ_r value of a particular material using one test method may not be the same value when testing the exact same material while using a different test method. Another concern is by the nature of the microwave circuit design, the fields within the material could be significantly different as compared to the method used to generate the ϵ_r value and this could give unexpected results as well.

This article will give an overview of the most common test methods used to determine the ϵ_r value for microwave laminates. The limits and capabilities of these tests will be demonstrated as well. Several other electrical characterization techniques will be discussed, which are typically employed by means of simple microwave circuit evaluations.

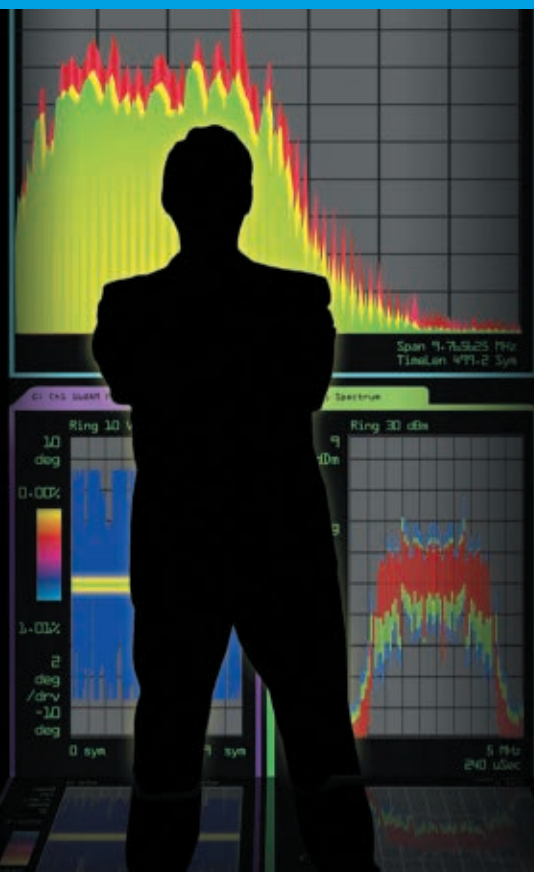
GENERAL TEST METHOD AND CONSIDERATIONS

In a very broad sense there are two different types of electrical characterization techniques for microwave PCB laminates; one is a method using resonance and the other is using

transmission/reflection techniques. Resonance methods are typically more accurate for determining ϵ_r ; however, they are limited to a specific frequency or a few discrete frequencies. The transmission/reflection methods usually yield results over a range of frequencies. Both of these general test procedures are usually done in frequency domain; however, there are derivatives of both using time domain. In this article, frequency domain techniques will be considered.

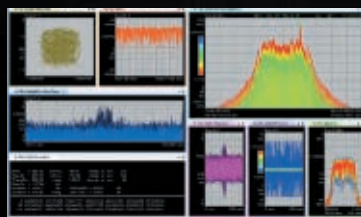
Understanding electromagnetic field orientations within the material under test can be very important in assessing how applicable the resultant ϵ_r value from a test method is related to a given microwave application. For example, assuming a test method that generated an ϵ_r value within the x-y plane or the length-width plane of the material and not the z-axis (thickness) and if the microwave application has fields that are dominant in the z-axis, then the given ϵ_r value may have significant accuracy issues for that particular application. The significance is really related to several factors, some of which are the sensitivity of the circuit application as well as the anisotropic ϵ_r nature of the laminate. A laminate with higher anisotropy will have a larger difference in ϵ_r when comparing values of the x-y plane to the z-axis. It is common for laminates used in the PCB industry to have some level of anisotropy. Sometimes this is due to layers of glass fiber within

JOHN COONROD
Rogers Corp., Rogers, CT



See into the future of wireless technology with tools that stay ahead of it.

Agilent 89600B vector signal analysis (VSA) software enables more simultaneous views of virtually every aspect of complex wireless signals. The result is an unprecedented ability to understand signal problem root causes today and in the future. That's clarity. That's Agilent.



NEW! 89600B VSA Software

Up to 20 traces, 20 markers each

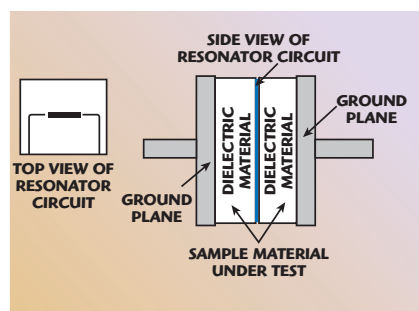
> 70 signal standards and modulations

Advanced time, frequency and modulation tools

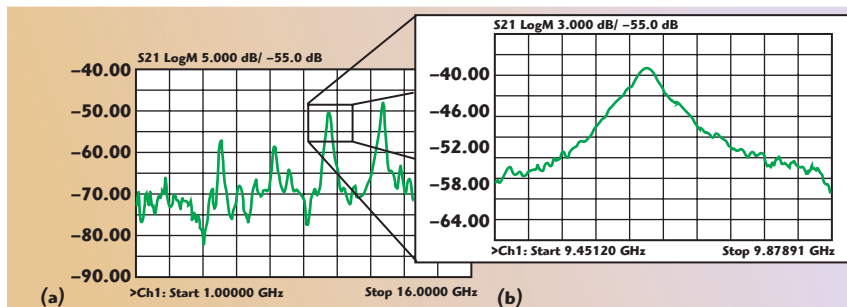
> 30 supported measurement platforms

Make successful VSA measurements: watch demo videos and download an application note
www.agilent.com/find/Agilent89600B





▲ Fig. 1 Simple drawing of the X-band clamped stripline resonator test.



▲ Fig. 2 Broadband frequency response of X-band clamped stripline resonator: (a) and isolated resonant frequency peak at approximately 10 GHz (b).

the laminate used for mechanical stabilization.

COMMON TEST METHODS TO DETERMINE ϵ_r

There are typically two test methods that are most often employed by the laminate suppliers to determine dielectric constant. Both of these test methods are defined in the IPC-TM-650 2.5.5.¹

The first method discussed uses a stripline resonator and is intended to determine the z-axis ϵ_r value of the material under test. The method is tailored toward the testing of raw laminate in a high volume manufacturing environment. Because of the design of this test method, the ϵ_r value may or may not apply to a microwave application. The test procedure is per IPC-TM-650 2.5.5.5c and can be found at www.ipc.org. Essentially, the procedure is to have two samples of the material to be tested placed on both sides of a thin resonator circuit and have two ground plates apply pressure from both sides. The outer clamping plates act as the ground planes for the stripline structure, with the resonator circuit pattern in the middle and the material under test making up the dielectric layers (shown in **Figure 1**).

The circuit pattern is designed to have the resonator element with a physical length of two wavelengths at 10 GHz, given a target ϵ_r value and a defined dielectric thickness. This test method is capable of determining the ϵ_r value and the dissipation factor of the material under test at frequency intervals of $\frac{1}{2}$ wavelengths up to about 12.5 GHz. Typically, the resonant peak at 10 GHz is evaluated; this is shown in the detailed view of **Figure 2b**.

There are two potential issues for this test method. One is that some amount of air can be entrapped with the material under test and the meth-



KRYTAR®

Microwave Components & Instruments
DC to 67 GHz



Directional Couplers to 67 GHz



3 dB 90° Hybrid Couplers to 40 GHz



Directional Detectors to 50 GHz



Double Arrow 3 dB 180° Hybrid Couplers to 26.5 GHz



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



MLDD Power Divider/Combiner to 45 GHz



RF & Microwave Power Meter 100 KHz to 40 GHz



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



Coaxial Terminations to 50 GHz



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

MIL Qualified Components Available

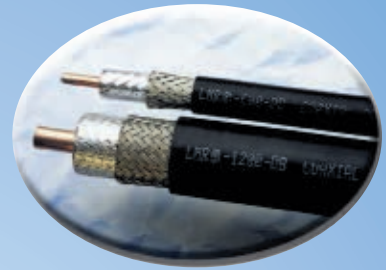
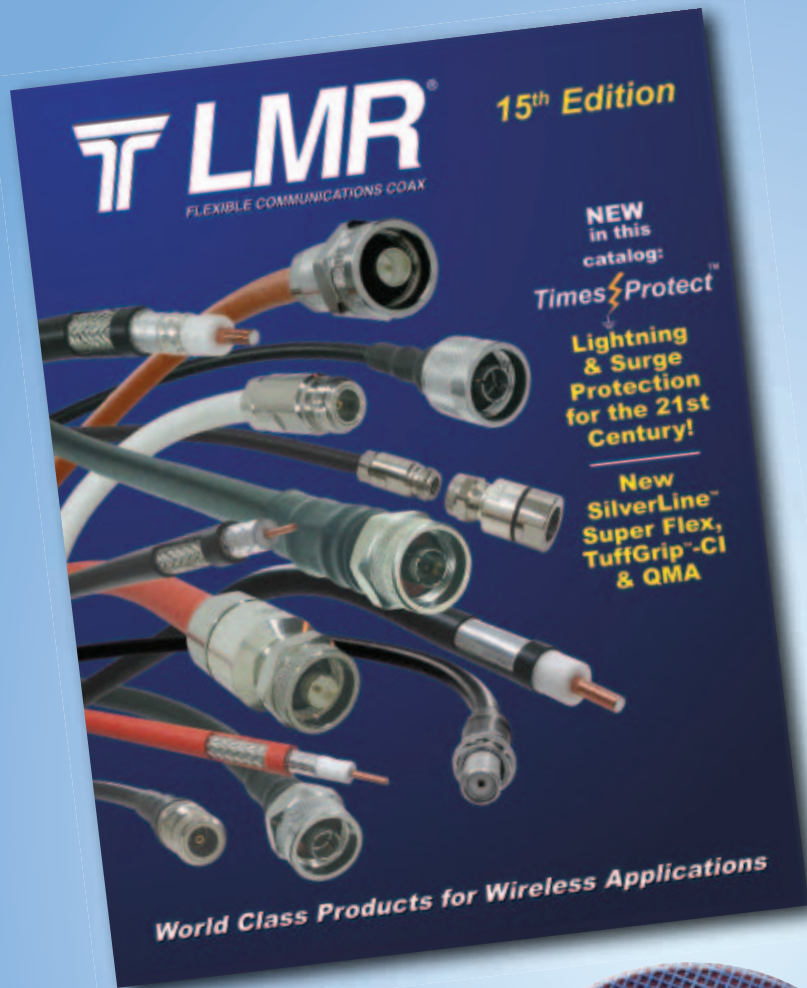
KRYTAR® 1288 Anvilwood Ave. Sunnyvale, CA 94089

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

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



Flexible Coax Solutions... They're All Right Here



*LMR®-DB Flexible
Watertight Coaxial Cable*



LMR® Bundled Cable



*Hardware, Accessories
and Installation Tools*



Advantage Connectors



*Fire Retardant LMR®-LLPL Plenum
and LMR® - FR Riser Coaxial Cables*

*A Full Line of Coaxial Cables, Connectors, Hardware Accessories and Tools
Plus Over 60 Years Experience. Visit our website for your free catalog!*

TIMES
MICROWAVE SYSTEMS



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

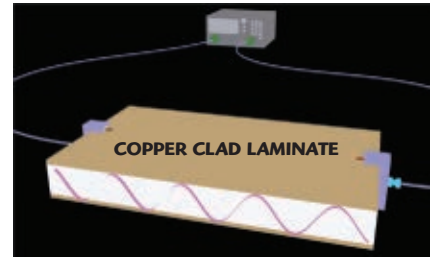
China Sales: No. 318 Yuan Shan Road, Shanghai, China 201108 • Tel: 86-21-51761234 Fax: 86-21-64424098

timesmicrowave.com

See us at MTT-S Booth 3310

od reports a lower than expected ϵ_r value. This issue is exaggerated when a laminate using a high profile copper is tested, due to the samples having more surface area when the copper is removed prior to the test. The second potential issue is the anisotropy effects of the material under test. The resonator circuit design is purposely loosely coupled in order to realize the Q of the material more so than the Q of the overall resonator circuit. The

coupling is done by a gap coupling on the resonator circuit pattern and in the gap areas there is higher concentration of fields. It is in these areas where the anisotropy effects of the laminate can alter the center frequency of the resonator and cause a potential difference in the ϵ_r calculation. The fields in the gap area utilize the x-y plane properties of the material under test, whereas the element of the resonator is generally using the z-axis of the



▲ Fig. 3 Basic illustration of the full sheet resonance test method.

material. The calculation for ϵ_r for this test method follows:

$$\epsilon_r = \left[\frac{nc}{2f_r(L + \Delta L)} \right]^2 \quad (1)$$

where n is the resonant frequency node, c is the speed of light in a vacuum, f_r is the resonant frequency, L is the physical length of the resonator element and ΔL is the added length in the gap coupled areas for the effects of electric field fringing.

The second common test method used in determining the ϵ_r of a high frequency laminate is the Full Sheet Resonance (FSR) test method. This is also defined by an IPC test method: IPC-TM-650 2.5.5.6. This method is a non-destructive test as opposed to the stripline test, which requires the sample to have the copper etched completely off prior to testing the sample. The FSR test method determines the ϵ_r value of the laminate in the z-axis; however, it does not determine the dissipation factor. The method basically uses the copper clad laminate under test as an open walled parallel plate waveguide and evaluates an established standing wave. A simple drawing to illustrate the test set up is shown in **Figure 3**.

From the resonant frequency peak of a standing wave, the ϵ_r of the laminate can be determined. As with many resonator test methods, there are several resonant peaks to evaluate. However, most will be at a relatively low frequency for this test. A standing wave frequency peak and specifically the associated wavelength are directly related to the physical size of the panel. Most panels under test are 24" × 18" in size; therefore, the first dominate mode resonant peak will occur on the length axis of the panel and will be a long wavelength and thus a low frequency. It is common to have the



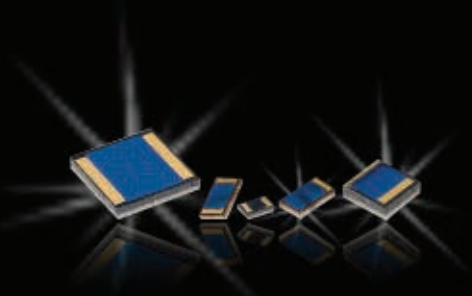
Join in for another decade of re-shaping the world of EM simulation

10 years
μWave Wizard

μWave Wizard™: The hybrid mode-matching EM-tool for sophisticated designs of antennas, filters, couplers, multiplexers, ...

Mician GmbH, Schlachte 21, 28195 Bremen, Germany, Tel.: +49 421 16899351, Fax: +49 421 16899352, www.mician.com

Visit us at IMS 2011 in Baltimore, MD, Booth 740



DiamondTM Rf Resistives

An engineer's best friend

Resistors, Terminations and Attenuators on CVD Diamond

Size	Power (W) CW/Pulse	Frequency (GHz)
0402	20/200	DC-18
0505	50/500	DC-18
0603	50/500	DC-18
1010	125/1,250	DC-12
1310	125/1,250 10 μ s PW 1% DC	DC-14

Attenuators available from 0 to 30 dB

The high power, low capacitance solution!

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



See us at MTT-S Booth 1612

first few measureable resonant peaks to be in the range of 100 to 300 MHz and a broadband image of a panel under test is shown in **Figure 4**.

The FSR test method does not have the issue of the entrapped air or anisotropy effects mentioned for the clamped stripline test; however, it does have limits. The low frequency testing will be less sensitive to some high frequency effects on determining ϵ_r . One such effect is related to the copper surface roughness of the

laminates, where it was found that the propagation constant can be affected by the copper roughness and therefore the apparent ϵ_r value is affected as well.²

The simple calculation for the ϵ_r value of a panel under test using the FSR method is given:

$$\epsilon_r = \left(\frac{c}{2f_r} \right)^2 \left[\left(\frac{m}{L} \right)^2 + \left(\frac{n}{W} \right)^2 \right] \quad (2)$$



▲ Fig. 4 Broadband frequency response of a panel under test using the FSR test method.

where c is the speed of light in a vacuum, f_r is the resonant frequency, and m and n are the resonant frequency nodes that relate to physical length (L) and width (W), respectively.

There are other common test methods used to evaluate the ϵ_r value of a PCB laminate and one that has become more popular lately is the Split Post Dielectric Resonator (SPDR) test method. This method uses perturbation methodologies with comparing resonant frequency peaks of the empty resonator versus a loaded resonator. The loaded resonator is a sample of the raw laminate with the copper fully removed. The SPDR test evaluates the ϵ_r value of the sample under test in the x-y plane only. This is a fast and user friendly test; however, it has a limit of the accuracy for the ϵ_r value being directly related to the accuracy of the thickness measurement of the sample.

It has been suggested that a good general indicator for anisotropy of a laminate is to use the combination of the SPDR test and either the clamped stripline test or the FSR test. The SPDR test will evaluate the ϵ_r value of the laminate in the x-y plane, whereas the other two tests evaluate the z-axis of the material.

COMMON MICROWAVE CIRCUIT EVALUATIONS FOR DETERMINING ϵ_r

There have been a multitude of techniques defined to determine the ϵ_r value of a laminate by means of microwave circuit evaluations. Typically, a circuit will be designed and modeled for a very specific response, with the assumption of a particular ϵ_r value of the laminate, while trying to minimize all other effects on the circuit performance.

Three methods will be discussed here that utilize relatively simple microwave circuitry and have been prov-

Capable. Portable. Affordable.

The future of the high powered microwave lab.



ISYS245 MICROWAVE GENERATOR

A high power source generating variable power in excess of 100 W at 2.45 GHz

Introducing the **ISYS245 Microwave Generator**—the most powerful compact source for today's microwave manufacturing floors and test benches. Employing innovative solid-state technology, it produces highly efficient microwave power at 2.45 GHz in the range of 0 to 100 W. In addition to providing precise reflection measurement, this cool, lightweight, full-function, stand-alone microwave generator can also perform as a microwave amplifier. Learn more and start thinking of the future of your lab by visiting www.EmblationMicrowave.com.



Massachusetts Bay Technologies, Inc. (MBT)

specializes in the design, manufacture and distribution of RF/Microwave semiconductor diodes. MBT is committed to the continuance of innovations in service to its customers, improvement of design, product performance and quality control.

MBT's product frequencies range from 100Hz up to and including millimeter wave; our quality devices are used in various industry applications such as university and laboratory research, consumer products, telecommunications, aerospace and military.

MBT's consistent objective is to provide a superior product with unsurpassed customer service to our clients. Our engineers are available to discuss your specific design and application requirements that are both cost and time effective. We look forward to providing you component expertise and a quality product.

MBT's product line includes but is not limited to the following RF/Microwave devices:

Abrupt Tuning Varactors Diodes
Hyperabrupt Tuning Varactors Diodes
Step Recovery/Multiplier Diodes
PIN/Beam Lead PIN/Limiter Diodes
Point Contact Diodes
Schottky Diodes
MIS Chip Capacitors
Custom Designed Components

Are you looking for a discontinued Alpha Industries, Frequency Sources, Hewlett Packard, M/A-Com, Microwave Associates, MEDL, Motorola, NEC, Philips, Parametric Industries, Siemens, Thomson CSF, Toshiba or Varian part? MBT will cross reference and manufacture your discrete, obsolete or custom RF/Microwave application.



Motivated By Performance, Focused on Reliability ®

Massachusetts Bay Technologies, Inc. 378 Page Street, Stoughton, MA 02072 • Tele: 781-344-8809 • Fax: 781-341-8177

• Website: www.massbaytech.com • Email: sales@massbaytech.com

© 2011 Massachusetts Bay Technologies, Inc. All trademarks of Massachusetts Bay Technologies

See us at MTT-S Booth 4303

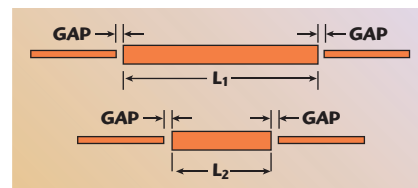
MASSACHUSETTS BAY TECHNOLOGIES

RF/MICROWAVE SEMICONDUCTORS

en to yield accurate results for ϵ_r characterization of a laminate. Due to the depth of information regarding these methods, the first will be discussed in an introductory manner with the appropriate references given for further investigation by the interested reader; the other two will be given with more functional detail.

A test method has been defined that uses a special microstrip resonator circuit to evaluate the ϵ_r values of a

laminate in the x-y plane as well as the z-axis. The method was developed by Sonnet Software Inc. and its procedure and supporting data is explained in detail with several papers.³⁻⁵ The special resonator is a long edge coupled microstrip dual-mode resonator known as a RA Resonator. The circuit is relatively simple to fabricate and offers an accurate means to acquire the ϵ_r values of a laminate in multiple planes while using the same test circuit.



▲ Fig. 5 Drawing of top view for two microstrip gap coupled resonators of different lengths.

The next test method uses a pair of microstrip circuits to generate a relatively accurate ϵ_r value at several discrete frequencies. A simple gap coupled microstrip resonator has been used for many years with a few concerns. The major concern has been related to the gap coupling. The resonator should be loosely coupled to better realize the Q of the material, in order to get a more accurate determination of the ϵ_r value. If the resonator is too loosely coupled, the resonant peak can be distorted and a good measurement compromised. If it is not loosely coupled enough, the resonant peak may shift in frequency and cause the calculation of the ϵ_r to have some error. Also, since the gap coupling is a microstrip discontinuity, there is a concern for radiation losses adversely affecting the determination of the dissipation factor. With the following technique, the gap coupling concerns have been addressed.

Two microstrip gap coupled resonators are made on the same substrate and within very near proximity of each other. The resonators should be the same in every way, with the only exception being the resonator element length. One circuit should be significantly longer than the other, as shown in **Figure 5**.

To determine the effective ϵ_r value of one of these resonators (1) is to be used and in that formula ΔL , is the added length of the resonator due to fringe effects in the gap area. With two resonators of different lengths using the same gap (ΔL), the effects of the gap can be eliminated. This is done by rewriting (1) for each of the two resonators, rearranging terms and finally solving the ΔL item to be eliminated follows:

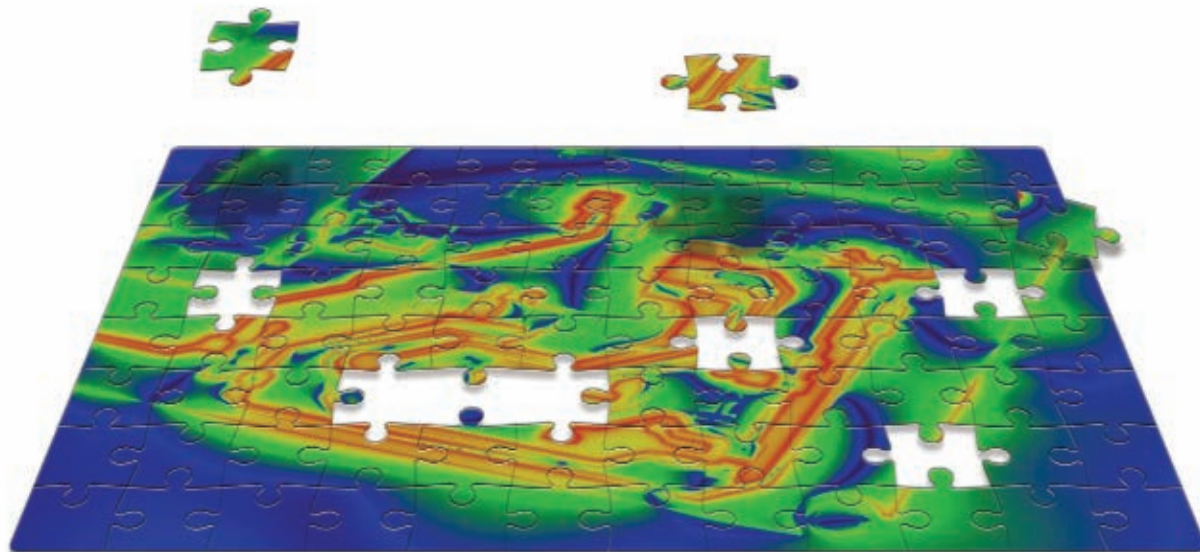
$$\text{Eff-}\epsilon_r = \left[\frac{nc}{2f_r(L + \Delta L)} \right]^2 \quad (3)$$

$$L_1 + \Delta L = \frac{n_1 c}{2f_{r1} \sqrt{\text{Eff-}\epsilon_r}} \quad (4)$$



Antenna Research Associates is a
Multi-division company creating
Tomorrow's RF
Antenna Technology today.
For More Information on

ARA's Products and Services
please visit www.ara-inc.com
or email sales@ara-inc.com
Visit ARA at MTT-S
Booth # 5119



Are You Missing Some Pieces to the Puzzle?

Let Remcom Consulting Complete It



Remcom Consulting is an ideal solution for those organizations that need electromagnetic expertise without an ongoing need for in-house EM simulation software. Remcom provides EM modeling experts, software developers, and high performance computational resources to meet your most challenging EM simulation analysis needs.

Commercial Consulting | Government Contracting | Custom Software Development



Remcom Consulting delivers immediate benefits:

- Electromagnetic expertise without adding internal resources
- Simulation results without the software investment
- Reduced time to market, lower costs, and a more reliable product

Learn more at: www.remcom.com/consulting

Visit Remcom at IMS 2011, Booth #1629

REMCOM[®]
Electromagnetic Simulation Solutions

+1.888.7.REMCOM (US/CAN)

+1.814.861.1299

www.remcom.com

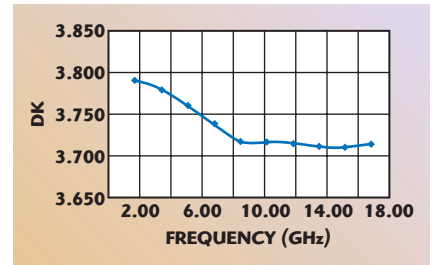
$$L_2 + \Delta L = \frac{n_2 c}{2f_{r2} \sqrt{\text{Eff_}\epsilon_r}} \quad (5)$$

$$\text{Eff_}\epsilon_r = \left[\frac{c(n_1 f_2 - n_2 f_1)}{2f_1 f_2 (L_2 - L_1)} \right]^2 \quad (6)$$

Since ΔL has a small dependence on frequency, it is desired that f_1 and f_2 are relatively close in value. This is typically done by designing the resonator lengths to be integral multiples

of each other and measuring higher order nodes of resonance. Back calculating the ϵ_r value from the effective ϵ_r has been done with the use of close form equations from Hammerstad and Jensen⁶ or field solving techniques.

This test method is further described in a book⁷ regarding electrical characterization techniques of high frequency materials and a plot of results when using a common high fre-



▲ Fig. 6 Results from testing two microstrip gap coupled resonators.

quency laminate is shown in **Figure 6**.

All the test methods described thus far have been resonator methods. The next test method is intended to determine the ϵ_r value of a laminate over a wide range of frequencies and using a transmission/reflection technique. This method also uses the advantage of having two microstrip circuits built on the same material and eliminating some variables that are common to evaluating this type of circuit. The circuit is a simple single-ended microstrip transmission line having two circuits of significantly different lengths. The procedure is detailed in a paper⁸ and the following is an overview.

Two circuits are made on the same substrate and very near in proximity to each other. Both circuits should be identical in every manner with the exception of length. One circuit should be significantly longer than the other by a multiple of three or more. Both circuits should use the same connectors for testing or ideally the same fixture. A measurement is to be taken for each circuit over a range of frequencies to obtain the phase angle at each frequency. The microstrip transmission line phase response formula is used to calculate the effective ϵ_r value at each frequency. The phase response formula used is:

$$\Phi = 2\pi f \frac{\sqrt{\text{Eff_}\epsilon_r}}{c} L \quad (7)$$

where Φ is the phase angle, f is the frequency, $\text{Eff_}\epsilon_r$ is the effective dielectric constant, c is the speed of light in a vacuum and L is the length of the transmission line. This is for a phase angle measurement at a specific frequency and a discrete transmission line length.

This method uses the two different transmission line lengths (ΔL) and their different phase angle ($\Delta\Phi$) at a

PEAK PERFORMANCE mm-wave Converter



Sivers IMA is the industry leader in broadband VCOs and custom integrated assemblies covering 2.0 to 220 GHz. We custom design radio transmitters and receivers in many bands for wireless telecommunication. One example is the above illustrated high performance mm-wave transceiver module, that can help radio link manufacturers slash time to market for next generation high capacity radio links.

Sivers IMA can supply all your broadband requirements, from discrete VCO components to entire subsystems including PLLs, synthesizers or FMCW frontends. We will design to your requirements and to the most demanding military/commercial specifications.

SIVERSIMA

SIVERS IMA IS AN ISO 9001:2008 CERTIFIED COMPANY

www.siversima.com | info@siversima.com

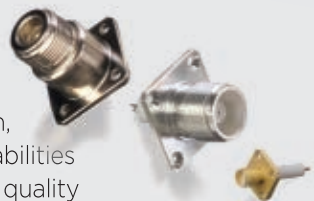
Visit us at
MTT-S 2011
Booth 3302



Connect TRU with your challenge

For 60 years, TRU Corporation has created pioneering solutions for RF and microwave interconnectivity with cable assemblies and connectors. Engineered solutions for demanding performance in defense and aerospace applications.

- Vertically integrated design, manufacture and test capabilities
- Field-proven reliability and quality
- Extensive range of high performance cable and connector interface solutions



To learn more about how TRU can connect with you, visit our new website: trucorporation.com

CELEBRATING 60 YEARS

TRU Corporation
Peabody, MA 01960 USA

1 800 262-9878
(1 800 COAX-TRU)
978 532-0775

To request literature:
marketing@trucorporation.com

©2011 TRU Corporation



EXPERIENCE. TRU INNOVATION.

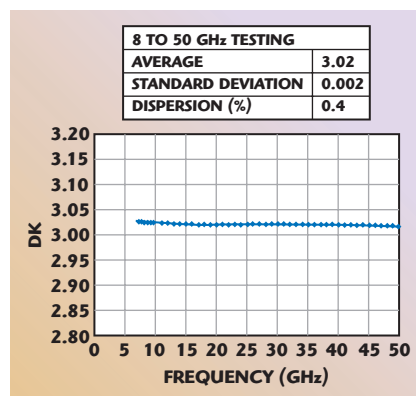
specific frequency to determine the effective ϵ_r . The frequency is then incremented, the new phase angles accounted for, the effective ϵ_r determined and then recalculated at the new frequency.

$$\Delta\Phi = 2\pi f \frac{\sqrt{\text{Eff-}\epsilon_r}}{c} \Delta L \quad (8)$$

$$\text{Eff-}\epsilon_r = \left(\frac{\Delta\Phi c}{2\pi f \Delta L} \right)^2 \quad (9)$$

At each point in the iteration process where the effective ϵ_r value is determined, a computer routine is used to back calculate the ϵ_r value of the laminate, as previously described. A plot of two circuits tested with this procedure using a common microwave laminate is shown in **Figure 7**.

Several different test methods for evaluating ϵ_r for microwave PCB laminates have been shown. Different test methods using microwave circuit



▲ Fig. 7 Results of the microstrip differential phase length test method.

characterization have been shown as well. Each of these methods have their own set of capabilities and limits that need to be understood in order to appreciate the significance of the ϵ_r value reported for a laminate in regards to a particular application.

It is strongly recommended for the designer to evaluate and define an appropriate test method that will best approximate their actual circuit application. The ϵ_r values supplied by the laminate manufacturers should be considered approximate in an effort to support the circuit designer for fine tuning their application with a material under consideration. ■

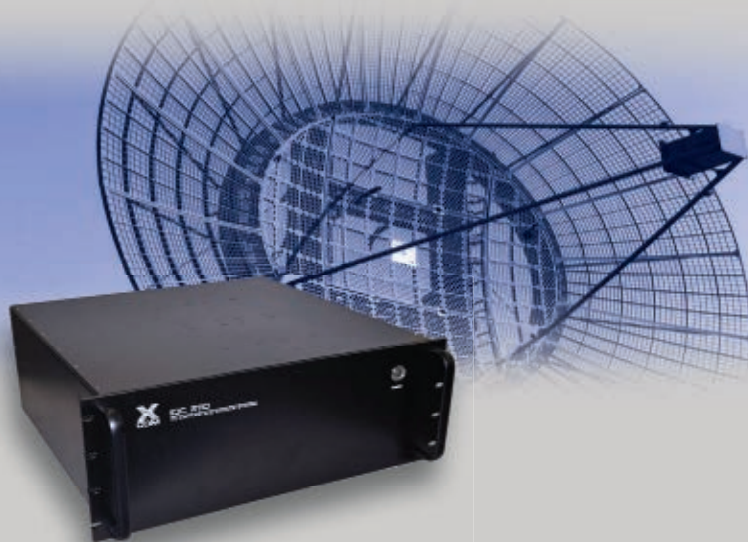
References

1. IPC-TM-650 Standard Test Methods, www.ipc.org.
2. J.W. Reynolds, P.A. LaFrance, J.C. Rautio and A.F. Horn III, "Effect of Conductor Profile on the Insertion Loss, Propagation Constant, and Dispersion in Thin High Frequency Transmission Lines," *DesignCon 2010*.
3. J.C. Rautio, "Measurement of Planar Substrate Uniaxial Anisotropy," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 57, No. 10, October 2009.
4. J.C. Rautio, "A Proposed Uniaxial Anisotropic Dielectric Measurement Technique," *IEEE MTT-S International Microwave Symposium Digest*, Guadalajara, Mexico, February 19-20, 2009, pp. 59-62.
5. J.C. Rautio, "Measurement of Uniaxial Anisotropy in Rogers RO3010 Substrate Material," *COMCAS 2009*.
6. E. Hammerstad and O. Jensen, "Accurate Models of Microstrip Computer Aided Design," *1980 MTT-S International Microwave Symposium Digest*, May 1980, pp. 407-409.
7. L.F. Chen, C.K. Ong, C.P. Neo, V.V. Varadan and V.K. Varadan, *Microwave Electronics, Measurement and Materials Characterization*, John Wiley & Sons Ltd., 2004.
8. N.K. Das, S.M. Voda and D.M. Pozar, "Two Methods for the Measurement of Substrate Dielectric Constant," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-35, No. 7, July 1987.

RO3010 is a licensed trademark of Rogers Corp.

RF SIGNAL RECORDING

Turn your Spectrum Analyzer into a continuous long duration RF Signal Recorder.



WIDEBAND, LONG DURATION RF SIGNAL RECORDING & PLAYBACK FOR SPECTRUM ANALYZERS

- 100% probability of capture for intermittent and complex signals
- Hours to days of potential capture time
- Re-create and playback recorded signals with exceptional fidelity
- The key to signal analysis for modern complex signals

www.xcomsystems.com • 703.390.1087



INNOVATIVE RF SOLUTIONS

X-COM Systems engineers custom RF test solutions in signal storage, generation and software for waveform creation and analysis for the DoD and worldwide technology firms.

NEW ATC 506WLC Series Ultra-Broadband Inductors

For Coverage Through 40 GHz

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



Part Number	Inductance (μH)	Operating Frequency Range	Insertion Loss**	Return Loss**	DC Resistance	Current Handling (DC max.)***
ATC 506WLC110KG115B	11 typ.	500 KHz* to 40 GHz	0.4 dB typ.	-18 dB typ.	7.0 Ω typ. @ 10 mA	115 mA dc, max.
ATC 506WLC6R0KG200B	6.0 typ.	880 KHz* to 40 GHz	0.6 dB typ.	-18 dB typ.	2.9 Ω typ. @ 10 mA	200 mA dc, max.
ATC 506WLC2R2KG250B	2.0 typ.	2.3 MHz* to 40 GHz	0.5 dB typ.	-17 dB typ.	1.45 Ω typ. @ 10 mA	250 mA dc, max.

*Lower -3 dB roll-off frequency

**Shunt Mounted

***Current for 100 °C temperature rise



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



www.atceramics.com

See us at MTT-S Booth 1906

ANALYTICAL DESIGN OF AN INVERSE CLASS F POWER AMPLIFIER FOR LINEAR AMPLIFICATION

In this article, a 2.5 to 2.6 GHz highly efficient inverse Class F power amplifier (PA), based on Cree's CGH40010 GaN HEMT, is presented for linear amplification. The second and third harmonic load impedances are found by harmonic load pull simulation, and controlled by the output harmonic matching network (HMN). Meanwhile, the second harmonic source impedance, which plays a crucial role in high efficiency PA design, is controlled by the input HMN. The parameters of the HMNs are obtained by analytical calculation. Measurement results show that the drain efficiency of the fabricated PA is over 75 percent at an output power of 41.4 dBm for the 26 dBm, 2.55 GHz CW input signal. For a 20 MHz four-carrier orthogonal frequency division multiplexing (OFDM) signal with 10.39 dB peak-to-average power ratio (PAPR), the adjacent channel leakage ratio (ACLR) of the PA is suppressed to below -45 dBc after employing signal crest factor reduction (CFR) and digital predistortion (DPD).

Recently, in order to achieve highly efficient amplification, switch mode power amplifiers (SMPA) with theoretical 100 percent efficiency have been introduced. However, in practice, the efficiency of SMPA cannot achieve as high as 100 percent because of the parasitic parameters of the transistor, the losses of matching networks, etc. Among the subclasses of SMPA, inverse Class F has the highest drain efficiency, due to shaping the drain voltage waveform as half-sinusoidal and the drain current waveform as a square-wave.¹⁻² Many successful design instances of inverse Class F PA have been reported.³⁻⁶

Modern and next generation wireless communication systems require high data rate and high spectrum utilization. In this case, the orthogonal frequency division multiplexing (OFDM) signal with high peak-to-average power ratio (PAPR) are being used. Although the inverse Class F PA obtains high efficiency at peak power level, the high PAPR causes low

efficiency at the average output power. And the higher the PAPR is, the lower the efficiency will be. Therefore, a crest factor reduction (CFR) technique⁷⁻⁸ is employed to reduce the PAPR so as to enhance the efficiency of the PA.

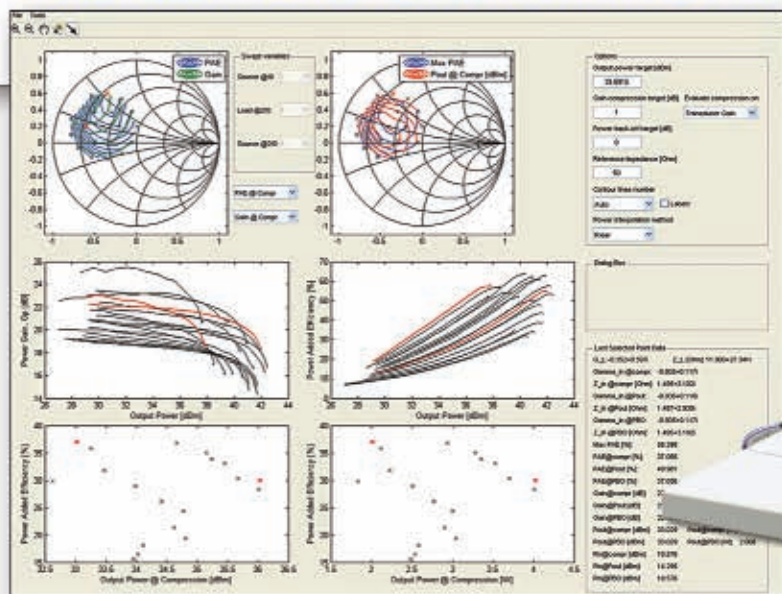
In this article, a 2.5 to 2.6 GHz inverse Class F PA is implemented using Cree's CGH40010 GaN HEMT for linear amplification in OFDM systems. The input and output harmonic matching networks (HMN) are analytically designed to make the harmonic impedances approximate the values obtained by harmonic source/load pull simulations. CW measurement shows a greater than 75 percent drain efficiency at 2.55 GHz. For a 20 MHz four-carrier OFDM signal with PAPR of 10.39 dB, after employing CFR and digital predistortion (DPD) techniques, the inverse Class F PA achieves good

YINGJIE XU, JINGQI WANG AND
XIAOWEI ZHU
Southeast University, Nanjing, China

Active Load Pull For The 21st Century — We Have You Covered!

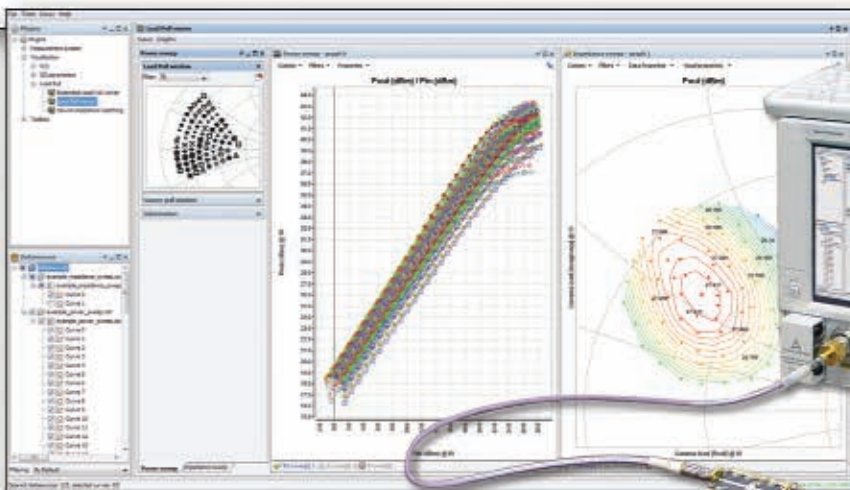
Maury Microwave Has the Most Complete Selection of Load Pull Solutions

See Maury's
Full Product Line at
IMS2011 (Booth #1016)



**MAURY's Mixed-Signal Active Load Pull Allows Wideband
Modulated Impedance Control for Base Station PAs**
(Learn more at maurymw.com/mt2000.htm)

Powered by **ANTEVERTA**



**Upgrade Your PNA-X with Maury IVCAD Software
and Start Load Pull-ing Today**
(Learn more at maurymw.com/actvp.htm)

Powered by
AMCAD Engineering
Advanced Modeling for Computer-Aided Design



**Maury Microwave – Your Complete Measurement & Modeling Solutions Partner
On the Web at MAURYMW.COM**



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

Agilent Technologies
Global Solutions Partner

linearity and 31.9 percent efficiency at an average output power of 34.3 dBm.

INVERSE CLASS F DESIGN PROCEDURE

Inverse Class F Operation and GaN HEMT

Ideally, an infinite number of even-harmonic resonators results in an inverse Class F mode with a half-sinusoidal voltage waveform and a square current waveform at the device output terminal.⁹ However, it is impractical to control an infinite number of harmonics using microstrip transmission lines. In this design, only the second and third harmonics are considered. The maximally flat drain voltage and current expressions of inverse Class F PA with the second harmonic open loaded and the third harmonic short loaded are shown below:¹⁰

$$v_d(\theta) = V_{dd} + (4/3)(V_{dd} - 2R_{on}I_{dc}) \cdot \sin \theta - (1/3)(V_{dd} - 2R_{on}I_{dc}) \cos 2\theta$$

$$i_d(\theta) = I_{dc} - (9/8)I_{dc} \sin \theta - (1/8)I_{dc} \sin 3\theta \quad (2)$$

where V_{dd} and I_{dc} are the drain DC supply voltage and current, R_{on} is the switching on-resistance of the transistor.

According to Equations 1 and 2, setting $V_{dd} = 28$ V, $I_{dc} = 0.6$ A and $R_{on} = 0.5$ Ω , the peak drain voltage value for inverse Class F equals to 73.7 V, which is much greater than the peak drain voltage value 55.2 V for Class F operation under the same condition. This results in a higher efficiency of inverse Class F than its Class F counterpart.

GaN HEMT's large material band gap permits it to operate at high drain voltage and high power density.¹¹ For Cree's CGH40010, the maximum drain to source voltage is 84 V,¹² which is large enough for inverse Class F operation with a peak drain voltage of 73.7 V. While for Freescale's LDMOS FET (such as MRF7S35015), the maximum drain to source voltage is 65 V,¹³ which could not meet the requirement of inverse Class F operation. In this case, a GaN HEMT becomes a promising candidate for inverse Class F PA design.

Load Pull/Source Pull Simulation Steps

1. With the large signal transistor

model of CGH40010 provided by Cree, load pull and source pull simulations are carried out in Agilent's Advanced Design System (ADS). The center frequency is set at 2.55 GHz, and the transistor is biased at $V_{gs} = -3.6$ V and $V_{ds} = 28$ V with an input power level of 26 dBm. The objective of the simulation is to find out the optimum load and source impedances at both the fundamental frequency and harmonics, when the power-added efficiency (PAE) is maximum, with a high output power. The simulation is performed through the following steps: Set the fundamental source impedance at a default value to perform fundamental load pull simulation, the optimum fundamental load impedance Z_{L_fund} is obtained. Perform fundamental source pull simulation with Z_{L_fund} to get the optimum fundamental source impedance Z_{S_fund} . Several iterations are needed before the optimum fundamental impedances converge. After convergence, $Z_{S_fund} = (6.4-j4) \Omega$ and $Z_{L_fund} = (13.21+j16.906) \Omega$ are obtained.

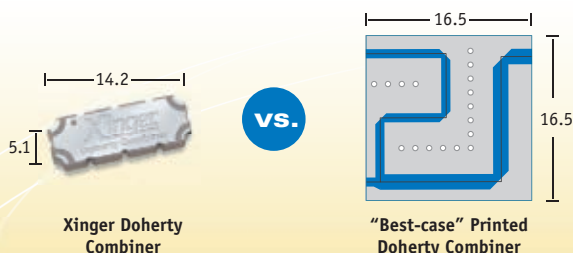
2. Perform inverse Class F harmonic load pull simulation with Z_{S_fund} and Z_{L_fund} . In this simulation, only the second and third harmonics are considered and the values of the harmonic impedances are restricted to be purely reactive for the successive design. After simulation, the optimum second harmonic load impedance $Z_{L_2nd} = j844.097 \Omega$ and the optimum third harmonic load impedance $Z_{L_3rd} = -j5.987 \Omega$ are obtained.
3. Perform harmonic source pull simulation. From simulation results, the third harmonic source impedance has little effect on the PAE, while the second harmonic source impedance affects it a lot. The optimum second harmonic source impedance is obtained as $Z_{S_2nd} = -j27.968 \Omega$. The PAE simulation results obtained by varying the second harmonic source impedance are shown in **Figure 1**. Without any losses, the maximum possible PAE could be 83 percent, when $Z_{S_2nd} = -j27.968 \Omega$. If the second harmonic source impedance is not well controlled in the design, the PAE would drop to 67 percent, a considerable decrease

Try our new, Xinger®-brand Doherty combiner on for size!



Measuring only **6.35 x 5.08mm (P-size)** or 14.2 x 5.1mm (E-size), Anaren's revolutionary new SMT Doherty combiners are up to 1/10th the size of printed Doherty implementations. That's valuable space you can use for other functionality or a smaller overall amp design.

BELOW: Our 1960MHz Xinger-brand Doherty combiner is approx 1/4 the size of a PCB Doherty (expressed in mm)



Beyond a smaller footprint, these new parts also offer you:

- > **Low insertion loss** – in a fraction of the space, achieve the same loss you'd get with thick, expensive, high-performance PCB
- > **Superior unit-to-unit consistency** – Xinger parts are pre-tested and offer highly repeatable performance compared to the variability seen with low-cost PCB manufacturing
- > **The option to choose less costly PCB** – switching to an SMT solution lets you use a standard FR4-type

board material (no more of overcompensating for poor insertion loss of printed combiners by using top-of-the-line board)

- > **High reliability** – our softboard SMT solution matches the CTE characteristics of PCB
- > **Xinger-brand Doherty splitters available, too** – save time and trouble, with our 5dB P-size couplers for asymmetrical Doherty implementations!

To learn more, receive complete specs, obtain a quote, or get a free test board (qualified prototypes only), email sales@anaren.com today or visit www.anaren.com

See us at MTT-S Booth 928



Anaren®

What'll we think of next?

800-411-6596 > www.anaren.com

In Europe, call 44-2392-232392

ISO 9001 certified

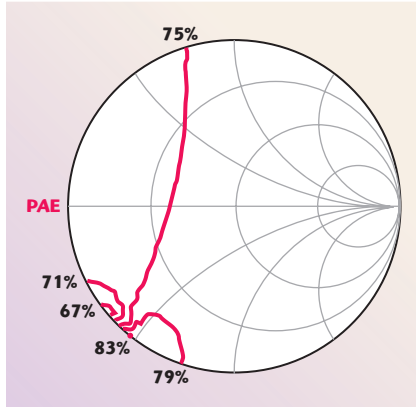
Visa/MasterCard accepted (except in Europe)

of 16 percent. The input HMN helps to provide a second harmonic source impedance as close as possible to Z_{S_2nd} .

HMN Analytical Design and Schematic Simulation

Figure 2 shows the circuit schematic of the proposed inverse Class F PA. The input/output HMN controls the harmonic source/load impedances for the values obtained by harmonic source/load pull simulation. The input/output fundamental matching network (FMN) then transforms the fundamental impedances $Z_{S_0}^*/Z_{L_0}^*$ to 50Ω . The analytical design procedure for both HMNs is described as follows.

In the output HMN, the electrical length θ_4 and θ_6 of the two open stubs are set at $\pi/4$ and $\pi/6$, which provide a short-circuit at the two junctions for the second and third harmonics, respectively. For the second harmonic load impedance, Equations 3 and 4 can be obtained:



▲ Fig. 1 Harmonic source pull simulation.

$$Z_c(2f_0) = Z_B(2f_0) \parallel (-jZ_4 \cot 90^\circ) = 0 \quad (3)$$

$$Z_L(2f_0) = Z_3 \frac{Z_c(2f_0) + jZ_3 \tan(2\theta_3)}{Z_3 + jZ_c(2f_0) \tan(2\theta_3)} = jZ_3 \tan(2\theta_3) \quad (4)$$

By solving the equation $Z_L(2f_0) = Z_{L_2nd} = j844.097 \Omega$, when $Z_3 = 50 \Omega$, one gets $\theta_3 = 43.3^\circ$. The value of Z_3 can be altered according to the width of the transistor's drain pad.

For the third harmonic load impedance, one gets:

$$Z_A(3f_0) = 0 \quad (5)$$

$$Z_B(3f_0) = Z_5 \frac{Z_A(3f_0) + jZ_5 \tan(3\theta_5)}{Z_5 + jZ_A(3f_0) \tan(3\theta_5)} = jZ_5 \tan(3\theta_5) \quad (6)$$

$$Z_C(3f_0) = Z_B(3f_0) \parallel (-jZ_4 \cot 135^\circ) = Z_B(3f_0) \parallel jZ_4 \quad (7)$$

$$Z_L(3f_0) = Z_3 \frac{Z_C(3f_0) + jZ_3 \tan(3\theta_3)}{Z_3 + jZ_C(3f_0) \tan(3\theta_3)} = \frac{jZ_3 \frac{Z_3 Z_4 \tan(3\theta_3) + (Z_4 + Z_3 \tan(3\theta_3)) Z_5 \tan(3\theta_5)}{Z_3 Z_4 + (Z_3 - Z_4 \tan(3\theta_3)) Z_5 \tan(3\theta_5)}}{Z_3 Z_4 + (Z_3 - Z_4 \tan(3\theta_3)) Z_5 \tan(3\theta_5)} \quad (8)$$

By solving the equation $Z_L(3f_0) = Z_{L_3rd} = -j5.987 \Omega$, when $Z_4 = 50 \Omega$ and $Z_5 = 50 \Omega$, one gets $\theta_5 = 28.9^\circ$. The parameters

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



2 Emery Avenue
Randolph, NJ 07869 USA
973-361-5700 Fax: 973-361-5722

www.gtmicrowave.com
e-mail: sales@gtmicrowave.com

UP TO 100 Watt AMPLIFIERS

NOW! 5 MHz to 18 GHz



\$945
from ea. qty. (1-9)

Heavy duty, ruggedness and reliable operation to meet your demanding communication applications describe **Mini-Circuits collection of 3, 5, 10, 16, 20, 30, 32, 50 and 100 Watt high power amplifiers!** Covering 5 MHz up to 18.0 GHz, these broadband solutions are available with or without integrated heat sink/fan to fit your system requirements. Each amplifier operates with low current consumption and is designed to work off a single DC supply, including the fan! Plus, each model can withstand open or short output load without damage under full CW output power. They also offer built-in protection against over-voltage, thermal overloads, and an internal regulated power supply to handle fluctuations from the supply source and *still* deliver high performance. Need a **robust** power amplifier solution? Then come to Mini-Circuits where quality & reliability is built into every unit.

IN STOCK! FAST DELIVERY!

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

Model	Freq. (MHz)	Gain (dB)	P _{out} (dBm) @Comp	Dynamic Range NF	IP3	DC Pwr. Volt	Current (A)	Price \$ ea.	Price X suffix
	f _L -f _H	Typ.	1dB Typ.	3dB Typ.	Typ.	Nom.	Max	Qty. 1-9	
With Heat Sink/Fan									
LZY-1+	20-512	43	+45.7	+47.0	8.6	+54	26	7.3	1995 1895
LZY-2+	500-1000	46	+45.0	+45.8	8.0	+54	28	8.0	1995 1895
ZHL-5W-1	5-500	44	+39.5	+40.5	4.0	+49	25	3.3	995 970
ZHL-5W-2G+	800-2000	45	+37.0	+38.0	8.0	+44	24	2.0	995 945
ZHL-10W-2G+	800-2000	43	+40.0	+41.0	7.0	+50	24	5.0	1295 1220
ZHL-16W-43+	1800-4000	45	+41.0	+42.0	6.0	+47	28	4.3	1595 1545
• ZHL-20W-13	20-1000	50	+41.0	+43.0	3.5	+50	24	2.8	1395 1320
ZHL-30W-252+	700-2500	50	+44.0	+46.0	5.5	+52	28	6.3	2995 2920
• ZHL-50W-52	50-500	50	+46.0	+48.0	6.0	+55	24	9.3	1395 1320
• ZHL-100W-52	50-500	50	+47.0	+48.5	6.5	+57	24	10.5	1995 1920
NEW									
ZVE-3W-183+	5900-18000	35	+34.0	+35.0	5.5	+44	15	2.2	1295 1220
ZVE-3W-83+	2000-8000	36	+33.0	+35.0	5.8	+42	15	1.5	1295 1220
• ZHL-100W-GAN+	20-500	42	+49.0	+50.0	7.0	+60	30	9.5	2395 2320
ZHL-30W-262+	2300-2550	50	+43.0	+45.0	7.0	+50	28	4.3	1995 1920

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

For models without heat sink, add **X** suffix to model No.
Example: (LZY-1+ LZY-1X+)



Mini-Circuits®
ISO 9001 ISO 14001 AS9100 CERTIFIED

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



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

IF/RF MICROWAVE COMPONENTS

See us at MTT-S Booth 1031

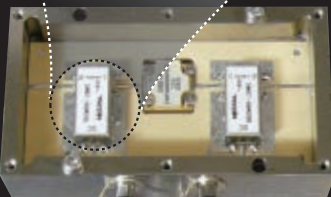
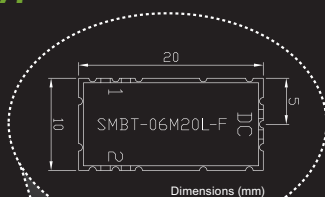
Ready-made Bias Network for GaN FET



* Left/Right Connection Available

Surface Mount Design

20MHz~6GHz
Typical Installation

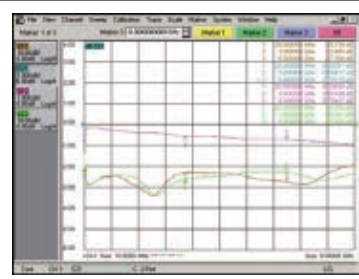


SPECIFICATION

Series	SMBT			
Model	SMBT-06M20□*F			
Impedance	50Ω			
Frequency Range	20MHz~6GHz			
	20~50MHz	50MHz~2GHz	2~3GHz	3~6GHz
VSWR (Return loss)	1.5 max.	1.22 max.	1.28 max.	1.4 max.
Insertion Loss	0.8dB max.		1.0dB max.	
RF Power	5W max.			
Bias Current	2A max.			
Bias Voltage	50V max.			
Dimensions	20 x 10 x 5 mm			
Weight	2g			
Temperature	-40℃ ~ +90℃			

*□=L or R for connection orientation

Typical VSWR & Insertion Loss



www.tecdia.com

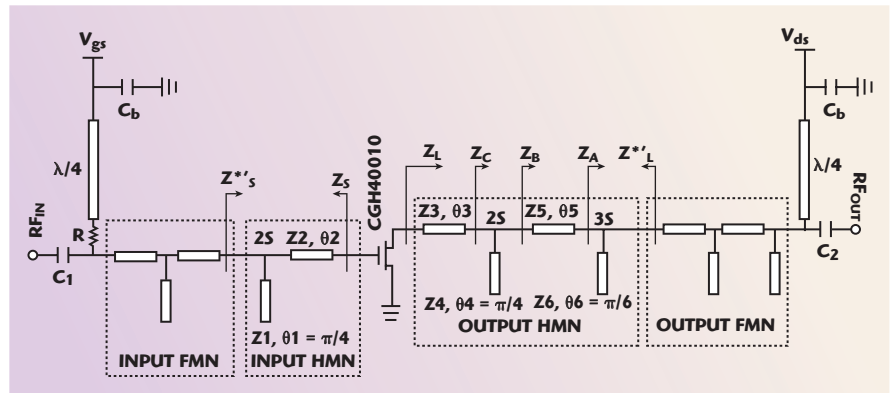


Fig. 2 Schematic of the designed inverse Class F PA.

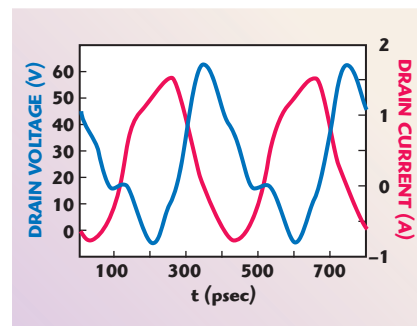


Fig. 3 Simulated drain voltage and current waveforms.

of the output HMN are now determined. According to the same principle, the parameters of the input HMN can be determined.

Figure 3 shows the simulated drain voltage and current waveforms of the proposed inverse Class F PA. It can be observed that the two waveforms are distorted, when compared with the ideal waveforms of inverse Class F operation. This is because the effects of the nonlinear parasitic parameters that exist in the transistor package. If the package is de-embedded and the waveforms are simulated at the intrinsic drain, the results would be closer to the ideal condition.

From the schematic harmonic balance (HB) simulation in ADS, the maximum in-band PAE of 84.2 percent is obtained at 2.55 GHz, with an output power of 39.54 dBm and a transducer power gain of 13.54 dB.

MEASUREMENT AND LINEARIZATION

A 2.5 to 2.6 GHz inverse Class F PA has been fabricated to validate the design approach. The selected substrate is RF-35 from Taconic Co. with a dielectric constant of 3.5 and a thickness of 30 mil.

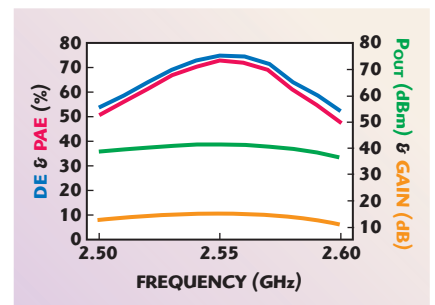


Fig. 4 Measured amplifier performance.

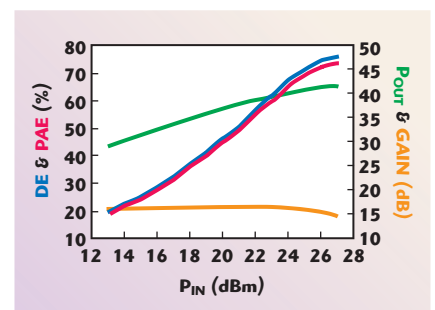


Fig. 5 Measured results vs. input power.

CW Signal Measurement

By setting $V_{gs} = -3.6$ V and $V_{ds} = 28$ V with a 26 dBm input power, the measured PAE, drain efficiency (DE), output power and power gain are plotted in Figure 4 within the frequency band from 2.5 to 2.6 GHz. DE is greater than 52 percent, PAE is greater than 47.7 percent and the output power is greater than 36.9 dBm within the 100 MHz bandwidth. The peak DE of 75.2 percent and peak PAE of 73 percent are observed at 2.55 GHz with a maximum output power and power gain of 41.43 and 15.43 dB, respectively.

Driven by a 2.55 GHz CW input signal with the power swept from 13 to 27 dBm, the measurement results of the inverse Class F PA are plotted

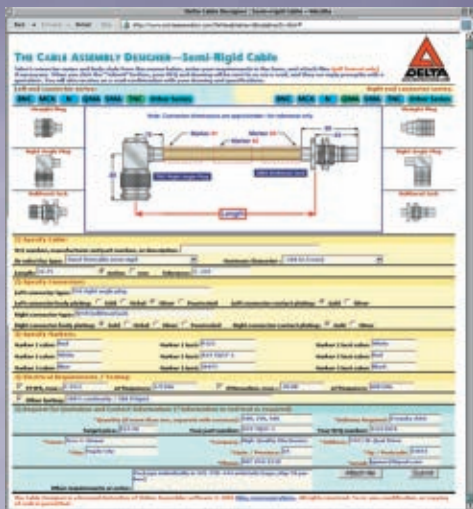
Value Added and Cable Assemblies

Now you can rely on Delta, a source of high-quality RF connectors for over fifty years, for all of your cable assembly needs, as well as other connector-related value-added products:

- Flexible and semi-rigid cable assemblies from high-volume, low-cost to sophisticated high-frequency types, using our fully automated cutting and stripping equipment for consistent and repetitive quality results. Short order quantities as well as volume production globally, from our manufacturing sites in the USA, Taiwan and China.
- One-piece body designs to support attenuator housing needs.
- Transmission line and antenna assemblies; other RF related subassemblies.
- Our new state-of-the-art, fully automated electroplating facility (NADCAP certification in process) is designed to serve **all** your plating requirements for RF components—**not just connectors**. Advanced plating software and in-house X-ray capabilities assures your plating specifications are consistently achieved. (Complementary processes such as vapor degreasing and contact crimping / pretinning are also available.) More information, including plating types and specifications, at www.deltaelectroplating.com

Let us be your "one-stop-shop" for adding value to your supply chain.

www.DeltaRF.com



Our website offers the unique **Cable Assembly Designer** tool to assist with all your cable assembly needs. Simply select the cable type, connectors, testing and marker requirements and click to send the RFQ to us.



→ **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



→ **Connect Here.**

Delta Microwave Electronics (Nanjing) Co., Ltd.
Tel: +86 25 84195408 • Fax: +86 25 84195407
No. 9 Tianquan Road, Qilin Industrial Park (South Zone),
Tangshan Street, Jiangning District, Nanjing 211135, China



ISO 9001:2008
CERTIFIED



See us at MTT-S Booth 3814

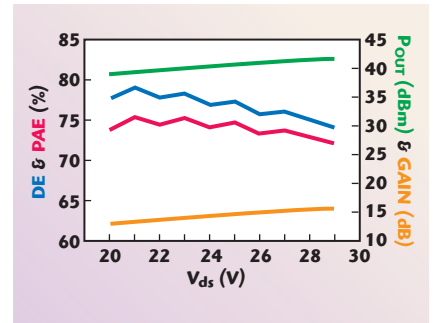
in **Figure 5** with $V_{gs} = -3.6$ V, $V_{ds} = 28$ V. When the input power reaches 27 dBm, the DE and PAE are 76 and 73.5 percent, respectively. However, the power gain has been compressed to 14.6 dB, a 2.2 dB compression, compared with the maximum power gain observed at a 20 dBm input power.

In **Figure 6**, the drain to source voltage is varied from 20 to 29 V, with the input power fixed at 26 dBm and $V_{gs} = -3.6$ V. DE and PAE achieve a

maximum of 79 and 75.4 percent, respectively, at $V_{ds} = 21$ V.

Linearization with Digital Predistortion

The PA DPD linearization system consists of a vector signal generator (Rohde & Schwarz SMBV100A), a vector signal analyzer (Agilent VSA-E4445A), a PC with Matlab and Agilent's 89600 and the proposed inverse Class F GaN PA. The SMBV100A, E4445A and PC are connected via a



▲ **Fig. 6** Measured results vs. drain to source voltage.

local area network (LAN). The configuration of the system is shown in **Figure 7**.

The baseband I/Q signals are modulated and up-converted to an RF signal in SMBV100A, the RF signal is then amplified and distorted by the PA. After attenuation, the RF output signal of the PA is down-converted and demodulated by E4445A. Finally, the output I/Q samples are collected in VSA 89600 for modeling. Using the Hammerstein architecture,¹⁴ the inverse PA model (digital predistorter) can be established with the input and output I/Q samples of the PA. With the digital predistorter, the distortion of the PA can be compensated.

The input signal of the PA is chosen as a four-carrier OFDM QPSK signal with a 20 MHz bandwidth and 10.39 dB PAPR at the 0.01 percent level of the complementary cumulative distribution function (CCDF). After CFR with a soft clipping technique,⁸ the PAPR is decreased to 8.05 dB.

Figure 8 shows the measured four-carrier OFDM PSD of the PA before and after linearization. The black trace indicates the original output of the PA. The adjacent channel leakage ratio (ACLR) is -37.48 dBc (lower) and -36.94 dBc (upper) at an average output power of 34.3 dBm. After DPD with Hammerstein, the output PSD of the PA is shown by the red trace, the ACLR of which is suppressed to -41 dBc (lower) and -39.38 dBc (upper). A slight improvement is achieved at this power level of the inverse Class F PA. When the baseband I/Q signal is processed by CFR, distorted by the digital predistorter, and then downloaded to SMBV100A as the input signal of the PA, the output PSD of the PA is shown by the blue trace, the ACLR of which is equal to -48.22 dBc (lower) and -45.8 dBc (upper). The efficien-

SATCOM Test Equipment

Payload communications testing

V-SAT earth station development

Mobile terminal testing

Solutions provided for...

WIN-T	- warfare information networks, tactical
MUOS	- mobile user objective system
IRIS	- Internet routing in space
Terrestar	- mobile communications

Satellite RF Link emulation and link budget testing for payload and terminal development. System allows phase continuous Doppler, delay, path loss, phase shift and flat fading to be independently programmed for each channel. Multiple channels permits satellite or earthstation handoff emulation for full constellation testing.



dBm, LLC

32A Spruce Street ♦ Oakland, NJ 07436
Tel (201) 677-0008 ♦ Fax (201) 677-9444

www.dbmcorp.com



RF Test Equipment for Wireless Communications

SURFACE-MOUNT FREQUENCY SYNTHESIZERS

MINIATURE, HIGH PERFORMANCE DESIGNS UP TO 10 GHz



Features:

- Fixed to > octave bandwidths
- Optional internal references
- Exceptionally low phase noise
- 3.3V to 12V operation, low power consumption
- High vibration tolerance
- Miniature packages (0.5" square)
- Easy programming interface



Custom Designs Available

EM Research™
The Ultimate Source for Miniature Frequency Synthesizers

Quality • Consistency • Performance

See us at MTT-S Booth 1149

(775) 345-2411 • sales@emresearch.com
www.emresearch.com



Designed &
Manufactured
in the U.S.A.



Solid State Switches



Detector Log Video Amplifiers



Solid State Variable Attenuators



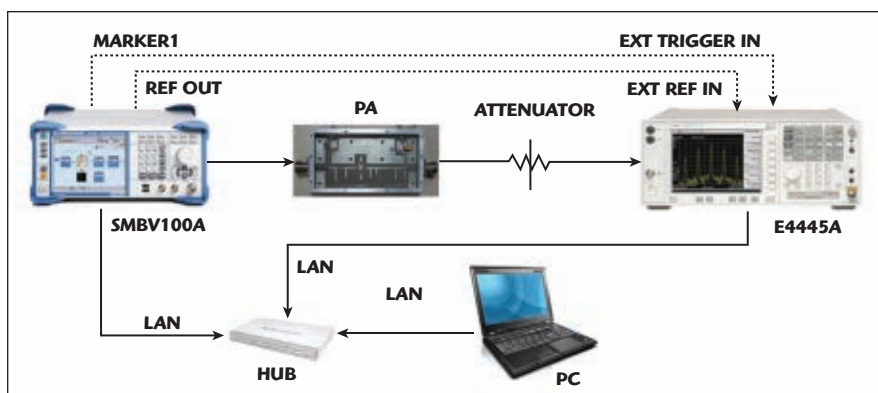
Switch Assemblies



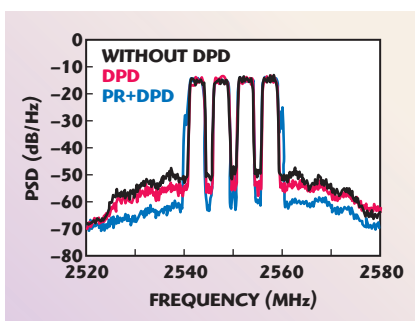
American Microwave Corporation

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

WWW.AMERICANMIC.COM



▲ Fig. 7 The PA DPD linearization system configuration.



▲ Fig. 8 Measured PSD before and after linearization.

cy of the PA is 31.9 percent at a 34.3 dBm average output power.

CONCLUSION

This article presented an analytical design approach of inverse Class F PA. The input and output HMNs controlled the source and load harmonic impedances appropriately. The fabricated 2.5 to 2.6 GHz GaN inverse Class F PA achieved a maximum in band drain efficiency greater than 75 percent, with an output power of 41.4 dBm at 2.55 GHz. For linearization, the PAPR of the 20 MHz four-carrier OFDM signal was reduced from 10.39 dB to 8.05 dB through a CFR technique. Then, by using DPD, based on Hammerstein, the ACLR was improved to less than -45 dBc at an average output power of 34.3 dBm with 31.9 percent efficiency. According to the experimental results, the proposed inverse Class F PA is suitable for linear amplification with high efficiency. ■

ACKNOWLEDGMENT

This work was supported by the National Key Technologies R&D Program of China under Grant 2010ZX03007-003-02 and in part by the National High-Tech Project under Grant 2009AA011801.

References

1. C.J. Wei, P. DiCarlo, Y.A. Tkachenko, R. McMorow and D. Bartle, "Analysis and Experimental Waveform Study on Inverse Class F Mode of Microwave Power FETs," 2000 IEEE MTT-S International Microwave Symposium Digest, pp. 525-528.
2. Y.Y. Woo, Y. Yang and B. Kim, "Analysis and Experiments for High-efficiency Class F and Inverse Class F Power Amplifiers," IEEE Transactions on Microwave Theory and Techniques, Vol. 54, No. 5, May 2006, pp. 1969-1974.
3. D.Y.T. Wu and S. Boumaiza, "10 W GaN Inverse Class F PA with Input/Output Harmonic Termination for High Efficiency WiMAX Transmitter," IEEE 10th Annual Wireless and Microwave Technology Conference Digest, April 2009, pp. 1-4.
4. A. Al Tanany, A. Sayed and G. Boeck, "Design of Class F-1 Power Amplifier Using GaN pHEMT for Industrial Applications," German Microwave Conference Digest, March 2009, pp. 1-4.
5. A. Grebennikov, "High-efficiency Transmission-line GaN HEMT Inverse Class F Power Amplifier for Active Antenna Arrays," 2009 Asia Pacific Microwave Conference Digest, pp. 317-320.
6. P. Saad, H.M. Nemati, M. Thorsell, K. Andersson and C. Fager, "An Inverse Class F GaN HEMT Power Amplifier with 78 Percent PAE at 3.5 GHz," 2009 European Microwave Conference Digest, pp. 496-499.
7. S.H. Han and J.H. Lee, "An Overview of Peak-to-average Power Ratio Reduction Techniques for Multicarrier Transmission," IEEE Wireless Communications, Vol. 12, No. 2, April 2005, pp. 56-65.
8. O. Väänänen, J. Vankka and K. Halonen, "Simple Algorithm for Peak Windowing and Its Application in GSM, EDGE and W-CDMA Systems," IEEE Proceedings, Communications, Vol. 152, No. 3, 2005, pp. 357-362.
9. A. Grebennikov and N.O. Sokal, Switch-mode RF Power Amplifiers, Elsevier, Burlington, MA, 2007.
10. Y. Xu, J. Wang and X. Zhu, "Analysis and Implementation of Inverse Class F Power Amplifier for 3.5 GHz Transmitters," 2010 Asia-Pacific Microwave Conference Proceedings.
11. Aethercomm, "Gallium Nitride Microwave Transistor Technology for Radar Applications," Microwave Journal, Vol. 51, No. 1, January 2008, pp. 106-114.
12. Technical Data, CGH40010, Cree, available: www.cree.com/products/pdf/CGH40010.pdf.
13. Technical Data, Document Number: MRF7S35015HS, Freescale Semiconductor, available: http://cache.freescale.com/files/rf_if/doc/data_sheet/MRF7S35015HS.pdf.
14. J. Zhai, J. Zhou, L. Zhang, J. Zhao and W. Hong, "Dynamic Behavioral Modeling of Power Amplifiers Using ANFIS-based Hammerstein," IEEE Microwave and Wireless Components Letters, Vol. 18, No. 10, October 2008, pp. 704-706.

Performance vs. price? At last, resistive parts that make a priority of both.

Anaren®

- ✓ Designed for commercial bands (GSM, 3G, 4G, LTE, etc...)
- ✓ High power handling
- ✓ Small footprint
- ✓ Low cost
- ✓ Range of packages (SMD, chip, flange, flangeless)
- ✓ RoHS compliant

Got a resistive component priority checklist of your own? Include Anaren on your RFQ list, and we'll show you how we measure up!



Our new resistive components are suitable for today's wireless and broadcast applications requiring excellent power-handling in small, cost-competitive packages.

Designed specifically for commercial wireless bands – and priced more competitively than ever before – Anaren's new wireless resistive components are the answer when performance and

price must share the top slot on your priority list:

- > DC to 6GHz. GSM, 3G, 4G, LTE, and many more
- > Higher power-handling in smaller packages
- > Choose from a range of packages including SMD, chip, flanged, and flangeless
- > Environmentally friendly, thanks to BeO-free AlN and Alumina designs – and RoHS compliant, lead-free finish

- > Accurate characterization of performance so you can spec these parts with confidence
- > Extremely cost-competitive – Anaren's unique designs and manufacturing help you hit your aggressive cost targets, while ensuring a quality product. (Every single component is tested before it leaves our plant!)
- > 40+ years of RF and microwave engineering experience, as well as decades of experience in manufacturing ceramic resistive products

Want resistive components – and a resistive technology supplier – that strike the optimal balance between performance and price? Email us at sales@anaren.com or visit www.anaren.com for samples, a quote, or application assistance.

See us at MTT-S Booth 928

Anaren®

What'll we think of next?®

www.anaren.com > 800-411-6596

Ask Anaren about:

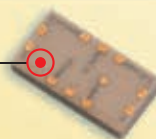
Tiny, high-performance Xinger®-III brand couplers



Need high-performance in a small package? Insist on Xinger®-III brand hybrid and directional couplers from Anaren. Compared to our still-available, still-exemplary Xinger-II parts, Xinger-III hybrids offer 5.35 times the power handling, 52-66% lower insertion loss, and 25-28% higher isolation. While Xinger-III directionals offer 37-65% lower insertion loss and 50% higher power handling (at 1/4 the size!) compared to their Xinger-II equivalents. Email sales@anaren.com to learn more or obtain samples.

Anaren®
What'll we think of next?®

Balun for analog-to-digital conversion



Designing an A-to-D converter? Our low-profile, sub-miniature transformer (part no. BD0205F5050A00) is ideal for the job! Offering an easy-to-use 4.1 x 2.1mm SMT package. Covering 200MHz to 500MHz. And with CMRR performances over 2x that of traditional wire wound components. Email cgg@anaren.com or visit www.anaren.com to download our latest app notes.

Anaren®
What'll we think of next?®

All-new Anaren Integrated Radio (AIR) modules



Say hello to the industry's easiest and most cost-effective RF implementation! AIR modules are developed using Texas Instruments' chip technology. Choose from 433MHz, 800MHz, 900MHz, and 2.4GHz models. There's virtually no RF engineering experience required. A tiny footprint saves precious board space. And much more! To learn more and acquire an eval kit, email AIR@anaren.com



Anaren®
What'll we think of next?®

DESIGN OF A METAMATERIAL BANDPASS FILTER USING THE ZOR OF A MODIFIED CIRCULAR MUSHROOM STRUCTURE

In this article, the design of a new bandpass filter, based on a modified circular mushroom metamaterial structure, is proposed. Half circular mushroom cells are used as the zero-order resonators (ZOR), and an intermediate gap is used to capacitively couple neighboring ZOR resonators to make a bandpass filter. The proposed bandpass filter design is validated by circuit 3D EM simulations and measurements, with reference to the target specifications, and the metamaterial properties are proven by showing the ZOR field distributions and dispersion diagram. A size reduction is also achieved.

Wireless communication gadget users nowadays tend to pursue more convenience, such as multi-functions and higher mobility. The former results in a multi-band service oriented device; the latter drives the development of reduced size equipment. Thus, the roles and expectations of RF components are becoming more challenging. In particular, quality filters and couplers are required to be designed by cutting-edge technology. With regard to overcoming the limitations in the current design capabilities and going beyond the boundary, a number of techniques have been exploited. New alternative approaches have been sought, and the concept of metamaterial structures has started to draw a lot of attention.

A composite right-/left-handed (RH/LH) transmission line (CRLH) has been studied for microwave component design. Among these metamaterial applications, the zero-order resonance (ZOR) concept is a valuable key of size reduction methods. The ZOR of no

phase variation between two ports is presented based on a one unit cell;¹⁻³ a CRLH transmission line with 24 cells shows an infinite wavelength.⁴ The ZOR and the negative resonance have been realized in the form of multi-cells of a rectangular patch with a shorting pin or a metal strip next to split ring resonators (SRR) under the name of the CRLH-TL structure. Since the multiple cells have one size and are repeated over a lengthened area, they have periodic stop- and pass-bands at integer multiples of the fundamental frequency, which possibly lowers the freedom of design.⁴⁻⁵ In this article, a new design methodology using a modified circular mushroom structure is suggested for ZORs, and a gap between the ZORs is used as a capacitive coupling element for implementing the target bandpass filtering.

GEONHO JANG
AND SUNGTEK KAHNG
University of Incheon, Incheon, Korea

Ultra Low Phase Noise

1 MHz to 18 GHz



Synthesizers & Systems

- Multiple Frequency Sources
- Configurable Frequency Standards
- Custom Synthesizers
- Fiber Optic Distribution
- Phase Noise Test Set
- Sub-Assembly Plates
- Outputs to 18 GHz



Military & Space

- Low Phase Noise OCXO's
- Integrated Designs to 12 GHz
- Vibration Isolated Sources
- Hi-Rel Screening
- MIL-PRF-55310
- COTS to S-Level



Blue Tops RF Modules

- Amplifiers
- Distribution Amplifiers
- Multipliers
- Digital Dividers
- Regenerative Dividers
- Phase Lock Loops
- Detectors



Wenzel Associates, Inc.
"Quietly the Best"



Crystal Oscillators

- Ultra Low Noise OCXO's
- Phase Locked Oscillators
- Noise Floors to <-185 dBc/Hz
- High Stability
- Low G Sensitivity
- Custom Designs



CROVEN CRYSTALS
Wenzel International, Inc.



Crystals

- AT, IT and SC-cuts
- Low Phase Noise
- Low Aging
- Low G Sensitivity to $<3E-10$
- Frequencies from 1 MHz to 360 MHz
- MIL-PRF-3098H
- S - Level Capability



Integrated Microwave Assemblies (IMAs)

- Synthesizers / Converters
- Fast Switching LO
- Multiplied Crystal Oscillators
- 200 MHz to 18 GHz
- Reference Modules
- Spaceborne Assemblies

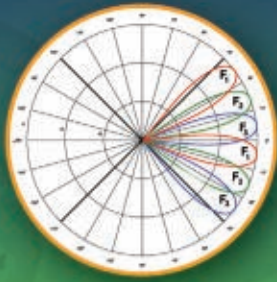
Wenzel Associates, Inc.
2215 Kramer Lane
Austin, Texas 78758
Phone: (512) 835-2038
Fax: (512) 719-4068
www.wenzel.com*

Croven Crystals
500 Beech Street
Whiteby, Ontario, Canada L1N
Phone: (905) 668-3324
Fax: (905) 668-5003
www.croven crystals.com

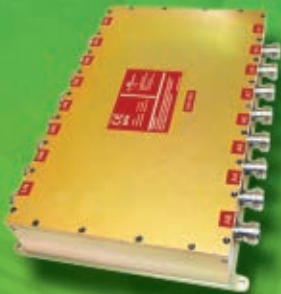
* Visit our Technical library for Time and Frequency related articles and application notes as well as Spreadsheets/Programs to calculate PLL Response, Phase Noise Under Vibration, Allan Variance from Phase Noise and more!

Visit Us at the MTT-S Show at Booth #3409

Beamforming Networks

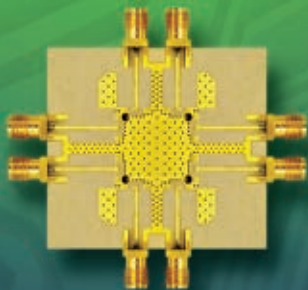


10 MHz
to
67 MHz



Monopulse Comparators

10 MHz
to
67 MHz



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 SPECIFICATIONS OF THE BANDPASS FILTER	
Parameter	Specification
Center freq.	3 GHz
Order	2
Bandwidth	200 MHz
Passband	0.5 dB

THEORY AND DESIGN

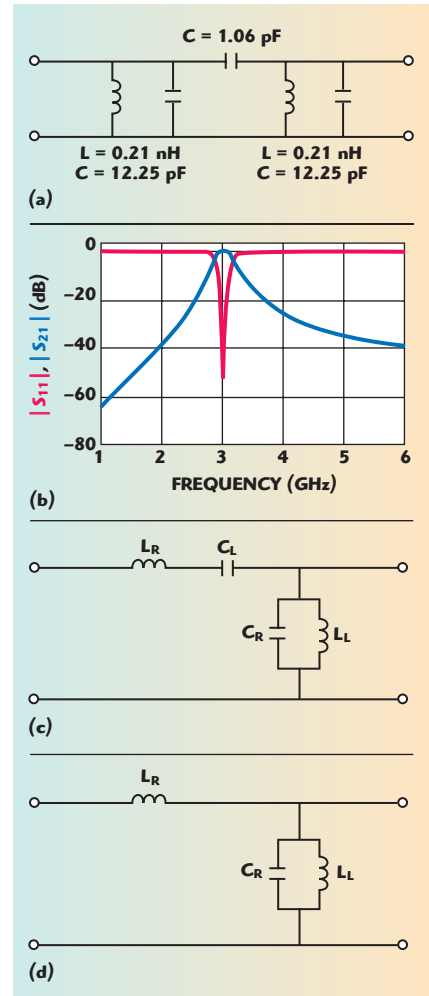
A bandpass filter is designed on the basis of the specifications shown in **Table 1**. The transfer function, a mathematical expression, which best fits the amplitude of the required frequency response, must be known, because the transfer function will be manipulated by the coupling between the resonators in the prototype circuit. The transfer function is given in Equation 1

$$S_{21}(s) = \frac{1.965}{s^2 + 1.983s + 1.965} \quad (1)$$

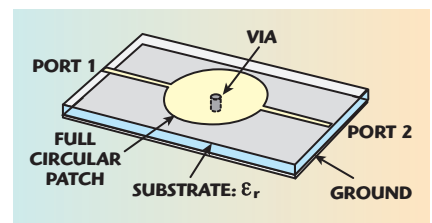
where $s = j\omega$ and $\omega = 2\pi f$ is the angular frequency.

It is then converted to a prototype, whose schematic is shown in **Figure 1**. As is typical for a classic filter, it comprises a series capacitance coupling two identical parallel resonators. After the circuit is simulated, the frequency response is obtained, where S_{21} meets the specifications from **Table 1**. For the same frequency response, this conventional filter can be changed to a metamaterial-version, like the double negative (DNG) or the epsilon negative (ENG), whose zero-order resonance renders size-minimization and performance-improvement very effectively.¹⁻⁴ In other words, if the dispersion diagram of a DNG or ENG equivalent circuit is obtained and the phenomenon at its ZOR is considered. The no-phase variation effect will set the size of the resonator free from a half-wavelength resonance condition and this possibly results in size reduction.

The DNG is found by dividing the conventional prototype circuit into the RH and LH parts and making their propagation constants of the same magnitude but out-of-phase. The ENG is obtained by making both the effective capacitance and effective inductance of the resonators become zero and positive, and making their



▲ **Fig. 1** Conventional and metamaterial prototype circuits of the bandpass filter: (a) conventional circuit, (b) frequency response, (c) DNG CRLH-TL equivalent circuit and (d) ENG-TL equivalent circuit.



▲ **Fig. 2** A full circular mushroom structure.

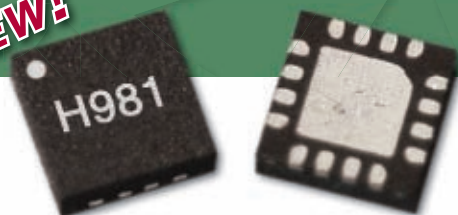
zero crossing point coincide with the aimed center frequency. As addressed earlier, this article uses a circular mushroom or its modification as the resonator and is the basis for implementing a bandpass filter. Considering a circular mushroom (see **Figure 2**), it consists of a full circular patch supported by a metal shorting pin connecting the patch and the ground. Without a gap from a feeding port, the circular mushroom itself can be-

ACTIVE BIAS CONTROLLER

New DC Power Management Product Line for Class-A Amplifiers!

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

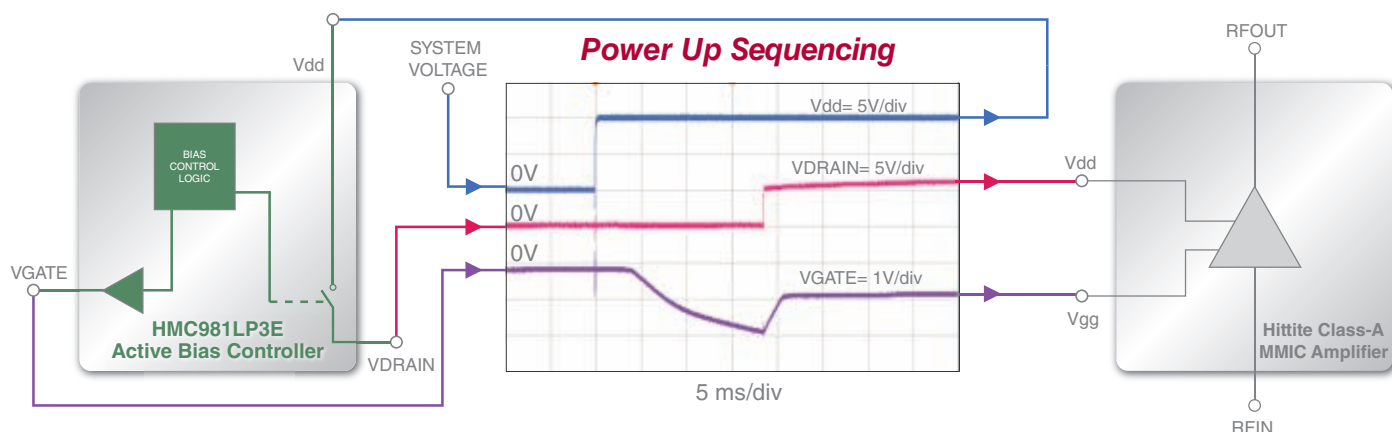
NEW!



HMC981LP3E
16 Lead 3 x 3 mm SMT Package

**Low Current, Compact Active Bias Controller
Covers +4.0 to +12V DC Supply Range!**

- ◆ **Integrated Negative Voltage Generator**
- ◆ **Automated Power-up Sequencing**
- ◆ **Active & Adjustable Output Voltages & Currents:**
Drain Voltage: +4.0 to +12 Vdc
Gate Voltage: -2.5 to +2.5 Vdc
- ◆ **Stable Bias Current Over
Temperature, Process Variation & Aging**



**Ideal for Power Management & Control in All
RF, Microwave, Millimeterwave & Fiber Optic Applications**

AMPLIFIERS THAT BENEFIT FROM HMC981LP3E ACTIVE BIAS CONTROLLER

Low Noise Amplifiers		Linear & Power Amplifiers	Wideband Power Amplifiers		Microwave & Optical Driver Amplifiers
HMC490	HMC-ALH140	HMC442	HMC460	HMC634	HMC870LC5
HMC490LP5E	HMC-ALH216	HMC442LC3B	HMC460LC5	HMC634LC4	HMC871LC5
HMC504LC4B	HMC-ALH310	HMC499	HMC463	HMC930	
HMC594	HMC-ALH311	HMC499LC4	HMC463LP5E		
HMC594LC3B	HMC-ALH313	HMC-ABH209	HMC465		
HMC609	HMC-ALH382	HMC-ABH264	HMC465LP5E		
HMC609LC4	HMC-ALH435	HMC-AUH317	HMC562		
HMC752LC4	HMC-ALH444	HMC-AUH318	HMC633		
HMC753LP4E	HMC-ALH476	HMC-AUH320	HMC633LC4		
HMC772LC4	HMC-ALH544				

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)
LL0110-1	0.01-1.0	-10	-	-11
LL0110-2		-5	-	-6
LL0110-3		0	-	-1
LL0110-4		+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:

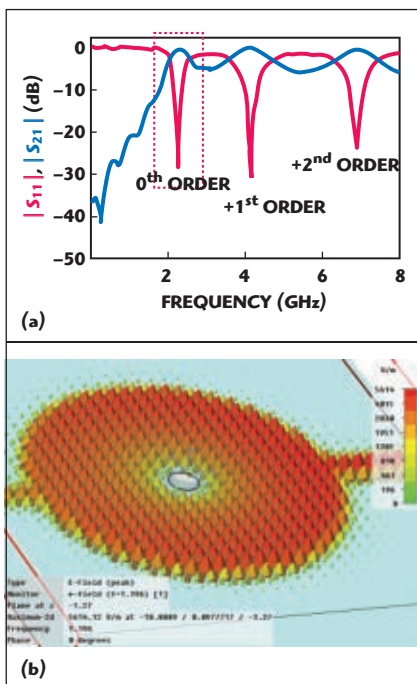
1. DC Supply required: +5V, 5mA Typ.
2. Typical and nominal leakage levels for input up to 1W CW.
3. Threshold level is the input power level when output power is 1dB compressed.

