Vol. 51 • No. 10

October 2008

Microwave Journal

www.mwjournal.com

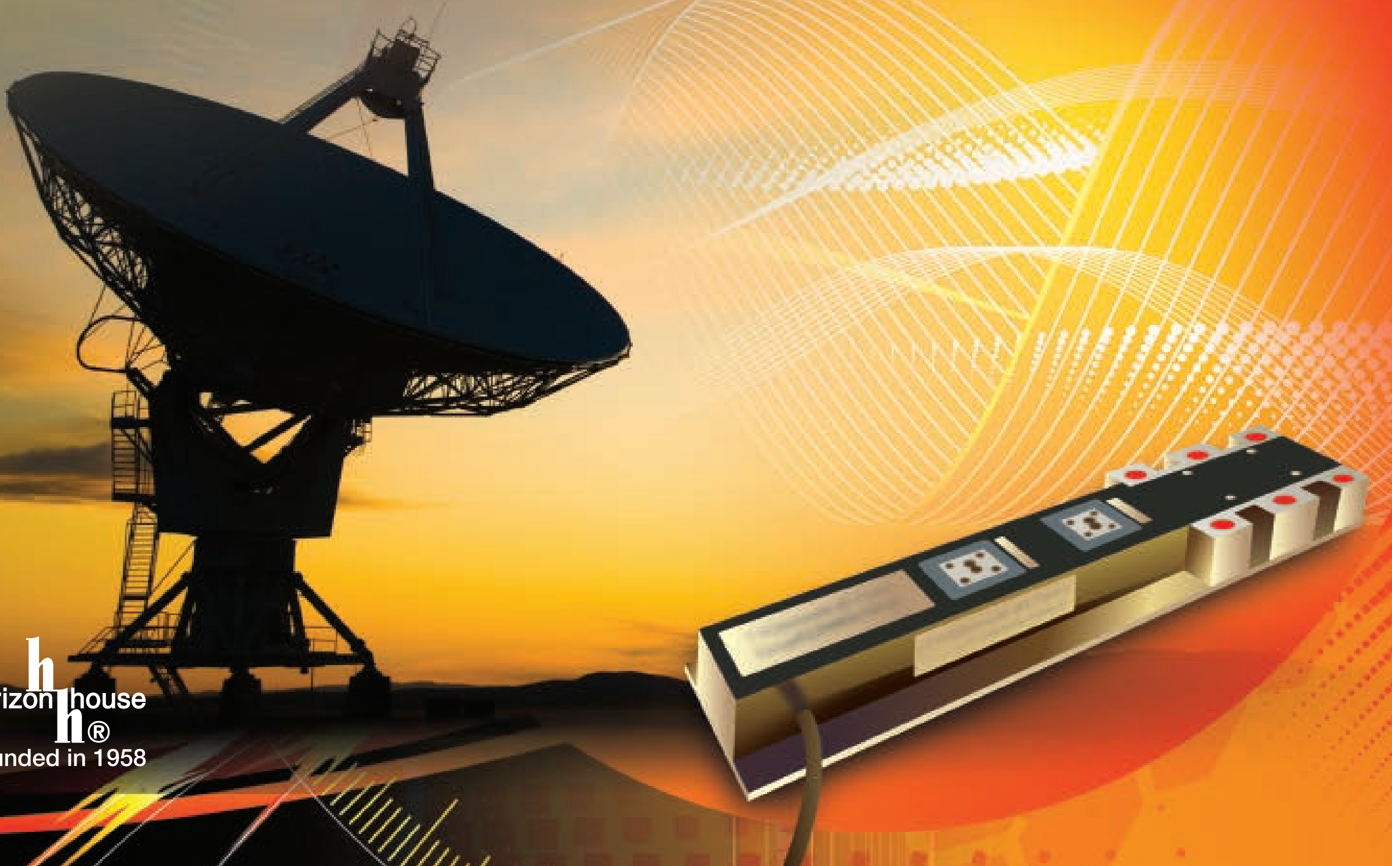
Microwave Journal 50 years 1958 2008 as the Industry Standard

Military and Government Electronics

High Power Traveling Wave Tubes

State-of-the-Art TWTs

Transceiver Duplexer Design Considerations



horizon house®
Founded in 1958

MECA TO THE RESCUE

ENGINEERS...
PROJECT MANAGERS...
EQUIPMENT INSTALLERS...