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

Please call for Detailed Brochures



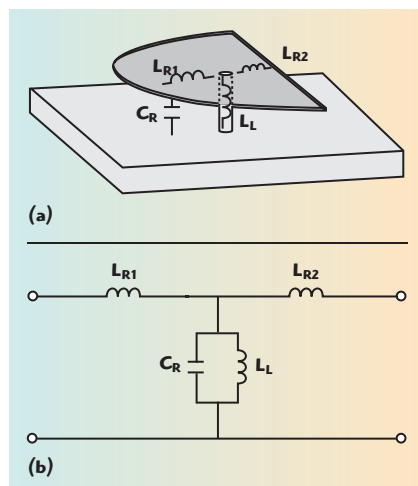
155 Baytech Drive, San Jose, CA 95134
Tel: (408) 941-8399 . Fax: (408) 941-8388
Email: Info@herotek.com
Website: www.herotek.com
Visa/Mastercard Accepted



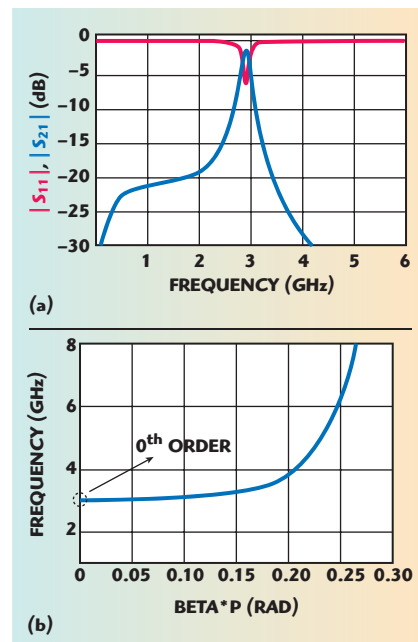
▲ Fig. 3 ZOR and its RH integer harmonics of a full circular mushroom structure: (a) ZOR around 3 GHz and (b) electric field distribution of the ZOR.

come an ENG rather than a DNG. If the full circular mushroom has gaps at the ports, it is the DNG. When a full circular mushroom is split to two half circular mushrooms by a gap, each of the two half circular mushrooms is an ENG, though the two half circular mushrooms with a gap can be interpreted as the DNG.

Again, if a full circular mushroom is connected to the input and output ports, the metallic patch, the substrate spacing and the shorting pin are interpreted as the series inductance, shunt capacitance and shunt inductance loading of an ENG circuit, respectively. This full circular mushroom was simulated by a 3D EM analysis, with the dielectric constant = 4.4, the height = 1.27 mm and the circular patch diameter = 20 mm. The frequency response is shown in Figure 3. As shown, the full circular mushroom has a ZOR with the in-phase electric field distribution over the whole structure, and its right-handed (RH) spurious harmonics in the frequency response. Also, if the number of cells of full circular mushrooms was extended to make a bandpass filter, it would work against an effective size reduction. In order to overcome the drawbacks of using full circular mushrooms, half circular mushroom reso-



▲ Fig. 4 Half circular mushroom resonator (a) and its ENG circuit model (b).



▲ Fig. 5 S-parameters (a) and dispersion diagram (b) of a half circular mushroom ZOR.

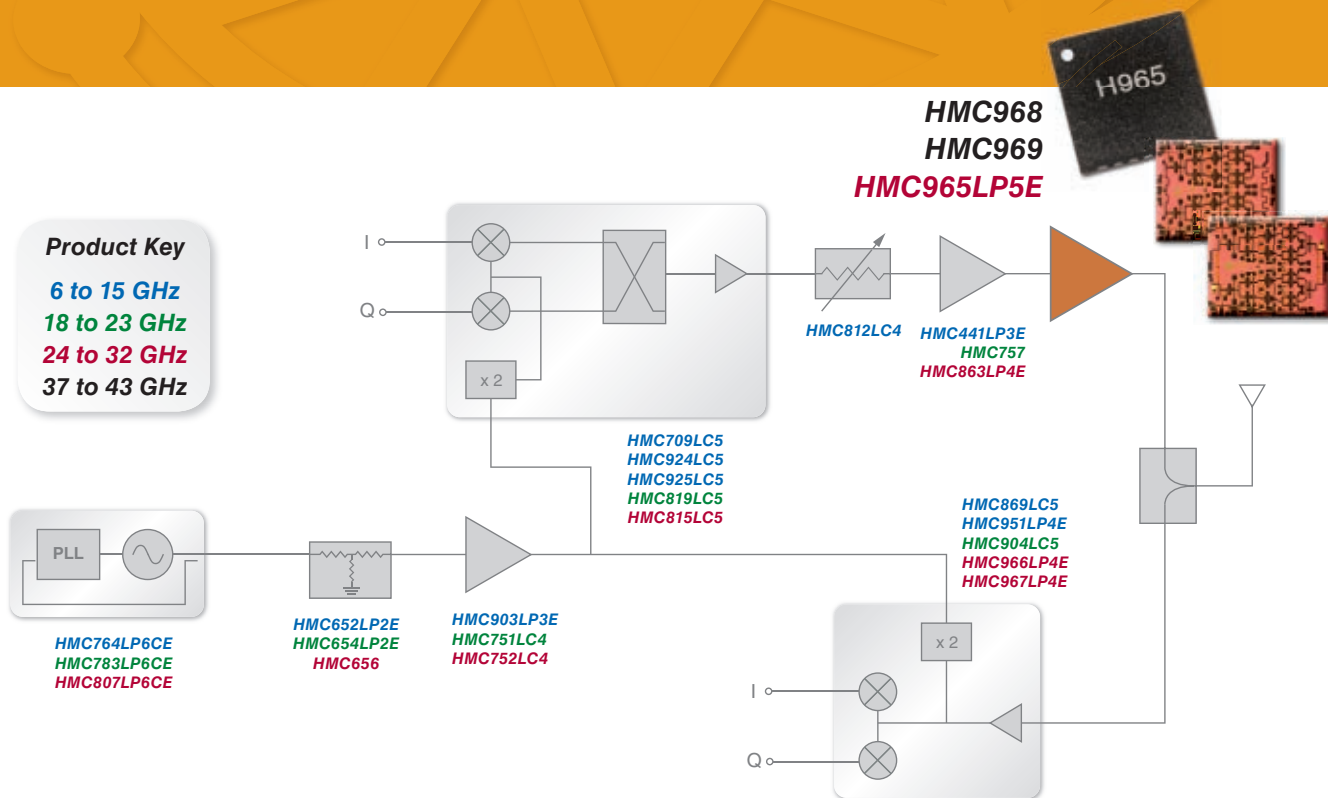
nators to minimize the physical size and a coupling element between the resonators to enlarge the stopband are considered, as shown in Figure 4.

The equivalent circuit of a one half circular mushroom resonator is determined to meet the performance of ZOR at 3 GHz and all its elements are calculated: $L_{R1} = 6$ nH, $L_{R2} = 11$ nH, $C_R = 4.8$ pF and $L_L = 0.7$ nH. According to this resonator circuit, the frequency response and the dispersion diagram of a half circular mushroom resonator are shown in Figure 5. S_{21} has its resonance at 3 GHz, but the bandwidth and the return loss are very poor, because a one half circular

POWER AMPLIFIERS

1 to 4 Watt PAs Cover 12 to 43.5 GHz for Microwave Radio Backhaul!

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



A SELECTION OF OUR LINEAR & POWER AMPLIFIERS

Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	P1dB (dBm)	Bias Supply	Package	Part Number
12 - 16	Power Amplifier 2 Watt	31	42	34.5	+7V @ 1200mA	Chip	HMC949
12 - 16	Power Amplifier 4 Watt	28	44.5	36.5	+7V @ 2400mA	Chip	HMC950
NEW! 12.5 - 15.5	Power Amplifier 2 Watt	27	40	32	+6V @ 1200mA	LP5	HMC965LP5E
16 - 24	Power Amplifier 1/2 Watt	20.5	34.5	26.5	+5V @ 400mA	LP4	HMC757LP4E
22 - 26.5	Power Amplifier 1/2 Watt	21.5	33	26.5	+6V @ 350mA	LP4	HMC863LP4E
27.3 - 33.5	Power Amplifier 2 Watt	23	43	33	+6V @ 1200mA	Chip	HMC906
NEW! 37 - 40	Power Amplifier 1 Watt	21	38	30.5	+6V @ 900mA	Chip	HMC968
NEW! 40 - 43.5	Power Amplifier 1 Watt	22	38	29	+6V @ 900mA	Chip	HMC969

High Quality / Quick Delivery

Low Cost / 2 Year Warrantee

RF Solutions



Power Amplifiers

Frequency range from DC up to 18GHz and power up to 1000W



LNAs



LC And Cavaty Filters

and more.....

www.jelang.com

Sales and Technical Support:
Elektrobit Inc.

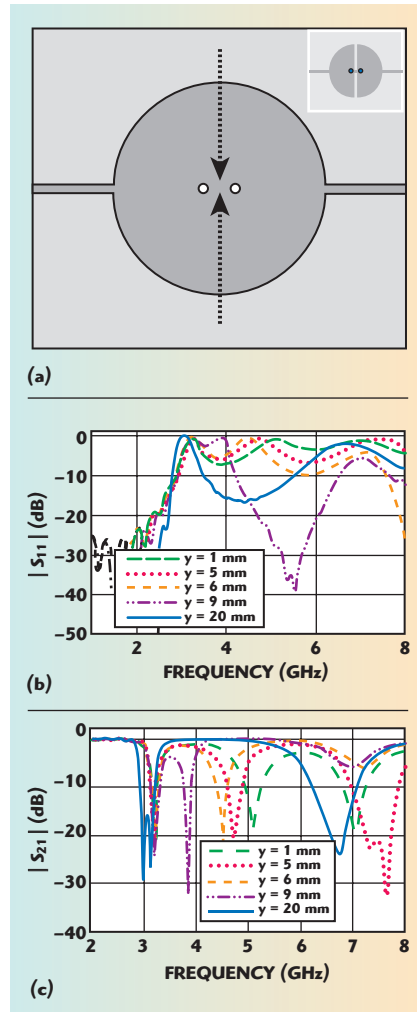
22745 29th Drive SE, Suite 200,
Bothell, WA 98021, USA

Tel : +1 425 444 2375

Fax : +1 425 686 3102

Email: jelang@elektrobit.com

Website : www.elektrobit.com

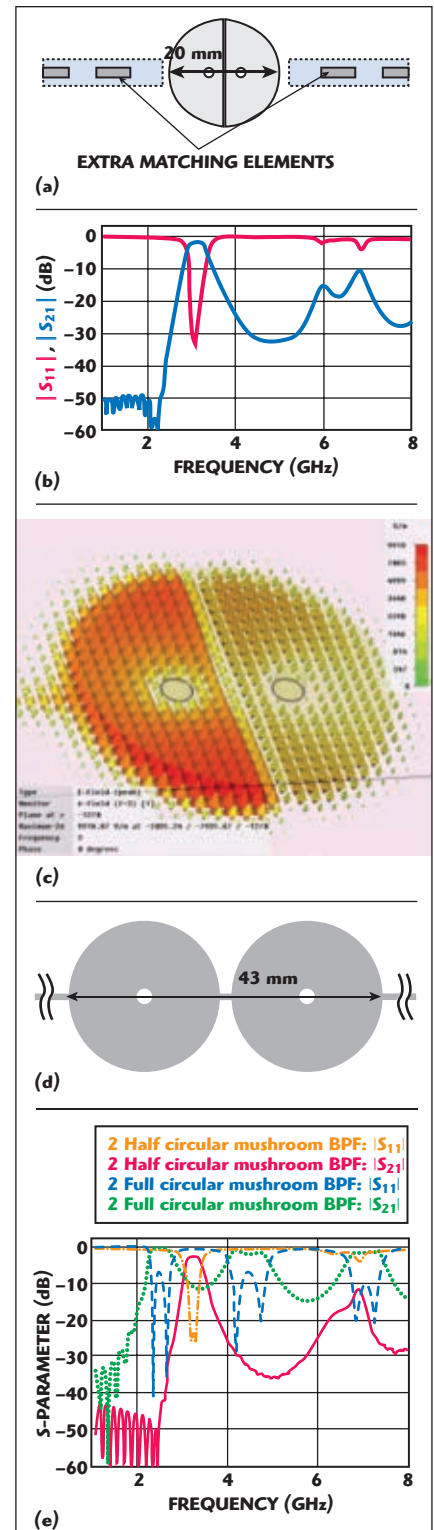


▲ Fig. 6 Coupling two half circular ZORs: (a) creating the two half circular mushrooms, (b) S_{11} as a function of slit length and (c) S_{21} as a function of slit length.

mushroom is just a resonator having a ZOR, not a bandpass filter. To make a complete bandpass filter, another coupled half circular mushroom resonator is needed.

When two half circular mushroom ZORs are put together with a coupling element, there are roughly three factors to adjust the coupling between the resonators: the slit gap, the slit length and the positions of the shorting pins. These factors have been varied to find the most appropriate values. In this particular design, among the number of coupling factors, just the slit length has been varied with the others fixed. From **Figure 6**, it is noted that the complete cut of the circle gives an acceptable performance. After undergoing further parameter studies, the optimized filter structure is found.

The gap between the two half circular resonators and the distance of



▲ Fig. 7 Performance of the proposed metamaterial bandpass filter: (a) geometry, (b) simulated frequency response, (c) ZOR field, (d) fabricated filter and (e) measured response.

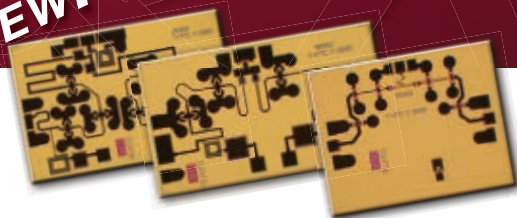
their shorting pins have been adjusted to form a passband centered at 3 GHz, with the closest spurious frequency component far apart. Actually, another

PIN SWITCHES

Offering Low Loss & High Isolation Over 2 to 86 GHz

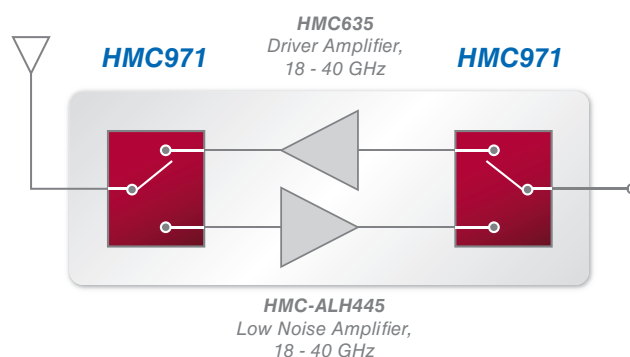
Analog, Digital & Mixed-Signal
ICs, Modules, Subsystems & Instrumentation

NEW!



**HMC970, HMC971, HMC975
Wideband SPDTs, 2 to 50 GHz**

- ◆ **High Isolation: Up to 50 dB**
- ◆ **Low Insertion Loss: as Low as 0.9 dB Typical**
- ◆ **All-Shunt or Non-Reflective Topology**
- ◆ **High Linearity: Up to +50 dBm Input IP3**



A SELECTION OF OUR PIN, SPDT & MULTI-THROW SWITCHES

Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package	ECCN Code	Part Number
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	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
NEW! 8 - 21	SPDT, PIN MMIC, 2W	1.2	40	33	-10 / +1.5 (30mA)	Chip	EAR99	HMC970
NEW! 18 - 40	SPDT, PIN MMIC, 2W	1.4	40	34	-10 / +1.5 (30mA)	Chip	EAR99	HMC971
NEW! 2 - 50	SPDT, PIN MMIC, 0.5W	0.9	45	27	-10 / +1.5 (30mA)	Chip	EAR99	HMC975
55 - 86	SPDT, PIN MMIC	2	30	-	-5 / 5V	Chip	5A991.h	HMC-SDD112
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 - 8	SP4T	1.8	42	21	0 / -5V	Chip	EAR99	HMC344
DC - 8	SP4T	2	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 - 10	SP8T	2	38	23	0 / -5V	Chip	EAR99	HMC322
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 - 8	Transfer	1.2	42	26	0 / +5V	LP3	EAR99	HMC427LP3E

For the Broadest Line of SPDT & Multi-Throw Switches Up to 86 GHz, Call Hittite Today!



Visit Us at MTT-S Booth #2009, June 7-9, 2011

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

Order On-Line at: www.hittite.com

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

Dare to Compare!

QUIET!

Now
Delivering

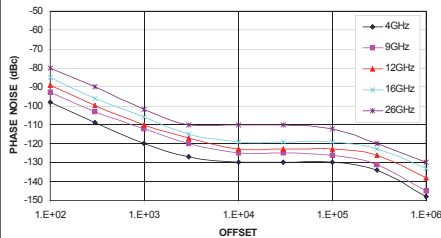
and PRECISE

OCXO, PLXO

Phase Locked & FR DROs

New Products! Details on website

TYPICAL PHASE NOISE OF NEXYN PLDRO



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 Corporation
1287 Forgewood Ave.
Sunnyvale, CA 94089

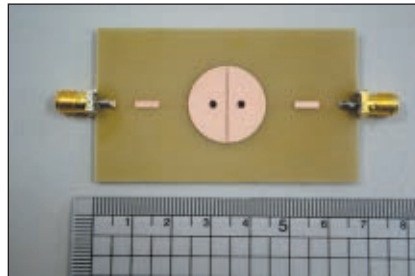
Tel: (408) 962-0895

Fax: (408) 743-5354

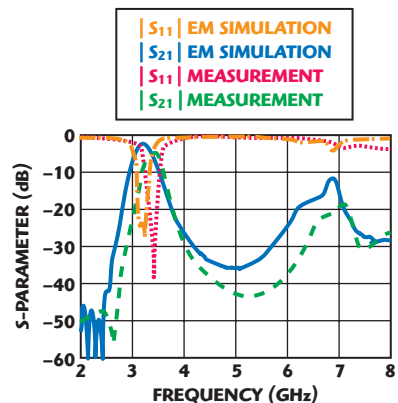
Visit our website at www.nexyn.com

Excellent Technical Support
Guaranteed Performance and
Competitive Pricing

TECHNICAL FEATURE



(a)



(b)

▲ Fig. 8 Finalized metamaterial bandpass filter with a two coupled half circular mushroom ZOR: (a) photograph and (b) performance.

er passband is seen at approximately 7 GHz, and to make sure this new filter has a wider stopband for good isolation, a pair of impedance matching elements is placed at the input and output ports, as shown in **Figure 7**. The proposed design results in a frequency response agreeing with the specification, 200 MHz bandwidth with insertion loss < 1 dB and RL better than 20 dB, with stopband > 2 GHz, checked with the 3D EM simulation. Using this verified proposed design method, the filter was fabricated and the measurements show good agreement with the simulation, except for the shift in frequency and magnitude due to the discrepancy between the actual and ideal substrate, as shown in **Figure 8**.

Finally, a comparison is made to show the strengths of the proposed filter over the full circular mushroom BPF in terms of size and isolation. Compared to the 2nd order full circular mushroom BPF, the proposed 2nd order half circular mushroom BPF is more than half in size and has a wider stopband.

CONCLUSION

Half circular mushroom cells were used as the ZORs and a gap was intro-

duced as coupling between neighboring ZOR resonators. A size reduction better than half that of a full size circular mushroom is achieved along with an improved stopband, compared to the full circular mushroom case or conventional filters based upon half-wavelength resonators. ■

ACKNOWLEDGMENT

This work is supported by the University of Incheon Research Promotion Program.

References

1. S. Kahng and J. Ju, "Design of the UWB Bandpass Filter Based on the 1 Cell of Microstrip CRLH-TL," *2008 IEEE International Conference on Microwave and Millimeter Wave Technology Proceedings*, Vol. 1, pp. 69-72.
2. S. Kahng and J. Ju, "Realized Metamaterial CRLH Bandpass Filter for UHF-band WLAN with Harmonics Suppressed," *2008 IEEE MTT-S International Microwave Symposium Workshop on Art of Miniaturizing RF and Microwave Passive Components*, pp. 98-101.
3. S. Kahng and J. Ju, "Design of a Dual-band Metamaterial Bandpass Filter Using Zeroth Order Resonance," *Progress in Electromagnetics Research C*, Vol. 12, March 2010, pp. 149-162.
4. C. Caloz and T. Itoh, *Electromagnetic Metamaterials: Transmission Line Theory and Microwave Application*, John Wiley & Sons Inc., Somerset, NJ, 2006.
5. R. Marques, et al., *Metamaterials with Negative Parameters: Theory, Design and Microwave Applications*, John Wiley & Sons Inc., Somerset, NJ, 2008.

Geonho Jang received his BE degree from the University of Incheon, Incheon, Korea, in 2009. He is currently working toward his MS degree in radio science and engineering in the department of information and telecommunication engineering at the University of Incheon. His interests include microwave components, antennas and metamaterials.

Sungtek Kahng received his PhD degree in electronics and communication engineering from Hanyang University, Korea, in 2000, with a specialty in radio science and engineering. From 2000 to early 2004, he worked for the Electronics and Telecommunication Research Institute on numerical electromagnetic characterization and developed RF passive components for satellites. In March 2004, he joined the department of information and telecommunication engineering at the University of Incheon, where he has continued research on analysis and advanced design methods of microwave components and antennas including metamaterial technologies and wireless power transfer.

SUPERIOR PERFORMANCE

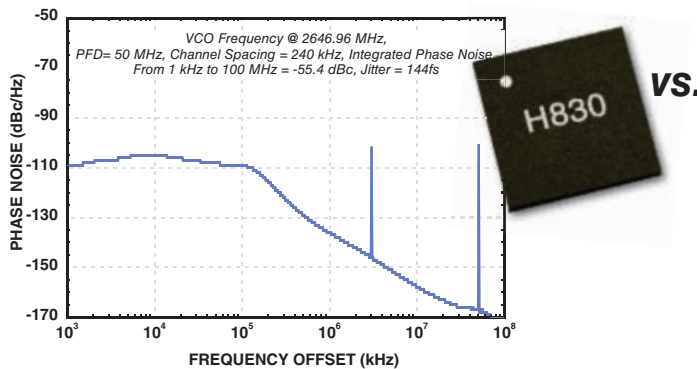
PLL + VCO Line Delivers Best Phase Noise & Spurious Performance!



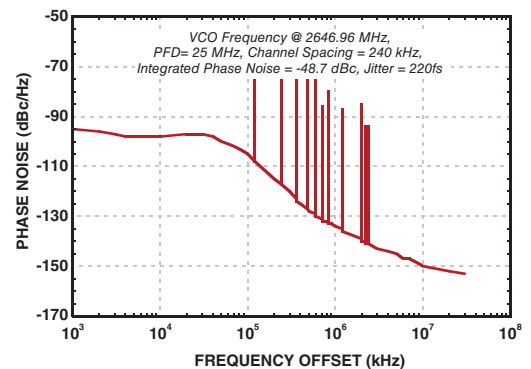
Analog, Digital & Mixed-Signal
ICs, Modules, Subsystems & Instrumentation



Hittite HMC830LP6GE Phase Noise



Typical Competitor Product Phase Noise



FOR THE BEST PLL + VCO PERFORMANCE, CALL HITTITE!

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	Part Number
fo/2								
665 - 825	Tri-Band RF VCO	-118 dBc/Hz	-148 dBc/Hz	11	180	0.05	LP6CE	HMC822LP6CE
795 - 945	Tri-Band RF VCO	-123 dBc/Hz	-148 dBc/Hz	10	180	0.06	LP6CE	HMC838LP6CE
780 - 870	RF VCO	-116 dBc/Hz	-148 dBc/Hz	14	180	0.06	LP6CE	HMC824LP6CE
860 - 1040	Tri-Band RF VCO	-118 dBc/Hz	-147 dBc/Hz	10	180	0.07	LP6CE	HMC821LP6CE
990 - 1105	RF VCO	-114 dBc/Hz	-146 dBc/Hz	11	180	0.07	LP6CE	HMC826LP6CE
NEW! 1025 - 1150	Tri-Band RF VCO	-123 dBc/Hz	-147 dBc/Hz	12	180	0.07	LP6CE	HMC837LP6CE
1050 - 1205	Tri-Band RF VCO	-121 dBc/Hz	-146 dBc/Hz	10	180	0.08	LP6CE	HMC839LP6CE
1095 - 1275	Tri-Band RF VCO	-118 dBc/Hz	-147 dBc/Hz	10	180	0.08	LP6CE	HMC820LP6CE
NEW! 1310 - 1415	Tri-Band RF VCO	-121 dBc/Hz	-145 dBc/Hz	10	180	0.09	LP6CE	HMC840LP6CE
fo								
1285 - 1415	RF VCO	-112 dBc/Hz	-143 dBc/Hz	10	180	0.09	LP6CE	HMC828LP6CE
1330 - 1650	Tri-Band RF VCO	-112 dBc/Hz	-142 dBc/Hz	6.5	180	0.11	LP6CE	HMC822LP6CE
1590 - 1890	Tri-Band RF VCO	-118 dBc/Hz	-143 dBc/Hz	7.5	180	0.12	LP6CE	HMC838LP6CE
1720 - 2080	Tri-Band RF VCO	-112 dBc/Hz	-141 dBc/Hz	6.5	180	0.13	LP6CE	HMC821LP6CE
1815 - 2010	RF VCO	-112 dBc/Hz	-143 dBc/Hz	7.5	180	0.13	LP6CE	HMC831LP6CE
NEW! 2050 - 2300	Tri-Band RF VCO	-117 dBc/Hz	-141 dBc/Hz	10.5	180	0.15	LP6CE	HMC837LP6CE
2100 - 2410	Tri-Band RF VCO	-115 dBc/Hz	-140 dBc/Hz	7.5	180	0.16	LP6CE	HMC839LP6CE
2190 - 2550	Tri-Band RF VCO	-112 dBc/Hz	-141 dBc/Hz	6.5	180	0.17	LP6CE	HMC820LP6CE
NEW! 2620 - 2830	Tri-Band RF VCO	-115 dBc/Hz	-139 dBc/Hz	9	180	0.18	LP6CE	HMC840LP6CE
2fo								
2660 - 3300	Tri-Band RF VCO	-106 dBc/Hz	-136 dBc/Hz	-4	180	0.21	LP6CE	HMC822LP6CE
3180 - 3780	Tri-Band RF VCO	-112 dBc/Hz	-135 dBc/Hz	-4	180	0.24	LP6CE	HMC838LP6CE
3365 - 3705	RF VCO	-107 dBc/Hz	-135 dBc/Hz	0	190	0.25	LP6CE	HMC836LP6CE
3440 - 4160	Tri-Band RF VCO	-106 dBc/Hz	-135 dBc/Hz	-4	180	0.27	LP6CE	HMC821LP6CE
NEW! 4100 - 4600	Tri-Band RF VCO	-111 dBc/Hz	-135 dBc/Hz	-0.5	180	0.30	LP6CE	HMC837LP6CE
4200 - 4820	Tri-Band RF VCO	-108 dBc/Hz	-135 dBc/Hz	-4	180	0.31	LP6CE	HMC839LP6CE
4380 - 5100	Tri-Band RF VCO	-106 dBc/Hz	-135 dBc/Hz	-4	180	0.33	LP6CE	HMC820LP6CE
NEW! 5240 - 5660	Tri-Band RF VCO	-109 dBc/Hz	-133 dBc/Hz	-3	180	0.37	LP6CE	HMC840LP6CE
Wideband								
NEW! 25 - 3000	Wideband RF VCO	-114 dBc/Hz @ 2 GHz Fract Mode	-141 dBc/Hz @ 2 GHz	5	<180	<0.13	LP6GE	HMC830LP6GE

**Ideal for Cellular/4G, Microwave Radio, Industrial / Medical
Test Equipment, Military Communications & Sensors!**

Visit Us at MTT-S Booth #2009, June 7-9, 2011



20 Alpha Road • Chelmsford, MA 01824
978-250-3343 tel • 978-250-3373 fax • sales@hittite.com

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

A HEMT LARGE-SIGNAL MODEL WITH IMPROVED TRANSCONDUCTANCE AND GATE CAPACITANCE PEAKING CHARACTERISTICS

In this article, an improved large-signal device model of HEMTs is presented, amenable for use in commercial nonlinear simulators. The proposed model includes independent modeling equations to control the peaking and compression behaviors of the HEMT transconductance (G_m) and gate capacitance (C_{gs}). The main advantage of this model is to provide a simple and coherent description of the bias-dependent drain current (I-V) and gate charge (Q-V) relationships, that are valid in all regions of operation. All the aspects of the model are validated for 0.25 μm gate lengths GaAs and GaN HEMTs. The simulation results of I-V, C-V, large-signal power and intermodulation distortion (IMD) characteristics show excellent agreement with the measured data.

The availability of general-purpose harmonic-balance and Volterra-Series simulators has generated a need for accurate nonlinear models of III-V field effect transistors (FET).¹ Due to the heterostructure complexity of HEMTs and the associated physical characteristics, they are most appropriately modeled based on a semi-empirical approach with parameters extracted from measurements.²

The major nonlinearities of HEMTs come from the bias-dependent drain current I-V and gate-charge Q-V relationships.³ In the past years, many equation-based large-signal HEMT models have been proposed to model those nonlinearities.¹⁻⁹ Among them, the widely-used Angelov I-V model² is one of the most successful drain current models, in virtue of its simplicity, higher-order differentiability, good convergence performances and well-defined

fitting parameters. But the Angelov I-V model often faces accuracy issues, where compromises have to be made for the overall fitting.⁴⁻⁶ On the other hand, the charge conservative EEHEMT Q-V model⁷ is one representative gate charge model. Unlike the Angelov capacitance model, which may induce non-convergence during HB simulations,¹⁰ the EEHEMT charge model starts with a single gate charge formulation satisfying the principle of charge conservation to overcome the convergence problem. However, the EEHEMT model fails to model the capacitance peaking characteristics near cutoff found in GaN⁸ and GaAs HEMTs.⁹

LIN-SHENG LIU

University of Electronic Science and Technology of China, Chengdu, China

Thin Film Filter Engineering

DLI's "Guru" Will Help You Define
Your Thin Film Filter Requirements.



Come visit DLI at the
IEEE MTT-s 2011
in Baltimore, Maryland
Booth 1006

Our "RF Guru" will help you fulfill your unique filter requirements. Visit www.dilabs.com, click on the RF Guru link, and complete the simple form. DLI's applications engineers can then make an initial assessment of your filter requirements and will contact you to further discuss solutions.



Typical Filter Range:

- ▶ Bandpass, Lowpass, Highpass and Notch Filters from 30MHz – 67 GHz
- ▶ Duplexers and Diplexers from 1GHz – 30 GHz
- ▶ Cavity Filters from 6GHz – 25 GHz

All filters employ DLI's high-K ceramics which allow for size reduction and extreme temperature stability compared to alumina and PWB materials. Solder surface mount and chip and wire filters are all possible.



www.dilabs.com

Dielectric Laboratories, Inc.

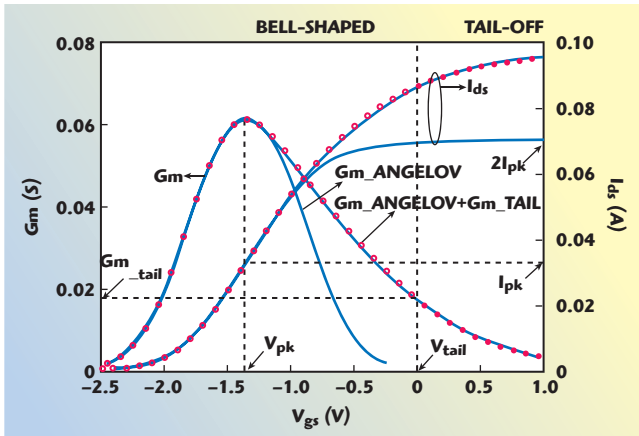
2777 Route 20 East, Cazenovia, NY 13035 USA

Phone: (315) 655-8710

Fax: (315) 655-0445

Email: sales@dilabs.com

DLI is the preeminent global supplier of Single-Layer and Multi-Layer Capacitors, Build to Print Thin Film circuits and Custom Thin Film application-specific ceramic components such as Filters, Gain Equalizers and Resonators.



▲ Fig. 1 Graphical interpretation of the proposed non-linear I-V model.

For this purpose, an improved large-signal HEMT model is presented with the Angelov I-V model and EE-HEMT Q-V model as prototypes. By maintaining the merits of the original models, the proposed model is capable of representing the nonlinear I-V and Q-V relationships between and across the entire bias range of different regimes. This has been done by introducing new modeling equations to independently control the G_m tail-off and C_{gs} peaking characteristics. Excellent agreement is observed between measured and simulated results by utilizing the 0.25 μm GaAs and GaN HEMT processes.

MODEL DESCRIPTION

Drain-current I-V Model

The Angelov I-V model² has frequently been used to model HEMTs with typical bell-shape G_m characteristics (see **Figure 1**). An analytical drain-source current I-V model as an extension of the Angelov model for GaAs and GaN HEMTs is developed here. This modified I-V model is given as follows:

$$I_{ds}(V_{gs}, V_{ds}) = I_{\text{angelov}} + I_{\text{Gmtail}} \quad (1)$$

$$I_{\text{angelov}} = I_{pk}(1 + \tanh(ph)) \tanh(\alpha_1 V_{ds}) \quad (2)$$

$$I_{\text{Gmtail}} = G_{m_tail} V_{efft} \tanh(\alpha_2 V_{ds}) \quad (3)$$

$$ph = P_1 V_{gsp} + P_2 V_{gsp}^2 + P_3 V_{gsp}^3 + \dots, \quad (4)$$

$$V_{gsp} = V_{eff11} - V_{pk}$$

$$V_{efft} = (1/m_1)(1/m_2) \left[1 - (1 + m_2 V_{eff12})^{-m_1} \right] \quad (5)$$

$$\text{for } m_1 > 0; V_{efft} = (1/m_2) \ln(1 + m_2 V_{eff12}) \text{ for } m_1 = 0$$

$$V_{eff11} = (V_{gst} - V_{gsta})/2 + V_{tail}, V_{eff12} = (V_{gst} + V_{gsta})/2 \quad (6)$$

$$V_{gst} = V_{gs} - V_{tail}, V_{gsta} = (1/n) \ln(2 \cosh(nV_{gst})) \quad (7)$$

$$V_{pk} = V_{pko} + w_0 V_{ds}, V_{tail} = V_{tailo} + w_1 V_{ds} \quad (8)$$

As described in the figure, the proposed I-V model consists of two parts: the I_{Angelov} part maintains the charac-



Isolators and Circulators

- AS9100 Quality Standards
- Frequency range from 40 MHz to 120 GHz
- Lumped, Stripline, Microstrip, Coaxial and Waveguide
- Single and Dual Junction Configurations
- Compact Size, High Performance
- Low and High Power
- Magnetically Shielded
- Commercial Market Applications
- Military and Aerospace Designs
- Catalog and Custom Designs

Since 1991, Renaissance has been a key supplier of Ferrite devices for major military and commercial applications. These state-of-the-art Isolators and Circulators cover the frequency range from 40 MHz to 120 GHz with low insertion loss and high isolation specifications. Most of our products are designed for custom applications. So please give us a call with your specific needs and we will meet or exceed your expectations.

The New Thinking in Wireless Technology

We are here to be part of your current and future innovation. Please contact us at 978-772-7774 or www.rec-usa.com/Ad/I3.html



ISO9001-2008
AS9100 Certified





COMMAND
+ CONTROL



SIGNAL PROCESSING
+ DATA COMM.



ENTERPRISE
NETWORK MGMT.

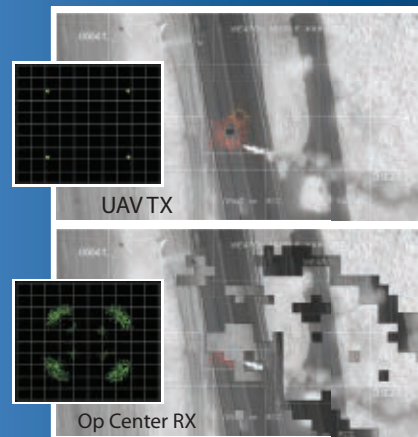
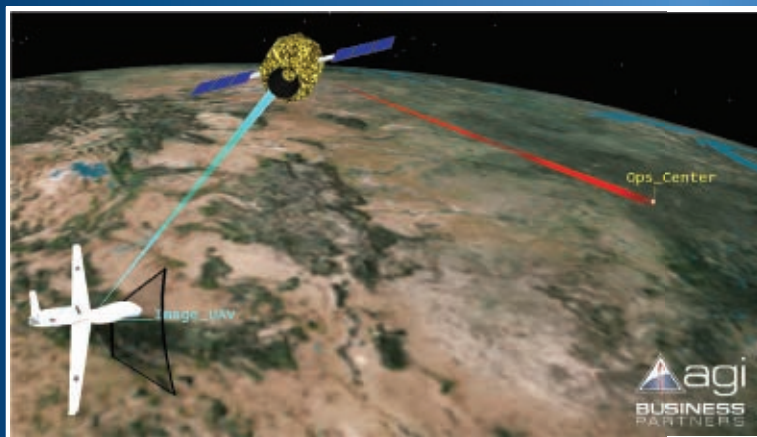


COMM. INFO
ASSURANCE



SERVICES

RF CHANNEL SIMULATION



WHEN COMMUNICATIONS REALLY COUNT

THE INTEGRAL DIFFERENCE

Develop and test realistically, thoroughly,
quickly and easily, under the most punishing
RF and complex motion conditions
imaginable - without ever leaving the lab.



The RT Logic Telemetry® T400CS Real-Time Channel Simulator
adds dynamic, phase continuous, physics-compliant signal and carrier
Doppler shift, delay, path loss, noise and interference to the signals
you test with.



719-598-2801 | sales@rtlogic.com | www.rtlogic.com

THE INTEGRAL SYSTEMS FAMILY OF SOLUTION PROVIDERS.

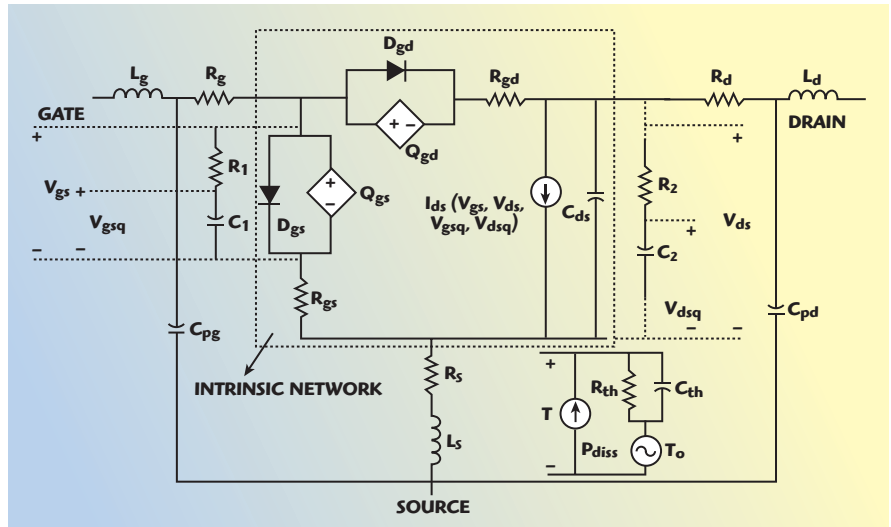


See us at MTT-S Booth 838

teristics of the Angelov model, where the extraction of the key model parameters, such as the peak G_m coefficient (P_1), gate voltage (V_{pk}) and drain current (I_{pk}) for maximum G_m , is still the same as in the original model. Besides, the tuning parameters in the ph function (P_2 and P_3) now have more freedom to model the G_m expansion when $V_{gs} < V_{pk}$ for the threshold region and the transition from pinch-off to turn-on. The added I_{tail} part (Equation 3) is to independently model the G_m compression behaviors distinguished by the V_{tail} parameter, the turning point of gate voltage where G_m tail-off begins. This modification with a multiplier term allows the elongation of the bell-shape G_m for $V_{gs} > V_{pk}$.¹⁵

The restriction of the “symmetrical” behavior of $2I_{pk} = I_{sat}$ in the original Angelov model³ confines its range of operation.⁶ The inclusion of the I_{tail} current source permits the drain current to increase beyond $2I_{pk}$ as a function of V_{gs} and results in significantly improved accuracy. As a consequence, no trade-offs need to be made for the overall fitting,⁴ and the improved I-V model enhances the bias range of operation for which accuracy is maintained, as compared in the figure.

In order to characterize the charge-trapping and self-



▲ Fig. 2 Complete “four-terminal” large-signal equivalent circuit of HEMTs.

heating effects³ found in most GaAs/GaN HEMTs, a four-terminal, large-signal, equivalent-circuit topology with frequency dispersion and thermal sub-circuits has been employed,¹¹ as shown in **Figure 2**. The trapping and temperature coefficients as the correction of the model parameters in Equations 1 to 8 are then determined by comparing the pulsed I-V characteristics at different quiescent biasing points and ambient temperatures.^{12,13}

DETECT DECEIVE DEFEAT

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

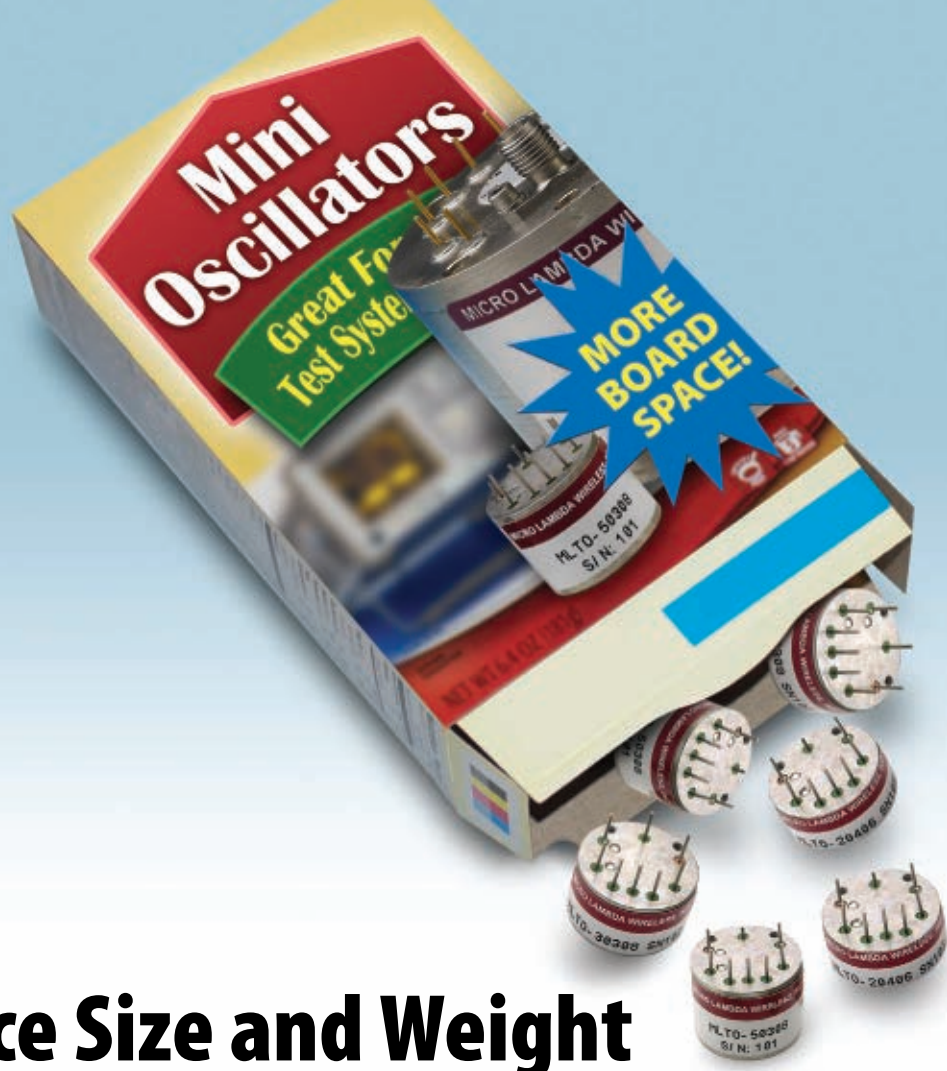
- Custom and standard products

mc.com/microwave

MERCURY
COMPUTER SYSTEMS™

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

Copyright © 2011 Mercury Computer Systems, Inc.



Reduce Size and Weight

The MLTO and MLTM-Series TO-8 YIG-Tuned oscillators from Micro Lambda Wireless provide designers a small compact and easy to use alternative for tuneable oscillator applications. These miniature oscillators provide wide tuning ranges covering 2 to 9 GHz, excellent phase noise performance of -125 dBc/Hz at 100 kHz offset in a TO-8 sized package. Both electromagnetic and permanent magnet designs operate off +8 Vdc and -5 Vdc and do not require a heater.

If PC board space is a premium, then these miniature oscillators are just what you are looking for.

Same great performance as standard oscillators at less than one third the size!

For more information about the MLTO & MLTM Series or other products, please contact Micro Lambda Wireless.

See our complete line of YIG-Tuned Oscillators



Mini-Oscillators
.5 to 10 GHz



1" cube Oscillators
.5 to 18 GHz



Low Noise Oscillators
2 to 20 GHz



Millimeterwave Oscillators
18 to 40 GHz

www.microlambdawireless.com

MICRO LAMBDA WIRELESS, INC.

"Look to the leader in YIG-Technology"

See us at MTT-S Booth 2502

Gate Charge Q-V Model

After de-embedding the extrinsic elements according to the well-known cold FET method,¹⁴ the multi-bias S-parameter measurements were used to extract the intrinsic bias-dependent gate capacitances C_{gs} and C_{gd} , and then the nonlinear gate capacitances were implemented using the charge-equation-based model as shown below:

$$Q_g(V_{gs}, V_{ds}) = Q_{g_eehemt} + Q_{g_peak} \quad (9)$$

$$Q_{g_eehemt} = p_1(V_p + (1/p_2)\ln(2\cosh(p_2V_p))) + C_{11off}V_{gs} - C_{12sat}V_{ds} \quad (10)$$

$$Q_{g_peak} = q_1(1 + \tanh(q_2V_q)) \quad (11)$$

$$V_p = V_{gs} - V_{inf1}, V_q = V_{gs} - V_{inf2} \quad (12)$$

$$p_1 = p_{1o} + \lambda_{p1}V_{ds} + p_{1t}\Delta T, q_1 = q_{1o} + \lambda_{q1}V_{ds} + q_{1t}\Delta T$$

$$V_{inf1} = V_{inf1o} + w_{i1}V_{ds}, V_{inf2} = V_{inf2o} + w_{i2}V_{ds}$$

The unified gate charge modeling equation in Equation 9 satisfies the charge-conservation principle¹⁰ to overcome convergence problem during simulations. Differentiating the gate charge expression with respect to V_{gs} yields the following expression for the gate capacitance C_{11} :

$$C_{11} = \partial Q_g / \partial V_{gs} = C_{11_eehemt} + C_{11_peak} \quad (13)$$

$$= p_1(1 + \tanh(p_2V_p)) + C_{11off} + q_1q_2 \operatorname{sech}^2(q_2V_q)$$

Figure 3 describes the operation of the fitting param-

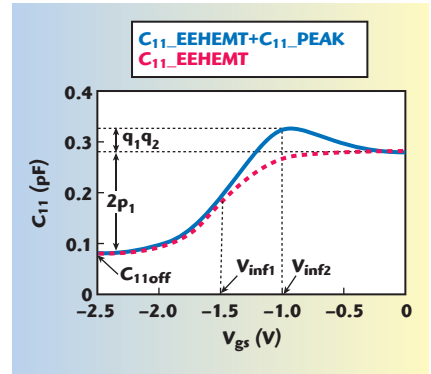
eters. It can be seen that the additional C_{11_peak} term, compared to the EEHEMT charge model, enables the peaking of the gate capacitance C_{11} near cutoff. Besides, the total gate charge Q_g needs to be subdivided between the respective charge sources Q_{gs} and Q_{gd} , so as to be implemented into the proposed large-signal equivalent-circuit model as in Figure 2. Similar bilateral smoothing functions used in the EEHEMT charge model⁷ are applied here, as given below:

$$V_{do} = \sqrt{V_{ds}^2 + \delta^2} \quad (14)$$

$$V_{go} = 1/2(2V_{gs} - V_{ds} + \sqrt{V_{ds}^2 + \delta^2}) \quad (15)$$

$$f_{1,2} = 1/2(1 \pm \tanh(3/\delta(V_{gs} - V_{gd} - V_{as}))) \quad (16)$$

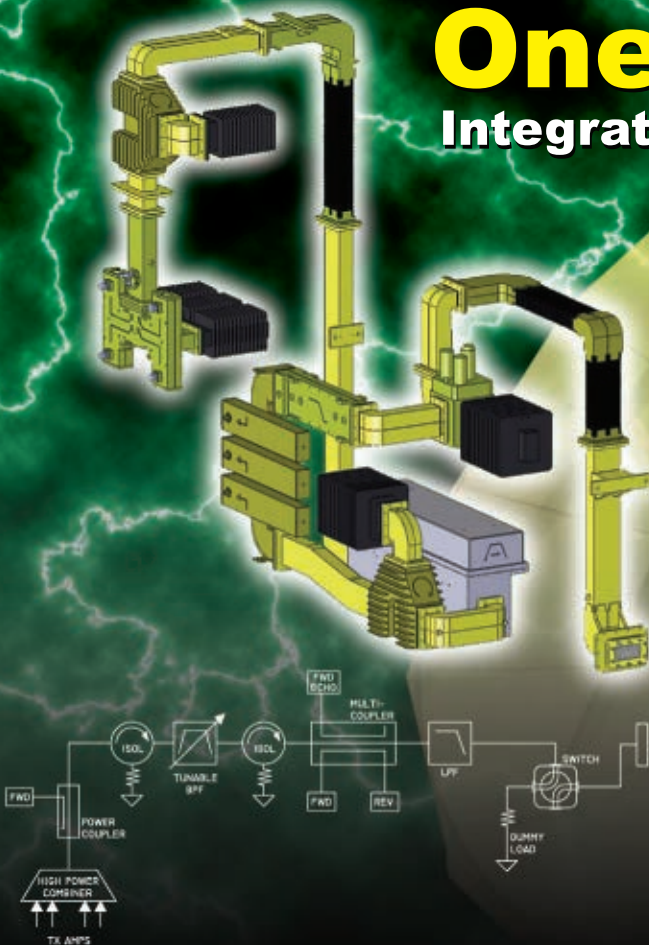
$$Q_{gs}(V_{gs}, V_{gd}) = (Q_g(V_{go}, V_{do}) - C_{gdsat}V_{gd})f_1 + C_{gdsat}V_{gs}f_2 \quad (17)$$



▲ Fig. 3 Interpretation of the gate charge Q-V model.

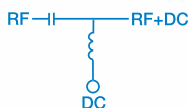
One Stop Shop Integrated Front End Assemblies

- 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



BIAS-TEES

Now up to 4A DC current 100 kHz-12 GHz

Mini-Circuits is your complete source for Bias-Tees, covering from 100 kHz to 12 GHz and handling up to 4A DC in a variety of coaxial, plug-in, and surface mount packages. All of our Bias-Tees boast low insertion loss and VSWR. Our patented TCBT LTCC ceramic designs are the smallest in the world and are ready for your projects where very low price, space limitation, and temperature stability are a must. Our ultra-wideband ZX85 Bias-Tees use our patented Unibody construction to give you small size and high repeatability. Whether your applications call for biasing amplifiers, laser diodes, or active antennas, DC blocking, DC return, satellite communications, test, or if you have custom requirements, just contact Mini-Circuits and let us fit your needs to a "TEE"!

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



RoHS compliant.

\$395* **IN STOCK**
from ea. Qty.1000

TYPICAL SPECIFICATIONS

Model	Freq (MHz)	Insertion Loss (dB)	Isolation (dB)	Max Current mA	Price Sea. Qty.10
TCBT-2R5G+	20-2500	0.35	44	200	6.95*
TCBT-6G+	50-6000	0.7	28	200	9.95
TCBT-14+	10-10,000	0.35	33	200	8.45

TCBT: LTCC, Actual Size .15" x .15", U.S. Patent 7,012,486.

Qty.1-9					
JEFT-4R2G+	10-4200	0.6	40	500	39.95
JEFT-4R2GW+	0.1-4200	0.6	40	500	59.95
PBTC-1G+	10-1000	0.3	33	500	25.95
PBTC-3G+	10-3000	0.3	30	500	35.95
PBTC-1GW+	0.1-1000	0.3	33	500	35.95
PBTC-3GW+	0.1-3000	0.3	30	500	46.95
ZFBT-4R2G+	10-4200	0.6	40	500	59.95
ZFBT-6G+	10-6000	0.6	40	500	79.95
ZFBT-4R2GW+	0.1-4200	0.6	40	500	79.95
ZFBT-6GW+	0.1-6000	0.6	40	500	89.95
ZFBT-4R2G-FT+	10-4200	0.6	N/A	500	59.95
ZFBT-6G-FT+	10-6000	0.6	N/A	500	79.95
ZFBT-4R2GW-FT+	0.1-4200	0.6	N/A	500	79.95
ZFBT-6GW-FT+	0.1-6000	0.6	N/A	500	89.95
ZFBT-282-1.5A+	10-2800	0.6	45	1500	56.95
ZFBT-352-FT+	30-3500	0.4	23	4000	48.95
ZNBT-60-1W+	2.5-6000	0.6	45	500	82.95
ZX85-12G+	0.2-12000	0.6	N/A	400	99.95

ZX85: U.S. Patent 6,790,049.

Note: Isolation dB applies to DC to (RF) and DC to (RF+DC) ports.

Mini-Circuits®
ISO 9001 ISO 14001 AS9100 CERTIFIED

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



U.S. patent 7730260 The Design Engineers Search Engine finds the model you need, Instantly • For detailed performance specs & shopping online see minicircuits.com

IF/RF MICROWAVE COMPONENTS

See us at MTT-S Booth 1031

395 rev L

$$Q_{gd}(V_{gs}, V_{gd}) = (Q_g(V_{go}, V_{do}) - C_{gdsat} V_{gs}) f_2 + C_{gdsat} V_{d1} \quad (18)$$

Finally, the gate-source and gate-drain diodes in forward conduction are modeled using the standard Schottky diode equation.⁵ The complete large-signal nonlinear model is implemented in Agilent's ADS through Verilog-A coding.

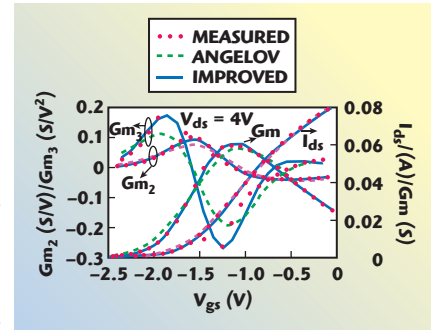
EXPERIMENTAL MODEL VERIFICATION

In order to demonstrate the usefulness of the proposed large-signal model, the 0.25 μm gate-lengths on-wafer GaAs double-heterojunction δ -doped PHEMT⁹ and the GaN metal-insulator-semiconductor HEMT (MISHEMT) with atomic-layer-deposited (ALD) Al_2O_3 gate insulator¹⁵ have been modeled and validated. As a first step, isothermal pulsed I-V measurements¹⁶ for the $2 \times 100 \mu\text{m}$ gate-widths GaAs and GaN HEMTs have been investigated. The extracted drain current and its first three derivatives (G_m , G_{m2} and G_{m3}) characteristics with respect to gate voltage are compared to measured values at the quiescent biasing point of $(V_{gsq}, V_{dsq}) = (0 \text{ V}, 0 \text{ V})$ in **Figures 4** and **5**, where an excellent fit is obtained for the entire bias range. These curves serve to illustrate the improvements of the derivative reproduction of the modified I-V model over the original Angelov model.

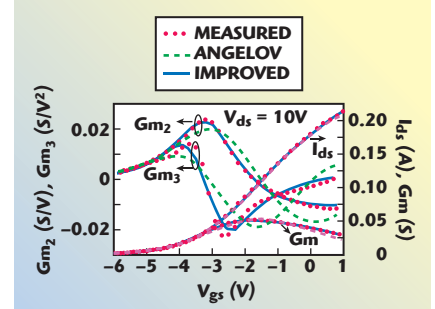
Furthermore, the measured gate capacitance $C_{11} = C_{gs} + C_{gd}$ was evaluated from the intrinsic Y-parameters.¹⁴ The verification of the gate charge model performance (C-V)

is shown in **Figure 6**. It can be seen that the two HEMT devices exhibit gate capacitance peaking characteristics, while the C_{11} of the GaN HEMT is nearly V_{ds} independent.

The utility of the power performance of the model is verified by comparing its output predictions with measured power data. The transmitted output power characteristics at the first two harmonics and the power-added-efficiency (PAE) at a particular biasing point in deep Class AB biasing conditions

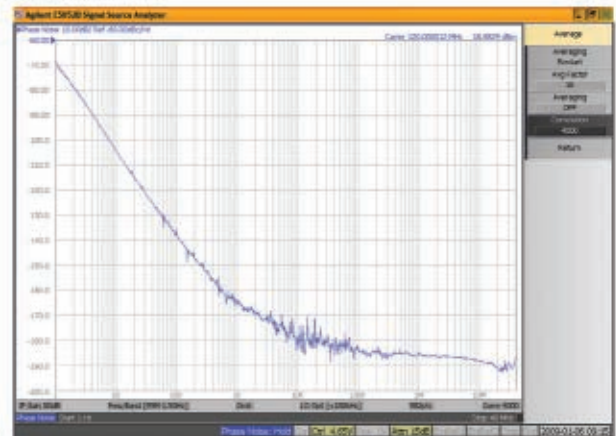


▲ Fig. 4 Measured (circles) and modeled (lines) pulsed I-V and its first three derivatives (G_m , G_{m2} and G_{m3}) characteristics of a GaAs HEMT.



▲ Fig. 5 Measured (circles) and modeled (lines) pulsed I-V and its first two derivatives (G_m , G_{m2} and G_{m3}) characteristics of a GaN HEMT.

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

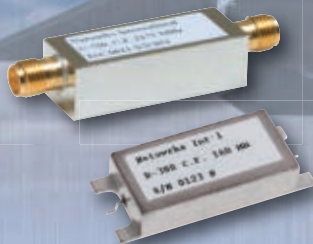
Trusted Partner for Mission Critical Applications

25TH
1986 ANNIVERSARY 2011

Celebrating 25 years of
excellence and innovation,
NIC thanks its customers
for the opportunities and its
employees for outstanding
service making the last 25
years a tremendous success

See us at MTT-S Booth 733

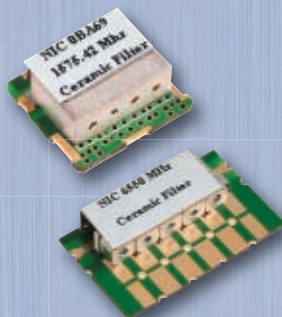
LC Filters



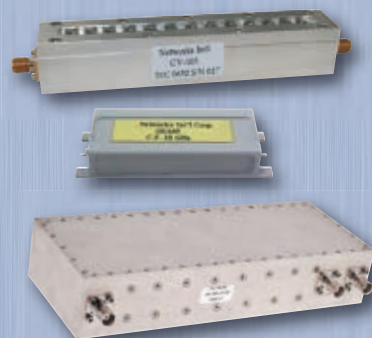
**Discrete & Monolithic
Crystal Filters**



Ceramic Filters



Cavity Filters & Diplexers



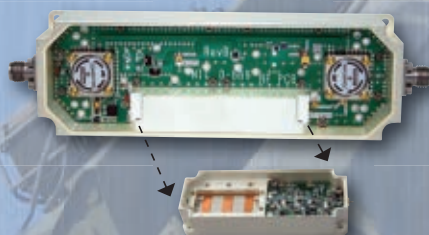
Switch Filter Banks



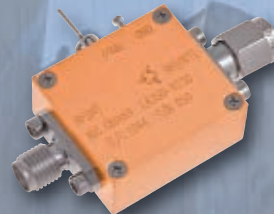
**Filter/Amplifier
Assemblies**



Integrated Assemblies



Low Noise Amplifiers



Radar | EW | Guidance & Navigation | Communications | GPS & Satellite



**ISO 9001:2000
AS9100B
CERTIFIED**

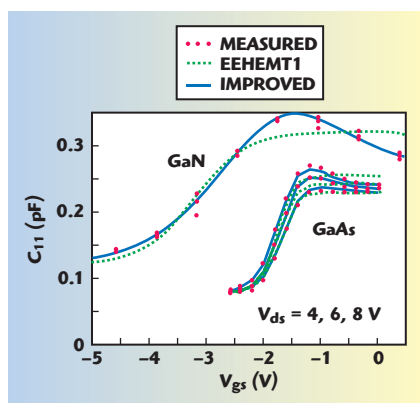


www.nickc.com

913.685.3400

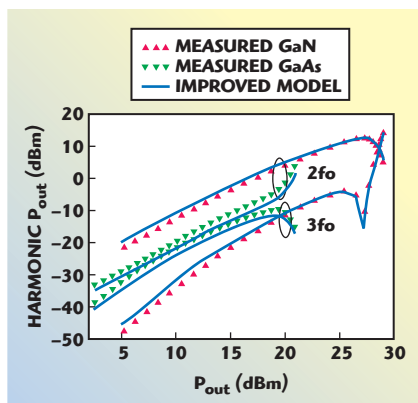
15237 Broadmoor
Overland Park, KS

e-mail: sales@nickc.com



▲ Fig. 6 Measured (circles) and modeled (lines) C-V results of the GaAs and GaN HEMTs.

are simulated and compared with measured data, as shown in **Figures 7** and **8**, respectively. For the GaAs HEMT, the frequency was 7.5 GHz and the bias -1.8 and 6.0 V, while for the GaN HEMT, the frequency was 4 GHz and the bias -3.7 V and 20.0 V. The input and output terminating impedances of the device were adjusted for maximum PAE performances. It can be seen that the model provides a very good prediction of the power characteristics. Moreover, the third-order

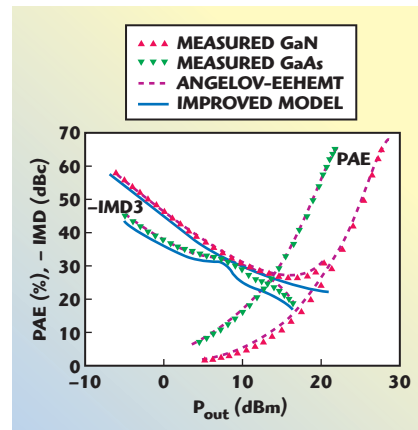


▲ Fig. 7 Measured (symbols) and modeled (lines) results for the output harmonics power levels.

intermodulation distortion (IMD3) has been characterized using two-tone tests (10 MHz spacing) under 50 Ω biasing conditions. According to the data and simulated output shown, the developed nonlinear model is capable of predicting the third-order IMD products more accurately.¹⁷

CONCLUSION

An improved large-signal model has been presented and validated for HEMTs. Based on the well-known



▲ Fig. 8 Measured (symbols) and modeled (lines) single tone PAE and two-tone, third order IMD performance.

Angelov drain-current I-V and EEHEMT gate-charge Q-V model, two extra drain-current and gate-charge modeling sources have been proposed to independently control the G_m tail-off and C_{gs} peaking characteristics, respectively. The modified nonlinear model has demonstrated the ability to model the I-V and C-V characteristics of the GaAs and GaN HEMTs. In addition, the large-signal model has been



SPECIAL HERMETIC PRODUCTS, INC.

Hi-Rel By Design

SHP seals are identifiable in many ways:

- The uniformity of the solder joint when installed
- The uniformity and fire polish of the glass
- The absence of voids and cracks in the glass
- The quality and consistency of plating
- The success of the companies who use them

Call us today for your FREE SAMPLES!

39 Souhegan Street – P.O. Box 269, Wilton, New Hampshire 03086 TEL (603)654-2002 FAX (603)654-2533
email: sales@shp-seals.com - website: www.shp-seals.com

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 MTT-S Booth 325



implemented in Agilent's ADS and can accurately predict the large-signal output power performances for the first two harmonics as well as third-order IMD characteristics. This model, developed from the widely-used Angelov and EE-HEMT models, is easy to be extracted, and thus can serve as a useful tool in commercial nonlinear simulators. ■

References

1. W. Curtice, "A MESFET Model for Use in the Design of GaAs Integrated Circuit," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 28, No. 5, May 1980, pp. 448-455.
2. I. Angelov, L. Bengtsson and M. Garica, "Extensions of the Chalmers Non-linear HEMT and MESFET Model," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 44, No. 10, October 1996, pp. 1664-1674.
3. L.S. Liu, J.G. Ma, and G.I. Ng, "Electrothermal Large-signal Model of III-V FETs Including Frequency Dispersion and Charge Conservation," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 57, No. 12, December 2009, pp. 3106-3117.
4. L.S. Liu, J.G. Ma and G.I. Ng, "Electrothermal Large-signal Model of III-V FETs Accounting for Frequency Dispersion and Charge Conservation," 2009 *IEEE MTT-S International Microwave Symposium Digest*, pp. 749-752.
5. P. Cabral, J. Pedro and N. Carvalho, "Nonlinear Device Model of Microwave Power GaN HEMTs for High Power Amplifier Design," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 52, No. 11, November 2004, pp. 2585-2592.
6. K.S. Yuk, G.R. Branner and D.J. McQuate, "A Wideband Multiharmonic Empirical Large-signal Model for High-power GaN HEMTs with Self-heating and Charge-trapping Effects," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 57, No. 12, December 2009, pp. 3322-3332.
7. "ADS Version ADS2005A, Documentation: Nonlinear Devices," Agilent Technologies, Santa Clara, CA, 2005.
8. J. Deng, W. Wang, S. Halder, W.R. Curtice, J.C.M. Hwang, V. Adivarahan and A. Khan, "Temperature-dependent RF Large-signal Model of GaN-based MOSHFETs," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 56, No. 12, December 2008, pp. 2709-2716.
9. L.S. Liu, J.G. Ma, G.I. Ng and Q.J. Zhang, "Nonlinear HEMT Model Direct Formulated from the Second-order Derivative of the I-V/Q-V Characteristics," 2010 *IEEE MTT-S International Microwave Symposium Digest*.
10. A. Snider, "Charge Conservation and the Transcapacitance Element: An Exposition," *IEEE Transactions on Education*, Vol. 38, No. 4, November 1995, pp. 376-379.
11. R.G. Brady, G. Rafael-Valdivia and T. Brazil, "Large-signal FET Modeling Based on Pulsed Measurements," 2007 *IEEE MTT-S International Microwave Symposium Digest*, pp. 593-596.
12. K.S. Yuk and G.R. Branner, "An Empirical Large-signal Model for SiC MESFETs with Self-heating Thermal Model," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 56, No. 11, November 2008, pp. 2671-2680.
13. A. Jarndal and G. Komp, "Large-signal Model for AlGaIn/GaN HEMTs Accurately Predicts Trapping- and Self-heating-induced Dispersion and Intermodulation Distortion," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 54, No. 11, November 2007, pp. 2830-2836.
14. G. Dambrine, A. Cappy, F. Heliodore and E. Playez, "A New Method for Determining the FET Small-signal Equivalent Circuit," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 36, No. 7, July 1988, pp. 1151-1159.
15. Z.H. Liu, G.I. Ng, S. Arulkumaran, Y.K.T. Maung, K.L. Teo, S.C. Foo, V. Sahmuganathan, T. Xu and C.H. Lee, "High Microwave-noise Performance of AlGaIn/GaN MISHEMTs on Silicon with Al₂O₃ Gate Insulator Grown by ALD," *IEEE Electron Device Letters*, Vol. 31, No. 2, February 2010, pp. 96-98.
16. "DiVA [Dynamic I-V Analyzer]," Nanometrics Inc., Milpitas, CA, 2008. Available: www.nanometrics.co.kr/products/Diva.html
17. S.A. Maas, "How to Model Intermodulation Distortion," 1991 *IEEE MTT-S International Microwave Symposium Digest*, pp. 149-151.

Lin-Sheng Liu received the bachelor's degree (with honors) in electronic engineering from the University of Electronic Science and Technology of China (UESTC), Chengdu, China, in 2005, and is currently working toward his Ph.D. degree in circuits and systems at UESTC. His current research interests include the characterizations/ modeling of III-V compound semiconductor devices and high-efficiency switch-mode PA design.

SP12T RF SWITCHES

Non-Terminated & Terminated

OUTSTANDING
PERFORMANCE

MADE IN
THE USA



Visit Us
At the
IMS 2011
Booth
#4809

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

When Performance Counts

Lowest Integrated Jitter

Wireline

Wireless

Military & Space

Industrial

◀◀ **Samples Available In 1 Week** ▶▶

Low Noise LVPECL XO

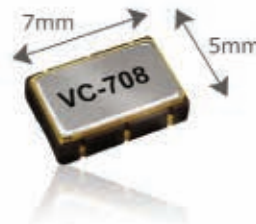
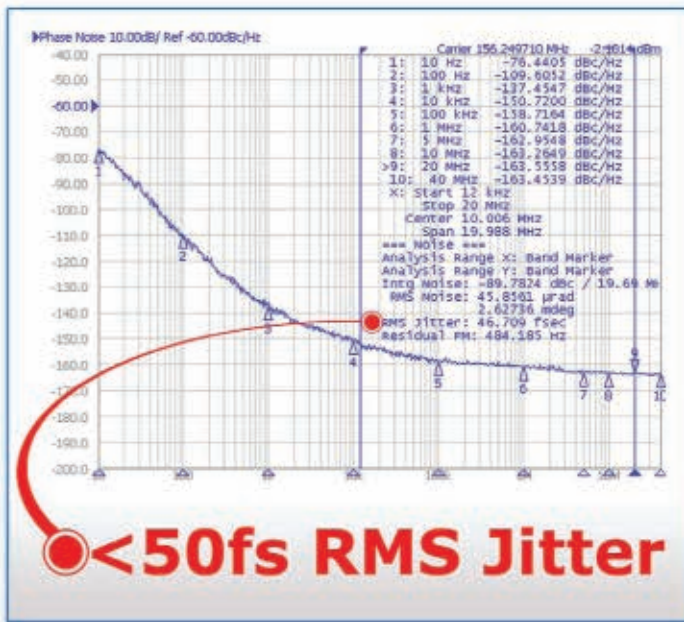
The **VC-708** is an ultra low noise LVPECL XO, designed for applications that require a cost effective and low footprint way to supply a high spectral purity clock source.

Communications, Industrial & Medical Applications

- High Speed Converters
- FPGA or ASIC Reference Clocks
- 10G, 40G, Ethernet PHYs

How You Benefit

- Improving signal integrity and enhancing your jitter budgets.
- Uncomparable phase noise resulting in the lowest jitter performance.
- Available Frequencies - 125 MHz, 156.25 MHz, 161.1328 MHz, 200 MHz.



No Spurious, No Synthesized Harmonics
Ultra-Low Jitter Performance

Precision Frequency Control and Timing Solutions

OCXO/EMXO

TCXO

VCXO

VCXO

Jitter Attenuation

SAW Filter

Clocks/XO

Crystals

Timing Solutions

Hi-Temp Electronics

For more information on this product visit www.vectron.com/products/xo/vc-708.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.**

See us at MTT-S Booth 1002



Helping Customers
 Innovate, Improve & Grow

VECTRON
 INTERNATIONAL

A DOWER COMPANY

DESIGN OF A WIDE STOPBAND BANDPASS FILTER WITH SOURCE-LOAD COUPLING

This article presents a microstrip bandpass filter (BPF) for wireless LAN applications. The BPF offers a wide upper stopband by using two novel slow-wave resonators. Two transmission zeros are generated on both sides of the passband as a result of source-load coupling. The measured results show that this BPF has good characteristics, including a low insertion loss of 1.66 dB at the center frequency of 2.4 GHz and a wide upper stopband up to 7 GHz. Comparison of measured and simulated results shows very good agreement.

With the rapid development of communication technology, there have been increasing demands for advanced radio frequency (RF) filters with small size, wide stopband and high selectivity. To realize better selectivity, the generation of transmission zeros is very important in the synthesis of modern filters. Most of the research efforts are focused on filters where both the source and the load are connected to only one resonator.^{1,2} Such filters can generate at most $N-2$ finite transmission zeros with N -coupled resonators. However, when source/load coupling is

involved, N finite transmission zeros from N -coupled resonators can be obtained.³⁻⁶

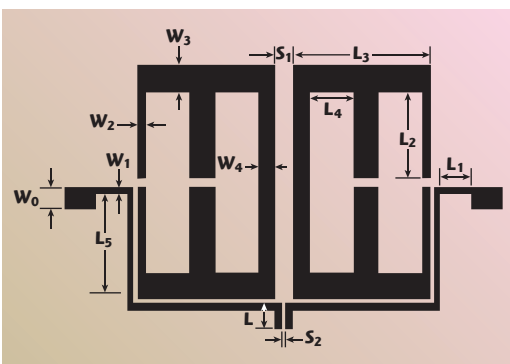
In order to improve the performance of out-of-band rejection, a number of technologies have been widely investigated. For example, utilizing stepped impedance resonators (SIR) or slow-wave resonators is the con-

venient method to realize wide stopband.⁷⁻⁹ In addition, a feeding scheme with L-shaped lines has been proposed to suppress the harmonic.¹⁰ Although conventional slow-wave resonators possess the advantages of miniaturization and a wide stopband, these filters suffer from loose coupling between resonator and feeding line, resulting in high external quality factor.

In this article, a two-order filter, operating at 2.4 GHz for application in a wireless local area network (WLAN) system, is proposed. Two slow-wave resonators and corresponding feeding structures are introduced to enhance the tunable range of the external quality factor. Using source/load coupling can realize two controllable transmission zeros. Measured and simulated results show that this filter cannot only obtain high selectivity, but also achieve wide upper stopband as well.

FILTER DESIGN

Figure 1 shows the layout of the proposed microstrip BPF using two slow-wave resona-



▲ Fig. 1 Layout of the proposed microstrip BPF.

ZHONG YIN XIAO, SHAN GAO, DE CHEN MA AND LIANG LIANG XIANG
Shanghai University, Shanghai, China



Z~Communications, Inc.

ISO 9001:2008 Certified



Voltage-Controlled Oscillators

40 MHz to 8 GHz

- Ultra Linear Tuning
- Filtered Harmonics
- Value Pricing
- Quick Turnaround
- Octave Bandwidths
- Superior Phase Noise
- Low pushing and pulling
- Low frequency drift

*Your Trusted Source for High Quality Products,
Performance and Delivery*

Low Phase Noise VCOs

VCO Part No.	Frequency (MHz)	Tuning Voltage (Vdc)	PN @ 10kHz (1 Hz BW, typ.) (dBc/Hz)
V220ME02-LF	200-239	0.5-4.5	-121
CRO0410A-LF	390-430	0.5-4.5	-117
CLV0625B-LF	540-710	0.5-11.5	-114
ZRO0833A1LF	826-841	0.3-4.7	-122
ZRO1560A1LF	1560-1560	0-5	-121
CRO1900B-LF	1898-1902	0.5-4.5	-121
CRO2065B-LF	2005-2065	0.5-4.5	-112
CRO2542A-LF	2545-2560	0.5-4.5	-115
CRO3344A-LF	3339-3349	0.5-4.5	-115
CRO5750Z-LF	5740-5760	0.5-4.5	-106

Octave Tuning VCOs

VCO Part No.	Frequency (MHz)	Tuning Voltage (Vdc)	PN @ 10kHz (1 Hz BW, typ.) (dBc/Hz)
V150ME03-LF	100-200	0-12.5	-115
V350ME24-LF	200-400	1-16	-95
V560ME11-LF	400-800	0.5-5.1	-101
V500ME03-LF	500-1000	0-11	-105
V585ME73-LF	600-1200	0-13	-100
V585ME30-LF	800-1600	1-21	-103
V585ME46-LF	1000-2000	1-20	-100
V600ME10-LF	1600-3200	0.5-20	-89
V600ME14-LF	2000-4000	0-24	-89
V600ME45-LF	3000-6000	0-24	-74

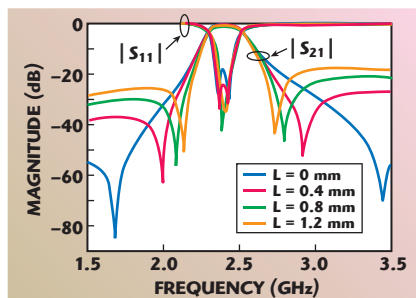
Visit us in Baltimore at the 2011 IEEE MTT-S International Microwave Symposium, June 7-9, **Booth 313**

For ordering and pricing information visit www.zcomm.com

14118 Stowe Drive, Suite B | Poway, CA 92064 | Tel: (858) 621-2700 | Fax: (858) 486-1927 | sales@zcomm.com

tors. **Figure 2** illustrates the structure of the proposed slow-wave resonator. Two opposite open stubs are added inside of the slow-wave resonator to achieve a compact size. Compared with the conventional slow-wave resonator, it results in a smaller external quality factor. The required 2.4 GHz

center frequency of the BPF (as specified in the IEEE 802.11a/b standard for WLAN), is obtained by adjusting the size of the resonator and the position of open stubs. In **Figure 3**, the simulated results show the frequency responses of the proposed BPF under different source/load coupling lengths L . The length L is introduced to provide source/load capacitive coupling. When L increases from 0 to 1.2 mm, the return loss in the passband is reduced, while a pair of transmission zeros is closer to the passband. Thus, sharper fall-off at both passband edges can be achieved.

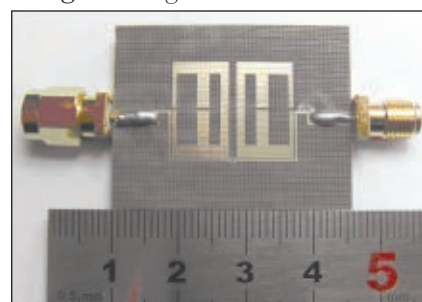


▲ Fig. 3 Simulated frequency responses of the proposed BPF for different source-lead coupling lengths.

According to the above analysis procedure, the dimensions of the filter are obtained as follows: $L = 0.6$ mm, $L_1 = 1.5$ mm, $L_2 = 5.2$ mm, $L_3 = 8.4$ mm, $L_4 = 1.7$ mm, $L_5 = 7.2$ mm, $W_0 = 2.1$ mm, $W_1 = 0.4$ mm, $W_2 = 0.6$ mm, $W_3 = 1.8$ mm, $W_4 = 1.2$ mm, $S_1 = 1.2$ mm and $S_2 = 0.2$ mm. The thickness of the substrate used here is 0.8 mm, and its relative dielectric constant is 2.78.

MEASURED RESULTS

A photograph of the fabricated BPF is shown in **Figure 4**. The S-parameters are measured by using a network analyzer, Agilent 8722ES, and are plotted in **Figure 5** together with EM simulat-



▲ Fig. 4 Photograph of fabricated microstrip bandpass filter.

10 MHz Distribution Amplifier

- Sine wave outputs (+13 dbm)
- Amplitude leveling
- Low additive phase noise
- High channel-to-channel isolation
- High return loss
- \$1250 (US list)



The new FS730 series of distribution amplifiers from SRS provide state-of-the-art solutions for distributing 10 MHz, Broadband (50 Ω and 75 Ω), CMOS Logic and SDI digital video. Both bench-top and rack-mount configurations are available.

The FS730/1 10 MHz distribution amplifier uses an input limiter design, which removes amplitude modulation from the signal, provides fixed amplitude outputs and blocks input noise. Virtually any 10 MHz waveform with a duty cycle near 50% may be used as an input.



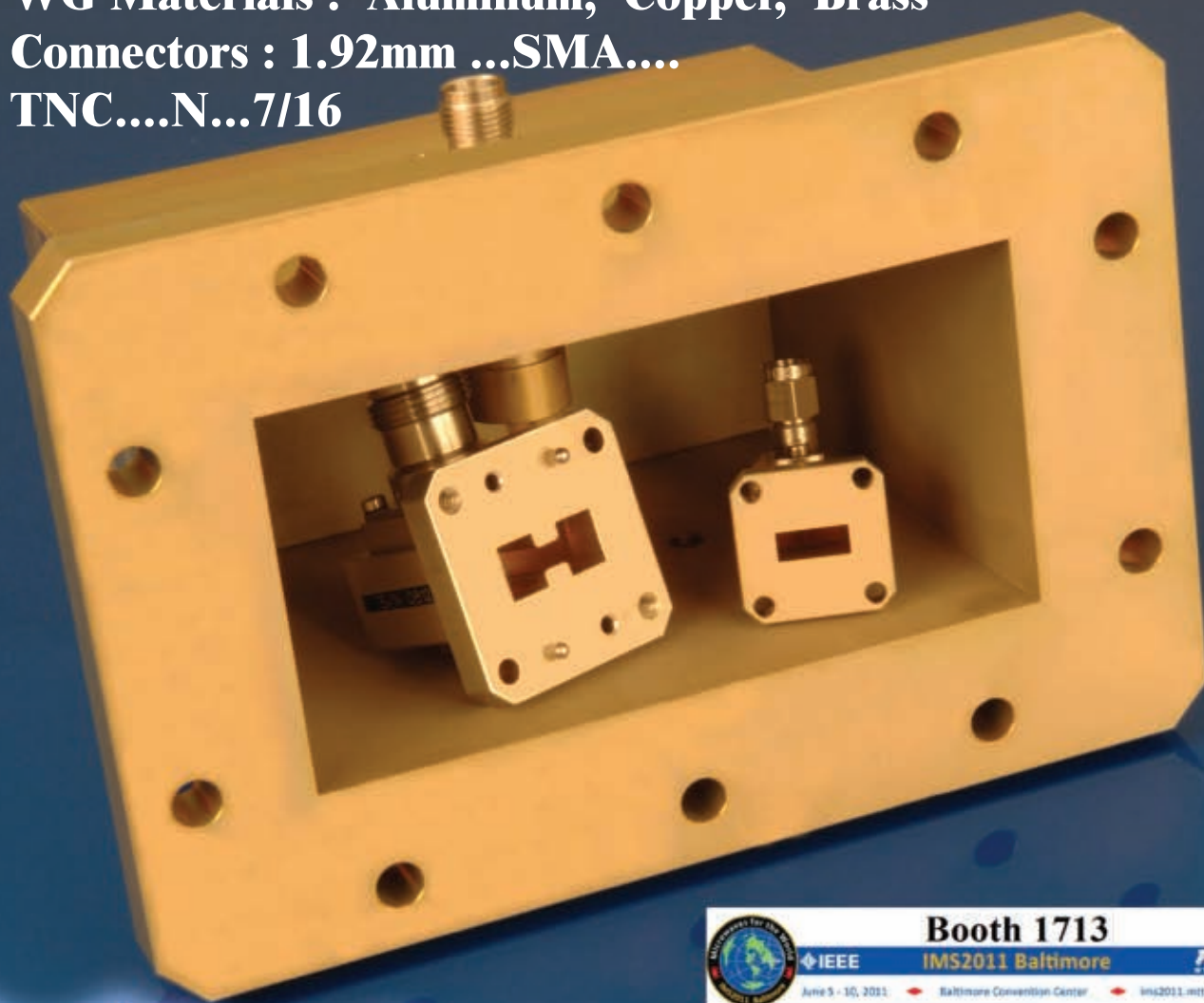
Big and Small, we have 'em all

Almost any Waveguide to almost any Coax Connector

WG Materials : Aluminum, Copper, Brass

Connectors : 1.92mm ...SMA....

TNC...N...7/16



Spectrum
Elektrotechnik GmbH

when Quality is needed

80905 Munich, Germany

Telephone: +49-89-3548-040

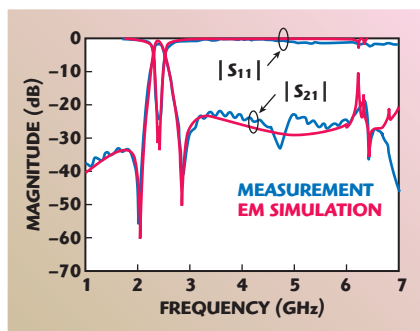
WWW.SPECTRUM-ET.COM

P.O. Box 450533

Facsimile: +49-89-3548-0490

Email: Sales@Spectrum-et.com

WG-Big&SmallE6IMS



▲ Fig. 5 Comparison of simulated and measured frequency responses.

ed results. The measured results show a return loss of 24 dB, a minimum insertion loss of 1.66 dB in the passband, FBW of 3.3 percent at 2.4 GHz, and better than -20 dB rejection level in the upper stopband, up to 7 GHz. Two transmission zeros are clearly observed at 2.01 GHz with -56 dB attenuation and 2.88 GHz with -41 dB attenuation. The insertion loss is mainly attributed to the SMA connector and the conductor and dielectric losses. Due to the pair generation of transmission zeros on both sides of the passband, a better selectivity is realized.

CONCLUSION

A novel microstrip bandpass filter, using slow-wave resonators, is presented. The measured results show good characteristics, such as low insertion loss in the passband, a wide upper stopband and high passband selectivity. This performance agrees closely with the simulation. With these features, the proposed BPF is suitable for WLAN applications.

ACKNOWLEDGMENTS

This work is supported by the Shanghai Natural Science Foundation (10ZR1411900) and the Leading Academic Discipline Project and STCSM (S30108 and 08DZ2231100) and the Graduate Student Innovative Foundation of Shanghai University (SHUCX092127). ■

References

1. C.S. Ahn, J. Lee and Y.S. Kim, "Design Flexibility of an Open-loop Resonator Filter Using Similarity Transformation of Coupling Matrix," *IEEE Microwave and Wireless Components Letters*, Vol. 15, No. 4, April 2005, pp. 262-264.
2. Y.M. Chen, S.F. Chang, C.C. Chang and T.J. Hung, "Design of Stepped-impedance Combine Bandpass Filters with Symmetric Insertion-loss Response and Wide Stopband Range," *IEEE*

Transactions on Microwave Theory and Techniques, Vol. 55, No. 10, October 2007, pp. 2191-2199.

3. X.C. Zhang, Z.Y. Yu and J. Xu, "Design of Microstrip Dual-mode Filters Based on Source-load Coupling," *IEEE Microwave and Wireless Components Letters*, Vol. 18, No. 10, October 2008, pp. 677-679.
4. Y.X. Wang, B.Z. Wang and J.P. Wang, "The Design of a Coupled Resonator Bandpass Filter with Wide Stop-band," *IEEE Microwave and Wireless Components Letters*, Vol. 18, No. 4, April 2008, pp. 251-253.
5. R.J. Cameron, "Advanced Coupling Matrix Synthesis Techniques for Microwave Filters," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 51, No. 1, January 2003, pp. 1-10.
6. U. Rosenberg and S. Amari, "Novel Coupling Schemes for Microwave Resonator Filters," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 50, No. 12, December 2002, pp. 2896-2902.
7. C.W. Tang and M.C. Chen, "Wide Stopband Parallel-coupled Stacked SIRs Bandpass Filters with Open-stub Lines," *IEEE Microwave and Wireless Components Letters*, Vol. 16, No. 12, December 2006, pp. 666-668.
8. Y.C. Chang, C.H. Kao, M.H. Weng and R.Y. Yang, "Design of the Compact Wideband Bandpass Filter with Low Loss, High Selectivity and Wide Stopband," *IEEE Microwave and Wireless Components Letters*, Vol. 18, No. 12, December 2008, pp. 770-772.
9. J.S. Hong and M.J. Lancaster, *Microstrip Filters for RF/Microwave Applications*, John Wiley & Sons, New York, NY, 2001.
10. X.D. Huang and C.H. Cheng, "A Novel Microstrip Dual-mode Bandpass Filter with Harmonic Suppression," *IEEE Microwave and Wireless Components Letters*, Vol. 16, No. 7, July 2006, pp. 404-406.

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 44 Ghz

LP Filter
HP Filter

Prescale 2-25 Ghz

20-50 Ghz Mixer

Freq. Ranges
2-18 Ghz
18-50 Ghz
38-70 Ghz
Power Split

X2 18-50 Ghz
38-70 Ghz

TTL Control
Switch 2-50 Ghz

1352 Blue Oaks Blvd Suite 140

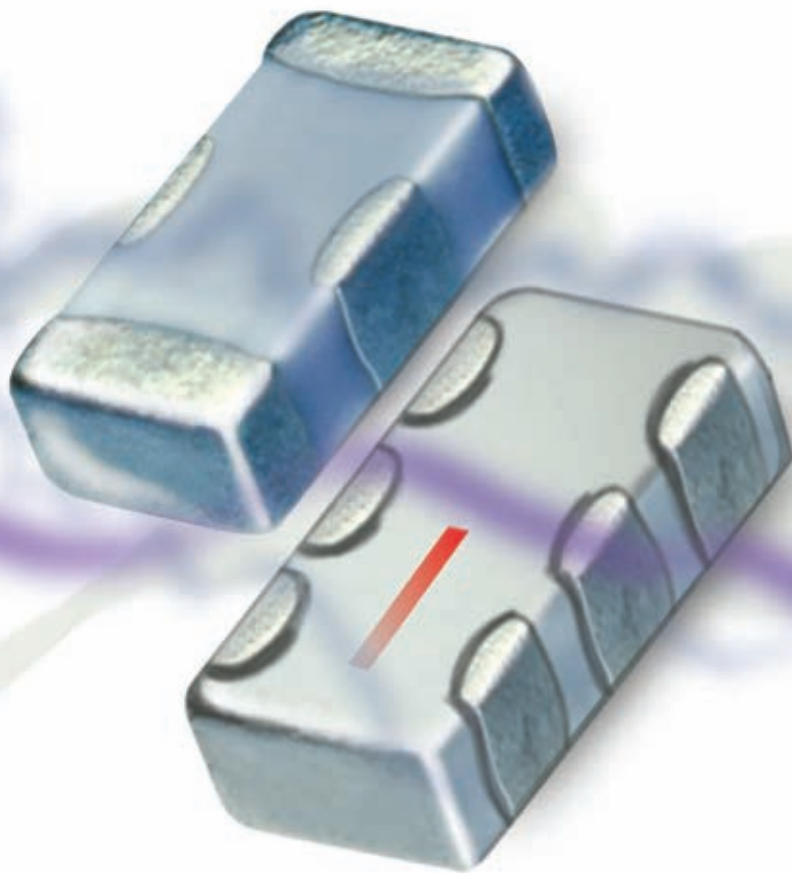


Roseville CA 95678 (916) 773-4424

Built to Last

www.wrighttec.com





CERAMIC FILTERS

LOW PASS BANDPASS HIGH PASS



*Value Packed
Recession Busters!*

from **99¢** ea. qty. 1000

In today's tough economic situation there is no choice: Reducing cost while improving value is a must. Mini-Circuits has the solution...**pay less and get more** for your purchases with our industry leading ultra small ceramic filters.

156

Over ~~141~~ models...45 MHz to 13 GHz

Measuring 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 environmental specifications. And you can even order direct from our web store and have a unit in your hands as early as tomorrow!

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

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



Choose any 8, LFCN, HFCN models.

Receive 5 of ea. model, for a total of 40 filters.

Order your KWC-LHP FILTER KIT TODAY!

 **RoHS compliant** U.S. Patent 6,943,646

Mini-Circuits®
ISO 9001 ISO 14001 AS9100 CERTIFIED

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



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

minicircuits.com

IF/RF MICROWAVE COMPONENTS

See us at MTT-S Booth 1031

432 rev L

FAST CALCULATION OF TRANSIMPEDANCE GAIN AND EQUIVALENT INPUT NOISE CURRENT DENSITY FOR HIGH-SPEED OPTICAL PREAMPLIFIER DESIGN

Analytical expressions for the relationships between the transimpedance gain and S-parameters, equivalent input noise current density and noise figure for high-speed optical transimpedance amplifier design are proposed in this article. This technique is based on the signal and noise equivalent circuit models of the optical transimpedance preamplifier. The transimpedance gain and equivalent input noise current density can be obtained directly from measured S-parameters and noise figure, without any additional measurement equipment. A 10 Gb/s high electron mobility transistor (HEMT)-based transimpedance preamplifier has been designed and the measured S-parameters and noise figure have been used to demonstrate this approach.

Optoelectronic integrated circuits (OEIC) have attracted the interest of many researchers because of their important role in the hardware for information technology. The optical receivers have key roles in high-speed optical fiber communications, in high-speed chip-to-chip interconnections in computers, efficient networking between computers and in other diverse areas such as medical imaging. One of the most critical building blocks in an optical link system is the transimpedance amplifier (TIA), which converts the photodiode (PD) current into an amplified voltage. The requirements for a typical TIA are high bandwidth, high transimpedance gain, adequate power gain, low noise, low input impedance, small area and low power consumption for array applications.¹⁻⁴

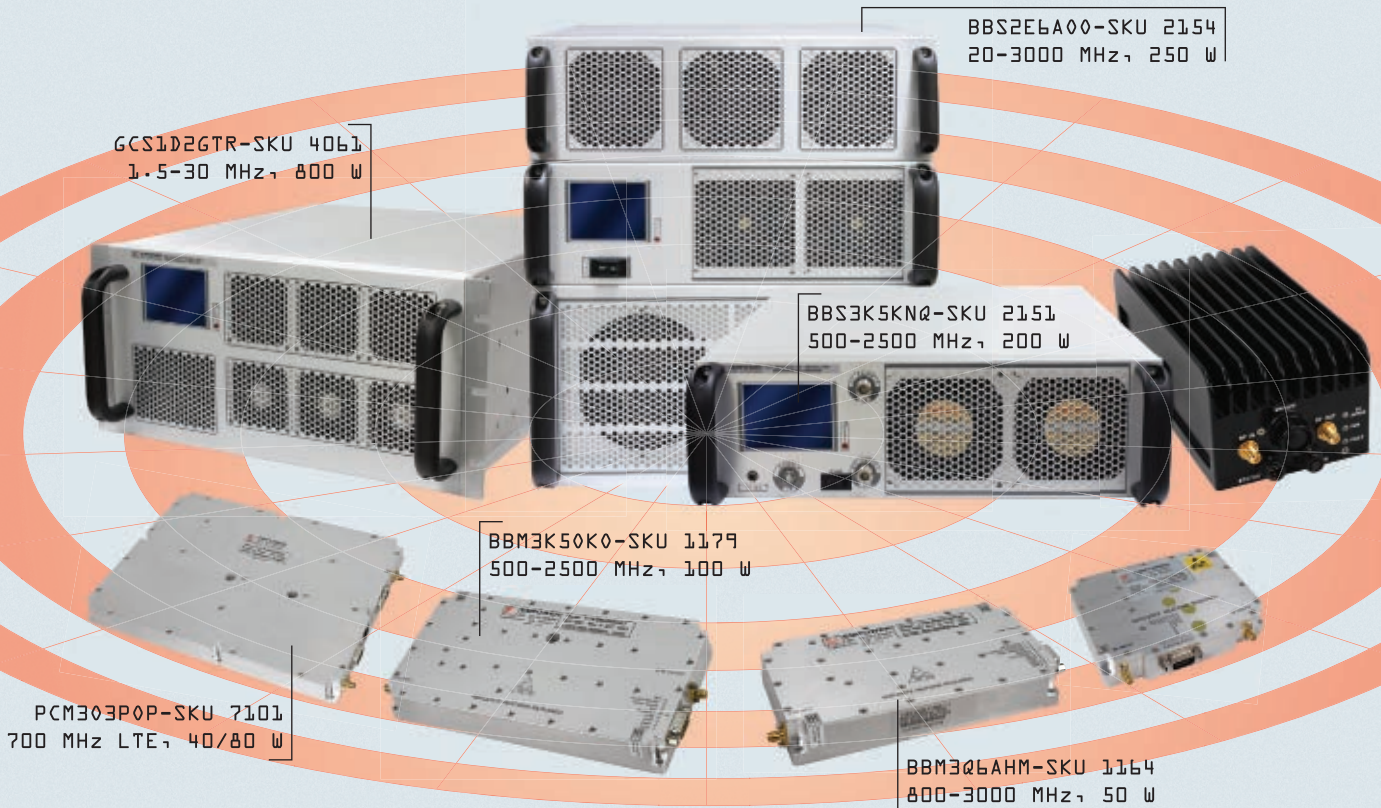
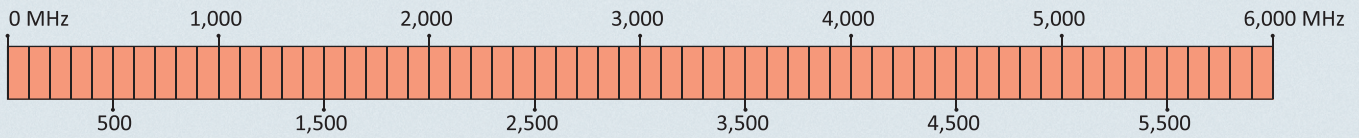
The major design goals of the TIAs are the transimpedance gain and equivalent input noise current density. The transimpedance gain of the TIAs must be large enough to overcome the noise of the subsequent stage, typically a 50 Ω driver or a limiting amplifier. The equivalent input noise current density determines the minimum input current that yields a given bit error rate, directly impacting the link budget. Unfortunately, the transimpedance gain and equivalent input noise current density cannot be measured directly from microwave and noise equipment, while the S-parameters and

JIANJUN GAO
East China Normal University
Shanghai, P.R. China

POWER AMPLIFIER SOLUTIONS

scalable solid state

MODULES - SYSTEMS - QUALIFIED CUSTOMIZATION



worldwide coverage



- Standard products and multi-function HPA solutions built per customer specification
- Experienced design team focused on **EW/Radar/Digital communications/Test applications**
- CE and MIL-STD certified products



www.EmpowerRF.com

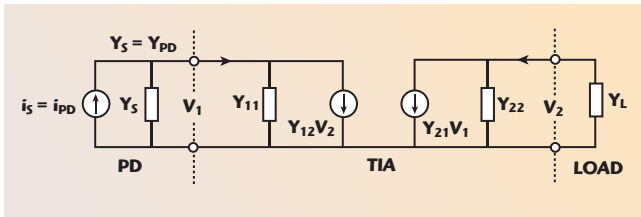


EMPOWER
RF SYSTEMS, INC.



IMS2011 Baltimore

BOOTH# 1047 & 947



▲ Fig. 1 Simulated model of the optical receiver front-end.

noise figure of the TIAs can be measured with a vector network analyzer (VNA) and a noise figure meter in a straightforward manner. Therefore, a

impedance gain and equivalent input noise current of optical receivers have been derived⁵ and simple expressions for the relationship between the

fast transformation between S-parameters/noise figure and transimpedance gain/equivalent input noise current density is needed.

Analytical expressions for transimpedance gain and equivalent input noise current of optical receivers have been derived⁵ and simple expressions for the relationship between the

transimpedance gain and Z-parameters are given.⁶⁻⁸ However, these expressions are not always valid and the transimpedance gain and equivalent input noise current density cannot be directly and accurately calculated from S-parameters and noise figure measurement data. Based on the author's knowledge, a comprehensive analysis for fast transformation between S-parameters/noise figure and transimpedance gain/equivalent input noise current density has not yet been published.

In this article, a simple but efficient transformation technique for TIAs is proposed and the analytical expressions for the relationships between the transimpedance gain and S-parameters, the equivalent input noise current density and the noise figure for high-speed optical transimpedance preamplifier design are derived. This technique is based on the signal and noise equivalent circuit model of the optical receiver front-end.

In contrast with previous publications,⁵⁻⁸ this method has the following advantages:

- The transimpedance gain can be directly derived from S-parameters for arbitrary source and load impedances and simplified expressions for two special cases (source impedances are zero and $50\ \Omega$) are also given.
- The equivalent input noise current density can be determined from noise figure measurements without four noise parameters (minimum noise figure, noise resistance and optimum source reflection coefficient) of TIA in $50\ \Omega$ and non- $50\ \Omega$ systems.

THEORETICAL ANALYSIS

Transimpedance Gain

The schematic of the optical receiver front-end circuit is shown in **Figure 1**, where Y_S is the photodiode (PD) input admittance. Typically this will be that of the PIN/APD and it is almost totally capacitive (that is $Y_S = j\omega C_{pd}$). Y_L is the load admittance, which is generated by the input admittance of the next stage (typically $Y_L = Y_0 = 0.02\ \text{mS}$).

The transimpedance is defined as the magnitude of the ratio of the output voltage V_2 at a load impedance and the photocurrent through the photo-

Thinking SMPM Think Aeroflex

SMPM Attenuators DC - 26.5 GHz



SMPM Terminations DC to 50 GHz



These new SMPM attenuators are ideal for use where space is limited. They provide reliable high performance, excellent RF characteristics, and all under .75" in length.

The SMPM terminations, are offered in two models, TMP400F and TMP500F, operating from DC to 40 GHz and 50 GHz respectively. Both the attenuator and termination mate with GPPO™ and SMPM male connectors and are ideal for both production and test and measurement applications alike.

These high frequency components each offer top cost-to-performance ratios, and excellent quality workmanship.

To learn more, request a quote, or to buy, visit:

www.aeroflex.com/mpmj

888-244-6638

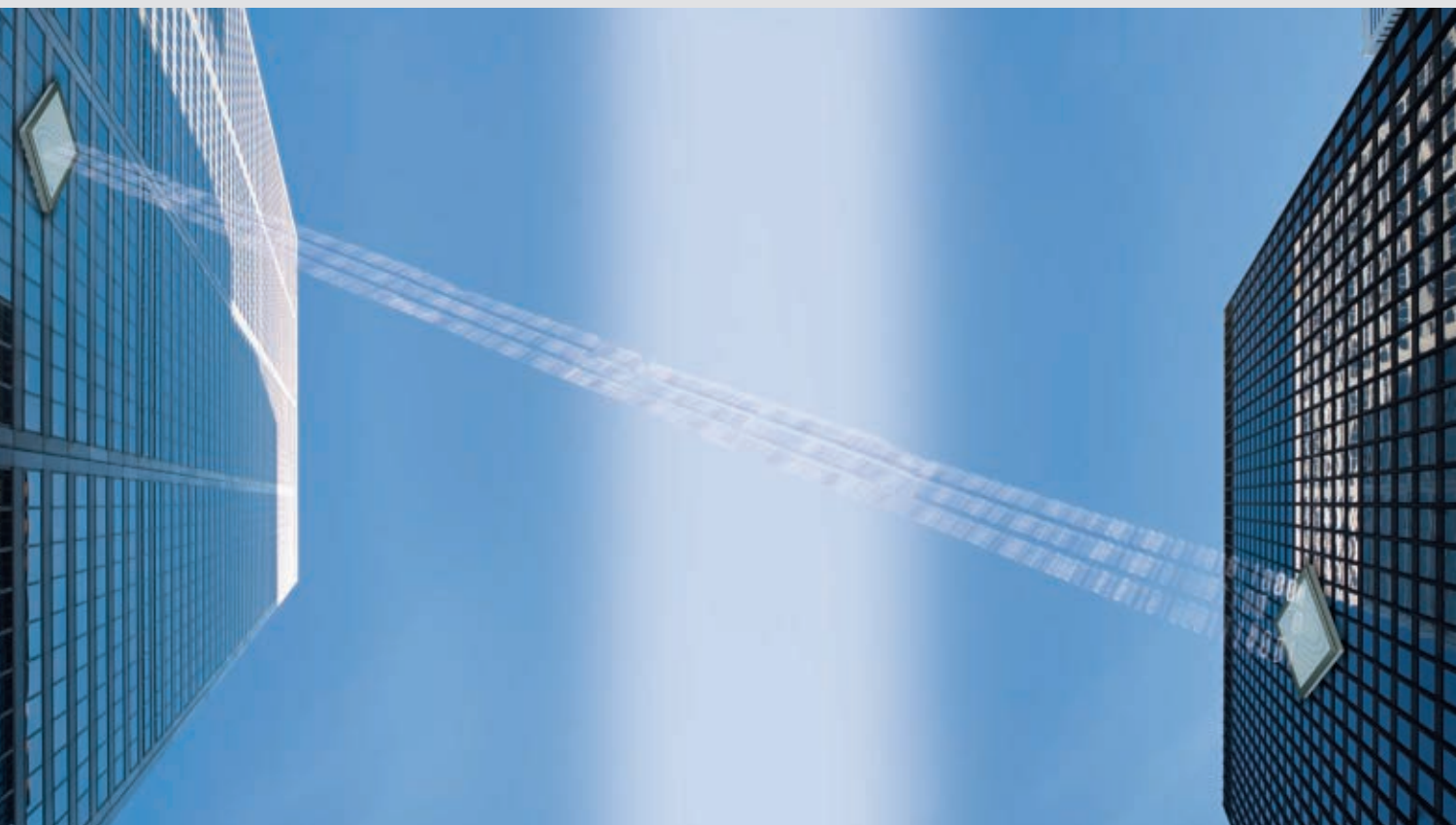
Aeroflex / Inmet
Ann Arbor, Michigan

AEROFLEX
INMET

An ISO 9001 Certified Company

Visit us at MTT-S, booth 2212

AEROFLEX
A passion for performance.



«Wireless Broadband Transmission»



60 GHz Wireless Ethernet Bridge

- High data rate (up to 2 Gbit/s)
- Immune to interference
- Easy installation and adjustment (point-to-point)
- Low power consumption
- Small form factor
- Only one cable connection

diode i_s . Based on the small-signal circuit model analysis for an optical receiver front-end and applying Kirchhoff's current law, the transimpedance gain of the optical receiver front-end can be expressed as:

$$Z_T = \frac{V_2}{i_s} = -\frac{Y_{21}}{(Y_S + Y_{11})(Y_L + Y_{22}) - Y_{21}Y_{12}} \quad (1)$$

The relationship between the S-parameters and Y-parameters can be expressed as:

$$Y_{11} = Y_o \frac{(1 + S_{22})(1 - S_{11}) + S_{12}S_{21}}{(1 + S_{22})(1 + S_{11}) - S_{12}S_{21}} \quad (2)$$

$$Y_{12} = Y_o \frac{-2S_{12}}{(1 + S_{22})(1 + S_{11}) - S_{12}S_{21}} \quad (3)$$

$$Y_{21} = Y_o \frac{-2S_{21}}{(1 + S_{22})(1 + S_{11}) - S_{12}S_{21}} \quad (4)$$

$$Y_{22} = Y_o \frac{(1 + S_{11})(1 - S_{22}) + S_{12}S_{21}}{(1 + S_{22})(1 + S_{11}) - S_{12}S_{21}} \quad (5)$$

where $Y_o (= 0.02 \text{ mS})$ is the characteristic admittance of the system.

Substituting Equations 2 to 5 into Equation 1:

$$Z_T = \frac{V_2}{i_s} = \frac{2S_{21}}{Y_o A + Y_L B + Y_S C + Y_S Y_L D / Y_o} \quad (6)$$

with

$$A = (1 - S_{11})(1 - S_{22}) - S_{12}S_{21}$$

$$B = (1 - S_{11})(1 + S_{22}) + S_{12}S_{21}$$

$$C = (1 + S_{11})(1 - S_{22}) + S_{12}S_{21}$$

$$D = (1 + S_{22})(1 + S_{11}) - S_{12}S_{21}$$

If the source impedance is infinite (that is $Y_S = 0$), and the output end of the TIA is connected to a matched load (that is $Y_L = Y_o = 0.02 \text{ mS}$), the corresponding transimpedance gain of the receiver front-end can be simplified as follows:


$$Z_T^T = \frac{S_{21}}{Y_o (1 - S_{11})} \quad (7)$$

when the TIA is operated in a 50Ω system ($Y_L = Y_S = Y_o = 20 \text{ mS}$), the transimpedance gain can be written as:

$$Z_T^{50} = \frac{S_{21}}{2Y_o} \quad (8)$$


The transimpedance gain and bandwidth versus Y_S and Y_L are summarized in **Table 1**. It can be observed that the transimpedance 3 dB bandwidth can be determined from the forward transmission coefficient S_{21} only when the input and output ports are terminated in matched loads. The physical meanings of the three transimpedance gains mentioned above are as follows: Z_T is the transimpedance gain of whole optical receiver front-end (PD+TIA); Z_T^T is the transimpedance gain of TIA; and Z_T^{50} is proportional to the power gain S_{21} of the TIA.

Microwave Multi-Octave Directional Couplers Up to 40 GHz



Frequency Range	I.L. (dB) min.	Coupling Flatness max.	Directivity (dB) min.	VSWR max.	Model Number
0.5-2.0 GHz	0.35	± 0.75 dB	23	1.20:1	CS*-02
1.0-4.0 GHz	0.35	± 0.50 dB	23	1.20:1	CS*-04
0.5-8.0 GHz	1.00	± 0.80 dB	15	1.50:1	CS10-24
2.0-8.0 GHz	0.35	± 0.40 dB	20	1.25:1	CS*-09
0.5-12.0 GHz	1.00	± 0.80 dB	15	1.50:1	CS*-19
1.0-18.0 GHz	0.90	± 0.50 dB	15 12	1.50:1	CS*-18
2.0-18.0 GHz	0.80	± 0.50 dB	15 12	1.50:1	CS*-15
4.0-18.0 GHz	0.60	± 0.50 dB	15 12	1.40:1	CS*-16
8.0-20.0 GHz	1.00	± 0.80 dB	15 12	1.50:1	CS*-21
6.0-26.5 GHz	0.70	± 0.80 dB	13	1.55:1	CS20-50
1.0-40.0 GHz	1.60	± 1.50 dB	10	1.80:1	CS20-53
2.0-40.0 GHz	1.60	± 1.00 dB	10	1.80:1	CS20-52
6.0-40.0 GHz	1.20	± 1.00 dB	10	1.70:1	CS10-51

10 to 500 watts power handling depending on coupling and model number.
SMA and Type N connectors available to 18 GHz.
* Coupling Value: 3, 6, 8, 10, 13, 16, 20 dB.



PULSAR
MICROWAVE CORPORATION

www.pulsarmicrowave.com

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

THE IMPOSSIBLE IS NOW POSSIBLE.



Thanks to proprietary new digital-to-analog converter technology, the new high speed Agilent M8190A Arbitrary Waveform Generator makes the impossible, possible. So now, you can enhance your reality and push the limits of your designs even more. That's groundbreaking. That's Agilent.

NEW! Arbitrary Waveform Generator

14 bit resolution

8 GSa/s sampling rate

2 GSa memory

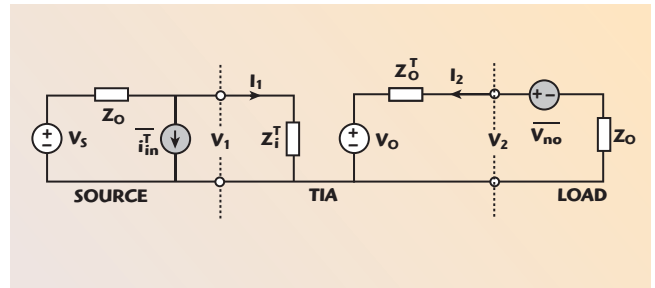
Explore the possibilities—Watch the video
www.agilent.com/find/AgilentAWG



TABLE I

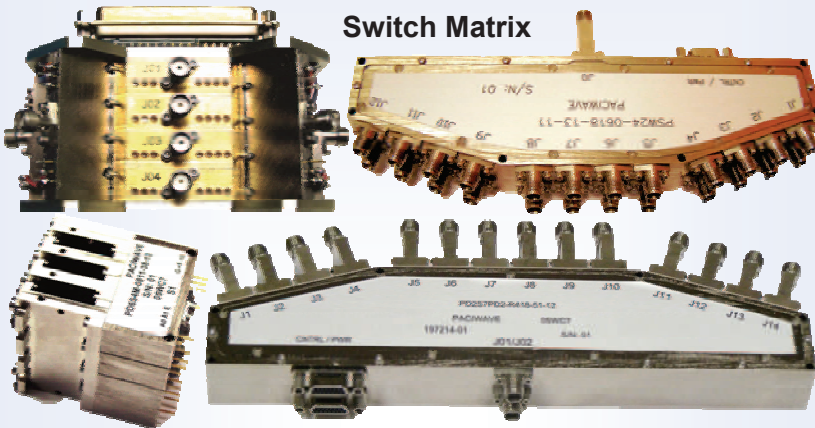
 TRANSIMPEDANCE GAIN VERSUS Y_S AND Y_L

Source and Load Impedances	Transimpedance Gain	Physical Meaning
Arbitrary Y_S and Y_L	Z_T	Receiver front-end (PD+TIA)
$Y_L = Y_O$, $Y_S = 0$	Z_T^T	TIA only
$Y_L = Y_S = Y_O$	Z_T^{50}	Power gain S_{21} of TIA


 Fig. 2 Noise model of the 50 Ω noise figure measurement system for an optical preamplifier.

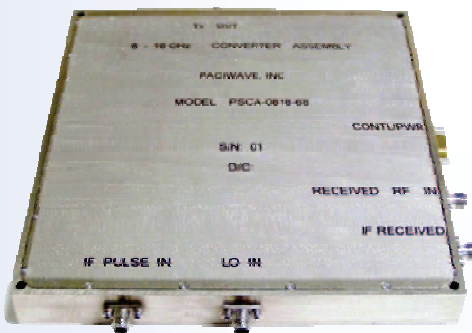
Custom Microwave Integrated Assemblies

As customer requirements drive microwave systems to higher and higher levels of performance, but in smaller and smaller packages, integrating multiple functions into a single compact package is the solution microwave designers have been pursuing. Pacwave is here to support you in the development and manufacture of your highly integrated microwave solutions. Give us a call.

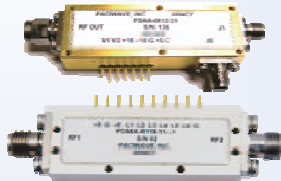
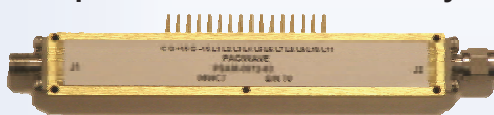


Channelized Frequency Converter

Switch Filter Bank



Amplifier-Attenuator Assembly



PACIWAVE, INC.
Microwave Custom Components & Subsystems
1286 Hammerwood Ave., Sunnyvale, CA 94085 USA
web: www.paciwave.com Phone +1-408-745-0385 FAX +1-408-745-7835
sales@paciwave.com

Please visit us at
IEEE IMS 2011 in
Baltimore, Booth
3510

Equivalent Input Noise Current Density of the TIA

Figure 2 shows the noise model of the noise figure measurement system for an optical preamplifier. It is noted that 50 Ω standard resistances have been used for source and load impedances ($Z_S = Z_L = Z_O = 50 \Omega$). Z_i^T and Z_o^T are the input and output impedances of the TIA, respectively. v_{no} is the total output noise voltage density, and i_{in}^T is the equivalent input noise current density of the TIA.

The noise figure of the TIA can be expressed as follows:¹⁰

$$F_{50} = 1 + \frac{\overline{v_{no}^2}}{4kT|A_v^2|Z_o} \quad (9)$$

then

$$\overline{v_{no}^2} = 4kT|A_v^2|Z_o(F_{50} - 1) \quad (10)$$

Where A_v is the voltage gain and can be expressed as:

$$A_v = \frac{V_2}{V_s} = \frac{S_{21}}{2} = \frac{Z_T^T}{Z_i^T + Z_o} \quad (11)$$

Where Z_T^T is the transimpedance of the TIA ($Z_T^T = V_2 / I_1$). The corresponding equivalent input noise current density of the TIA i_{in}^T can be derived as follows:

$$i_{in}^T = \frac{\overline{v_{no}}}{|Z_T^T|} = \frac{\sqrt{(F_{50} - 1)4kT_0 Z_o}}{|Z_o + Z_i^T|} \quad (12)$$

With $Z_i^T = Z_o \frac{1 + S_{11}}{1 - S_{11}}$ substituted in

Equation 12,

$$i_{in}^T = \frac{\overline{v_{no}}}{|Z_T^T|} = |1 - S_{11}| \sqrt{\frac{(F_{50} - 1)kT_0}{Z_o}} \quad (13)$$

**GREAT SERVICE ISN'T EXPENSIVE...
...IT'S PRICELESS.**

EXCELLENT
SERVICE

EXCELLENT
DELIVERY

EXCELLENT
QUALITY

RF COAXIAL RELAYS

SMA, N AND PCB LAUNCH

STANDARD AND CUSTOM DESIGNS

RELCOMM
TECHNOLOGIES, INC.

- Mission Critical Communications:
 - Security, Safety and Intelligence
 - Commercial Telecom Infrastructure
 - Military Defense Fixed, Mobile & Shipboard
- Instrumentation:
 - Test and Measurement

RF Relay Store.com is the answer to your urgent small quantity needs.

RF Coaxial Relays available from Stock at www.rfrelaystore.com

sales@relcommtech.com • www.relcommtech.com • 410-749-4488

See us at MTT-S Booth 2005

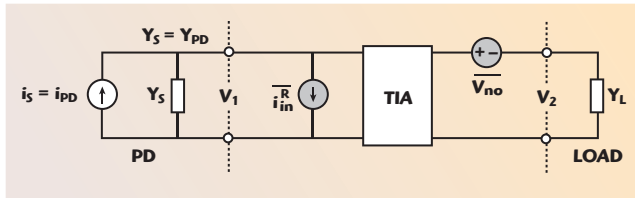
EXCELLENCE BY DESIGN



Equivalent Input Noise Current Density of the Optical Receiver Front-end

Figure 3 shows the noise model of a typical optical receiver front-end in a non- $50\ \Omega$ system, where i_{in}^R is the total equivalent input noise current density and v_{no} is the total output noise

voltage density of the receiver front-end. It is noted that the input port of the TIA is connected to the PD, not the matched load. Therefore, Equa-



▲ Fig. 3 Noise model of the optical receiver front-end.



Designed and developed for your most rigorous and complex applications!

High Reliability • New Product Development / 700+ Products • Value Added Services

- Catalog and custom RF and microwave components to 20 GHz
- 10-50 Watt GaN amplifiers for military and industrial applications
- Integrated assemblies combining multiple component functions
- Integrated subassemblies - Set On Receivers, Frequency Locked Oscillators and Instantaneous Frequency Measurements
- Value added die and component services

MARKETS

- Aerospace: commercial and defense satellites and ground-based satellite control systems
- Defense: avionics, EW, communications and radar
- Industrial: semiconductor and component test and medical equipment

CERTIFICATIONS

- AS9100 • MIL-PRF-38534, Classes H and K • ISO 9001:2008

Teledyne Cougar is your source for RF & Microwave Components, Hi-power Amplifiers, Integrated Subassemblies, Integrated Assemblies, VCOs, Detectors, Mixers and Value-add Service needs.



TELEDYNE COUGAR

A Teledyne Technologies Company

ISO 9001:2008 • AS9100

MIL-PRF-38534 • Class H & Class K Certified

927 Thompson Place • Sunnyvale, CA 94085 • 408-522-3838 • Fax 408-522-3839

www.teledyne-cougar.com • email: cougar@teledyne.com

tion 13 is only valid for TIA design, not for the whole receiver front-end.

Assuming that the total output noise voltage density v_{no} is generated mainly by the TIA (here the noise contribution of the PD is neglected), the equivalent input noise current density of the receiver front-end i_{in}^R can be expressed as follows:

$$i_{in}^R = \frac{v_{no}}{|Z_T|} =$$

$$\frac{1}{2} \left[Y_o A + Y_L B + Y_S C + Y_S Y_L D / Y_o \right] \cdot \sqrt{kT_o Z_o (F_{50} - 1)} \quad (14)$$

Traditionally, the output end of TIA is connected to a matched load ($Y_L = Y_o = 0.02\ \text{mS}$), then i_{in}^R can be written as:

$$i_{in}^R = \frac{v_{no}}{|Z_T|} = \left[1 - S_{11} + (1 + S_{11}) Y_s / Y_o \right] \cdot \sqrt{\frac{kT_o Z_o (F_{50} - 1)}{Z_o}} \quad (15)$$

when the TIA is operated in a $50\ \Omega$ system ($Y_L = Y_S = Y_o = 20\ \text{mS}$), the equivalent input noise current density can be simplified:

$$i_{in}^{50} = 2 \sqrt{\frac{kT_o (F_{50} - 1)}{Z_o}} \quad (16)$$

It is noted that Equation 16 is the conventional formula for predicting the equivalent input noise current density for a TIA IC. The i_{in}^{50} is dependent on the noise figure only, and independent on the S-parameters of the TIA. The equivalent input noise current density versus Y_s and Y_L is summarized in **Table 2**.

EXPERIMENTAL ANALYSIS

In order to demonstrate the expressions derived in the Theoretical Analysis section for the TIA, a HEMT-based TIA, which operates at 10 Gb/s, has been designed using a $0.2\ \mu\text{m}$ PHEMT process.¹¹ Figure 4 shows a schematic of the developed TIA IC, using both enhancement- and depletion-mode (E-D) transistors. This IC consists of three parts: a parallel-feedback amplifier core, a source-follower buffer and an output match stage. The

LET OUR PRODUCTS SOLVE YOUR PROBLEMS

Offering a complete line of High Performance Solid-State Components & Assemblies to 40GHz

Amplifiers

Attenuators

Detectors

DLVA's

ERDLVA's

Filters

Frequency
Discriminators

IQ Modulators

Integrated Modules

Limiters

Log Amps

Modulators

Phase Shifters

Power Dividers

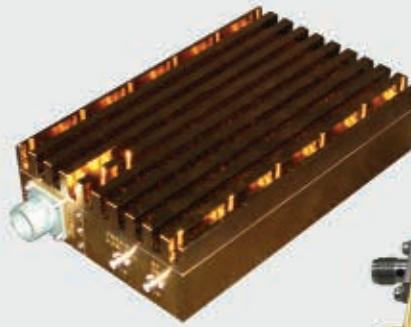
Receiver Front-Ends

SDLVA's

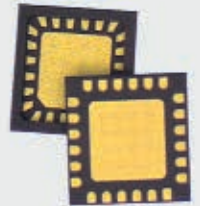
Solid-State Switches

Switch Filter Banks

Threshold Detectors



PMI is a dedicated OEM that strives for total customer satisfaction by providing our customers with rapid response and high-quality products at reasonable pricing. We utilize our 40 years of design heritage to provide solutions and not just a product. PMI offers custom products at catalog prices. Trust in PMI to be your partner and success is right around the corner.



Maryland Based OEM



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

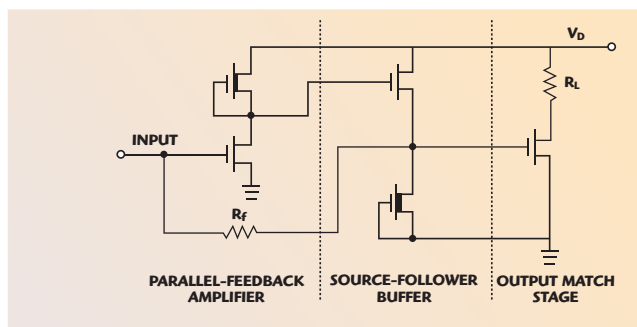
ISO9001:2008 Certified

Please visit us in Booth No. 2304 at the IEEE MTT-S in Baltimore, MD
June 5 to 10th.

TABLE II

EQUIVALENT INPUT NOISE CURRENT DENSITY VERSUS Y_S AND Y_L

Source and Load Impedances	Input Noise Current Density	Physical Meaning
Arbitrary Y_S and Y_L	$\overline{i_{in}^2 R}$	Receiver front-end (PD+TIA)
$Y_L = Y_O$, $Y_S = 0$	$\overline{i_{in}^2 T}$	TIA only
$Y_L = Y_S = Y_O$	$\overline{i_{in}^2 50}$	Only dependent on noise figure TIA



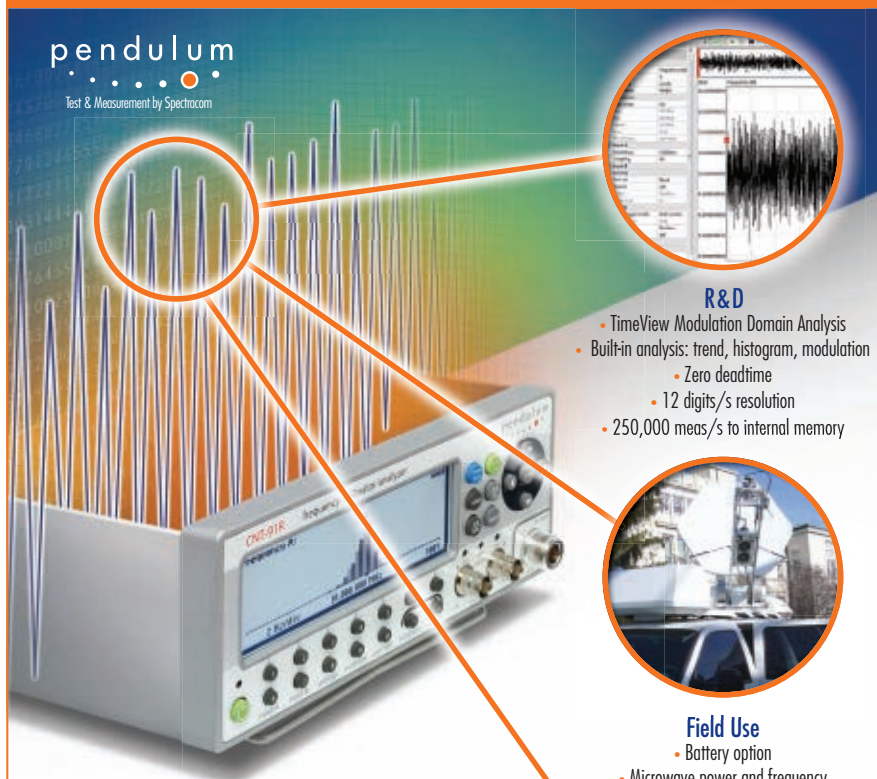
▲ Fig. 4 Schematic of the 10 Gb/s HEMT-based TIA IC.

CNT-90 FAMILY

TIMER / COUNTER / ANALYZERS

pendulum

Test & Measurement by Spectracom



R&D

- TimeView Modulation Domain Analysis
- Built-in analysis: trend, histogram, modulation
 - Zero deadtime
 - 12 digits/s resolution
- 250,000 meas/s to internal memory

Field Use

- Battery option
- Microwave power and frequency analysis up to 60 GHz
- Portable calibrator with rubidium
 - Easy to use

Test Systems

- Measurement speed up to 15,000/s via GPIB or USB
- 53131 compatibility
- Affordable

Real Time Frequency Analysis within Reach

A comprehensive family of measurement AND analysis tools for R&D, Field use, Production and Metrology.

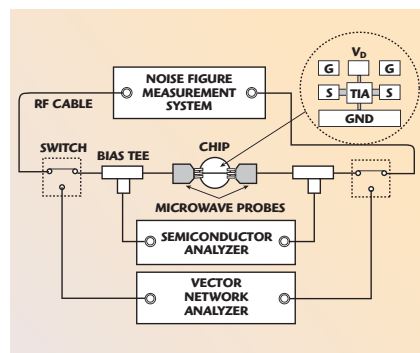
The performance you need, wherever you need it.



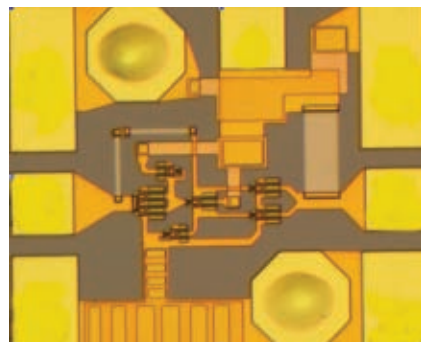
SPECTRACOM
Synchronizing Critical Operations®

+1.585.321.5800 (North America)
sales@spectracomcorp.com

+46 8 598 510 00 (Europe)
www.spectracomcorp.com



▲ Fig. 5 Experimental setup.



▲ Fig. 6 Photograph of the 10 Gb/s HEMT TIA chip.

source-follower buffer improves the flatness of the gain-frequency characteristics by separating the parallel-feedback loop from the large input capacitance of the output buffer (that is eliminating the Miller capacitance loading to the previous stages). The output stage is designed for a 50 Ω output impedance match. **Figure 5** shows the experimental setup. All measurements were carried out on-wafer, using Air-Coplanar Probes. The wafer probes were calibrated using the Line-Reflect-Match (LRM) calibration method for S-parameter measurement. The noise parameter measurement method proposed here has been tested on wafer up to 26 GHz. The corresponding chip photograph of the 10 Gb/s HEMT TIA is shown in **Figure 6**.¹¹

Explore the Limits. T&M Solutions for Aerospace and Defense.

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

www2.rohde-schwarz.com/ad/space_SMU/mwj



Technological highlights: signal generation

- Frequency range up to 43.5 GHz
- Excellent spectral purity, e.g. typ. -120 dBc (1 Hz) at 10 GHz, 10 kHz offset
- High output power, e.g. typ. +25 dBm at 20 GHz
- Flexible pulse generation for radar applications
- Easy replacement of legacy instruments

See us at MTT-S Booth 2115

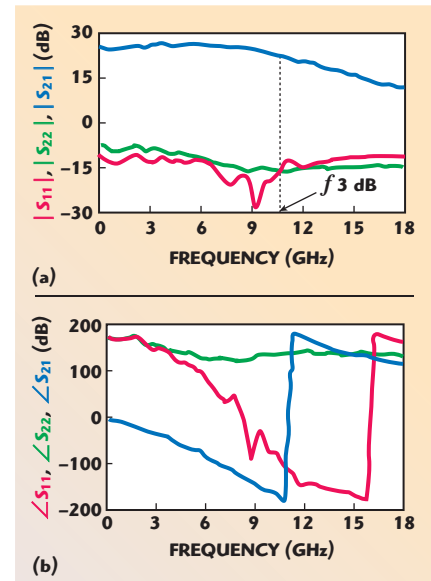


ROHDE & SCHWARZ

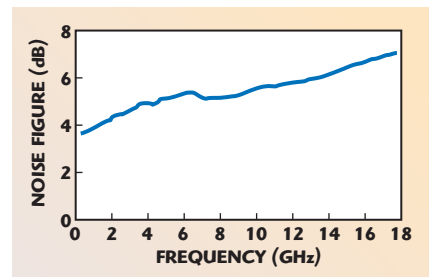
Figure 7 shows the measured magnitudes and phases of the S-parameters of the TIA IC. The high gain $|S_{21}|$ of 25 dB and the broad 3 dB bandwidth over 10.8 GHz have been obtained. Good matching is also achieved, $|S_{11}|$ less than -10 dB and $|S_{22}|$ less than -7 dB for the whole frequency range. The corresponding noise figure versus frequency is shown in **Figure 8**.

The transimpedance gain (TG) and

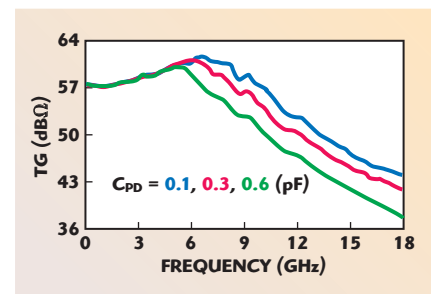
equivalent input noise current density (EINCD) can be obtained from AC and noise signal analysis by using commercial circuit design tools (such as SPICE). However, it is difficult to measure them directly using conventional microwave signal and noise measurement systems. Alternatively, they can be calculated from S-parameters and noise figure measurements by using the proposed transformation expressions.



▲ **Fig. 7** S-parameters of the 10 Gb/s HEMT-based TIA IC: (a) magnitude and (b) phase.



▲ **Fig. 8** Measured noise figure of the 10 Gb/s HEMT-based TIA IC.



▲ **Fig. 9** Transimpedance gain vs. frequency for the 10 Gb/s TIA.

Figure 9 shows the transimpedance gain, which is derived from the measured S-parameters of the 10 Gb/s TIA; the corresponding 3 dB bandwidth versus capacitance of the PD is shown in **Figure 10**. It can be found that the 3 dB bandwidth of the TIA transimpedance gain is approximately 11.5 GHz, and the corresponding optical receiver front-end 3 dB bandwidth decreases with the increase of the capacitance of the PD ($Y_S = j\omega C_{pd}$). As long as the capacitance of the PD is kept less than 0.6 pF (3 dB

Visit us! 2011MTTS:Booth3512

Frontlynk®

Connectors and Cables up to

110 GHz

Great Performance

Mass Customization

Fast Delivery

Right in Taiwan

MMCX SMA N High Frequency SMPM 1.0 mm

DC to 26 GHz 40 GHz to 110 GHz

FRONTLYNK TECHNOLOGIES INC. Non-Magnetic AVAILABLE!

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

FLAT GAIN

AMPLIFIERS



NF as low as **2.5 dB**, **P_{out}** up to **+20.5 dBm**, **800 MHz** to **3.8 GHz** from **\$179** ea. (qty. 1000)

Ultra flat gain, as low as ± 0.2 dB across the entire frequency range, paves the way to all kinds of applications for our new YSF amplifiers. Together, these 7 models cover the 800-3200 MHz spectrum, from cellular and satellite L bands to GPS, PCS, UMTS, and WiMAX. Whenever gain flatness and repeatability are critical, and high dynamic range (low NF and high IP3) are required, Mini-Circuits YSF amplifiers are an ideal solution.

Excellent combination of gain, noise, and distortion parameters. These amplifiers meet or exceed other key performance criteria with 20 dB gains, noise factors as low as 2.5, a 20 dBm P1dB, and a 35 dBm IP3.

They even simplify PCB configuration, with a small footprint (5 x 6 mm) and no external matching requirements. Our MSiP™ design provides the internal feedback, matching, bias, and DC blocking that make it all possible. So why wait? Place your order today, and we'll have them in your hands as early as tomorrow.

Model No.	Freq. (MHz)	Gain (dB)	Gain Flatness (±dB)	P _{out} (dBm) @ Comp	Dynamic Range	Price \$ ea.
	f _L -f _H	Typ.		1dB Typ. 3dB Typ.	NF dB Typ. IP3 dBm Typ.	Qty. 10
YSF-122+	800-1200	20.4	0.2	20.5 21.3	3.4 36	2.69
YSF-2151+	900-2150	20.0	0.4	20.0 21.0	3.1 35	2.95
YSF-162+	1200-1600	20.1	0.2	20.0 21.0	3.2 35	2.69
YSF-232+	1700-2300	20.0	0.2	20.0 21.0	2.8 35	2.69
YSF-272+	2300-2700	19.0	0.7	20.0 21.0	2.5 35	2.59
YSF-382+	3300-3800	14.5	0.9	20.0 21.0	2.5 36	2.59
YSF-322+	900-3200	17.0	2.2	20.0 21.0	2.5 35	2.85

DC PWR. Voltage (nom.) 5v Current (max.) 145 mA  RoHS compliant



MSiP

MINI-CIRCUITS SYSTEM IN PACKAGE

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

Mini-Circuits®
ISO 9001 ISO 14001 AS9100 CERTIFIED

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



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

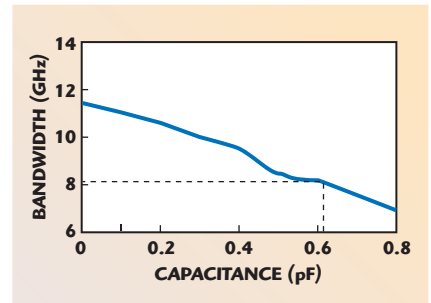
IF/RF MICROWAVE COMPONENTS

See us at MTT-S Booth 1031

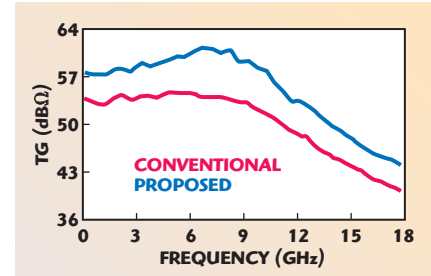
486 rev org

bandwidth of 8 GHz), the proposed TIA can be operated at a 10 Gb/s bit rate. **Figure 11** shows the comparison of the predicted transimpedance gain for the 10 Gb/s TIA obtained from Equations 7 and 8. It is obvious that the gain and bandwidth predicted by Equation 7 is better than that of a TIA operating in a matching system. That means the transimpedance gain will be underestimated using the conventional formula.

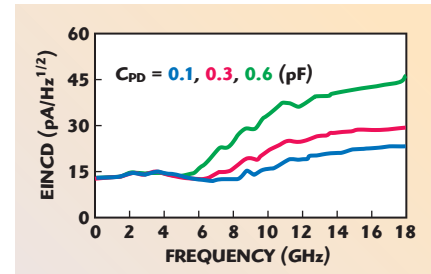
Figure 12 shows the EINCD, which is derived from the measured noise figure of 10 Gb/s TIA. The corresponding average values versus capacitance of the PD are shown in **Figure 13**. It can be found that equivalent input noise current density increases with the increase of capacitance of the PD ($Y_S = j\omega C_{pd}$). As long as the capacitance of the PD is kept less than 0.3 pF, the equivalent input noise current density of the proposed TIA can be less than $20 \text{ pA} / \sqrt{\text{Hz}}$. **Fig-**



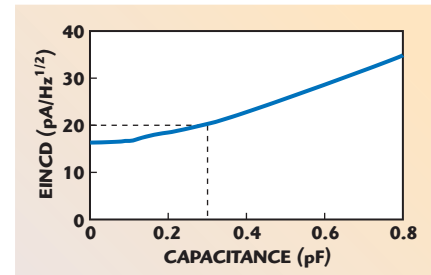
▲ Fig. 10 3 dB bandwidth of the transimpedance gain vs. capacitance of PD.



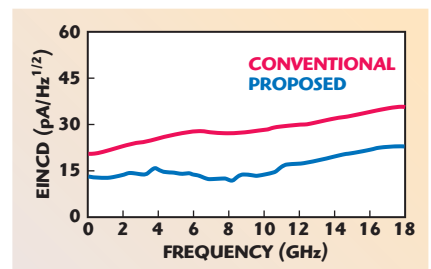
▲ Fig. 11 Comparison of transimpedance gains for 10 Gb/s TIA.



▲ Fig. 12 Equivalent input noise current density (EINCD) vs. frequency for the 10 Gb/s TIA.

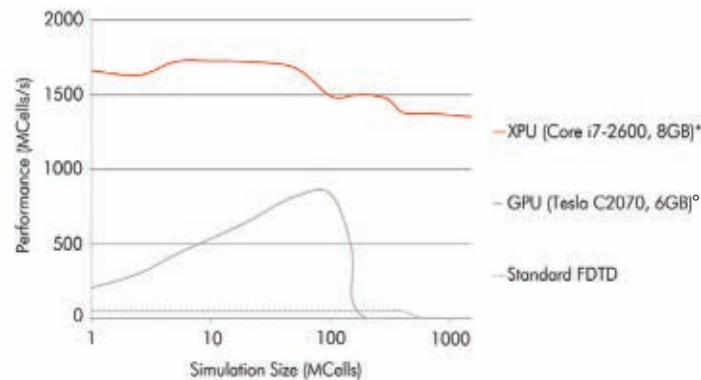
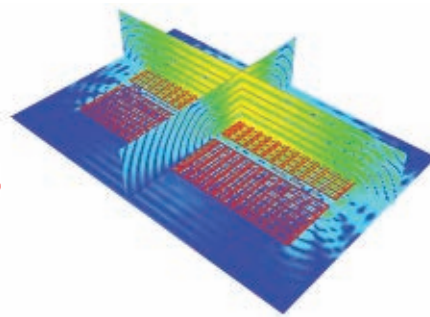


▲ Fig. 13 Equivalent input noise current density (EINCD) vs. capacitance of PD.



▲ Fig. 14 Comparison of the equivalent input noise current density (EINCD) for the 10 Gb/s TIA.

Visit us on IMS in May at Booth 2224



→ EMPIRE XCcel™

Empire XCcel™ features the unique XPU* 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 XCcel™ 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 XCcel™ is a product of IMST GmbH
Core i7, Xeon are trademarks of Intel Corporation
Tesla is a trademark of NVIDIA Corporation
*12 port Multitask, cubic growth, including losses
PGA, observation: >400 MCells, 2xXeon E560, 48 GB
° 8 layer CPML Benchmark, cubic growth, no observation
- XPU is an innovative proven software controlled workflow
among CPUs - invented at IMST

Emerson Connectivity Solutions

Your Front Line of Defense in Microwave.

MTT-S IMS
Booth 517



Midwest Microwave

Connectivity Solutions



- Performance from DC to 40GHz
- QPL Approved M3933/M39030/M39012
- Standard Catalog and custom designs
- Precision High Quality

- The difference starts with the cable
- Engineered to perform in the toughest environments
- Custom cable assemblies from DC to 50 GHz
- Available with all popular connectors

Semflex

Connectivity Solutions



- All contacts are plated with 50 micro-inches of Gold for excellent durability and high frequency performance
- Plug interfaces and semi-rigid bulkhead jack bodies include gaskets for environmental sealing
- Cabled contacts are captivated upon assembly
- Flexible cable contacts can be crimped or soldered

Johnson

Connectivity Solutions



- Delivers standard and custom design
- Field and battle-proven design quality and performance
- Proven track record of meeting the most demanding requirements

Trompeter

Connectivity Solutions



Emerson Connectivity Solutions is a global manufacturer of connectivity products, specifically Microwave Components and Cable Assemblies, which support wireline & wireless communications, networking, RF/Microwave, test & measurement, broadcast, medical, military and industrial applications.

For product information: www.emersonconnectivity.com or call 507-833-8822



EMERSON. CONSIDER IT SOLVED.™

ure 14 shows the comparison of predicted equivalent input noise current density for the 10 Gb/s TIA by using the proposed Equation 13 and the conventional Equation 16. It is obvious that the equivalent input noise current density predicted by Equation 13 is better than that predicted by the conventional formula. This means the equivalent input noise current density will be overestimated using the conventional formula.

CONCLUSION

Analytical expressions for the relationships between the transimpedance gain from S-parameters, equivalent input noise current density and noise figure for high-speed optical transimpedance preamplifier design is proposed in this article. The validity of the new approach is proven by using a 10 Gb/s high electron mobility transistor (HEMT)-based transimpedance preamplifier. ■

References

1. S. Kimura and Y. Imai, "0 to 40 GHz GaAs MES-FET Distributed Baseband Amplifier ICs for High-speed Optical Transmission," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 44, No. 11, November 1996, pp. 2076-2082.
2. J.S. Weiner, J.S. Lee and A. Leven, et al., "An InGaAs-InP HBT Differential Transimpedance Amplifier with 47 GHz Bandwidth," *IEEE Journal of Solid-State Circuits*, Vol. 39, No. 10, October 2004, pp. 1720-1723.
3. J. Gao, B. Gao and C. Liang, "PIN PD Microwave Equivalent Circuit Model for Optical Receiver Design," *Microwave and Optical Technology Letters*, Vol. 38, No. 2, pp. 102-104.
4. C. Kromer, G. Sialm, T. Morf, M.L. Schmatz, F. Ellinger, D. Erni and H. Jackel, "A Low-power 20 GHz 52 dB Transimpedance Amplifier in 80 nm CMOS," *IEEE Journal of Solid-State Circuits*, Vol. 39, No. 6, June 2004, pp. 885-894.
5. A. Leven, R. Reuter and Y. Baeyens, "Unified Analytical Expressions for Transimpedance and Equivalent Input Noise Current of Optical Receivers," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 48, No. 10, October 2000, pp. 1701-1706.
6. Y. Suzuki and K. Honjo, "Wideband Transimpedance Amplifiers Using AlGaAs/InGaAs Pseudomorphic 2-D EG FETs," *IEEE Journal of Solid-State Circuits*, Vol. 33, No. 10, October 1998, pp. 1559-1562.
7. J.S. Weiner, A. Leven, V. Houtsma, Y. Baeyens, Y.K. Chen, P. Paschke, Y. Yang, J. Frackowiak, W. J. Sun, A. Tate, R. Reyes, R.E. Kopf and N.G. Weimann, "SiGe Differential Transimpedance Amplifier with 50 GHz Bandwidth," *IEEE Journal of Solid-State Circuits*, Vol. 38, No. 9, September 2003, pp. 1512-1517.
8. M.B. Das, J.W. Chen and E. John, "Designing Optoelectronic Integrated Circuit (OEIC) Receivers for High Sensitivity and Maximally Flat Frequency Response," *IEEE Journal of Lightwave Technology*, Vol. 13, No. 9, September 1995, pp. 1876-1884.
9. J. Ortiz and C. Denig, "Noise Figure Analysis Using SPICE," *Microwave Journal*, Vol. 35, No. 4, April 1992, pp. 89-94.
10. J. Gao, *RF and Microwave Modeling and Measurement Techniques for Field Effect Transistors*, SciTech, USA, 2009.
11. S. Cai, Z. Wang, J. Gao and E. Zhu, "Analysis and Design of 10 Gb/s 0.2 μ m PHEMT Transimpedance Amplifier," *Chinese Journal of Semiconductors*, Vol. 27, No. 10, October 2006, pp. 1809-1813.

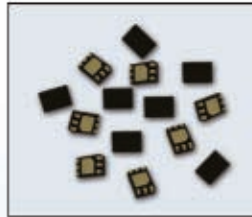
Jianjun Gao received his BEng and PhD degrees from Tsinghua University in 1991 and 1999, respectively, and his MEng degree from the Hebei Semiconductor Research Institute in 1994. From 1999 to 2001, he was a post-doctoral research fellow at the Microelectronics R&D Center, Chinese Academy of Sciences, developing PHEMT optical modulator drivers. In 2001, he joined the school of Electrical and Electronic Engineering, Nanyang Technological University (NTU), Singapore, as a research fellow in semiconductor device modeling and on wafer measurement. In 2003, he joined the Institute for High-Frequency and Semiconductor System Technologies, Berlin University of Technology, Germany, as a research associate working on InP HBT modeling and circuit design for high speed optical communication. In 2004, he joined the Electronics Engineering Department, Carleton University, Canada, as a post-doctoral fellow, working on the semiconductor neural network modeling technique. From 2004 to 2007, he was a full professor in the radio engineering department at Southeast University, Nanjing, China. Since 2007, he has been a full professor in the school of information science and technology, East China Normal University, Shanghai, China. His main areas of research include characterization, modeling and on wafer measurement of microwave semiconductor devices, optoelectronics device and high-speed integrated circuit for radio frequency and optical communication.

RF/Microwave Monolithic Passives & Integrated Modules



90° Hybrids

The VFHY100 series of 90 degree hybrids exhibit very good performance across the frequency range 600 MHz to 4.0 GHz and are offered in a miniature 1.5 x 2.0 mm leadless package. Typical performance is 30 dB of isolation, a 1.1:1 VSWR and phase balance of ± 1 degree.



2-Way Power Dividers

The VFDP200 series of 2-way power dividers consist of seven models spanning the range of 698 MHz to 3.8 GHz. These devices offer best in class performance in industry's smallest form factor available.



Voltage Variable Attenuators

The VFVA500 series consists of six models which span the frequency range of 600 MHz to 4.0 GHz and are offered in a 3.2 x 4.9 mm MCM package. These devices provide a minimum of 25 dB attenuation across a 0-5V control range.



Directional Coupler

The VFDC100-010 is a high performance directional coupler that works across the broad frequency range of 500 MHz to 4.0 GHz. The device is based on a highly repeatable monolithic design that provides excellent directivity, low mainline insertion loss, and very low VSWR. It comes in a miniature 1.5 x 2.0 mm surface mount leadless package.



Fixed Attenuators

The VFAT series of fixed attenuators consists of 3 dB, 6 dB, 10 dB & 20 dB values. These devices offer excellent attenuation flatness and low VSWR from DC to 8.0 GHz and are available in a miniature 1.5 x 2.0 mm package.



Come see us at
Booth #1633



Scan QR code with
your smart phone



Valpey Fisher Corporation

75 South Street, Hopkinton, MA 01748 • 800-882-6737 • www.valpeyfisher.com • sales@valpeyfisher.com

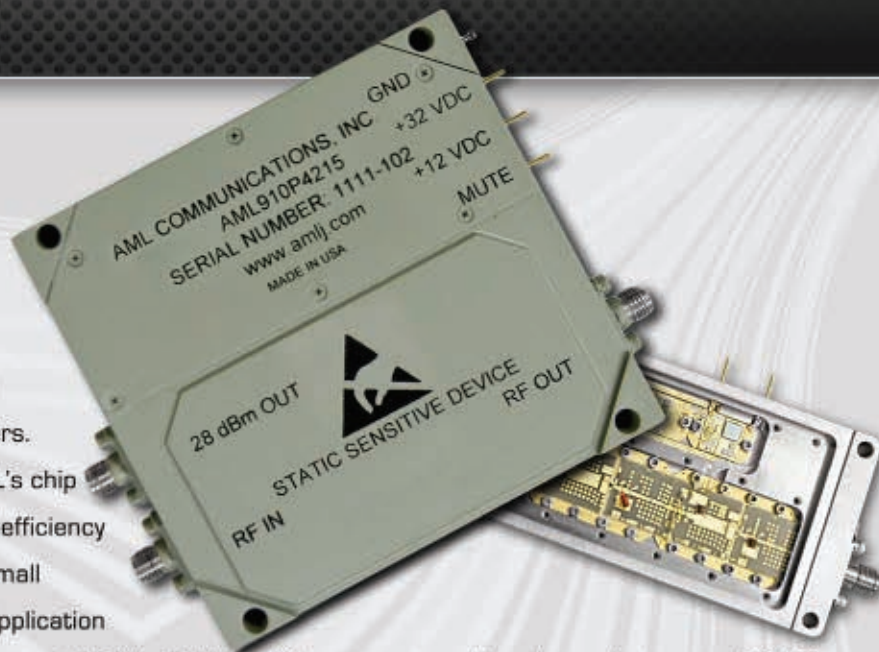


Communications

AML's 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 AML's 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 11 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
AML056P4013	0.5 - 6.0	40	35	36	4	28V, 0.5A	22%
AML056P4014	0.5 - 6.0	40	37	38	6	28V, 1.0A	20%
AML056P4511	0.5 - 6.0	45	39	40	10	28V, 1.3A	25%
AML056P4512	0.5 - 6.0	45	43	44	25	28V, 2.5A	25%
AML13P5013	1.0 - 3.0	50	46	47	50	28V, 4.8A	25%
AML16P4511	1.5 - 6.0	45	39	40	10	28V, 1.0A	26%
AML16P4512	1.5 - 6.0	45	42	43	20	28V, 2.6A	25%
AML16P4513	1.5 - 6.0	45	44	45	30	28V, 4.8A	25%
AML26P4011	2.0 - 6.0	40	40	41	12	28V, 1.0A	30%
AML26P4012	2.0 - 6.0	45	43	44	25	28V, 2.5A	35%
AML26P4013	2.0 - 6.0	45	46	47	50	28V, 4.8A	35%
AML59P4512	5.5 - 9.0	45	45	46	40	28V, 3.6A	38%
AML59P4513	5.5 - 9.0	45	48	49	80	28V, 7.2A	38%
AML910P4213	9.9 - 10.7	43	37	38	6	32V, 0.5A	30%
AML910P4214	9.9 - 10.7	43	39	40	10	32V, 0.8A	30%
AML910P4215	9.9 - 10.7	46	41.5	42	15	32V, 1.3A	30%
AML910P4216	9.9 - 10.7	46	42	43	20	32V, 1.3A	30%
AML811P5011	7.8 - 11.0	45	43	44	25	28V, 2.6A	30%
AML811P5012	7.8 - 11.0	50	46	47	50	28V, 5.5A	30%
AML811P5013	7.8 - 11.0	50	49	50	100	28V, 11A	30%

Options: Fast TTL On/Off (<100ns)

Features: Wide operating temperature range: -54° to + 85°C [hermetically sealed]

See us at MTT-S Booth 2024



MULTIPLICATION DISCHARGE IN COAXIAL COMPONENTS

The development of coaxial microwave components capable of handling high peak power without the presence of multipactor is an important part of component design for space and vacuum environments. Multipactor is a resonance type of discharge that can occur under vacuum conditions.¹ The electric component of the electromagnetic field can have sufficient energy to cause the emission of electrons from the material surface. In a vacuum environment, the electron free path distance is greater than the electrode separation distance. This change in the distance relationship allows free electrons to impact the electrode surface. These collisions create a secondary electron emission from the electrode structure. The synchronization between the secondary electron emissions and the frequency of the electric field alternating polarity will accelerate the electrons back to the source electrode (see **Figure 1**). Under the appropriate conditions, the number of electrons will increase exponentially up to a saturation point,

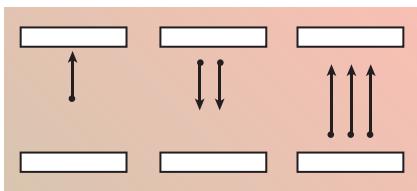
at which the electron density is large enough to block the electric field. This electron charge build up can cause a resonance type of breakdown in the form of a multiplication discharge.¹ Multipaction discharge itself can also cause an additional sat-

uration mechanism through its interaction with the electrodes.²

There are two main conditions that must be present for multipactor. First, the one way transit time between the two electrodes is an odd number of half cycles N , where N is an odd positive integer ($N = 1, 3, 5 \dots$). Second, the secondary electron emission coefficient of the impact surface must exceed unity.

The multiplication discharge phenomenon is not always undesirable. In the 1930s, American Philo Farnsworth designed an amplifier vacuum tube for television signal transmission, based on the multipactor. This tube was later superseded by Zworykin's Iconoscope.¹ However, Farnsworth first derived the name multipactor from "AC Electron Multiplier,"² originally describing hardware rather than the mode of the electron emission itself. Over time, in most space and vacuum applications, the term has come to define the harmonic electron breakdown.

Multipactor creates a sheet like cloud of electrons, which are oscillating between the two electrode surfaces.¹ The discharge will heat the surfaces of the electrodes, increase signal noise, block the electric field and appear as a brief electron current between the



▲ Fig. 1 Multipactor between two planes.

RUDY FUKS
Astrolab Inc., Warren, NJ

**CUSTOM DESIGNS
TO ORDER...**

**... ASK ABOUT OUR
COST EFFECTIVE
SOLUTIONS.**

TRIMMER CAPACITORS



- Low Cost Trimmer Capacitors
- Miniature Trimmers
- Standard Air Trimmers
- High Voltage PTFE Dielectric Trimmers
- High Voltage Extended Range Series FTPE Dielectric Trimmers
- Very High Voltage Trimmers
- Ultra High Voltage PTFE Dielectric Trimmers
- High Q Sealed Sapphire Trimmer Capacitors
- Precision Microwave Tuners
- Dielectric Resonant Oscillator Tuners
- Precision Microwave Cavity Tuners
- Half Turn Trimmers
- Engineering Prototype Kits

The Trimmer Capacitor Company



973-586-8585

www.voltronicscorp.com



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

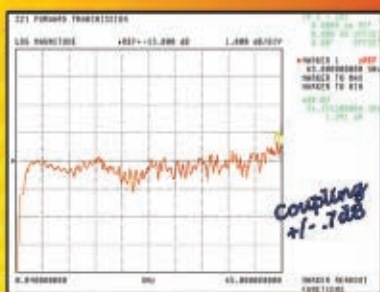
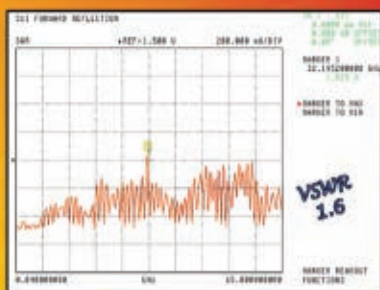
www.dovercmp.com

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

See us at MTT-S Booth 1005

1-67 GHz

Directional Couplers



**Our Competitors
Dream about it.**

**We Design &
Manufacture it!**



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

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

two electrodes. In the case of a high mode (N mode) multipactor, several electron cloud sheets (exactly $2N-1$) will oscillate between the surfaces under steady state conditions. Additionally, in some high power tubes, multipactor can emit visible light and X-rays. Single surface multipaction discharge can also occur on dielectric component surfaces, if there is a bias DC field, electric or magnetic, and a high frequency electric field is present parallel to the dielectric surface. This single surface discharge phenomenon on the dielectric surface is not applicable for coaxial lines. For further reading on the history of multipaction discharge analysis, current theory and practical information, see the works of Vaughan,¹ Kishek² and Ming Yu.³

The focus of Vaughan's work with multipactor was in the field of high and very high power microwave tubes.¹ Vaughan noted that multipactor is essentially a medium power phenomenon.¹ The reason for this statement is that under very high energy, multipactor is not possible. The impact velocity of the emitted electron is of such a magnitude that it penetrates too deep inside the second electrode to cause secondary electron emission from its surface. This type of impact does not meet the second required condition for multipactor, since the secondary electron emission coefficient is less than one.

With regard to coaxial cables and connectors, Vaughan's statement that multipactor as "essentially a medium power phenomenon" is not true in the majority of the cases. Coaxial cables and connectors, inherently, have a limited power handling relative to microwave tubes. In most cases, multipactor in a coaxial line is a high power phenomenon in that it occurs at a power level near the maximum capacity of the component. In fact, the multipaction discharge within a coaxial line is usually not catastrophic in and of itself. However, the discharge can vaporize some of the dielectric material within the coaxial line and create ionized gas particles. If the coaxial line is not properly vented, these collected gas particles can initiate an ionization breakdown within the structure. The ionization breakdown is typically the destructive failure mode.

Extensive research of the multipactor phenomenon has been performed

in recent years. The European Space Agency (ESA) has hosted several multipactor workshops for space applications. There are also multiple options for multipactor calculations from Jet Propulsion Laboratories⁴ and ESA.⁵ However, most of the references describe multipactor in the applications of high power microwave tubes, plasma physics and particle acceleration. Many papers have been published with analysis and applications, yet there are few practical papers that reveal any guidance in designing coaxial components for space applications, where multipactor is a serious concern.

Most early references analyzed the simplest case, that being multipactor between two parallel plates. This application has a uniform field. Coaxial line analysis is much more complicated, because the field is not uniform. However, an examination of two parallel plates is necessary to establish the fundamental factors, which will later be analyzed in the frame of a coaxial system. For further reading on the multipactor analytical study under simplified conditions see the work of Udiljak, et al.⁷

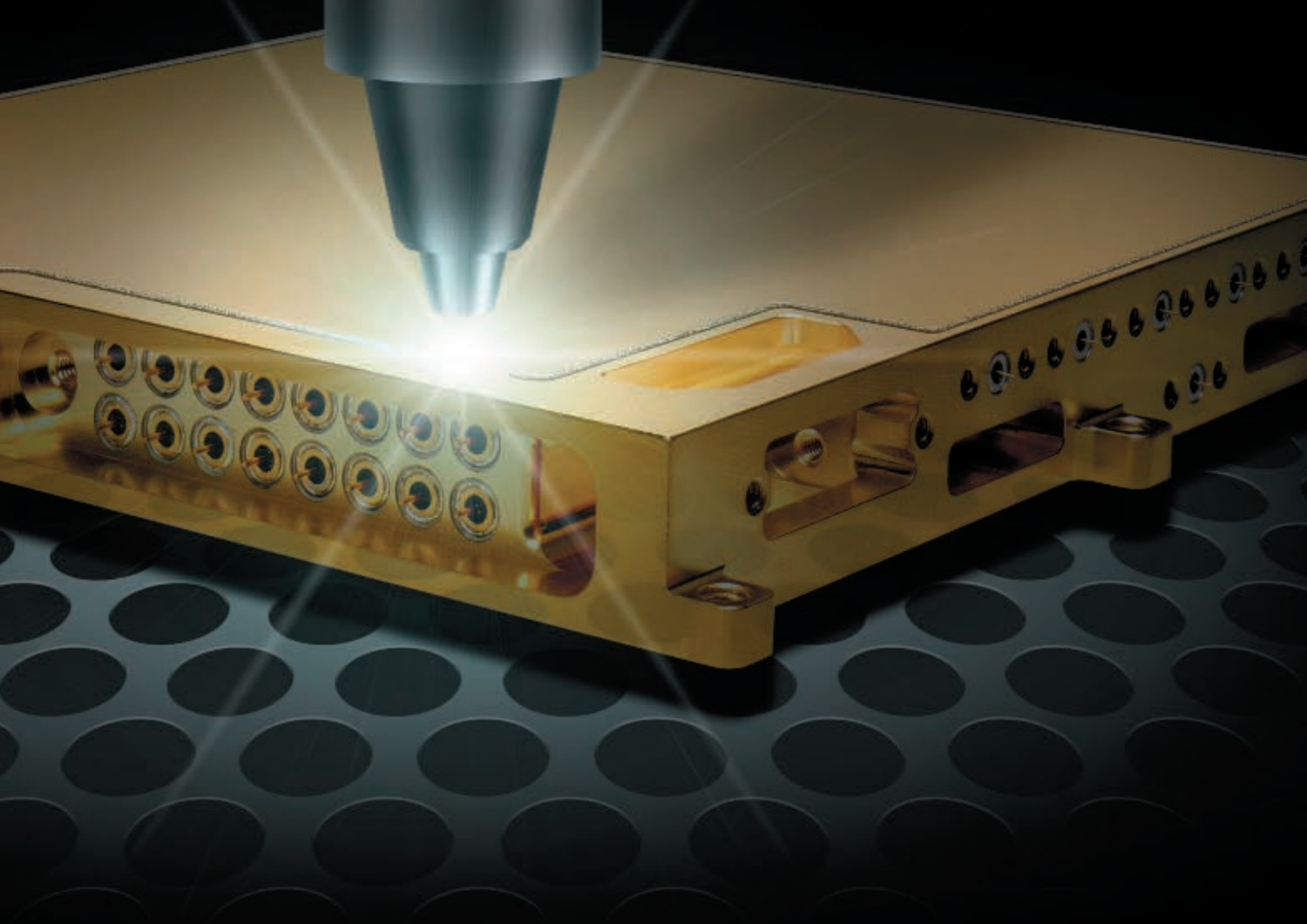
According to Udiljak,⁶ the resonance condition for an applied electric harmonic field between two plates is:

$$E_0 = \frac{m\omega(\omega d - N\pi\lambda_0)}{e(N\pi \cos \alpha + 2 \sin \alpha)} \quad (1)$$

where m is the mass of an electron (9.1×10^{-31} kg), e is the electron charge (1.6×10^{-19} C), d is the distance between the plates, $\omega = 2\pi f$ and $\omega t = N\pi + \alpha$.

It is possible to calculate the multipactor zones from Equation 1. The multipactor zones are usually depicted in charts, which show the relationship of power (or voltage) versus the frequency-distance product. However, this analysis was done with respect to the electric field only, in the simplified conditions. This is in accordance with most references, which have removed the magnetic field influence because it is assumed to be negligible.

However, according to the Ampere-Maxwell law, the electric field will produce a circulating magnetic field. In a coaxial structure, the magnetic field lines are in concentric circular sweeps around the center conductor circumference.



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.™

- WCDMA/HSPA MIXED MODE PA'S
- LTE ■ CDMA/EVDO
- EDGE & WIMAX PA'S
- 50 OHM GAIN BLOCKS
- WIFI PA'S & WIFI FRONT ENDS



We Have A Chip For That



See us at MTT-S Booth 1144

ES MICROWAVE LLC.

Since 1985 we have offered our custom design filters and sub-assemblies in combine, interdigital and suspended-substrate technologies.

Broadband

Suspended-Substrate

Filters, Duplexers, 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

The force that describes the electron movement under the influence of both electric and magnetic fields, named the Lorentz Force \mathbf{F} , is defined as:

$$\mathbf{F} = q(\mathbf{E} + \mathbf{V} \times \mathbf{B}) \quad (2)$$

where q is the electron charge, \mathbf{E} is the electric field, \mathbf{V} is the electron velocity and \mathbf{B} is the magnetic field induction. This equation shows that the magnetic field deflects the electron movement from a straight path. This deflection can be important.

At first look, the influence of the magnetic force does indeed look negligible. However, consider a special case. Suppose the first electron is displaced a very small distance in the axial direction. Under multipaction discharge conditions, when secondary electrons are released in a coaxial line, the fields are reversed. However, the vector product $\mathbf{V} \times \mathbf{B}$ will remain in the same direction because the velocity vector \mathbf{V} has also changed direction. This means that the secondary electrons will be displaced in the same axial direction over an additional short distance. As the multipactor increases the rate of electron discharge, the space charge axial displacement caused by the cross product of vectors \mathbf{V} and \mathbf{B} will grow as well. The axial displacement in the coaxial line will move in the same direction as the incident wave because vectors \mathbf{V} and \mathbf{E} are in the same direction, which means that the vector product $\mathbf{V} \times \mathbf{B}$ is in the same direction as the Poynting vector. Since the typical frequency for a space application is in the gigahertz range, the axial displacement is going to be comparable to the radial gap in a very short time. Modifying Equation 2 and substituting $\mathbf{B} = \mu_0 \mathbf{H}$ (for vacuum $\mu = \mu_0$) and $\mathbf{H} = \mathbf{E}/Z_0$, Equation 2 can be modified as:

$$\mathbf{F} = q(\mathbf{E} + \mathbf{V} \times \mathbf{E}\mu_0/Z_0) \quad (3)$$

Equation 3 shows that the axial displacement is related to the radial acceleration by the factor $V\mu_0/Z_0$. The ratio μ_0/Z_0 (3.33×10^{-9}) is a very small value. However, at microwave frequencies, there will be billions of such cycles per second. Additionally, the electron velocity V will increase at the end of each cycle. The influence of the electron velocity can be more

simply shown through the analysis of the two plane multipactor rather than the more complicated structure and field distribution of a coaxial line. According to Vaughan,¹ the electron impact velocity V_i is:

$$V_i = \frac{2\omega d \cos \alpha}{N\pi \cos \alpha + 2 \sin \alpha} + V_0 \quad (4)$$

where $\omega = 2\pi f$ and V_0 is the initial velocity. The multipaction discharge condition is present when $\omega t = N\pi + \alpha$, where α is the initial phase. In the simplest case, for a first order multipactor with zero initial velocity ($N = 1$, $V_0 = 0$, and α is an integer number of π), Equation 4 can be rewritten as:

$$V_i \approx \frac{2\omega d}{\pi} \quad (5)$$

Equation 5 presents a very simplified model because, first, the use of a two plane first order multipactor; and second, according to Vaughan, the value of V_0 is unknown because "it is a statistical distribution rather than a single variable value."¹ There are some differences in correlating the phase relations from a two plane structure to that of a coaxial line. Udiljak⁶ points out that in a coaxial line, the transmission time is normally longer for electrons emitted from the outer conductor than for electrons emitted from the inner conductor. This means that the phase relations in a coaxial line are less favorable for multipactor, when compared to the simplified model of two planes.

However, Equation 5 shows that, in each cycle, the electron velocity is growing from zero to a very large value because it is linearly proportional to the frequency. The proportional relationship of the impact velocity of the electron to frequency is evident from the fact that, as the frequency increases, the electron velocity must be significantly higher in order to reach the opposite electrode before the polarity reverses. This means that the axial displacement caused by the magnetic field is in fact not negligible and can have substantial effects, particularly at microwave frequencies. From this, it is evident that the velocity dependence on frequency makes the electron axial displacement to increase nonlinearly, as the frequency increases.

From plasma physics, the nonlinear force that a charged particle ex-

Circled the Globe For Suppliers?

Search No Further.

Weinschel Associates (WA) delivers solutions for your toughest requirements - on-time and in compliance. Look to WA to launch your next program with Space and MIL-Qualified RF and Microwave Components.

Space & Mil-Qualified Components

- Attenuators
- Terminations
- Dividers
- DC Blocks
- Tuners
- High Performance Designs
- Power Handling to Design Specifications
- Frequency Range: DC to 40 GHz
- Legacy Design Solutions Available



A Tradition of Quality / A Commitment to Customer Service

www.WeinschelAssociates.com



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

See us at MTT-S Booth 428

periences in an inhomogeneous oscillating electromagnetic field is known as the Ponderomotive or Miller force. The Ponderomotive force influences the particle to drift toward the weak field area. This force is particularly important in the coaxial line because of the inhomogeneous field, which is stronger in the region of the center conductor. However, the axial displacement is different from that of the Ponderomotive force, which depends solely upon the electric field and has a radial influence on the electron position in a coaxial line.

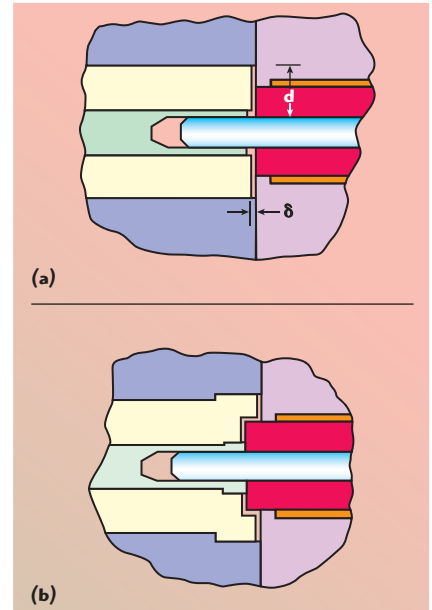
One could say that the axial displacement is not important and that it may have no influence on multipaction. However, as noted before, most references contain data regarding multipactor between two planes. Usually, only a coaxial airline structure is discussed. The airline, however, has little practical interest. Most coaxial transmission lines, particularly for space applications, are fully or partially loaded by a dielectric material. In this case, the axial displacement has a large influence for a partially filled line, which is typical for any cable

connector junction. **Figure 2** shows a simplified coaxial cable-connector junction that is widely used for high frequency applications. One can see the air gap with height d and width δ . This air gap is a short line of high impedance that improves the electrical match between the cable and connector coaxial line sizes. Typically this air gap is the most susceptible part of the cable assembly to a multipactor event.

According to Udiljak,⁶ the rate of electron build up $N_e(t)$ is determined by the following equation:

$$N_e(t) = N_e(0) \left(\sigma_{se} \right)^{\frac{2ft}{N}} \quad (6)$$

where $N_e(0)$ is the initial electron quantity and σ_{se} is the secondary electron emission yield. For example, an electron cloud growing from 1 to 10^{14} takes 20 ns at 2 GHz, when the secondary electron emission yield $\sigma_{se} = 1.5$. This is close to the same time relationship as shown by Vaughan.¹ This means that electrons can hit the electrode a few dozen times and the overall axial displacement is microscopic, because of the ratio of $\mu_0/Z_0 = 3.33 \times 10^{-9}$ in Equation 3. However, the velocity can



▲ Fig. 2 Cable-connector junction: (a) simplified connector and (b) practical design for high voltage handling.

reach a significant value, particularly at a high frequency (see Equation 5). Therefore, the multipacting electrons will be displaced in an axial direction to a distance almost equivalent to that between the electrodes (d) in a very short amount of time. However, the electron cloud will hit the dielectric wall under a much smaller displacement (see distance δ) than the distance between electrodes (d).

In most practical cases, the gap width is at least ten times less than the height (d). Apparently, from the moment that the electrons hit the dielectric surface, the phase conditions for multipaction will be violated despite the fact that oblique incidence will increase the secondary emission. The presence of the dielectric wall inhibits the electron build up. This means that multipaction is small or may not exist. The properties of the dielectric barrier can be extended to other dielectric loaded interfaces, for example the junction of two SMA interfaces. Note that the single surface multipactor will have much greater axial displacement because the electron cloud will grow at a much slower rate.

Also note that, statistically, the electron can be located in any spot along the distance δ . This shows that the typical axial displacement required to hit the dielectric surface can be much smaller than δ . Some references⁶⁻⁸ point out that there are two different types of multipactor in coaxial lines:

FREQUENCY SYNTHESIZERS

- Custom frequency bands to 25 GHz
- Low phase noise, low spurious
- Frequency control via RS232, RS422, RS485 & Parallel BCD
- EMI enclosures
- 5V operation

PHASE-LOCKED OSCILLATORS

- Crystal oscillators to 150 MHz
- CROs to 6 GHz
- DROs to 16 GHz
- Ref: External or Internal
- 5V operation

CUSTOM FREQUENCY SOURCES

- Microwave frequency synthesizers and PLOs
- Multiple source assemblies
- Developed using latest technologies for best performance and superb value

Your source for world class performance, quality & low cost

LUFF RESEARCH, INC

20 N. Tyson Avenue
Floral Park, NY 11001 USA



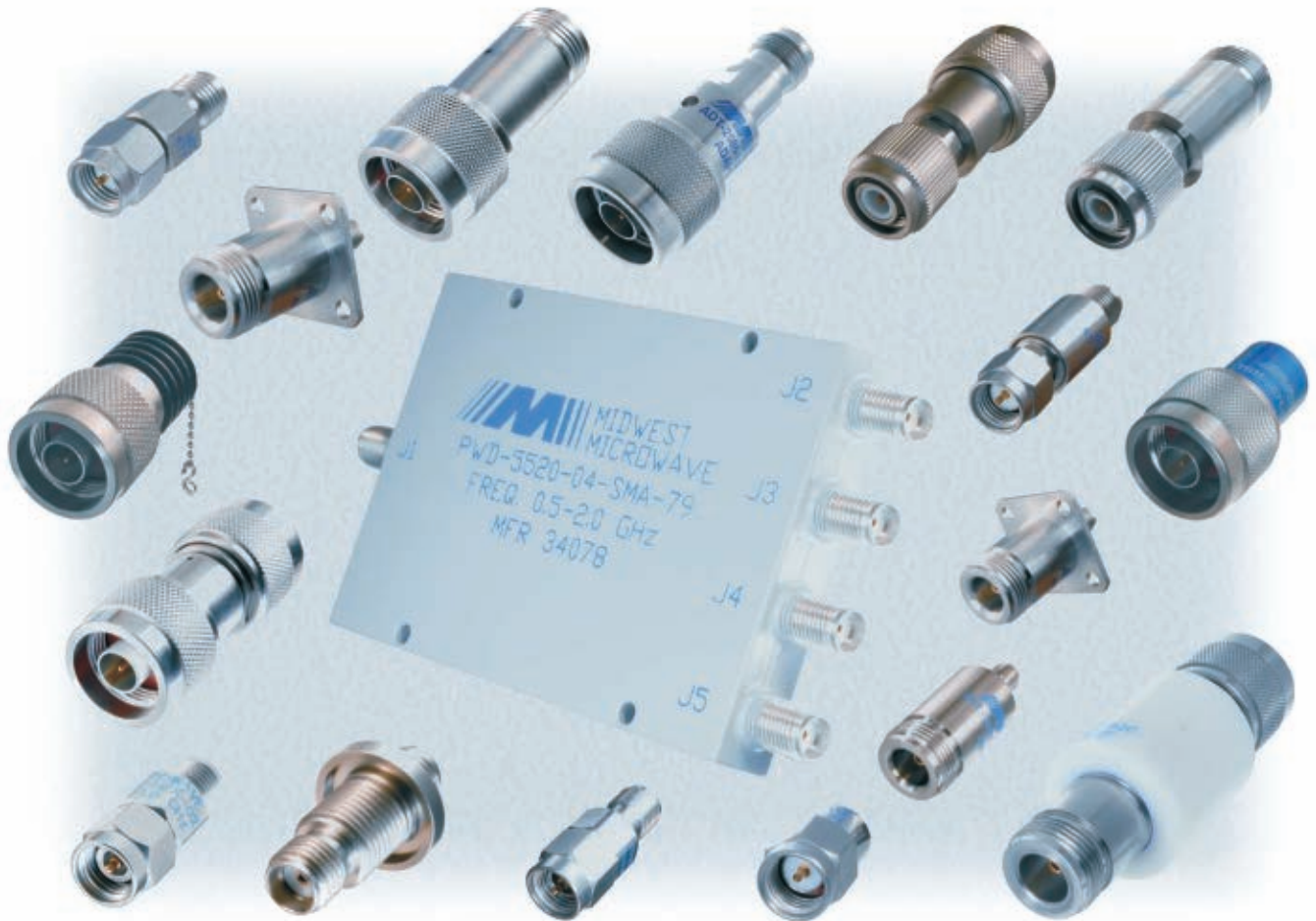
Tel: (516) 358-2880 Fax: (516) 358-2757

Web: www.luffresearch.com

E-mail: sales@luffresearch.com

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@cswift.com
www.cswift.com

CLOSED EVERY ST. PATRICK'S DAY!

ISOLATORS CIRCULATORS FILTERS



Passive RF Components
Isolators/Circulators
Custom Waveguide Assemblies



M2 Global: a leading supplier of rf isolators, circulators, filters, and other passive microwave components to the telecommunications and defense industries.

We offer high performance, cost-effective solutions in waveguide, coax, and drop-in configurations, specifically designed to support all the latest applications in radar, satellite and commercial wireless communications. For additional information contact us at sales@m2global.com

GIVE M2 GLOBAL THE CHANCE TO "KNOCK YOUR SOCKS OFF" WITH INDUSTRY BEST PRODUCTS AND SERVICES.

- Standard & custom designs
- Low IMD and insertion loss
- Dual junction, encapsulation
- Proven reliability
- RoHS compliant
- AS9100 certified
- ISO 9001:2000 certified
- Disabled veteran owned

5714 Epsilon
San Antonio, TX 78249
Phone: (210) 561-4800
Fax: (210) 561-4874
www.m2global.com

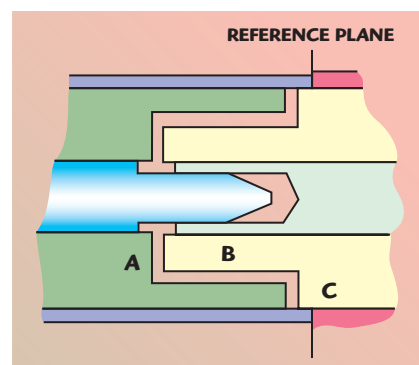
TECHNICAL FEATURE

a two sided discharge between inner and outer conductor and the one sided discharge on the outer conductor only. The main reason for the single surface multipactor is the decreasing electron velocity due to the Ponderomotive force. Therefore, the electron is reversed back before reaching the center conductor. The single-sided multipactor can be present in high impedance lines only. It should be noted that the single surface multipaction was not yet confirmed by experiments as of 2007.

A practical design for high voltage handling is also shown in the figure. Here, the two dielectrics overlap each other, thereby increasing the voltage handling. However, if the overlap is too large, it can compromise the electrical match particularly at high frequencies. Theoretically, multipactor can happen between metal and dielectric surfaces in the gap area. However, the conclusion is the same: the narrower the gap is, the more it will suppress multipactor. According to some space equipment manufacturers, the main danger for such junctions is not multipaction itself, but rather trapped air that can easily create the conditions necessary for ionization breakdown. This breakdown can happen under relatively low power. From Paschen's Law,¹² for every pressure, there is a gap with a low breakdown point. Therefore, it is extremely important to design the connector to provide for positive venting of the junction.

Typical coaxial connectors for high power space applications have a dielectric loaded interface with overlapping surfaces. There are several coaxial connectors that have been specifically designed for space power applications, but they do not comply with the industry connector interface standard MIL-STD-348.¹³ The most common, industry standard, coaxial connector interface, for space power applications, is the TNC. The mated TNC connector interface is shown in **Figure 3**.