Rely on MECA to deliver rugged and reliable, US made components for next generation deployments.

Power Divider/Combiners • Fixed Attenuators
Directional/Hybrid Couplers • Isolators/Circulators
RF Loads • Bias Tees • DC Blocks

START YOUR CRITICAL PROJECTS ON-TIME, EVERYTIME!

SINCE 1961 MECA *MADE IN USA*

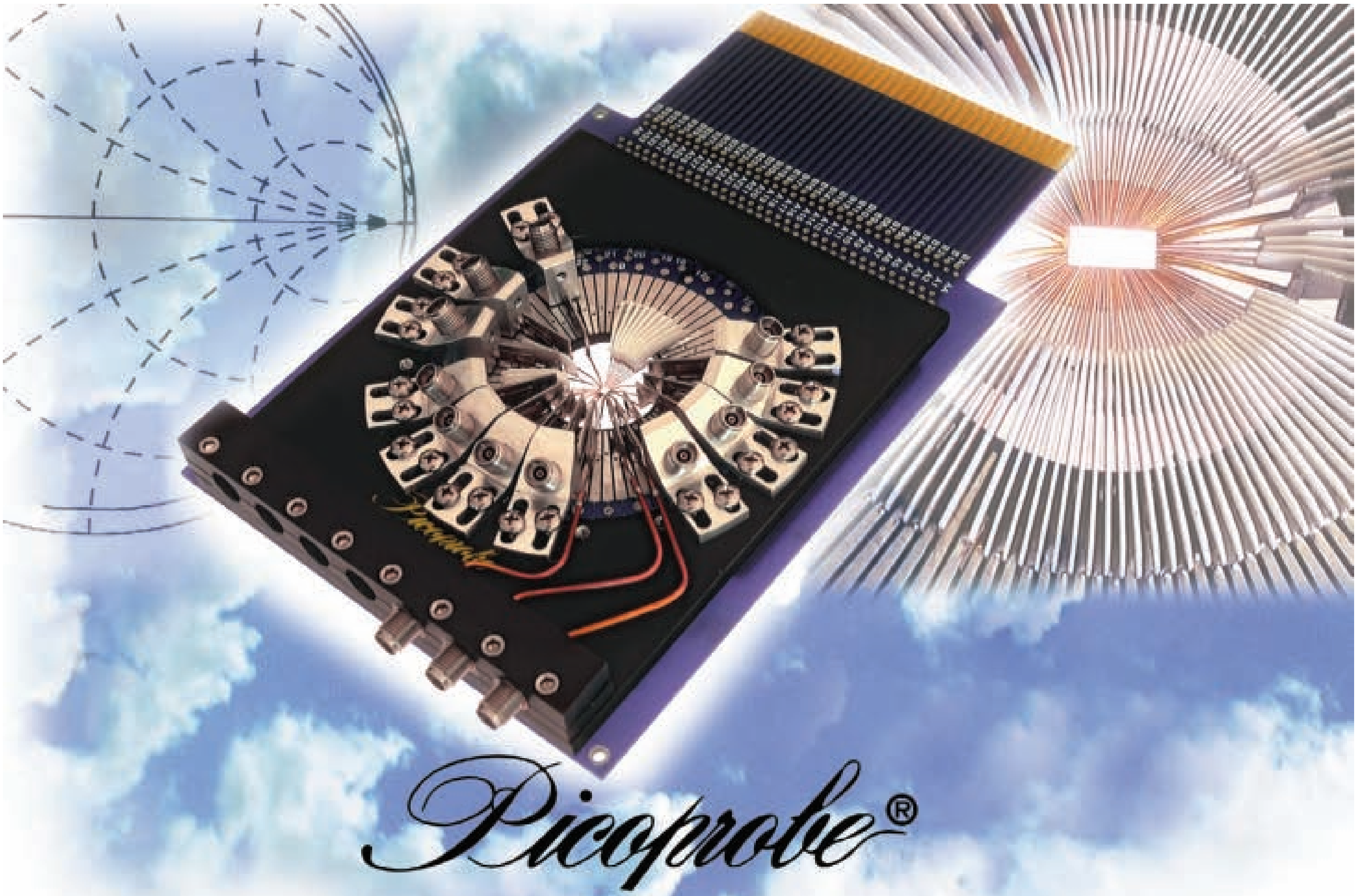
Microwave **E**lectronic **C**omponents of **A**merica