One can see that the TNC interface has an overlapped dielectric. There is no line of sight between the inner and outer conductors. There are three main regions, in the connector interface A, B and C, where multipactor can occur. Theoretically, multipactor can occur in region A, between the center conductor and dielectric. How-



▲ Fig. 3 TNC interface junction.

ever, total breakdown of the TNC line appears to be impossible, because the TEM mode has no axial electric field. Thus, nothing can accelerate electrons in an axial direction within region B. As shown earlier, the Lorentz force equation (Equation 2) reveals that the electron will be deflected in the axial direction. With this knowledge, the TNC interface junction can be evaluated in the same manner as the practical cable-connector junction for high voltage handling. Apparently, if the air gap between mating dielectrics is narrow, it will suppress multipactor in region A because it inhibits electron acceleration. According to some space equipment manufacturers, the TNC interface is highly resistive to multipactor and in many cases it is impossible to initiate a multipactor event under extremely high power levels.

There are two main references for multipaction calculation: the Woo report and the ESA calculator. The R. Woo⁴ report was published in 1967 and is based on JPL NASA experimental data. Another option is the ESA calculator. The ESA calculator was released more recently and is much more convenient to operate. It can be downloaded for free from the ESA website (<http://multipactor.esa.int/downloads.html>). Particularly impressive are the options available to calculate multipaction for multicarrier signals. The ESA calculator also has the ability to calculate the multipaction handling for standard coaxial connector interfaces. However, when using the ESA calculator, there are some points that must be considered, when evaluating its outputs. It is surprising to find that the calculator gives the same outputs for a TNC connector as for N and 7 mm connectors. The N and 7 mm are both based on a 7 mm air line and both should have

Southwest Microwave, Inc.

**Recognized World-Wide as the
Performance Leader in Connectors & Adapters**

- **SMA, SSMA, 2.92 mm, 2.4 mm, N, TNC, Cable Connectors and Adapters**
- **Transmission Line Approach to Connector Design**
- **Typical VSWR < 1.10:1 (Industry's Lowest)**
- **RF Leakage < -100 dB (Industry's Lowest)**
- **Field Replaceable/Insertable**
- **Material Traceability & Single Lot Control**
- **COTS Up-Screened for Hi-Rel**
- **100% U.S. Made**



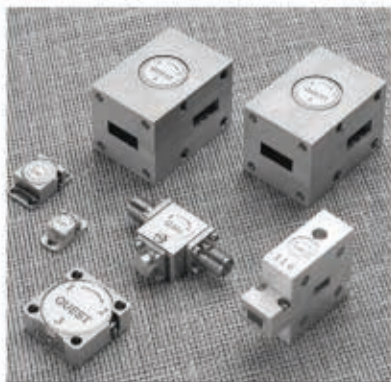
For more information please visit:

www.southwestmicrowave.com

Southwest Microwave, Inc. • Tempe, Arizona USA • 480-783-0201

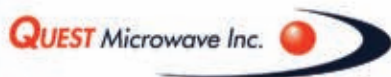
See us at MTT-S Booth 824

CIRCULATORS & ISOLATORS



QUEST for Quality
QUEST for Performance
QUEST for the **BEST...**
JOIN US

Quality products
 with quick delivery
 and competitive
 prices are our
 standard



225 Vineyard Court
 Morgan Hill, California 95037

877-QUESTMW (783-7869)
 (408) 778-4949 Phone
 (408) 778-4950 Fax

circulators@questmw.com e-mail
<http://www.questmw.com> website

TECHNICAL FEATURE

the same multipactor outputs. However, the TNC interface is based on an overlapped dielectric and it typically can handle much more power. For example, see the comparison in Rosario, et al.⁹ Additionally, there is only a single SMA connector option within the ESA calculator. The available connector is specified with a nominal gap of 0.99 mm, which is equivalent to the thick wall SMA plug interface per MIL-STD-348, Figure 310-3.¹³ However, this design is not representative of all SMA connectors available. Many SMA plug connectors are designed with a nominal gap of 1.25 mm, which is equivalent to the SMA plug interface per MIL-STD-348, Figure 310-1. This difference should be taken into account when considering the use of an SMA connector in space power applications.

Special attention needs to be given to the determination of an adequate safety margin. ESA recommends a multipaction safety margin of 3 to 4 dB by test and 8 to 12 dB by analysis. An additional safety margin is required for unmatched transmission lines.¹¹ As was noticed by Ming Yu,³ the Woo report⁴ gives outputs in root mean square (RMS) voltage values, whereas the curves from the ESA calculator⁵ gives the output peak voltage. The primary difference between these outputs is that the RMS value already contains a 3 dB margin.

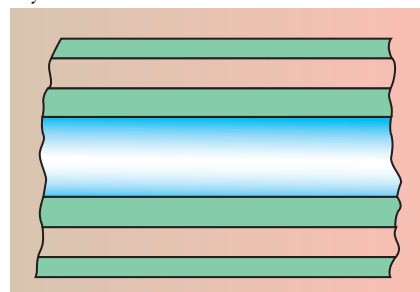
A final and very important issue when evaluating a coaxial connector for space power applications is the presence of cavities and voids within the components. Some manufacturers advocate a policy that avoids any holes or voids in space level components, particularly in coaxial connector junctions. It is practically impossible to design and produce components without any holes or voids. In this case, the air junctions are usually filled with a sealing compound. The common view is that this will help to create a 100 percent multipaction free design. However, solid dielectrics and sealing compounds have a significantly higher thermal resistivity than dielectrics compensated with axial cavities. The difference is particularly noticeable when using a Fluoroloy H (Rulon H) dielectric, which is commonly found in the coaxial connectors for space power applications. Weirback¹⁰ calculates the thermal distribution within coaxial

lines using different dielectric materials and geometry. Essentially, this difference indicates that a connector using solid dielectric will handle less average power than a dielectric with cavity compensation.

There are two reasons for such a phenomenon. First, the removed dielectric will reduce the dielectric loss, which is significant for lossy dielectric media such as Fluoroloy H. The increased attenuation dissipates more energy than the increased thermal conductivity of Fluoroloy H can transfer, creating a net increase in dielectric temperature. The second reason is that a drilled out dielectric needs a larger diameter center conductor in order to maintain the same impedance.

Generally speaking, the drilled out dielectric has a higher risk of multipactor, when compared to a solid one, because multipactor is now also possible between the two dielectric surfaces. However, it is possible to reduce the voltage across the holes, which will have two effects. First, this will reduce the risk of multipactor; second, it will improve the average power handling.

Figure 4 shows a possible coaxial line dielectric structure that has good temperature handling and was tested to be multipaction free. The four-hole model and simulated E-field distribution is shown in **Figure 5**. The simulation was performed using HFSS from Ansoft.¹⁴ The response clearly shows that there is a high density electric field inside the holes. However, the shape of the holes creates an asynchronous phase relationship with the signal frequency that is highly unfavorable for electron cloud build-up. An additional multipactor inhibiting feature of this design is the high primary electron energy, defined in eV, required to create the secondary electron emission. While the secondary electron emission coefficient can

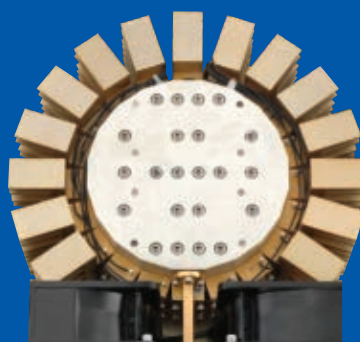


▲ **Fig. 4** Coaxial line with drilled-out dielectric.

*State-of-the-Art Components,
Integrated Modules, and Subsystems*

QUINSTAR
TECHNOLOGY, INC.

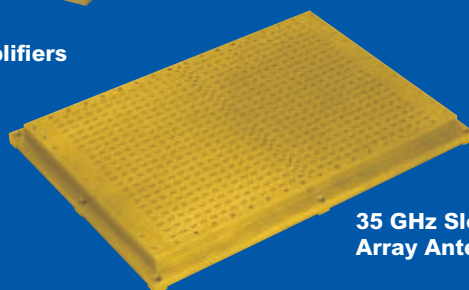
94 GHz OMT with
Scalar Horn



60 GHz - 20 Watt
High Power Amplifier



94 GHz
Power Amplifiers



35 GHz Slot
Array Antenna



Second Harmonic Mixers



Transceiver
Module

Next Generation Millimeter Wave Products



105 GHz Interferometer

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

QUINSTAR TECHNOLOGY, INC.

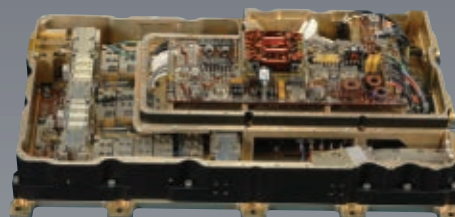
24085 Garnier Street, Torrance, CA 90505
Tel 310-320-1111 • Fax 310-320-9968

sales@quinstar.com
www.quinstar.com

See us at MTT-S Booth 310



Rack-Mounted
Amplifiers and Sources



39 GHz 10 Watt Space Qualified
Power Amplifier (SSPA)



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

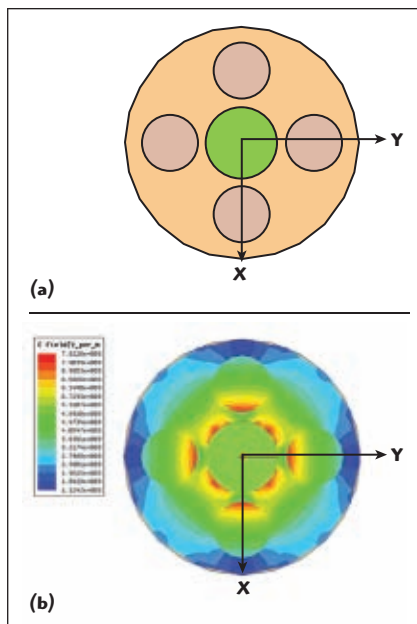
"Quality Products at Competitive Prices"
"Custom Designs are Available"

Product Line:

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

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

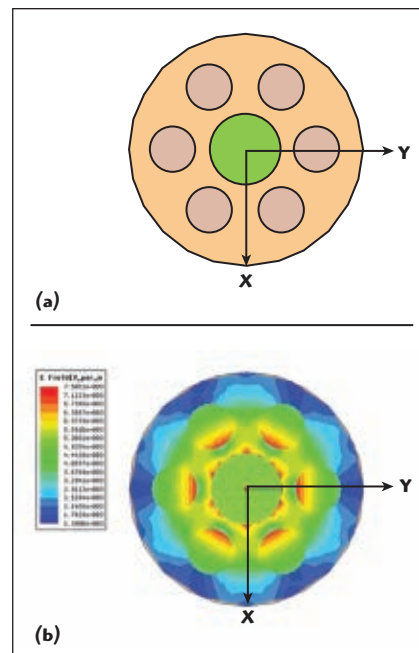
www.umcc111.com



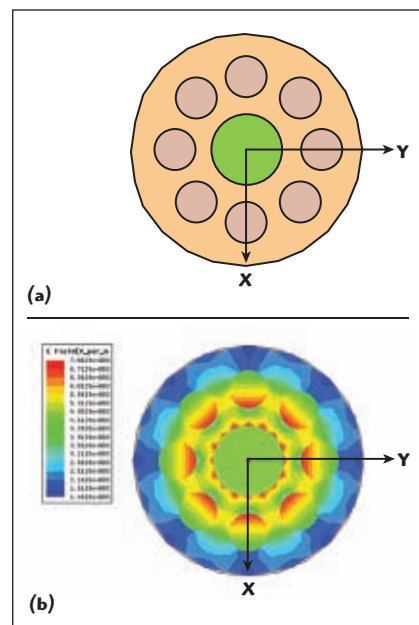
▲ Fig. 5 Four-airhole structure (a) and electrical field distribution (b).

be high for some dielectrics (including Teflon), the primary electron energy required to initiate this emission is about three times more for Teflon-based dielectrics than for copper. The voltage drop (V_d) across the holes can be calculated using the field calculator in HFSS. The calculation for the dielectric line showed that in a four-hole structure of Fluoroloy H, this voltage is 83 percent of a total voltage (V_{max}) between the inner and outer conductors. This is a substantial value. The inhomogeneous voltage distribution is typical for a partial dielectric structure. The higher voltage is always in the portion of the line with the lower dielectric constant. A six-hole structure, as shown in **Figure 6**, was analyzed to determine the geometrical impact of hole structure to voltage drop. The six-hole structure needs smaller diameter holes to maintain a 50Ω impedance. This line geometry showed a better voltage ratio of 71 percent. Following this progression, an eight-hole structure as shown in **Figure 7** reduced the voltage ratio to 63 percent.

An additional feature that can be modified is the radial position of the holes. **Figure 8** shows the holes moved outwards radially within the dielectric structure, where the electromagnetic field is much weaker. In order to maintain a 50Ω characteristic impedance, the hole diameter needs to be increased as the holes are



▲ Fig. 6 Six-airhole structure (a) and electrical field distribution (b).



▲ Fig. 7 Eight-airhole structure (a) and electrical field distribution (b).

moved radially away from the center of the line (compare the larger holes of Figure 8 to those of Figure 7). The results show an additional decrease in the voltage ratio, lowering it to 61 percent. A further advantage of the larger hole diameter is the increase in the frequency-distance product, which makes the component less susceptible to multipactor.

Based upon these analyses, the conclusion can be drawn that the eight-hole structure of Figure 8 ap-



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 MTT-S Booth 3404



Whenever, Wherever!

Fits into tight places
15x15 mils

Handles 50V

Spews 180pF

X7R: NO SWEAT

ALTAS[®]
ULTRA Hi-K SLC
"Heroic selection of values packed in 10 to 100 mils wide chips."
*RoHS Compliant

Sales Offices

JAPAN 46th F, Sunshine60, Higashi Ikebukuro 3-1-1, Toshima-ku, Tokyo, Japan 170-6046
TEL. +81-3-3988-3500 E-MAIL. sales@tecdia.co.jp

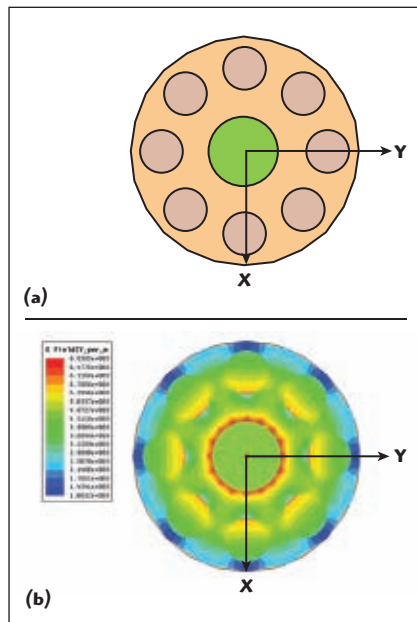
USA 2700 Augustine Drive, Suite 110, Santa Clara, CA 95054, U.S.A
TEL. +1-408-748-0100 E-MAIL. sales@tecdia.com

TAIWAN 9F-2, No. 207, Fu Shing Rd, Tao Yuan City 330, Taiwan
TEL. +886-3-337-0550 E-MAIL. sales_tw@tecdia.com

KOREA Room 517, Samho Park Tower, Ingye-Dong Suwon, Gyeonggi-Do, Korea, 442-070
TEL. +82-31-308-6500 E-MAIL. csm@tecdia.co.kr

CHINA Tower A #910 City Center of Shanghai, 100 YunYi Road, Shanghai P.R.C.200051
TEL. +86-21-6237-2208 E-MAIL. sales_ch@tecdia.com

WWW.TECDIA.COM



▲ Fig. 8 Eight displaced air hole structure (a) and electrical field distribution (b).

pears to be the most reliable design in preventing multipactor. This is due to its lower voltage ratio and increased frequency-distance product. It is important to note that both of these performance improvements are due to the placement of the dielectric voids close to the outer conductor to take advantage of the relatively small field density that is present. In reviewing the models presented in this article, the reader must recognize that ideal dielectric voids were used in forming the basis of these conclusions. The ideal holes do not take into consideration burrs, loose material, or other contamination that may be present in actual machined dielectrics that will have a great influence on multipactor. Connectors must be carefully inspected for the absence of foreign objects and loose particles to ensure their ability to meet the requirements of space power applications.

CONCLUSION

The design of multipaction free coaxial components is a very important part of high power space and vacuum engineering. Here, under the term "coaxial components," the author is primarily referring to practical applications such as the cable to connector junction and coaxial interfaces with overlapped dielectrics. The differences in the flow of electrons and development of multipactor within a partially loaded dielectric coaxial line

versus a traditional air line have been presented. It is apparent that the full analysis of practical coaxial components is extremely complicated. Multipaction detection and test methods are separate issues, which are not covered in this article. ■

ACKNOWLEDGMENTS

The author would like to thank Dr. Perry Malouf from Applied Physics Laboratory, Johns Hopkins University, Dr. Vladimir Volman from Lockheed Martin, Alex Lapidus from L-3 Communications Narda Microwave-West, as well as his colleagues from Astrolab, Stephen Toma and particularly special thanks to Andrew Weirback.

Teflon is a registered trademark of Dupont.

Fluoroloy H and Rulon H are trademarks of Saint Gobain Corp.

References

1. J. Rodney M. Vaughan, "Multipactor," *IEEE Transactions on Electron Devices*, Vol. 35, No. 7, July 1988, pp. 1172-1180.
2. R.A. Kishek, Y.Y. Lau, L.K. Ang, A. Valfells and R.M. Gilgenbach, "Multipactor Discharge on Metals and Dielectric. Historical Review and Recent Theories," *Physics of Plasmas*, Vol. 5, No. 5, May 1998, pp. 2120-2126.
3. M. Yu, "Power-handling Capability for RF Filters," *IEEE Microwave Magazine*, Vol. 8, No. 5, October 2007, pp. 88-97.
4. R. Woo, *Technical Report 32-1500. Final Report on RF Voltage Breakdown in Coaxial Transmission Lines*, NASA, 1970.
5. ESA calculator. Calculator can be downloaded free from the ESA website (<http://multipactor.esa.int/downloads.html>).
6. R. Udiljak, "Multipactor in Low Pressure Gas and in Non-uniform RF Field Structures," *Thesis for Degree of Doctor of Philosophy*, Chalmers University of Technology, Göteborg, Sweden, 2007.
7. R. Udiljak, D. Anderson, M. Lisak, V.E. Semenov and J. Puech, "Multipactor in a Coaxial Transmission Line. I. Analytical Study," *Physics of Plasmas*, Vol. 14, No. 3, March 2007.
8. V.E. Semenov, N. Zharova, R. Udiljak, D. Anderson, M. Lisak and J. Puech, "Multipactor in a Coaxial Transmission line. II. Particle-in-cell Simulations," *Physics of Plasmas*, Vol. 14, No. 3, March 2007.
9. N. Rosario, H.F. Lenzing, K.P. Reardon, M.S. Zarro and C.G. Baran, "Investigation of Telstar 4 Spacecraft Ku-band and C-band Antenna Components for Multipaction Breakdown," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 42, No. 4, April 1994, pp. 558-564.
10. A. Weirback, "Determining the CW Power Rating of Coaxial Components," *High Frequency Electronics*, Vol. 7, No. 7, July 2008.
11. Rudy Fuks, "Compute Power Rating For Unmatched Lines," *Microwaves & RF*, October 1998.
12. http://en.wikipedia.org/wiki/Paschen%27s_law.
13. MIL-STD-348A, Radio Frequency Connector, Interfaces For.
14. HFSS, version 12, Ansoft (part of ANSYS Corp.).

Aerospace • Marine • Medical • Military • Satellite • Test

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



Visit Us At
Booth #2511



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.

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

RF MICROWAVE CONNECTORS

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

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®



CONSIDERATIONS FOR ACCURATELY MEASURING PULSED ACTIVE DEVICES

Understanding device behavior under desired operating conditions is a critical step in the design of any high performance active RF device (e.g., an amplifier or converter). If the component operates in continuous-wave (CW) mode, that characterization can be as simple as measuring its S-parameters using a vector network analyzer (VNA). When it operates in pulsed mode, however, characterization is not so simple. In addition to S-parameters, many other active parameters must be measured in pulse mode. In the case of an amplifier, those parameters include the 1 dB compression (P1dB), intermodulation distortion (IMD) and third-order intercept point (IP3). The amplifier's noise figure, higher-order distortion products and harmonics, among other things, may also be characterized depending on its intended application. Because these active parameters are power-dependent, additional considerations are needed to ensure precise characterization. Understanding the changes required to the VNA to support these measurements is also critical.

To better understand the challenge of accurately measuring pulsed active devices let us first look at the different pulsed operation modes: pulsed-RF and pulsed-bias. The pulsed-RF operation drives a device with a pulse-modulated RF signal and the DC bias is always on. Amplifiers used in receivers in pulse-modulated applications are typically tested under pulsed-RF operation, which requires RF pulse modulators for the stimulus and pulse generators to synchronize (or gate)

the VNA receivers to capture the modulated RF signals.

With pulsed-bias operation, the DC bias is switched on and off to generate a pulse-modulated signal. The input is mostly a CW signal. Pulse generators may be needed to turn on and off the DC bias. The VNA receivers are synchronized to measure the output signal when the device is on.

For pulsed-RF network analysis, three types of measurements are performed—average pulse, point-in-pulse and pulse profile—using either wideband or narrowband detection techniques. Wideband detection is used when the pulse width is wide enough for VNA receivers to be able to measure the majority of the pulsed-RF spectrum. When the pulse width is too narrow, narrowband detection is used to measure only the center spectral response by removing all other pulsed-RF spectrum components.

VNA CONSIDERATIONS

When characterizing active devices in pulsed mode using either wideband or narrowband detection, there are a number of considerations that the engineer should keep in mind; namely, required changes to the VNA and techniques for enabling power-dependent active device characterization, including compression and distortion.

Active devices operating under pulsed conditions can be measured with a VNA, but some

HIROYUKI MAEHARA
Agilent Technologies Inc., Santa Clara, CA



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



Visit Us At Booth #1140



WWW.ARC-TECH.COM/CABLES

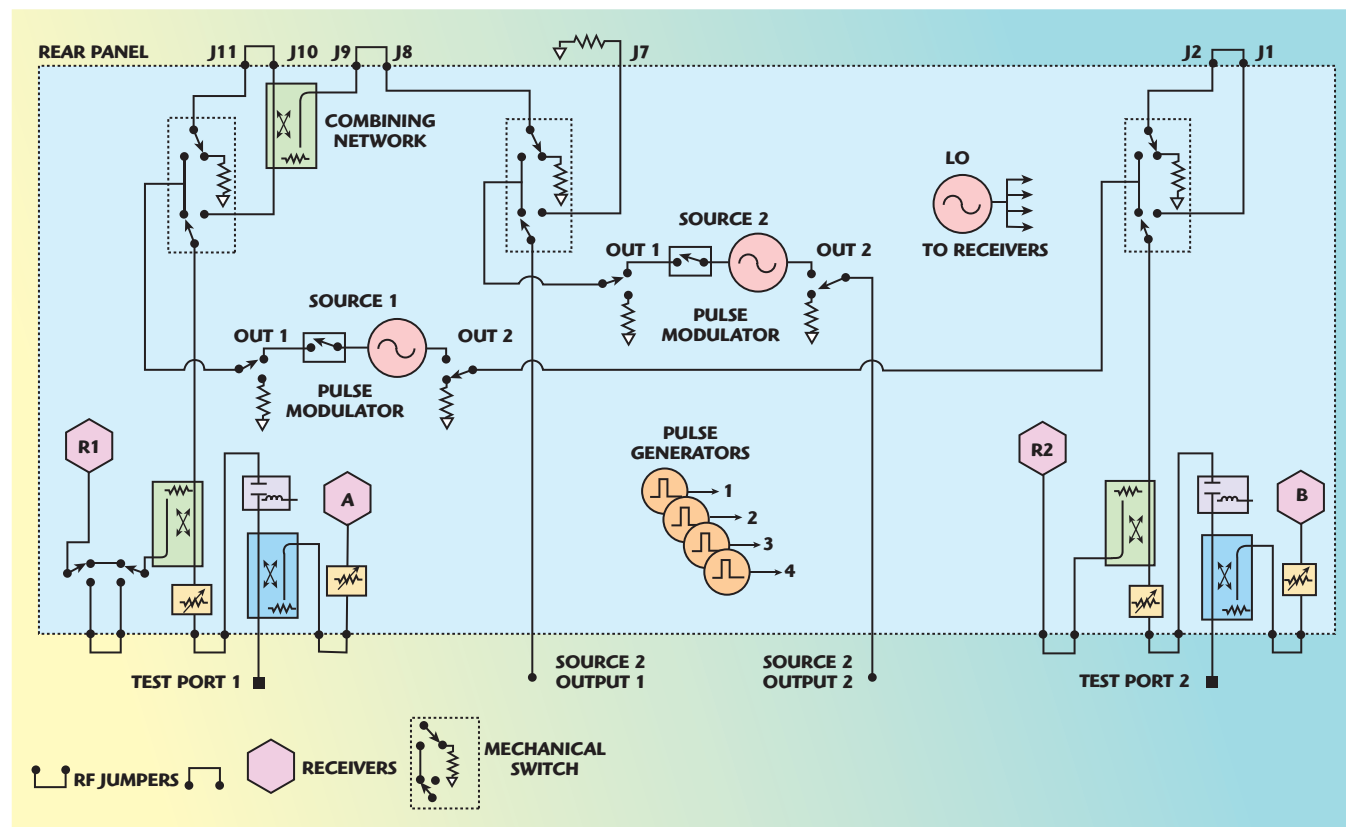


hardware modifications are required. For pulsed-RF operation, pulse modulators and generators must be added to the VNA. Pulsed-bias operation may require the addition of pulse generators. One example of an analyzer with integrated pulse generators and modulators is the Agilent Technologies' PNA-X (see **Figure 1**). The in-

ternal pulse modulators and generators enable pulse measurements without external equipment, enabling precise pulse control, synchronization and fine timing resolution. Another required change to the VNA is the addition of a pulse input/output (I/O) port, which provides accessibility to internal pulse generators and modulators, and en-

ables synchronous pulse measurements with external pulse generators or a device-under-test (DUT).

An important consideration that must be taken into account when measuring active devices operating under pulse conditions is pulse system delays (e.g., delays in the pulse system from the pulse trigger to pulse genera-



▲ Fig. 1 Agilent's PNA-X is one example of an analyzer with integrated pulse generators and modulators.



Your compact high-performance synthesizer solution

Spinnaker Microwave offers a complete line of frequency synthesizers including everything from low cost surface-mount to broadband state-of-the-art systems. Our design expertise includes: single and multiple loops, integer and fractional divider schemes, switched VCO/filter designs, digitally tuned oscillators, frequency multipliers, integrated up/down converters, direct analog and DDS-based designs.

- **DC to 40 GHz Coverage**
- **The Most Compact Designs Available**
- **<1 psec Switching Speed**
- **Integrated Phase Noise Down to 0.02 deg RMS**
- **Low Cost, Lightweight Integrated Module**

- **Military and Commercial Applications:** Active Jamming, Radar, Communications, SATCOM, EW, Test Equipment
- **Operating Temperature: -45°C to +85°C**
- **Built for High Vibration Environments**

At Spinnaker Microwave, our products are designed with one thing in mind – your specifications. We pride ourselves on delivering quality signal sources custom tailored to your unique application. Contact Spinnaker Microwave today for the high-performance microwave sources you can count on.



SPINNAKER
MICROWAVE, INC.

3281 Kifer Rd, Santa Clara, CA 95051 • Tel: 408-732-9828 • Fax: 408-732-9793 • www.spinnakermicrowave.com

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 defense, aerospace, industrial, commercial, RF, Test & Measurement and Space markets.



MICROWAVE COAXIAL SWITCHES

- SPDT, Transfer, Multi-Throw Switches and Switch Matrices
- 5 million cycles characteristic life
- DC to 33 GHz
- Custom products
- 3-State attenuated switch

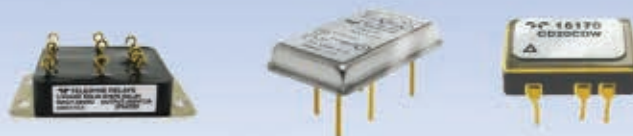
ELECTROMECHANICAL RELAYS

- Signal integrity up to 12 Gbps
- SMT solutions
- DC-8 GHz



MILITARY & COTS SOLID-STATE RELAYS

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



INDUSTRIAL/COMMERCIAL SOLID-STATE RELAYS

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



*Please visit us
Booth #1812
MTT-S • June 5-10*

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

 **TELEDYNE RELAYS**
A Teledyne Technologies Company

 **TELEDYNE**
COAX SWITCHES



tors, to pulse modulators, and to the ADC for data acquisition). **Figure 2** shows a timing diagram with 5 MHz IF bandwidth, from the external pulse trigger through the data acquisition with wideband detection technique. Approximately 60 to 100 ns after the pulse trigger at the PULSE SYNC IN port, the internal pulse generators generate a pulse to drive the pulse

modulator and the receiver data acquisition timing. The pulse modulator has about a 30 ns delay to modulate the RF signals. User-specified delays for pulse generators are used to adjust the modulation and measurement timings to account for pulse system delays. If any of the pulse system delays (e.g., pulse trigger and modulation delays), plus other system delays

from the test port cables and DUT's electrical length, are relatively long compared to the pulse width and the VNA's receiver data acquisition time, then the timing of each must be carefully adjusted. Additionally, the data acquisition window should be placed at the middle of the pulses (approximately), and a wide enough IF bandwidth chosen to complete the data acquisition in approximately a half of the pulse width. By doing this, most timing errors can be avoided.

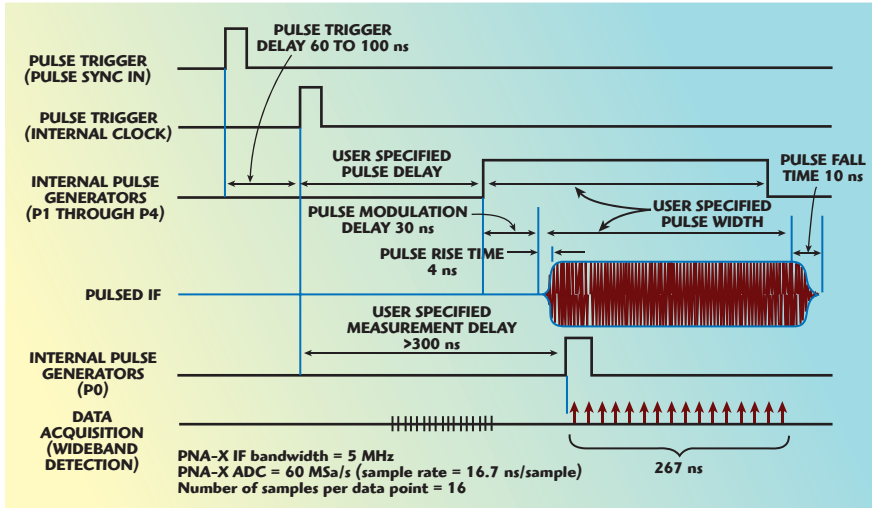
POWER-DEPENDENT ACTIVE DEVICE CHARACTERIZATION

Devices that operate under pulsed condition are often discrete active devices or modules that consist of amplifiers and/or mixers. The performance of these devices is typically power-dependent. Therefore, they are characterized in linear and nonlinear operating conditions. Inaccurate stimulus power may introduce considerable measurement errors.

In some VNAs, the stimulus power is factory calibrated. This provides a reasonably accurate stimulus power level at the test ports, even without source power calibration. When accurate stimulus power is required at the device input (typically at the end of the test port cable), source power calibration is performed. The calibration compensates for the path loss and corrects errors, which in turn, enables the stimulus power accuracy to be set to a specified tolerance level from the power sensor accuracy. For pulsed-RF measurements, this simple calibration becomes problematic. Because most power sensors measure average RF power, the sensor readings are $10\log(\text{duty cycle})$ lower than the peak pulse power during source power calibration in pulse mode. Two approaches may be employed to overcome this source power calibration problem.

Source Power Calibration Using Power Sensor Loss

This technique is used to calibrate the stimulus with the pulse modulation on. To successfully perform a source power calibration, the power sensor loss feature must be used to ensure the VNA's source does not go unlevelled as it tries to bring the test port power to the desired calibrated power level. The pulse desensitization effect due to the pulse duty cycle ap-



▲ Fig. 2 Timing diagram with 5 MHz BW from the external pulse trigger through the data acquisition.

The Future of Pulsed IV and Pulsed S-Parameter Systems!

Powered by **AMCAD Engineering**
Advanced Modeling for Computer-Aided Design

See Maury's Full Product Line at IMS2011 (Booth #1016)

Maury and AMCAD Offer Modular and Turnkey Pulsed IV, Pulsed S-Parameter and Modeling Systems for Every Budget!

See More Information at: maurymw.com/piv.htm
2900 Inland Empire Blvd., Ontario, California 91764 • USA
Tel: 909-987-4715 • Fax: 909-987-1112 • Email: maury@maurymw.com
On The Web at MAURYMW.COM

MAURY MICROWAVE CORPORATION
Agilent Technologies
Global Solutions Partner

Micable Inc.

ISO9001:2008 CERTIFIED



C10 series

New

DC-26.5GHz high performance test cable assemblies

Advantages & Features:

- *Excellent phase stability vs. flexure*
- *Perfect flexibility and good touch*
- *Double shielded*
- *Stainless steel connectors of enhanced protective construction*
- *Upgraded strain relief design for extended service life*

Applications:

- *Superior replacements for test cables of original instrument*
- *Volume quantity test of production line*
- *Test at R&D labs*
- *Test for environmental & temperature chamber*
- *Radio frequency related fields*

C10 Series is the reliable and economy cable assemblies of high performance, extensively applied in varied tests of broadband and connections. C10 series is designed with a special enhanced protective construction, featuring the super strain relief with proven extended service life and higher stability for bending, connecting and disconnecting over and over again.

Micable is your quality fast and low cost solution !

affiliated with



Micable Inc.

Tel: 86 591-87382856

Email: sales@micable.cn

Website: www.micable.cn

Seeking world-wide agents



USA Distributor Center:

SSI Cable Corporation

Tel: (360)426-5719

Email: bsmith@ssicable.com

See us at MTT-S Booth 934

appears as attenuation, thus the power offset is always negative. For example, the power offset value for a pulsed-RF stimulus with 5 percent duty cycle is $10\log(0.05) = -13$ dB.

Accurate Pulse Stimulus Using Receiver Leveling

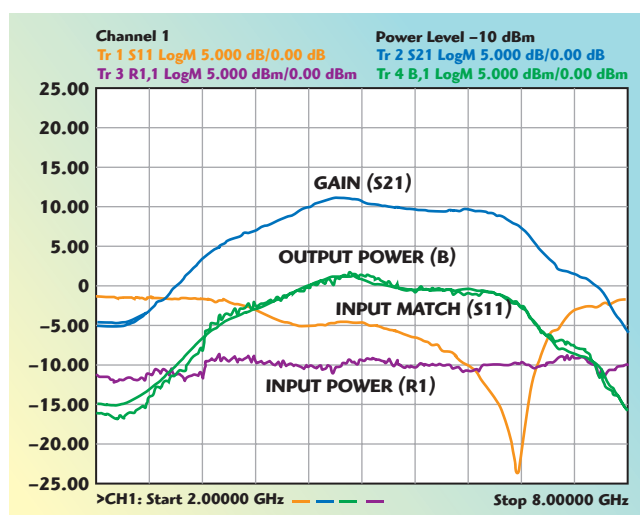
The VNA receiver is used to monitor the pulsed-RF power and correct the source power level for every measurement sweep in receiver leveling mode. Once the receiver leveling is selected, the source level is adjusted with the receiver readings and the source power correction coefficients are ignored (source power calibration is not used even if it is turned on). Reference receivers are typically used for receiver leveling, although any receiver or even a power sensor (if added as a receiver to the VNA) can be used. The source level accuracy in receiver leveling mode depends on the receiver's absolute power measurement accuracy, making receiver calibration essential.

Reference receivers can be calibrated by performing receiver calibration independently or as part of a source power calibration, although the latter is recommended. During calibration, the leveling mode must be open loop with the same source chain settings as the measurements, and the pulse modulation must be turned off. Also, the receiver setting must be the same between the receiver calibration and the pulsed measurements.

Once calibrated, the receiver can

accurately measure the peak pulse power in wideband detection and adjust the source power until it is either in the specified tolerance or reaches the maximum number of iterations before the measurement sweep. In narrowband detection mode, the receiver measures the power lower than the peak pulse power by $20\log(\text{duty cycle})$. The power offset may be used with receiver leveling in narrowband pulse measurements.

Note that for S-parameter measurements, where the DUT is in linear operation, power is not a concern and open loop leveling is suitable. When making absolute power and/or power-dependent performance measurements, the pulsed stimulus power matters greatly and must be accurately leveled. In this case (wideband detection), receiver leveling is recommended (see **Figure 3**). The difference in memory traces is very small in the input match and gain measurements, but is larger in the absolute power measurements. It can be used with both wideband and narrowband detection and applied to swept-power measurements, as well



▲ Fig. 3 Calibrated wideband pulsed S-parameters and absolute power measurements with a comparison between open loop and receiver leveling modes.

as compression and two-tone IMD measurements.

Accurately measuring pulsed active devices can be a difficult task, especially when those measurements are power dependent. Receiver leveling offers one means of addressing this issue. Another consideration the engineer must be aware of when characterizing active devices is selecting a VNA that supports pulse generators and modulators. Employing the right solution and appropriate techniques for accurately leveling the pulsed stimulus power are critical for enabling both S-parameter measurements and accurate power-dependent active device characterization, including compression and distortion. ■

RF & MICROWAVE COAXIAL CABLE ASSEMBLIES

Make the Connection

- MIL-C-17 type
- High Performance Flexible
- Low Loss Flexible
- Conformable
- Semi-Rigid

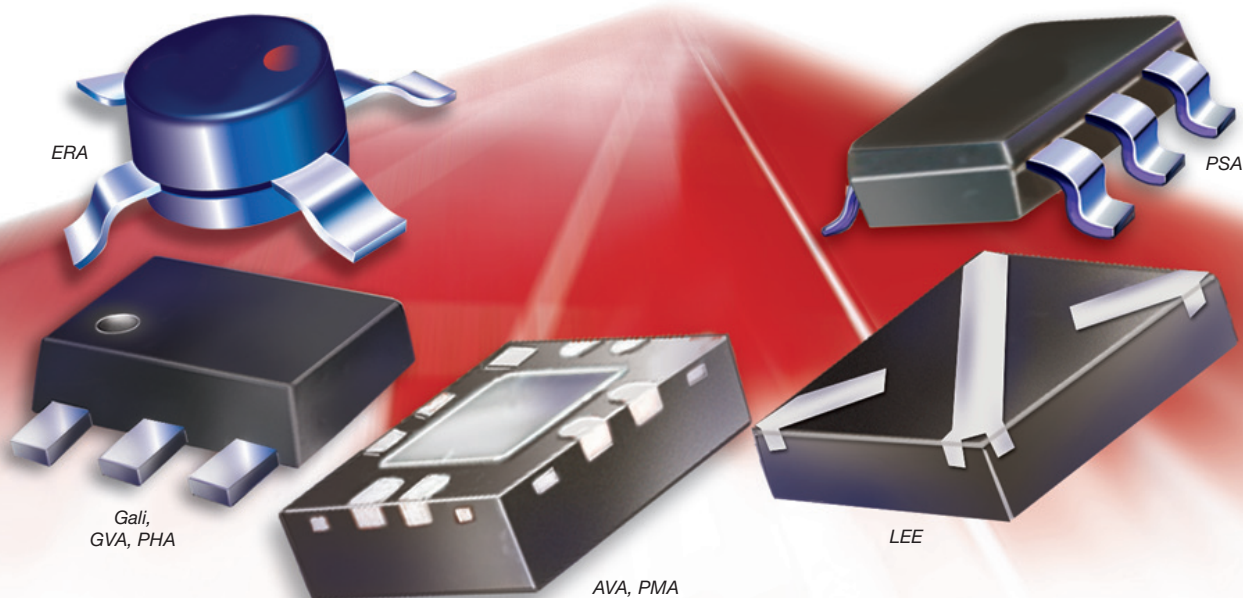
visit our **NEW WEBSITE** to
custom configure your
cabling requirements

ESM
CABLE CORP.

www.esmcablecorp.com

MMIC AMPLIFIERS


DC to 20 GHz from 73¢ qty.1000



NF_{from} 0.5 dB, IP3_{to} +48 dBm, Gain 10_{to} 30 dB, P_{out} _{to} +30 dBm

Think of all you stand to gain. With more than ¹²⁴~~120~~ catalog models, Mini-Circuits offers one of the industry's broadest selection of low-cost MMIC amplifiers. Our ultra-broadband InGaP HBT and PHEMT amplifiers offer low noise figure, high IP3, and a wide selection of gain to enable optimization in your commercial, industrial or military application.

Our tight process control guarantees consistent performance across multiple production runs, so you can have confidence in every unit. In fact, cascading multiple amplifiers often produce less than 1dB total gain variation at any given frequency. These MMIC amplifiers can even meet your most critical size and power consumption requirements with supply voltages as low as 2.8 V, and current consumption down to 20 mA, and packages as small as SOT-363.

Visit our website to select the amplifier that meets your specific needs. Each model includes pricing, full electrical, mechanical, and environmental specifications, and a full set of characterization data including S-Parameters. So why wait, place your order today and have units in your hands as early as tomorrow.  RoHS compliant

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

Mini-Circuits®
ISO 9001 ISO 14001 AS9100 CERTIFIED

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

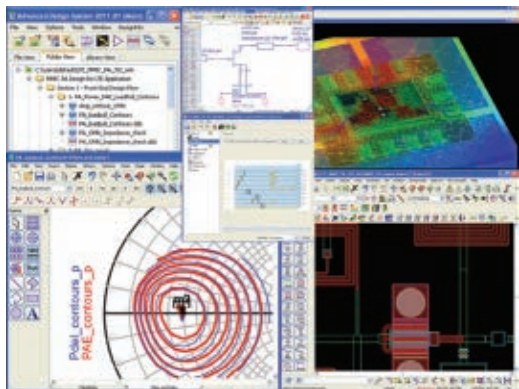


The Design Engineers Search Engine finds the model you need, Instantly • For detailed performance specs & shopping online see minicircuits.com

IF/RF MICROWAVE COMPONENTS

See us at MTT-S Booth 1031

476 Rev C



ADS 2011 USHERS IN A NEW ERA IN RF/MICROWAVE DESIGN

Advanced Design System (ADS) 2011 from Agilent Technologies represents the most significant release of the ADS product in over a decade. With improvements to virtually all areas of the platform, it offers something for anyone doing RF/microwave design, whether of a monolithic microwave integrated circuit (MMIC), module or printed circuit board (PCB). What really sets ADS 2011 apart is its ability to design and verify multiple technologies concurrently.

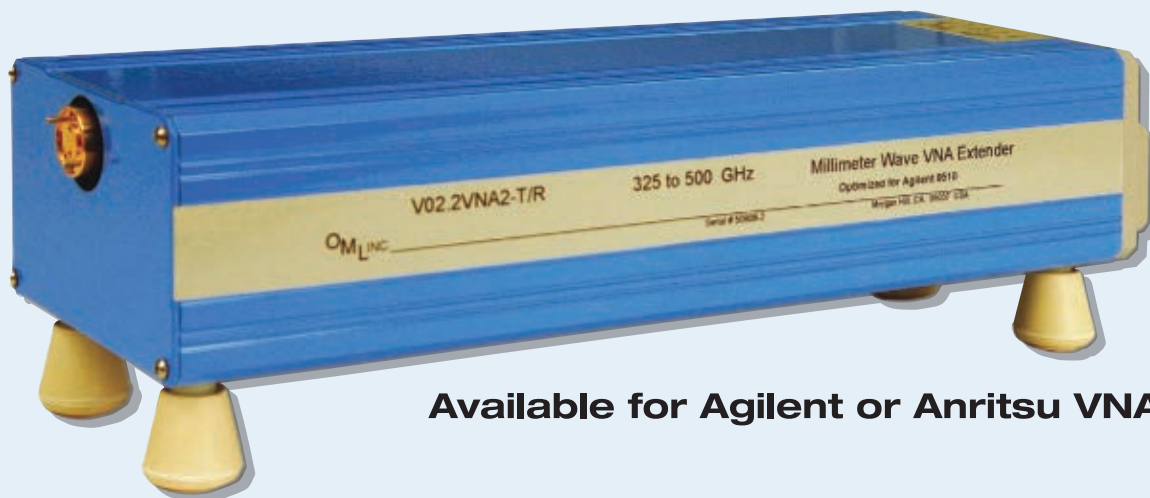
ADDRESSING THE CHALLENGE OF MULTI-TECHNOLOGY DESIGN

Today's RF design industry is in the midst of a transformation. For evidence, look no further than the commercial wireless and aerospace/defense industries where trends like increasing complexity and integration have become commonplace. Today's products are no longer single MMICs put into a package. Instead, multiple chips are now combined into packages or modules, and this increased product

integration brings circuit elements closer together, within and across technology boundaries. As a consequence, engineers can no longer ignore the interactions between these different technologies. To achieve success requires a platform that works in a multi-technology design space. ADS 2011 meets the challenge with a comprehensive multi-technology design platform.

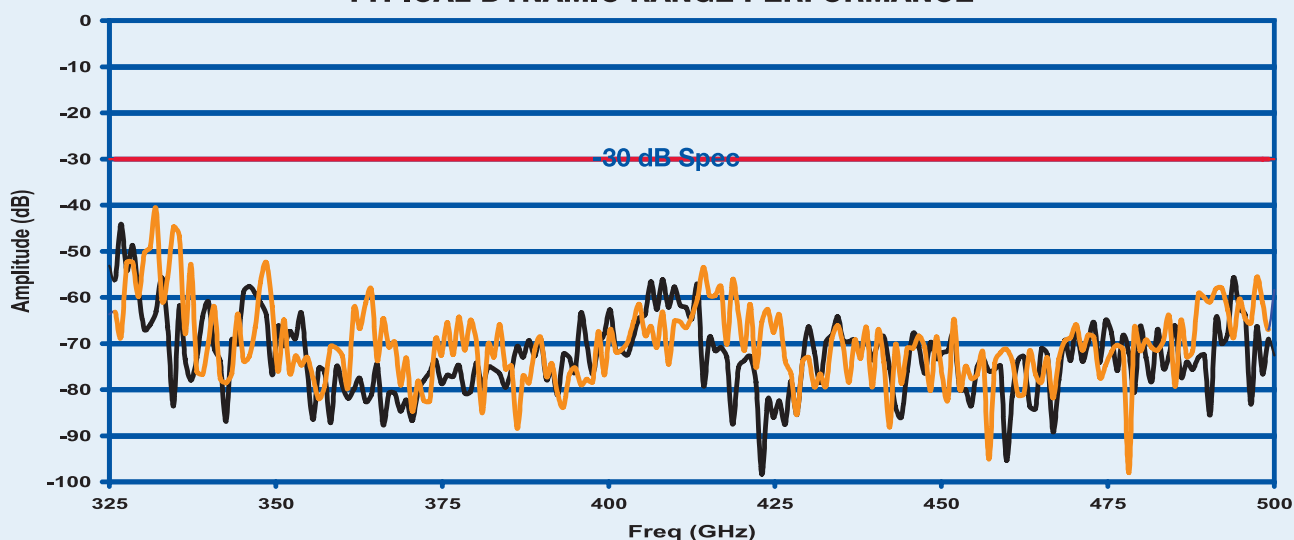
Existing design tools generally work only in a single technology space. More often than not, the tool used to design the IC is different than the one used to design the module that it goes in or the PCB, making it difficult or even impossible to take into account the important interactions between the technologies. With ADS 2011, not only can engineers design ICs, modules and PCBs all in the same environment, they can also easily assemble these multiple technologies with complete access to

AGILENT TECHNOLOGIES INC.
Santa Clara, CA

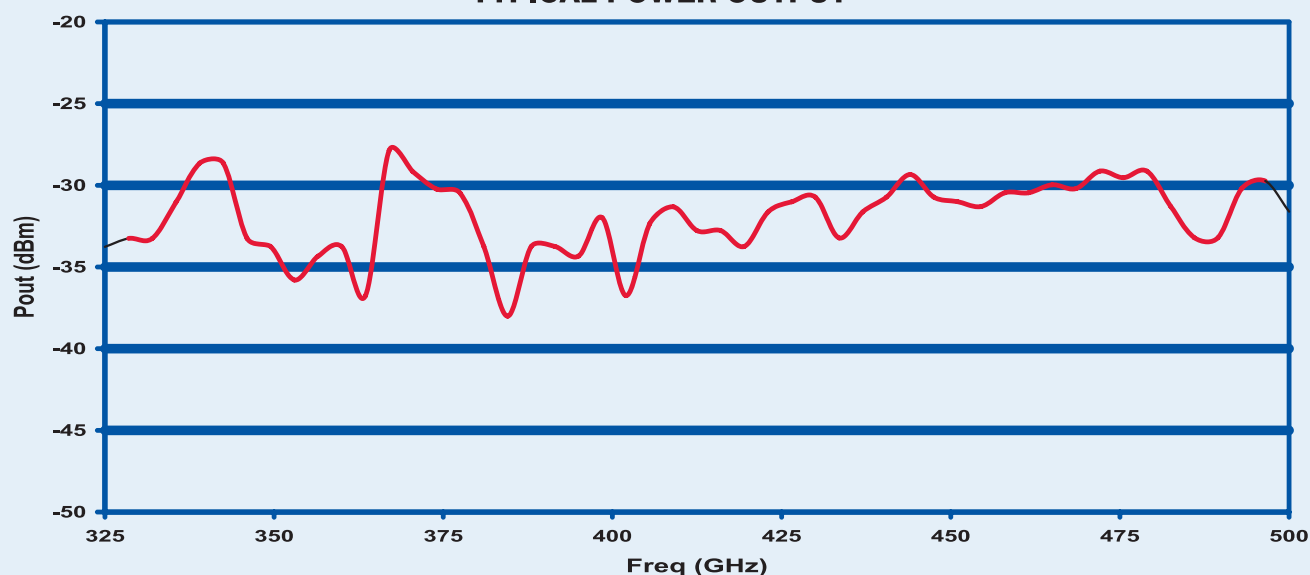


Available for Agilent or Anritsu VNA's

TYPICAL DYNAMIC RANGE PERFORMANCE



TYPICAL POWER OUTPUT



Visit our exhibit at the 77th ARTG Conference in Baltimore June 10th, 2011

Innovation in Millimeter Wave Measurements

www.omlinc.com

(408) 779-2698



all the analysis and design technology within the ADS flow.

MULTI-TECHNOLOGY DESIGN IN ACTION

As an example of the ADS 2011 multi-technology design capabilities, consider the design of a 10 GHz local oscillator amplifier (see **Figure 1**). Here is an IC mounted in a package that is then placed on a PCB. The design encompasses three different technologies. With ADS 2011, one can assemble this multi-technology design without making any changes to the individual designs. There are no worries about any conflicts between component names, PDKs, physical layer definitions, or other aspects of the technology definition. Once assembled, one can perform circuit simulation on the entire structure, ensuring that the entire design will perform to the original specifications.

In addition to circuit simulation, EM simulation can be performed on this multi-technology structure using either the Momentum 3D Planar

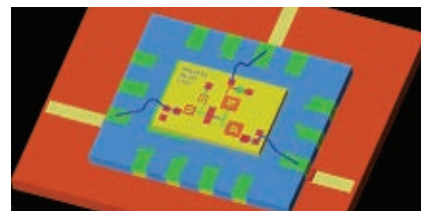
simulator, or the 3D Finite Element simulator (see **Figure 2**). This enables engineers to discover EM coupling effects, even across technology boundaries. By resolving these issues prior to fabrication, engineers can avoid expensive manufacturing re-spins and keep product delivery on schedule.

PUTTING EM TECHNOLOGY WITHIN EVERY ENGINEER'S REACH

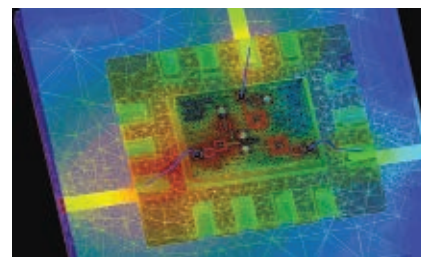
Historically, EM tools have been restricted to experts, and therefore only used sparingly. In today's world of smaller form factors and physical complexity, EM analysis has become a necessity in order to achieve design success. Over the last few years, ADS has brought together a suite of EM technologies including 3D Planar and FEM solvers in a single integrated platform. With ADS 2011, significant strides have been made to make EM analysis accessible to a broader community of engineers.

To start, ADS 2011 features a unified, graphical layer definition editor

that makes it easy to define the substrate technology (dielectric, metal, vias and material properties). To set up and run a simulation, multiple dialogs have been consolidated into a single dialog that is used for both the Momentum and FEM simulators.



▲ Fig. 1 A multi-technology 10 GHz amplifier.



▲ Fig. 2 Performing multi-technology EM analysis.

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 channel, multichannel up to 21

Test and Measurement Equipment

- Standard and compact calibration kits
- Precision connectors and adaptors



CALIBRATION KITS

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
MTT in Baltimore
at booth 431

SPINNER Atlanta, Inc.
info-atlanta@spinner-group.com
www.spinner-group.com



High Frequency Performance Worldwide

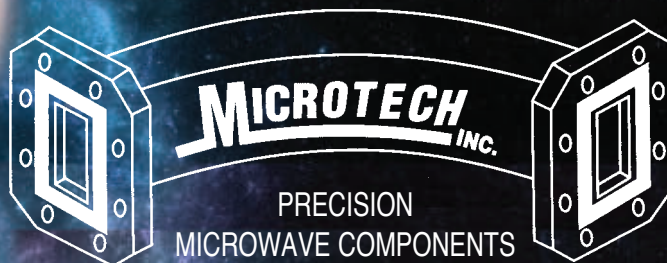
Microtech —

Leading The Race Into
Space

And Beyond

*Space Qualified Technology
That's Out Of This World*

AS9100 Certified



PRECISION
MICROWAVE COMPONENTS

1425 Highland Ave. • Cheshire, CT 06410 USA

203-272-3234 • Fax 203-271-0352

E-Mail: sales@microtech-inc.com

Visit us at: www.microtech-inc.com

See us at MTT-S Booth 2125

RF Integration Technology



- Complex functional blocks for Radar and EW systems
- Smaller, lighter, more reliable
- Patented Multi-Mix® technology

Beamformers
DLVAs
Filter Banks
Frequency Converters
Radiating Structures
Switch Matrices
Synthesizers
T/R Modules

Microwave Solutions

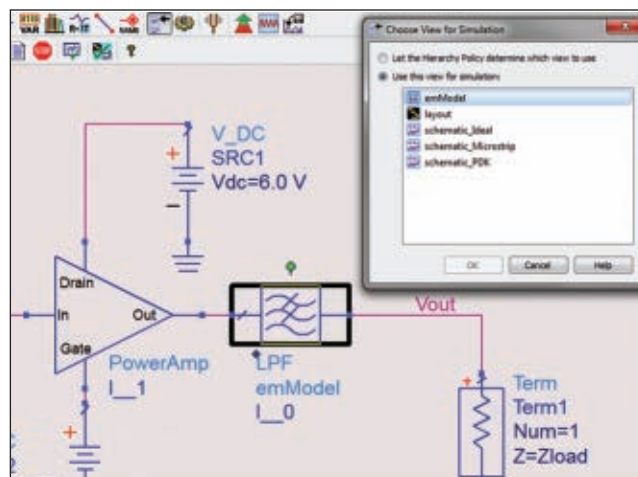
SIGNAL TECHNOLOGY • MERRIMAC

To learn more call 480-961-6269
or visit www.craneae.com/mw

Visit us at IMS/MTTS • Baltimore, MD • Booth 1822



PRODUCT FEATURE



▲ Fig. 3 Multiple data views in ADS 2011.

Once the simulation setup has been done, it can be saved and re-used for other designs and even shared with other engineers. In addition, the underlying technology has been improved with the capacity and performance required to solve much larger problems than were possible even a few years ago. Finally, parameterized 3D solid models can be imported as components to ADS 2011 from Electromagnetic Professional (EMPro), Agilent's 3D EM modeling and simulation platform. These components can then be combined with the circuit layout and simulated as an integrated physical structure.

NEW FLEXIBILITY AND PRODUCTIVITY FOR DESIGN AND SIMULATION

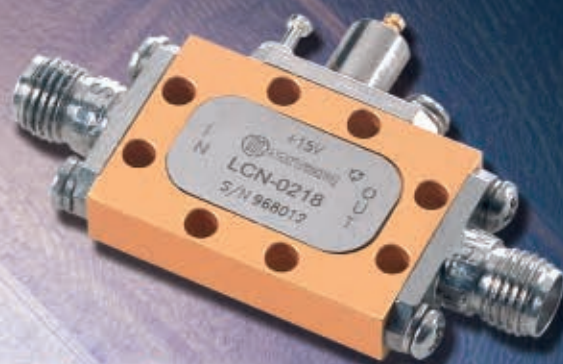
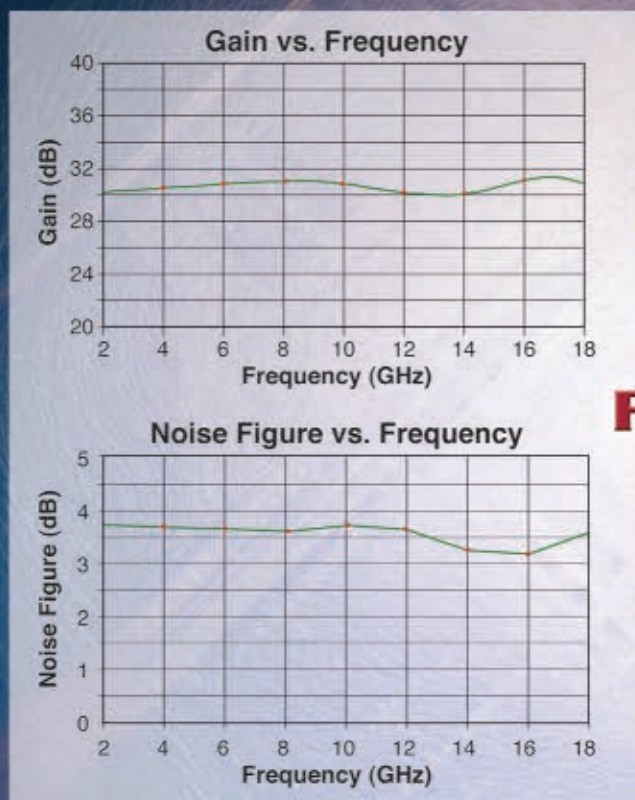
A key improvement for ADS 2011 is the new organization of the design data. Each sub-circuit or component in the design is now a cell that can have a variety of views, which represent different models (e.g., circuit, behavioral and EM), or even design variations (see **Figure 3**). This makes it easier to explore the design space, make trade-offs between simulation speed and accuracy, and keep the schematic cleaner and better organized. Additionally, a new load-pull controller simplifies data import and shortens the time to design and simulation. Other new features include a Multi-level Hemispherical Model that more accurately models surface roughness for transmission line and Momentum simulations and improved Smith Chart graphing.

ADS 2011 also boasts significant improvements for layout, not the least of which is a new, industry standard database that provides improvements in performance and capacity. Editing "handles" added to all basic layout objects make layout editing more efficient. Bond wires are now easier to create and edit, and can be modeled directly by Momentum. Further improvements to designer efficiency come from a new command line editor with dozens of common functions and a new layout toolbar.

A FOUNDATION FOR TODAY'S CHALLENGES AND BEYOND

With the introduction of ADS 2011, the ADS platform becomes the first RF/microwave design tool that is built directly on the industry standard Open Access database (supported by Si2, an organization of nearly 100 industry-

COST EFFECTIVE - HIGH PERFORMANCE AMPLIFIERS



Featuring:

- Industry Standard Hermetic Housing
- Operating Temperature: 0 to 50°C
- Removable SMA Connectors
- Drop-in Compatibility

**Great
Single Unit
Pricing!**

MODEL NUMBER	FREQUENCY RANGE (GHz)	GAIN (dB, Min.)	GAIN VARIATION (±dB, Max.)	NOISE FIGURE (dB, Max.)	VSWR IN/OUT	POWER OUT @ 1 dB COMP. (dBm, Min.)	DC POWER @ +15 V (mA, Nom.)	PRICE (US Dollars)
NEW COST EFFECTIVE - HIGH PERFORMANCE AMPLIFIER MODELS								
LCN-0102	1 - 2	30	1.0	1.2	2:1	15	125	\$325
LCN-0204	2 - 4	30	1.0	1.2	2:1	15	125	\$375
LCN-0408	4 - 8	28	1.0	1.5	2:1	10	150	\$350
LCN-0812	8 - 12	25	1.0	1.8	2:1	10	150	\$425
LCN-1218	12 - 18	30	1.5	2.8	2:1	10	200	\$595
LCN-0618	6 - 18	28	1.5	2.8	2:1	10	200	\$575
LCN-0218	2 - 18	28	2.0	4.0	2.5:1	10	200	\$599

Note: Specifications at 23°C. 1 Year Warranty.

Delivery From Stock!



For additional information, please contact our Sales Department
at (631) 439-9220 or e-mail components@miteq.com



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

www.miteq.com

See us at MTT-S Booth 1909

I N T E G R A T E D

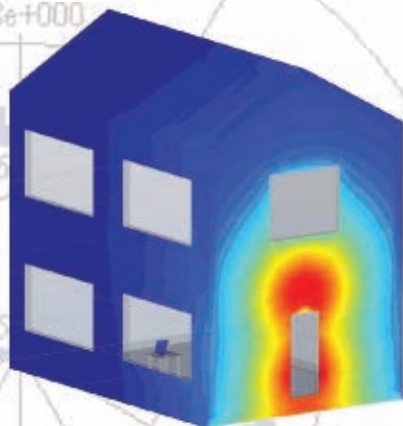
INTRODUCING: Chronos

FINITE DIFFERENCE TIME DOMAIN ANALYSIS SOFTWARE

LIMITED-TIME OFFER*: \$9,900 US FOR CORPORATE USERS

Analyze and Model:

- Planar microwave and antenna structures
- Wire antennas
- UWB antennas
- Microwave circuits, waveguides, and coaxial structures
- Near field and far field applications



Fast. Accurate. Easy-to-use.

- Very short learning curve; no scripting required
- Highest level of support in the industry

PUT OUR SOFTWARE TO THE TEST

CALL FOR AN EVALUATION AND START IMPROVING
PRODUCTIVITY TODAY. A live demo is also available.

*Offer expires on September 30th, 2011



I N T E G R A T E D
ENGINEERING SOFTWARE

Call +1 204.632.5636

email info@integratedsoft.com

or visit www.integratedsoft.com/products/chronos



leading companies). This proven design database provides the capacity and performance to address not only single technology design, but also the increased demands of a native, multi-technology design platform. Unlike the proprietary databases found in other RF/microwave tools today, the OpenAccess database has been engineered for industry-wide interoperability, and a variety of other leading EDA tools are currently built on OpenAccess.

With the rapid evolution of RF/microwave design, today's tools need to keep pace with the critical circuit and EM simulation technologies required to address conventional single-technology design. However, this alone is no longer sufficient to deal with the interactions between multiple technologies being combined into complex systems. What is needed is a true multi-technology design platform that combines the necessary database capabilities and capacity with the advanced simulation technologies needed to find and resolve issues across technology boundaries before going to manufacturing. ADS 2011 provides a comprehensive design environment to address these multi-technology design challenges in a single integrated design platform.



Agilent Technologies Inc.,
Santa Clara, CA
(800) 829-4444,
www.agilent.com

**Visit Agilent Technologies
in Booth #813 at this year's
IEEE MTT-S International
Microwave Symposium
being held June 5-10, 2011
in Baltimore, MD.**

S. M. ELECTRONICS L.L.C. DBA
FAIRVIEW MICROWAVE

ATTENUATORS 0-50 GHZ

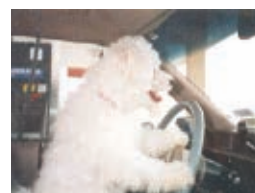
					
SA50 \$288.00 2.4MM 50GHZ	SA4014 \$142.00 2.92MM 1W 40GHZ	SA26B \$75.00 SMA 27GHZ	SA18H \$30.50 SMA 18 GHZ	SA6H \$20.00 SMA 6GHZ	SA6Q \$29.00 QMA 6GHZ 2W
					
SA3011 \$12.75 SMA 3GHZ BRASS	SA4017 \$500.00 2.92 40GHZ 5W	SA3S5W \$36.00 SMA 3GHZ 5W	SA3N10W \$70.00 N 3GHZ 10W	SA18S10W \$122.00 SMA 18GHZ 10W	SA3T \$29.00 TNC 3GHZ 2W
					
SA18N \$47.00 N 18GHZ	SA3NS \$26.00 N 3GHZ	SA3N5W \$40.00 N 3GHZ 5W	SA18N10W \$123.00 N 18GHZ 10W	SA4N-50 \$170.00 N 4GHZ 50W	SA18N100 \$700.00 N 18GHZ 100W

ADAPTERS 0-65 GHZ

					
SM3250 \$198.00 2.92 M/F 40GHZ	SM3929 \$409.00 1.85-1.85 65GHZ	SM3985 \$135.00 1.85-3.5 34GHZ	SM8902 \$105.00 MINISMP-SMA 26GHZ	SM4216 \$25.00 N-M-SMA 6GHZ	SM4742 \$39.50 SMA-TNC 18GHZ

DC BLOCKS, EQUALIZERS, TERMINATIONS, DIVIDERS, COUPLERS, CABLES

					
SD3235 \$47.00 DC BLOCK SMA 5KHZ-23GHZ	EQUALIZERS 1-18 GHZ	ST5038 \$260.00 2.4MM 1W 50GHZ	SMP0218 \$275.00 DIVIDER SMA'S 2-18GHZ	ST3N501 \$129 3GHZ 50W	CABLES SMA, N, 2.92 0-65 GHZ

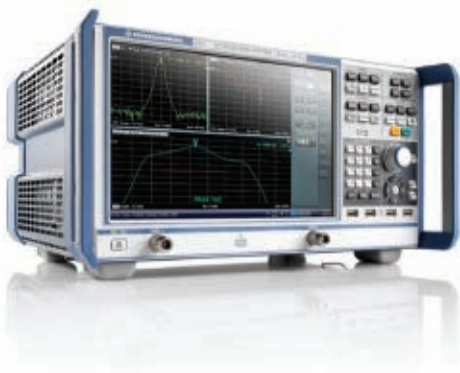


FAST DELIVERY!



WWW.FAIRVIEWMICROWAVE.COM 1-800-715-4396

460 S HIGHWAY 5 FAIRVIEW, TX 75069 1-800-715-4396 FAX: 972-984-1218 EMAIL: SALES@FAIRVIEWMICROWAVE.COM



NEW NETWORK ANALYZER GENERATION SETS THE PACE

The new R&S ZNB family of network analyzers stands out due to its wide dynamic range of up to 140 dB (at 10 Hz IF bandwidth), its low trace noise of 0.004 dB (RMS) (at 10 kHz IF bandwidth) and its high output power of up to +13 dBm that can be varied electronically in a range of more than 90 dB. The state-of-the-art operating concept of these network analyzers makes configuration, measurement and analysis simple.

All basic and frequently used functions can be controlled via keys, and functions needed for the individual test sequences are available via context-sensitive menus on the touch screen. Working with diagrams and traces, setting up markers for analysis, and zooming in on details—all it takes is a simple movement of the finger on the large, high-resolution 12.1-inch screen. Due to their shallow depth, the compact two-port and four-port analyzers leave plenty of space on the workbench for the measurement application.

Operation is extremely low-noise thanks to low power consumption and an elaborate cooling concept. With the available frequency ranges of 9 kHz to 4.5 GHz and 9 kHz to 8.5 GHz, the network analyzers are primarily intended for use in the mobile radio and wireless communications and electronic goods indus-

tries. The R&S ZNB is suitable for developing, producing and servicing RF components such as amplifiers, mixers, filters or cables, which are often used in large quantities by manufacturers of base stations and mobile terminal equipment.

THREE OPERATING STEPS

The R&S ZNB does away with side and sub-menus and, in addition to hard keys and soft keys, it includes a soft panel as a new control element. The soft panel not only displays control functions that may be needed for a measurement, but also supports all instrument functions at the press of a maximum of three keys. The analyzers of the R&S ZNB family offer tangible network analysis as they allow users—simply by touching the screen—to shift traces between diagrams, position markers on traces, move scaling reference lines, or change test parameters via context-sensitive menus right at the point where the parameters are displayed.

Measurement tasks such as characterizing amplifiers and RF modules, which involve a large number of test parameters, can be split up and assigned to several clearly arranged

ROHDE & SCHWARZ
Munich, Germany

High power, small footprint broadband power amplifiers

2 to 18 GHz 8W power amplifiers

- High linearity
- Small and lightweight
- Custom designs available

Space switches

- Direct replacement for legacy switches
- High isolation >45dB
- Compact hermetic packages
- Integrated control logic
- Available in Class K

Broadband power amps

- Designs up to 65GHz
- High efficiency and linearity
- Power up to 150W pulsed, 120W CW
- High reliability

At Aeroflex Plainview, we're all about experience, and offering cost-effective solutions that do not sacrifice performance and quality. We combine extensive space design and packaging expertise with cutting-edge, proven technologies to provide highly-integrated microwave assemblies, amplifiers, switches, and up/down converters that operate up to 65GHz.

800-645-8862

aeroflex.com/bband

See us at MTT-S Booth 2212

BROADBAND POWER AMPLIFIERS

MODEL NUMBER	FREQUENCY (GHZ)	GAIN (DB)	POWER (DBM)	OIP3 (DBM)	NF (DB)	SUPPLY/CURRENT V/MA
PA020180-3922	2.0 - 18	38	Psat > 39	48	-	+28 / 1200
PA020180-3025	2.0 - 18	30	P1dB > 30	40	9	+12 / 2000
PA002005-21	0.2 - 0.5	20	P1dB > 21	35	1.1	+5 / 100
PA001002-22	0.1 - 0.2	19	P1dB > 23	37	1.5	+5 / 100
PA001040-27	0.1 - 4.0	25	P1dB > 27	40	5	+10 / 290

AEROFLEX
A passion for performance.



AnaPico AG
Zurich, Switzerland
Tel: +41 444 40 00 51
e-mail: info@anapico.com
www.anapico.com

SWISS QUALITY STILL AT MICRO- WAVES.



APSIN20G Microwave Signal Generator

Come and see at IMS booth 2323 how affordable a high-performance microwave signal generator can be.

- 10 MHz to 20 GHz+ range with milli-Hz frequency resolution
- Excellent phase noise -108 dBc/Hz at 10 GHz (20 kHz offset)
- Fast switching speed < 200 μ s
- Powerful modulation (wideband FM, chirp, pulse trains)
- Easy programmable remote control with standard SCPI command set and available programming support for LAN/ USB/GPIB
- Small and low power consumption – available with internal battery module

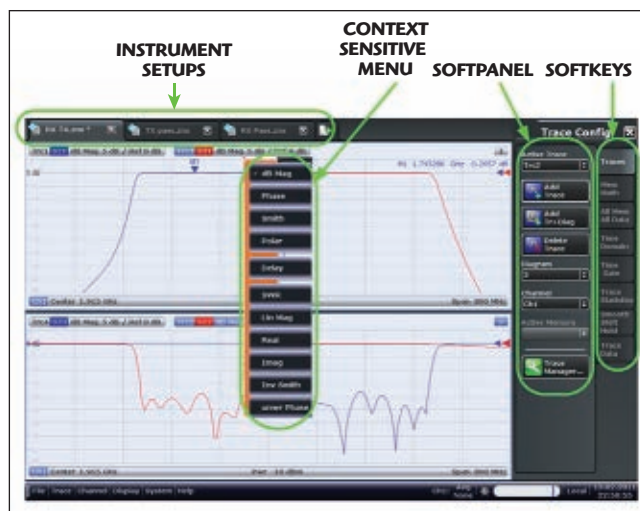
instrument setups with just a few traces. All instrument setups are available at a finger's touch, and because there are no submenus, each step that needs to be performed is clearly accessible on the touch screen. This straightforward operating concept (shown in **Figure 1**) not only benefits untrained or infrequent users, but also makes operation easier for experienced users and increases measurement efficiency.

The R&S ZNB offers users a wide choice of options when it comes to displaying results. Traces can be freely assigned to diagrams and channels, and assignments can be changed at any time during the measurement. To maximize the display area, which may be a useful option during manual adjustments, the soft panel can be hidden to make the entire screen area available for displaying results. Recognizing that solving a wide variety of tasks is easiest in one's mother tongue, the new network analyzers offer a large range of language options, including English, Chinese, Japanese, French and Russian (see **Figure 2**).

Fast or accurate? This is often a question faced by users in a production mode. However, with the R&S ZNB there is no longer the need to trade off speed against accuracy as the network analyzer combines a fast synthesizer with high sensitivity and a wide dynamic range.

WIDE DYNAMIC RANGE

The speed of measurements involving high attenuation—for example in the stopband of a base station duplex filter—is determined by the required dynamic range and the corresponding IF bandwidth. Reducing the IF bandwidth by a factor of 10 will increase the dynamic range by 10 dB. In the case of narrower IF bandwidths, the measurement time per point is approximately 1/IF bandwidth. The larger the IF bandwidth, the shorter



▲ Fig. 1 R&S ZNB control elements.




▲ Fig. 2 R&S ZNB language selection.

the measurement time.

A 10 dB increase in dynamic range will boost measurement speed by a factor of 10. The R&S ZNB offers a dynamic range of up to 140 dB at 10 Hz IF bandwidth. At a dynamic range of 120 dB, the measurement time per point is therefore 1 ms. In addition to

High Reliability

Military and Aerospace applications require materials with excellent electrical and physical properties, and above all, a history of proven performance.



C-RAM
LOSSY AND
MULTI-BAND
FOAM ABSORBERS

C-RAM
ELASTOMERIC
ABSORBERS

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.



C-RAM
Anechoic
Absorbers



DESIGN, BUILD
TURN-KEY
ANECHOIC
CHAMBERS

Solid Solutions

For.....
Tomorrows
Applications

ABSORBERS
FABRICATED
TO YOUR
SPECIFICATION

Our experienced Engineers
can assist you with your
design requirements



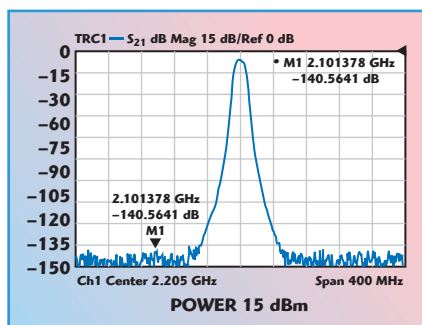
**CUMING
MICROWAVE**
CORPORATION

Credit: US NAVY

Raptor photo: Rick Llinares www.dash2.com

225 Bodwell St. Avon, Ma. 02322
(T) 800-432-6464(F) 508-584-2309

www.cumingmw.com
mwsales@cumingcorp.com

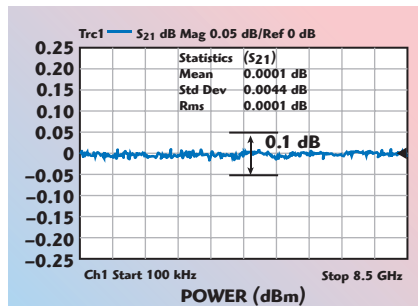


▲ Fig. 3 Filter measurement at 10 Hz IF bandwidth.

high measurement speed, this also offers a signal-to-noise ratio (SNR) sufficient to provide high measurement accuracy. **Figure 3** shows filter measurements at 10 Hz IF bandwidth.

MEASUREMENTS WITH LOW ATTENUATION

Measurements involving low attenuation—for example in the pass-band of a base station duplex filter—can be carried out at maximum IF bandwidth. Measurement time is not determined by the IF bandwidth, but by the speed of the synthesizer.



▲ Fig. 4 Trace noise at 10 MHz IF bandwidth is less than 0.1 dB.

At an IF bandwidth of 1 MHz, the R&S ZNB requires no more than 4 ms for a sweep with 401 points. The measurement error is virtually negligible even at this high IF bandwidth due to the low trace noise. **Figure 4** shows the trace noise at 10 MHz IF bandwidth 0.1 dB.

CALIBRATION KITS

The R&S ZNB supports a variety of different calibration methods. The Un-known Through, Open, Short, Match (UOSM) calibration method deserves a special mention as it sup-

ports simple calibration kits that do not contain a Through standard. Calibration with such kits is carried out using a simple adapter not known to the vector network analyzer instead of a high-quality Through standard.

While such adapters are inexpensive, they lead to measurement uncertainties of up to a few tenths of a dB with calibration methods requiring Through, Open, Short and Match standards. When using the UOSM method, the adapter's characteristics are irrelevant, and accuracy after calibration is comparable to that achieved with a high-quality Through calibration standard.

For applications calling for speedy calibration, e.g. in production, the R&S ZNB supports automatic calibration units. Controlled via USB, these units carry out full calibration within 30 sec of the press of a key. This affords an enormous speed advantage and minimizes the risk of operator errors over manual calibration especially when full four-port calibration is performed, e.g. on balanced two-port components. **Figure 5** shows the R&S ZV-Z51 calibration unit.

SHENZHEN YULONGTONG ELECTRON Co.,LTD.

E-mail: andy_xiang@yulongtong.cn export@yulongtong.cn



www.yulongtong.com

Visit us at Booth #646
2011 MTT IMS Show



◎ Coaxial Attenuator/Termination with frequency range up to 26.5GHz



◎ Coaxial Attenuator with power up to 1000w



◎ RF Resistor with power up to 800w and frequency range up to 18GHz

ISO9001: 2008 CERTIFIED



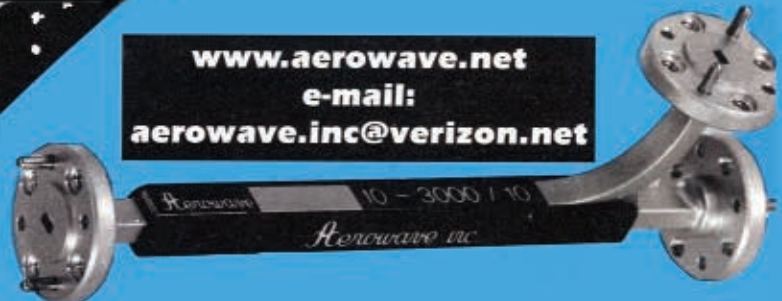
- ★ sample availability
- ★ short leadtime
- ★ high frequency, power range and small tolerance
- ★ comply with all RoHS requirement
- ★ low VSWR guaranteed

3/F Block D, Chiwan Industrial Park, Shenzhen, China Fax: 86-755-26832033 Tel: 86-755-26835000

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



▲ Fig. 5 Calibration unit for the R&S ZNB.

Careful calibration increases measurement accuracy, but interrupts the development or production process. As temperature and long-term stability determine the calibration interval, the R&S ZNB hardware has been developed with these factors in mind. Good raw data is also crucial to stability. This data indicates a network analyzer's accuracy when no internal error correction is active and no user

calibration has been performed. The new network analyzers offer raw test port match of up to 25 dB and directivity of up to 35 dB.

AMPLIFIER MEASUREMENT

The R&S ZNB offers a wealth of functions for measuring amplifiers. In addition to S-parameters, it determines output power, stability factors, power consumption, impedances and Z-parameters as a function of frequency or power. The high output power of up to +13 dBm and the wide electronic power sweep range of over 90 dB enable fast and wear-free amplifier measurements under different stimulus conditions.

The electronic receiver attenuators are designed for input powers of up to +27 dBm, enabling the network analyzer to perform compression-free measurements even on amplifiers with high output powers. Amplifier characterization also includes determining the RF to DC transfer characteristics of power-monitoring level detectors and measuring power consumption to determine efficiency.

For this purpose, the R&S ZNB offers four DC inputs with a voltage range of ± 10 V and sensitivity of 10 μ V. With future proofing in mind, the R&S ZNB supports the remote control command sets of other Rohde & Schwarz network analyzers and those of other manufacturers' instruments.

Productivity redefined—the new R&S ZNB network analyzers feature simple operation, flexible analyses, long-term stability, high IF bandwidths and a dynamic range previously found only in high-end instruments. Whether in production or development, they offer enhanced measurement speed and reliable accuracy at reduced calibration effort and support users in optimally organizing their measurement processes. The two-port model is available with four-port models coming online in September 2011.



Rohde & Schwarz,
Munich, Germany
+49 89 4129 12345,
www.rohde-schwarz.com.

GaAs InP GaN

OMMIC
Innovating with III-V's

Your Partner to Success

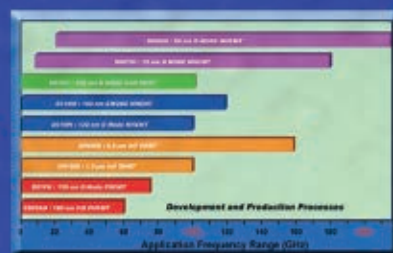
L-band to E-band MMICs

Power Amplifiers Low Noise Amplifiers

Phase Shifters Attenuators Mixers

Integrated Core Chips Switches

Fibre Optic Interfacing



www.ommic.com

OMMIC, 2 chemin du Moulin - 94 453 Limeil-Brévannes - France.
information@ommic.com

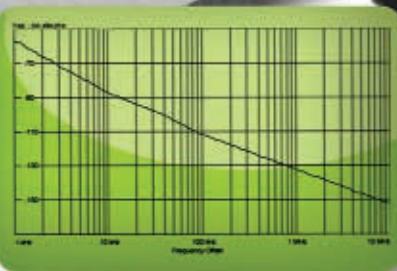
Booth 4104
IMS 2011
Baltimore

Model	Frequency Range (MHz)	Tuning Voltage (VDC)	DC Bias VDC @ I [Typ.]	Phase Noise @ 10 kHz (dBc/Hz) [Typ.]	Size (Inch)
DCO Series					
DCO60100-5	500 - 1000	0.5 - 15	+5 @ 34 mA	-100	0.3 x 0.3 x 0.08
DCO6080-3	600 - 800	0 - 3	+3 @ 15 mA	-105	0.3 x 0.3 x 0.08
DCO7075-3	700 - 750	0.5 - 3	+3 @ 12 mA	-108	0.3 x 0.3 x 0.08
DCO80100-5	800 - 1000	0.5 - 8	+5 @ 26 mA	-111	0.3 x 0.3 x 0.08
DCO8190-5	810 - 900	0.5 - 18	+5 @ 34 mA	-118	0.3 x 0.3 x 0.08
DCO100200-5	1000 - 2000	0.5 - 24	+5 @ 36 mA	-95	0.3 x 0.3 x 0.08
DCO1198-8	1195 - 1205	0.5 - 8	+8 @ 30 mA	-115	0.3 x 0.3 x 0.08
DCO170340-5	1700 - 3400	0.5 - 24	+5 @ 29 mA	-90	0.3 x 0.3 x 0.08
DCO200400-5	2000 - 4000	0.5 - 18	+5 @ 46 mA	-90	0.3 x 0.3 x 0.08
DCO200400-3	2000 - 4000	0.5 - 18	+3 @ 46 mA	-89	0.3 x 0.3 x 0.08
DCO300600-5	3000 - 6000	0.5 - 18	+5 @ 35 mA	-80	0.3 x 0.3 x 0.08
DCO300600-3	3000 - 6000	0.5 - 18	+3 @ 35 mA	-78	0.3 x 0.3 x 0.08
DCO400800-5	4000 - 8000	0.5 - 18	+5 @ 20 mA	-78	0.3 x 0.3 x 0.08
DCO400800-3	4000 - 8000	0.5 - 18	+3 @ 20 mA	-76	0.3 x 0.3 x 0.08
DCO432493-5	4325 - 4950	0.5 - 11	+5 @ 22 mA	-88	0.3 x 0.3 x 0.08
DCO432493-3	4325 - 4950	0.5 - 11	+3 @ 22 mA	-86	0.3 x 0.3 x 0.08
DCO473542-5	4730 - 5420	0.5 - 22	+5 @ 20 mA	-88	0.3 x 0.3 x 0.08
DCO473542-3	4730 - 5420	0.5 - 22	+3 @ 20 mA	-86	0.3 x 0.3 x 0.08
DCO490517-5	4900 - 5175	0.5 - 5	+5 @ 22 mA	-88	0.3 x 0.3 x 0.08
DCO490517-3	4900 - 5175	0.5 - 5	+3 @ 22 mA	-86	0.3 x 0.3 x 0.08
DCO495550-5	4950 - 5500	0.5 - 12	+5 @ 22 mA	-83	0.3 x 0.3 x 0.08
DCO495550-3	4950 - 5500	0.5 - 12	+3 @ 22 mA	-85	0.3 x 0.3 x 0.08
DCO579582-5	5780 - 5880	0.5 - 10	+5 @ 20 mA	-90	0.3 x 0.3 x 0.08
DCO608634-5	6080 - 6340	0.5 - 5	+5 @ 20 mA	-85	0.3 x 0.3 x 0.08
DCO608634-3	6080 - 6340	0.5 - 5	+3 @ 20 mA	-86	0.3 x 0.3 x 0.08
DCO615712-5	6150 - 7120	0.5 - 18	+5 @ 22 mA	-85	0.3 x 0.3 x 0.08
DCO615712-3	6150 - 7120	0.5 - 18	+3 @ 22 mA	-83	0.3 x 0.3 x 0.08

Model	Frequency Range (GHz)	Tuning Voltage (VDC)	DC Bias VDC @ I [Typ.]	Phase Noise @ 10 kHz (dBc/Hz) [Typ.]	Size (Inch)
DXO Series					
DXO810900-5	8.1 - 8.925	0.5 - 15	+5 @ 32 mA	-82	0.3 x 0.3 x 0.08
DXO810900-3	8.1 - 8.925	0.5 - 15	+3 @ 32 mA	-80	0.3 x 0.3 x 0.08
DXO900965-5	9.0 - 9.65	0.5 - 12	+5 @ 27 mA	-80	0.3 x 0.3 x 0.08
DXO900965-3	9.0 - 9.65	0.5 - 12	+3 @ 27 mA	-78	0.3 x 0.3 x 0.08
DXO10701095-5	10.70 - 10.95	0.5 - 15	+5 @ 25 mA	-82	0.3 x 0.3 x 0.08
DXO11441200-5	11.44 - 12.0	0.5 - 15	+5 @ 30 mA	-82	0.3 x 0.3 x 0.08
DXO11751220-5	11.75 - 12.2	0.5 - 15	+5 @ 30 mA	-80	0.3 x 0.3 x 0.08

Features

- Exceptional Phase Noise
- Dimensions: 0.3" x 0.3" x 0.1"
- Excellent Tuning Linearity
- Models Available from 4 to 12 GHz
- High Immunity To Phase Hits
- Lead Free RoHS Compliant
- Patented Technology



For additional information, contact Synergy's sales and application team.
Phone: (973) 881-8800 Fax: (973) 881-8361 E-mail: sales@synergymwave.com
201 McLean Boulevard, Paterson, NJ 07504

Visit Our Website At WWW.SYNERGYMWAVE.COM



SECOND GENERATION RF LINEARIZER TARGETS 4G SMALL CELL DEPLOYMENTS

Cellular service providers are struggling to keep up with the surging demand for data services. As this demand continues to outstrip the available infrastructure capacity, operators are recognizing the need for heterogeneous network deployments. This trend, from voice-centric macro base stations to lower power, wider bandwidth small cell, distributed antenna, and MIMO architectures increases the requirement for more linearity out of power amplifiers at lower output power levels.

Deployment of these heterogeneous network base stations with smaller coverage areas and low power transmit architectures will significantly increase the volume of transmitters as well as necessitate lowered equipment and deployment costs. Furthermore, the worldwide trend to reduce carbon emissions is also driving operators to seek solutions that are highly energy efficient. Prior to Scintera, no commercially available solution existed that could cost-effectively linearize PAs from 50 W down to 250 mW (average output power at the antenna) while also meeting operator's and OEM's stringent performance and system requirements.

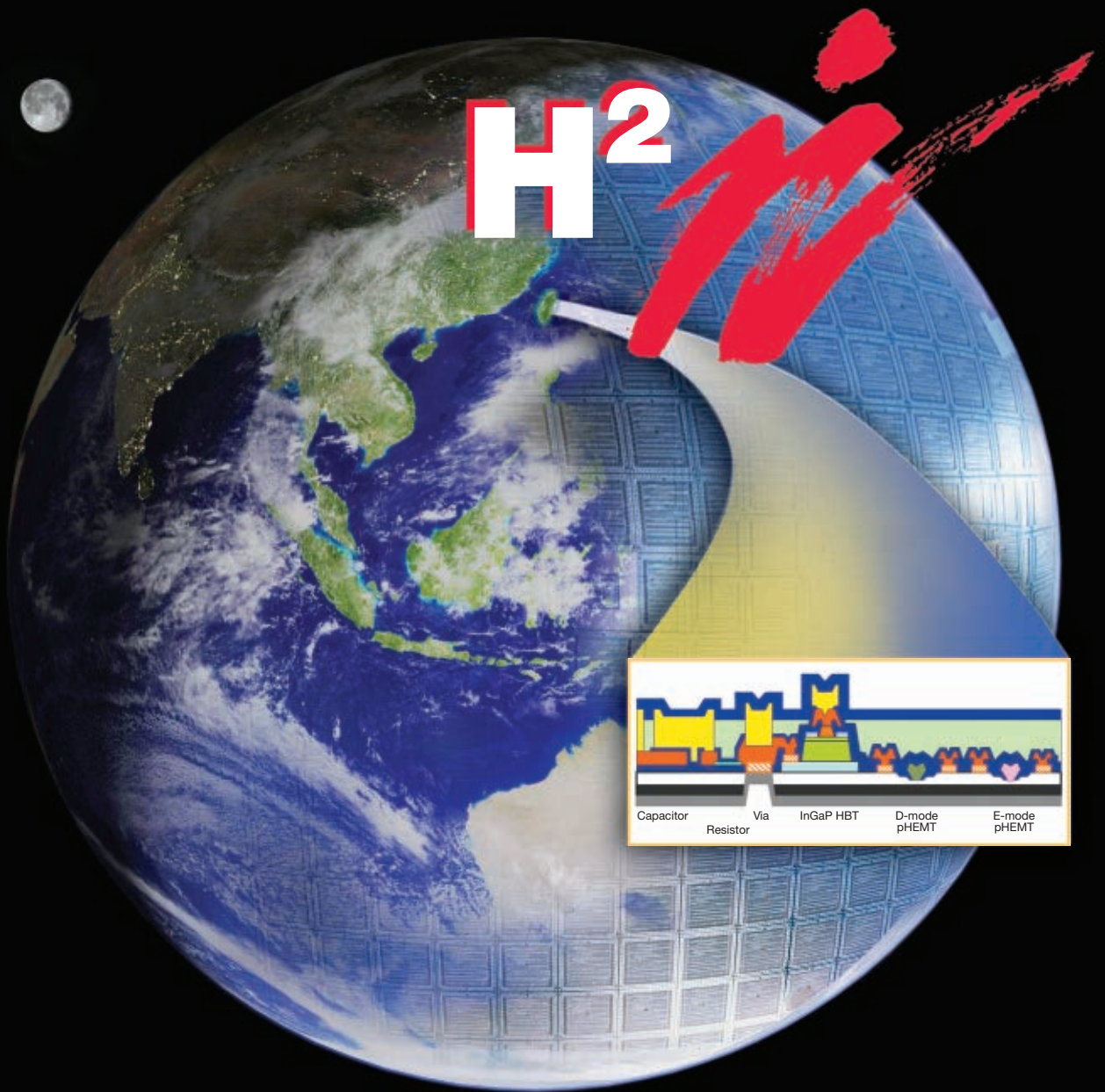
Scintera's SC1889 is a second generation RF PA linearizer (RFPAL) and, as can be seen in **Figure 1**, features a compact footprint and low external BOM. The SC1889 consumes minimal power while providing excellent correction per-

formance across static signals including CDMA and W-CDMA, and dynamic signals including WiMAX and LTE. The SC1889 represents one of the key enabling technologies for the successful deployment of small cells for heterogeneous networks. The SC1889 can increase system efficiency of lower power base station PAs (10 W average power at antenna and lower) by up to 2×, if linearizing Class A/B amplifiers, and up to 4× by enabling the use of more efficient Doherty amplifiers. In either configuration, Scintera's SC1889 will cut capital and operation/energy costs by an amount proportional to the efficiency improvement.

ACTIVE AND PASSIVE LINEARIZATION

The two legacy linearization solutions deployed include digital predistortion (DPD) and operating the PA in backoff. While DPD is an active linearization solution, the most popular linearization method by far is passive linearization that requires reducing (backing off) the PA output power until achieving the desired linearity. This method typically requires doubling the size of the RF power devices compared to active linearization.

SCINTERA
Sunnyvale, CA



Innovative GaAs integration technology

HBT + pHEMT @ WIN = H²W

	Parameter	Spec
HBT	Beta	75
	Ft	30 GHz
	Fmax	110 GHz
	BVceo	19 V
	Gm_Peak	500 mS/mm
e-pHEMT	Idss	0.01 uA/mm
	BVdg	21 V
	Vth	0.35 V
	Fmin	0.44 dB
	Ft	30 GHz
d-pHEMT	Fmax	90 GHz
	Gm_Peak	330 mS/mm
	Idss	230 mA/mm
	BVdg	20 V
	Vp	-1.0 V
	Ron	2.0 Ohm-mm
	Fmin	0.31 dB
	Ft	30 GHz
	Fmax	70 GHz

It's a **whole new world** for designers with breakthrough integration technology from WIN Semiconductors. Combining GaAs HBT, enhancement and depletion pHEMT technologies on a single wafer enables innovative product solutions.

WIN Semiconductors—the world's leading GaAs foundry.

www.winfoundry.com
See us at MTT-S Booth 810



PIN DIODE CONTROL DEVICES

PIN DIODE

ATTENUATORS

- 0.1–20GHz
- Broad & narrow band models
- Wide dynamic range
- Custom designs

Attenuator types offered are: Current Controlled, Voltage Controlled, Linearized Voltage Controlled, Digitally Controlled and Digital Diode Attenuators.

PIN DIODE

SWITCHES

- Broad & narrow band models
- 0.1–20GHz
- Small size
- Custom designs

SPST thru SP8T and Transfer type models are offered and all switches are low loss with isolation up to 100dB. Reflective and non-reflective models are available along with TTL compatible logic inputs. Switching speeds are 1 μ sec.—30nsec. and SMA connectors are standard. Custom designs including special logic inputs, voltages, connectors and package styles are available. All switches meet MIL-E-5400

PIN DIODE

PHASE SHIFTERS

- 0.5–20GHz
- Switched Line
- Varactor Controlled
- Vector Modulators
- Bi-Phase Modulators
- QPSK Modulators
- Custom Designs

SUBASSEMBLIES

Passive Components and Control Devices can be integrated into subassemblies to fit your special requirements. Call for more information and technical assistance.

Custom Designs

CALL OR WRITE

waveline
SOLID STATE INC.

P.O. Box 718, West Caldwell, NJ 07006
(973) 226-9100 Fax: 973-226-1565
E-mail: wavelineinc.com

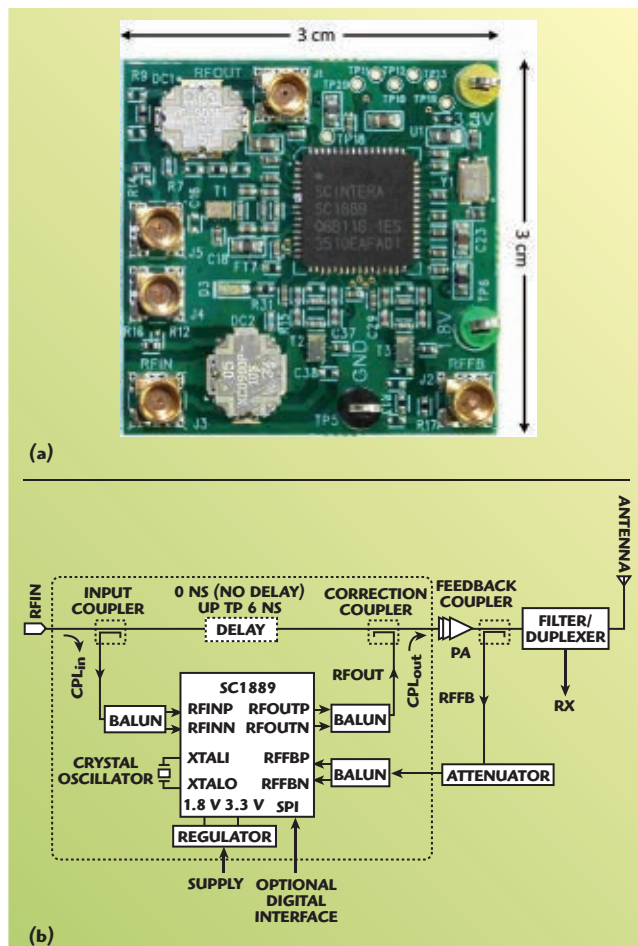
Due to cost, complexity and system power consumption considerations, RFPAL is one of the best linearization solutions to effectively displace passive linearization in small cell applications with average output power levels (at the antenna) of 5 W down to 500 mW. It is important to note that with advanced communication protocols with wide signal bandwidth requirements like LTE, or in wideband multi-carrier/multiprotocol systems, backing off the PA output power may not be an option as the PA may never reach the desired linearity at any power level. In these systems, Scintera's RFPAL represents a practical linearization solution for small cell network deployments.

RF PREDISTORTION VS DIGITAL PREDISTORTION

Scintera's RF predistortion technology shares similarities with DPD in that both compensate for AM-AM and AM-PM distortion, intermodulations and PA memory effects and utilizes adaptive feedback. The similarities end with their circuit and system implementations.

Scintera takes a new approach to RF power amplifier linearization by repartitioning portions of the predistortion algorithm from the digital to the analog/RF domain. Additionally, the entire adaptive feedback path including the analog to digital converters (ADC) is integrated within the RFPAL. The result is an elegant, single chip and highly integrated solution that maintains the flexibility of digital approaches while offering the simplicity and power consumption of analog approaches.

PRODUCT FEATURE



▲ Fig. 1 Scintera's complete standalone linearization solution in a 3 × 3 cm footprint on a PCB (a) and block diagram (b).

BENEFITS

Many factors determine the system performance of any linearization solution. Comparing RFPAL against solutions operating in backoff, customers can realize the greatest performance benefits. As highlighted in **Table 1**, for a given average output power level at the antenna, by "spending" 0.8 W on active linearization, customers can realize up to a 4× improvement in efficiency, thus enabling proportional decreases in the system power consumption. Additionally, linearization enables operation of the PA closer to its PSAT operation point and typically can cut the power transistor size and cost in half. A direct benefit of the improved power consumption is a reduced yearly operating cost (electricity) which, at higher antenna power levels, can offset the initial cost of the RFPAL system in a relatively short time. The system power consumption and system efficiency can be seen in **Figure 2**.

An often overlooked benefit is the

RF & MW Filters

for Cellular, Satcom, and Defense Systems



ISM 902-928 MHz
SMR iDEN 800 MHz Band
AMPS, GSM, CDMA, D-AMPS
LTE 700 MHz all bands
VHF, UHF



INMARSAT
Iridium
GPS
All Satcom bands
Outdoor applications



An ISO9001
Certified Company

GSA approved

*Custom made Filters,
Design and Manufacturing Expertise...
Thousands of Standard products*

*Technologies offered: Cavity, Ceramics
Lumped Elements, Crystal, SAW, Voltage Tuned,
Waveguide, Helical, Distributed, Discrete.*



Anatech Electronics, Inc.
RF & MW Filters, and products



Visit us at
The IMS2011
In Baltimore!
Booth # 4507

Check our new websites!

www.anatechelectronics.com

for your custom products

www.amcrf.com

our webstore

Tel: 973-772-4242

Fax: 973-772-4646

sales@anatechelectronics.com

New products

Many give aways

US Frequency Spectrum Chart

Leave you business Card and

WIN an IPOD

Sorry! only visitors

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 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
See us at MTT-S Booth 540

Military Microwaves 2011

A Special Supplement to
Microwave Journal®

Coming in August



Bonus Distribution at

European Microwave Week
Manchester, UK

MILCOM
Baltimore, MD

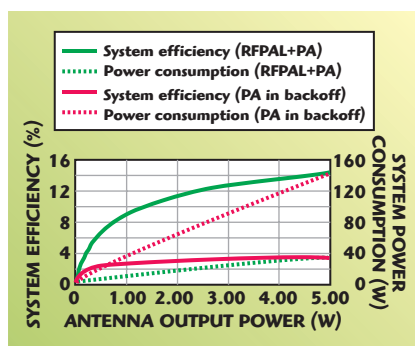
Contact your Sales Representative
for Advertising Opportunities

See us at MTT-S Booth 3414

PRODUCT FEATURE

TABLE I CALCULATION FOR SYSTEM POWER CONSUMPTION, SYSTEM EFFICIENCY AND YEARLY OPERATING COST			
Parameter	RFPAL (Doherty Amplifier)	Back Off (Class A/B amplifier)	Unit
Desired max antenna Pout (avg)	37	37	dBm
Component IL between PA and antenna	3.5	3.5	dB
PA output power (max antenna power - IL)	40.5	40.5	dBm
PA efficiency at 40.5 dBm (avg)	35.0%	8.0%	
Linearization power consumption	0.8	0	W
Pre-amp + driver power consumption	2	2	W
Total power consumption (w/o final stage PA)	2.8	2	W
System efficiency at max antenna Pout = 37 dBm	14.4%	3.5%	
System power consumption at max antenna Pout = 37 dBm	34.9	142.3	W
Cost of energy (cost per kWhour)	\$0.05	\$0.05	
Yearly cost of operation per system	\$15.28	\$62.35	
Added yearly cost of operation compared to RFPAL		\$47.07	

INDICATES ENTERED VALUES



▲ Fig. 2 Graph of system power consumption and system efficiency against antenna output power.

dramatic reduction in size/volume and cost associated with the power supplies and cooling elements (heat-sinks, fans, etc.). The power supply savings can be proportionally higher than the improvement in efficiency due to power supply cost increasing faster than supply capacity. At the same time, the RFPAL will deliver similar or better ACLR (distortion) performance than when the PA was operated in backoff (a simplified version of the calculator is available online at www.scintera.com/RF-PA-linearization-predistortion-efficiency-calculator).

Finally, Scintera's RFPAL lends itself to fast system design times and requires no expertise in predistortion algorithms. The RFPAL offers stand-alone operation that is very nearly "plug and play," thus accelerating time to market and enabling any company, large or small, to enjoy the benefits of

active linearization. Typically, linearization results are achieved within a half day of opening the evaluation kit.

RELIABILITY

Replacing a system operating in backoff with RFPAL provides an improvement in device and system reliability. By improving the efficiency of the device and thus lowering its operational case temperature leads to a decrease in the failures in time (FIT) rate. With more than 50,000 systems based on Scintera's first generation RFPAL, the SC1887, deployed in the field with no failures or returns, Scintera's RFPAL clearly demonstrates the robustness and ruggedness required to meet even the most stringent operator requirements.

Based on field-proven technology, Scintera's SC1889 represents a new alternative to existing linearizing solutions. It is an elegant and compact solution that reduces development costs and speeds time to market. Applicable across a broad range of signals, including 2G, 3G, 4G wireless and other modulation types. The SC1889 solves some of the key challenges faced by operators trying to deploy data services and will continue to play a key role in the transition to 4G and beyond.

Scintera,
Sunnyvale, CA (408) 636-2600,
www.scintera.com.

3 GHz AIN Terminations



Disk Resistors



Enhanced AIN Thick Film Substrates



AIN High Power Terminations



Electronic Technology



RES-NET MICROWAVE, INC.

P.O. Box 1260
Clearwater, FL 33757
Ph: 727.530.9555
Fx: 727.531.8215

www.res-netmicrowave.com

"THINKING AT A HIGHER FREQUENCY"

Res-net has both thick-film and thin-film SMT terminations, resistors, and attenuators available in DC to 40 GHz. Res-net also has high power passives to 6 GHz with power up to 2KW. Our enhanced thick-film process allows for custom circuit layouts on Alumina, Aluminum Nitride, and Beryllium Oxide. Res-net is currently developing new products so go online to www.res-netmicrowave.com to see what is new.

- Frequency to 40 GHz
- Power to 2,000 watts
- 50 ohm impedance
- Operating temperature from -55°C to +150°C
- RoHS compliant
- Low VSWR

See us at MTT-S, Booth 449

**Coaxial Cable
Flexible Cable
MIL-DTL-17**

**Cable Assemblies
Low Loss Cable
Phase Matched Cable**



WAVETRONIX, INC.

727.530.9555 / www.wavetronix-eti.com

**See us
at MTT-S,
Booth 449**



ULTRA LOW NOISE, HIGH IP3 MONOLITHIC AMPLIFIER

The Mini-Circuits PMA2-162LN+ is an ultra low noise MMIC amplifier covering 0.7 to 1.6 GHz with a unique combination of low noise and high IP3 making it ideal for sensitive receiver applications. The design operates on a single 4 V supply and is internally matched to 50 ohms. It offers high dynamic range in addition to good input and output return loss without the need for external components. It is packaged in a $2 \times 2 \times 0.55$ mm (MCLP) leadless surface-mount package with very good thermal performance.

The PMA2-162LN+ has a low noise figure of 0.5 dB and high IP3

Parameter	Typical Value at 1 GHz (dB)
Noise figure	0.47
Gain	22.7
Input return loss	20.4
Output return loss	18.9
Pout P1dB	19.9
Output IP3	29.9

of 30 dBm typical at 1 GHz. The gain is 22.7 dB typical and output power P1dB of 20 dBm typical at 1 GHz. The operating temperature is -40° to $+85^{\circ}\text{C}$ with high reliability due to the low, small-signal operating current of

80 mA nominal, which maintains the junction temperatures typically below 100°C at a ground lead temperature of 85°C . It has a Class 1B HBM ESD rating (500 V). Typical applications include base station infrastructure, portable wireless, LTE, GPS, GSM and airborne radar.

VENDORVIEW

Mini-Circuits,
Brooklyn, NY,
(718) 934-4500,
www.minicircuits.com



Be nimble

vaunix.com

Build a USB powered test bench on-the-fly.

Signal Generators through 20 GHz starting at \$1,399. Digital Attenuators starting at \$375.

CERNEX, Inc.

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

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

CONVERTERS UP TO 110GHz
ANTENNAS UP TO 220GHz

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

FILTERS/DIPLEXERS
SOURCES UP TO 160GHz

SWITCHES UP TO 160GHz
PHASESHIFTERS UP TO 160GHz

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

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

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

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

POWER COMBINERS/DIVIDERS EQUALIZERS

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

See us at MTT-S Booth 3207





HIGH SPEED ANALOG-TO-DIGITAL CONVERTER FAMILY

Hittite Microwave Corp. has introduced a new high speed analog-to-digital converter (ADC) product line that exhibits ultra-low power dissipation and high cost efficiency while maintaining high performance.

The HMCAD1520, HMCAD1511 and HMCAD1510 are multi-mode ADCs with integrated crosspoint switches (Mux Array). HMCAD1520 offers 12-bit resolution up to 640 MSPS in high speed mode, and 14-bits up to 105 MSPS in precision mode. The HMCAD1520 is ideal for communication applications, including diversity receivers and digital pre-distortion loops, as well as test & measurement applications such as spectrum analyzers and precision oscilloscopes. The HMCAD1510 and HMCAD1511 offer 8-bit resolution up to 500 and 1000 MSPS respectively, which enables significant power savings and unique functionality in test & measurement applications such as digital oscilloscopes. HMCAD1511 is

also an excellent choice for satellite receivers. The HMCAD1520 can be combined with HMC960LPE DC to 100 MHz dual DVGA and the HMC900LP5E 50 MHz dual baseband low pass filter to provide a complete direct conversion line-up. HMCAD1520, HMCAD1511 and HMCAD1510 offer an integrated clock divider that provides a flexible and easy to implement clock path without sacrificing performance.

The HMCAD1060 is a versatile, Quad 14-bit ADC running up to 105 MSPS with optional power saving modes. The different reduced power dissipation modes can be selected during operation to trade off power dissipation against accuracy. Low switching times between the modes enables the system to continuously keep power dissipation and performance at optimum levels. This makes the HMCAD1060 ideal for communication applications such as certain types of low power software-defined radios and diversity receivers where low power dissipation is a critical parameter.

The HMCAD1102, HMCAD1101 and HMCAD1100 are Octal 12- and 13-bit ADCs that operate up to 80 MSPS and are ideal for medical ultrasound and non-destructive testing. The HMCAD1102 is the only discrete Octal 12-bit ADC offering an 80 MSPS sample rate, and is an excellent choice in diversity base band receivers.

The dual HMCAD1050-40/80 and single HMCAD1051-40/80 are 13-bit ADCs, while the dual HMCAD1040-40/80 and single HMCAD1041-40/80 are 10-bit ADCs operating up to 80 MSPS. These ADCs offer the industry's best SNR performance for the lowest power consumption. These ADCs are ideal choices in power critical applications requiring 10- to 13-bit analog-to-digital conversion at input frequencies up to 50 MHz.



Hittite Microwave Corp.,
Chelmsford, MA,
sales@hittite.com, www.hittite.com

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 Baltimore, MD Booth #3614, June 7,8,9, 2011.*

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

CELEBRATING 10 YEARS OF QUALITY, PERFORMANCE AND RELIABILITY IN PRECISION COAXIAL CONNECTORS

EDGE LAUNCH
CONNECTORS



BETWEEN SERIES
ADAPTERS



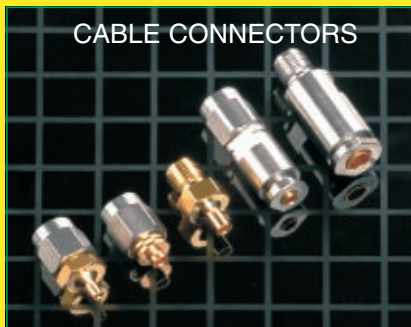
BULKHEAD & PANEL
ADAPTERS



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.



Manufacturer of Precision Coaxial Connectors
4343 Fortune Place, Suite A, West Melbourne, FL 32904
Phone: 321-409-0509 Fax: 321-409-0510
sales@sgmcmicrowave.com
www.sgmcmicrowave.com

See us at MTT-S Booth 3806

600 W UHF POWER TRANSISTOR

than 31 percent. Featuring excellent linearity, high gain of 21 dB and ruggedness corresponding to VSWR greater than 40:1, the BLF888A is ideal for advanced digital transmitter applications.

The performance of the BLF888A is enabled by NXP's 50 V high voltage LDMOS process technology in combination with advanced thermal concepts, resulting in high power density and thermal resistance as low as 0.15 K/W. As a result, the BLF888A allows broadcast equipment manufacturers to optimize existing or new transmitter installations for performance and total cost of ownership. For complete power amplifier line-ups, the BLF888A combines optimally with the BLF881 driver transistor. The transistor is available in two versions:

BLF888A, a bolt-down package and BLF888AS, an earless package, which enables a more compact PCB design. The BLF888AS can be soldered to achieve a further decrease in junction temperature.

**NXP Semiconductors,
Eindhoven, The Netherlands,
www.nxp.com.**



NXP Semiconductors has introduced an ultra high frequency (UHF) 600 W RF power transistor that is a LDMOS device for broadcast transmitters and industrial applications. The BLF888A is the most powerful LDMOS broadcast transistor in the market to date. For a DVB-T signal over the full UHF band from 470 to 860 MHz, the transistor can deliver 120 W average DVB-T signal power with efficiencies greater

**Visit NXP Semiconductors
in Booth #420
at this year's
IEEE MTT-S International
Microwave Symposium being
held June 5-10, 2011 in
Baltimore, MD.**



IEEE COMCAS 2011

The International IEEE Conference on Microwaves, Communications, Antennas and Electronic Systems

Hilton Hotel, Tel Aviv, Israel, November 7-9, 2011

www.comcas.org

Call for Papers

COMCAS 2011 continues the tradition of providing a multidisciplinary forum for the exchange of ideas in the areas of microwaves, antennas, communications, solid state integrated circuits, sensing and electronic systems engineering. The venue will be exciting and enjoyable with many opportunities for networking, candid exchange of ideas and a strong sense of community.

- Microwave and MM-wave technologies
- Antennas (modeling, phased array, etc.)
- Solid State Devices RFICs, Circuits and Modeling
- Circuit Modeling / Theory
- RF Power Amplifiers and Devices
- Communications Systems Modeling, Simulation and Analysis
- Cognitive and Software-Defined Radios
- Electromagnetic Compatibility
- Remote Sensing
- Radar and Electronic Systems
- Mixed Signal Analog/RF/Digital Circuits and Systems
- RF/Microwave Photonics
- Integrated Power Management Circuits and Devices
- RFIDs, MEMS
- New and emerging technologies

Invited papers and tutorial talks from international experts will be presented in key topical areas. Please join us for the 3rd Annual IEEE COMCAS meeting in the exciting and vibrant city of Tel Aviv, Israel from 7-9 November 2011.

All submitted papers will be peer reviewed. Accepted papers will be published in the COMCAS 2011 Proceedings which will be available through IEEE Xplore™ after the conference. Papers should first be submitted as a 1 to 2 page summary.

Please refer to the detailed author instructions provided on the conference web site www.comcas.org.

The technical program will be complemented with a Technical Exhibition, which will be held on November 7-8, offering companies and agencies a unique opportunity to visit Israel and present related products and services in display and printed advertisement.

For further details please contact the Conference Secretariat.

The official language of the Conference is English. Conference Secretariat: comcas@ortra.com

Deadline for Summary Submission: 15 June 2011

Final manuscripts due: 15 September 2011

Conference Chairman: **Shmuel Auster**

TPC Co-Chairman: **Barry Perlman, Roger Pollard**

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/mwj

See us at MTT-S Booth 2115

The logo for Rohde & Schwarz Legacy Pro is displayed on a light blue background. It features the text "R&S® Legacy Pro" in a sans-serif font. The "R&S" is in blue, and "Legacy Pro" is in black. A thin blue oval line curves around the text.

R&S® Legacy Pro

A rectangular button with the word "SYSTEM" in blue capital letters. The button is part of a larger control panel with other buttons visible below it.

SYSTEM



ROHDE & SCHWARZ

NEW WAVES: MTT-S IMS PRODUCT SHOWCASE

FOR MORE NEW PRODUCTS, VISIT WWW.MWJOURNAL.COM/BUYERSGUIDE

FEATURING **VENDORVIEW** STOREFRONTS

The following booth numbers are complete as of April 8, 2011.

26.5 GHz SMPM Attenuator



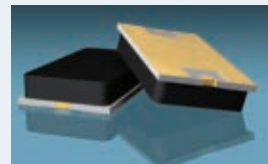
Aeroflex/Inmet introduced a 26.5 GHz fixed attenuator that incorporates the SMPM connector.

The self-aligning push-on connector is a miniature version of its SMP attenuator and provides reliable high performance, excellent RF characteristics and mates non-destructively with GPPO™ connectors. Designed for use in tight quarters whether the requirement is in manufacturing or semiconductor chip test applications, this new 2 W device offers standard attenuation values of 3, 6, 10, 20 and 30 dB all under 0.75" in length. Non-standard attenuation values are available.

Aeroflex/Inmet,
Ann Arbor, MI (734) 426-5553,
www.aeroflex.com.

Booth 2212

Drop-in, Surface-mount Limiters



This LM series of surface-mount limiters is designed for receiver protection applications through 8 GHz.

These RoHS-compliant devices provide high power protection at levels to 100 W CW and 2 kW peak power in surface-mount technology (SMT) packages measuring only 8 × 5 × 2.5 mm. Ideal for receiver protection applications at L-band (1 to 2 GHz), S-band (2 to 4 GHz) and C-band (4 to 8 GHz) frequencies. LM series limiters provide considerably higher thermal capacity than silicon and GaAs MMIC solutions. The limiters' small size and excellent thermal conductivity supports low-profile circuit designs without sacrificing protection for sensitive receiver front-end components.

Aeroflex/Metelics,
Londonderry, NH (888) 641-7364,
www.aeroflex.com/metelics.

Booth 2212

Digital Attenuator



Aeroflex/Weinschel's new model 4202-63 is a digital attenuator that operates over the 0.4 to 6 GHz frequency range

and provides an attenuation range from 0 to 63 dB in 1 dB increments. This attenuator offers excellent repeatability and performance; SMA female connectors; built-in TTL Interface and ruggedized construction. Custom configurations are available upon request.

Aeroflex/Weinschel Inc.,
Frederick, MD (301) 846-9222,
www.aeroflex.com/weinschel.

Booth 2212

Design and Simulation Platform



Agilent Technologies announced shipment of the latest version of its RF and microwave design and simulation platform, Advanced Design System 2011 (ADS). ADS 2011 delivers new features for new and existing Advanced Design System users, including electromagnetic technologies for faster, more accurate simulations; a new use model that makes electromagnetic simulation easy for all engineers; and layout improvements for easier physical design. Advanced Design System 2011 also features dozens of new capabilities and improvements designed to enhance the platform's functionality and usability.

Agilent Technologies Inc.,
Santa Clara, CA (800) 829-4444,
www.agilent.com.

Booth 813

PXA Signal Analyzer



This PXA signal analyzer is a high performance millimeter-wave signal analyzer that operates in a

frequency range up to 50 GHz. With external mixing, it can cover 325 GHz and beyond. The result is easier, more accurate millimeter-wave measurements. The PXA delivers a level of performance at millimeter-wave frequencies that is unmatched by competing solutions, offering accurate, sensitive and frequency-stable signal analysis. Its ability to measure small signals in the presence of very large signals is unparalleled and enables customers to develop the most advanced radar, surveillance and wireless communications systems.

Agilent Technologies Inc.,
Santa Clara, CA (800) 829-4444,
www.agilent.com.

Booth 813

Switch Matrix on a Substrate



AMC brings microwave integrated circuit technology to the solid-state switch matrix resulting in a

hybrid switch matrix on a single substrate. Using a multilayer substrate, AMC is able to design for SMT production various configurations of RF/microwave switches with custom driver/logic circuitry and custom mechanical requirements. With two sides for discrete components, AMC can integrate a variety of other components including filters, amplifiers, combiners/splitters, bias Ts and fault circuits.

American Microwave Corp. (AMC),
Frederick, MD (301) 662-4700,
www.americanmic.com.

Booth 4319

Ultra-broadband Capacitor



ATC's new 550L ultra-broadband capacitor (UBC) has been designed and manufactured with the highest quality materials

to provide reliable and repeatable ultra-broadband performance from 16 kHz through 40+ GHz. Now available with gold terminations, this unique component provides ultra-low insertion loss, flat frequency response and an excellent match over multiple octaves of frequency spectrum. The 550L has been engineered in a one piece orientation-insensitive 0402 SMT package, making it fully compatible with high speed automated pick-and-place manufacturing operations. Its superior broadband performance and reliability make it ideal for the requirements of the most stringent ultra-broadband applications.

American Technical Ceramics,
Huntington Station, NY
(631) 622-4700, www.atceramics.com.

Booth 1906

15 W GaN Amplifier

AML910P4215 is a 15 W, X-band, GaN amplifier that delivers minimum 30 percent power added efficiency. AML910P4215 operates over 9.9 to



10.7 GHz. Amplifier requires operating voltages of +32 V and +12 V DC. This amplifier has an integrated isolator at the

output; TTL controlled muting function with 1 μ s on/off speed; and a second output coupled from the main line with +28 dBm power. Package dimensions are 3.6" × 3.4" × 0.67". Operating temperature range is -30° to +60°C.

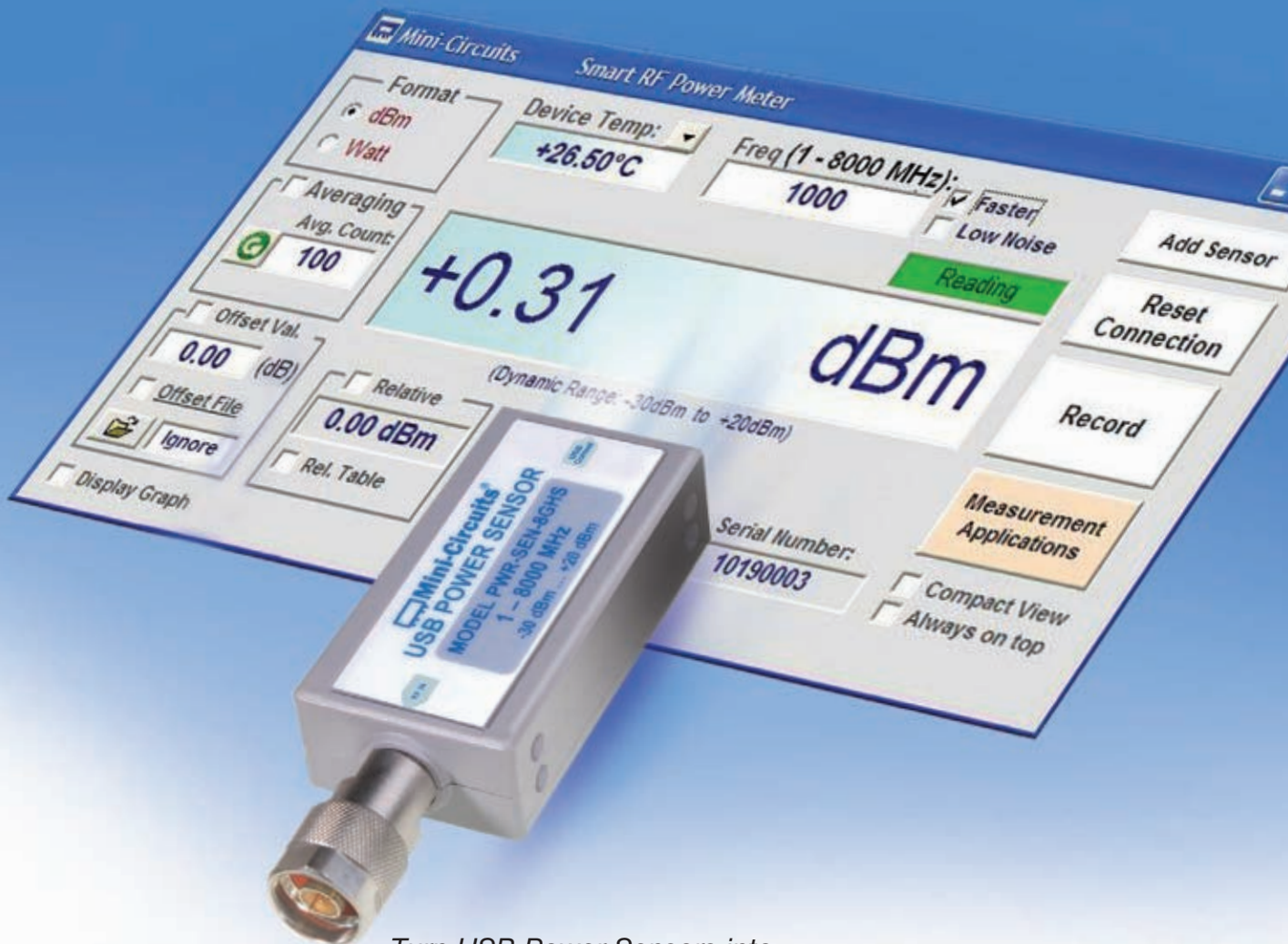
AML Communications Inc.,
Camarillo, CA (805) 388-1345,
www.amlj.com.

Booth 2024

Microwave Signal Generator



Anapico's APSIN20G is a 10 MHz to 20 GHz fast-switching microwave signal generator with excellent -108 dBc/Hz SSB phase noise at 10 GHz and a



Turn USB Power Sensors into
Smart RF POWER METERS
 -30 to +20 dBm 9 kHz to 8 GHz

- Lightning-fast measurement, as quick as 30ms
- Averaging of measurement
- 50 dB dynamic range
- Linux® support
- Compatible with LabVIEW®, Delphi®, C++, C#, Visual Basic®, and .NET software*

Don't break your bank with expensive conventional power meters. Mini-Circuits USB Power Sensors turn almost any Linux® or Windows® based computer into a low-cost testing platform for all kinds of RF components. Reference calibration is built in, and your USB port supplies required power. Our GUI offers a full range of watt or dB measurements, including averaging, frequency sweeps, and multi-sensor support.

Our power sensors can be carried in your pocket, or mounted remotely for manual or automated system monitoring (internet connectivity required). Data can be viewed onscreen or exported to Excel® spreadsheets for reporting and analytic tools. Mini-Circuits Power Sensors cost half as much as you might expect, so why do without? Place an order today, and we can have it in your hands as early as tomorrow.

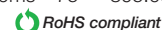
All Power Sensor models include:

- Power Sensor Unit
- Power Data Analysis Software
- SMA Adaptor (50Ω only)
- USB Cable



* Linux is a registered trademark of Linus Torvalds. LabVIEW is a registered trademark of National Instruments Corporation. Delphi is a registered trademark of Codegear LLC. Visual Basic, Excel, and Windows are registered trademarks of Microsoft Corporation. Neither Mini-Circuits nor the Mini-Circuits USB Power Sensor are affiliated with or endorsed by the owners of the above referenced trademarks. Mini-Circuits and the Mini-Circuits logo are registered trademarks of Scientific Components Corporation.

Model	Frequency	Speed	Ω	Price \$ ea. qty. 1-4
PWR-6G	1MHz-6 GHz	300 ms	50	695.00
PWR-6GHS	1MHz-6 GHz	30 ms	50	795.00
PWR-8GHS	1MHz-8 GHz	30 ms	50	869.00
PWR-4GHS	9 kHz-4 GHz	30 ms	50	795.00
PWR-2GHS-75	100kHz-2GHz	30 ms	75	795.00
PWR-2.5 GHS-75	100kHz-2.5 GHz	30ms	75	895.00



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

Mini-Circuits®
 ISO 9001 ISO 14001 AS9100 CERTIFIED

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



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

IF/RF MICROWAVE COMPONENTS

See us at MTT-S Booth 1031

488 rev C

DON'T LET THE SIZE FOOL YOU



MINIATURE FILTERS



HUGE PERFORMANCE

High Performance Filters from
100 MHz to 18 GHz.

Visit **Active Spectrum** at the
IMS2011 Expo, Booth #347



www.asimicrowave.com

NEW WAVES



wide range of modulation capabilities including DCFM and fast pulse-modulation. The versatile, fan-less instrument is available in a compact and robust design. The APPH6000 is an ultra-low noise floor signal source analyzer from 10 to 6.2 GHz. Available with dual-channel cross-correlator, the residual noise floor is as low as -190 dBc/Hz. The APPH6000 features fast measurement speeds and is highly automated with easy-to-use remote control through LAN VXI-11 or USB port.
AnaPico AG,
Zurich, Switzerland +41 44 440 00 51,
www.anapico.com.

Booth 2323

Cavity Filters for 700 MHz LTE



Anatech Electronics will feature its cavity band-pass filters designed for 700 MHz deployments

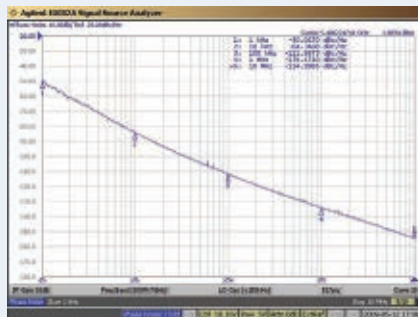


of LTE systems, with models available for all uplink and downlink bands. The filters have very high rejection (at least 40 dB at 700 kHz from passband edges), low loss and high return loss. They also meet the need for extremely low passive intermodulation distortion (PIM), with levels of -150 dBc or better, and are available for both indoor and outdoor installations.

Anatech Electronics,
Garfield, NJ (973) 772-4242,
www.anatechelectronics.com,
www.amcrf.com (Web store).

Booth 4507

Voltage-controlled Oscillators

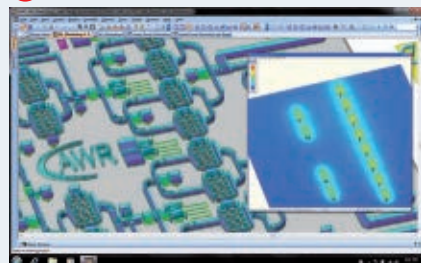


APA Wireless introduces a new line of voltage-controlled oscillators (4254SM5 and 5362SM5) that operate independently of ground-plane and load impedance. These VCOs will drive a short circuit, open circuit, or anything in between regardless of ground plane over the industrial temperature range. Excellent phase noise and linearity in the four to six GHz range, these devices provide exceptional performance in a variety of phase-locked and free running applications.

APA Wireless,
Oakland Park, FL (954) 563-8833,
www.apawireless.com.

Booth 317

High Frequency EDA



Visit AWR Corp. in booth #1618 for a demonstration of the company's 2011 release including Microwave Office's new electrical-thermal MMIC co-simulation design flow, simulation-state management technology, and yield analysis/optimization via a graphical shape-based manipulation approach; Visual System Simulator's new envelope simulator; as well as AX-IEM's asynchronous electromagnetic (EM) simulation support. Last but not least, catch a sneak preview of AWR's new 3D FEM EM analysis technology.

AWR Corp.,
El Segundo, CA (310) 726-3000,
www.awrcorp.com.

Booth 1618

Solid-state Amplifier



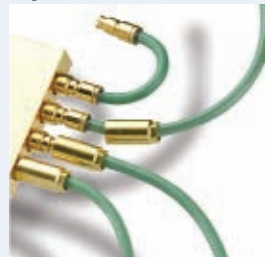
The new solid-state microwave amplifier, model 175S1G4 operates in a frequency range from 0.8 to 4.2

GHz and has a power output of 175 W. This amplifier employs a new design that delivers more than twice the power of older models. The new, more efficient design consumes less power and incorporates both USB and Ethernet interfaces in addition to the standard IEEE and RS-232 interfaces. With these improvements, AR has maintained the superior rugged design for load tolerance and excellent linearity.

AR RF/Microwave Instrumentation,
Souderton, PA (215) 723-8181,
www.arworld.us.

Booth 1103

Open Source Connector



The SMPM-T is the smallest threaded open source connector on the market offering centerline-to-centerline spacing of just 0.20 inches. Its innovative combination of a MIL-STD-348 SMPM Female interface connector with a retractable threaded Nut provides unprecedented electrical and mechanical stability in even the harshest operating environments. The SMPM-T connector is space qualified and available along with Astrolab's microbend™ "Bend-To-The-End" technology. AS 9100 and ISO 9001 certified.

Astrolab,
Warren, NJ (732) 560-3800,
www.astrolab.com.

Booth 931

DIRECT MODULATION MICROWAVE *FIBER OPTIC LINKS* To 20 GHz

FEATURES:

- Low Noise Figure
- Low Signal Loss (Typ. RF Loss: 0.4 dB/km)
- Small Size And Low Power Consumption
- No External Control Circuits Required
- Variable Gain Control Option In Receiver
- Low Maintenance And Simple Installation
- Custom Configurations Available
- Backed By A 3-Year Warranty*

WIDE RANGE OF APPLICATIONS:

- EMC Testing • Antenna Remoting • Radio Over Fiber
- Interfacility RF Communication Link • Radio Astronomy
- Radar Applications • Aircraft And Shipboard Applications
- SATCOM Applications • Links For Satellite Ground Stations
- ELINT, EW And EMC Applications • Tactical Common Data Links

Electrical Specifications (1 Meter of Fiber)

Electrical Specifications (A Model of Noise)										
Series	Frequency	Gain (dB)	Noise Figure (dB)	Input Power @ P1dB (dBm, Min.)	Spurious Free Dynamic Range (dB/Hz, Typ.)	Phase Noise (dBc, Typ.)	Group Delay (ns)	VSWR (In/Out)	Available Wavelengths	
									Standard (nm)	Optional Wavelengths
Transmitters and Receivers										
SLL	5 kHz - 2.5 GHz	12	18	-14	103	>100	0.2	2:1	1550/1310	18 CWDM Ch
	100 MHz - 2.5 GHz	12	18	-14	103	>100	0.2	2:1	1550/1310	18 CWDM Ch
LBL	50 KHz - 3 GHz	15	11	-14	106	>100	0.2	2:1	1550/1310	18 CWDM Ch, 45 DWDM Ch
	50 KHz - 4.5 GHz	15	11	-14	106	>100	0.2	2:1	1550/1310	18 CWDM Ch, 45 DWDM Ch
	10 MHz - 3 GHz	15	11	-14	106	>100	0.2	2:1	1550/1310	18 CWDM Ch, 45 DWDM Ch
	10 MHz - 4.5 GHz	15	11	-14	106	>100	0.2	2:1	1550/1310	18 CWDM Ch, 45 DWDM Ch
LBL-HD	950 MHz - 2.5 GHz	0	22	7	114	>100	0.2	2:1	1550/1310	18 CWDM Ch
SCML	50 kHz - 6 GHz	15	15	-14	103	>100	0.2	2:1	1550	1310/1490 nm
	100 MHz - 6 GHz	15	15	-14	103	>100	0.2	2:1	1550	1310/1490 nm
	100 MHz -11 GHz	15	15	-14	103	>100	0.2	2:1	1550	1310/1490 nm
	100 MHz -13 GHz	15	15	-14	103	>100	0.2	2:1	1550	1310/1490 nm
	100 MHz -15 GHz	15	15	-14	103	>100	0.2	2:1	1550	1310/1490 nm
	100 MHz - 18 GHz	15	15	-14	103	>100	0.2	2:1	1550	1310/1490 nm
	10 MHz - 18 GHz	15	15	-14	103	>100	0.2	2:1	1550	1310/1490 nm
High Gain Broadband Receivers										
DR-125G-A	30 KHz -12.5 GHz35 O/E (or TIG = 2800 ohms)							2:1	1280-1580	
SCMR-100K20G	100 KHz - 20 GHz32 O/E (or TIG = 2000 ohms)							2:1	1280-1580	

CWDM: Course Wavelength Division Multiplexing, DWDM: Dense Wavelength Division Multiplexing

Enclosures Are Available For Multiple Tx or Rx Combinations



For additional information or technical support, please contact our
Sales Department at (631) 439-9220 or e-mail components@miteq.com



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

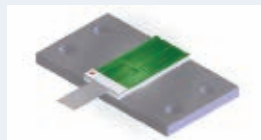
www.miteq.com

*3-year warranty applies to rack-mounted and indoor equipment

See us at MTT-S Booth 1909

NEW WAVES

High Power Flanged Termination



Barry Industries Inc. announced its new 1000 W high power flanged termination. This

RoHS compliant 50 ohm termination has an input power rating of 1000 W, continuous wave. It offers a frequency range of DC to 1 GHz, and has an excellent input return loss of 28.5 dB, 1.10:1. For a datasheet, contact michellef@barryind.com and request part number T50R0-1000-3X. Barry also offers a full line of low and high power custom resistors, terminations and attenuators in a variety of substrate and metallization options.

Barry Industries Inc.,
Attleboro, MA (508) 226-3350,
www.barryind.com.

Booth 726

Ultra-low Noise Amplifiers



Ciao Wireless introduced its ultra-low noise amplifiers with noise figures as

low as 0.30 dB. Designs are offered over most 300 MHz bandwidths between 0.5 and 2.9 GHz. Gain levels offered between 30 and 60 dB. Delivery in one to two weeks ARO with competitive pricing offered.

Ciao Wireless,
Camarillo, CA (805) 389-3224,
www.ciaowireless.com.

Booth 3609

L-band Switch Matrix System



This L-band switch matrix system is designed for demanding SATCOM ground station installations. The matrix has a base configuration of 12x48 (down-converter to modem) and is expandable to 24x192 ports. The system is configured with separate receive and transmit paths and cabinets.

Each is separately controllable, covering the range of 1 to 2 GHz and providing an output IP3 of +34 dBm minimum. This system is an outstanding choice for demanding multi-carrier applications.

Crane Aerospace & Electronics,
Beverly, MA (978) 524-7200,
www.craneae.com/mv.

Booth 1822

RF Coaxial Cable Assembly



These LL335 series cable assemblies are a new addition to the company's line of low-loss RF coaxial ca-

bles. Designed to operate up to 18 GHz, the CCSMA-MM-LL335 cable assemblies boast extremely low loss, with attenuation ratings of 0.03 dB/ft at 500 MHz, and 0.20 dB/ft at 18 GHz. Crystek LL335 cables offer a minimum bend radius of 1.5 in. and are available in-stock in 36-, 48- and 60-inch lengths. The cables are supplied with high frequency SMA or N-Type connectors, featuring rugged stainless-steel solder-clamp construction and heavy-duty strain relief with a neoprene jacket.

Crystek Corp.,
Fort Myers, FL (239) 561-3311,
www.crystek.com.

Booth 325

6 to 18 GHz Power Amplifier



CTT announced a new, compact, solid-state power amplifier (SSPA) that operates in a frequency range from 6 to 18

GHz for a wide variety of RF and microwave applications. This amplifier design provides good efficiency, high operating temperature range and small size. CTT's latest compact SSPA is a GaN-based MMIC design that offers 40 W of output power in a compact package. Additional specifications include a minimum of +46 dB of gain, maximum, gain flatness of ± 2.5 dB and noise figure of 8.0 dB. Power saturation (Psat) performance is +44.5 dBm, minimum and +46.0 dBm, typical. The compact package measures 4.14" x 3.0" x 0.68".

CTT Inc.,
Sunnyvale, CA (408) 541-0596,
www.cttinc.com.

Booth 2302

6 to 18 GHz Low Noise Amplifier



Custom MMIC Design Services announced the release of the CMD157, a 6 to 18 GHz low

noise PHEMT amplifier in a plastic encapsulated, 3 mm QFN package. The CMD157 has a gain of 27 dB, a noise figure of 1.5 dB and a bias requirement of 53 mA at 3 V. With applications including microwave communication and phased array systems, the CMD157 offers exceptional performance. The CMD157 is part of a broad line of plastic encapsulated amplifiers being introduced by CMD5 this month.

Custom MMIC Design Services Inc.,
Westford, MA (978) 467-4290,
www.custommmic.com.

Booth 650

Full-band Amplifiers



the frequency ranges starting at Ka-band up to W-band amplifiers. These full-band amplifiers will be available in three configurations: high power, low noise and general purpose. Features include: broadband performance across entire band; compact size and weight; single DC pow-

er supply/internal regulated sequential biasing and variable I/O options.

Ducommun Technologies Inc.,
Carson, CA (310) 513-7256,
www.ducommun.com.

Booth 404

Connectorized Clock Oscillators

The PLXO series of phase-locked crystal oscillators are designed to operate at select custom frequencies from 5 to 500 MHz as reference clocks in military and commercial RF/micro-



wave systems. Locked to an external frequency reference (or optional internal reference), the PLXO units feature low

RMS jitter (< 0.05 pSec, typical), excellent phase noise (Fout = 233 MHz, < -120 dBc/Hz at 1 KHz, typical) and low power consumption at +3.3, +5, +8 or +12 V DC. Housed in a miniature connectorized package (1.50" x 1.50" x 0.6") to withstand harsh environments, the PLXO units also feature no sub-harmonics and operate over an optional wide temperature range (-40° to +85°C).

EM Research Inc.,
Reno, NV
(775) 345-2411,
www.emresearch.com.

Booth 1149

65:1 VSWR Power Transistors



Freescale and Richardson RFPD have partnered to build a microsite dedicated to the new Freescale 50 V

LDMOS rugged RF transistors. These transistors are able to withstand a 65:1 VSWR mismatch and continue to deliver full output power of 1.25 kW, 600 W and 300 W, respectively. Due to the number of customers redesigning circuits, Richardson RFPD and Freescale Semiconductor partnered to create this one-stop shop for RF design engineers.

Freescale,
www.rell.com/RuggedLDMOS.

Booth 1028

Microwave Power Amplifiers



Giga-tronics has introduced the GT-1020A and GT-1040A in-

strument-grade broadband microwave power amplifiers that cover 100 MHz to 20 GHz and 10 MHz to 40 GHz respectively, with flat frequency response, low noise figure and low harmonics. Designed using broadband MMIC technology, these amplifiers typically provide 1/2 W (+27 dBm) at 20 GHz and 1/4 W (+24 dBm) at 40 GHz with > 25 dB gain and < 6 dB noise figure. Gain flatness is typically ± 2.5 dB over the full frequency range.

Giga-tronics Inc.,
San Ramon, CA
(925) 328-4650,
www.gigatronics.com.

Booth 1409

Protecting your radar system just got a whole lot easier



New high power surface mount limiters from Aeroflex / Metelics are making your receiver/protector sections a whole lot easier to design. These drop-in devices include 11 completely integrated components that have been optimized for S and C band radar systems. In comparison to silicon and GaAs MMICs, which lack thermal capacity and thermal conductivity, these devices offer stable peak power handling through 8 GHz.

- Frequency bands from 20 to 8000 MHz
- 100 W C.W. and 1 KW Peak Power Handling
- Flat Leakage Power of 20 dBm
- 8 x 5 x 2.5 mm SMT Packaging

We've put our semiconductor experience to work in developing a variety of broadband and octave band models. Call or visit our website for details.

603-641-3800

www.aeroflex.com/metelicsMJ

See us at MTT-S Booth 2212

Evaluation Boards Available

High Power Surface Mount Limiters

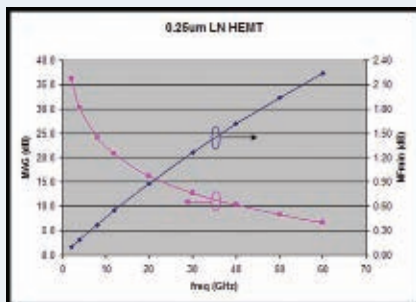
Part Number	Type	Frequency (MHz)*	Loss (dB)	C.W. Power (W)
LM200802-M-A-300	Medium Power Broadband	20-8000	1.4	20
LM501202-L-C-300	Octave Band, Low Power	500-2000	0.4	4
LM501202-M-C-300	Octave Band, Med Power	500-2000	0.6	30
LM202802-L-C-300	Octave Band, Low Power	2000-8000	1.0	4
LM202802-M-C-300	Octave Band, Med Power	2000-8000	1.2	30
LM401102-Q-C-301	Octave Band, High Power, "Quasi-Active"	400-1000	0.3	100
LM102202-Q-C-301	Octave Band, High Power, "Quasi-Active"	1000-2000	0.5	100
LM202802-Q-C-301	Octave Band, High Power, "Quasi-Active"	2000-8000	1.4	100

AEROFLEX
A passion for performance.

NEW WAVES

Low Noise PHEMT

GCS has developed a low noise PHEMT technology with an optical $0.25\ \mu\text{m}$ gate, $f_T > 80\ \text{GHz}$ and $f_{\text{max}} > 150\ \text{GHz}$. The technology achieves a noise figure minimum of $< 0.6\ \text{dB}$ with a gain $> 15\ \text{dB}$ at $12\ \text{GHz}$. A 6 to $18\ \text{GHz}$ balanced LNA fabricated with this technology has shown better noise and gain performance than NEC33200. This process is fully qualified with a MTTF $> 8 \times 10^7$ hours at channel



temperature = 125°C . GCS is offering this process to all foundry customers.

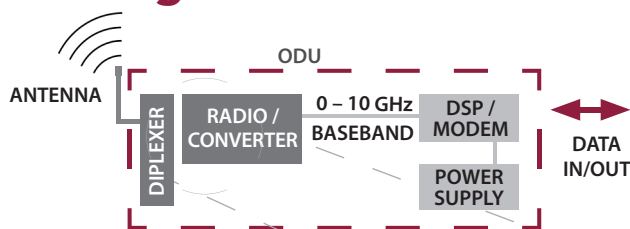
Global Communication Semiconductors LLC, Torrance, CA
(310) 530-7274, www.gcsincorp.com.

Booth 2504

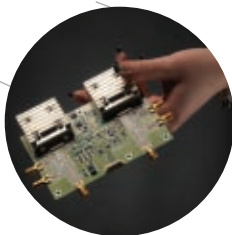
ATTENTION all Radio Link Manufacturers!



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 $10\ \text{Gb/s}$ - at radically reduced cost!



SIVERS IMA

SIVERS IMA IS AN ISO 9001:2008
CERTIFIED COMPANY

www.siversima.com | info@siversima.com

Broadband Conical Inductors



These new conical inductors respond to market demand for more standard and custom conical design options for micro-

wave applications. Gowanda's "C" series includes standard flying lead and SMT designs with up to $150\ \text{W}$ power capability, excellent coplanarity, robust construction and typical operation from $40\ \text{MHz}$ to $40\ \text{GHz}$. The company's custom capabilities – already well-established for Gowanda's RF and power inductors – have been enhanced to provide conicals with application-specific core configurations, electrical parameters, footprints, frequencies, wattage and wiring options (copper, gold plate, specialty).

Gowanda Electronics,
Gowanda, NY (716) 532-2234,
www.gowanda.com.

Booth 730

Analog-to-Digital Converter



Hittite Microwave Corp. has introduced a new high speed analog-to-digital converter (ADC) product line. Hittite's multifunction ADC products are easy-to-use, exhibit ultra-low

power dissipation and superior cost efficiency while maintaining high performance and complementing Hittite's existing RF, microwave and mixed-signal IC product lines. The new ADC product line significantly expands Hittite's product offering in communications, test & measurement, military, industrial and medical applications.

Hittite Microwave Corp.,
Chelmsford, MA
(978) 250-3343,
www.hittite.com.

Booth 2009

Phase Noise Analyzers



Holzworth Instrumentation will showcase the HA7000 series

phase noise analyzers at IMS 2011. The advanced cross correlation engine delivers fast data acquisition speeds to low levels (example: $-180\ \text{dBc/Hz}$ $< 20\ \text{sec}$). Holzworth's self-calibrating, integrated architecture makes for quick setups while eliminating the need for on-site troubleshooting support. These designs offer a highly intuitive interface, coupled with price points that truly support ease of implementation. The HA7400 series analyzers deliver on what's expected of the industry's next generation test instruments.

Holzworth Instrumentation,
Boulder, CO (303) 325-3473,
www.holzworth.com.

Booth 2419

High Performance Interconnects

HSI LLC designs and manufactures high performance interconnects for use by OEMs in

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

**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.**

**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.**

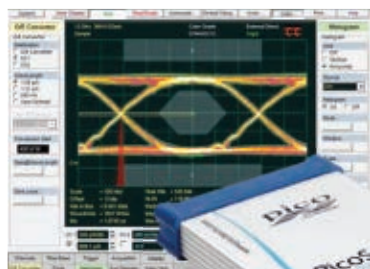


**Receivers
Transceivers
Transmitters
Switch Matrices
Block Converters
Radar Subsystems
Coherent Converters
Communication Systems
Integrated Amplifier Assemblies**



THE PICOSCOPE 9200A SERIES

12GHz SAMPLING OSCILLOSCOPES FOR YOUR PC



NEW!
Optical
input



A complete sampling oscilloscope for your PC

- ▶ Communication and telecoms signal analysis
- ▶ TDR/TDT
- ▶ Signal characterization
- ▶ Pre-compliance testing
- ▶ Production pass/fail testing

High Performance for smaller budgets

- ▶ 12 GHz bandwidth
- ▶ Onboard generators for TDR/TDT
- ▶ Measures optical and electrical signals

High end software features included as standard

- ▶ Eye diagram analysis
- ▶ Mask testing (incl. 40+ standard masks)
- ▶ Channel Math and FFT capability

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 capability		✓		✓
Price	£5,995	£7,495	£12,495	£13,995

www.picotech.com/scope901

pico
Technology

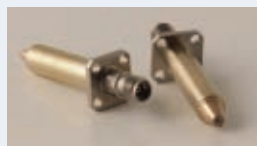
NEW WAVES

Mil-Aero, instrumentation, industrial, medical and other industries. HSI specializes in microwave cable assemblies to 70 GHz as well as micro-miniature coaxial structures as small as 50 awg. HSI has over 150 man-years in experience with these products/industries. Current customers include leading OEMs in military communications systems, UAVs, test instrumentation and other critical, leading-edge apps. The company provides solutions to OEMs demanding mechanical/electrical/environmental requirements, including superior signal integrity and low weight, high density packaging.

High Speed Interconnections LLC (HSI),
Scottsdale, AZ (888) 565-7878.

Booth 340

RF Probe with Integrated Attenuator



The HFS-835: RF probe with integrated attenuator is especially suitable for assembly in test fixtures with space restrictions or to prevent shearing forces to the probe, which can occur when an externally connected attenuator is directly connected with the input interface of a conventional

RF probe. It is available with nominal attenuation values of: 3, 6, 10 and 20 dB. It is designed for use up to 3 GHz at an impedance of 50 Ω and its flange design allows easy integration with a fixture or mounting.

INGUN Prüfmittelbau GmbH,
Konstanz, Germany +49 7531 8105-0, www.ingun.de.

Booth 3804

Radar Pallet Amplifier



Integra Technologies announced an S-band radar pallet that will significantly reduce cycle time in your next high powered design. Part number ILP2731M260 is a 50 ohm matched high power pulsed radar pallet amplifier for S-band radar systems produced for drop-in manufacturability. The pallet amplifier

supplies a minimum of 260 W of peak pulse power under the conditions of 300 us pulse width and 10 percent duty cycle operating over the instantaneous bandwidth of 2.70 to 3.10 GHz. The unit operates in class AB mode with 32 V drain bias optimizing the gain and efficiency parameters.

Integra Technologies Inc.,
El Segundo, CA (310) 606-0855,
www.integrattech.com.

Booth 4015

Surface-mount Chip Resistors



The HVI series of chip resistors is especially suited for high voltage applications. The HVI series is offered in sizes 0402 to 2512, values to 1 Gohm and tolerances to 1 percent. These resistors feature a nickel barrier layer for excellent solder leach resistance and proprietary thick film architecture allowing the 2512 size to withstand a continuous 3 kV and overload of 4 kV. Applications for the HVI series high voltage chip resistors include but are not limited to power supplies, power converters, defibrillators, sensors, detectors, pacemakers and power meters. Samples are available.

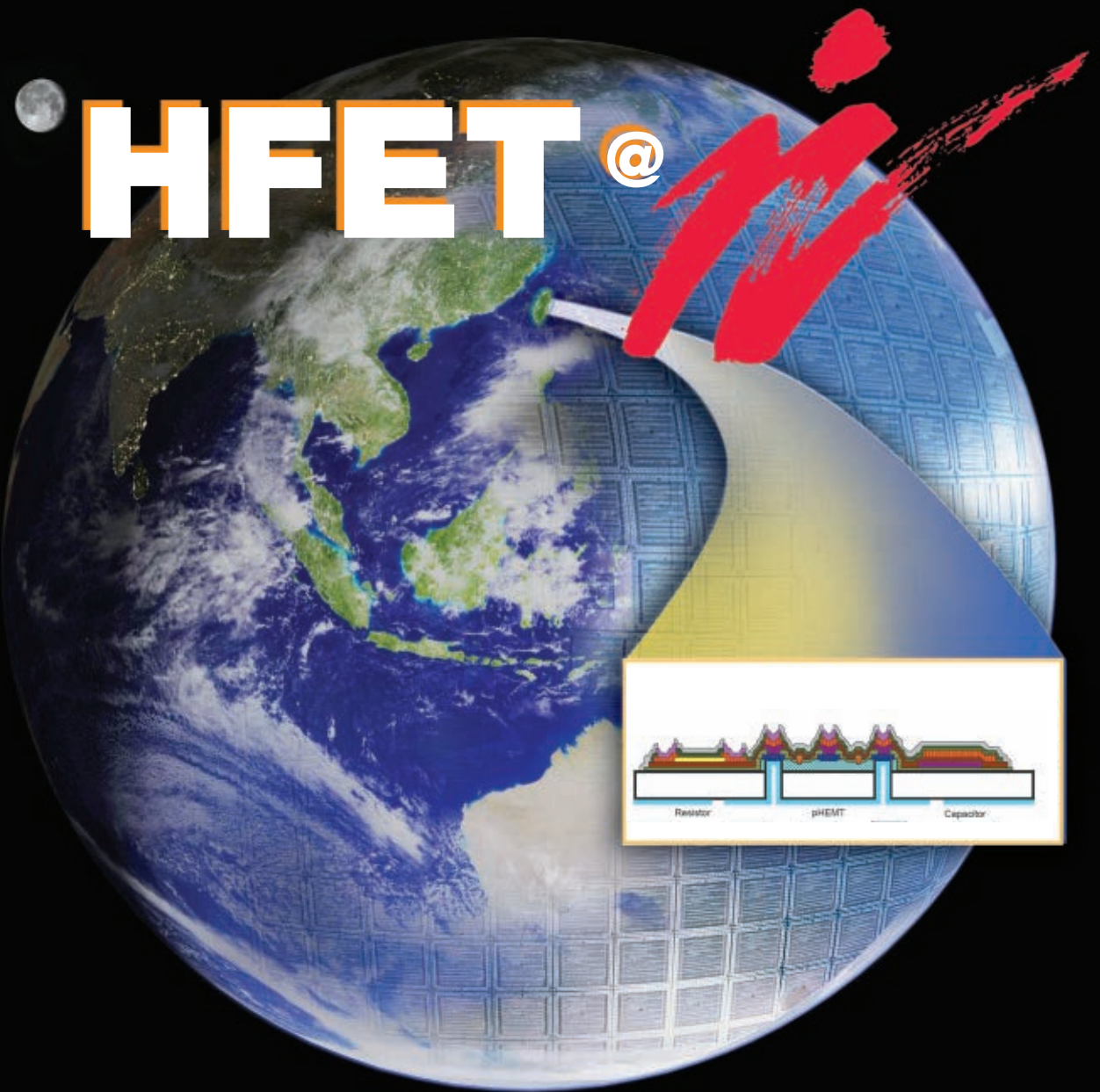
International Manufacturing Services Inc.,
Portsmouth, RI (401) 683-9700,
www.ims-resistors.com.

Booth 2106

Phase-locked Outdoor Block Converters



Jersey Microwave's KABUC-ODU series is offered in Ka-bands up to 1500 MHz bandwidth. Standard or custom specifications are available. IF from 950 to 2450 MHz, RF band segments up to 38 GHz. Typical performance includes 5 to 20 dB gain with



High linearity high voltage technology High Voltage HFET @ WIN

Parameter	Value
f_t @ $V_{DS}=4$ V	12.5 GHz
BVDGO @ $V_{GS}=-3.0$ V	33 V
$IDSS$ @ $V_{DS}=4$ V	175 mA/mm
I_{dmax} @ $V_{DS}=4$ V, $V_{GS}=+0.5$ V	250 mA/mm
V_{PO} @ $V_{DS}=4$ V	-1.1 V
MIM Capacitance	500 pF/mm ²
CGS	1900 pF/mm ²
EPI Sheet Resistance	250 Ohm/sq
TFR Sheet Resistance	50 Ohm/sq

High linearity, high breakdown power process is ready for your most demanding applications.

WIN Semiconductors-the world's leading GaAs foundry.

www.winfoundry.com

See us at MTT-S Booth 810



NEW WAVES

< 1.0 dB flatness over the RF frequency band, ± 0.2 dB over any 40 MHz segment. Low spurious and superior phase noise performance. Internal or external reference is available. Remote M&C functionality.

Jersey Microwave LLC,
Flanders, NJ (908) 684-2390, www.jerseymicrowave.com.

Booth 630

Quadrature Hybrid Coupler



This 90 degree quadrature hybrid coupler offers high performance over the broadband frequency range of 1.7 to 36 GHz in a single compact and lightweight package. Model 3017360 is a multi-purpose, quadrature hybrid stripline design that exhibits excellent amplitude balance with ultra-broadband quadrature phasing between the output ports. KRYTAR's technological advances has extended the frequency range of this four-port unit from 1.7 to 36 GHz with coupling loss of 3 dB, greater than 12 dB isolation, ± 1.7 dB amplitude imbalance and ± 12 degrees of phase imbalance. Size: 2.6" (L) \times 0.625" (W) \times 0.50" (H).

KRYTAR Inc.,
Sunnyvale, CA (408) 734-5999, www.krytar.com.

Booth 1712

Microwave Power Modules



These microwave power modules (MPM) are designed for Ku- and Ka-band communication applications. The new modules are geared for use in airborne, naval or ground communication applications and are specifically designed in a weight-

balanced, split-package configuration intended for direct antenna mounts. Available in either Ku- or Ka-band configurations, L-3's new MPM designs significantly reduce conventional RF system losses, enhancing overall efficiency while also improving problematic pointing and position stabilization issues. At just 1.1 inches high, this compact two-piece set weighs in at a balanced 5.2 pounds and is MIL-STD-461E compliant.

L-3 Electron Devices,
San Carlos, CA (650) 486-5594,
www.l-3com.com.

Booth 502, 602

Hall Effect Measurement System



Lake Shore Cryotronics Inc., in collaboration with Toyo Corp. of Japan, introduced the new 8400 series Hall effect measurement system (HMS). Available in September 2011, the 8400 series HMS with optional AC field measurement capability allows you to measure hall mobilities down to 0.001 cm²/Vs—lower than ever possible using traditional DC field Hall measurement techniques.

Lake Shore Cryotronics Inc.,
Westerville, OH (614) 891-2244,
www.lakeshore.com.

Booth 3603

Circuit Board Prototyping



LPKF Laser & Electronics continues its efforts in circuit board prototyping with the redesign of the ProtoMat® S-Series. Each system features improved functions, a higher level of automation and upgrade options. The entry-level ProtoMat S43 is a milling machine that provides a great introduction into the world of professional

rapid PCB prototyping. For those with an occasional use and/or limited budget, the ProtoMat S43 has the precision and capacity for drilling, de-paneling and structuring printed circuit boards and engraving front panels. It comes equipped with a 40,000 RPM spindle motor, a working area of 9" \times 12", and has the ability to produce multiple design iterations in the same day.

LPKF Laser and Electronics,
Tualatin, OR (503) 454-4232,
www.lpkfusa.com.

Booth 2202

Six-bit Digital Attenuator



M/A-COM Technology Solutions Inc. introduced the MAAD-008866, a six-bit, 0.5 dB step digital attenuator for 75 Ohm systems operating up to 1 GHz. This attenuator is ideal when high accuracy, low power consumption (4 microAmps typical at 5 V, steady state) and low intermodulation products are required. The MAAD-008866 includes an integrated TTL/CMOS compatible driver and offers parallel and serial control with a power-up state function. The device achieves an insertion loss of 1.4 dB with a typical input return loss of 18 dB from 5 to 1,000 MHz. Attenuation accuracy is plus/minus 0.15 dB plus 4 percent of attenuation setting.

M/A-COM Technology Solutions,
Lowell, MA (978) 656-2500,
www.macomtech.com.

Booth 1418

Harmonic Load Pull Solutions



Maury Microwave Corp. will showcase two state-of-the-art active and hybrid-active harmonic load-pull solutions: VNA-based vector-receiver load-pull and mixed-signal active load-pull. The vector-receiver system is based upon Maury's IVCAD measurement and modeling device characterization software and its single-, double- and triple-frequency tuning solutions. The MT2000 series

rakon

World leaders in frequency control solutions

Rakon is a global leader in the supply and manufacture of high precision, high reliability frequency control solutions.

Around the world, government and commercial programmes specify Rakon oscillators for use in power, space, defence and research applications.

Rakon offers a comprehensive range of crystals, XOs, VCXOs, TCXOs, OCXOs, SAW oscillators, crystal filters, Digital Dispersive Delay Lines (DDL), Digital Pulse Compression Sub-Systems (DPCSS) and complete RF subsystems.

Email: sales@rakon.com
www.rakon.com/Products/highrel

TCXO VCXO QUARTZ CRYSTALS OCXO TCXO VCXO QUARTZ CRYSTALS VCXO QUARTZ CRYSTALS VCXO TCXO QUARTZ CRYSTALS VCXO TCXO OCXO QUARTZ CRYSTALS OCXO

Network with the RF/Microwave Industry

CTIA Pavilion

Join the leading suppliers of high frequency electronics solutions in The RF/Microwave Zone at CTIA. MWJ organizes a complementary array of RF and microwave companies in this technology pavilion to provide one-stop-shopping for potential buyers at this global event.

The Magazine

Your ad in *Microwave Journal* reaches 50,000 qualified design engineers and engineering managers in the publication that RF and microwave professionals rate as the number one magazine in its field. More companies advertise in MWJ than in any competing publication because they know that MWJ delivers.

The Website

Reach more than 60,000 registered users with your message on the "Home Page of the RF/Microwave Industry". The website combines the editorial content from the magazine with unique engineering tools and resources and provides an array of lead generating advertising/ sponsorship opportunities.

European Microwave Week

Exhibit at the largest RF/Microwave trade show in Europe and showcase your company's products to this global audience. The Symposium boasts four conferences and various workshops and courses by leading experts to attract highly qualified delegates.

White Papers

Deliver your company's technical expertise to a targeted audience of thousands of design engineers looking for solutions to design and development challenges. Position your company as a thought leader and innovator and generate high quality sales leads.

Cables & Connectors Supplement

Leading suppliers of cables, connectors and related components love this supplement for its targeted content and bonus distribution at CTIA and IMS. Your ad reaches engineers looking for the latest developments in transmission-line technology.

Newsletters

MWJ delivers the weekly Microwave FLASH and Microwave ADVISOR and the monthly MicroView to targeted audiences of opt-in subscribers. Your sponsorship of these popular newsletters provides exposure to more than 40,000 readers and is a proven lead generating tool.

Military Microwaves Supplement

If your company sells into the defense sector, you won't want to miss this annual publication. Always our most popular print supplement with advertisers, this piece features the latest developments in component and sub-system architecture and delivers bonus distribution to the EuMW and MILCOM events.

Blogs

Be the expert! Sponsored blogs are hosted on the mwjournal.com home page and position your company as a technical resource for the industry. Blogs are promoted in the weekly Microwave FLASH newsletter and in the magazine.

Mobile Communications Supplement

This annual publication focuses on the rapidly evolving wireless communications market with cutting-edge content from industry experts. Bonus distribution at the Mobile World Congress provides exposure to this enormous audience of potential buyers.

Expert Advice

Industry experts share their insights and knowledge in this regular feature to the MWJ website. Interaction with members of the community creates a blog environment providing perspectives on different market segments.

Webinars

Are you interested in receiving over 1,000 quality leads from a single webinar sponsorship? Our webinar series with partners Besser Associates and Strategy Analytics do just that, while also presenting your company's message to this global audience.

Executive Interviews

MWJ editors speak with industry executives to gain insight to their company's current activities and long-term objectives. This monthly feature is archived in the Resources section of the MWJ website.

Show Coverage

Online Show Dailies and Newsletters provide in-depth coverage of the EuMW and IMS events and excellent opportunities for exhibitors to deliver their message to attendees of the industry's two biggest industry trade shows.

Vendor View Storefronts

These featured storefronts in the Buyer's Guide section of the MWJ website provide a portal for your company's news, products, MWJ articles, white papers and downloads. Vendor View companies get their products featured in the Microwave ADVISOR and the RFIQ tool generates instant leads to your marketing group.

China Website

MWJ is pleased to announce the debut of our China website, designed to meet the needs of the rapidly growing Asian RF and microwave market. This website provides the opportunity for your company to target this important market through banner ads and sponsorships.



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



See us at MTT-S Booth 320

NEW WAVES

in offering wideband impedance control for modulated PAs. In addition, Maury will showcase its pulsed IV, pulsed S-parameter and noise parameter measurement solutions.

Maury Microwave Corp.,
Ontario, CA (909) 987-4715,
www.maurymw.com.

Booth 1016

EZ-Mate Connectors



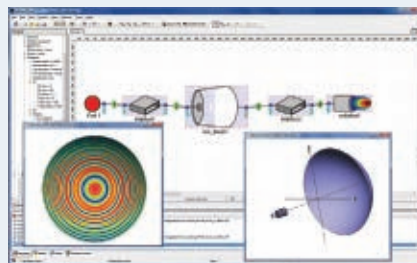
MegaPhase's EZ-Mate™ connectors assist in making quick and reliable connections without finger wear.

Engineering personnel who connect and disconnect cables tens and hundreds of times in a day can now easily connect using the MegaPhase EZ-Mate. To assure connectors can be easily and reliably mated, MegaPhase has designed and now offers EZ-Mate Type N, TNC and SMA connectors. Engineers can easily manipulate the half knurled, half hex shaped stainless steel connector. EZ-Mate's benefits are particularly critical when working in tight spaces. The unique design of the EZ-Mate also allows test professionals the option to use a torque wrench in lieu of easy finger operation.

MegaPhase LLC,
Stroudsburg, PA (570) 424-8400,
www.megaphase.com.

Booth 4202

Analysis and Optimization Tool



pWave Wizard™'s radiation module now includes a reflector antenna analysis and optimization tool. The incident EM-field on the reflector is calculated by using the spherical wave expansion of the radiated horn antenna field. The calculation of the farfield of basic reflectors such as parabol, hyperbol and ellipsoid is being performed by physical optics approximation. The radiated reflector field is also available as spherical-wave-expansion, which can be applied as a feeding system in other reflectors. The definition of the reflector geometry is completed by just a few parameters and includes an automatic mesh generation. Any optimization of the antenna performance parameters including the reflector is supported.

Mician GmbH,
Bremen, Germany
+49 421 168 993 56,
www.mician.com.

Booth 740

Ka-band SATCOM Preamplifier

Microsemi RF Integrated Solutions has a new addition to its JCA Amplifier™ product line, specifically targeted for SATCOM applications. The MSC2931-50-15 is a preamplifier with gain



flatness of ± 0.5 dB and up to 50 dB of gain over the 29.5 to 31.0 GHz frequency range. Variable attenuators can be added to optimize gain and

phase expansion for your application. The amplifier is designed to operate over the full military temperature range of -40° to 85°C and has a P1dB of 15 dBm minimum. Current, for a typical two attenuator configuration, is 750 mA from a single DC supply of +12 V. The amplifier is supplied with field replaceable K-type connectors and is RoHS compliant.

Microsemi Corp.,
Irvine, CA (800) 713-4113,
www.microsemi.com.

Booth 722

High Isolation Waveguide Switch



This X-band high isolation waveguide switch cascades MAG's successful single element switch, providing high isolation (> 50

dB), and handling moderate peak (50 kW) and average (200 W) power in a compact, economical construction. This switch provides 1 dB nominal insertion loss over a bandwidth in excess of 10 percent. Tandem rotators operate in opposition or summation, driving the horizontal or vertical arm of an orthomode transducer, providing 25 microsecond switching time. MAG is also developing this architecture at other frequency bands.

Microwave Applications Group (MAG),
Santa Maria, CA (805) 928-5711,
www.magsmx.com.

Booth 326

RF Frequency Counter



Mini-Circuits' UFC-6000 (RoHS compliant) is a small, light weight frequency counter operating over the frequency range 1 to 6000 MHz. The counter is cased in a rugged shielded case (size: $6.16'' \times 3.68'' \times 1.38''$) with a 16×2 character LCD screen, a reference input BNC(F) port and a signal input SMA(F) port. Using the



USB interface allows remote display of measured frequencies, and eliminates the need for an additional power supply.

The counter can also operate independently using an external power supply. The UFC-6000 is supplied along with a software CD containing a graphical user interface program featuring an API DLL com object. Also included are a 2.7 ft. USB cable and a power adaptor suitable for both US and EU power systems with a USB A female connector. Price: \$495.00 (Qty. 1-4).

Mini-Circuits,

X-Parameter Modeling Services

Modelithics now offers its customers nonlinear X-parameter measurement and modeling services. This state-of-the-art technology is enabled through use of Agilent Technologies' PNA-X series nonlinear vector network analyzer (NVNA) and provides circuit board designers with mathematically correct extensions of S-parameters for large-signal conditions for devices such as amplifiers, mixers and RFIC/MMIC functional blocks. Additionally, this technology characterizes the amplitudes and relative phase of harmonics, characterizes impedance mismatches, and can be applied to transistor modeling as an alternative to traditional compact equivalent modeling.

Modelithics Inc.,
Tampa, FL (813) 866-6335,
www.modelithics.com

Booth 713

DIN Valve Connectors



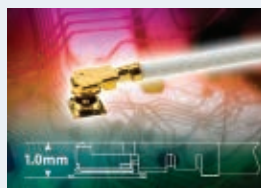
Molex Inc. has released the next generation of Brad® mPm® DIN valve connectors featuring the addition of Form C and Form Micro

housings. Combining IP67 sealing properties with an external-thread design, the mPm DIN valve connector range provides superior cable retention for increased performance and reliability. mPm DIN valve connectors simplify the manufacturing process and reduce overall applied costs for hydraulic, pneumatic and electromagnetic drive systems. The external nut on the Molex mPm DIN valve connector provides greater and consistent torque, which ensures cable retention and high reliability.

Molex Inc.,
Lisle, IL (800) 786-6539
www.molex.com

Booth 2102

RF Micro Coaxial Connectors



The JSC series of low profile RF micro coaxial connectors offer a maximum profile of just 1.0 mm, making it ideal for high-

tech wireless products. The low profile is possible through advanced manufacturing techniques used for both the board mounted connector and the micro coaxial cable. The JSC series comprises of board mounted receptacle (MM5829-2700) that mates with a RF cable (MXJA01xxxxx) that has a diameter of 0.81 mm. The receptacle measures 2 × 1.8 × 0.5 mm and the mated height of both the receptacle and cable plug is 1.0 mm maximum. The part is designed to withstand up to 30 mating cycles and emits an audible click on connecting. The connector and cable structure is optimized to ensure excellent RF performance up to 12 GHz.

Murata Electronics North America,
Smyrna, GA (800) 241-6574,
www.murata-northamerica.com

Booth 1607

IMA Technology VENDORVIEW



This integrated microwave assembly (IMA) product uses the company's new proprietary microwave multi-

layer circuits (MMC) technology with digital signal processing. These IMA products allow for extremely compact, densely populated modules, consistent with SWaP goals. Embedded microprocessors and FPGA devices make possible adaptive adjustments that compensate for system dynamics and environmental extremes. Narda's IMA products are offered in frequency ranges from DC to 60 GHz for applications in EW, MILSATCOM, radar, missile, UAV and related markets. In addition, IMA products and capabilities from its San Diego Tech Center have been added to the Narda portfolio and will be on display as well.

Narda Microwave - East,
an L-3 Communications Co.,
Hauppauge, NY
(631) 231-1700,
www.nardamicrowave.com

Booth 502, 602

2016 Size TCXO



This TCXO offers two outputs of the same reference clock frequency. The need for a TCXO that can

provide reference clock signal to both of the two functions has increased amidst the ambivalent two needs: miniaturization and multifunction. In order to meet these market needs, NDK has developed a TCXO with two outputs of the same frequency. This TCXO can provide reference clock signal to both of the two functions via independent outputs. Its enable/disable function offers more efficient power management, leading to lower power consumption. This TCXO alone can provide the reference clock signal to both of the two functions. This will help downsize the circuit boards in mobile information terminals. Size: 2.0 × 1.6 × 0.7 mm.

NDK America Inc.,
Belvidere, IL (815) 544-7900,
www.ndk.com

Booth 710

6550 MHz Ceramic Filter



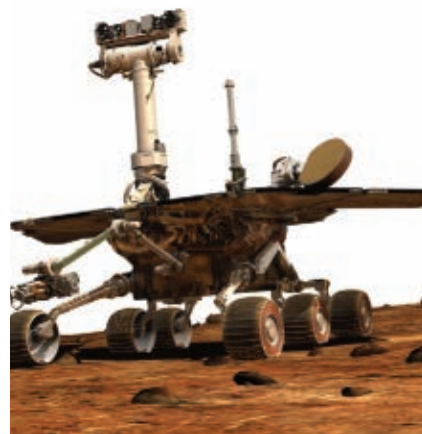
NIC's 6550 MHz ceramic filter is a high frequency ceramic filter built for use in C-band applications. The fea-

tures include low insertion loss of < 2.5 dB at center frequency, rejection of > 50 dB at 6000 MHz and > 40 dB at 7200 MHz, built in a small package size of 0.83" × 0.51" × 0.19". Custom designs are available up to C-band.

Networks International Corp.,
Overland Park, KS
(913) 685-3400,
www.nicck.com

Booth 733

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

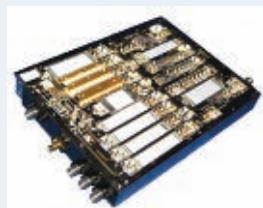
WIRE AND CABLE



NEW WAVES

0.5 to 18 GHz ELINT Receiver

VENDORVIEW



Norden Millimeter has developed a 0.5 to 18 GHz ELINT receiver with a proprietary frequency plan to reduce unwanted spurious.

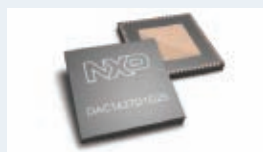
This receiver features an RF frequency range of 0.5 to 18 GHz; IF frequency of 1 GHz ± 200 MHz; conversion gain of 8.75 to 12.75 dB; noise figure of 14.5 dB maximum; image rejection of 80 dBc; LO re-radiation at RF port of -90 dBm maximum; mixer spurs and harmonics of 60 dBc with 50 percent of input band and 50 dBc at 100 percent of input band.

Norden Millimeter Inc.,
Placerville, CA (530) 642-9123,
www.nordengroup.com.

Booth 635

Digital-to-analog Converters

NXP Semiconductors has recently introduced the DAC1627D1G25, a high-speed 16-bit dual channel digital-to-analog converter (DAC) with selectable 2x, 4x and 8x interpolating filters optimized for multi-carrier and broadband wireless transmitters at sample rate up to 1.25 Gps. Supplied from a 3.3 V and a 1.8 V source, the



DAC1627D1G25 integrates a differential scalable output current up to 30 mA. Digital on-chip modulation up-converts the complex I and Q inputs from baseband to IF. The mixer frequency is set by a high resolution 40 bit numerically controlled oscillator (NCO). High resolution internal gain, phase and offset control provide outstanding image and LO rejection at the system analog modulator output.

NXP Semiconductors,
High Speed Converters,
San Jose, CA, www.nxp.com.

Booth 420

2.45 GHz ISM Band Market



The growing popularity of the 2.45 GHz ISM band requires an optimized set of RF power

products. NXP meets this need with a family of products running on a 28 V supply and delivers 10 to 140 W of power. The BLF2425ML(S)-140 is the most powerful device with 140 W and a gain of 17 dB and 52 percent efficiency.

NXP Semiconductors, RF Power,
San Jose, CA,
www.nxp.com.

Booth 420

Ku-band Downconverters

The TFF101xHN is a family of Ku-band down-



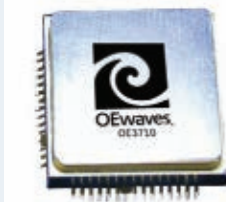
converters that includes an integrated mixer, PLL/VCO and IF gain stage, all within a leadless 16-pin

package. The devices operate from 10.7 to 12.75 GHz and require only seven external passive components, including the 25 MHz crystal. The downconverters are completely RF tested devices and achieve OIP3 of 13 dBm at only 54 mA, conversion gain up to 45 dB, and excellent integrated phase noise of less than 1.8° RMS.

NXP Semiconductors,
RF Small Signal, San Jose, CA,
www.nxp.com.

Booth 420

Opto-electronic Oscillator



OEwaves Inc. has achieved unprecedented phase noise performance in a microchip package based on proprietary ultra-high quality

factor (Q) crystalline optical resonators and the opto-electronic oscillator architecture. Capable of microwave frequencies beyond 100 GHz, such high performance microwave photonic oscillator chip revolutionizes communication system performances required by the next generation military/defense and commercial microwave applications. With significantly lower phase noise/jitter than conventional oscillator technology in comparable form factor, the system's spectral purity can be significantly improved without compromising size weight and power (SWaP).

OEwaves Inc.,
Pasadena, CA (626) 449-5000,
www.oewaves.com.

Booth 324

Four-way Power Divider



This model is a Wilkinson type four-way power divider that operates in a frequency range suited for communication satellite system and other Ku-band projects.

The low price, compact designed divider has SMA-jack connectors. This power divider offers dimensions of 54 x 38.2 x 13.5 mm (excluding connectors). The four-way power divider operates in a frequency range from 12 to 15 GHz, VSWR of < 1.5, loss of < 0.60 dB and isolation of < 20 dB. Other custom designed dividers can be provided upon request.

Orient Microwave Corp.,
Shiga, Japan +81-749-45-8121,
www.orient-microwave.com.

Booth 1732

18 GHz Coaxial Adapters

P1dB introduces precision stainless steel SMA to SMA (\$9.95 each) and N to SMA (\$13.95 each) 18 GHz coaxial adapters for the most demanding test bench and production test applications. The SMA adapters are available in Male to Male, Female to Female and Male to Female with maximum VSWR of 1.20:1 at 18 GHz. The N to SMA adapters are available in Male to Male, Female

to Female and Male to Female with maximum VSWR of 1.25:1 at 18 GHz.

P1dB Exclusive Stocking Distributor,
RFMW Ltd., San Jose, CA (408) 414-1450,
www.rfmuc.com.

Booth 2507

Hi Q/Low ESR Capacitors



Passive Plus Inc. now offers an extended working voltage capability for the company's core Hi Q/Low ESR capacitor line.

Available in six case sizes: 0.055" x 0.055" extended up to 300 W VDC; 0.110" x 0.110" extended up to 1,500 W VDC; 0.220" x 0.250" extended up to 5,000 W VDC; 0.380" x 0.380" extended up to 7,200 W VDC; 0.600" x 0.400" extended up to 8,000 W VDC; and 0.760" x 0.760" extended up to 10,000 W VDC. All product lines are available in P90 or NPO dielectrics with a variety of terminations and lead styles. All products are also available in non-magnetic termination styles. Delivery: stock to two weeks.

Passive Plus Inc.,
Huntington Station, NY
(631) 425-0938,
www.passiveplus.com.

Booth 2404

Digitally Tunable Capacitors



Peregrine's PE64904 (SPI) and PE64905 (I²C) DTCs are solid-state, digitally-controlled variable capacitors targeting

100 MHz to 3 GHz. These unprecedented UltraCMOS™ RFICs enable frequency agile tunable matching networks, increasing radiated power and improving antenna performance. Utilizing DuNE digitally tunable capacitors (DTC), monolithic tunable filters can also replace antiquated switchable filter banks, reducing radio complexity and cost. Featuring capacitance of 1.05 to 5.1 pF; 131 fF step size; Q~40 for lowest Cap state at high frequency; 2 kV HBM ESD; fast 10 μ s switching time and low-power operation.

Peregrine Semiconductor Corp.,
San Diego, CA
ww(858) 731-9400,
<http://dtc.psemi.com>.

Booth 1626

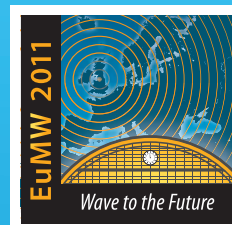
Phase-locked Oscillator

The PLS-11600-P100I is a high performance, low noise, 11.6 GHz phase-locked oscillator (PLO) with a 100 MHz OCXO internal reference. The design of this PLO's primary source consists of a low-noise, fundamental bipolar-silicon-transistor oscillator. In addition, a buffer amplifier in the output path provides the

desired power output and load isolation. Power output is 13 dBm minimum into a 50 ohm load. Phase noise at 10 kHz and 100 kHz offsets is typically



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



**EUROPEAN
MICROWAVE
WEEK**
Manchester
9-14 October 2011
www.eumweek.com

European Microwave Week is the largest event dedicated to RF, Microwave, Radar and Wireless Technologies in Europe. Capitalising on the success of the previous shows, the event promises growth in the number of visitors and delegates.