866.444.6322 | sales@e-meca.com | www.e-meca.com

459 East Main Street • Denville, NJ 07834 • 973.625.0661 • Fax: 973.625.9277

THE FASTEST SOLUTIONS TO YOUR RF/MICROWAVE COMPONENT NEEDS

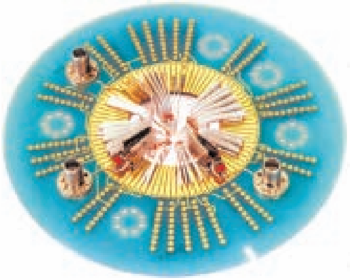
Visit http://mwj.hotims.com/16346-78 or use RS# 78 at www.mwjournal.com/info



Picoprobe elevates probe cards to a higher level…

(…110 GHz to be exact.)

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



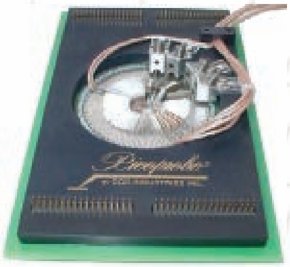
Through unique modular design techniques, hundreds of low frequency probe needles and a variety of microwave probes with operating frequencies from DC to 40, 67, or even 110 GHz can be custom configured to your layout.

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

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

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

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



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

GGB INDUSTRIES, INC. • P.O. BOX 10958 • NAPLES, FL 34101

Telephone (239) 643-4400 • Fax (239) 643-4403 • E-mail email@ggb.com • www.picoprobe.com