EuMW2011 will provide:

- 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

Organised by:



Official Publication:



Supported by:



Supported by:



Co-sponsored by:



Co-sponsored by:



Co-sponsored by:



EuMA
European Microwave
Association

41ST EUROPEAN MICROWAVE CONFERENCE 2011

The 41st European Microwave Conference



The 8th European Radar Conference

**EuMIC
2011**

The 6th European Microwave
Integrated Circuits Conference

Co-sponsored by:



Interested in exhibiting? Book online NOW!
www.eumweek.com

For further information, please contact:

Richard Vaughan
Horizon House Publications Ltd.
16 Sussex Street London SW1V 4RW, UK
E:rvaughan@horizonhouse.co.uk
Tel: +44 20 7596 8742
Fax: +44 20 7596 8749

Kristen Anderson
Horizon House Publications Inc.
685 Canton Street Norwood, MA 02062, USA
E:kanderson@mwjournal.com
Tel: +1 781 769 9750
Fax: +1 781 769 5037

See us at MTT-S Booth 3411

NEW WAVES

better than -117 dBc/Hz. The PLS-11600-P1001 is housed in a compact (2.25" x 2.25" x 0.92") connectorized package.

Phase Matrix Inc.,
San Jose, CA (408) 428-1000,
www.phasematrix.com.

Booth 4418

Detector Log Video Amplifier



PMI model SDLVA-218-71-70MV is a CW immune, extended range detection log video amplifier (ERDLVA) that offers 71 dB dynamic range over the frequency range of 2 to 18 GHz.



This model offers a maximum rise time of 35 nsec and a recovery time of less than 350 nsec. CW immunity is provided for signal

levels up to -40 dBm. The unit is temperature compensated such that log linearity over temperature remains less than ± 1.5 dB over the full operating temperature range of -20° to +85°C. This model is supplied in a compact housing measuring only 3.5" x 2.5" x 0.5". Optional frequency ranges covering 100 MHz to 26.5 GHz are available.

Planar Monolithics Industries Inc.,
Frederick, MD (301) 662-5019,
www.pmi-rf.com.

Booth 2304

Precision Connectors



This line of precision connectors is designed exclusively for Dynawave Ca-

ble's Dynaflex DF218, DF118 and DF126 cable. Both straight and right angle Male connectors are offered for SMA (18/26 GHz), TNCA (18 GHz) and Type N (18 GHz) series. The connectors feature solder/clamp terminations and fully captive soldered center contacts for better connector retention. Female connectors are also available in straight and bulkhead configurations. These connectors are designed for minimum VSWR and insertion loss over the specified frequency range.

Precision Connector Inc.,
Franklin, IN (317) 346-0029,
www.precisionconnector.com.

Booth 4818

Solid-state Power Amplifiers

QuinStar has developed millimeter-wave high power solid-state power amplifiers covering 25 to 100 GHz with unprecedented power output.



Standard and customized models are offered for applications from instrumentation to space systems. Output power

for standardized amplifiers ranges from 25 W at 35 GHz to 2 W at 94 GHz. Application-specific amplifiers with higher power, unique performance and environmental or mechanical requirements could be offered at economical prices and short lead-time.

QuinStar Technology Inc.,
Torrance, CA (310) 320-1111,
www.quinstar.com.

Booth 310

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 combine 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 4-12 sections.

Reactel Inc.,
Gaithersburg, MD (301) 519-3660,
www.reactel.com.

Booth 3915

Coupler Cable



Response Microwave announced the availability of its new drop-in or connectorized hybrid couplers suitable for use

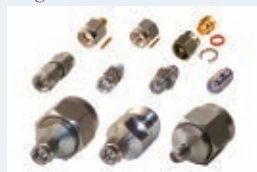
as a directional coupler or 90° quadrature hybrid. The new RMCL series offers average power handling options between 60 and 1400 W average and nominal coupling options from 2.8 through 52 dB. Typical electrical performance includes insertion loss of 0.3 dB, VSWR of 1.20:1 and isolation of 20 dB. Units can be cascaded to obtain broadband widths and are ideal for use in military power amplifier combine/divide stages or antenna feed networks.

Response Microwave Inc.,
Devens, MA (978) 772-3767,
www.responsemicrowave.com.

Booth 4414

SMA Test Grade Adapters

These precision SMA test grade adapters feature passivated stainless steel construction for long life in environments where repetitive



attachment to test equipment is required. All adapters are designed for outstanding electrical performance with low loss and low VSWR to 18 GHz. Test grade adapters are rugged and versatile for use in lab or field applications.

RF Precision Products,
Division of RF Industries, San Diego, CA
(858) 549-6340,
www.rfp2.com.

Booth 4615

Discrete Matched Power Amplifier



The RF3928 is a 50 V, 280 W discrete matched power amplifier for S-band pulsed radar, air traffic control and surveillance, and general purpose

amplifier applications. Using an advanced GaN semiconductor process, this high performance transistor achieves > 50 percent efficiency and 10 dB gain covering broadband 2.8 to 3.4 GHz. RF3928 comes in a hermetic flanged ceramic package with excellent thermal stability via advanced heat sink and power dissipation technologies. Optimized matching networks provide wideband gain and power performance in a single amplifier.

RFMD,
Greensboro, NC (336) 664-1233,
www.rfmd.com.

Booth 1402

Adjustable Delay Line Phase Shifter



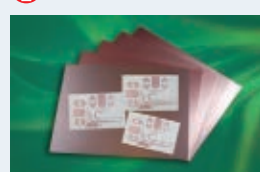
RLC Electronics' manually adjustable delay line (phase shifter) offers continuous adjustment of electrical delay

over the frequency range from DC to 40 GHz. Adjustment is through a multi-turn, locking shaft. Low insertion loss and VSWR are maintained throughout the adjustment range. The unit comes with a choice of male or female 2.92 mm connectors. Specifications include: insertion loss of 2.5 dB maximum; VSWR of 2.0:1 maximum; delay adjustment range of 56 picoseconds minimum; and phase shift range of 20 degrees/GHz minimum.

RLC Electronics Inc.,
Mount Kisco, NY (914) 241-1334,
www.rlcelectronics.com.

Booth 739

RT/duroid 6035HTC



RT/duroid® 6035HTC laminates exhibit outstanding thermal conductivity of 1.44 W/mK and a low

loss tangent of 0.0013 at 10 GHz, for excellent high frequency performance. The high thermal conductivity and low loss of RT/duroid 6035HTC result in exceptional heat transfer away from high power devices for improved circuit and device reliability. These laminates are fabricated with thermally stable, reverse-treated and electrodeposited copper foils. These low-profile copper foils help minimize conductor losses in high frequency circuits, with the thermal stability needed for high reliability in high temperature

Official Guide 2011 IEEE MTT-S International Microwave Symposium MicroApps Program



The MicroApps Program features practical application papers describing state-of-the-art products and processes of interest to the microwave community. MicroApps will receive a free CD/DVD presentation, sponsored by  **Agilent Technologies**

IMS2011 MicroApps Keynote Address

What Makes Successful Mergers?

Wednesday, 8 June 2011

17:00-18:00

Baltimore Convention Center, MicroApps Theater, Booth #413

Keynote Speaker: John Ocampo, M/A-COM Technology Solutions

Abstract: Is it good for your customers? Is it good for your shareholders? If the response is not a resounding yes to both, then it's not going to be a good one.

Even after it passes the first screen, a number of challenges remain. Are the cultures similar or radically different? Can key employees be retained? Will business partners embrace the combined entity, or will it cause friction? The list goes on and on, and if you are lucky, it will still take many years to reach a verdict.

M/A-COM Technology Solutions (MTS) and Mimix Broadband merged in May 2010. Although it is still early to declare victory, signs point to a successful merger. Mimix

bookings and revenue have more than doubled since the merger. Mimix brought an important technology that MTS needed. Conversely, MTS had the brand, sales channels, and infrastructure to support new products that Mimix lacked. Until Apple comes up with a crystal ball (iBall, you heard it here first), we're sticking with a few hard and fast rules to screen M&A opportunities that we are happy to share.



Biography: John Ocampo is Chairman of the Board at M/A-COM Technology Solutions, Inc. He is also a co-founder and President of Gaas Labs. Prior to creating Gaas Labs, John co-founded Sirenza Microdevices, Inc.

(Nasdaq: SMDI), a supplier of radio frequency semiconductors and related components for the commercial communications, consumer and aerospace, defense and homeland security equipment markets. While leading Sirenza through a successful IPO and eventual sale to RF Micro Devices, Inc. (Nasdaq: RFMD), John served at various times in a number of key roles, including President and CEO, CTO and Chairman. Prior to co-founding Sirenza, John served as General Manager at Magnum Microwave, an RF component manufacturer, and as Engineering Manager at Avanteq, a telecommunications engineering company later acquired by Hewlett-Packard. John holds a B.S.E.E. from Santa Clara University.





TUESDAY

WEDNESDAY

THURSDAY

0910			System-Level Simulation in the Design of Advanced Radar Systems Joel Kirshman, <i>AWR</i>
0930	Prediction of RF Breakdown in Combine Filters with FEST3D F.J. Pérez, J. Gil, C. Vicente, V. E. Boria, <i>Aurorasat</i>	Fast and Accurate CAD Solutions for Passive Waveguide Components and Horn Antenna Feed Systems with the μ Wave Wizard Ralf Beyer, <i>Mician</i>	The Art of Benchmarking RF Test Time David Hall, <i>National Instruments</i>
0950	Practical Methods for Estimating the Q of Spiral Inductors Using EM Planar Simulators John Dunn, Charlotte Blair, <i>AWR</i>	Customized, Deembedded Ports in 3D Planar EM Tools: Extending Deembedding to Arbitrary Geometries John Dunn, <i>AWR</i>	The Alphabet Soup of Vector Network Analyzer Calibration Craig Kirkpatrick, <i>Cascade Microtech</i>
1010	Tools for Creating FET and MMIC Thermal Profiles Ted Miracco ¹ , John Fiala ² , ¹ <i>AWR</i> , ² <i>CapeSym</i>	SEMCAD X Microwave: Enhanced Simulation of Waveguide Structures Erdem Oflil, Pedro Crespo-Valero ¹ , Jorge Ruiz-Cruz ² , ¹ <i>SPEAG</i> , ² <i>UAM</i>	Advances in Signal Analyzer Noise Floor and Dynamic Range John Hansen, <i>Agilent</i>
1030	Applications and Techniques for Low Phase Noise Signal Generation John Hansen, <i>Agilent</i>	Using X-Parameters to Optimize Notch Filter Placement in PA George Crumrine, <i>Agilent</i>	Easy, Fast and Versatile Time Domain Waveform Measurement of Microwave Power Transistors Fabien De Groote, Jan Verspecht, Jean-Pierre Teyssier, Jad Faraj, <i>Verspecht-Teyssier-DeGroote</i>
1050	Understanding Contributors to Test Time for VSA Measurements David Hall, <i>National Instruments</i>	IQ Mixer Measurements: Techniques for Complete Characterization of IQ Mixers Using a Multi-Port Vector Network Analyzer Dara Sarisani, <i>Agilent</i>	EMPIRE XCell – Efficient Solving of Large Scale EM Problems A. Lauer, W. Simon, A. Wien, <i>EMPIRE XCell</i>
1110	Techniques for Validating a Vector Network Analyzer Calibration When Using Microwave Probes Craig Kirkpatrick, <i>Cascade Microtech</i>	pHEMT Amplifier MMICs with Enhanced Robustness Against Process Variations Charles Trantarella, David Folding, <i>Custom MMIC Design Services</i>	Transient FEM Solver and Hybrid FE-IE Method; New Technologies in HFSS 13.0 Matthew H. Commens, <i>ANSYS</i>
1130	Ultra Low Phase Noise Measurement Technique Using Innovative Optical Delay Lines Guillaume De Giovanni, <i>NoiseXT</i>	Design Benefits of Integrating Simulation and Measurement Environments: An LNA Example Gary Wray, <i>AWR</i>	QuickWave Electromagnetic Software with CAD Input and GPU Processing Malgorzata Celuch, Maciej Sypniewski, <i>QWED</i>
1150	A Multi-Level Conductor Surface Roughness Model Yunhui Chu, <i>Agilent</i>		Application Principles for Circulators and Isolators Anthony Edridge, Gene Garcia, <i>M2 Global</i>
1210	Understanding the Proper Dielectric Constant of High Frequency Laminates to Be Used for Circuit Modeling and Design John Coonrod, Allen F. Horn, <i>Rogers</i>	1200 - 1330 Nonlinear Characterization Expert Forum	The Design and Test of Broadband Launches Up to 50 GHz on Thin and Thick Substrates Bill Rossas, <i>Southwest Microwave</i>
1230	Volume Manufacturing Trends for Automotive Radar Devices Jake Sanderson, <i>Agilent</i>	SPEAKERS: • Loren Betts, Research Scientist/Senior Engineer, <i>Agilent Technologies</i> • Steve Reyes, Product Marketing Manager Network Analyzers, <i>Anritsu</i> • Marc Vanden Bossche, Founder and CEO, <i>NMDG Engineering</i> • Johannes Benedikt, CTO, <i>Mesuro</i>	Low-PIM Filter Solutions for Broadband Emission Monitoring Rafi Hershtig, Tim Dolan, <i>K&L Microwave</i>
1250	Improved Soldering Techniques for Cylindrical RF Connectors Using HIG Induction Technology Chip Palombini, <i>iTherm</i>		Mixed-Signal Active Load Pull – The Fast Track to 3G/4G Amplifier Design Mauro Marchetti, <i>Maury Microwave</i>
1310	Power Amplifier Design Utilizing the NVNA and X-Parameters Loren Betts ¹ , Dylan T. Bepalko ² , Slim Boumaiza ³ , ¹ <i>Agilent</i> , ² <i>University of Waterloo</i>		A Comparison of Noise Parameter Measurement Techniques Erick Kueckels, <i>Maury Microwave</i>
1330	Wideband Direct Digital Radio Modeling and Verification David Leiss, Rulon VanDyke, <i>Agilent</i>		Vector-Receiver Load Pull – Measurement Accuracy at Its Best Steve Dudkiewicz, <i>Maury Microwave</i>
1350	Improved Microwave Device Characterization and Qualification Using Affordable Microwave Microprobing Techniques for High-Yield Production of Microwave Components Gregory Mau, <i>Custom Microwave Components</i> , Jerry Schappacher, <i>Jmicro Technology</i>	Simulation and Evaluation of Communications Systems in Conformance with Third- and Fourth-Generation Wireless Standards Joel Kirshman, <i>AWR</i>	Active and Hybrid Load Pull – A Paradigm Shift Gary Simpson, <i>Maury Microwave</i>
1410	Time Domain Measurements in Waveguide Keith Anderson, <i>Agilent</i>	Remcom's XFDTD and Wireless InSite: Advanced Tools for Advanced Communication Systems Analysis Joseph J. Rokita, Kyle Labowski, <i>Remcom</i>	Local Fundamental Frequency Enhancements for X-Parameter Models Radek Biernacki, Mihai Marcu, <i>Agilent</i>
1430	Pulsed S-Parameter Measurements Using PXI Instruments David Broadbent, <i>National Instruments</i>	Digital Radio Testing Using an RF Channel Replicator Joe Mazzochette, <i>EOX</i>	Beyond the S-Parameter: The Benefits of Nonlinear Device Models Mike Heimlich, <i>AWR</i>
1450	Emergence of the Online Design Center Sherry Hess, Dave Kuhn, <i>AWR</i>	Advanced Terahertz Device Characterization Keith Anderson, <i>Agilent</i>	
1510	Design for Manufacturing: Yield Analysis During EM Simulation Mark Saffian, <i>AWR</i>	High Performance RF Photonic Link Technologies Dalma Novak, <i>Pharad</i>	
1530	STAN Tool: A New Method for Linear and Nonlinear Stability Analysis of Microwave Circuits Stéphane Deltier, <i>AMCAD Engineering</i>	A Practical Approach to Verifying RFICs with Fast Mismatch Analysis George Estep, Paul Colestock, <i>Agilent</i>	
1550	Maximizing VSA Dynamic Range Through Appropriate IF Path Selection Raajit Lall, <i>National Instruments</i>	Calibration and Accuracy in Millimeter Systems Keith Anderson, <i>Agilent</i>	
1610	Waveguide Characteristics and Measurement Errors Keith Anderson, <i>Agilent</i>	Instant RF Design Starts with Simulate-able RF Application Notes How-Siang Yap ¹ , Mike Virostko ² , ¹ <i>Agilent</i> , ² <i>Hittite</i>	
1630	Memory Effects in RF Circuits: Definition, Manifestations and Fast, Accurate Simulation George Estep, Arnaud Soury, <i>Agilent</i>	New Rotary Joint Product Lines for SATCOM Applications Andreas Lermann, <i>SPINNER</i>	
1650			
1710		1700 - Keynote Address: What Makes Successful Mergers? John Ocampo, Chairman of M/A-COM Technology Solutions	
1730			
1800			



IEEE

IMS2011 Baltimore



June 5 - 10, 2011

Microwave Week is coming to Baltimore, MD

Sign up now and save up to **25% off** your registration!

Don't miss your chance to see the latest RF/Microwave technology advancements while accessing **over 500 companies** technologies and services.

Visit **IMS2011.ORG** for complete details and to download your Program Book. Review technical sessions, workshop descriptions and exhibiting companies so you can make the most of your time at Microwave Week!

Technical areas of interest include:

Microwave Field and Circuit Techniques

Passive RF and Microwave Components

Active RF and Microwave Components

RF and Microwave Systems and Applications



Download the Program Book and register at <http://ims2011.mtt.org>

NEW WAVES

applications, even at the power levels found in many military electronic-warfare (EW) and commercial communications systems.

Rogers Corp.,
Advanced Circuit Materials Division,
Chandler, AZ (480) 961-1382,
www.rogerscorp.com/acm.

Booth 2515

Real-time Spectrum Analyzer

VENDORVIEW



The R&S FSVR family, said to be the world's first signal and real-time spectrum analyzers

up to 40 GHz, combines the functions of an all-purpose signal and spectrum analyzer with a real-time spectrum analyzer. In real-time mode, the spectrum analyzer detects everything from sporadic events to ultrashort signals. Measurement without blind times is a major advantage for developers of RF components for commercial transmission systems such as LTE, WiMAX™, WLAN, Bluetooth® and RFID, and for general RF applications such as radar and frequency hopping transmission.

Rohde & Schwarz,
Munich, Germany +49 89 4129 12345,
www.rohde-schwarz.com.

Booth 2115

Connectors and Cables

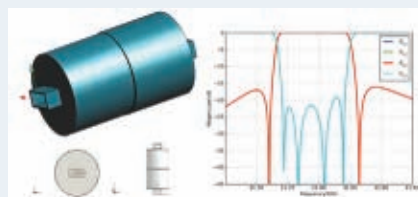
Rosenberger will introduce several new products including: new PCB-connector used for test applications to 110 GHz. WSMP connector series ultra-high density, push on interconnects, 45 percent smaller than MiniSMP offering a broad RF range through 100 GHz. Phase stable VNA ruggedized cable to 70 GHz. Rmor™ ruggedized cables for harsh environments. In addition, Rosenberger will show its latest in Passive Intermodulation (PIM) test equipment that incorporates network analyzer functionality and distance to intermodulation source.

Rosenberger of North America LLC,
Akron, PA (717) 859-8900,
www.rosenbergerna.com.

Booth 1411

Enhanced Simulation of Waveguide Structures

SPEAG developed a new state-of-the-art solver based on the mode-matching technique for the simulation of passive waveguide structures within their simulation suite. The new solver has been integrated into the existing SEMCAD X framework to provide the user with a com-



monly elaborated simulation environment. Together with the EM and thermal solvers based on the FDTD techniques, SEMCAD X Microwave can be successfully applied to a wide variety of electromagnetic problems ranging from microwave devices, EMC, optics, to bio-medical applications.

Schmid & Partner Engineering AG (SPEAG),
Zurich, Switzerland +41 44 245 9700,
www.speag.com.

Booth 3204

Low Noise Amplifier

VENDORVIEW

The SKY67014-396LF, the first of three new LNAs for battery powered receiver applications in the 450, 900 and 2400 MHz ISM bands, features noise figure < 1.0 dB, 12 dB gain and 15 dBm OP1dB, and draws 5 mA of current at 3.3 V. This GaAs PHEMT LNA is in a 2 mm square, eight-pin RoHS compliant SMT



package. Integrated active bias circuitry reduces external matching requirements and enables a wide supply voltage range of 1.5 to 5 V. An OIP3 of 27 dBm at 2.5 GHz is achievable with 20 mA.

Skyworks Solutions Inc.,
Woburn, MA (781) 376-3000,
www.skyworksinc.com.

Booth 1428

End Launch Connectors



Southwest Microwave's End Launch connector series is being expanded to 1.85 mm, DC to

65 GHz, version in a high and low silhouette mounting block. These high performance connectors are designed to provide the industries lowest VSWR for single-layer or multilayer circuit boards with the microwave layer on top. They are ideally suited for high frequency chip set evaluation, demo boards, test fixtures and board characterization. The connector requires no soldering, and they are reusable and repairable.

Southwest Microwave Inc.,
Tempe, AZ (480) 783-0201,
www.southwestmicrowave.com.

Booth 824

DC Link Power Film Capacitors



DC. Due to harsh operating conditions of wind and photovoltaic installations, components used in power inverter applications require superior life expectancy. Spectrum's DC link power capacitors utilize segmented, self-healing metallized polypropylene, internally fused using a T-design pattern, giving them a life expectancy of over 100,000 hours. Spectrum's DC link power film capacitors feature low ESR (1 to 4.3 Ω,

typical) and low ESL (50 to 80 nH, typical), ripple currents up to 70A RMS from 10 kHz to 100 kHz, and a capacitance range of 160 to 680 μF standard.

Spectrum Advanced Specialty Products,
Fairview, PA (814) 474-0325,
www.specemc.com.

Booth 1415

Broadband 50 W Amplifiers



Spectrum Microwave continues adding to its line of S.M.A.R.T. power amplifiers with the addition

of a 20 to 800 MHz, 50 W design. With 45 dB of linear gain, this 21 to 30 V DC unit produces 50 W off of only 5.1 amps at 28 V. The QBS-559 amplifier offers a unique feature by automatically adjusting the active biasing to enhance efficiency under various load mismatch conditions. This rugged, high efficiency, push-pull design can even withstand a 10:1 load mismatch. It offers both an internal DC to DC converter as well as an integral heatsink. A variety of fault and monitoring options are also available.

Spectrum Microwave Inc.,
Philadelphia, PA (215) 464-4000,
www.spectrummicrowave.com.

Booth 1415

Precision Airlines



Airlines work as a reference impedance for the DUT and the VNA and are used for precision time domain reflectometry measurements. For a more convenient

handling at the VNA side of the airline, the inner conductor is supported by one low-loss dielectric bead. SPINNER precision airlines, which are available for the connector series 7-16, N and 3.5 mm, feature lowest return loss and best possible impedance values.

SPINNER GmbH,
München, Germany +49 (0)89 12601-0,
www.spinner-group.com.

Booth 431

RF Microwave Kit



SRI's RF microwave is a custom precision RF kit for the microwave industry. Kits can contain any variety or quantity of high frequency con-

nectors and adapters that SRI produces: 1.85, 2.4, 2.9, 3.5 mm, N, SMA, TNC, ZMA, Superites and custom connectors. SRI can also provide a one-stop shopping by sourcing the cables. With its wide range of standard products and custom capabilities, SRI Connector Gage is ready to partner with you to provide high performance, cost-effective coaxial interconnect solutions. SRI offers precision connectors in many other form factors, including 3.5 mm, N, SMA, TNC and ZMA. SRI will execute virtually any coax design related to its product line and deliver it quickly, usually in less than eight weeks.

SRI Connector Gage Inc.,



**IEEE MTT-S IMS 2011 MicroApps
Nonlinear Characterization Expert Forum
Baltimore, Maryland, June 8, 12:00 – 1:30 pm**

A 90 minute forum and webcast, featuring experts in RF nonlinear device measurement and characterization.

Our panel of experts will discuss solutions and trends in nonlinear device characterization from the perspective of new measurement equipment, techniques and device representation in EDA tools. An open panel discussion session will follow the presentations with audience questions from both live and online participants.

SPEAKERS:

- Loren Betts, Research Scientist/Senior Engineer, Agilent Technologies
- Steve Reyes, Product Marketing Manager Network Analyzers, Anritsu
- Marc Vanden Bossche, Founder and CEO, NMDG Engineering
- Johannes Benedikt, CTO, Mesuro

Sponsored by:



Agilent Technologies

Anritsu



ROHDE & SCHWARZ

Tektronix

Organized by:

Microwave Journal and
IMS MicroApps Steering Committee

Not attending MTT-S IMS?
Register for the FREE live webcast
www.mwjjournal.com/ims_2011_microapps_experts



Frequency Matters.

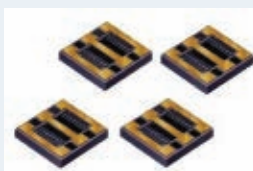
NEW WAVES

Melbourne, FL (321) 258-9688,
www.sricconnectorgage.com.

Booth 531

High Reliability Chip Resistors

The Z termination line of miniature, high reliability chip resistors are available in thin and thick film single surface and wrap around designs. The resistors range in size from 0402 (0.040" x 0.020") to 2512 (0.025" x 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 resistors are a RoHS compliant product.

State of the Art Inc.,
State College, PA (814) 458-3401,
www.resistor.com.

Booth 1805

Metalized Substrates

Stellar Industries new Copper On Silver



conductor offers an economical solution for DC to RF medium substrate power applications. Combining the low cost of thick film silver with Stellar's copper plating technology - Copper On Silver is available for custom designs on alumina, aluminum nitride and beryllium oxide ceramics. Stellar offers the widest selection of copper metallization technologies from Direct Bond Copper (DBC) to thick film copper to Thin Film Copper Plate Up (CPU) for every frequency and power requirement.

Stellar Industries Corp.,
Millbury, MA (508) 865-1668,
www.stellar-ceramics.com.

Booth 319

GaN HEMTs



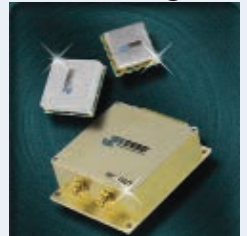
Sumitomo Electric will be featuring its full line of GaN HEMTs for this year's MTT-S IMS Show. Applications include base station, radar and many other general

purpose uses. One of the featured products, EGN21C16012D, supports 2.1G LTE. This is a 160 W Psat device with internal matching circuits and is ideal for 40 W Doherty applications. The high impedance of this GaN HEMT device makes a wide bandwidth of 1.8 to 2.2 GHz possible.

Sumitomo Electric Device Innovation USA,
San Jose, CA (408) 232-9500,
www.sei-device.com.

Booth 620

Low Noise High Frequency Sources



These new ultra-low noise signal sources are designed for single frequency applications such as clock translators for instrumentation and radar markets. These products can

also be ideal companions as clock translators for high speed ADC and DDS clocks for improved signal purity. These products convey significant noise floor improvements over multiplied crystal oscillator solutions employed today. The product is available as phase locked sources both in surface-mount FCTS series and SMA coaxial KFCTS series. Products can be made available as phase-locked sources from 300 to 2500 MHz. Model KFCTS1000-10 operates at 1000 MHz, reaches -140 dBc/Hz at 10 kHz offset with ultimate noise floor nearing -170 dBc/Hz at frequency carrier offset of >600 kHz.

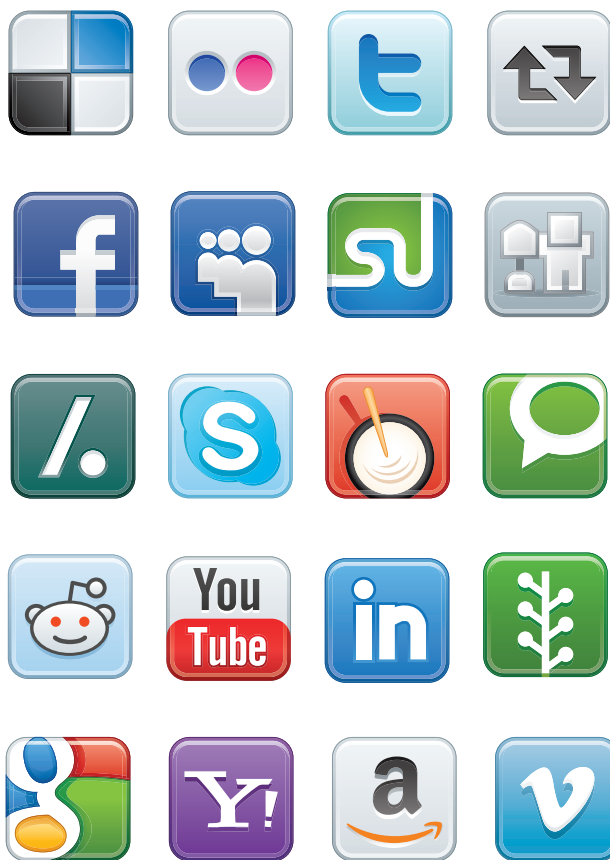
Synergy Microwave Corp.,
Paterson, NJ (973) 881-8800,
www.synergymicrowave.com.

Booth 507, 607

Signal Analyzer



New at MTT-S this year Tektronix will showcase its RSA5000 series signal analyzer. The new instruments



Button up your marcom.

Web 2.0 Branding, Advertising, Marketing, PR
Jaime Leger • 401.487.8566 • leger@slnadv.com



SHEPPARD LEGER NOWAK INC
www.slnadv.com

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



**EUROPEAN
MICROWAVE
WEEK**
Manchester
9-14 October 2011
www.eumweek.com

EuMW2011 returns to this wonderful city for what promises to be an important and unforgettable event. Bringing industry, academia and commerce together, European Microwave Week 2011 is a SIX day event, including THREE cutting edge conferences and ONE dynamic trade and technology exhibition featuring leading players from across the globe.

THE EXHIBITION (11 -13 October 2011)

The European Microwave Exhibition is central to the week

- International Companies – meet the industry's biggest names and network on a global scale
- Cutting-edge Technology – exhibitors showcase the latest product innovations, offer hands on demonstrations and provide the opportunity to talk technical with the experts
- Technical Workshops - get first hand technical advice and guidance from some of the industry's leading innovators

THE CONFERENCES AND WORKSHOPS (9 – 14 October 2011)

Spanning the length of the week, choose from three separate but complementary conferences:

- European Microwave Integrated Circuits Conference (EuMIC) – 10-11 October 2011
- European Microwave Conference (EuMC) – 11-13 October 2011
- European Radar Conference (EuRAD) – 13-14 October 2011
- Workshops & Short Courses - 9,10 &12 October 2011

SIGN UP!

Organised by:



Official Publication:



Supported by:



Co-sponsored by:



Co-sponsored by:



EuMA
European Microwave
Association

41ST EUROPEAN MICROWAVE CONFERENCE 2011
The 41st European Microwave Conference



The 8th European Radar Conference

EuMIC 2011
The 6th European Microwave
Integrated Circuits Conference

Co-sponsored by:



See us at MTT-S Booth 3411

To register as a conference delegate or a visitor to the exhibition log onto

www.eumweek.com

Featured White Papers

The information you need, from the technology leaders you trust.



Optimizing High Performance RF Components for LTE and LTE Advanced Base Stations

Randy Cochran, Phil Knights, Jarek Lucek, NXP



Microwave Applicator with Conveyor Belt System

Application Note, Presented by COMSOL



PNA-X Nonlinear Vector Network Analyzer and X-Parameters in Power Amplifier Design

Loren Betts, Agilent Technologies



Taking Mobile to Rural Africa: The Vital Role of Hybrid Satellite-Microwave Backhaul

White Paper, Intelsat

Check out these new online Technical Papers featured on the home page of Microwave Journal and the MWJ white paper archive in our new Technical Library (www.mwjjournal.com/resources)



Frequency Matters.

NEW WAVES

raise the price-performance bar for mid-range signal analyzers by offering more than double currently available acquisition bandwidth and the world's best real time capabilities. By combining



reduced time-to-insight and lower cost, the new series is ideal for numerous design and operations applications including spectrum management, radar, electronic warfare, radio communications and EMI/EMC. US MSRP starting as low as \$36,400. Also being showcased, Tektronix will highlight its AWC7000C and AWC5000C series of arbitrary waveform generators (AWG) that bring performance and usability enhancements to the industry's most capable family of signal generation solutions.

Tektronix Inc.,
Beaverton, OR (800) 833-9200,
www.tektronix.com.

Booth 1432

CE Marked Thermal Platforms

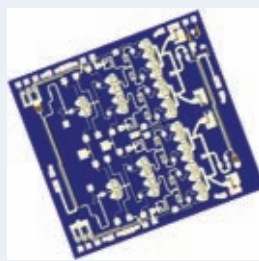


TotalTemp Technologies Inc., a manufacturer of temperature testing equipment, announced the debut of its new line of CE Marked Thermal Platforms (a.k.a. Hot/Cold Plates). These Thermal Platform Systems are specifically designed to conform to the EU electrical safety standard. TotalTemp will have these systems on display at the 2011 IEEE MTT-S International Microwave Symposium.

TotalTemp Technologies Inc.,
San Diego, CA (888) 712-2228,
www.totaltemptech.com.

Booth 1730

Ku-band Power Amplifier

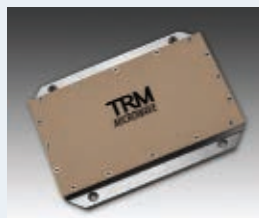


Expanding on the popularity of the packaged version, the TGA2533 provides over 2 W P1dB from 12.7 to 15.4 GHz in a DIE format. With an integrated power detector and 43 dBm TOI, this device is ideal for linear power amplifiers or test equipment in the point-to-point radio and VSAT markets. Running off 6 V at 1300 mA, the TGA2533 offers 28 dB of gain in a $3.2 \times 3.0 \times 0.1$ mm DIE.

TriQuint Stocking Distributor,
RFMW Ltd.,
San Jose, CA (408) 414-1450,
www.rfmw.com.

Booth 2218

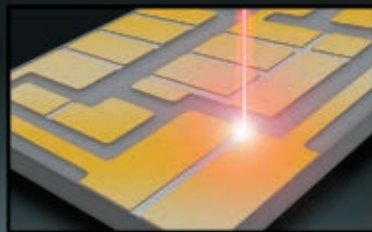
4x4 Broadband Beamformer



Serving both airborne and communication system applications, the BFN-4412 is a multi-octave component combining ferrite, coaxial and microstrip technologies achieving high performance in a low profile, small footprint ($2.0 \times 3.5 \times 0.7$). Engineered and manufactured in the US, this unit is also used in military radar warning receiver (RWR) designs and early warning and countermeasure control systems. Internally, the BFN-4412 incorporates eight-zero degree dividers, four-zero degree combiners, four-180° combiners and 50 ohm coax delay lines. Operating in the frequency range of

LASER ABLATION

LASER FAST



Solder dams, tight tolerances a specialty.

Westford, MA
978-692-6180
LaserServicesUSA.com

LASER
SERVICES

See us at MTT-S Booth 2123

Applying the Science of Microwave Materials



ECCOSORB®
ECCOSTOCK®
ECCOSHIELD®

Application specific solutions
ranging from 100 MHz-100 GHz

1-800-650-5740
www.eccosorb.com

Visit us at
IMS 2011-Baltimore, MD
Booth #3507



VectraWave



X Band HPA and MPA

HPA 8 12 GHz 17dB 40dBm	VWA 50028 AA
HPA SMA package	VWA 00080 AA
MPA 8 12 GHz 22dB 27dBm	VWA 50035 AA
MPA SMA package	VWA 00097 AA
Power controller	VWA 50011 AA

ULTRA-WIDE BAND MMIC

MPA DC 28GHz 17dB 21dBm	VWA 50014 AA
MPA DC 35GHz 10dB 15dBm	VWA 50015 AB
MPA DC 35GHz 14dB 18dBm	VWA 50015 AB
MPA DC 35GHz 10dB 15dBm	VWA 50015 AC
MPA DC 45GHz 11dB 15dBm	VWA 50025 AA

www.vectrawave.com contact@vectrawave.com
IMS booth #4513



Modco offers a low-noise general purpose amplifier. Model Number WB100-6000DJ covers a frequency range of 100MHz through 6000MHz. The amplifier is housed in an Iridite Gold finished aluminum housing measuring 1.25" x 1.25" x 0.60". It is supplied with three SMA F Connectors. The device operates from a single +5V supply and consumes 60mA

www.modcoinc.com

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



VIRTUAL S-PARAMETER NETWORK ANALYZERS

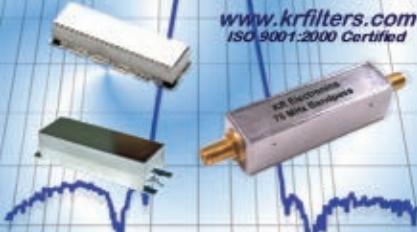
OBZOR TR1300/1 (300 kHz - 1.3 GHz)	\$ 1 800
OBZOR-304/1 (300 kHz - 3.2 GHz)	\$ 8 800
OBZOR-804/1 (300 kHz - 8.0 GHz)	\$ 14 990

Russia - **PLANAR LLC**
www.planar.chel.ru
welcome@planar.chel.ru
+7 351 265 1069

Singapore - **RF Instruments Pte Ltd**
www.rf-instruments.com
+65 63236546

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

FAST PULSE TEST SOLUTIONS



Avtech offers over 500 standard models of high-speed pulse generators, drivers, amplifiers and accessories ideal for both R&D and automated factory-floor testing. Some of our standard models include:

AVR-EB4-B: for reverse-recovery time tests
AV-156F-B: for airbag initiator tests
AVO-9A-B: for pulsed laser diode tests
AV-151J-B: for piezoelectric tests
AVOZ-D2-B: for production testing attenuators
AVR-DV1-B: for phototriac dV/dt tests

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



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

NEW WAVES

500 to 2000 MHz, it delivers typical specifications of: insertion loss of less than 2.5 dB in the low band, greater than 18 dB isolation maximum. **TRM Microwave**, Bedford, NH (603) 627-6000, www.trmmicrowave.com.

Booth 3902

High Power Circulator

Model CT-1713-S operates at 20 KW peak, 2 KW average power over the frequency range of 380 to 420 MHz. This unit provides isolation of 20



UTE Microwave Inc., Asbury Park, NJ (732) 922-1009, www.utemicrowave.com.

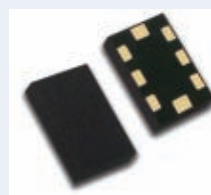
Booth 1040

Voltage Variable Attenuators



Valpey Fisher's VFVA500 series consists of six models that span the frequency range of 600 MHz to 4 GHz and are offered in a

dB minimum, insertion loss of 0.3 dB maximum and 1.20 maximum VSWR. Connectors are 7/8 EIA. Typical applications include radar, medical and scientific equipment.



3.2 x 4.9 mm MCM package. These devices provide a minimum of 25 dB attenuation across a 0 to 5 V control range. Come by Valpey Fisher's booth #1633

for more information.

Valpey Fisher Corp., Hopkinton, MA (508) 435-6831, www.valpeyfisher.com.

Booth 1633

PTFE Cables

W.L. Gore & Associates continues to enhance its engineered PTFE (polytetrafluoroethylene) technology for use in flat and round cables, making them the premier choice for demanding, extreme environments such as semiconductor manufacturing, aerospace and industrial

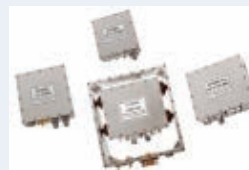


applications. Gore's customized materials and unique cable designs have resulted in products that minimize particulation and outgassing while maximizing longevity—a combination of qualities not found in any other cable technology. The low coefficient of friction and excellent tear resistance of Gore's expanded PTFE composite jacket material enable its high flex cables to maintain excellent signal integrity.

W.L. Gore & Associates, Landenberg, PA (410) 506-7787, www.gore.com.

Booth 320

OCXOs



The Citrine family of OCXOs is available in a frequency range from 5 to 500 MHz and was designed towards the goal of

achieving the lowest possible phase noise performance in a dynamic environment. The utilization of "Low-G" Coven Crystal is what enables the oscillator to obtain a g-sensitivity down to <3E10/g. The standard Citrine specs utilize COTS parts, which are ideal for ruggedized environments such as airborne, ship board and ground-based military vehicles. If required, the Citrine line of crystal oscillators can be configured with Hi-Rel components.

Wenzel Associates Inc., Austin, TX (512) 450-1400, www.wenzel.com.

Booth 3409

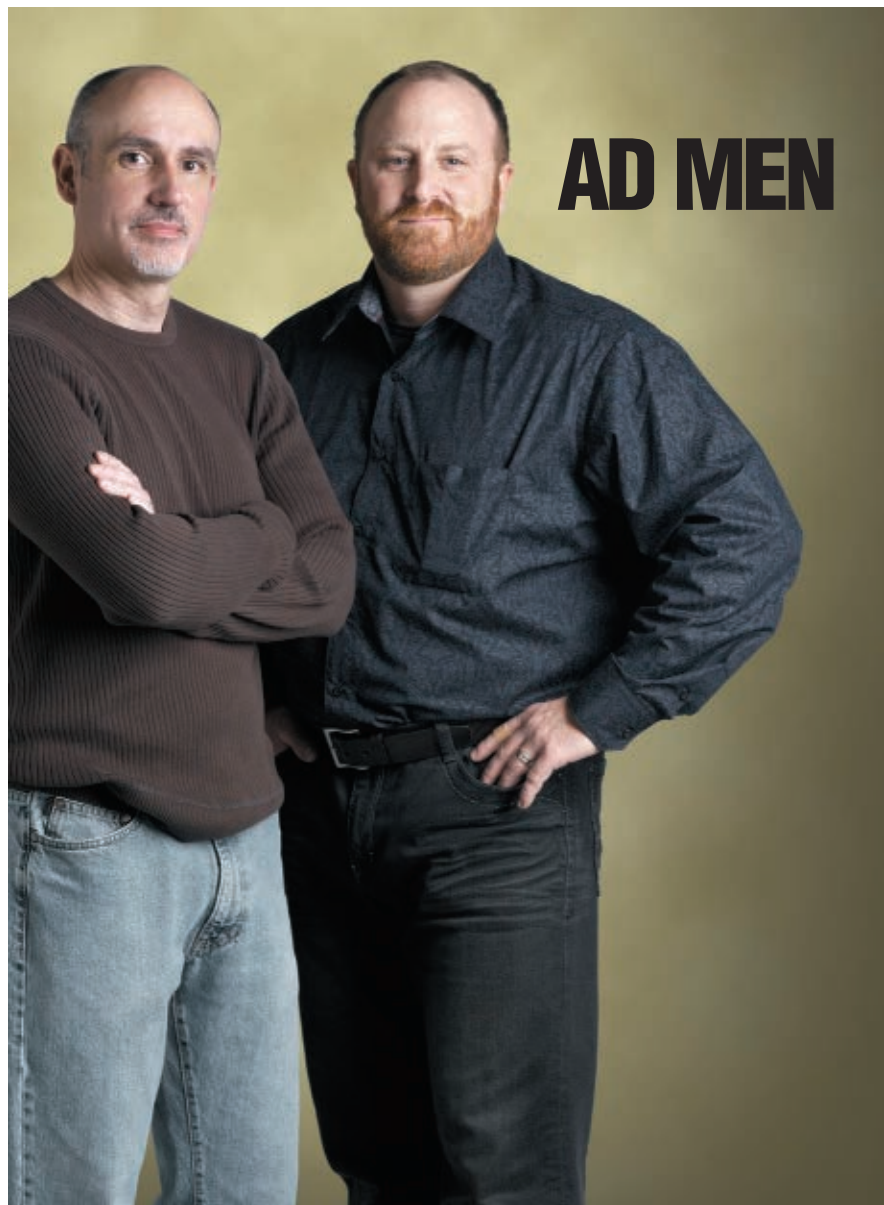
90° Hybrid Coupler



The Werlatone 90° hybrid coupler, model QH8600, is the first four-port, stripline design, covering the full 30 to 520 MHz bandwidth.



The latest in a series of multi-octave 90° hybrid couplers, the QH8600 is rated at 250 W CW with exceptional loss and port-to-port isolation. With no screws or rivets to hold the circuit's layers together, this chemically bonded, drop-in design provides excellent repeatability in a compact 0.95" x 1.50" x 0.29" form factor. Removes the labor associated



David Bush

David Strand

STRAND

Advertising • Web • PR

StrandMarketing.com

with traditional core windings on 30 to 520 MHz amplifiers.

Werlatone Inc.,
Patterson, NY (845) 278-2220,
www.werlatone.com.

Booth 3402

Assembly and Test Equipment

Design and manufacturer of automatic, semi-automatic, and manual ESD protected micro-electronic assembly and test equipment and accessories since 1966. Ultrasonic, thermosonic, and thermocompression wire/ribbon bonders, eutectic and epoxy die bonders, insulated wire bonders and pull testers, LED illuminators, heated and cold workholders, temperature controllers, ultrasonic transducers, ultrasonic power supplies and wire despoilers.

West Bond Inc.,
Anaheim, CA (714) 978-1551,
www.westbond.com.

Booth 3614

Pure-play Wafer Foundry

WIN Semiconductors Corp., established in 1999, has become the world's largest 6" GaAs pure-play wafer foundry. WIN's current capacity from two fabs is 14,000 wafers per month. In addition to 1 μ m, 2 μ m and high voltage HBT processes, 0.5 μ m E-D, 0.15 μ m low noise and power, HFET, BiFET (H2W), and Ka/Ku-band 0.25 μ m PHEMT processes, WIN is now offering 8 V, 0.25 μ m and 0.1 μ m power PHEMT processes.

WIN Semiconductors Corp.,
Tao Yuan Shien, Taiwan 886-3-397-5999,
www.winfoundry.com.

Booth 810

Fixed Frequency Synthesizer



The SFS10000C-LF is a single frequency signal source that is pre-programmed to operate at 10 GHz. This fixed frequency PLL utilizes ceramic resonator topology to achieve typical phase noise performance of -100 dBc/Hz at 10 kHz offset with a reference spur suppression of -70 dBc. Size: 1" x 1" x 0.22".

Z-Communications Inc.,
San Diego, CA (858) 621-2700,
www.zcomm.com.

Booth 313

LOW NOISE AMPLIFIERS
www.SATELLINK.COM

SATELLINK, INC.
3525 MILLER PARK DR.
GARLAND, TX 75042
CALL (972) 487-1434
FAX (972) 487-1204

MICROWAVE JOURNAL ■ MAY 2011

MICRO-ADS

DI COAX SETUPS

• Std Sizes • Cal Std's • Loading Aids

M07T 1 MHz - 18 GHz, 1000T 1 MHz - 5 GHz
1500T 1 MHz - 3 GHz, 3000T 1MHz - 2 GHz



Model M07T with Platform

μ, ϵ, σ - MuEpsIn™ sfwr

Granular Materials, Liquids, Solids

www.damaskosinc.com

(610)358-0200 fax(610)558-1019

SECTOR MICROWAVE INDUSTRIES, INC.



(631) 242-2300 FAX (631) 242-8158
www.sectormicrowave.com

LASER CUTTING

LASER FAST



Frozen epoxies & absorber materials
in stock.

Westford, MA
978-692-6180
LaserServicesUSA.com

LASER
SERVICES

See us at MTT-S Booth 2123

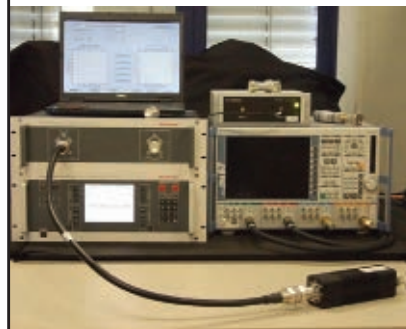


First Vector PIM-Measurement Place

Heuermann together with Rosenberger presents the first measurement set-up to fulfill cost-efficient and accurate PIM-tests including the measurement to the distance of the IM-obstacle. Infos at booth 1411.

www.hhft.de
info@hhft.de

Phone: +49 2408 9379019
FAX: +49 2408 9379952



Value.....



What gives our switches value?

We provide more features as a standard. More than any other switch provider out there. While the other guys are charging you extra for so called "options", we include them in all our switches. Things like 4 indicating contacts, 100% sealed & flanges are all standard on our units. Come see why AST is the most reliable and affordable switch on the market

AST Advanced
Switch
Technology

www.astswitch.com

PUSH-ON SMA & N Adapters

PUSH-ON SMA Cable Assemblies

Custom Connector



RFTEC
Since 1993

www.rftec.com



Classic Works in RF Engineering, Volume 2: Microwave and RF Filters

Ralph Levy

With this month's cover feature about the rich history of RF and microwave filter companies in the Mid-Atlantic region of the country, we review a classic book on filters. The purpose of *Classic Works in RF Engineering, Volume 2: Microwave and RF Filters* is to present the reader with a selection of the many papers on RF and microwave filters that is most relevant to the requirements that exist today. Papers that were superseded by later work or were considered too complicated were not included. The object therefore is to present the reader with a comprehensive overview of the subject equivalent to that of a textbook

on filter theory and realization. The book starts with the classic paper by Seymour Cohn on direct-coupled-resonator filters and proceeds to cover many types of filters and applications.

This highly practical book is a comprehensive resource on RF and microwave filter theory, design, analysis and applications. It contains 50 classic papers from the 1950s to 2007 on critical topics in the field—from aperture-coupled filters to Zolotarev low pass filters and everything in between. The book includes design procedures, formulas, examples and performance data to help tackle challenging projects without having to research the complete body of literature.

Including insightful introductions to each chapter of papers from Leading Authority and Editor, Ralph Levy, each paper brings definitive project-ready guidance, including theoretical background, applications, selection criteria, design steps, calculations, examples, and input on filter components like capacitors, resistors

and inductors. The book includes over 100 diagrams and schematics that help clarify the material at every stage, along with a wealth of problem-solving tips from the top innovators in the field. Whether one needs details on combline, resonator, waveguide, or bandstop filters, this unique volume saves countless hours searching the literature. It is recommended as a great overview and resource on filter technology and applications.

To order this book, contact:

Artech House
685 Canton St., Norwood, MA 02062
800-225-9977;
or
16 Sussex St., London SW1V 4RW, UK
+44 (0) 20 7596-8750
418 pages; \$139, £92
ISBN: 978-1-59693-212-8



ARTECH HOUSE

The Newest, Practical Resources for RF & Microwave Engineers



Klystrons, Traveling Wave Tubes, Magnetrons, Crossed-Field Amplifiers, and Gyrotrons

A.S. Gilmour, Jr.
Hardcover. 882 pp.
ISBN: 978-1-60807-184-5
\$159/£109



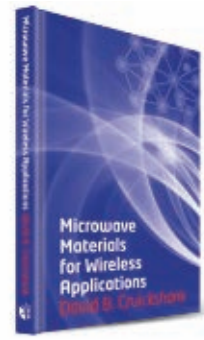
Q Factor Measurements Using MATLAB®

Darko Kajfez
DVD/Spiral-Bound User's Guide.
190 pp. 2011
ISBN: 978-1-60807-161-6
\$249/£159



Introduction to RF Design Using EM Simulators

Hiroaki Kogure, Yoshie Kogure, and James Rautio
Hardcover. 310 pp. 2011
ISBN: 978-1-60807-155-5
\$109/£75



Microwave Materials for Wireless Applications

David B. Cruickshank
Hardcover. 248 pp. 2011
ISBN: 978-1-60807-092-3
\$99/£66

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.



ARTECH HOUSE BOSTON | LONDON

685 Canton Street, Norwood, MA 02062 USA
16 Sussex Street, London SW1V 4RW UK

eLEARNING center

May Short Course Webinars

RF/Microwave Training Series

Presented by Besser Associates

Mixers and Frequency Converters

The mixer uses the signal from a local oscillator to convert an incoming RF signal to an intermediate frequency for baseband processing of the transmitted data. This webinar looks at various mixer types, design considerations and key specifications such as conversion loss, isolation, noise figure and spurious outputs.

Live webcast: 5/17/11. 11:00 AM EDT

Sponsored by Mini-Circuits

Innovations in EDA Series

Presented by Agilent Technologies

Direct Filter Synthesis for Customized Response

This webcast looks at direct filter synthesis derived from user-specified input. Direct synthesis eliminates reliance on optimization, which often leads to unnecessarily complex filter topologies with sub-optimal performance.

Available for on demand viewing after 5/5/11

Sponsored by Agilent Technologies

**Register to attend at
mwjournal.com/webinars**

Technical Education Series

Presented by COMSOL

RF and Microwave Heating

This webinar is meant for anyone interested in simulation of RF and microwave heating in antennas, circuit boards, living tissue, or any device that has a combination of lossy dielectric and metallic domains.

Live webcast: 5/19/11. 2:00 PM EDT

Sponsored by COMSOL

Special Event Web Simulcast:

MTT-S IMS MicroApps

Nonlinear Characterization Expert Forum

June 8, 2011. 12:00 - 1:30 pm

This live forum and webcast, featuring experts in RF nonlinear device measurement and characterization explores the trends in nonlinear device characterization from the perspective of new measurement equipment, techniques and device representation in EDA tools. An open panel discussion session will follow the presentations including audience questions from both live and online participants.

To view live webcast online, register at:

www.mwjournal.com/ims_2011_microapps_experts

Past Webinars On Demand

RF/Microwave Training Series

Presented by Besser Associates

- Electrically Small Antennas
- RF Oscillators
- RF Power Amplifiers - Digital Pre-distortion Techniques

Innovations in EDA Series

Presented by Agilent EESof EDA

- Opto-Electronic Signal Integrity on Optical Fiber Chip-to-Chip Links
- Multi-Technology RF Design Using the New Advances in ADS 2011
- Memory Effects in RF Circuits: Manifestations and Simulation
- X-Parameter Case Study: GaN High Power Amplifier (HPA) Design

Innovations in RF Test Series

Presented by Agilent Technologies

- Use Capture, Playback & Triggering to Completely Analyze a Signal
- See the Future of Arbitrary Waveform Generators
- Three Steps to Successful Modulation Analysis with a Vector Signal Analyzer

Market Research Series

Presented by Strategy Analytics

- Fundamentals and Applications of AESA Radar
- MilSatcom Electronic Market Trends Through 2020

Technical Education Series

- LNA design and characterization using modern RF/microwave software together with T&M instrument

Sponsored and Presented by AWR Corp. and Rohde & Schwarz

- Make Your LTE Call Now!

Sponsored and Presented by Rohde & Schwarz

- GaAs LNA Design Trade-offs in the Working World

Sponsored and Presented by Freescale Semiconductor

- Transient FEM solvers and Hybrid FE/IE Methods in HFSS 13

Sponsored and Presented by Ansoft (ANSYS Product Portfolio)

- Integrating Simulation Technology in CST Studio 2011

Sponsored and Presented by CST

- Creating Real-World EM Simulations

Sponsored and Presented by COMSOL



See us at MTT-S Booth 3414



Frequency Matters.

ADVERTISER	PAGE No.	ADVERTISER	PAGE No.
Active Spectrum, Inc.	260	Fairview Microwave	237
AdTech Ceramics	72	Florida RF Labs Inc.	137
Advanced Switch Technology	281,283	Frontlynk Technologies Inc.	200
Aeroflex / Control Components	71	G.T. Microwave Inc.	150
Aeroflex / Inmet, Inc.	190	Greenray Industries, Inc.	52
Aeroflex / Metelics, Inc.	9,263	Herley Industries, Inc.	40
Aeroflex / Plainview	239	Herotek, Inc.	162
Aeroflex / Weinschel, Inc.	15	Heuermann HF-Technik GmbH	283
Aerowave Inc.	243	Hittite Microwave Corporation	161,163,165,167
Aethercomm	73	Holzworth Instrumentation	58,112
Agilent Technologies, Inc.	25,65,130, 131,133,193	Huber + Suhner AG	191
Akon, Inc.	116	IEEE Comcas 2011	256
American Microwave Corporation	156	IEEE International Symposium on Electromagnetic Compatibility	289
American Technical Ceramics	145	IEEE MTT-S International Microwave Symposium	275
AML Communications Inc.	205	IMST GmbH	202
Anadigics	210	Insulated Wire Inc.	93
Analog Devices	89	Integrated Engineering Software	236
AnaPico AG	240	International Manufacturing Services, Inc.	68
Anaren Microwave	148,149,157	ITT Microwave Systems	100
Anatech Electronics, Inc.	249	JFW Industries, Inc.	95
Ansys, Inc.	37	K&L Microwave, Inc.	7
Antenna Research Associates	140	KR Electronics, Inc.	281
AR RF/Microwave Instrumentation	59	Krytar	134
ARC Technologies, Inc.	223	Laser Services	281,283
Artech House	284	Linear Technology Corporation	109
Auriga Microwave	96-97	Lorch Microwave	57
Avtech Electrosystems	281	LPKF Laser & Electronics	54
AWR	11	Luff Research, Inc.	212
B&Z Technologies, LLC	35	M/A-COM Technology Solutions	46,47,48, 49,50,51
Carlisle Interconnect Technologies	13	M2 Global Technology, Ltd.	214
Cernex, Inc.	253	Massachusetts Bay Technologies, Inc.	139
Channel Microwave Corporation	20	Maury Microwave Corporation	147,226
Charter Engineering, Inc.	180	MECA Electronics, Inc.	6
Ciao Wireless, Inc.	98	Mercury Computer Systems	172
Cobham Defense Electronic Systems	67	MIcable Inc.	227
Coilcraft	17	MiCIAN GmbH	136
Coleman Microwave Company	174	Micro Lambda Wireless, Inc.	173
COMSOL, Inc.	33	Micro-Coax Components	219
Comtech PST Corp.	44	MicroTech Inc.	233
CPI Beverly Microwave Division	77	Microtool, Inc.	114
Crane Aerospace & Electronics	234	Microwave Development Laboratories	85
Crystek Corporation	179	Microwave Journal	250,269,277, 280,285
CST of America, Inc.	31	Millitech	122
CTT Inc.	86-87	Mini-Circuits	4-5,18,39,105, 106,123,151, 175,187,201, 229,259,287
Cuming Microwave Corporation	241	MITEQ Inc.	3,55,129, 235,261
Damaskos Inc.	283	Modco, Inc.	281
dBm, LLC	154	Modpak, Inc.	281
Delta Electronics Mfg. Corp.	153	Narda Microwave-East, an L3 Communications Co.	101
Dielectric Laboratories Inc.	169	Networks International Corporation	177
Ducommun Technologies	53,75	Nexyn Corporation	166
Dynawave Incorporated	221	Noisecom	COV 2
East Coast Microwave	120	NoiseWave Corp.	8
Eastern Wireless TeleComm, Inc.	22-23	Norden Millimeter Inc.	128
Elektrobit Inc.	164	OML Inc.	231
Elektrobit Ltd.	104	OMMIC	244
EM Research, Inc.	155	Paciwave, Inc.	194
Emblation Microwave	138	Pascall Electronics Limited	176
EMC Technology Inc.	137	Phase Matrix, Inc.	92
Emerson & Cuming Microwave Products	281	Pico Technology	266
Emerson Network Power	203	Pivotone Communication Technologies, Inc.	43
Empower RF Systems, Inc.	189		
Endwave	26		
ES Microwave, LLC	210		
ESM Cable Corporation	228		
ET Industries	126,160,208		
EuMW 2011	273,279		



VERY LOW DISTORTION **MIXERS**

+36dBm IP3 2 to 3100 MHz from **\$9⁹⁵ea.** qty. 1000

Mini-Circuits shielded LAVI frequency mixers deliver the breakthrough combination of very high IP3 and IP2, ultra-wideband operation, and outstanding electrical performance. By combining our advanced ceramic, core & wire, and semi-conductor technologies, we've created these evolutionary patented broadband mixers that are specially designed to help improve overall dynamic range.

With a wide selection of models, you'll find a LAVI mixer optimized for your down converter and up converter requirements. Visit the Mini-Circuits website at www.minicircuits.com for comprehensive performance data, circuit layouts, and environmental specifications. Price & availability for on-line ordering is provided for your convenience.

Check these LAVI Mixer outstanding features!

- Very wide band, 2 to 3100 MHz
- Ultra high IP2 (+60 dBm) and IP3 (+36 dBm)
- -73 dBc harmonic rejection 2LO-2RF, 2RF-LO
- Super high isolation, up to 52 dB
- High 1dB compression, up to +23 dBm
- Extremely low conversion loss, from 6.3 dB

 RoHS compliant U.S. Patent Number 6,807,407

Mini-Circuits...Your partners for success since 1969



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



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

IF/RF MICROWAVE COMPONENTS

See us at MTT-S Booth 1031

451 Rev G

ADVERTISER	PAGE No.	ADVERTISER	PAGE No.
PLANAR LLC	281	Spinner GmbH	232
Planar Monolithic Industries, Inc.	197	Stanford Research Systems	184
Programmed Test Sources, Inc.	COV 3	State of the Art, Inc.	42
Pulsar Microwave Corporation	192	Strand Marketing, Inc.	282
Quest Microwave Inc.	216	Sumitomo Electric USA Inc.	102
QuinStar Technology, Inc.	217	SV Microwave, Inc.	69
R&K Company Limited	250	Swift & Associates	213
Radio Frequency Systems	108	Syfer	118
Rakon Ltd.	268	Synergy Microwave Corporation	111,245
Reactel, Incorporated	80	Taconic	76
RelComm Technologies, Inc.	195	Tecdia, Inc.	152,220
Remcom	141	Tektronix Component Solutions	115
Renaissance Electronics Corporation	170	Teledyne Coax Switches	225
Res-Net Microwave Inc.	251	Teledyne Cougar	196
RF Cable Assembly, Division of RF Industries	114	Teledyne Relays	225
RF TEC Mfg., Inc.	283	Teledyne Storm Products	117
RFHIC	32,34,36	Thunderline-Z	209
RFMD	41	Times Microwave Systems	135
Richardson RFPD Inc.	121	TRAK Microwave Corporation	94
RLC Electronics, Inc.	29	TriQuint Semiconductor, Inc.	61
Rogers Corporation	79	Tru Corporation	143
Rohde & Schwarz GmbH	27,63,199,257	T-Tech, Inc.	118
Rosenberger	125	Universal Microwave Components Corporation	218
RT Logic	171	UTE Microwave Inc.	91
Santron Inc.	119	Valpey Fisher Corporation	38,204
Satellink, Inc.	283	Vaunix Technology Corporation	252
Sector Microwave Industries, Inc.	283	VectraWave S.A.	281
SemiGen	90	Vectron International	181
SGMC Microwave	255	Voltronics Corporation	207
Shenzhen Yulongtong Electron Co., Ltd.	242	W.L. Gore & Associates, Inc.	270,271
Sivers IMA AB	142,264	Waveline Inc.	248
Skyworks Solutions, Inc.	113	Wavetronix, Inc.	251
SLN Advertising	278	Weinschel Associates	68,211
Sonnet Software, Inc.	21	Wenzel Associates, Inc.	159
Southwest Microwave Inc.	215	Werlatone, Inc.	COV 4
Spacek Labs Inc.	265	West Bond Inc.	254
Special Hermetic Products, Inc.	178	Win Semiconductors Corp.	45,127,
Spectracom	198		247,267
Spectrum Advanced Specialty Products	72	Wright Technologies	186
Spectrum Elektrotechnik GmbH	185	X-COM Systems	144
Spinnaker Microwave, Inc.	224	Z-Communications, Inc.	183



COMING IN JUNE:
SEMICONDUCTORS/MMICs/RFICS

- **SUCH GREAT HEIGHTS – THE INNER WORKINGS OF AN RFIC POWERHOUSE**
- **RF SOI SOLUTIONS AS A PLATFORM FOR WIRELESS FRONT-END APPLICATIONS**
- **MMIC INTEGRATION AND INTERCONNECTS**

SALES REPRESENTATIVES

CARL SHEFFRES, PUBLISHER

Eastern and Central Time Zones
Chuck Boyd
Northeast Reg. Sales Mgr.
(New England, Upstate NY, Eastern Canada)
685 Canton Street
Norwood, MA 02062
Tel: (781) 769-9750
FAX: (781) 769-5037
cboyd@mwjournal.com

Michael Hallman
Eastern Reg. Sales Mgr.
(Mid-Atlantic, Southeast, Midwest)
4 Valley View Court
Middletown, MD 21769
Tel: (301) 371-8830
FAX: (301) 371-8832
mhallman@mwjournal.com

ED KIESSLING, TRAFFIC MANAGER

Pacific and Mountain Time Zones
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
Katsuhiko Ishii
Ace Media Service Inc.
12-6, 4-Chome,
Nishiiko, Adachi-Ku
Tokyo 121-0824, Japan
Tel: +81 3 5691 3335
FAX: +81 3 5691 3336
amskatsu@dream.com

China
Michael Tsui
ACT International
Tel: 86-755-25988571
Tel: 86-21-62511200
FAX: 86-10-58607751
michaelT@actintl.com.hk

Hong Kong
Mark Mak
ACT International
Tel: 852-28386298
markm@actintl.com.hk



Frequency Matters.

2011 IEEE International Symposium on Electromagnetic Compatibility

August 14-19, 2011 • Long Beach Convention Center

CALIFORNIA

Benefits of Attending:

- Top-rated, peer-reviewed technical paper sessions
- Special and invited paper sessions
- Workshops and tutorials
- Demonstrations and experiments
- Global EMC University—tutorials with CEUs
- Exhibitors showcasing the latest EMC products and services
- Fun, imaginative, entertaining social events
- Adjacent modern hotel and exhibit facilities - no shuttles, cab rides or long walks
- Close to a wide variety of great tour attractions



EMC
SOCIETY®



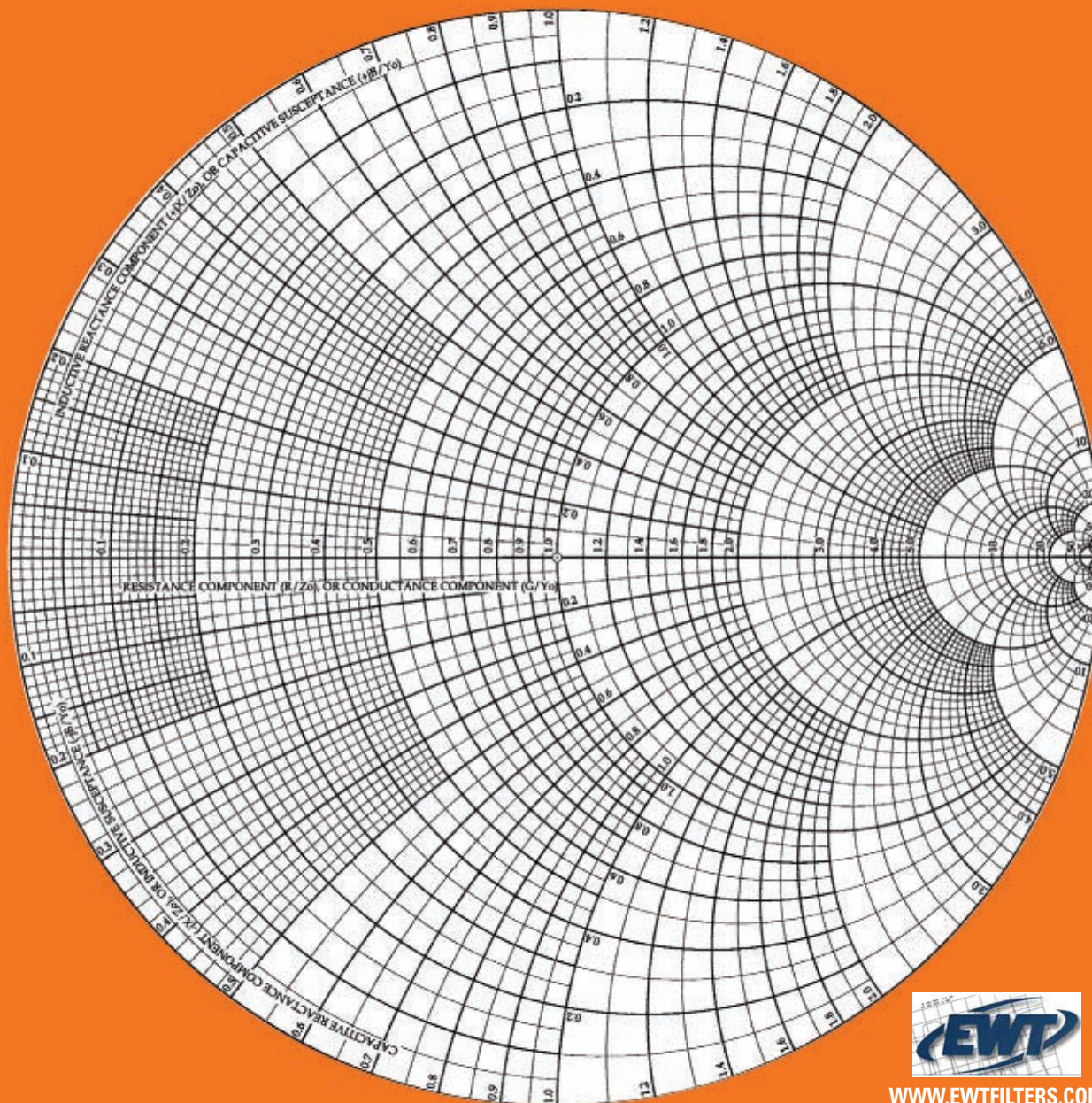
IEEE

www.emc2011.org



CONNECT THESE IMPEDANCE POINTS AND DO BE PATIENT
TO GET A GLIMPSE OF BALTIMORE'S FAVORITE _____

ANSWER AVAILABLE ONLINE AT WWW.MWJOURNAL.COM



WWW.EWTFILTERS.COM

- | | | | | | |
|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| 1. $1.00 + j0.25$ | 11. $0.34 + j0.25$ | 21. $0.38 - j0.24$ | 31. $0.65 - j0.85$ | 41. $2.20 - j2.00$ | 51. $2.20 + j1.00$ |
| 2. $0.65 + j0.15$ | 12. $0.32 + j0.06$ | 22. $0.24 - j0.32$ | 32. $1.20 - j1.10$ | 42. $2.00 - j0.90$ | 52. $1.40 + j1.10$ |
| 3. $0.50 + j0.05$ | 13. $0.40 - j0.05$ | 23. $0.10 - j0.42$ | 33. $1.10 - j1.60$ | 43. $2.20 - j0.60$ | 53. $1.20 + j1.30$ |
| 4. $0.40 + j0.10$ | 14. $0.40 - j0.10$ | 24. $0.24 - j0.36$ | 34. $0.80 - j1.90$ | 44. $3.00 - j1.40$ | 54. $0.60 + j0.90$ |
| 5. $0.40 + j0.25$ | 15. $0.20 - j0.12$ | 25. $0.40 - j0.32$ | 35. $1.30 - j1.70$ | 45. $2.40 - j2.80$ | 55. $1.00 + j0.85$ |
| 6. $0.50 + j0.30$ | 16. $0.15 - j0.22$ | 26. $0.40 - j0.46$ | 36. $1.40 - j1.10$ | 46. $1.00 - j3.20$ | 56. $0.65 + j0.75$ |
| 7. $0.55 + j0.60$ | 17. $0.08 - j0.32$ | 27. $0.26 - j0.50$ | 37. $1.70 - j1.10$ | 47. $3.40 - j3.00$ | 57. $1.10 + j0.60$ |
| 8. $0.42 + j0.40$ | 18. $0.18 - j0.24$ | 28. $0.20 - j0.65$ | 38. $1.80 - j1.50$ | 48. $3.60 - j1.00$ | 58. $1.30 + j0.80$ |
| 9. $0.40 + j0.60$ | 19. $0.25 - j0.18$ | 29. $0.30 - j0.55$ | 39. $1.70 - j2.00$ | 49. $2.20 - j0.20$ | 59. $1.80 + j0.80$ |
| 10. $0.30 + j0.35$ | 20. $0.36 - j0.18$ | 30. $0.45 - j0.55$ | 40. $1.00 - j2.60$ | 50. $2.00 + j0.20$ | 60. $1.60 + j0.30$ |

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 μ s frequency
switching broadband

↑
at a
reasonable
cost



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

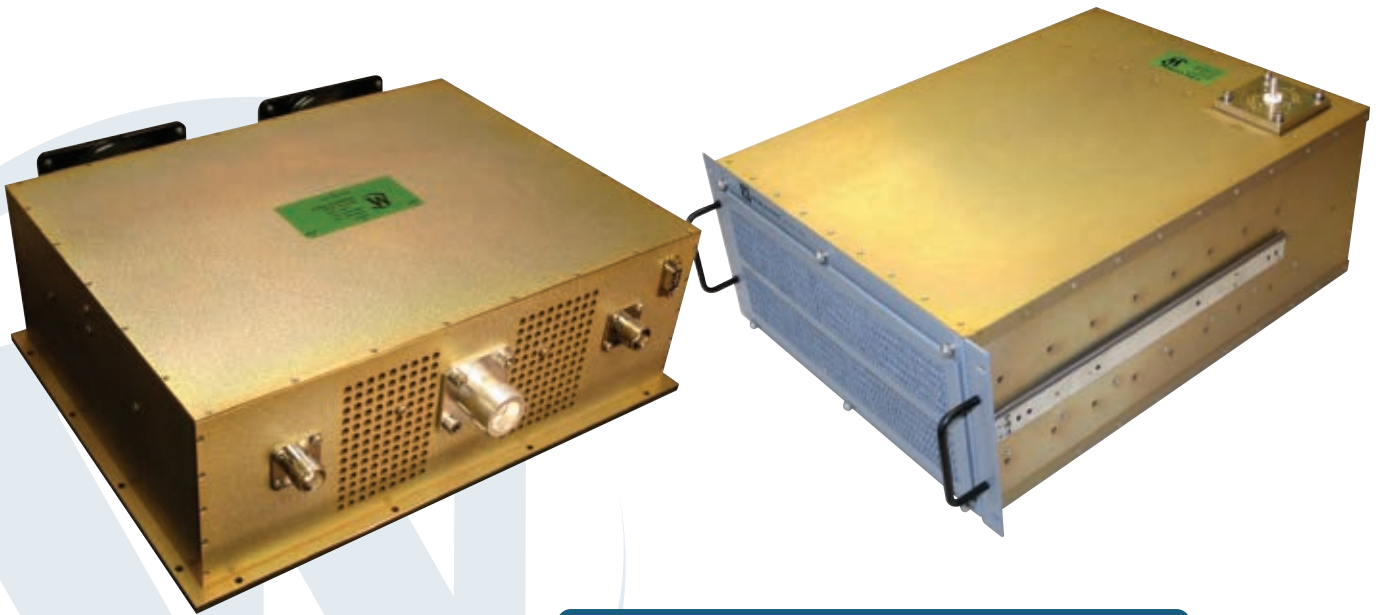
PTS
FREQUENCY SYNTHESIZERS

Mismatch Tolerant®

HIGH POWER COMBINERS

BIG STUFF!

- Power Levels to 20 kW CW
- Low Insertion Loss
- Isolated and Non-Isolated Designs
- Rack Mount, Drawer Mount, Radial Type
- Coherent and Non-Coherent Combining



Product Search

For current designs

Request a quote

For custom specs

Werlatone, Inc.
17 Jon Barrett Road
Patterson, New York 12563
T 845.278.2220
F 845.278.3440
sales@werlatone.com
www.werlatone.com
See us at MTT-S Booth 3402

A few of our Customer driven designs.

Model	Type	Frequency (MHz)	Power (W CW)	Insertion Loss (dB)	VSWR	Isolation (dB)	Size (Inches)
D8265	2-Way	1-50	5,000	0.3	1.25	20	15.5 x 15 x 5.25
D2075	2-Way	1.5-30	6,000	0.2	1.25	20	15.5 x 11.75 x 5.25
D8969	2-Way	1.5-30	12,500	0.2	1.25	20	17 x 17 x 8
D6139	4-Way	1.5-32	5,000	0.25	1.25	20	13 x 11 x 5
D6774	4-Way	1.5-32	20,000	0.3	1.20	20	21 x 17.25 x 11
D6846	6-Way	1.5-30	4,000	0.35	1.35	20	3 U, 19" Rack
D8421	8-Way	1.5-30	12,000	0.3	1.30	20	22.5 x 19.5 x 8.75
D7685	4-Way	2-100	2,500	0.5	1.30	20	14.75 x 13 x 7
D2786	4-Way	20-150	4,000	0.5	1.35	20	18 x 17 x 5
D6078	2-Way	100-500	2,000	0.25	1.20	20	13 x 7 x 2.25
H7521	2-Way (180°)	200-400	2,500	0.3	1.30	20	15 x 10 x 2
D7502	2-Way	400-1000	2,500	0.25	1.20	NI*	9.38 x 3.5 x 1.25

*NI+No Isolating Terminations

Our Patented, Low Loss Combiner designs tolerate high unbalanced input powers, while operating into severe Load Mismatch conditions.

Semiconductors

First Response

Medical

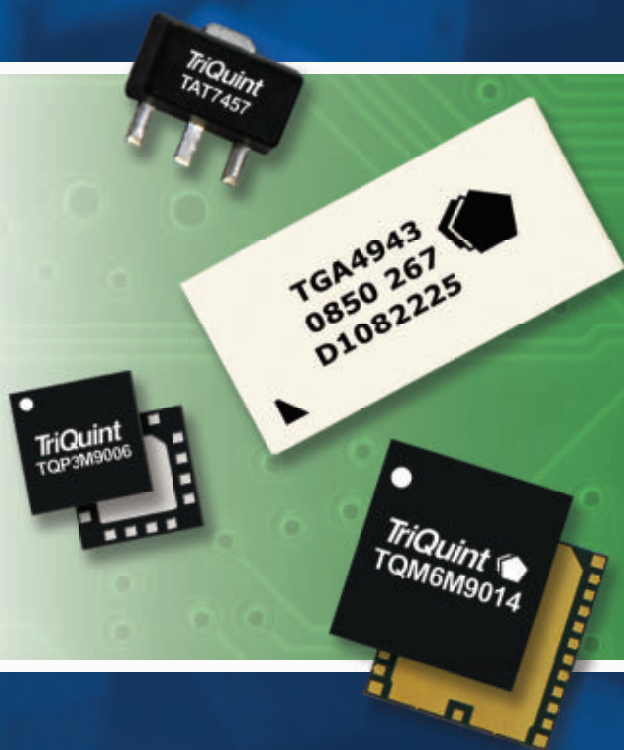
In-Building

Military Comm and EW



Military & More

Product Selection Guide



**Choose TriQuint's
Innovative RF Solutions**



*Connecting the Digital World
to the Global Network®*

TriQuint 
SEMICONDUCTOR

Welcome to Our Product Selection Guide

Table of Contents

ABOUT TRIQUINT SEMICONDUCTOR	3
GUIDE BY MARKET	
Automotive	4
Base Station.....	5
BWA / WiMAX / LTE.....	9
Cable	10
Defense & Aerospace	12
Mobile Devices	12
Optical	16
PiP Radio	17
RFID	21
Space.....	21
VSAT	23
GUIDE BY PRODUCT TYPE	
Amplifiers	
Up to 1W	24
1W to 4W	25
More than 4W.....	26
Variable Gain	27
Gain Block.....	27
Low Noise	28
Discrete Transistors	28
Control Products	
Frequency Converters & Mixers	29
Signal Conditioning	30
Switches.....	31
Protectors	31
Filters	
SAW.....	31
BAW	36
Integrated Products.....	36
Optical Components	39
PRODUCTS BY FREQUENCY	40
CUSTOMER SUPPORT.....	43

This guide contains a subset of the total selection of products available from TriQuint. If you are unable to locate the product you need, please contact your local sales representative or the factory for more information.

Welcome to TriQuint Semiconductor's 2011-12 Product Selection Guide. Our guide lists over 600 standard products - we also highlight 48 new releases and four new space-qualified products. TriQuint products are organized both by key market applications and product types. We've also included block diagrams with color coding to indicate where TriQuint product solutions exist.



We invite you to visit our website at **www.triquint.com** to obtain full product specifications and to utilize our block diagrams which make it easy to drill down to specific products. TriQuint's Tech Connect page, **www.triquint.com/techconnect**, offers additional ways to simplify RF connectivity through a growing collection of technical resources for key applications. While visiting our website, click on 'subscribe' to receive TriQuint's quarterly e-newsletter and new product announcements.

TriQuint products are available through our worldwide sales, representative and distribution networks. Visit triquint.com/sales to connect with members of TriQuint's extended sales network serving your market.



About TriQuint Semiconductor

TriQuint Semiconductor
'Connects the Digital World
to the Global Network®'
through our wide selection
of innovative RF solutions.

We design, develop and manufacture advanced, high-performance RF solutions with Gallium Arsenide (GaAs), Gallium Nitride (GaN), Surface Acoustic Wave (SAW) and Bulk Acoustic Wave (BAW) technologies. Our product portfolio of active and acoustic technologies serves mobile device, 3G / 4G base station, microwave, optical, CATV / FTTH, WLAN and defense / aerospace applications.



RF products serving start-up firms as well as the world's largest, most well-established companies. We also support the need for custom solutions through the industry's widest selection of foundry processes based on GaAs and GaN technologies.

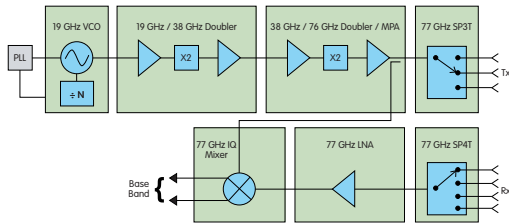
Growth throughout 2010 and 2011 has led to capacity expansion at all three US manufacturing facilities as well as our San Jose Design Center. These expansions will further equip us to meet today's product demands while we position TriQuint to serve the growing needs of wireless manufacturers around the world.



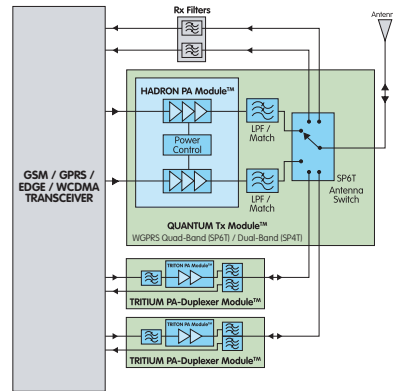
TriQuint solutions, designed and crafted with the industry's largest in-house technology portfolio, enable quicker design turns while lowering overall system costs. We are an award-winning provider of innovative

Key advantages of GaAs, GaN, SAW and BAW technologies:

- GaAs can operate efficiently at higher breakdown voltages compared to silicon-based semiconductor technologies while generating less noise in frequencies in excess of 250 MHz. GaAs offers high efficiency, linearity and good wideband performance.
- GaN offers greater power handling and density than GaAs beginning at 20 MHz. Intrinsic GaN technology advantages enables performance at a given power level using fewer or smaller devices. GaN offers strong linearity and efficiency, plus greater wideband capability.
- SAW filter technology offers excellent performance and economy through 2.5 GHz. We are growing our SAW capacity to include an array of temperature-compensated SAW products that will expand this versatile technology's capabilities for new and emerging applications.
- BAW filters offer superior loss levels, stronger ESD performance and greater resistance to temperature effects from 2.5 to 6 GHz. BAW is ideal for challenging applications including co-existence filter requirements.



Example of a 77 GHz Radar Front-End



**Cellular & GPS
Transceiver for
Auto Telematics**

Amplifiers & Low Noise Amplifiers

Description	Frequency Range (GHz)	Psat (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
77 GHz LNA	72 - 80	5	20	5	3.5 / 54	Die	TGA4705-FC
77 GHz MPA	76 - 80	14	12	—	3.5 / 75	Die	TGA4706-FC

Switches

Description	Frequency Range (GHz)	Insertion Loss	Isolation (dB)	P1dB (dBm)	Control Voltage (V)	Package Style	Part Number
SP3T	60 - 90	2.3	20	>-13	-5 / 1.35	Die	TGS4305-FC
SP4T	70 - 90	3	20	>-8	-5 / 1.35	Die	TGS4306-FC

Frequency Converters & Mixers

Description	RF Frequency Range (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	Psat (dBm)	Voltage / Current (V / mA)	Package Style	Part Number
19 GHz VCO w/8:1 Prescaler	18.5 - 19.5	—	-105**	7.0	5 / 158	Die	TGV2204-FC
19 / 38 GHz Converter / MPA	36 - 40	9	—	14.5	3.5 / 65	Die	TGC4703-FC
38 / 77 GHz Converter / MPA	76 - 77	6	—	15.0	4 / 230	Die	TGC4704-FC
77 GHz Down Converting I/Q Mixer	75 - 82	-13.5	22	—	1.1 / 7	Die	TGC4702-FC

NOTES: ** = Phase Noise (dBc / Hz @ 1 MHz Offset)

Integrated Products

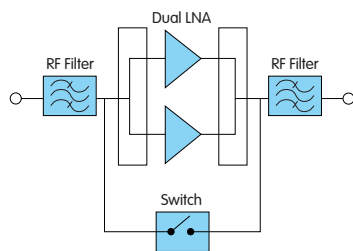
Description	Frequency Bands	Features	Package Size (mm)	Part Number
QB GSM / GPRS Tx Module; PA / LPF / SP6T Switch	GSM850 / 900, DCS / PCS	High System Efficiency & Small Size	6x6x1.1	TQM6M4003
QB GSM / GPRS / EDGE-Polar PA Module	GSM850 / 900, DCS / PCS	-90 dBm Typ Rx Noise, +3 to +8 dBm Pin Nominal	5x5x1	TQM7M5012
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 1	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM767021
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 2	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM666022
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Bands 5 and 6	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM616025
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 8	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM626028L
Quad-Band GSM / GPRS / EDGE-Linear TRP Tx Module: PA / LPF / SP8T WEDGE Switch w/ Quad-Band WCDMA Antenna Pass-Through	GSM850 / 900, DCS / PCS & WCDMA B1, B2, B5 / 6, B8	Integrated QB GSM / GPRS / EDGE PA & Antenna Switch Supporting WCDMA TRP Compliant at 4:1 Mismatch	7x7.5x1.1	TQM6M9014

Filters & Duplexers

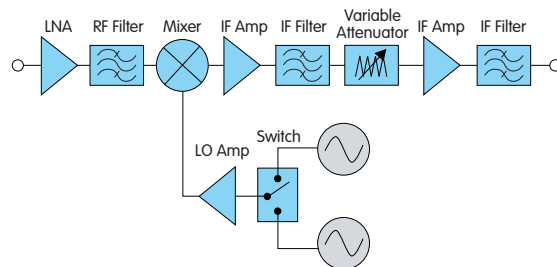
Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
Duplexer, Cell Band	836.5 / 881.5	25 / 25	1.9 / 1.9	SE / SE	–	3.8x3.8	856356
CDMA 2-in-1 Rx Filter	881.5 / 1960	25 / 60	1.6 / 2.2	SE / BAL	–	2x1.5	856565
GPS RF Filter	1575.42	2	1.25	SE / SE	30 @ 1624	2x1.5	856584
GPS RF Filter	1575.42	2	0.75	SE / SE	35 @ 1635	1.4x1.2	856561
GPS RF Filter	1575.42	2	1.1	SE / BAL	20 @ 1635	1.4x1.2	856576
GPS RF Filter, Auto	1575.42	2	1.8	SE / SE	45 @ 1637	3x3	856039
GPS RF Filter, Auto	1575.42	2	1.3	SE / SE	45 @ 1640	3x3	856139
SDARS Filter	2332.5	45	1.7	SE / BAL	35 @ 2100	1.4x1.2	856604
GPS / SDARS Diplexer	1575.42 / 2332.5	3 / 25	0.6 / .08	SE / SE	GPS Port: 40 @ 2332 SDARS Port: 31 @ 1572	3x3	TQM2M9016*

NOTES: * = New

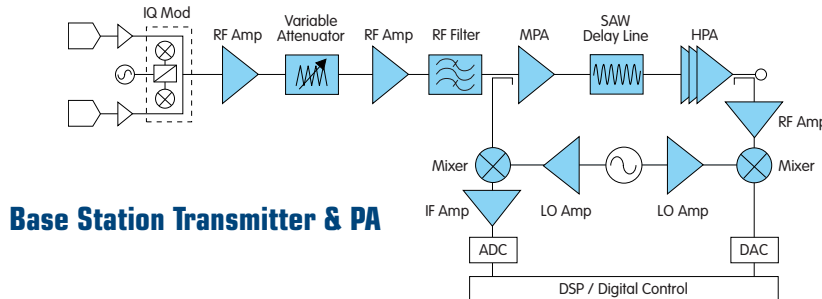
GUIDE BY MARKET | Base Station



Tower Mounted LNA



Base Station Receiver (Single Branch Shown)



Base Station Transmitter & PA

General Purpose Amplifiers

Description	Frequency Range (MHz)	P1dB / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
General Purpose Gain Block	DC - 3000	18.5 / 33	16.5	3.8	6 / 75	SOT89	AG603
General Purpose Gain Block	DC - 3500	18.5 / 33	13.6	4.4	6 / 75	SOT89	AG602
General Purpose Gain Block	DC - 3500	20.5 / 33.5	17.2	3.5	7 / 96	SOT89	EC1078
General Purpose Gain Block	DC - 4000	19.5 / 31	18.5	2.9	6 / 70	SOT89	EC1019
General Purpose Gain Block	DC - 4000	17.5 / 32	21.5	3.4	6 / 65	SOT89	ECG005
General Purpose Gain Block	DC - 4000	23.5 / 37	14.3	4.6	9 / 120	SOT89	ECG008
General Purpose Gain Block	DC - 4000	18 / 34.5	15.3	5.5	6 / 70	SOT89	ECG040
General Purpose Gain Block	DC - 5500	15 / 30	14.2	3.7	5 / 45	SOT86 / SOT363 / SOT89	ECG006
General Purpose Gain Block	DC - 6000	5.8 / 18.5	11	4.4	5 / 20	SOT86 / SOT363	AG201
General Purpose Gain Block	DC - 6000	7.5 / 19.5	17.7	3.1	5 / 20	SOT86 / SOT363	AG203
General Purpose Gain Block	DC - 6000	12 / 25	14.3	3.2	5 / 35	SOT86 / SOT363	AG302
General Purpose Gain Block	DC - 6000	12.5 / 25	18.4	3	5 / 35	SOT86 / SOT363	AG303
General Purpose Gain Block	DC - 6000	16 / 28.5	14.5	3.7	6 / 60	SOT86 / SOT89	AG402
General Purpose Gain Block	DC - 6000	16 / 28	18.9	3	6 / 60	SOT86 / SOT89	AG403
General Purpose Gain Block	DC - 6000	14.5 / 27.5	19.1	2.9	6 / 45	SOT86 / SOT89	AG503

General Purpose Amplifiers (cont.)

Description	Frequency Range (MHz)	P1dB / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
General Purpose Gain Block	DC - 6000	19 / 33	18.2	3.5	6 / 75	SOT86 / SOT89	AG604
General Purpose Gain Block	DC - 6000	12.5 / 26	21.4	3.4	5 / 30	SOT363 / SOT89	ECG001
General Purpose Gain Block	DC - 6000	15 / 29	19.5	3.7	5 / 45	SOT86 / SOT363 / SOT89	ECG002
General Purpose Gain Block	DC - 6000	23 / 36	19	3.5	9 / 110	SOT89	ECG003
General Purpose Gain Block	DC - 6000	13 / 27	15.5	3.2	5 / 35	SOT89	ECG004
General Purpose Gain Block	DC - 6000	18 / 32	20.1	3.4	6 / 65	SOT86 / SOT89	ECG055
MESFET IF Gain Block	50 - 870	20 / 41	13	3	5 / 150	SOT89	AH3
MESFET IF Amplifier	50 - 1000	22 / 42	19	2.2	5 / 150	SOT89	AH31
+5V Active Bias IF Gain Block	50 - 1000	20.5 / 44	19.5	5	5 / 95	SOT89	WJA1500
+5V Active Bias IF Gain Block	50 - 1000	19.5 / 36.5	19.3	4.7	5 / 65	SOT89	WJA1505
+5V Active Bias IF Gain Block	50 - 1000	20 / 47	14.4	5.4	5 / 95	SOT89	WJA1510
+5V Active Bias Gain Block	50 - 2300	19 / 36.5	15	5.2	5 / 85	SOT89	WJA1010
+5V Active Bias Gain Block	50 - 3000	20 / 44	19	5.4	5 / 100	SOT89	WJA1001
+5V Active Bias Gain Block	50 - 4000	20 / 40	18.5	5.6	5 / 90	SOT89	WJA1021
+5V Active Bias Gain Block	50 - 4000	19.5 / 37	14.5	5.5	5 / 80	SOT89	WJA1030
E-pHEMT LNA Gain Block	50 - 4000	20 / 37.5	21.5	1.1	5 / 85	SOT89	TQP3M9008
E-pHEMT LNA Gain Block	50 - 4000	21.4 / 37.5	22	1.1	5 / 85	3x3 QFN	TQP3M9018*
E-pHEMT LNA Gain Block	50 - 4000	22 / 40.5	24.7	0.9	5 / 125	SOT89	TQP3M9009
E-pHEMT LNA Gain Block	50 - 4000	22 / 40.5	24.7	0.9	5 / 125	3x3 QFN	TQP3M9019*
E-pHEMT LNA Gain Block	50 - 4000	21.5 / 40	15	2	5 / 85	SOT89	TQP3M9028*
MESFET Gain Block	60 - 3000	15 / 32	14	2.4	4.5 / 50	SOT89	AG101
MESFET Gain Block	60 - 3000	18 / 36	14	2.4	4.5 / 70	SOT89	AG102
MESFET Gain Block	60 - 3000	18 / 39	14	2.4	4.5 / 78	SOT89	AM1
MESFET Dual Amplifier	150 - 3000	24 / 46	12	4.1	5 / 300	SOIC-8	AH11
MESFET Amplifier	250 - 4000	21.5 / 42	14	3.2	5 / 150	SOT89	AH1
E-pHEMT LNA Gain Block	500 - 4000	22 / 35	19	0.8	5 / 55	3x3 QFN	TQP3M9005*
E-pHEMT LNA Gain Block	500 - 4000	22.5 / 38.5	18.5	1	5 / 90	3x3 QFN	TQP3M9006*
E-pHEMT LNA Gain Block	500 - 4000	23.5 / 42	18	1.3	5 / 135	SOT89	TQP3M9007*

NOTES: * = New

High Linearity Driver Amplifiers

Description	Frequency Range (MHz)	P1dB / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
26.5 dBm MESFET Amplifier	50 - 1500	26.5 / 47	13.5	3.5	9 / 200	SOT89	AH101
30 dBm MESFET Amplifier	50 - 2200	30 / 47	17	2.5	11 / 330	6x6 QFN	AH202
24.5 dBm HBT Amplifier	50 - 4000	24.5 / 41.5	21	4.5	5 / 88	SOT89	TQP7M9101*
24 dBm HBT Amplifier	60 - 2500	24 / 40	19	5	5 / 150	SOT89	AH114
27 dBm MESFET Amplifier	60 - 2700	27 / 46	29	2.5	4.5; 9 / 275	SOIC-8	AH103A
24.7 dBm HBT Amplifier	60 - 3500	24.7 / 40	19.5	4	5 / 160	SOT89	AH118
25 dBm HBT Amplifier	60 - 3500	25 / 40	19.5	4.6	5 / 115	SOT89	AH128
27 dBm MESFET Amplifier	350 - 3000	27 / 46	14.5	3.1	9 / 200	SOT89	AH102A
31 dBm HBT Amplifier	400 - 2300	31 / 46	18	7	5 / 450	4x4 QFN	ECP100
31 dBm HBT Amplifier	400 - 2300	31 / 46	18	7	5 / 450	SOIC-8	AH215
33 dBm HBT Amplifier	400 - 2300	33 / 49	18	8	5 / 800	4x4 QFN	ECP200
33 dBm HBT Amplifier	400 - 2300	33 / 49	18	8	5 / 800	SOIC-8	AH312
27.5 dBm HBT Amplifier	400 - 4000	27.5 / 44	21	4	5 / 140	SOT89	TQP7M9102*
28.5 dBm HBT Amplifier	400 - 3600	28.5 / 45	20	4.5	5 / 150	SOT89	AH125
31 dBm HBT Amplifier	400 - 2700	31 / 47	20	5.9	5 / 300	SOIC-8	AH225
33 dBm HBT Amplifier	400 - 2700	33 / 49	19.5	4.6	5 / 500	SOIC-8	AH322
35.5 dBm HBT Amplifier	400 - 2700	35.5 / 50	16	7	5 / 800	4x5 DFN	AH420

NOTES: * = New

High Linearity Driver Amplifiers (cont.)

Description	Frequency Range (MHz)	P1dB / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
33 dBm HBT Amplifier	700 - 2700	33 / 50	27.5	7	5 / 680	5x5 QFN	AH323
39 dBm HBT Amplifier	700 - 2900	39 / -	16.5	8	12 / 300	5x6 DFN	AP561
28 dBm HBT Amplifier	700 - 3800	28 / 42	28.5	2.9	5 / 225	4x4 QFN	TQP8M9013
28.7 dBm HBT Amplifier	800 - 1000	28.7 / 43	17.5	7	5 / 250	SOIC-8	AH116
28.5 dBm HBT Amplifier	1800 - 2300	28.5 / 44	14.5	6	5 / 250	SOIC-8	AH115
30 dBm HBT Amplifier	1800 - 2700	30 / 46	24.6	5.5	5 / 400	SOIC-8 / 4x5 DFN	AH212
39 dBm HBT Amplifier	3300 - 3800	39 / -	11.5	8	12 / 400	5x6 DFN	AP562
33 dBm HBT Amplifier	3300 - 3800	33 / -	25	7.3	5 / 600	5x5 QFN	AH315

Variable Gain Amplifiers

Description	Frequency Range (MHz)	P1dB / OIP3 (dBm)	Gain (dB)	Gain Range (dB)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
Variable Gain Amplifier	50 - 2200	22 / 42	15.5	20	5 / 150	4x4 QFN	VG025
Variable Gain Amplifier	700 - 1000	22 / 40	16	29	5 / 150	6x6 QFN	VG101
Variable Gain Amplifier	700 - 2800	27.5 / 43	29	30	5 / 240	5x5 QFN	TQM8M9074*
Variable Gain Amplifier	1800 - 2700	22 / 39.5	13.5	26.5	5 / 150	6x6 QFN	VG111
Digital Variable Gain Amplifier	1800 - 2700	24.5 / 41.5	31	31.5	5 / 200	6x6 QFN	TQM879006*

NOTES: * = New

Low Noise Amplifiers

Description	Frequency Range (GHz)	P1dB / IIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
LNA, Balanced FET Low Band	700 - 915	- / 13.5	20.5	0.55	4 / 70	4x4 QFN	TQP3M6004
LNA, Discrete Low Band High Linearity	700 - 915	26 / 23.5	16	0.8	5 / 150	SOT89	TGF2021-04-SD
LNA, Balanced FET	800 - 3000	21 / 11	22	0.4	4 / 100	2x2 QFN	TGA2602-SM
LNA, Balanced FET Mid Band	1700 - 2000	- / 14.4	18	0.55	3.5 / 50	4x4 QFN	TQP3M6005*

NOTES: * = New

28V Transistors

Description	Frequency Range (MHz)	P1dB / IMD3 (dBm) / (dBc)	Gain (dB)	Efficiency (%)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
InGaP HBT PA, 1.8W, Ultra High Linearity	800 - 2350	32.5 / -60	15.8	55	28 / 40	5x6 DFN	AP601
InGaP HBT PA, 3.7W, Ultra High Linearity	800 - 2350	35.7 / -62	15.5	55	28 / 80	5x6 DFN	AP602
InGaP HBT PA, 7W Ultra High Linearity	800 - 2350	38.5 / -51	17	53	28 / 160	5x6 DFN	AP603

TriPower™ High Power Transistors

Description	Frequency Range (GHz)	P1dB (Psat)	Gain (dB)	PAE (%)	Voltage / Current (V / mA)	Package Style	Part Number
120W TriPower™ HVHBT Amplifier	2.11 - 2.17	51.1	16.6	64.5	28 / 550	Flanged Screw Down	TG2H214120-FL*
120W TriPower™ HVHBT Amplifier	2.11 - 2.17	51.1	16.6	64.5	28 / 550	Flanged Solder Down	TG2H214120-FS*
220W TriPower™ HVHBT Amplifier	2.11 - 2.17	53.9	16.4	65.4	28 / 600	Flanged Screw Down	TG2H214220-FL*

NOTES: * = New

Control Products

Description	Frequency Range (MHz)	Insertion Loss (dB)	Isolation / Atten Range (dB)	P1dB (dBm)	Control Voltage (V)	Package Style (mm)	Part Number
SP3T Switch	DC - 2000	0.45	28 / -	>36.5	2.6 / 0	3x3 QFN	TQP4M3018
SP3T Switch	DC - 2000	0.6	22 / -	>34.5	2.6 / 0	2x2 QFN	TQP4M3019
Through Line	DC - 6000	0.1	-	-	-	3x3 QFN	TQM4M9073*
6-Bit, Digital Attenuator, Parallel Ctrl	DC - 4000	1.3	- / 31.5	30	5 / 0	4x4 QFN	TQP4M9071

NOTES: * = New

Control Products (cont.)

Description	Frequency Range (MHz)	Insertion Loss (dB)	Isolation / Atten Range (dB)	P1dB (dBm)	Control Voltage (V)	Package Style (mm)	Part Number
6-Bit, Digital Attenuator, Serial Ctrl	DC - 4000	1.3	- / 31.5	30	5 / 0	4x4 QFN	TQP4M9072
SPDT Switch	1000 - 6000	0.6	28 / -	31.5	3 / 0	1.3x2 DFN	TQS5200
DPDT Switch	1000 - 6000	0.8	33 / -	33	3 / 0	3x3 QFN	TQS5202

Frequency Converters & Mixers

Description	RF Frequency Range (MHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Voltage Current (V / mA)	Package Style (mm)	Part Number
WB Mixer, LO	500 - 2500	-5.7	8	24	3 - 6 / 6	MW6	CMY210
WB Mixer, LO, IF	500 - 2500	10	8	9	3 - 6 / 12	SCT598	CMY212
WB Mixer, LO, IF, Low Current	500 - 2500	9.5	10	10	3 - 6 / 8	SCT598	CMY213
Mixer, LO	700 - 1500	-9	17	36	5 / 50	MSOP-8	ML483
Single Branch Converter, RF, LO, IF	800 - 915	22	60	15	5 / 360	6x6 QFN	CV110-1A
Single Branch Converter, RF, LO, IF	800 - 960	22	60	15	5 / 360	6x6 QFN	CV110-3A
Dual Branch Converter, LO, IF	800 - 960	10.5	14	18.5	5 / 390	6x6 QFN	CV210-3A
Mixer, LO	1500 - 3200	-8.5	2	35	5 / 45	MSOP-8	ML485
Single Branch Converter, RF, LO, IF	1700 - 2000	21	45	17	5 / 360	6x6 QFN	CV111-1A
Single Branch Converter, RF, LO, IF	1900 - 2200	21	40	17	5 / 360	6x6 QFN	CV111-3A
Mixer, LO	1900 - 2700	-8.1	9	30	5 / 110	SOIC-8	ML501

NOTES: RF = RF Amplifier, LO = LO Amplifier, IF = IF Amplifier

Discrete Transistors

Description	Frequency Range (MHz)	P1dB / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage Current (V / mA)	Package Style (mm)	Part Number
MESFET	DC - 2500	26.5 / -	11	1.72 / 55	2 - 6 / 350	SOT223	CLY5
MESFET	DC - 3000	23.5 / -	15.5	1.48 / 55	2 - 6 / 180	MW6	CLY2
0.5W HFET	DC - 6000	28 / 40	18	3.2 / -	8 / 100	SOT89	TGF2960-SD
1W HFET	DC - 6000	31 / 43	16	4 / -	8 / 200	SOT89	TGF2961-SD
MESFET	50 - 4000	21 / 42	19	2 / -	5 / 140	SOT89	FH1
MESFET	50 - 4000	18 / 36	19	2 / -	5 / 140	SOT89	FH101
0.5W HFET	50 - 4000	27 / 40	19	2.7 / -	8 / 125	SOT89	FP1189
1W HFET	50 - 4000	30 / 44	18	4.5 / -	8 / 250	SOT89	FP2189
2.5W HFET	50 - 4000	34 / 46	18	3.5 / -	9 / 450	6x6 QFN	FP31QF

RF Filters

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
FRS RF or GPS IF Filter	465	6	1.4	SE / SE	40 @ 445	3x3	856288
RF Filter - Band 12 Uplink	707	18	1.5	SE / SE	9 @ 728	3x3	856884
RF Filter - Band 12 Downlink	737	18	1.8	SE / SE	37 @ 708	3x3	856883
RF Filter - Band 13 Downlink	751.5	11	1.5	SE / SE	40 @ 776	3x3	856794*
RF Filter - Band 13 Uplink	781.5	11	1.5	SE / SE	38 @ 757	3x3	856764
RF Filter - Band 13 Uplink	782	10	1.52	SE / SE	15 @ 765	3x3	856844
RF Filter - Band 5 Uplink	836.5	25	2.7	SE / SE	28 @ 869	3x3	855729
RF Filter - Band 5 Uplink	836.5	25	2.7	SE / SE	28 @ 869	3x3	856503*
RF Filter - Band 5 Uplink	836.5	25	1.9	SE / SE	35 @ 869	3x3	855821
RF Filter - Band 5 Uplink	836.5	25	2	SE / SE	10 @ 869	3x3	856704
RF Filter - Band 20 Uplink	847	30	1.3	SE / SE	10 @ 882	3x3	856932*
RF Filter - Band 5 Downlink	881.5	25	2.7	SE / SE	40 @ 849	3x3	856504*
RF Filter - Band 5 Downlink	881.5	25	2.7	SE / SE	40 @ 849	3x3	855728

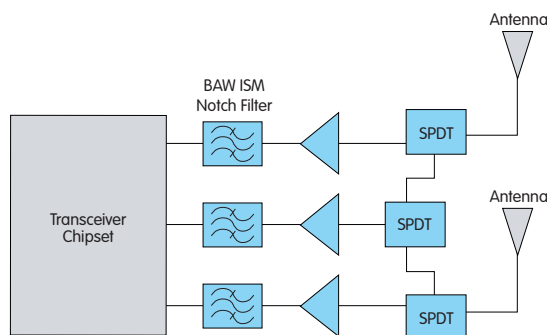
NOTES: * = New

RF Filters (cont.)

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
RF Filter – Band 5 Downlink	881.5	25	1.8	SE / SE	35 @ 849	3x3	855782
Cell Band Delay Filter, 450 ns	881.5	25	25	SE / BAL	–	7x5.5	856716
RF Filter – Band 8 Uplink	897.5	35	1.9	SE / SE	14 @ 930	3x3	856671
RF Filter – Band 8 Uplink	897.5	35	1.5	SE / SE	15 @ 930	3x3	856657
RF Filter – Band 8 Uplink	897.5	35	1.4	SE / SE	10 @ 984	3x3	856824
RF Filter – Band 8 Downlink	942.5	35	2	SE / SE	5 @ 915	3x3	855820
RF Filter – Band 8 Downlink	942.5	35	3.2	SE / SE	12 @ 915	3x3	855810
RF Filter – Band 8 Downlink	942.5	35	2.5	SE / SE	25 @ 915	3x3	856528
GSM Band Delay Filter, 450 ns	942.5	35	25.5	SE / SE	–	7x5.5	856766
RF Filter – Band 11 Uplink	1445.4	35	1.25	SE / SE	20 @ 1495.9	3x3	856928*
RF Filter – Band 3 Uplink	1747.5	75	2	SE / SE	22 @ 1676	3x3	856654
RF Filter – Band 3 Downlink	1842.5	75	1.9	SE / SE	10 @ 1785	3x3	855860
RF Filter – Band 2 Uplink	1880	60	2.4	SE / SE	7 @ 1930	3x3	855849
RF Filter – Band 2 Uplink	1880	60	2.8	SE / SE	30 @ 1930	3x3	856530
RF Filter – Band 2 Uplink	1880	60	2.2	SE / SE	15 @ 1806	3x3	856705
RF Filter – Band 2 Uplink	1880	60	2.3	SE / SE	10 @ 1790	3x3	856880
RF Filter – Band 1 Uplink	1950	60	2.2	SE / SE	40 @ 2110	3x3	856532
RF Filter – Band 1 Uplink	1950	60	1.8	SE / SE	20 @ 2100	3x3	856678
RF Filter – Band 2 Downlink	1960	60	2.1	SE / SE	10.3 @ 1910	3x3	855817
RF Filter – Band 2 Downlink	1960	60	2.25	SE / SE	14 @ 1910	3x3	856531
Delay Filter, PCS 450 ns	1960	60	25	SE / BAL	–	7x5.5	856717
Delay Filter, UMTS 450 ns	2140	60	25	SE / BAL	–	7x5.5	856649
RF Filter – Band 1 Downlink	2140	60	2.3	SE / SE	25 @ 1980	3x3	856738

NOTES: * = New

TriQuint Semiconductor offers a wide variety of **base station IF filters**. To view a selection of the most common filters, please go to the SAW filter section on pages 31 - 36.



Broadband Transceiver

Amplifiers

Description	Frequency Range (GHz)	P1dB / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
39 dBm HBT Amplifier	0.7 - 2.9	39 / –	16.5	8	12 / 300	5x5 QFN	AP561
33 dBm HBT Amplifier	3.3 - 3.8	33 / –	25	–	5 / 600	5x5 QFN	AH315
39 dBm HBT Amplifier	3.3 - 3.8	39 / –	11.5	–	12 / 400	5x6 DFN	AP562
WiMAX Driver Amp / PA, SB	3.4 - 3.8	30 / 42	24	–	6 / 770	5x5 QFN	TGA2703-SM

NOTES: SB = Self Biased

Discrete Transistors

Description	Frequency Range (GHz)	P1dB / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
MESFET	DC - 3000	23.5 / -	15.5	1.48 / 55	2 - 6 / 180	MW6	CLY2
0.5W HFET	DC - 6000	28 / 40	18	3.2 / -	8 / 100	SOT89	TGF2960-SD
1W HFET	DC - 6000	31 / 43	16	4 / -	8 / 200	SOT89	TGF2961-SD
MESFET	50 - 4000	21 / 42	19	2 / -	5 / 140	SOT89	FH1
MESFET	50 - 4000	18 / 36	19	2 / -	5 / 140	SOT89	FH101
0.5W HFET	50 - 4000	27 / 40	19	2.7 / -	8 / 125	SOT89	FP1189
1W HFET	50 - 4000	30 / 44	18	4.5 / -	8 / 250	SOT89	FP2189
2.5W HFET	50 - 4000	34 / 46	18	3.5 / -	9 / 450	6x6 QFN	FP31QF

Switches

Description	Frequency Range (GHz)	Insertion Loss (dB)	Isolation (dB)	P1dB (dBm)	Control Voltage (V)	Package Style (mm)	Part Number
SP2T 802.11 a, b, g	DC - 6	0.6	28	31.5	3 / 0	1.3x2 DFN	TQS5200

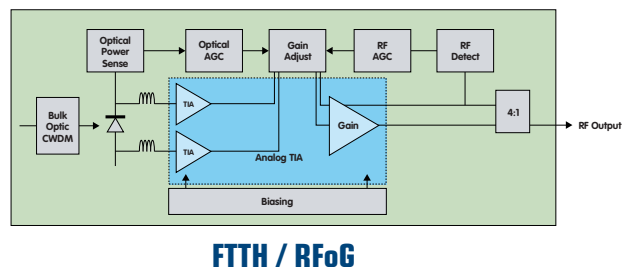
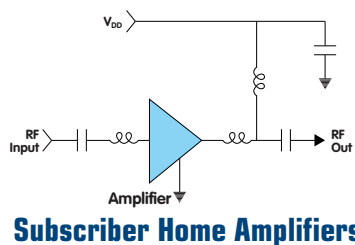
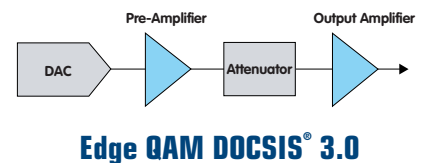
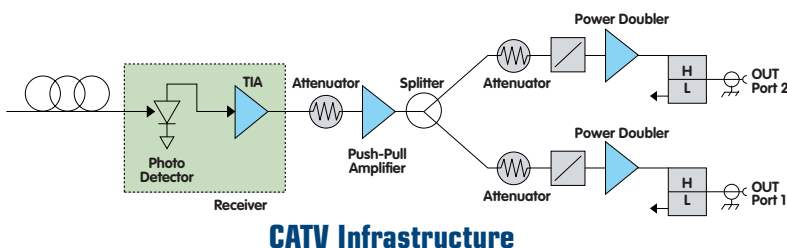
Filters For Coexistence

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
ISM Passband Filter for Coexistence	2436	72	2	SE / SE	20 @ 2495	1.7x1.3	885007
ISM Notch RF Filter for Coexistence	2440	72	1.5 (Out of Band IL)	SE / SE	25 @ 2440 (Notch Rej)	1.7x1.3	885008
ISM Notch RF Filter for Coexistence	2440	85	2 (Out of Band IL)	SE / SE	18 @ 2440 (Notch Rej)	1.7x1.3	885010

IF Filters

TriQuint Semiconductor offers a wide variety of BWA / WiMAX IF filters. To view a selection of the most common filters, please go to the SAW filter section on pages 31-36.

GUIDE BY MARKET | Cable



Amplifiers

Description	Application	Frequency Range (MHz)	P1dB / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
CATV Gain Block, Flex Gain	Home Amplifier	DC-2000	21 / 38	16-21	2	5 - 8 / 100	SOT89	TAT7457*
Dual HBT Amplifier	General Purpose	DC - 2700	19 / 33	18	3.5	>6 / 75	SOT86 / SOT89	AG604
On-Chip Linearized Amplifier	DOCSIS® 3.0 OUTPUT	40 - 1000	- / 43	17	4.7	5 / 380	SOIC-8	TAT7467H
CATV Gain Block	DOCSIS® 3.0 OUTPUT	40 - 1000	27 / 46	20	1.5	8 / 350	4x4 QFN	TGA2803-SM
CATV Gain Block	DOCSIS® 3.0 OUTPUT	40 - 1000	27 / 46	20	1.5	8 / 350	5x5 QFN	TGA2806-SM
CATV Gain Block	DOCSIS® 3.0 OUTPUT	40 - 1000	28 / -	18.5	2.5	6 / 318	5x5 QFN	TGA2807-SM
Dual pHEMT Amplifier, High Gain	Infrastructure GP	50 - 1000	- / 38	17.5	3.2	5 / 235	SOIC-8	TAT7469
Dual pHEMT Amplifier	Infrastructure GP	50 - 1000	- / 41	13	4	6 / 190	SOIC-8	TAT7466
Dual MESFET Amplifier	Infrastructure GP	50 - 1000	25.5 / 43	11.1	4.5	5 / 320	SOIC-8	AH22S
Fiber to the Home TIA + Output Amp	Fiber to the Home, RFoG, Low Input	50 - 1000	-60 dBc CTB / CSO	38	2.9 pA / rHz EIN	10 - 12 / 120	4x4 QFN	TAT6254B*
CATV Gain Block, High Gain	Home Amplifier, MOCA Multi	50 - 1000	- / 41	22.5	2	8 / 190	SOT89	TAT7430B
CATV Gain Block, High Gain	Home Amplifier, MOCA	50 - 1000	- / 39	18	2	6 / 145	SOT89	TAT7427
CATV Gain Block	Home Amplifier	50 - 1000	- / 39	16	2.7	6 / 130	SOT89	TAT7461
MESFET Amplifier	General Purpose	50 - 1000	20 / 40	14.8	3.5	5 / 150	SOT89	AH2
Single Ended Darlington	Return Path Amplifier	50 - 1000	20 / 37	13.5	4.5	>7 / 165	SOIC-8	AG606
Fiber to the Home TIA + Output Amp	Fiber to the Home, RFoG	50 - 1000	-62 dBc CTB / CSO	32	3.9 pA / rHz EIN	5, 12 / 200, 130	4x4 QFN	TAT6254D
Fiber to the Home TIA + Output Amp	Fiber to the Home, High Output	50 - 1000	-63 dBc CTB / CSO	33	3.9 pA / rHz EIN	5, 12 / 200, 130	4x4 QFN	TAT6254C
MESFET Amplifier	General Purpose	50 - 1500	30 / 50	10.4	5.3	9 / 400	SOT89	AH101
Dual pHEMT Amplifier, Wideband	CATV+SAT Wideband Amp / VONU	50 - 2600	-77 dBc CTB / -83 dBc CSO	13	4.4	5 / 160	SOIC-8	TAT7464
CATV Gain Block, Wideband	CATV+SAT Wideband Amp / VONU	50 - 2600	- / 36	16.5	2.5	5 / 100	SOT89	TAT7460
HFET Gain Block	General Purpose	50 - 4000	27 / 39	12.4	2.7	8 / 200	SOT89	FP1189
MMIC Gain Block	General Purpose	60 - 3000	15 / 32	14	2.4	4 - 5 / 50	SOT89	AG101
MESFET Gain Block	General Purpose	60 - 3000	21 / 39	10	2.4	4.5 / 150	SOT89	AM1

NOTES: * = New

Filters

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
Cable IF Filter	36.15	8	19.7	SE / SE	38 @ 10.23	DIP	855748
Cable IF Filter	44	6	20.4	SE / SE	38 @ 7.6	DIP	855079
Cable IF Filter	202.75	1.2	6.6	SE / SE	40 @ 10	13.3x6.5	855068
Cable IF Filter	499.25	1	7	SE / SE	35 @ 6	9x7	855104
Tuner IF Filter	1086	10	4	BAL / BAL	40 @ 1046	3x3	855964
Tuner IF Filter	1086	10	4	BAL / BAL	40 @ 1046	3x3	856330
Tuner IF Filter	1090	10	5	BAL / BAL	50 @ 1050	3.8x3.8	856096
Tuner IF Filter	1216	8	3.75	BAL / BAL	12 @ 24	3x3	856365
Tuner IF Filter	1220	10	4.5	BAL / BAL	30 @ 60	3x3	856298
Tuner IF Filter	1220	50	3.9	BAL / BAL	33 @ 96	3.8x3.8	856598
Tuner IF Filter	1250	96	6	BAL / BAL	44 @ 1152	3x3	856653
Tuner IF Filter	1892	8	4.2	BAL / BAL	23 @ 1932	2.5x2	856236

Protectors

Description	Application	Leakage Current (nanoAmps)	Trigger Voltage (V)	Series Capacitance (pF)	Package Area (mm²)	Package Style	Part Number
CATV Protector	ESD & Secondary Protection	20 @ 1V, 500 @ 15V	18, 25, 41	0.29, 0.29, 0.22	1.8	T / SLP-3	TQP200002

GUIDE BY MARKET | Defense & Aerospace

TriQuint Semiconductor has been supporting the defense and aerospace market for more than 25 years with the industry's most advanced technology and world class customer support. We continue to build on that legacy with our pioneering innovation and leadership in Gallium Nitride (GaN) as well as new packaged product releases and multichip module capabilities. With a full-service wafer fab including the option of our DoD-accredited 'Trusted Foundry' program, plus our internal package and test capability, TriQuint is uniquely positioned to offer a complete solution to our customer's most demanding requirements. The flexibility that TriQuint provides in offering a variety of process technologies, products and packaging styles is ideal in supporting a growing number of applications such as:

- **Phased Array Radar**
- **Electronic Warfare**
- **Communications**
- **Missile Systems**
- **GPS Navigation Systems**

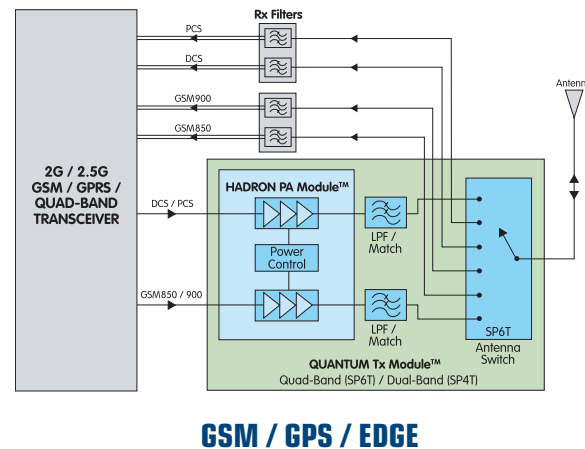
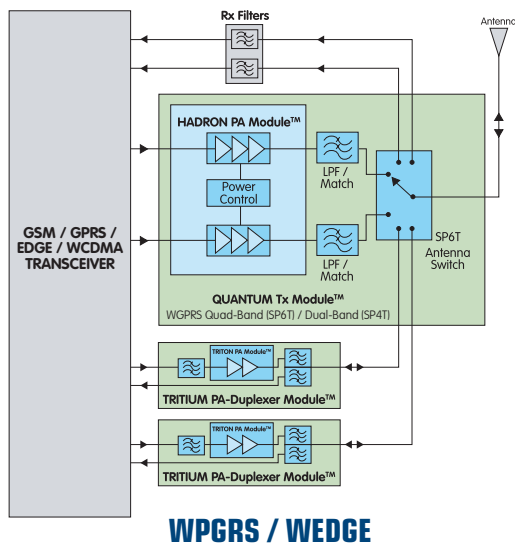
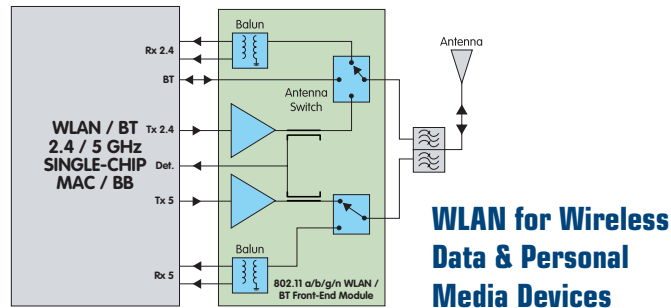
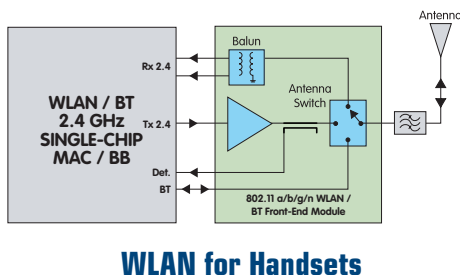
Many TriQuint products listed in this brochure support both commercial and defense-related applications. Those listed under a specific commercial market are also available for defense and aerospace use. If needed, products can be specially screened to meet the unique requirements of our customers. Offering 100% electrical screening along with visual inspection to either MIL-STD-883 Class B or Class S, our customers can be assured they are receiving a high-quality, highly reliable product.

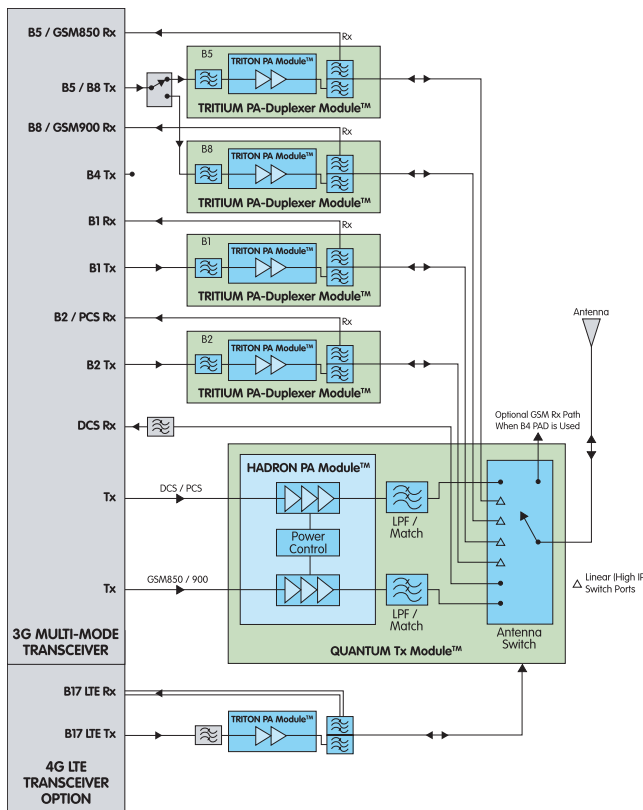
The TriQuint portfolio includes a large array of amplifiers along with key control products such as phase shifters, switches, attenuators and limiters that are ideal for defense and aerospace applications. Along with these active components, TriQuint also offers filter and oscillator products utilizing our in-house SAW and BAW technologies. Filter solutions with center frequencies between 30 MHz and 20 GHz are available in package sizes potentially as small as 1.5x0.8mm. Oscillators, with phase noise as low as -180 dBc/Hz and exceptional g-sensitivity, provide best-in-class performance. Come see what TriQuint can do for you.



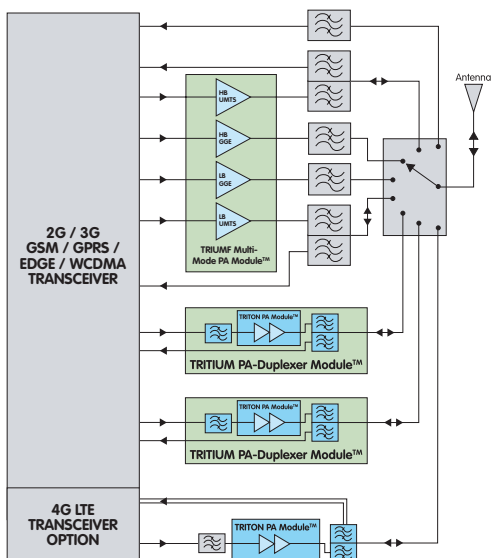
Image Courtesy of Jamie Hunter/Aviacom

GUIDE BY MARKET | Mobile Devices

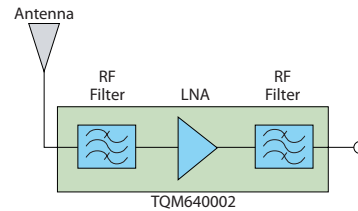




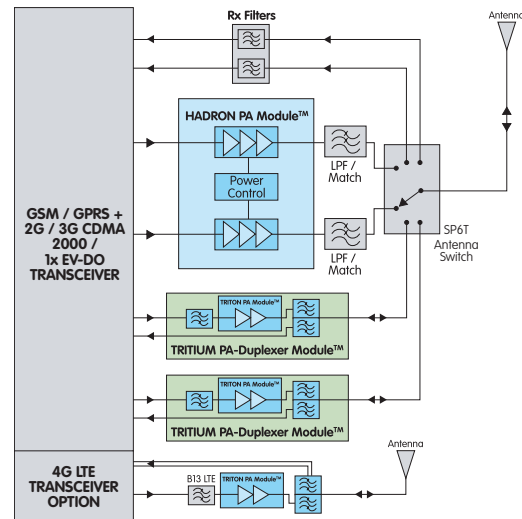
3G - WCDMA / WGPRES / WEDGE, 4G - LTE



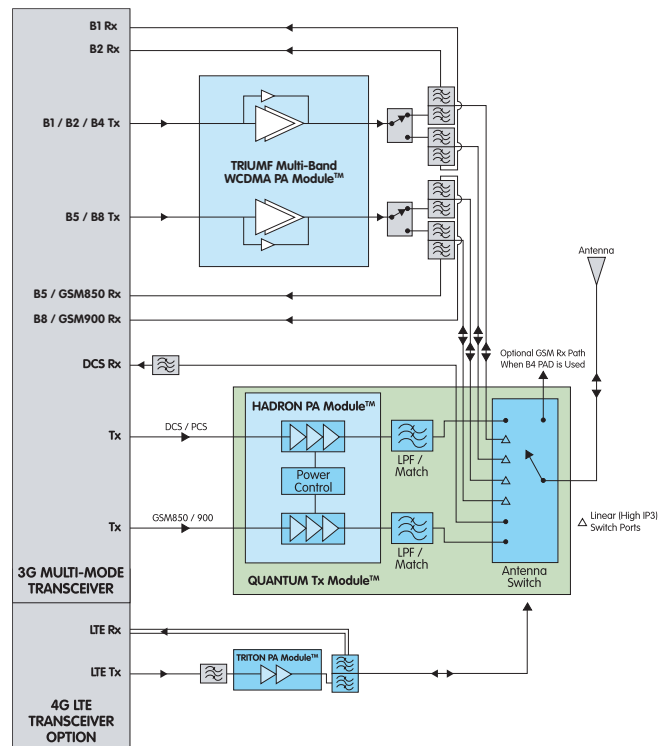
3G - WGPRES / WEDGE, 4G - LTE



GPS Integrated Module



3G - CDMA / EV-DO, 4G - LTE



3G - WCDMA / WGPRES / WEDGE, 4G - LTE

GSM / GPRS PA Module

Description	Bands	Features	Package Size (mm)	Part Number
Quad-Band GSM / GPRS PA Module	GSM900 & GSM850 / PCS	Low Band lbatt<1.5A @ Pcal w / PAE 55%	5x5x1	TQM7M4007

QUANTUM Tx Module™ Family (GSM / GPRS / EDGE)

Description	Bands	Features	Package Size (mm)	Part Number
Dual-Band GSM / GPRS Tx Module; PA / LPF / SP4T Switch; Quad-Band Tx & Dual-Band Rx	GSM900 / DCS or GSM850 / PCS	High Efficiency Broadband Tx, 2 Rx Ports	6x6x1	TQM6M4048
Quad-Band GSM / GPRS Tx Module; PA / LPF / SP6T Switch; Quad-Band Tx & Quad-Band Rx	GSM900 / DCS & GSM850 / PCS	High Efficiency Broadband Tx, 4 Rx Ports	6x6x1	TQM6M4049
Dual-Band GSM / GPRS Tx Module; PA / LPF / SP4T Switch; Quad-Band Tx & Dual-Band Rx	GSM900 / DCS or GSM850 / PCS	High Efficiency Broadband Tx, 2 Rx Ports	6x6x1	TQM6M4050*
Dual-Band GSM / GPRS Tx Module; PA / LPF / SP4T Switch; Quad-Band Tx & Dual-Band Rx	GSM900 / DCS or GSM850 / PCS	High Efficiency Broadband Tx, 2 Rx Ports	5x6x1	TQM6M4068*

NOTES: * = New

HADRON II PA Module™ Family (EDGE, 5x5mm Footprint)

Description	Bands	Features	Package Size (mm)	Part Number
Quad-Band GSM / GPRS / EDGE-Linear PA Module	GSM900 / DCS & GSM850 / PCS	Low Band lbatt < 1.5A @ Pcal w/PAE 55%	5x5x1	TQM7M5005H
Quad-Band GSM / GPRS / EDGE-Polar PA Module	GSM900 / DCS & GSM850 / PCS	+3 to +8 dBm Pin Nominal	5x5x1	TQM7M5012H
Quad-Band GSM / GPRS / EDGE-Linear PA Module	GSM900 / DCS & GSM850 / PCS	Input Power Controlled for GMSK & 8PSK	5x5x1	TQM7M5013
Quad-Band GSM / GPRS / EDGE-Polar PA Module	GSM900 / DCS & GSM850 / PCS	+3 to +8 dBm Pin Nominal	5x5x1	TQM7M5022

CDMA Switches

Description	Bands	Features	Package Size (mm)	Part Number
CDMA SP3T Switch	Cellular / PCS / AWS	Antenna Routing	2x2x0.6	TQP4M3019

TRITON PA Module™ Family (CDMA, WCDMA / HSUPA, LTE)

Description	Bands	Features	Package Size (mm)	Part Number
WCDMA / HSUPA PA Module, w/Coupler	Band 1	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM776011
CDMA & WCDMA / HSUPA PA Module, w/Coupler	PCS / Band 2	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM766012
CDMA & WCDMA / HSUPA PA Module, w/Coupler	AWS / Band 4	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM756014
CDMA & WCDMA / HSUPA PA Module, w/Coupler	Cellular / Band 5	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM716015
WCDMA / HSUPA PA Module, w/Coupler	Band 8	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM726018
LTE PA Module, w/Coupler	Band 13	LTE 1-Bit (Hi / Lo Power Modes)	3x3x0.9	TQM700013*

NOTES: * = New

TRITIUM II PA-Duplexer Module™ Family (CDMA, 7x4mm Footprint)

Description	Bands	Features	Package Size (mm)	Part Number
CDMA PA-Duplexer Module; SE Input w/Coupler	Cellular	2-Bit (Hi / Med / Lo Power Modes)	7x4x1.1	TQM613029
CDMA PA-Duplexer Module; SE Input w/Coupler	PCS	2-Bit (Hi / Med / Lo Power Modes)	7x4x1.1	TQM663029A
CDMA PA-Duplexer Module; SE Input w/Coupler	AWS	2-Bit (Hi / Med / Lo Power Modes)	7x4x1.1	TQM653029

TRITIUM III PA-Duplexer Module™ Family (WCDMA / HSUPA, 7x4mm Footprint)

Description	Bands	Features	Package Size (mm)	Part Number
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 1	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM676021
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 2	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM666022
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 4	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM656024
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Bands 5 & 6	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM616025
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 8	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM626028L

QUANTUM II Tx Module™ Family (WGPRES & WEDGE)

Description	Bands	Features	Package Size (mm)	Part Number
Quad-Band GSM / GPRS / EDGE-Linear TRP Tx Module: PA / LPF / SP8T WEDGE Switch w/ Quad-Band WCDMA Antenna Pass-Through	GSM850 / 900, DCS / PCS & WCDMA B1, B2, B5 / 6, B8	Integrated QB GSM / GPRS / EDGE PA & Antenna Switch Supporting WCDMA TRP Compliant at 4:1 Mismatch	7x7.5x1.1	TQM6M9014
Dual-Band GSM Tx Module: PA / LPF / SP6T WGPRES Switch w/ Dual-Band WCDMA Antenna Pass-Through	GSM900 / DCS of GSM850 / PCS & 2 WCDMA Bands	Integrated DB GSM / GPRS & 2 WCDMA Antenna Switch Ports	5x6x1	TQM6M9069*

NOTES: * = New

TRIUMF Module™ Family- GSM / GPRS / EDGE / WCDMA / HSUPA / LTE

Description	Bands	Features	Package Size (mm)	Part Number
Multi-Mode Quad-Band GMSK / EDGE / WCDMA PA Module	GSM850 / 900, DCS / PCS & WCDMA B1 & B8	2-Bit (Hi / Med / Lo Power Modes)	5x7.5x1	TQM7M9023*
Multi-Mode Quad-Band GMSK / EDGE / WCDMA PA Module	GSM850 / 900, DCS / PCS & WCDMA B1 & B5	2-Bit (Hi / Med / Lo Power Modes)	5x7.5x1	TQM7M9032*
Multi-Band WCDMA / HSUPA / HSPA+ / PA Module	High Bands 1,2,3,4,9,10 & Low Bands 5,6,8	1-Bit (Hi / Lo Power Modes); 1-Bit Band Specific Pout Adjust	5x4x0.9	TQM7M9070*

NOTES: * = New

3G / 4G Duplexers

Description	Bands	Features	Package Size (mm)	Part Number
LTE SE / BAL SAW Duplexer	Band 13	1.5 dB (Tx) / 1.6 dB (Rx) Insertion Loss	2.5x2x0.6	856879
LTE SE / BAL SAW Duplexer	Band 17	1.8 dB (Tx) / 2 dB (Rx) Insertion Loss	2.5x2x0.6	856931
LTE SE / BAL SAW Duplexer	Band 20	High Performance Temp. Compensated SAW	2.5x2x0.6	856979*
BC10 SE / BAL SAW Duplexer	BC10 (PCS)	Excellent Triple Beat performance	2.5x2x0.6	856999*
BC14 SE / SE BAW Duplexer	BC14 (Cellular)	Excellent Triple Beat performance	2.5x2x0.9	TQM963014*

NOTES: * = New

WLAN PA

Description	Bands	Features	Package Size (mm)	Part Number
802.11a 5 GHz WLAN PA MMIC	802.11 a	ETSLP-16 Package, Detector, Hi / Lo Linearity Mode	3x3x0.45	TQP787011

WLAN Switch

Description	Bands	Features	Package Size (mm)	Part Number
2.4 GHz & 5 GHz SPDT Switch MMIC	802.11 a, b, g	Slim-7 Package	1.3x2x0.45	TQS5200

WLAN LNA / Antenna Switch

Description	Bands	Features	Package Size (mm)	Part Number
2.4 GHz WLAN LNA + SP3T Switch MMIC WLAN Tx & Bluetooth® Paths	802.11 b, g	LNA Bypass, ETSLP-12 Package	1.5x1.5x0.55	TQP879001A

WLAN PA / Antenna Switch

Description	Bands	Features	Package Size (mm)	Part Number
2.4 GHz WLAN PA + Switch MMIC w/WLAN Rx Balun & Bluetooth® Path	802.11 a	ETSLP-16 Package, Coupler / Detector	3x3x0.45	TQM679002A
2.4 GHz & 5 GHz WLAN PA + Switch MMIC w/WLAN Rx Baluns & Bluetooth® Path	802.11 a, b, g, n	ETSLP-24 Package, Coupler / Detector	4x4x0.45	TQP6M9002

WLAN Filters

Description	Bands	Features	Package Size (mm)	Part Number
ISM Passband Filter	2436 MHz	72 MHz Bandwidth, 2 dB Insertion Loss	1.7x1.3x0.46	885007

Bluetooth® PA

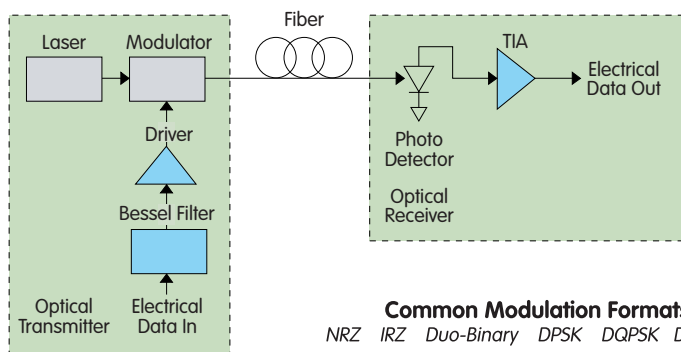
Description	Bands	Features	Package Size (mm)	Part Number
Bluetooth® EDR v2.0 Class 1 PA MMIC	2.4 to 2.5 GHz ISM Band	STSLP-12 Package	2x2x0.57	TQP770001

GPS LNA / Filter Module

Description	Bands	Features	Package Size (mm)	Part Number
GPS Filter-LNA-Filter Module	1575 MHz, GPS L1	Low Noise (1.56 dB) and High Gain (16 dB)	3x3x1.0	TQM640002

GPS Filters

Description	Bands	Features	Package Size (mm)	Part Number
GPS SAW Filter, SE / SE	1575 MHz, GPS L1	Ultra-low Insertion Loss of 0.5 dB (Hermetic CSP)	1.4x1.2x0.46	856756
GPS SAW Filter, SE / SE	1575 MHz, GPS L1	0.75 dB Insertion Loss (Hermetic CSP)	1.4x1.2x0.46	856561
GPS SAW Filter, SE / BAL	1575 MHz, GPS L1	1.1 dB Insertion Loss (Hermetic CSP)	1.4x1.2x0.46	856576
GPS SAW Filter, SE / SE	1575 MHz, GPS L1	0.6 dB Insertion Loss (Hermetic CSP)	1.4x1.2x0.46	856793



Optical Systems
(10, 40 & 100 Gb/s)

Common Modulation Formats
NRZ IRZ Duo-Binary DPSK DQPSK DP-QPSK

Drivers

Description	Frequency Range (GHz)	Power	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
9.9 - 12.5 Gb/s 3V - 7V Driver	DC - 13	3 - 7Vpp	32	–	3.3 - 5 / 115	8x8 QFN	TGA4956-SM
9.9 - 12.5 Gb/s Mod. Driver	DC - 16	3 - 10Vpp	35	2.5	5.5 - 8 / 210	11.4x8.9 SL	TGA4953-SL
9.9 - 12.5 Gb/s Mod. Driver	DC - 16	3 - 9Vpp	35	2.5	5.5 - 8 / 210	11.4x8.9 SL	TGA4954-SL
12.5 Gb/s NRZ Driver	DC - 18	3 - 11Vpp	16	–	8 / 285	Die	TGA4807
12.5 Gb/s NRZ Driver	DC - 18	6 - 8Vpp	16	3.5	5 - 8 / 70 - 175	Die	TGA1328-SCC
12.5 Gb/s NRZ Driver	DC - 18	4 - 8Vpp	16	3.5	8 / 175	8.9x8.9 SL	TGA8652-SL
15 Gb/s 10V Linear Mod. Driver	DC - 20	3 - 10Vpp	22	–	7 / 280	6x6 QFN	TGA4826-SM
40 & 100 Gb/s 8 Vpp SE Driver	DC - 30	3 - 9Vpp	32	–	6 - 7 / 270	14.4x7 SL	TGA4943-SL
45 Gb/s 8V pp SE Driver	DC - 35	5 - 9Vpp	30	–	6 - 7 / 300	16x8 SL	TGA4942-SL**
45 Gb/s 9Vpp Diff In / Out Driver	DC - 50	6 - 10Vpp Diff	27 Diff	–	5 - 6 / 500	Die	TGA4958**
32 Gb/s 9Vpp Diff In / Out Driver	DC - 35	6 - 9Vpp Diff	25 Diff	–	5 - 6 / 500	10x7 SL	TGA4959-SL**
Wideband Driver (40 Gb/s)	DC - 35	4Vpp	12	–	5 / 135	Die	TGA4832
43 Gb/s Driver	DC - 78	3.5Vpp	8	5	6 / 82	Die	TGA4803
10.7 - 12.5 Gb/s Linear Mod. Driver	0.03 - 8	12.5Vpp	20	–	8 / 310	8x8 QFN	TGA4823-2-SM

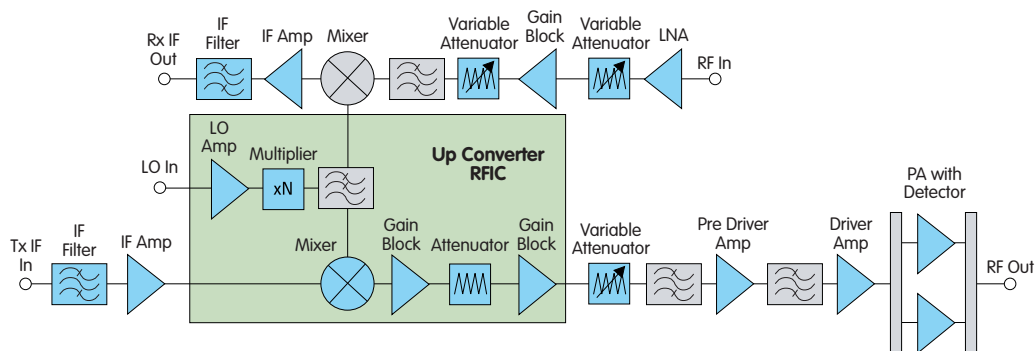
NOTES: ** = Coming Soon, SB = Self Biased, SE = Single-Ended

Amplifiers

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
LNA / Gain Block (40 Gb/s)	DC - 40	11.5	13	3.2	5 / 50	Die	TGA4830
CATV TFA / Gain Block	0.04 - 1	27 / 46	20	1.5	8 / 350	4x4 QFN	TGA2803-SM

Control Products

Description	Frequency Range (GHz)	Insertion Loss (dB)	Control Range (dB)	P1dB (dBm)	Supply Voltage (V)	Package Style (mm)	Part Number
Analog Attenuator	DC - 30	2	17	–	0 to -2	3x3 QFN	TGL4203-SM
Analog Attenuator	DC - >50	2	17	–	0 to -2	Die	TGL4203
Discrete Thru (0 dB Attenuator)	DC - 65	0	0	–	–	Die	TGL4201-00
Discrete Attenuators	DC - 65	–	2, 3, 6, 10	–	–	Die	TGL4201-02, 03, 06, 10
Bessel Filter	–	6, 7, 8, 9, 10 & 11 Cut-Off Freq	–	–	–	Die	TGB2010-00, -09 etc.
Bessel Filter	–	5, 6, 6.5, 7.5, 8 & 9 Cut-Off Freq	–	–	–	2x2 QFN	TGB2010-00, -09-SM etc.



Point-to-Point Radio

Amplifiers

Description	Frequency Range (GHz)	PldB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
2W HPA	5.5 - 8.5	32 (34) / 41	30	7 / -	6 / 1260	5x5 QFN	TGA2706-SM
2.5W HPA	5.9 - 8.5	34 / 42	18	7.5 / 37	6 / 1000	6x6 QFN	TGA2701-SM
HPA	6 - 18	(34.5) / -	24	- / 20	8 / 1200	Die	TGA9092-SCC
Gain Block	6 - 18	12.5 / -	13	5 / -	5 / 80	Die	TGA8035-SCC
2.8W HPA	6 - 18	(34.5) / -	24	- / 20	7 - 9 / 800 - 1200	Die	TGA2501
HPA	7 - 8.5	(38) / -	21	- / 42	7 / 2000	Die	TGA2701
Driver Amp	7 - 13	(30) / 37	25	- / 30	9 / 450	Die	TGA2700
Wideband Driver Amp	8 - 18	13 / -	17	5 / -	4.5 / 50	Die	TGA8399C
HPA	9 - 10.5	(38) / -	20	- / >38	4 - 9 / 2000	Die	TGA2704
HPA	10.5 - 12	(38) / -	19	- / >39	4 - 9 / 2000	Die	TGA2710
Driver Amp, SB	11 - 17	17 / -	23	6 / -	6 / 75	4x4 QFN	TGA2507-SM
Driver Amp	12 - 16	26 (26.5) / 37	23	7 / -	5 / 300	3x3 QFN	TGA2524-SM*
Driver Amp, SB	12 - 18	14 / -	17	-	6 / 40	Die	TGA2506
Driver Amp, SB	12 - 18	20 / -	28	6 / -	6 / 80	Die	TGA2507
1W HPA	12 - 19	30 / -	30	-	5 - 7 / 435	Die	TGA2508
HPA	12 - 19	29 / -	25	-	5 - 7 / 435	4x4 QFN	TGA2508-SM
2W HPA	12.3 - 15.7	(31) / -	33	7.0 / -	6 / 850	Die	TGA2520
2W HPA	12.5 - 16	(32) / 37	32	-	6 - 7 / 680	4x4 QFN	TGA2503-SM
2W HPA	12.5 - 17	(34) / -	26	- / 25	7.5 / 650	Die	TGA2510
2W HPA	12.5 - 17	(33.5) / -	25	- / 25	7.5 / 650	6.4x9.4 SG	TGA2510-SG
2W HPA	12.7 - 15.4	34 (35) / 43	28	6 / -	6 / 1300	Die	TGA2533*
2W HPA	12.7 - 15.4	33 (34.5) / 43	27	6 / -	6 / 1300	5x5 QFN	TGA2533-SM*
2W HPA	13 - 17	(34) / 40	32	-	6 - 7 / 680	Die	TGA2503
2W HPA	13 - 17	(34) / -	25	-	6 - 7 / 640	Die	TGA2505
2W HPA	13 - 17	(34) / -	33	-	5 - 8 / 680	17.8x8.4 FL	TGA2904-FL
2W HPA, PD	13 - 17	(34) / 38.5	26	- / 30	7.5 / 650	6.4x9.4 SG	TGA2902-1-SCC-SG
2W HPA	13 - 17	(34) / 40	33	-	5 - 8 / 680	6.4x9.4 SG	TGA8658-SG
4W HPA, Balanced	13 - 17	(36) / 44	25	- / 30	6 - 7 / 1300	Die	TGA2502
2W HPA, PD	13.75 - 14.5	(34) / 38.5	26	- / 30	7.5 / 650	6.4x9.4 SG	TGA2902-2-SCC-SG
1W HPA, PD	17 - 20	30 (32) / 42	20	-	5 - 7 / 825	Die	TGA4530
HPA	17 - 20	31 / 41	22	6.5 / -	6 / 820	4x4 QFN	TGA4532-SM
HPA	17 - 20	30.5 / 41	23	-	6 / 900	Die	TGA4532
Driver Amp	17 - 24	22 / -	19	4 / -	5 / 270	4x4 QFN	TGA2521-SM
HPA	17 - 24	31 (32) / 40	23	6 / -	7 / 720	Die	TGA4531
HPA, AGC, PD	17 - 24	(29) / 38	22	-	5 / 712	4x4 QFN	TGA2522-SM
HPA	17 - 27	29 (31) / 37	22	-	7 / 760	Die	TGA4502-SCC
Gain Block & 2x / 3x Multiplier	17 - 37	18 (22) / 26	20	7 / -	5 / 140	3x3 QFN	TGA4030-SM
Gain Block & 2x / 3x Multiplier	17 - 40	18 (22) / 24	22	7 / -	5 / 140	3x3 QFN	TGA4031-SM
Gain Block, Multiplier	17 - 43	22 / -	25	-	5 / 225	Die	TGA4040
2W HPA	18 - 23	32 (33) / 39	26	-	7 / 840	Die	TGA4022
HPA	18 - 27	29 / 37	14	-	6 / 480	Die	TGA1135-SCC
MPA	19 - 27	25 / 32	22	-	5 - 7 / 220	Die	TGA1073G-SCC
Gain Block	19 - 38	(22) / 30	20	-	5 / 160	Die	TGA4036
HPA	21 - 24	31 (32) / 41	22	6 / -	6 / 880	4x4 QFN	TGA4533-SM*
MPA	25 - 35	25 / -	18	-	6 / 220	4x4 QFN	TGA4902-SM
MPA	26 - 35	25 (32) / -	19	-	5 - 7 / 220	Die	TGA1073A-SCC
1W HPA	27 - 31	30 / -	22	- / 25	4 - 6 / 420	Die	TGA4509
2W HPA	27 - 31	32.5 (33) / 36.5	20	-	6 / 840	Die	TGA4513
HPA	27 - 32	28.5 / -	25	-	6 - 8 / 420	Die	TGA1073B-SCC
1W HPA	28 - 31	30 / -	19	- / 25	6 / 420	4x4 QFN	TGA4509-SM
Driver Amp	29 - 37	16 / -	16	-	6 / 60	Die	TGA4510

NOTES: * = New, SB = Self Biased, AGC = Automatic Gain Control, PD = Power Detector

Amplifiers (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
2W HPA	30 - 40	31.5 (33) / –	20	–	6 / 1050	Die	TGA4516
MPA	32 - 45	24 (25) / 33	16	–	6 / 175	Die	TGA4521
MPA	33 - 47	27 (27.5) / 36	18	–	6 / 400	Die	TGA4522
HPA	37 - 40	28 / 38	24	–	5 / 600	Die	TGA4538
HPA	36 - 40	26 / –	15	–	5 - 7 / 240	Die	TGA1073C-SCC
HPA	36 - 40	30 / –	14	–	6 - 7 / 500	Die	TGA1171-SCC

Low Noise Amplifiers

Description	Frequency Range (GHz)	P1dB / IIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
LNA, AGC	2 - 18	18 / 29	17	2	5 / 75	Die	TGA2525
LNA, AGC	2 - 20	19 / –	17.5	2.5	5 / 100	Die	TGA2526
LNA, AGC	2 - 20	17.5 / –	9	3.5	5 - 8 / 60	Die	TGA1342-SCC
LNA, AGC	2 - 20	16 / –	17	2.5	5 / 75	4x4 QFN	TGA2513-SM
LNA, AGC	2 - 23	17 / 26	17	2	5 / 75	Die	TGA2513
LNA, SB, AGC	4 - 14	6 / 16	22	2.3	5 / 90	4x4 QFN	TGA2512-1-SM
LNA, AGC, GB	4 - 14	13 / 24	25	2.3	5 / 160	4x4 QFN	TGA2512-2-SM
LNA, SB, AGC	5 - 15	6 / 13	27	1.4	5 / 90	Die	TGA2512
LNA, SB	6 - 13	11 / –	26	1.5	5 / 65	Die	TGA8399B-SCC
LNA, SB, AGC	6 - 14	6 / 12	20	1.3	5 / 90	Die	TGA2511
LNA	20 - 27	12 / –	21	2.2	3.5 / 60	Die	TGA4506
LNA	28 - 36	12 / 21	22	2.3	3 / 60	Die	TGA4507
LNA	30 - 42	14 / –	21	2.8	3 / 40	Die	TGA4508
LNA	57 - 69	–	13	4	3 / 41	Die	TGA4600

NOTES: SB = Self Biased, AGC = Automatic Gain Control, GB = Gate Bias

Discrete Transistors

Description	Frequency Range (GHz)	P1dB (Psat) (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
24mm HFET	DC - 4	40	13	– / 51	8 / 2170	Die	TGF4124
18mm HFET	DC - 6	38.5	13.5	– / 53	8 / 1690	Die	TGF4118
12mm HFET	DC - 8	37	14	– / 55	8 / 750	Die	TGF4112
4.8mm HFET	DC - 10.5	34	8.5	– / 53	8 / 200	Die	TGF4250-SCC
9.6mm HFET	DC - 10.5	37	9.5	– / 52	8.5 / 520	Die	TGF4260-SCC
1.2mm HFET	DC - 12	28.5	10	– / 55	8 / 50	Die	TGF4230-SCC
2.4mm HFET	DC - 12	31.5	10	– / 56	8 / 100	Die	TGF4240-SCC
1mm Pwr pHEMT	DC - 12	(31.5)	11	– / 55	12 / 900	Die	TGF2021-01
2mm Pwr pHEMT	DC - 12	(34.5)	11	– / 55	12 / 150	Die	TGF2021-02
4mm Pwr pHEMT	DC - 12	(37.5)	11	– / 55	12 / 300	Die	TGF2021-04
8mm Pwr pHEMT	DC - 12	(40.2)	11	– / 55	12 / 600	Die	TGF2021-08
12mm Pwr pHEMT	DC - 12	(42)	11	– / 52	12 / 900	Die	TGF2021-12
0.3mm MESFET	DC - 18	13	11	1.5 / –	3 / 15	Die	TGF1350-SCC
0.6mm Pwr pHEMT	DC - 20	(29)	13	– / 56	12 / 45	Die	TGF2022-06
1.2mm Pwr pHEMT	DC - 20	(32)	13	– / 56	12 / 90	Die	TGF2022-12
2.4mm Pwr pHEMT	DC - 20	(35)	13	– / 58	12 / 180	Die	TGF2022-24
4.8mm Pwr pHEMT	DC - 20	(38)	13	– / 58	12 / 360	Die	TGF2022-48
6mm Pwr pHEMT	DC - 20	(39)	12.5	– / 53	12 / 448	Die	TGF2022-60
0.3mm pHEMT	DC - 22	16	13	0.8 / –	3 / 15	Die	TGF4350

Switches

Description	Frequency Range (GHz)	Insertion Loss (dB)	Isolation (dB)	P1dB (dBm)	Control Voltage (V)	Package Style (mm)	Part Number
SP2T 802.11 a, b, g	DC - 6	0.6	28	31.5	3 / 0	1.3x2 DFN	TGS5200
SPDT FET	DC - 18	1.5	36	27	-5	Die	TGS2306
SPDT FET	DC - 18	2	39	21	-7 / 0	Die	TGS8250-SCC
SP3T VPIN	1 - 20	0.5	35	23	10 mA	Die	TGS2303
SP4T VPIN	1 - 20	0.6	38	23	10 mA	Die	TGS2304-SCC
SP3T VPIN	4 - 18	1	35	20	+/- 2.7	Die	TGS2313
SPDT VPIN	4 - 20	0.9	35	>20	+/- 2.7	Die	TGS2302
SPDT VPIN	24 - 43	<2	36	27	+/- 5	Die	TGS4301
SPDT VPIN	27 - 46	0.9	30	>34	+/- 5 / 15	Die	TGS4302
SPDT VPIN Absorptive	32 - 40	1	36	>33	+/- 5 / 18	Die	TGS4304

Frequency Converters & Mixers

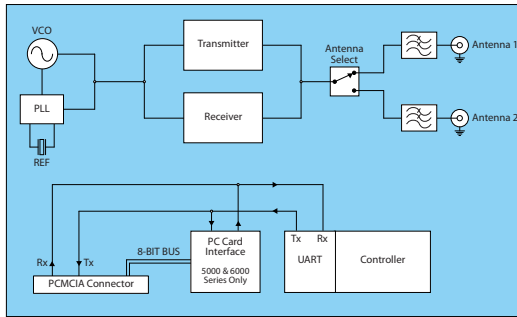
Description	RF Frequency Range (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
Doubler w/Amplifier	16 - 30	18	30	-	5 / 150	Die	TGC4403
Doubler w/Amplifier	16 - 30	18	30	-	5 / 150	4x4 QFN	TGC4403-SM
Upconverting Mixer	17 - 26	-9	40	-	-0.9 / 0	4x4 QFN	TGC4402-SM
Upconverting Mixer	17 - 27	-9	35	18	-0.9 / 0	Die	TGC4402
Upconverter	17 - 27	13	30	-	5 / 425	Die	TGC4405
Upconverter	17 - 27	13	30	-	5 / 425	4x4 QFN	TGC4405-SM
Gain Block & 2x / 3x Multiplier	17 - 37	9	-	6	5 / 140	3x3 QFN	TGA4030-SM
Gain Block & 2x / 3x Multiplier	17 - 40	9	-	2	5 / 140	3x3 QFN	TGA4031-SM
Doubler (Input 10 - 20 GHz)	20 - 40	-12	25	18	-	Die	TGC1430F
Tripler (Input 8.5 - 13.5 GHz)	20 - 40	-15	15	18	-	Die	TGC1430G

Control Products

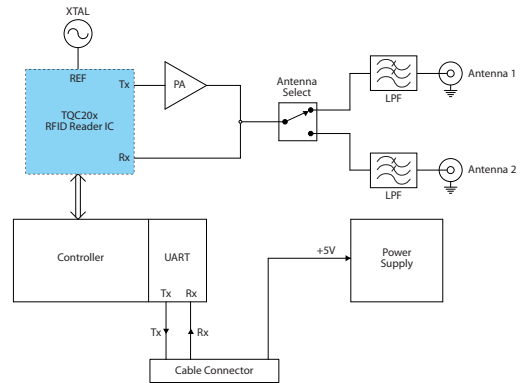
Description	Frequency Range (GHz)	Insertion Loss (dB)	Control Range (dB)	P1dB (dBm)	Supply Voltage (V)	Package Style (mm)	Part Number
Discrete Thru (0 dB Attenuator)	DC - 65	0	0	-	-	Die	TGL4201-00
Analog Attenuator	DC - >50	2	17	-	0 to -2	Die	TGL4203
Analog Attenuator	DC - 30	2	17	-	0 to -2	3x3 QFN	TGL4203-SM
Discrete Attenuators	DC - 65	-	2, 3, 6, 10	-	-	Die	TGL4201-02, 03, 06, 10
Analog Attenuator	2 - 20	2	15	23	2.5	Die	TGL8784-SCC
Passive Wideband Limiter	3 - 25	<0.5	-	18	-	Die	TGL2201
Langue Coupler	12 - 21	<0.25	-	-	-	Die	TGB2001
Langue Coupler	18 - 32	<0.25	-	-	-	Die	TGB4001
Langue Coupler	27 - 45	<0.25	-	-	-	Die	TGB4002

Filters

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
High Selectivity IF Filter	140	1.5	12.1	SE and BAL	48 @ 143	9.1x4.8	856691
High Selectivity IF Filter	140	3	13.6	SE and BAL	46 @ 144	9.1x4.8	856692
High Selectivity IF Filter	140	6	11	BAL / BAL	39 @ 147	9.1x4.8	856693
High Selectivity IF Filter	140	7	13.6	SE and BAL	43 @ 147	9.1x4.8	856694
High Selectivity IF Filter	140	10	10	BAL / BAL	41 @ 152.5	9.1x4.8	856695
High Selectivity IF Filter	140	14	8.5	SE and BAL	43 @ 155	9.1x4.8	856696
High Selectivity IF Filter	140	20	9.8	BAL / BAL	40 @ 158.5	9.1x4.8	856697
High Selectivity IF Filter	140	28	18	SE and BAL	42 @ 168	9.1x4.8	856698



WJR Series Functional Block Diagram



WJM Series Application Block Diagram

UHF RFID Modules

Description	Frequency Range (MHz)	Channels / Spacing (kHz)	Max Output Power (W)	Protocol Support	Region of Operation	Interface	Part Number
Reader PCMCIA Form Factor Module (ETSI 302.208)	865.7 - 867.5	4 / 600	1	ISO18000-6B & -6C	Europe	Serial TTL	WJR7081
Reader PCMCIA Form Factor Module (FCC Pt 15)	902.75 - 927.25	50 / 500	1	ISO18000-6C	N. America	Serial TTL	WJR7000
Embedded Reader Module (FCC Pt 15)	902.75 - 927.25	50 / 500	1	ISO18000-6B & -6C	N. America	Serial TTL	WJM3000
Embedded Reader Module (FCC Pt 15)	902.75 - 927.25	50 / 500	0.25	ISO18000-6B & -6C	N. America	Serial TTL	WJM1000
PCMCIA Form Factor Module	910.6 - 913.4	15 / 200	1	ISO18000-6B & -6C	Korea	Serial TTL	WJR7090
PCMCIA Reader Module (FCC Pt 15)	902.75 - 927.25	50 / 500	0.5	ISO18000-6B & -6C	N. America	PCMCIA	WJR6000

Qualified Amplifiers

TriQuint has a proud space / aerospace history, supplying highly-reliable active / acoustic devices for satellite and planetary missions. Space qualification includes high-level visual inspection, 100% element electrical results and wafer lot qualification testing. See tables for standard products already space qualified; most foundry and standard products throughout this brochure may be space qualified.

Qualified Amplifiers

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
12.5 Gb/s NRZ Driver	DC - 18	24 / -	16	3.5 / -	5 - 8 / 70 - 175	Die	TGA1328-SCC
Wideband Driver (40 Gb/s)	DC - 35	18 / -	12	-	5 / 135	Die	TGA4832
Gain Block, SB	2 - 10	17 / -	17	6 / -	5 / 90	Die	TGA8810-SCC
Gain Block	2 - 18	20 / -	7.5	5.5 / -	6 / 100	Die	TGA8300-SCC
Wideband Gain Block, AGC	2 - 20	20 / -	7.5	7 / -	6 / 150	Die	TGA8622-SCC
Wideband PA, AGC	2 - 20	26 / -	8	-	8 / 440	Die	TGA8334-SCC
0.5W PA	6 - 18	27 / -	11	8 / -	8 / 400	Die	TGA8014-SCC
HPA	6.5 - 11.5	37 (39) / -	19	- / 35	7 - 9 / 1200	Die	TGA9083-SCC
Wideband Driver Amp	8 - 18	13 / -	17	5 / -	4.5 / 50	Die	TGA8399C
HPA	9 - 10.5	(38) / -	20	- / >38	4 - 9 / 2000	Die	TGA2704
Driver Amp, SB	11 - 17	17 / -	23	6 / -	6 / 75	4x4 QFN	TGA2507-SM

NOTES: SB = Self Biased, AGC = Automatic Gain Control

Qualified Amplifiers (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
Driver Amp, SB	12 - 18	20 / –	28	6 / –	6 / 80	Die	TGA2507
2W HPA	12.5 - 17	(34) / –	26	– / 25	7.5 / 650	Die	TGA2510*
4W HPA, Balanced	13 - 17	(36) / 44	25	– / 30	6 - 7 / 1300	Die	TGA2502
2W HPA	18 - 23	32 (33) / 39	26	–	7 / 840	Die	TGA4022*
Gain Block	19 - 38	(22) / 30	20	–	5 / 160	Die	TGA4036
HPA	24 - 31	35.5 (36) / –	23	–	6 / 2100	Die	TGA4505
3.5W HPA	31 - 37	(35.5) / –	20	–	6 / 2000	Die	TGA4517
MPA	32 - 45	24 (25) / 33	16	–	6 / 175	Die	TGA4521
HPA	36 - 40	30 / –	14	–	6 - 7 / 500	Die	TGA1171-SCC*

NOTES: * = **Newly Qualified**, SB = Self Biased

Qualified Low Noise Amplifiers

Description	Frequency Range (GHz)	P1dB (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
LNA, AGC	DC - 14	16	11	3.1	8 / 80	Die	TGA8349-SCC
LNA, AGC	2 - 18	16	19	4	5 / 120	Die	TGA8344-SCC
LNA, AGC	2 - 20	17.5	9	3.5	5 - 8 / 60	Die	TGA1342-SCC
LNA, AGC	2 - 20	17.5	9	3.5	5 - 8 / 60	Die	TGA8310-SCC
LNA, SB	6 - 13	11	26	1.5	5 / 65	Die	TGA8399B-SCC
LNA	20 - 27	12	21	2.2	3.5 / 60	Die	TGA4506
LNA	28 - 36	12 / 21	22	2.3	3 / 60	Die	TGA4507*
LNA	30 - 42	14	21	2.8	3 / 40	Die	TGA4508

NOTES: * = **Newly Qualified**, SB = Self Biased, AGC = Automatic Gain Control

Qualified Frequency Converters & Mixers

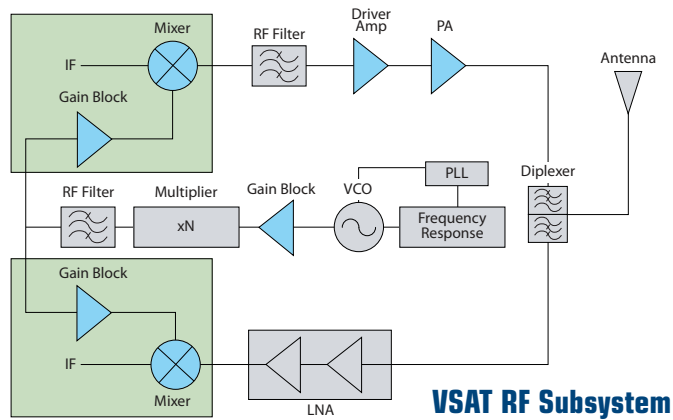
Description	RF Frequency Range (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Voltage / Current (V / mA)	Package Style	Part Number
Tripler (Input 8.5 - 13.5 GHz)	20 - 40	-15	15	18	–	Die	TGC1430G

Qualified Optical Drivers

Description	Frequency Range (GHz)	Power	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
12.5 Gb/s NRZ Driver	DC - 18	6 - 8Vpp	16	3.5	5 - 8 / 70 - 175	Die	TGA1328-SCC
Wideband Driver (40 Gb/s)	DC - 35	4Vpp	12	–	5 / 135	Die	TGA4832

Qualified Control Products

Description	Frequency Range (GHz)	Insertion Loss (dB)	Control Range (dB)	P1dB (dBm)	Supply Voltage (V)	Package Style	Part Number
Analog Attenuator	DC - >50	2	17	–	0 to -2	Die	TGL4203
Analog Attenuator	2 / 20	2 - 20	15	23	2.5	Die	TGL8784-SCC



Amplifiers

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
Driver Amp, SB	11 - 17	17 / -	23	6 / -	6 / 75	4x4 QFN	TGA2507-SM
Driver Amp, SB	12 - 18	14 / -	17	-	6 / 40	Die	TGA2506
Driver Amp, SB	12 - 18	20 / -	28	6 / -	6 / 80	Die	TGA2507
1W HPA	12 - 19	30 / -	30	-	5 - 7 / 435	Die	TGA2508
HPA	12 - 19	29 / -	25	-	5 - 7 / 435	4x4 QFN	TGA2508-SM
2W HPA	12.3 - 15.7	(31) / -	33	7 / -	6 / 850	Die	TGA2520
2W HPA	12.5 - 16	(32) / 37	32	-	6 - 7 / 680	4x4 QFN	TGA2503-SM
2W HPA	12.5 - 17	(34) / -	26	- / 25	7.5 / 650	Die	TGA2510
2W HPA	12.5 - 17	(33.5) / -	25	- / 25	7.5 / 650	9.4x6.4 SG	TGA2510-SG
4W HPA	13 - 15	(36) / 41	25	-	7 / 1300	8.4x17.8 FL	TGA8659-FL
6.5W HPA	13 - 16	(38) / -	24	-	8 / 2600	11.4x17.3 FL	TGA2514-FL
2W HPA	13 - 17	(34) / 40	32	-	6 - 7 / 680	Die	TGA2503
2W HPA	13 - 17	(34) / -	25	-	6 - 7 / 640	Die	TGA2505
2W HPA	13 - 17	(34) / -	33	-	5 - 8 / 680	8.4x17.8 FL	TGA2904-FL
2W HPA	13 - 17	(34) / 40	33	-	5 - 8 / 680	9.4x6.4 SG	TGA8658-SG
2W HPA, PD	13 - 17	(34) / 38.5	26	- / 30	7.5 / 650	9.4x6.4 SG	TGA2902-1-SG
4W HPA, Balanced	13 - 17	(36) / 44	25	- / 30	6 - 7 / 1300	Die	TGA2502
6.5W HPA	13 - 18	(38) / 44	24	-	8 / 3600	Die	TGA2514
2W HPA, PD	13.75 - 14.5	(34) / 38.5	26	- / 30	7.5 / 650	9.4x6.4 SG	TGA2902-2-SG
4W HPA	24 - 31	35.5 (36) / -	23	-	6 / 2100	Die	TGA4505
4W HPA	25 - 31	35.5 (36) / -	22	-	6 / 2100	13.34x9.65 CP	TGA4905-CP
MPA	25 - 35	25 / -	18	-	6 / 220	4x4 QFN	TGA4902-SM
7W HPA	26 - 31	(38.5) / -	22	-	6 / 4200	13.4x16.5 CP	TGA4915-CP
1W HPA	27 - 31	30 / -	22	- / 25	4 - 6 / 420	Die	TGA4509
2W HPA	27 - 31	32.5 (33) / 36.5	20	- / 25	6 / 840	Die	TGA4513
MPA	27 - 32	24 / -	15	-	5 / 170	4x4 QFN	TGA4903-SM
1W HPA	28 - 31	30 / -	19	- / 25	6 / 420	4x4 QFN	TGA4509-SM
4W HPA	28 - 31	36 (36.5) / -	22	- / 22	6 / 1600	Die	TGA4906
4W HPA	28 - 31	36 (36.5) / -	22	- / 22	6 / 1600	5x5 QFN	TGA4906-SM
7W HPA	28 - 31	(38.5) / -	22	- / 20	6 / 3200	Die	TGA4916
Driver Amp	28 - 32	17 / 24	14.5	-	6 / 60	3x3 QFN	TGA4512-SM
Driver Amp	29 - 37	16 / -	16	-	6 / 60	Die	TGA4510

NOTES: SB = Self Biased, PD = Power Detector

Frequency Converters & Mixers

Description	RF Frequency Range (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
Doubler w/Amplifier	16 - 30	18	30	-	5 / 150	Die	TGC4403
Doubler w/Amplifier	16 - 30	15	25	-	5 / 150	4x4 QFN	TGC4406-SM

Up to 1W

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage Current (V / mA)	Package Style (mm)	Part Number
CATV Gain Block, Flex Gain	DC - 2	21 / 38	16 - 21	2 / -	5 - 8 / 100	SOT89	TAT7457*
12.5 Gb/s NRZ Driver	DC - 18	24 / -	16	3.5 / -	5 - 8 / 70 - 175	Die	TGA1328-SCC
12.5 Gb/s NRZ Driver	DC - 18	25 / -	16	3.5 / -	8 / 175	8.9x8.9 SL	TGA8652-SL
Wideband Driver (40 Gb/s)	DC - 35	18 / -	12	-	5 / 135	Die	TGA44832
CATV TIA / Gain Block, SB	0.04 - 1	27 / 46	20	1.5 / -	8 / 350	5x5 QFN	TGA2806-SM
CATV Gain Block	0.04 - 1	28 / -	18.5	2.5 / -	6 / 318	5x5 QFN	TGA2807-SM
On-Chip Linearized Amplifier DOCSIS® 3.0 Out	0.04 - 1	- / 43	17	4.7 / -	5 / 380	SOIC-8	TAT7467H
MESFET Amplifier	0.05 - 1	20 / 40	14.8	3.5 / -	5 / 150	SOT89	AH2
Dual HBT Amplifier	0.05 - 1	20 / 37	13.5	4.5 / -	>7 / 165	SOIC-8	AG606
Dual MESFET Amplifier	0.05 - 1	25.5 / 43	11.1	4.5 / -	5 / 320	SOIC-8	AH22S
MESFET IF Amplifier	0.05 - 1	22 / 42	19	2.2 / -	5 / 150	SOT89	AH31
Fiber to the Home TIA + Output Amp	0.05 - 1	-60 dBc CTB / CSO	38	2.9 pA / rHz EIN	10 - 12 / 120	4x4 QFN	TAT6254B*
Fiber to the Home TIA + Output Amp (RFoG)	0.05 - 1	-62 dBc CTB / CSO	32	3.9 pA / rHz EIN	5, 12 / 200, 130	4x4 QFN	TAT6254D
Fiber to the Home TIA + Output Amp (Hi Out)	0.05 - 1	-63 dBc CTB / CSO	33	3.9 pA / rHz EIN	5, 12 / 200, 130	4x4 QFN	TAT6254C
Dual pHEMT Amplifier, High Gain	0.05 - 1	- / 38	17.5	3.2 / -	5 / 235	SOIC-8	TAT7469
CATV Gain Block, High Gain, MOCA Multi	0.05 - 1	- / 41	22.5	2 / -	8 / 190	SOT89	TAT7430B
CATV Gain Block, High Gain, MOCA	0.05 - 1	- / 39	18	2 / -	6 / 145	SOT89	TAT7427
CATV Gain Block	0.05 - 1	- / 39	16	2.7 / -	6 / 130	SOT89	TAT7461
MESFET Amplifier	0.05 - 1.5	26.5 / 47	13.5	3.5 / -	9 / 200	SOT89	AH101
Dual pHEMT Amplifier	0.05 - 2	- / 41	13	4 / -	6 / 190	SOIC-8	TAT7466
30 dBm MESFET Amplifier	0.05 - 2.2	30 / 47	17	2.5 / -	11 / 330	6x6 QFN	AH202
Dual pHEMT Amplifier, Wideband	0.05 - 2.6	-77 dBc CTB / -83 dBc CSO	13	4.4 / -	5 / 160	SOIC-8	TAT7464
CATV Gain Block, Wideband	0.05 - 2.6	- / 36	16.5	2.5 / -	5 / 100	SOT89	TAT7460
24 dBm HBT Amplifier	0.06 - 2.5	24 / 40	19	5 / -	5 / 150	SOT89	AH114
MESFET Amplifier, 2-Stage	0.06 - 2.7	27 / 46	29	2.5 / -	4.5; 9 / 275	SOIC-8	AH103A
MESFET Gain Block	0.06 - 3	15 / 32	14	2.4 / -	4.5 / 50	SOT89	AG101
MESFET Gain Block	0.06 - 3	18 / 36	14	2.4 / -	4.5 / 70	SOT89	AG102
MESFET Gain Block	0.06 - 3	18 / 39	14	2.4 / -	4.5 / 78	SOT89	AM1
24.7 dBm HBT Amplifier	0.06 - 3.5	24.7 / 40	19.5	4 / -	5 / 160	SOT89	AH118
24.5 dBm HBT Amplifier	0.05 - 4	24.5 / 41.4	21	4.5 / -	5 / 88	SOT89	TQP7M9101*
25 dBm HBT Amplifier	0.06 - 3.5	25 / 40	19.5	4.6 / -	5 / 115	SOT89	AH128
MESFET Dual Amplifier	0.15 - 3	24 / 46	12	4.1 / -	5 / 300	SOIC-8	AH11
MESFET Amplifier	0.25 - 4	21.5 / 42	14	3.2 / -	5 / 150	SOT89	AH1
MESFET Amplifier	0.35 - 3	27 / 46	14.5	3.1 / -	9 / 200	SOT89	AH102A
27.5 dBm HBT Amplifier	0.4 - 4	27.5 / 44	21	4 / -	5 / 140	SOT89	TQP7M9102*
28.5 dBm HBT Amplifier	0.4 - 3.6	28.5 / 45	20	4.5 / -	5 / 150	SOT89	AH125
28 dBm HBT Amplifier	0.7 - 3.8	28 / 42	28.5	2.9 / -	5 / 225	4x4 QFN	TQP8M9013
28.7 dBm HBT Amplifier	0.8 - 1	28.7 / 43	17.5	7 / -	5 / 250	SOIC-8	AH116
28.5 dBm HBT Amplifier	1.8 - 2.3	28.5 / 44	14.5	6 / -	5 / 250	SOIC-8	AH115
Wideband PA, AGC	2 - 20	26 / -	8	-	8 / 440	Die	TGA8334-SCC
Wideband PA, AGC	2 - 22	28.5 (30) / 36	17	-	12 / 1100	Die	TGA2509
Bluetooth® Class 1 PA	2.4 - 2.5	21.5 / -	27	- / 50	0 - 3.3 / 160	2x2 QFN	TQP770001
WiMAX Driver Amp / PA, SB	3.4 - 3.8	30 / 42	24	-	6 / 770	5x5 QFN	TGA2703-SM
0.5W PA	6 - 18	27 / -	11	8 / -	8 / 400	Die	TGA8014-SCC
Driver Amp	7 - 13	(30) / 37	25	- / 30	9 / 450	Die	TGA2700
Wideband Driver Amp	8 - 18	13 / -	17	5 / -	4.5 / 50	Die	TGA8399C
Driver Amp	12 - 16	26 (26.5) / 37	23	7 / -	5 / 300	3x3 QFN	TGA2524-SM*
1W HPA	12 - 19	30 / -	30	-	5 - 7 / 435	Die	TGA2508
HPA	12 - 19	29 / -	25	-	5 - 7 / 435	4x4 QFN	TGA2508-SM

NOTES: * = New, SB = Self Biased, AGC = Automatic Gain Control

Up to 1W (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
1W HPA, PD	17 - 20	30 (32) / 42	20	–	5 - 7 / 825	Die	TGA4530
Driver Amp	17 - 24	22 / –	19	4 / –	5 / 270	4x4 QFN	TGA2521-SM
HPA, AGC, PD	17 - 24	(29) / 38	22	–	5 / 712	4x4 QFN	TGA2522-SM
HPA	17 - 27	29 (31) / 37	22	–	7 / 760	Die	TGA4502-SCC
HPA	18 - 27	29 / 37	14	–	6 / 480	Die	TGA1135-SCC
MPA	19 - 27	25 / 32	22	–	5 - 7 / 220	Die	TGA1073G-SCC
MPA	25 - 35	25 / –	18	–	6 / 220	4x4 QFN	TGA4902-SM
MPA	26 - 35	25 (32) / –	19	–	5 - 7 / 220	Die	TGA1073A-SCC
1W HPA	27 - 31	30 / –	22	– / 25	4 - 6 / 420	Die	TGA4509
MPA	27 - 32	24 / –	15	–	5 / 170	4x4 QFN	TGA4903-SM
HPA	27 - 32	28.5 / –	25	–	6 - 8 / 420	Die	TGA1073B-SCC
1W HPA	28 - 31	30 / –	19	– / 25	6 / 420	4x4 QFN	TGA4509-SM
Driver Amp	28 - 32	17 / 24	14.5	–	6 / 60	3x3 QFN	TGA4512-SM
Driver Amp	29 - 37	16 / –	16	–	6 / 60	Die	TGA4510
MPA	32 - 45	24 (25) / 33	16	–	6 / 175	Die	TGA4521
HPA	36 - 40	26 / –	15	–	5 - 7 / 240	Die	TGA1073C-SCC
HPA	36 - 40	30 / –	14	–	6 - 7 / 500	Die	TGA1171-SCC
MPA	33 - 47	27 (27.5) / 36	18	–	6 / 400	Die	TGA4522
HPA	37 - 40	28 / 38	24	6 / –	5 / 600	Die	TGA4538
0.5W HPA	40 - 45	28 / –	9	–	7 / 500	Die	TGA4043
Driver Amp	41 - 45	18 / –	14	–	6 / 168	Die	TGA4042

NOTES: AGC = Automatic Gain Control, PD = Power Detector

1W to 4W

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
31 dBm HBT Amplifier	0.4 - 2.3	31 / 46	18	7 / –	5 / 450	4x4 QFN	ECP100
33 dBm HBT Amplifier	0.4 - 2.3	33 / 49	18	8 / –	5 / 800	4x4 QFN	ECP200
31 dBm HBT Amplifier	0.4 - 2.3	31 / 46	18	7 / –	5 / 450	SOIC-8	AH215
33 dBm HBT Amplifier	0.4 - 2.3	33 / 49	18	8 / –	5 / 800	SOIC-8	AH312
31.5 dBm HBT Amplifier	0.4 - 2.7	31 / 47	20	5.9 / –	5 / 300	SOIC-8	AH225
33.5 dBm HBT Amplifier	0.4 - 2.7	33.5 / 50	19	4.6 / –	5 / 500	SOIC-8	AH322
35.5 dBm HBT Amplifier	0.4 - 2.7	35.5 / 50	16	7 / –	5 / 800	4x5 DFN	AH420
33 dBm HBT Amplifier	0.7 - 2.7	33 / 50	27.5	7 / –	5 / 680	5x5 QFN	AH323
InGaP HBT PA, 1.8W, Ultra High Linearity	0.8 - 2.35	32.5 / 49	15.8	– / 55	28 / 40	5x6 DFN	AP601
InGaP HBT PA, 3.7W, Ultra High Linearity	0.8 - 2.35	35.7 / 52	15.5	– / 55	28 / 80	5x6 DFN	AP602
30 dBm HBT Amplifier	1.8 - 2.7	30.5 / 46.5	27	5.5 / –	5 / 400	SOIC-8 / 4x5 DFN	AH212
33 dBm HBT Amplifier	3.3 - 3.8	33 / –	25	–	5 / 600	5x5 QFN	AH315
2W HPA	5.5 - 8.5	32 (34) / 41	30	7 / –	6 / 1260	5x5 QFN	TGA2706-SM
2.5W HPA	5.9 - 8.5	34 (35) / 42	18	7.5 / 37	6 / 1000	6x6 QFN	TGA2701-SM
2.8W HPA	6 - 18	(34.5) / –	24	– / 20	7 - 9 / 800 - 1200	Die	TGA2501
HPA	6 - 18	(34.5) / –	24	– / 20	8 / 1200	Die	TGA9092-SCC
2W HPA	12.3 - 15.7	(31) / –	33	7 / –	6 / 850	Die	TGA2520
2W HPA	12.5 - 16	(32) / 37	32	–	6 - 7 / 680	4x4 QFN	TGA2503-SM
2W HPA	12.5 - 17	(34) / –	26	– / 25	7.5 / 650	Die	TGA2510
2W HPA	12.5 - 17	(33.5) / –	25	– / 25	7.5 / 650	6.4x9.4 SG	TGA2510-SG
2W HPA	12.7 - 15.4	34 (35) / 43	28	6 / –	6 / 1300	Die	TGA2533*
2W HPA	12.7 - 15.4	33 (34.5) / 43	27	6 / –	6 / 1300	5x5 QFN	TGA2533-SM*
4W HPA	13 - 15	(36) / 41	25	–	7 / 1300	17.8x8.4 FL	TGA8659-FL
2W HPA	13 - 17	(34) / 40	32	–	6 - 7 / 680	Die	TGA2503
2W HPA	13 - 17	(34) / –	25	–	6 - 7 / 640	Die	TGA2505
2W HPA, PD	13 - 17	(34) / 38.5	26	– / 30	7.5 / 650	6.4x9.4 SG	TGA2902-1-SG

NOTES: * = New, PD = Power Detector

1W to 4W (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
2W HPA	13 - 17	(34) / –	33	–	5 - 8 / 680	17.8x8.4 FL	TGA2904-FL
2W HPA	13 - 17	(34) / 40	33	–	5 - 8 / 680	6.4x9.4 SG	TGA8658-SG
2W HPA, PD	13.75 - 14.5	(34) / 38.5	26	– / 30	7.5 / 650	6.4x9.4 SG	TGA2902-2-SG
HPA	17 - 20	30.5 / 41	23	– / –	6 / 900	Die	TGA4532
HPA	17 - 20	31 (32) / 41	22	6.5 / –	6 / 820	4x4 QFN	TGA4532-SM
HPA	17 - 24	31 (32) / 40	23	6 / –	7 / 720	Die	TGA4531
2W HPA	18 - 23	32 (33) / 39	26	–	7 / 840	Die	TGA4022
HPA	21 - 24	31 (32) / 41	22	6 / –	6 / 880	4x4 QFN	TGA4533-SM*
4W HPA	24 - 31	35.5 (36) / –	23	–	6 / 2100	Die	TGA4505
4W HPA	25 - 31	35.5 (36) / –	22	–	6 / 2100	13.34x9.65 CP	TGA4905-CP
2W HPA	27 - 31	32.5 (33) / 36.5	20	– / 25	6 / 840	Die	TGA4513
3.5W HPA	30-38	(35) / –	18	– / 20	6 / 2100	Die	TGA2575*
2W HPA	30 - 40	31.5 (33) / –	20	–	6 / 1050	Die	TGA4516
2W HPA	31 - 35	31.5 (33.5) / –	19	–	6 - 7 / 1150	Die	TGA4514
3.5W HPA	31 - 37	(35.5) / –	20	–	6 / 2000	Die	TGA4517
2W HPA	41 - 47	(33) / –	16	–	6 / 2000	Die	TGA4046
77 GHz MPA	76 - 80	14 / –	12	–	3.5 / 75	Die	TGA4706-FC

NOTES: * = New, PD = Power Detector

More Than 4W

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	PAE (%)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
10W HPA	0.03 - 3	39.5 / 43	19.5	40	35 / 360	Flange	TGA2540-FL
39 dBm HBT Amplifier	0.7 - 2.9	39 / –	16.5	8	12 / 300	5x6 DFN	AP561
InGaP HBT PA, 7W Ultra High Linearity	0.8 - 2.35	38.5 / 55.5	17	53	28 / 160	5x6 DFN	AP603
14W HPA	2 - 18	41.5 / –	10	23	35 / 1200	Die	TGA2573
120W TriPower™ HVHBT Amplifier	2.11 - 2.17	51.1 / –	16.6	64.5	28 / 550	Flanged Screw Down	TG2H214120-FL*
120W TriPower™ HVHBT Amplifier	2.11 - 2.17	51.1 / –	16.6	64.5	28 / 550	Flanged Solder Down	TG2H214120-FS*
220W TriPower™ HVHBT Amplifier	2.11 - 2.17	53.9 / –	16.4	65.4	28 / 600	Flanged Screw Down	TG2H214220-FL*
30W HPA	2.5 - 6	(45) / –	27	38	30 / 1400	Die	TGA2576*
39 dBm HBT Amplifier	3.3 - 3.8	39 / –	11.5	–	12 / 400	5x6 DFN	AP562
HPA	6.5 - 11.5	37 (39) / –	19	35	7 - 9 / 1200	Die	TGA9083-SCC
16W HPA	6.5 - 12.5	42 / –	27	35	12 / 3000	Die	TGA2517
HPA	7 - 8.5	(38) / –	21	42	7 / 2000	Die	TGA2701
HPA	9 - 10.5	(38) / –	20	>38	4 - 9 / 2000	Die	TGA2704
HPA	10.5 - 12	(38) / –	19	>39	4 - 9 / 2000	Die	TGA2710
6.5W HPA	13 - 16	(38) / –	24	–	8 / 2600	11.4x17.3 FL	TGA2514-FL
4W HPA, Balanced	13 - 17	(36) / 44	25	30	6 - 7 / 1300	Die	TGA2502
6.5W HPA	13 - 18	(38) / 44	24	–	8 / 3600	Die	TGA2514
20W HPA	14 - 16	(43) / –	19	>30	35 / 2000	Die	TGA2572*
7W HPA	26 - 31	(38.5) / –	22	–	6 / 4200	13.4x16.5 CP	TGA4915-CP
4W HPA	28 - 31	36 (36.5) / –	22	22	6 / 1600	Die	TGA4906
4W HPA	28 - 31	36 (36.5) / –	22	22	6 / 1600	5x5 QFN	TGA4906-SM
7W HPA	28 - 31	(38.5) / –	22	20	6 / 3200	Die	TGA4916

NOTES: * = New

Variable Gain Amplifiers

Description	Frequency Range (GHz)	P1dB / OIP3 (dB)	Gain (dB)	Gain Range (dB)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
Variable Gain Amplifier	0.05 - 2.2	22 / 42	15.5	20	5 / 150	4x4 QFN	VG025
Variable Gain Amplifier	0.7 - 1	22 / 40	16	29	5 / 150	6x6 QFN	VG101
Variable Gain Amplifier	0.7 - 2.8	27.5 / 43	29	30	5 / 240	5x5 QFN	TQM8M9074*
Variable Gain Amplifier	1.8 - 2.7	22 / 39.5	13.5	26.5	5 / 150	6x6 QFN	VG111
Digital Variable Gain Amplifier	1.8 - 2.7	24.5 / 41.5	31	31.5	5 / 200	6x6 QFN	TQM879006*

NOTES: * = New

Gain Block

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
General Purpose Gain Block	DC - 3	18.5 / 33	16.5	3.8	6 / 75	SOT89	AG603
General Purpose Gain Block	DC - 3.5	18.5 / 33	13.6	4.4	6 / 75	SOT89	AG602
General Purpose Gain Block	DC - 3.5	20.5 / 33.5	17.2	3.5	7 / 96	SOT89	EC1078
General Purpose Gain Block	DC - 4	19.5 / 31	18.5	2.9	6 / 70	SOT89	EC1019
General Purpose Gain Block	DC - 4	17.5 / 32	21.5	3.4	6 / 65	SOT89	ECG005
General Purpose Gain Block	DC - 4	23.5 / 37	14.3	4.6	9 / 120	SOT89	ECG008
General Purpose Gain Block	DC - 4	18 / 34.5	15.3	5.5	6 / 70	SOT89	ECG040
General Purpose Gain Block	DC - 5.5	15 / 30	14.2	3.7	5 / 45	SOT86 / SOT363 /	ECG006
General Purpose Gain Block	DC - 6	5.8 / 18.5	11	4.4	5 / 20	SOT86 / SOT363	AG201
General Purpose Gain Block	DC - 6	7.5 / 19.5	17.7	3.1	5 / 20	SOT86 / SOT363	AG203
General Purpose Gain Block	DC - 6	12 / 25	14.3	3.2	5 / 35	SOT86 / SOT363	AG302
General Purpose Gain Block	DC - 6	12.5 / 25	18.4	3	5 / 35	SOT86 / SOT363	AG303
General Purpose Gain Block	DC - 6	16 / 28.5	14.5	3.7	6 / 60	SOT86 / SOT89	AG402
General Purpose Gain Block	DC - 6	16 / 28	18.9	3	6 / 60	SOT86 / SOT89	AG403
General Purpose Gain Block	DC - 6	14.5 / 27.5	19.1	2.9	6 / 45	SOT86 / SOT89	AG503
General Purpose Gain Block	DC - 6	19 / 33	18.2	3.5	6 / 75	SOT86 / SOT89	AG604
General Purpose Gain Block	DC - 6	12.5 / 26	21.4	3.4	5 / 30	SOT363 / SOT89	ECG001
General Purpose Gain Block	DC - 6	15 / 29	19.5	3.7	5 / 45	SOT86 / SOT363 /	ECG002
General Purpose Gain Block	DC - 6	23 / 36	19	3.5	9 / 110	SOT89	ECG003
General Purpose Gain Block	DC - 6	13 / 27	15.5	3.2	5 / 35	SOT89	ECG004
General Purpose Gain Block	DC - 6	18.2 / 32	20.1	3.4	6 / 65	SOT86 / SOT89	ECG055
MESFET IF Gain Block	0.05 - 0.87	20 / 41	13	3	5 / 150	SOT89	AH3
LNA / Gain Block (40 Gb/s)	DC - 40	11.5 / 20	13	3.2	5 / 50	Die	TGA4830
CATV TIA / Gain Block, SB	0.04 - 1	27 / 46	20	1.5	8 / 350	4x4 QFN	TGA2803-SM
+5V Active Bias IF Gain Block	0.05 - 1	20.5 / 33	17.5	5	5 / 95	SOT89	WJA1500
+5V Active Bias IF Gain Block	0.05 - 1	19 / 33.5	17.5	4.7	5 / 65	SOT89	WJA1505
+5V Active Bias IF Gain Block	0.05 - 1	20 / 36	14	5.4	5 / 95	SOT89	WJA1510
+5V Active Bias Gain Block	0.05 - 2.3	19 / 28.5	14	5.2	5 / 85	SOT89	WJA1010
+5V Active Bias Gain Block	0.05 - 3	20 / 34	16.7	5.4	5 / 100	SOT89	WJA1001
E-pHEMT LNA Gain Block	0.05 - 4	21 / 36	20	1.3	5 / 85	SOT89	TQP3M9008
E-pHEMT LNA Gain Block	0.05 - 4	21.4 / 37.5	22	1.1	5 / 85	3x3 QFN	TQP3M9018*
E-pHEMT LNA Gain Block	0.05 - 4	22 / 40	21.5	1.3	5 / 125	SOT89	TQP3M9009
E-pHEMT LNA Gain Block	0.05 - 4	22 / 40.5	24.7	0.9	5 / 125	3x3 QFN	TQP3M9019*
E-pHEMT LNA Gain Block	0.05 - 4	21.5 / 40	15	2.0	5 / 85	SOT89	TQP3M9028*
+5V Active Bias Gain Block	0.05 - 4	20 / 37.5	16.7	5.6	5 / 90	SOT89	WJA1021
+5V Active Bias Gain Block	0.05 - 4	19.3 / 36.5	14.5	5.5	5 / 80	SOT89	WJA1030
E-pHEMT LNA Gain Block	0.5 - 4	22 / 35	19	0.8	5 / 55	3x3 QFN	TQP3M9005*
E-pHEMT LNA Gain Block	0.5 - 4	22.5 / 38.5	18.5	1	5 / 90	3x3 QFN	TQP3M9006*
E-pHEMT LNA Gain Block	0.5 - 4	23.5 / 42	18	1.3	5 / 135	SOT89	TQP3M9007*
Gain Block, SB	2 - 10	17 / -	17	6	5 / 90	Die	TGA8810-SCC
Gain Block	2 - 18	20 / -	7.5	5.5	6 / 100	Die	TGA8300-SCC

NOTES: * = New, SB = Self Biased

Gain Block

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
Wideband Gain Block, AGC	2 - 20	20 / –	7.5	7	6 / 150	Die	TGA8622-SCC
Gain Block	6 - 18	12.5 / –	13	5	5 / 80	Die	TGA8035-SCC
Driver Amp, SB	11 - 17	17 / –	23	6	6 / 75	4x4 QFN	TGA2507-SM
Driver Amp, SB	12 - 18	14 / –	17	–	6 / 40	Die	TGA2506
Driver Amp, SB	12 - 18	20 / –	28	6	6 / 80	Die	TGA2507
Gain Block & 2x / 3x Multiplier	17 - 37	18 (22) / 26	20	7	5 / 140	3x3 QFN	TGA4030-SM
Gain Block & 2x / 3x Multiplier	17 - 40	18 (22) / 24	22	7	5 / 140	3x3 QFN	TGA4031-SM
Gain Block, Multiplier	17 - 43	22 / –	25	–	5 / 225	Die	TGA4040
Gain Block	19 - 38	(22) / 30	20	–	5 / 160	Die	TGA4036

NOTES: SB = Self Biased, AGC = Automatic Gain Control

Low Noise

Description	Frequency Range (GHz)	P1dB / IIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
LNA, AGC	DC - 14	16 / –	11	3.1	8 / 80	Die	TGA8349-SCC
LNA / Gain Block (40 Gb/s)	DC - 40	11.5 / 20	13	3.2	5 / 50	Die	TGA4830
E-pHEMT LNA Gain Block	0.05 - 4	21 / 36	20	1.3	5 / 85	SOT89	TQP3M9008
E-pHEMT LNA Gain Block	0.05 - 4	21.4 / 37.5	22	1.1	5 / 85	3x3 QFN	TQP3M9018*
E-pHEMT LNA Gain Block	0.05 - 4	22 / 40	21.5	1.3	5 / 125	SOT89	TQP3M9009
E-pHEMT LNA Gain Block	0.05 - 4	22 / 40.5	24.7	0.9	5 / 125	3x3 QFN	TQP3M9019*
E-pHEMT LNA Gain Block	0.05 - 4	21.5 / 40	15	2	5 / 85	SOT89	TQP3M9028*
E-pHEMT LNA Gain Block	0.5 - 4	22 / 35	19	0.8	5 / 55	3x3 QFN	TQP3M9005*
E-pHEMT LNA Gain Block	0.5 - 4	22.5 / 38.5	18.5	1	5 / 90	3x3 QFN	TQP3M9006*
E-pHEMT LNA Gain Block	0.5 - 4	23.5 / 42	18	1.3	5 / 135	SOT89	TQP3M9007*
LNA, Balanced FET Low Band	0.7 - 0.92	– / 13.5	20.5	0.55	4 / 70	4x4 QFN	TQP3M6004
LNA, Discrete Low Band	0.7 - 0.92	26 / 23.5	16	0.8	5 / 150	SOT89	TGF2021-04-SD
LNA, Balanced FET	0.8 - 3	21 / 11	22	0.7	4 / 100	2x2 QFN	TGA2602-SM
LNA, Balanced FET Mid Band	1.7 - 2	– / 14.4	18	0.55	3.5 / 50	4x4 QFN	TQP3M6005*
LNA, AGC	2 - 18	18 / 29	17	2	5 / 75	Die	TGA2525
LNA, AGC	2 - 18	16 / –	19	4	5 / 120	Die	TGA8344-SCC
LNA, AGC	2 - 20	17.5 / –	9	3.5	5 - 8 / 60	Die	TGA1342-SCC
LNA, AGC	2 - 20	19 / –	17.5	2.5	5 / 100	Die	TGA2526
LNA, AGC	2 - 20	17.5 / –	9	3.5	5 - 8 / 60	Die	TGA8310-SCC
LNA, AGC	2 - 20	16 / –	17	2.5	5 / 75	4x4 QFN	TGA2513-SM
LNA, AGC	2 - 23	17 / 26	17	2	5 / 75	Die	TGA2513
LNA, SB, AGC	4 - 14	6 / 16	22	2.3	5 / 90	4x4 QFN	TGA2512-1-SM
LNA, AGC, GB	4 - 14	13 / 24	25	2.3	5 / 160	4x4 QFN	TGA2512-2-SM
LNA, SB, AGC	5 - 15	6 / 13	27	1.4	5 / 90	Die	TGA2512
LNA, SB	6 - 13	11 / –	26	1.5	5 / 65	Die	TGA8399B-SCC
LNA, SB, AGC	6 - 14	6 / 12	20	1.3	5 / 90	Die	TGA2511
LNA	20 - 27	12 / –	21	2.2	3.5 / 60	Die	TGA4506
LNA	28 - 36	12 / 21	22	2.3	3 / 60	Die	TGA4507
LNA	30 - 42	14 / –	21	2.8	3 / 40	Die	TGA4508
LNA	57 - 69	–	13	4	3 / 41	Die	TGA4600
77 GHz LNA	72 - 80	–	20	5	3.5 / 54	Die	TGA4705-FC

NOTES: * = New, SB = Self Biased, AGC = Automatic Gain Control, GB = Gate Bias

Discrete Transistors

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
MESFET	DC - 2.5	26.5 / –	11	1.72 / 55	2 - 6 / 350	SOT223	CLY5
MESFET	DC - 3	23.5 / –	15.5	1.48 / 55	2 - 6 / 180	MW6	CLY2

Discrete Transistors (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
24mm HFET	DC - 4	40 / -	13	- / 51	8 / 2170	Die	TGF4124
18mm HFET	DC - 6	38.5 / -	13.5	- / 53	8 / 1690	Die	TGF4118
0.5W HFET	DC - 6	28 / 40	18	3.2 / -	8 / 100	SOT89	TGF2960-SD
1W HFET	DC - 6	31 / 43	16	4 / -	8 / 200	SOT89	TGF2961-SD
12mm HFET	DC - 8	37 / -	14	- / 55	8 / 750	Die	TGF4112
4.8mm HFET	DC - 10.5	34 / -	8.5	- / 53	8 / 200	Die	TGF4250-SCC
9.6mm HFET	DC - 10.5	37 / -	9.5	- / 52	8.5 / 520	Die	TGF4260-SCC
1.2mm HFET	DC - 12	28.5 / -	10	- / 55	8 / 50	Die	TGF4230-SCC
2.4mm HFET	DC - 12	31.5 / -	10	- / 56	8 / 100	Die	TGF4240-SCC
1mm Pwr pHEMT	DC - 12	(31.5) / -	11	- / 55	12 / 900	Die	TGF2021-01
2mm Pwr pHEMT	DC - 12	(34.5) / -	11	- / 55	12 / 150	Die	TGF2021-02
4mm Pwr pHEMT	DC - 12	(37.5) / -	11	- / 55	12 / 300	Die	TGF2021-04
8mm Pwr pHEMT	DC - 12	(40.2) / -	11	- / 55	12 / 600	Die	TGF2021-08
12mm Pwr pHEMT	DC - 12	(42) / -	11	- / 52	12 / 900	Die	TGF2021-12
0.3mm MESFET	DC - 18	13 / -	11	1.5 / -	3 / 15	Die	TGF1350-SCC
1.25mm GaN HEMT	DC - 18	(38) / -	15	- / 55	28 / 125	Die	TGF2023-01
2.5mm GaN HEMT	DC - 18	(41) / -	15	- / 55	28 / 250	Die	TGF2023-02
5.0 GaN HEMT	DC - 18	(44) / -	15	- / 55	28 / 500	Die	TGF2023-05
10mm GaN HEMT	DC - 18	(47) / -	15	- / 55	28 / 1000	Die	TGF2023-10
20mm GaN HEMT	DC - 18	(50) / -	15	- / 55	28 / 2000	Die	TGF2023-20
0.6mm Pwr pHEMT	DC - 20	(29) / -	13	- / 56	12 / 45	Die	TGF2022-06
1.2mm Pwr pHEMT	DC - 20	(32) / -	13	- / 56	12 / 90	Die	TGF2022-12
2.4mm Pwr pHEMT	DC - 20	(35) / -	13	- / 58	12 / 180	Die	TGF2022-24
4.8mm Pwr pHEMT	DC - 20	(38) / -	13	- / 58	12 / 360	Die	TGF2022-48
6mm Pwr pHEMT	DC - 20	(39) / -	12.5	- / 53	12 / 448	Die	TGF2022-60
0.3mm pHEMT	DC - 22	16 / -	13	0.8 / -	3 / 15	Die	TGF4350
7W GaN HEMT	DC - 6	(40.4) / -	9.5	- / 50	28 / 50	Ceramic Flat Lead	TIG6000528-Q3
18W GaN HEMT	DC - 6	(43.4) / -	15	- / 50	28 / 50	Ceramic Flat Lead	TIG6001528-Q3*
55W GaN HEMT	DC - 3.5	47.2 / -	15	- / 50	28 / 200	Ceramic Flat Lead	TIG4005528-FS*
MESFET	0.05 - 4	21 / 42	19	2 / -	5 / 140	SOT89	FH1
MESFET	0.05 - 4	18 / 36	19	2 / -	5 / 140	SOT89	FH101
0.5W HFET	0.05 - 4	27 / 40	19	2.7 / -	8 / 125	SOT89	FP1189
1W HFET	0.05 - 4	30 / 44	18	4.5 / -	8 / 250	SOT89	FP2189
2.5W HFET	0.05 - 4	34 / 46	18	3.5 / -	9 / 450	6x6 QFN	FP31QF
30W LDMOS	0.5 - 2	45 / -	10	- / 45	28 / 200	PowerBand™	T1L2003028-SP
10W pHEMT	0.5 - 3	40 / -	10	- / 45	12 / 200	PowerBand™	T1P2701012-SP

NOTES: * = New

Frequency Converters & Mixers

Description	RF Frequency Range (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
WB Mixer, LO	0.5 - 2.5	-5.7	8	24	3 - 6 / 6	MW6	CMY210
WB Mixer, LO, IF	0.5 - 2.5	10	8	9	3 - 6 / 12	SCT598	CMY212
WB Mixer, LO, IF, Low Current	0.5 - 2.5	9.5	10	10	3 - 6 / 8	SCT598	CMY213
Mixer, LO	0.7 - 1	-9	17	36	5 / 50	MSOP-8	ML483
Single Branch Converter, RF, LO, IF	0.8 - 0.92	22	60	15	5 / 360	6x6 QFN	CV110-1A
Single Branch Converter, RF, LO, IF	0.8 - 0.96	22	60	15	5 / 360	6x6 QFN	CV110-3A
Dual Branch Converter, LO, IF	0.8 - 0.96	10.5	14	18.5	5 / 390	6x6 QFN	CV210-3A
Mixer, LO	1.5 - 3.2	-8.5	2	35	5 / 40	MSOP-8	ML485
Single Branch Converter, RF, LO, IF	1.7 - 2.0	21	45	17	5 / 360	6x6 QFN	CV111-1A

Frequency Converters & Mixers (cont.)

Description	RF Frequency Range (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
Single Branch Converter, RF, LO, IF	1.9 - 2.2	21	40	17	5 / 360	6x6 QFN	CV111-3A
Mixer, LO	1.9 - 2.7	-8.1	9	30	5 / 110	SOIC-8	ML501
Doubler w/Amplifier	16 - 30	18	30	22	5 / 150	Die	TGC4403
Doubler w/Amplifier	16 - 30	18	30	19	5 / 150	4x4 QFN	TGC4403-SM
Upconverting Mixer	17 - 26	-9	40	–	-0.9 / 0	4x4 QFN	TGC4402-SM
Upconverting Mixer	17 - 27	-9	35	18	-0.9 / 0	Die	TGC4402
Upconverter	17 - 27	13	30	–	5 / 425	Die	TGC4405
Upconverter	17 - 27	13	30	–	5 / 425	4x4 QFN	TGC4405-SM
Gain Block & 2x / 3x Multiplier	17 - 37	9	–	6	5 / 140	3x3 QFN	TGA4030-SM
Gain Block & 2x / 3x Multiplier	17 - 40	9	–	2	5 / 140	3x3 QFN	TGA4031-SM
19 GHz VCO w/8:1 Prescaler	18.5 - 19.5	–	-105**	7	5 / 158	Die	TGV2204-FC
Doubler (Input 10 - 20 GHz)	20 - 40	-12	25	18	–	Die	TGC1430F
Tripler (Input 8.5 - 13.5 GHz)	20 - 40	-15	15	18	–	Die	TGC1430G
19 / 38 GHz Converter / MPA	36 - 40	9	–	14.5	3.5 / 65	Die	TGC4703-FC
Down Converting I/Q Mixer	75 - 82	-13.5	22	–	1.1 / 7	Die	TGC4702-FC
38 / 77 GHz Converter / MPA	76 - 77	6	–	15	4 / 230	Die	TGC4704-FC

NOTES: ** = Phase Noise (dBc / Hz @ 1 MHz Offset), LO = LO Amplifier, IF = IF Amplifier

Signal Conditioning

Description	Frequency Range (GHz)	Insertion Loss (dB)	Control Range dB or (Deg.)	PI dB (dBm)	Supply Voltage (V)	Package Style (mm)	Part Number
Through Line	DC - 6	0.1	–	–	–	3x3 QFN	TQM4M9073*
6-Bit, Digital Attenuator, Parallel Ctrl	DC - 4	1.3	31.5	30	5 / 0	4x4 QFN	TQP4M9071
6-Bit, Digital Attenuator, Serial Ctrl	DC - 4	1.3	31.5	30	5 / 0	4x4 QFN	TQP4M9072
Analog Attenuator	DC - 30	2	17	–	0 to -2	3x3 QFN	TGL4203-SM
Analog Attenuator	DC - >50	2	17	–	0 to -2	Die	TGL4203
Discrete Thru (0 dB Attenuator)	DC - 65	0	0	–	–	Die	TGL4201-00
Discrete Attenuators	DC - 65	–	2, 3, 6, 10	–	–	Die	TGL4201-02, 03, 06, 10
Passive Wideband Limiter	2 - 12	<1	–	18	–	3x3 QFN	TGL2201-SM*
Analog Attenuator	2 - 20	2	15	23	2.5	Die	TGL8784-SCC
Passive Wideband Limiter	3 - 25	<0.5	–	18	–	Die	TGL2201
5-Bit Phase Shifter	6 - 18	9	(348)	–	6	Die	TGP6336
Bessel Filter	–	6, 7, 8, 9, 10 & 11 Cut-Off Freq	–	–	–	Die	TGB2010-00, -09 etc.
Bessel Filter	–	5, 6, 6.5, 7.5, 8 & 9 Cut-Off Freq	–	–	–	2x2 QFN	TGB2010-00, -09-SM etc.
6-Bit Phase Shifter	8.5 - 11	5	(354)	–	0 / -5	Die	TGP2103
Lange Coupler	12 - 21	<0.25	–	–	–	Die	TGB2001
5-Bit Phase Shifter	18 - 20	5	(180)	–	-2.5	Die	TGP1439
Lange Coupler	18 - 32	<0.25	–	–	–	Die	TGB4001
Lange Coupler	27 - 45	<0.25	–	–	–	Die	TGB4002
5-Bit Phase Shifter	28 - 32	6	(348)	–	5	Die	TGP2100
5-Bit Phase Shifter	33 - 37	6	(348)	–	-5	Die	TGP2102
1-Bit Phase Shifter	34 - 36	4	180	–	0 / 5	Die	TGP2104

NOTES: * = New

Switches

Description	Frequency Range (GHz)	Insertion Loss (dB)	Isolation (dB)	PI dB (dBm)	Control Voltage (V)	Package Style (mm)	Part Number
SP3T High Power CDMA	DC - 2	0.6	22	34.5	2.6 / 0	2x2 QFN	TQP4M3019
SP2T 802.11 a, b, g	DC - 6	0.6	28	31.5	3 / 0	1.3x2 DFN	TQS5200
Diversity Switch 802.11 a, b, g	DC - 6	0.8	33	33	3 / 0	3x3 QFN	TQS5202
SPDT - GaN	DC - 6	<1	40	45	-40 / 0	Die	TGS2351*
SPDT - GaN	DC - 6	<1	40	45	-40 / 0	4x4 QFN	TGS2351-SM*
SPDT - GaN	DC - 12	<1	35	43	-40 / 0	Die	TGS2352*
SPDT - GaN	DC - 18	<1	30	40	-40 / 0	Die	TGS2353*
SPDT FET	DC - 18	1.5	36	27	-5	Die	TGS2306
SPDT FET	DC - 18	2	39	21	-7 / 0	Die	TGS8250-SCC
SP3T VPIN	1 - 20	0.5	35	23	10 mA	Die	TGS2303
SP4T VPIN	1 - 20	0.6	38	23	10 mA	Die	TGS2304-SCC
SP3T VPIN	4 - 18	1	35	20	+/- 2.7	Die	TGS2313
SPDT VPIN	4 - 20	0.9	35	>20	+/- 2.7	Die	TGS2302
SPDT VPIN	24 - 43	<2	36	27	+/- 5	Die	TGS4301
SPDT VPIN	27 - 46	0.9	30	>34	+/- 5 / 15	Die	TGS4302
SPDT VPIN Absorptive	32 - 40	1	36	>33	+/- 5 / 18	Die	TGS4304
SP3T	60 - 90	2.3	20	>-13	-5 / 1.35	Die	TGS4305-FC
SP4T	70 - 90	3	20	>-8	-5 / 1.35	Die	TGS4306-FC

NOTES: * = New

Protectors

Description	Application	Leakage Current (nanoAmps)	Trigger Voltage (V)	Series Capacitance (pF)	Package Area (mm ²)	Package Style	Part Number
CATV Protector	ESD & Secondary Protection	20 @ 1V, 500 @ 15V	18, 25, 41	0.29, 0.29, 0.22	1.8	T / SLP-3	TQP200002

SAW

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
Cable IF Filter	36.15	8	19.7	SE / SE	38 @ 10.23	DIP	855748
Cable IF Filter	44	6	20.4	SE / SE	38 @ 7.6	DIP	855079
CDMA IF Filter	69.99	1.26	17.1	SE / SE	25 @ 1.68	24.6x9	856199
BWA / WiMAX IF Filter	70	8	12.95	SE / SE	35 @ 3.2	13.3x6.5	855677
Low Loss IF Filter	70	0.5	7.6	SE / SE	35 @ 1.28	19x6.5	854651
Low Loss IF Filter	70	1	7.3	SE / SE	40 @ 2.8	19x6.5	854652
Low Loss IF Filter	70	1.5	7.5	SE / SE	40 @ 3.2	19x6.5	854653
Low Loss IF Filter	70	2	7.85	SE / SE	40 @ 4.25	19x6.5	854654
Low Loss IF Filter	70	2.5	8.75	SE / SE	40 @ 4.6	19x6.5	854655
Low Loss IF Filter	70	3	6.95	SE / SE	35 @ 6.9	13.3x6.5	854656
Low Loss IF Filter	70	3.5	7.25	SE / SE	35 @ 7.2	13.3x6.5	854657
Low Loss IF Filter	70	4	6.8	SE / SE	40 @ 8.25	13.3x6.5	854658
Low Loss IF Filter	70	4.5	6.8	SE / SE	35 @ 8.5	13.3x6.5	854659
Low Loss IF Filter	70	5	7.25	SE / SE	40 @ 9.35	13.3x6.5	854660
Low Loss IF Filter	70	6	7.5	SE / SE	40 @ 10.2	13.3x6.5	854661
Low Loss IF Filter	70	7	8.5	SE / SE	40 @ 11.55	13.3x6.5	854662
Low Loss IF Filter	70	8	9	SE / SE	40 @ 13.25	13.3x6.5	854663
Low Loss IF Filter	70	9	9.75	SE / SE	40 @ 13.9	13.3x6.5	854664
Low Loss IF Filter	70	10	10	SE / SE	40 @ 15	13.3x6.5	854665
Low Loss IF Filter	70	12	11.5	SE / SE	40 @ 17.35	13.3x6.5	854666

SAW (cont.)

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
Low Loss IF Filter	70	14	12.5	SE / SE	40 @ 19.5	13.3x6.5	854667
Low Loss IF Filter	70	16	12.5	SE / SE	40 @ 21.4	13.3x6.5	854668
Low Loss IF Filter	70	18	13.5	SE / SE	40 @ 23.4	13.3x6.5	854669
Low Loss IF Filter	70	20	14.5	SE / SE	40 @ 25.4	13.3x6.5	854670
Low Loss IF Filter	70	22	15	SE / SE	40 @ 27.25	13.3x6.5	854671
Low Loss IF Filter	70	24	16.25	SE / SE	40 @ 29.65	13.3x6.5	854672
Low Loss IF Filter	70	26	17	SE / SE	40 @ 32	13.3x6.5	854673
Low Loss IF Filter	70	28	17.6	SE / SE	40 @ 33.75	13.3x6.5	854674
Low Loss IF Filter	70	30	17.5	SE / SE	40 @ 37	13.3x6.5	854675
Low Loss IF Filter	70	36	20.2	SE / SE	40 @ 43.3	13.3x6.5	854678
Low Loss IF Filter	70	40	21.5	SE / SE	40 @ 47.25	13.3x6.5	854680
High Selectivity IF Filter	70	0.3	16.36	SE / SE	40 @ 0.9	24.6x9	855735
High Selectivity IF Filter	70	0.5	21.3	SE / SE	40 @ 1.63	24.6x9	855736
High Selectivity IF Filter	70	1	22.2	SE / SE	40 @ 2.11	24.6x9	855737
High Selectivity IF Filter	70	1.5	21.6	SE / SE	40 @ 2.52	24.6x9	855738
High Selectivity IF Filter	70	2	23	SE / SE	40 @ 3.4	24.6x9	855739
High Selectivity IF Filter	70	2.5	20.25	SE / SE	40 @ 4.3	24.6x9	855740
High Selectivity IF Filter	70	3	23	SE / SE	40 @ 4.46	24.6x9	855741
High Selectivity IF Filter	70	3.5	19	SE / SE	40 @ 6	15.3x6.5	855742
High Selectivity IF Filter	70	4	23	SE / SE	40 @ 6	19x6.5	855743
High Selectivity IF Filter	70	4.5	23.7	SE / SE	40 @ 6.64	19x6.5	855744
High Selectivity IF Filter	70	5.5	22.2	SE / SE	40 @ 7.84	19x6.5	855745
CDMA IF Filter	73.59	1.2	11.9	SE / SE	45 @ 79.58	19x6.5	856111
Medical IF Filter	73	0.3	6	SE / SE	45 @ 69.9	24.6x9	856152*
BWA / WiMAX IF Filter	80	8	11.7	SE / SE	35 @ 14.25	13.3x6.5	855679
GSM IF Filter	86.6	0.4	5.3	SE / BAL	28 @ 1.58	19x6.5	854823
GSM IF Filter	87	0.4	4.4	BAL / BAL	28 @ 1.59	19x6.5	855500
CDMA IF Filter	118.58	3.69	17.4	SE / SE	43 @ 123.48	13.3x6.5	855958
GSM IF Filter	125	0.4	5.9	SE / SE	20 @ 2.4	9.1x4.8	856444
Low Loss Filter	140	1.7	11	SE / SE	40 @ 3.5	19x6.5	855579*
Low Loss IF Filter	140	4	10.85	SE / SE	40 @ 9.1	13.3x6.5	854909
Low Loss IF Filter	140	7	5.5	SE / SE	40 @ 11.1	13.3x6.5	854913
Low Loss IF Filter	140	10	8.3	SE / SE	35 @ 15	13.3x6.5	854916
Low Loss IF Filter	140	10	11	SE / SE	35 @ 15	13.3x6.5	856656
Low Loss IF Filter	140	12	8.87	SE / SE	35 @ 21.3	13.3x6.5	854917
Low Loss IF Filter	140	15	11	SE / SE	35 @ 22	13.3x6.5	856684
Low Loss IF Filter	140	16	8.4	SE / SE	35 @ 22	13.3x6.5	854919
Low Loss IF Filter	140	18	9.1	SE / SE	40 @ 48	13.3x6.5	854920
Low Loss IF Filter	140	18.4	9.1	SE / SE	36 @ 26.4	7x5.5	856929*
Low Loss IF Filter	140	20	11	SE / SE	35 @ 24	13.3x6.5	856592
Low Loss IF Filter	140	24	11.3	SE / SE	35 @ 33.5	13.3x6.5	854923
Low Loss IF Filter	140	32	11.5	SE / SE	35 @ 44	13.3x6.5	854927
High Selectivity IF Filter	140	0.8	20.8	SE / SE	40 @ 1.93	19x6.5	856062
High Selectivity IF Filter	140	1.5	21.9	SE / SE	40 @ 3.5	19x6.5	856063
High Selectivity IF Filter	140	2	21.5	SE / SE	40 @ 3.45	19x6.5	856064
High Selectivity IF Filter	140	3	22.4	SE / SE	40 @ 4.86	19x6.5	856065
High Selectivity IF Filter	140	6	23	SE / SE	40 @ 8.34	13.3x6.5	856066
High Selectivity IF Filter	140	7	24.5	SE / SE	40 @ 9.15	13.3x6.5	856067
High Selectivity IF Filter	140	8	23.4	SE / SE	40 @ 11.28	13.3x6.5	856068
High Selectivity IF Filter	140	10	20.87	SE / SE	40 @ 13.17	13.3x6.5	856069
High Selectivity IF Filter	140	14	23.3	SE / SE	40 @ 18.26	13.3x6.5	856070
High Selectivity IF Filter	140	16	21.7	SE / SE	40 @ 20.69	13.3x6.5	856071

NOTES: * = New

SAW (cont.)

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
High Selectivity IF Filter	140	28	20	SE / SE	40 @ 37	9x7	856019
High Selectivity IF Filter	140	28.56	27.7	SE / SE	40 @ 44	13.3x6.5	856817
High Selectivity IF Filter	140	32	21.7	SE / SE	40 @ 40.7	9x7	856072
High Selectivity IF Filter	140	44	21.75	SE / SE	40 @ 54.1	9x7	856073
High Selectivity IF Filter	140	56	18.65	SE / SE	40 @ 75.6	9x7	856074
High Selectivity Filter	140	60	22.4	BAL / BAL	40 @ 74.7	9.1x4.8	856774*
High Selectivity IF Filter	140	64	17.8	SE / SE	40 @ 84	9x7	856020
High Selectivity IF Filter	140	72	21	SE / SE	40 @ 102	9x7	856314
High Selectivity IF Filter	140	1.5	12.1	SE and BAL	48 @ 143	9.1x4.8	856691
High Selectivity IF Filter	140	3	13.6	SE and BAL	46 @ 144	9.1x4.8	856692
High Selectivity IF Filter	140	6	11	BAL / BAL	39 @ 147	9.1x4.8	856693
High Selectivity IF Filter	140	7	13.6	SE and BAL	43 @ 147	9.1x4.8	856694
High Selectivity IF Filter	140	10	10	BAL / BAL	41 @ 152.5	9.1x4.8	856695
High Selectivity IF Filter	140	14	8.5	SE and BAL	43 @ 155	9.1x4.8	856696
High Selectivity IF Filter	140	20	9.8	BAL / BAL	40 @ 158.5	9.1x4.8	856697
High Selectivity IF Filter	140	28	18	SE and BAL	42 @ 168	9.1x4.8	856698
CDMA IF Filter	141	1.18	11.7	SE / SE	42.5 @ 2.5	19x6.5	855395
High Selectivity IF Filter	144	75	21.2	SE / SE	40 @ 91.81	9x7	856727
CDMA IF Filter	150	1.18	18.6	SE / BAL	30 @ 4.5	19x6.5	854833-1
CDMA IF Filter	150	8	12.1	SE / SE	35 @ 14.25	13.3x6.5	855678
CDMA IF Filter	153.6	3.75	12.04	SE / SE	45 @ 9.8	13.3x6.5	856048
TDSCDMA / WCDMA IF Filter	153.6	15	10	SE / SE	40 @ 25	13.3x6.5	856748
CDMA IF Filter	160	1.18	19.5	SE / BAL	30 @ 4.5	19x6.5	855049
Repeater IF Filter	161.5	25	22	SE / SE	50 @ 131	9x7	855886*
WCDMA IF Filter	167	5	8	SE / SE	20 @ 11.8	9.1x4.8	856683
CDMA IF Filter	167.1	1.18	10.9	SE / SE	15 @ 2	19x6.5	855394
CDMA IF Filter	167.1	11	13.1	SE / SE	40 @ 16	13.3x6.5	855753
WCDMA IF Filter	168.5	20	8	SE / BAL	33 @ 190	5x5	856512
WCDMA IF Filter	168.96	3.84	11.5	SE / SE	30 @ 16	9.1x4.8	856320
GSM IF Filter	170.6	0.18	5	BAL / BAL	40 @ 1.6	9.1x4.8	856706
WCDMA IF Filter	172.8	8.84	12.5	SE / BAL	32 @ 16	7x5.5	856620
WCDMA IF Filter	172.8	20	8	SE / BAL	30 @ 194.3	5x5	856802
WCDMA IF Filter	172.8	21	8.2	BAL / BAL	50 @ 200	7x5.5	856893
WCDMA IF Filter	190	5.5	9.8	SE / BAL	30 @ 7.6	13.3x6.5	855529
WCDMA IF Filter	190	5	8	SE / SE	25 @ 9	5x5	855770
GSM IF Filter	190	0.2	4.2	BAL / BAL	30 @ 12	7x5.5	855625
GSM IF Filter	199	0.2	5.4	SE / SE	20 @ 1.2	9x7	856730
GSM IF Filter	199	0.2	6	SE / SE	45 @ 1.6	19x6.5	855131
GSM IF Filter	201	0.22	6.1	BAL / BAL	27 @ 0.8	13.3x6.5	856541
Cable IF Filter	202.75	1.2	6.6	SE / SE	40 @ 10	13.3x6.5	855068
GSM IF Filter	208	0.4	5.9	SE / SE	20 @ 2.4	9.1x4.8	856445
WCDMA IF Filter	208	3.84	11.5	BAL / BAL	17 @ 5.03	9.1x4.8	856496
GSM IF Filter	211	0.2	5.2	SE / SE	25 @ 0.8	13.3x6.5	856378
WCDMA IF Filter	219	20	9.6	BAL / BAL	35 @ 36	9x7	856795
WCDMA IF Filter	230	4	16.2	SE / SE	40 @ 10	13.3x6.5	855832
CDMA IF Filter	240	3.6	14.3	SE / SE	12 @ 5	13.3x6.5	855992
CDMA IF Filter	240	1.1	13	SE / SE	10 @ 1.8	19x6.5	856151
CDMA IF Filter	249.6	3.84	16.11	SE / SE	40 @ 11	7x5.5	855915
CDMA IF Filter	326.4	15	12.61	SE / SE	40 @ 25	7x5.5	855914
BWA / WiMAX IF Filter	330	5.45	18.26	SE / SE	50 @ 13.6	15.3x6.5	855730
WCDMA / LTE IF Filter	344	65	9.5	BAL / BAL	45 @ 66.6	5x5	857004*
BWA / WiMAX IF Filter	350	1.7	13.7	SE / BAL	45 @ 6	13.3x6.5	855399
BWA / WiMAX IF Filter	350	1	8.2	SE / BAL	45 @ 15	7x5.5	855377

NOTES: * = New

SAW (cont.)

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
WCDMA IF Filter	358.4	19.2	10.1	BAL / BAL	25 @ 375.4	7x5.5	856771
WCDMA IF Filter	358.4	24.8	9	BAL / BAL	30 @ 335.8	7x5.5	856966*
WLAN IF Filter	374	17	8.5	SE / BAL	10 @ 33	7x5.5	855653
WLAN IF Filter	374	17	8.5	SE / BAL	35 @ 33	5x5	855898
WLAN IF Filter	374	17	9	SE / BAL	30 @ 33	3.8x3.8	856278
BWA / WiMAX IF Filter	374	10	9	BAL / BAL	10 @ 25	3.8x3.8	856466
WCDMA IF Filter	380	5.4	15.4	SE / BAL	30 @ 8.3	13.3x6.5	855530
BWA / WiMAX IF Filter	380	7	10	BAL / BAL	40 @ 20	7x5.5	856490
BWA / WiMAX IF Filter	380	10	8.7	BAL / BAL	40 @ 36	7x5.5	856631
WCDMA IF Filter	398	4.3	9.9	SE / SE	50 @ 36	9.1x4.8	855561
WCDMA / WiMAX IF Filter	398	15	7.5	SE / SE	30 @ 60	9.1x4.8	855559
BWA / WiMAX IF Filter	398	10	11.2	BAL / BAL	35 @ 388.5	5x5	856652
BWA / WiMAX IF Filter	426	5.16	18.02	SE / SE	50 @ 14	13.3x6.5	855731
WiBRO IF Filter	456	8.75	7.9	BAL / BAL	36 @ 443.25	5x5	856549
BWA / WiMAX IF Filter	456	10	8.3	BAL / BAL	37 @ 440	7x5.5	856672
BWA / WiMAX IF Filter	456	10	8.3	BAL / BAL	37 @ 440	5x5	856638
WCDMA IF Filter	456	19	10	BAL / BAL	25 @ 439	7x5.5	856687
General Purpose IF Filter	460	3.75	11.1	SE / SE	35 @ 8	7x5.5	856282
BWA / WiMAX IF Filter	464	3.5	10.6	BAL / BAL	53 @ 417	7x5.5	856623
FRS RF or GPS IF Filter	465	6	1.43	SE / SE	40 @ 445	3x3	856288
WiMAX IF Filter	467	10	3	SE / SE	40 @ 438	3.8x3.8	856586*
BWA / WiMAX IF Filter	479.75	9	19.5	SE / SE	35 @ 22	7x5.5	855271
BWA / WiMAX IF Filter	479.75	23	9.8	BAL / BAL	35 @ 36	7x5.5	855272
Cable IF Filter	499.25	1	7	SE / SE	35 @ 6	9x7	855104
BWA / WiMAX IF Filter	520	6	10.8	SE / SE	30 @ 514	5x5	856680*
BWA / WiMAX IF Filter	520	11	9.5	SE / SE	35 @ 506	5x5	856625*
WLAN IF Filter	549.5	1	11.6	SE / SE	40 @ 547.4	9x7	855985*
WLAN IF Filter	549.5	10	11.8	SE / SE	40 @ 536.5	7x5.5	855959*
BWA / WiMAX IF Filter	580	10	10.7	BAL / BAL	40 @ 36	5x5	856665
RF Filter – Band 12 Uplink	707	18	1.5	SE / SE	9 @ 728	3x3	856884
Duplexer, Band 17	710 / 740	12 / 12	1.2 / 1.8	SE / BAL	–	2.5x2	856931
RF Filter – Band 12 Downlink	737	18	1.8	SE / SE	37 @ 708	3x3	856883
RF Filter – Band 13 Downlink	751.5	11	1.5	SE / SE	40 @ 776	3x3	856794*
Duplexer, Band 13	751 / 782	9 / 9	2.3 / 1.8	SE / BAL	–	2.5x2	856879
WiMAX IF Filter	756	10	1.9	SE / SE	30 @ 727	3.8x3.8	856690*
BWA IF Filter	756	20	0.9	SE / SE	30 @ 716	3.8x3.8	856866*
RF Filter – Band 13 Uplink	781.5	11	1.5	SE / SE	38 @ 757	3x3	856764
RF Filter – Band 13 Uplink	782	10	1.52	SE / SE	15 @ 765	3x3	856844
BWA / WiMAX IF Filter	810	10	3.5	SE / SE	10 @ 31	3x3	856526
Duplexer, Band 20	806 / 847	30 / 30	2.5 / 3	SE / BAL	–	2.5x2	856979*
Duplexer, BC10	833 / 878	32 / 32	2.5 / 2.5	SE / BAL	–	2.5x2	856999*
RF Filter – Band 5 Uplink	836.5	25	2.7	SE / SE	28 @ 869	3x3	856503*
RF Filter – Band 5 Uplink	836.5	25	2.7	SE / SE	28 @ 869	3x3	855729
RF Filter – Band 5 Uplink	836.5	25	2	SE / SE	10 @ 869	3x3	856704
RF Filter – Band 5 Uplink	836.5	25	1.9	SE / SE	35 @ 869	3x3	855821
Duplexer, Cell Band	836.5 / 881.5	25 / 25	1.9 / 1.9	SE / SE	–	3.8x3.8	856356
RF Filter – Band 20 Uplink	847	30	1.3	SE / SE	10 @ 882	3x3	856932*
EU ISM 875 Band RF Filter	875	13	2.4	SE / SE	55 @ 849	2x1.5	856963*
RF Filter – Band 5 Downlink	881.5	25	2.7	SE / SE	40 @ 849	3x3	855728
RF Filter – Band 5 Downlink	881.5	25	1.8	SE / SE	35 @ 849	3x3	855782
CDMA 2-in-1 Rx Filter	881.5 / 1960	25 / 60	1.6 / 2.2	SE / BAL	–	2x1.5	856565
RF Filter – Band 5 Downlink	881.5	25	2.7	SE / SE	40 @ 849	3x3	856504*

NOTES: * = New

SAW (cont.)

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
Cell Band Delay Filter 450 NS	881.5	25	2.5	SE / BAL	–	7x5.5	856716
RF Filter – Band 8 Uplink	897.5	35	1.4	SE / SE	10 @ 984	3x3	856824
RF Filter – Band 8 Uplink	897.5	35	1.5	SE / SE	15 @ 930	3x3	856657
RF Filter – Band 8 Uplink	897.5	35	1.9	SE / SE	14 @ 930	3x3	856671
ISM 915 Band RF Filter	915	26	2.3	SE / SE	35 @ 882.5	2x1.5	856327
ISM 915 Band RF Filter	915	4.4	2.4	SE / SE	55 @ 849	3x3	856686
ISM 921.5 Band RF Filter	921.5	13	2.4	SE / SE	55 @ 825	2x1.5	856905*
RF Filter – Band 8 Downlink	942.5	35	2	SE / SE	5 @ 915	3x3	855820
RF Filter – Band 8 Downlink	942.5	35	3.2	SE / SE	12 @ 915	3x3	855810
RF Filter – Band 8 Downlink	942.5	35	2.5	SE / SE	25 @ 915	3x3	856528
GSM Band Delay Filter, 450 ns	942.5	35	25.5	SE / SE	–	7x5.5	856766
WLAN IF Filter	970	9	24	SE / SE	35 @ 945	9.1x4.8	856338*
WLAN IF Filter	970	18	24.7	SE / SE	35 @ 945	7x5.5	856339*
Tuner IF Filter	1086	10	4	BAL / BAL	40 @ 1046	3x3	855964
Tuner IF Filter	1086	10	4	BAL / BAL	40 @ 1046	3x3	856330
Tuner IF Filter	1090	10	5	BAL / BAL	50 @ 1050	3.8x3.8	856096
WLAN IF Filter	1150	16	4.4	BAL / BAL	20 @ 1170	3x3	856256
GPS L5 RF Filter	1176	20	2.4	SE / SE	20 @ 1226	2x1.5	856440
Tuner IF Filter	1216	8	3.75	BAL / BAL	12 @ 24	3x3	856365
Tuner IF Filter	1220	10	4.5	BAL / BAL	30 @ 60	3x3	856298
Tuner IF Filter	1220	50	3.9	BAL / BAL	33 @ 96	3.8x3.8	856598
GPS L2 RF Filter	1227.6	20	1.1	SE / SE	27 @ 1152	2x1.5	856700
Tuner IF Filter	1250	96	6	BAL / BAL	44 @ 1152	3x3	856653
RF Filter – Band 11 Uplink	1445.4	35	1.25	SE / SE	20 @ 1495.9	3x3	856928*
GPS RF Filter	1575.42	2	1.3	SE / SE	30 @ 1625	3x3	855969
GPS RF Filter	1575.42	2	1.25	SE / SE	30 @ 1624	2x1.5	856584
GPS RF Filter	1575.42	2	0.75	SE / SE	35 @ 1635	1.4x1.2	856561
GPS RF Filter	1575.42	2	1.1	SE / BAL	20 @ 1635	1.4x1.2	856576
GPS RF Filter	1575.42	2	1	SE / SE	27 @ 800	1.5x1.5	856463
GPS RF Filter	1575.42	2	0.5	SE / SE	20 @ Cell Bands	1.4x1.2	856756
GPS RF Filter	1575.42	2	0.7	SE / SE	27 @ 1700	1.5x1.5	856398
GPS RF Filter	1575.42	2	0.6	SE / SE	21 @ Cell Bands	1.4x1.2	856793
GPS RF Filter, Auto	1575.42	2	1.8	SE / SE	45 @ 1637	3x3	856039
GPS RF Filter, Auto	1575.42	2	1.3	SE / SE	45 @ 1640	3x3	856139
GPS / SDARS Diplexer	1575.42 / 2332.5	3 / 25	0.6 / 0.8	SE / SE	GPS Port: 40 @ 2332 SDARS Port: 36 @ 1572	3x3	TQM2M9016*
RF Filter – Band 3 Uplink	1747.5	75	2	SE / SE	22 @ 1676	3x3	856654
RF Filter – Band 3 Downlink	1842.5	75	1.9	SE / SE	10 @ 1785	3x3	855860
RF Filter – Band 2 Uplink	1880	60	2.2	SE / SE	15 @ 1806	3x3	856705
RF Filter – Band 2 Uplink	1880	60	2.3	SE / SE	10 @ 1790	3x3	856880
RF Filter – Band 2 Uplink	1880	60	2.4	SE / SE	7 @ 1930	3x3	855849
RF Filter – Band 2 Uplink	1880	60	2.8	SE / SE	30 @ 1930	3x3	856530
Tuner IF Filter	1892	8	4.2	BAL / BAL	23 @ 1932	2.5x2	856236
RF Filter – Band 1 Uplink	1950	60	1.8	SE / SE	20 @ 2100	3x3	856678
RF Filter – Band 1 Uplink	1950	60	2.2	SE / SE	40 @ 2110	3x3	856532
RF Filter – Band 2 Downlink	1960	60	2.1	SE / SE	10.3 @ 1910	3x3	855817
RF Filter – Band 2 Downlink	1960	60	2.9	SE / SE	15 @ 1910	3x3	855859
RF Filter – Band 2 Downlink	1960	60	2.25	SE / SE	14 @ 1910	3x3	856531
Delay Filter, PCS 450 ns	1960	60	25	SE / BAL	–	7x5.5	856717
Delay Filter, UMTS 450 ns	2140	60	25	SE / BAL	–	7x5.5	856649
RF Filter – Band 1 Downlink	2140	60	2.3	SE / SE	25 @ 1980	3x3	856738
SDARS Filter	2332.5	45	1.7	SE / BAL	35 @ 2100	1.4x1.2	856604

NOTES: * = New

SAW (cont.)

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
Bluetooth® RF Filter	2441	83.5	2.8	SE / SE	26 @ 2200	3x3	855916
Bluetooth® RF Filter	2441	83.5	2	SE / SE	28 @ 2300	1.4x1.2	856539

NOTES: * = New

BAW

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
RF Filter	710	20	2	SE / SE	50 @ 140	3.81x2.54	880370
RF Filter, ISM	915	15	3.5	SE / SE	40 @ 35	6.35x4.57	880371
RF Filter	1030	15	2.5	SE / SE	40 @ 45	3.81x2.54	880367
RF Filter	1090	15	2.5	SE / SE	40 @ 45	3.81x2.54	880374
GPS RF Filter, L5	1176	28	2.75	SE / SE	40 @ 140	3.26x1.6	880364
GPS RF Filter, L2	1227	30	2.75	SE / SE	40 @ 140	3.26x1.6	880272
GPS RF Filter, L2	1227	15	1.5	SE / SE	40 @ 250	3.26x1.6	880366
GPS RF Filter, L2	1227	15	3	SE / SE	40 @ 45	3.81x2.54	880372
RF Filter	1280	20	3	SE / SE	40 @ 105	3.81x2.54	880368
GPS RF Filter, L3 / L4	1380	30	3	SE / SE	40 @ 160	3.26x1.6	880365
GPS RF Filter, L1	1575	30	3	SE / SE	40 @ 160	3.26x1.6	880273
GPS RF Filter, L1	1575	18	1.5	SE / SE	40 @ 350	3.26x1.6	880085
GPS RF Filter, L1	1575	25	3	SE / SE	40 @ 60	3.81x2.54	880373
RF Filter	2324	38	3	SE / SE	40 @ 150	3.81x2.54	880148
SDARS	2332.5	45	1.7	SE / BAL	35 @ 2100	1.4x1.2	856604
ISM Passband Filter for Coexistence	2436	72	2	SE / SE	20 @ 2495	1.7x1.3	885007
ISM Notch RF Filter for Coexistence	2440	72	1.5 (Out of Band IL)	SE / SE	25 @ 2440 (Notch Rej)	1.7x1.3	885008
ISM Notch RF Filter for Coexistence	2440	85	2 (Out of Band IL)	SE / SE	18 @ 2440 (Notch Rej)	1.7x1.3	885010
RF Filter, MMDS	2560	30	3	SE / SE	40 @ 150	3.81x2.54	880157
RF Filter, ISM	5775	100	4.5	SE / SE	20 @ 350	3.26x1.6	880369

Automotive

Description	Frequency Bands	Features	Package Size (mm)	Part Number
QB GSM / GPRS Tx Module; PA / LPF / SP6T Switch	GSM850 / 900, DCS / PCS	High System Efficiency & Small Size	6x6x1.1	TQM6M4003
QB GSM / GPRS / EDGE-Polar PA Module	GSM850 / 900, DCS / PCS	-90 dBm Typ Rx Noise, +3 to +8 dBm Pin Nominal	5x5x1	TQM7M5012

GPS

Description	Frequency Bands	Features	Package Size (mm)	Part Number
GPS Filter-LNA-Filter Module	1575 MHz, GPS L1	Low Noise (1.56 dB) and High Gain (16 dB)	3x3x1	TQM640002

GSM / GPRS / EDGE

Description	Frequency Bands	Features	Package Size (mm)	Part Number
QB GSM / GPRS PA Module	GSM850 / 900, DCS / PCS	Low Band Ibatt < 1.5A @ Pcal w/PAE 55%	5x5x1	TQM7M4007

GSM / GPRS / EDGE (cont.)

Description	Frequency Bands	Features	Package Size (mm)	Part Number
QB GSM / GPRS / EDGE-Linear HADRON II PA Module™	GSM850 / 900, DCS / PCS	Low Band Ibat < 1.5A @ Pcal w/PAE 55%	5x5x1	TQM7M5005H
QB GSM / GPRS Tx Module; PA / LPF / SP6T	GSM900 / DCS or GSM850 / PCS	High Efficiency Broadband Tx, 4 Rx Ports	6x6x1	TQM6M4003
DB GSM / GPRS QUANTUM Tx Module™; PA / LPF / SP4T, Quad-Band Tx & Dual-Band Rx	GSM900 / DCS or GSM850 / PCS	High Efficiency Broadband Tx, 2 Rx Ports	6x6x1	TQM6M4050*
DB GSM / GPRS QUANTUM Tx Module™; PA / LPF / SP4T, Quad-Band Tx & Dual-Band Rx	GSM900 / DCS or GSM850 / PCS	High Efficiency Broadband Tx, 2 Rx Ports	5x6x1	TQM6M4068*
DB GSM / GPRS QUANTUM Tx Module™; PA / LPF / SP4T, Quad-Band Tx & Dual-Band Rx	GSM900 / DCS or GSM850 / PCS	High Efficiency Broadband Tx, 2 Rx Ports	6x6x1	TQM6M4048
QB GSM / GPRS QUANTUM Tx Module™; PA / LPF / SP6T	GSM850 / 900, DCS / PCS	High Efficiency Broadband Tx, 4 Rx Ports	6x6x1	TQM6M4049

NOTES: * = New

3G - CDMA / EV-DO, 4G - LTE

Description	Bands	Features	Package Size (mm)	Part Number
CDMA TRITIUM II PA-Duplexer Module™; SE Input w/Coupler	Cellular	2-Bit (Hi / Med / Lo Power Modes)	7x4x1.1	TQM613029
CDMA TRITIUM II PA-Duplexer Module™; SE Input w/Coupler	PCS	2-Bit (Hi / Med / Lo Power Modes)	7x4x1.1	TQM663029A
CDMA TRITIUM II PA-Duplexer Module™; SE Input w/Coupler	AWS	2-Bit (Hi / Med / Lo Power Modes)	7x4x1.1	TQM653029
CDMA SP3T Switch	Cellular / PCS / AWS	Antenna Routing	3x3x0.9	TQP4M3018
CDMA SP3T Switch	Cellular / PCS / AWS	Antenna Routing	2x2x0.57	TQP4M3019
LTE TRITON PA Module™, w/Coupler	Band 13	LTE, 2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM700013
CDMA TRITON PA Module™, w/Coupler	PCS	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM766012
CDMA TRITON PA Module™, w/Coupler	AWS	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM756014
CDMA TRITON PA Module™, w/Coupler	Cellular	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM716015
CDMA TRITON PA Module™, w/Coupler	PCS	1-Bit (Hi / Lo Power Modes)	3x3x0.9	TQM766062
CDMA TRITON PA Module™, w/Coupler	Cellular	1-Bit (Hi / Lo Power Modes)	3x3x0.9	TQM716065

3G - WCDMA / WGPRES / WEDGE, 4G - LTE

Description	Bands	Features	Package Size (mm)	Part Number
QB GSM / GPRS / EDGE-Polar HADRON II PA Module™	GSM850 / 900, DCS / PCS	-90 dBm Typ Rx Noise, +3 to +8 dBm Pin Nom	5x5x1	TQM7M5012H
QB GSM / GPRS / EDGE-Linear HADRON II PA Module™	GSM850 / 900, DCS / PCS	Input Power Controlled for GMSK & 8PSK	5x5x1	TQM7M5013
QB GSM / GPRS / EDGE-Polar HADRON II PA Module™	GSM850 / 900, DCS / PCS	+3 to +8 dBm Pin Nominal, Current Limiter	5x5x1	TQM7M5022
WCDMA / HSUPA TRITON PA Module™, w/Coupler	Band 1	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM776011
WCDMA / HSUPA TRITON PA Module™, w/Coupler	PCS / Band 2	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM766012
WCDMA / HSUPA TRITON PA Module™, w/Coupler	Band 4	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM756014
WCDMA / HSUPA TRITON PA Module™, w/Coupler	Band 5	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM716015
WCDMA / HSUPA TRITON PA Module™, w/Coupler	Band 8	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM726018
LTE PA Module, w/Coupler	Band 13	LTE 1-Bit (Hi / Lo Power Modes)	3x3x0.9	TQM700013*
WCDMA / HSUPA TRITIUM III PA-Duplexer Module™; SE Input w/Coupler, Detector	Band 1	1-Bit (Hi / Lo Power Modes)	7x4.0x1.1	TQM676021
WCDMA / HSUPA TRITIUM III PA-Duplexer Module™; SE Input w/Coupler, Detector	Band 2	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM666022
WCDMA / HSUPA TRITIUM III PA-Duplexer Module™; SE Input w/Coupler, Detector	Band 4	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM656024
WCDMA / HSUPA TRITIUM III PA-Duplexer Module™; SE Input w/Coupler, Detector	Bands 5 and 6	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM616025
WCDMA / HSUPA TRITIUM III PA-Duplexer Module™; SE Input w/Coupler, Detector	Bands 5 and 6	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM616020

NOTES: * = New

3G – WCDMA / WGPRES / WEDGE, 4G – LTE (cont.)

Description	Bands	Features	Package Size (mm)	Part Number
WCDMA / HSUPA TRITIUM III PA-Duplexer Module™; SE Input w/Coupler, Detector	Band 8	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM626028L
DB GSM / GPRS Tx Module: PA / LPF / SP6T WGPRES Switch w/Dual-Band WCDMA Antenna Pass-Through	GSM900 / DCS or GSM850 / PCS & 2 WCDMA Bands	Integrated DB GSM / GPRS & 2 WCDMA Antenna Switch Ports	5x6x1	TQM6M9069*
QB GSM / GPRS / EDGE-Linear TRP QUANTUM II Tx Module™: PA / LPF / SP8T WEDGE Switch w/Quad-Band WCDMA Antenna Pass-Through	GSM850 / 900, DCS / PCS & WCDMA B1, B2, B5 / 6, B8	Integrated QB GSM / GPRS / EDGE PA & Antenna Switch Supporting WCDMA	7x7.5x1.1	TQM6M9014
Multi-Mode Quad-Band GMSK / EDGE / WCDMA TRIUMF PA Module	GSM850 / 900, DCS / PCS & WCDMA B1 & B8	2-Bit (Hi / Med / Lo Power Modes)	5x7.5x1	TQM7M9023*
Multi-Mode Quad-Band GMSK / EDGE / WCDMA TRIUMF PA Module	GSM850 / 900, DCS / PCS & WCDMA B1 & B5	2-Bit (Hi / Med / Lo Power Modes)	5x7.5x1	TQM7M9032*
Multi-Band WCDMA / HSUPA / HSPA+ / TRIUMF PA Module	High Bands 1,2,3,4,9,10 & Low Bands 5,6,8	1-Bit (Hi / Lo Power Modes); 1-Bit Band Specific Pout Adjust	5x4x0.9	TQM7M9070*

NOTES: * = New

WLAN & Bluetooth® for Handsets

Description	Bands	Features	Package Size (mm)	Part Number
5 GHz WLAN PA MMIC	802.11 a	ETSLP-16 Package	3x3x0.45	TQP787011
2.4 GHz WLAN LNA + SP3T Switch MMIC w/WLAN Tx & Bluetooth® Paths	802.11 b, g	LNA Bypass, ETSLP-12 Package	1.5x1.5x0.55	TQP879001A
2.4 GHz WLAN PA + Switch MMIC w/WLAN Rx Balun & Bluetooth® Path	802.11 b, g, n	ETSLP-16 Package, Coupler / Detector	3x3x0.45	TQM679002A
2.4 GHz and 5 GHz WLAN PA + Switch MMIC w/WLAN Rx Baluns & Bluetooth® Path	802.11 a, b, g, n	ETSLP-24 Package, Coupler / Detector	4x4x0.45	TQP6M9002

WLAN & Bluetooth® for Wireless Data & Personal Media Devices

Description	Bands	Features	Package Size (mm)	Part Number
5 GHz WLAN PA MMIC	802.11 a	ETSLP-16 Package	3x3x0.45	TQP787011
2.4 GHz WLAN LNA + SP3T Switch MMIC w/WLAN Tx & Bluetooth® Paths	802.11 b, g	LNA Bypass, ETSLP-12 Package	1.5x1.5x0.55	TQP879001A
2.4 GHz WLAN PA + Switch MMIC w/WLAN Rx Balun & Bluetooth® Path	802.11 b, g, n	ETSLP-16 Package, Coupler / Detector	3x3x0.45	TQM679002A
2.4 GHz & 5 GHz WLAN PA + Switch MMIC w/WLAN Rx Baluns & Bluetooth® Path	802.11 a, b, g, n	ETSLP-24 Package, Coupler / Detector	4x4x0.45	TQP6M9002
Bluetooth® EDR v2.0 Class 1 PA MMIC	2.4 to 2.5 GHz ISM Band	STSLP-12 Package	2x2x0.57	TQP770001

UHF RFID

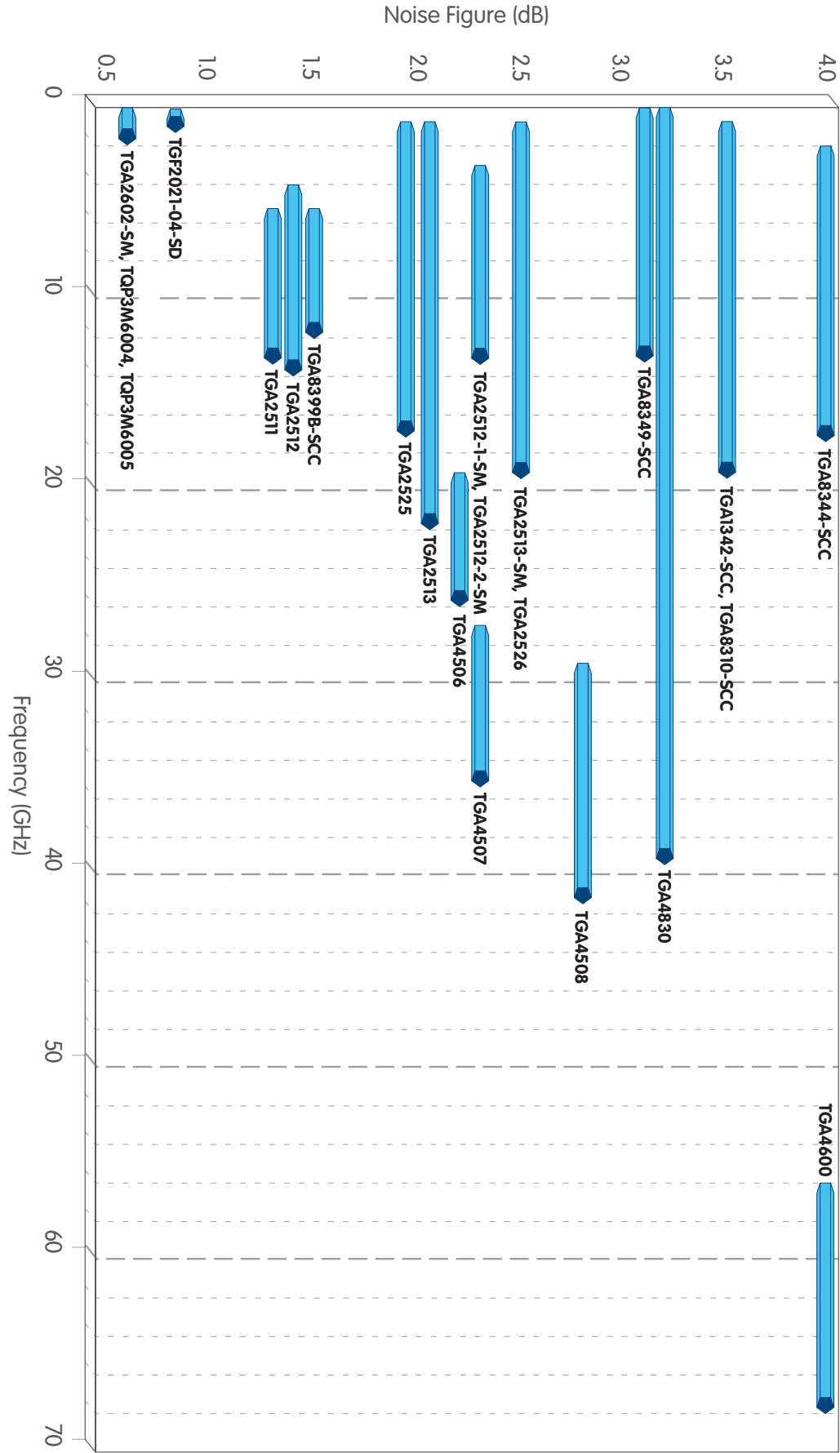
Description	Frequency (MHz)	Channels / Spacing (kHz)	Max Output Power (W)	Protocol Support	Region of Operation	Interface	Part Number
Reader PCMCIA Form Factor Module (ETSI 302.208)	865.7 - 867.5	4 / 600	1	ISO18000-6B & -6C	Europe	Serial TTL	WJR7081
Reader PCMCIA Form Factor Module (FCC Pt 15)	902.75 - 927.25	50 / 500	1	ISO18000-6C	N. America	Serial TTL	WJR7000
Embedded Reader Mod (FCC Pt 15)	902.75 - 927.25	50 / 500	1	ISO18000-6B & -6C	N. America	Serial TTL	WJM3000
Embedded Reader Mod (FCC Pt 15)	902.75 - 927.25	50 / 500	0.25	ISO18000-6B & -6C	N. America	Serial TTL	WJM1000
PCMCIA Form Factor Module	910.6 - 913.4	15 / 200	1	ISO18000-6B & -6C	Korea	Serial TTL	WJR7090
PCMCIA Reader Module (FCC Pt 15)	902.75 - 927.25	50 / 500	0.5	ISO18000-6B & -6C	N. America	PCMCIA	WJR6000

Amplifiers

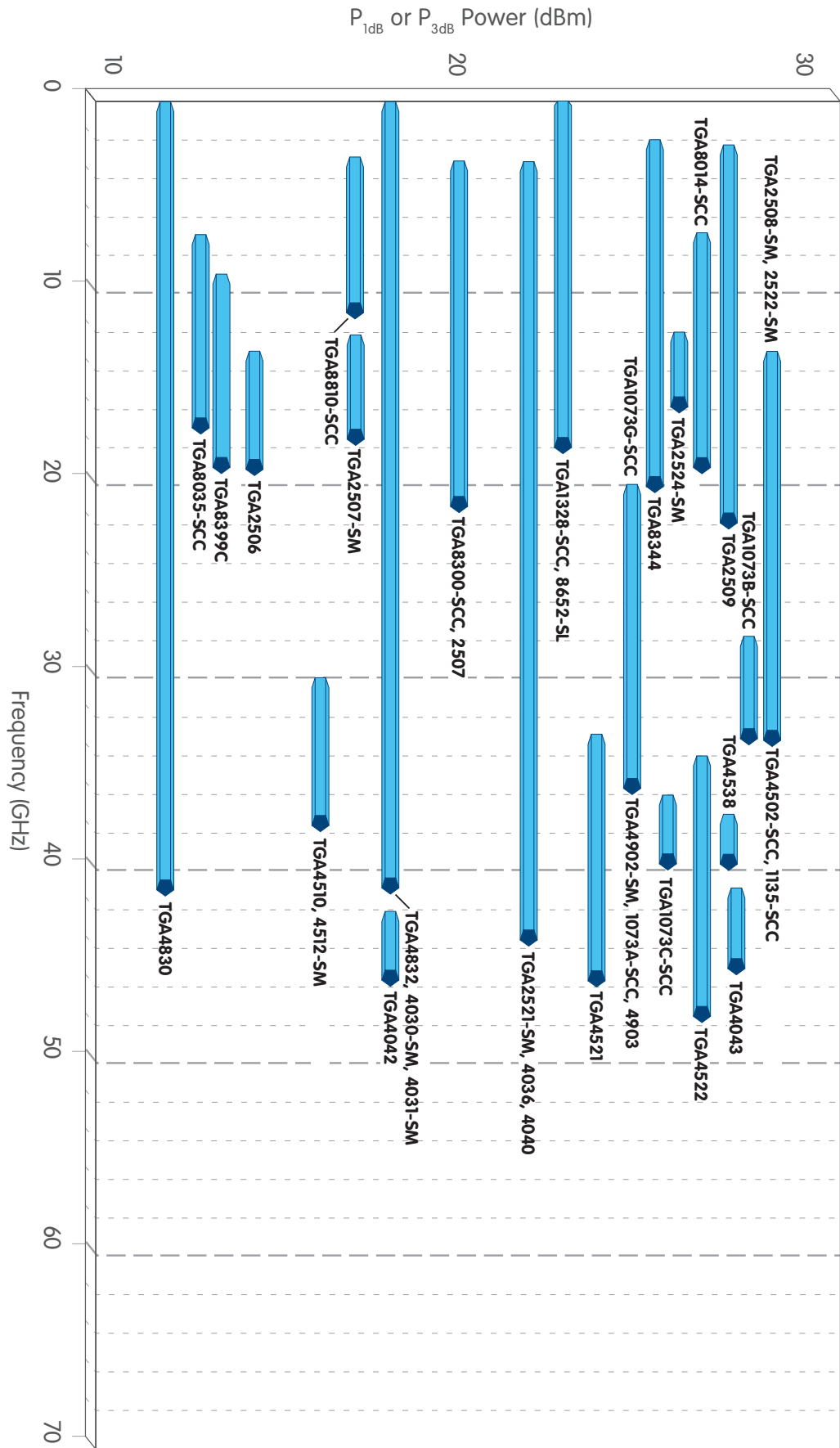
Description	Frequency (GHz)	Power (Vpp or dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style (mm)	Part Number
9.9 - 12.5Gb/s 3V - 7V Driver	DC - 13	3 - 7Vpp	32	–	3.3 - 5 / 115	8x8 QFN	TGA4956-SM
9.9 - 12.5 Gb/s Modulator Driver	DC - 16	3 - 10Vpp	35	2.5	5.5 - 8 / 210	11.4x8.9 SL	TGA4953-SL
9.9 - 12.5 Gb/s Modulator Driver	DC - 16	3 - 9Vpp	35	2.5	5.5 - 8 / 210	11.4x8.9 SL	TGA4954-SL
12.5 Gb/s NRZ Driver	DC - 18	3 - 11Vpp	16	–	8 / 285	Die	TGA4807
12.5 Gb/s NRZ Driver	DC - 18	6 - 8Vpp	16	3.5	5 - 8 / 70 - 175	Die	TGA1328-SCC
12.5 Gb/s NRZ Driver	DC - 18	4 - 8Vpp	16	3.5	8 / 175	8.9x8.9 SL	TGA8652-SL
15 Gb/s 10V Linear Modulator Driver	DC - 20	3 - 10Vpp	22	–	7 / 280	6x6 QFN	TGA4826-SM
40 & 100 Gb/s 8Vpp SE Driver	DC - 30	3 - 9Vpp	32	–	6 - 7 / 270	14.4x7 SL	TGA4943-SL
Wideband Driver (40 Gb/s)	DC - 35	4Vpp	12	–	5 / 135	Die	TGA4832
LNA / Gain Block (40 Gb/s)	DC - 40	11.5	13	3.2	5 / 50	Die	TGA4830
45 Gb/s 8Vpp SE Driver	DC - 35	5 - 9Vpp	30	–	6 - 7 / 300	14.4x7 SL	TGA4942-SL**
45 Gb/s 10Vpp Diff In / Out Driver	DC - 50	6 - 10Vpp Diff	27 Diff	–	5 - 6 / 500	Die	TGA4958-SL**
32 Gb/s 9Vpp Diff In / Out Driver	DC - 35	6 - 9Vpp Diff	25 Diff	–	5 - 6 / 500	SL	TGA4959-SL**
43 Gb/s Driver	DC - 78	3.5Vpp	8	5	6 / 82	Die	TGA4803
10.7 - 12.5 Gb/s Linear Modulator Driver	30 kHz - 8	12.5Vpp	20	–	8 / 310	8x8 QFN	TGA4823-2-SM

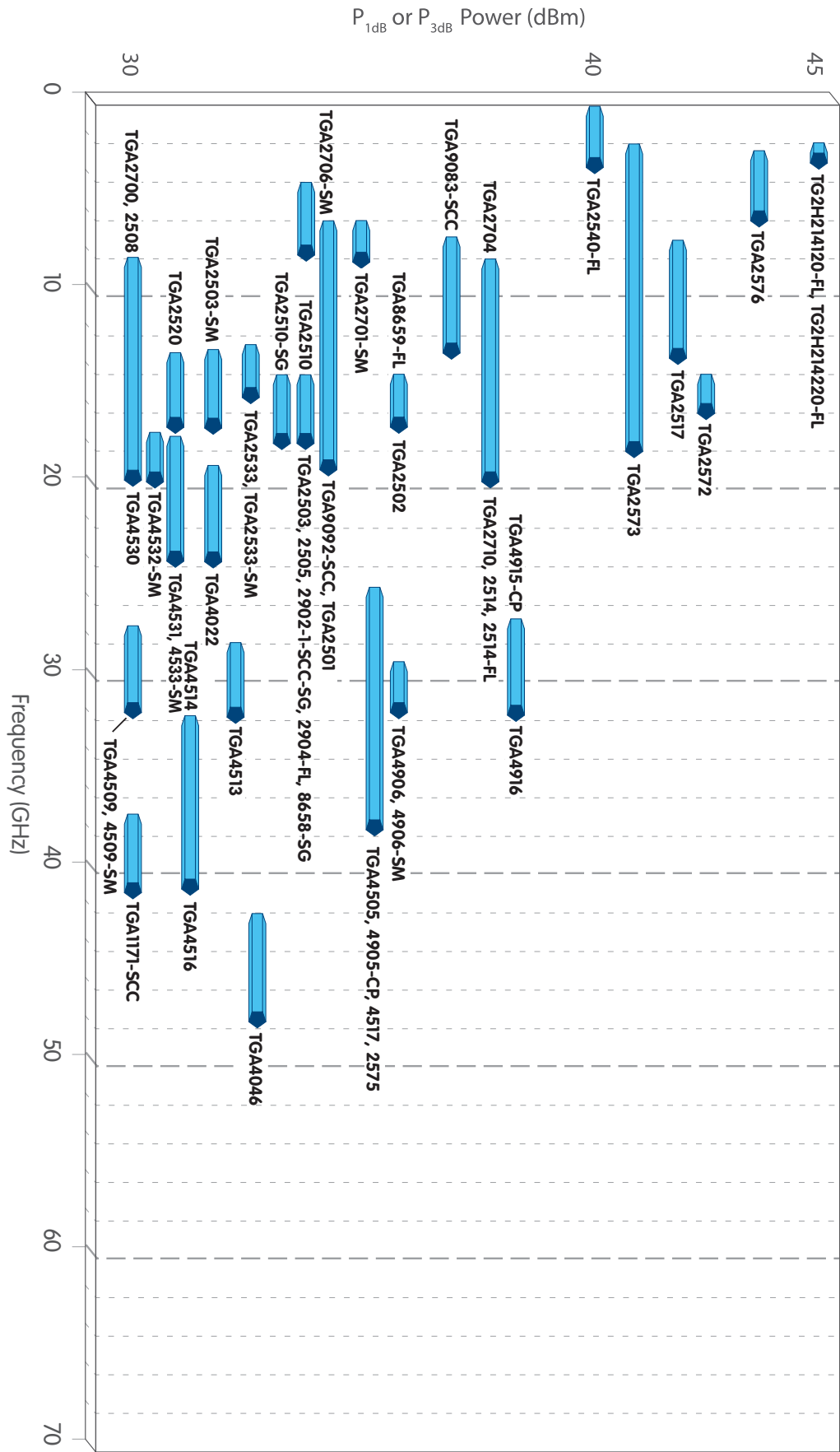
NOTES: ** = Coming Soon, SE = Single-Ended





Selected Low Noise Amplifiers, LNA Noise Figure vs. Frequency
For a complete list of low noise amplifiers, please refer to page 28.





Selected More Than 1W Higher Frequency Amplifiers, Power vs. Frequency
For a complete list of more than 1W amplifiers, please refer to pages 25 and 26.

PACKAGING

For detailed information on TriQuint product packaging, please visit our website at www.triquint.com/prodserv.

ORDERING

TriQuint products can be purchased through:

- **TriQuint Field Sales Offices:**

We have regional sales offices across the globe to work closely with you on your next TriQuint product purchase. To identify the closest regional sales office, please go to our website at www.triquint.com/sales.

- **Local Sales Representatives:**

Local sales representatives are skilled at examining application needs from a variety of angles to aid the design process. Their insight and specialized experience, paired with your goals, can find the combination of products that best meet overall objectives. Since these representatives work with a variety of customers in many different design environments, their experience can be valuable in determining the right 'fit' for your particular application. To locate a sales representative, please visit our website at www.triquint.com/sales.

- **Distributors - Buy / Resale Reps:**

TriQuint products can be purchased from any one of the distributors or buy / resale reps listed on our website at www.triquint.com/sales.

TERMS & CONDITIONS

For a complete listing of TriQuint terms and conditions of sale, please visit our website at www.triquint.com/sales.

EXPORT COMPLIANCE

Virtually all products TriQuint offers for sale as detailed in the Product Selection Guide are available for export in compliance with US government regulations. Please contact your TriQuint salesperson for details.

PRODUCT SUPPORT

- **Product Data Sheets and Literature:**

Detailed information on our products including datasheets and other literature can be found on the TriQuint website at www.triquint.com/prodserv.

- **Applications Support:**

Detailed product support information can be found on the TriQuint website at www.triquint.com/prodserv.

RELIABILITY PROGRAMS

Our programs are in line with JEDEC and other industry standards.

ENVIRONMENTAL POLICY

TriQuint Semiconductor is committed to managing environmental matters as an integral part of our business, complying with all applicable laws, regulations and other requirements, preventing pollution and continually improving.

ENVIRONMENTAL SYSTEMS

- ISO-14001:2004 (Select Sites)

QUALITY POLICY

The people of TriQuint Semiconductor are committed to continuous improvement, quality, reliability and customer satisfaction in everything we do.

QUALITY SYSTEMS

- ISO-9001:2008 Certified (Select Sites)
- ISO / TS 16949:2009 Certified (Select Sites)
- ISO / AS9100 Certified (Select Sites)

QUALITY TOOLS UTILIZED

- Design Failure Mode & Effects Analysis (DFMEA)
- Process Failure Mode & Effects Analysis (PFMEA)
- Process Control Plan (PCP)
- Production Part Approval Process (PPAP)
- Eight Discipline Problem Solving (8-D)
- Real Time Statistical Process Control (SPC)
- Measurement System Analysis (MSA)
- Advanced Product Quality Planning (APQP)

For further details on TriQuint quality information, please visit our website at www.triquint.com/company/quality.

PRODUCT COMPLIANCE POLICIES

TriQuint is committed to meeting all global product environmental regulations that affect its products. These regulations include:

- Directive 2002 / 95 / EC (RoHS Directive)
- Management Methods for Control of Pollution Caused by Electronic Information Products (China RoHS)
- Directive 94 / 62 / EC (Packaging Directive)
- Directive 2006 / 122 / EC (PFOS Directive)
- Regulation (EC) No 1907 / 2006 (REACH Regulation)
- Commission Decision 2009 / 251 / EC (Dimethylfumarate (DMF) Ban)

All active TriQuint commercial standard products are compliant with these directives. Contact TriQuint for the RoHS compliance status of custom products, military products and products manufactured prior to June 2006. All new product designs are halogen-free since late 2008. TriQuint does not use any REACH Substances of Very High Concern (SVHCs) in its products or packaging materials (as of May 2011). Also, TriQuint is committed to complying with Section 1502 (Conflict Minerals) of the Dodd-Frank Wall Street Regulation and Consumer Protection Act. We are actively surveying our supply chain to ensure that our products are "Conflict Free".

In addition to being compliant with the above product compliance laws and regulations, TriQuint participates in the following customer programs:

- Sony Green Partner
- Samsung Eco-Partner

Please contact TriQuint at rohs_info@tqs.com for any product compliance information requests. For further details on TriQuint environmental, health & safety information, please visit our website at www.triquint.com/company/ehs.

NOTICE

The data provided in this selection guide is subject to change without notice. TriQuint reserves the right to make changes to specifications and other information at any time.

Connecting the Digital World
to the Global Network®

TriQuint 
SEMICONDUCTOR

Below is a List of our Authorized Channel Partners:



MARUBUN CORPORATION



To find out who is authorized in your area, visit www.triquint.com/sales.

OREGON, UNITED STATES

Phone: +1.503.615.9000
Facsimile: +1.503.615.8900
E-mail: infoamericas@tqs.com

TEXAS, UNITED STATES

Phone: +1.972.994.8200
Facsimile: +1.972.994.8504
E-mail: infoamericas@tqs.com

FLORIDA, UNITED STATES

Phone: +1.407.886.8860
Facsimile: +1.407.886.7061
E-mail: infoamericas@tqs.com

EUROPE / MID EAST / AFRICA

Phone: +49.89.99628.2600
Facsimile: +49.89.99628.2699
E-mail: infoemea@tqs.com

CHINA

Phone: +86.21.5011.7290
Facsimile: +86.21.5011.7295
E-mail: infoasia@tqs.com

TAIWAN

Phone: +886.2.2758.3066
Facsimile: +886.2.2758.3185
E-mail: infoasia@tqs.com

KOREA

Phone: +82.31.788.7231
Facsimile: +82.31.788.7245
E-mail: infoasia@tqs.com

JAPAN

Phone: +81.3.5449.7105
Facsimile: +81.3.5449.3021
E-mail: infoasia@tqs.com

Visit www.triquint.com/subscribe and register for TriQuint product and process updates.