Visit http://mwj.hotims.com/16346-52 or use RS# 52 at www.mwjournal.com/info

VCOs

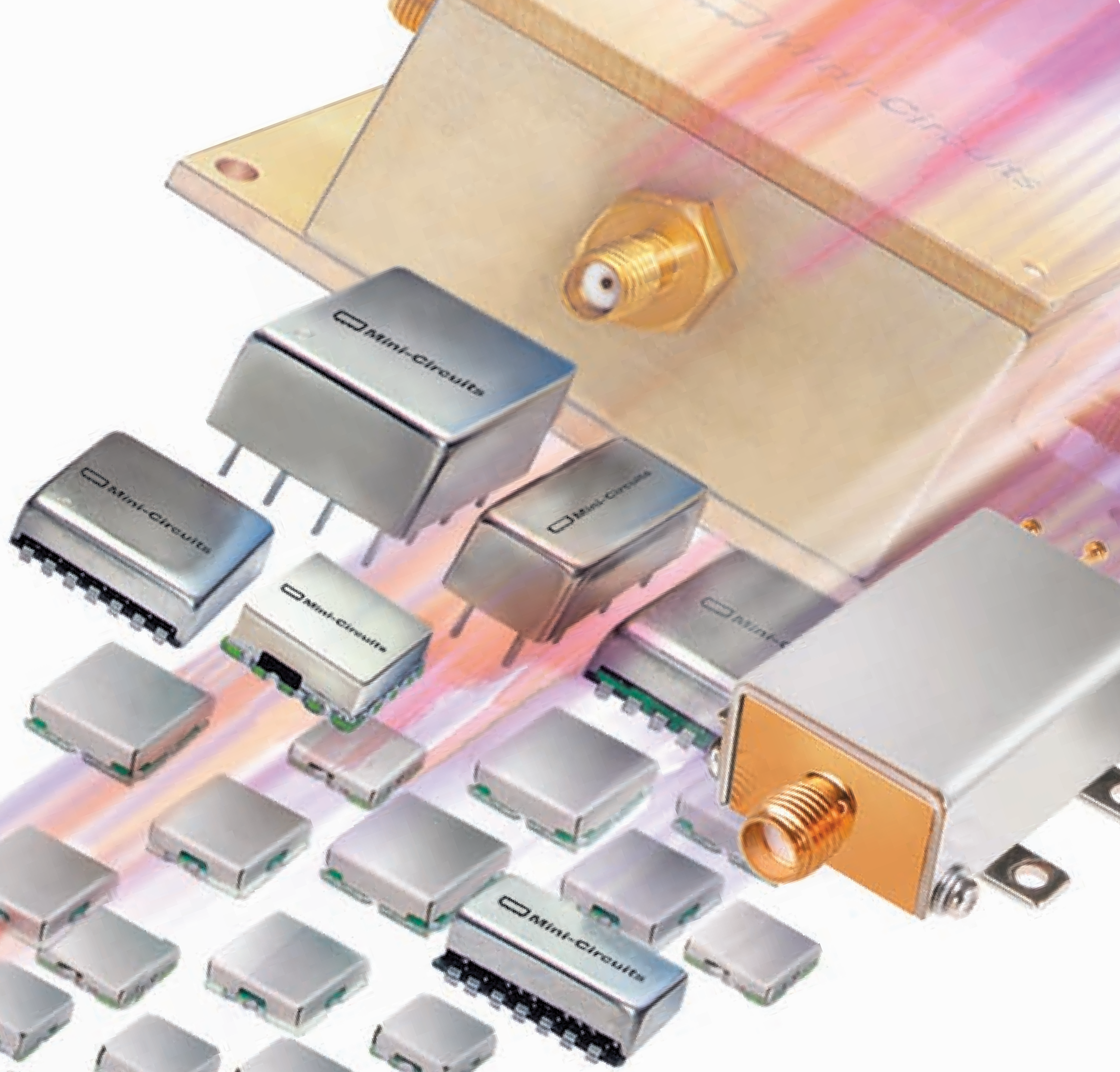
10 to 6740 MHz from 11^{95} ea. (qty. 5)

RoHS COMPLIANT

RoHS models available, consult factory.

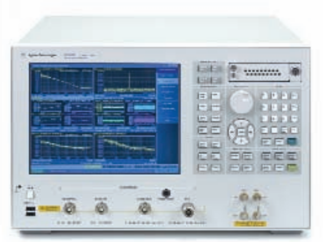
Want a miniature surface mount, shielded plug-in, or rugged connectorized voltage controlled oscillator with the right stuff for your project ? Contact Mini-Circuits! From custom designs to standard catalog models ***always in stock***, we'll supply extra robust, 100% tested VCO solutions you need at a price you can afford. Choose from narrow, to broad, to octave bandwidths. Select from models with low phase noise, linear tuning, load insensitivity, dual output, wide modulation bandwidths, or 5V models optimized for PLL ICs and synthesizers. And pick from an innovative array of miniature surface mount packages as small as 0.25" square, all featuring our exclusive glue-down process on each circuit component to give you ultimate reliability during reflow soldering. You can quickly find the model you need using our online catalog or "The YONI2 Search Engine" at the Mini-Circuits web site. Just enter your specs into YONI2…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 fast response, low prices, and quick turnaround. For your commercial, industrial, and military applications, choose 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



Detailed Performance Data & Specs For Mini-Circuits VCOs
*Available Online at: **www.minicircuits.com/oscillat.html***

Mini-Circuits®
ISO 9001 ISO 14001 CERTIFIED

ALL NEW minicircuits.com

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

YONI2™ Patent Pending ***The Design Engineers Search Engine** Provides ACTUAL Data Instantly From MINI-CIRCUITS At: **www.minicircuits.com***

IF/RF MICROWAVE COMPONENTS

402 Rev G

Visit http://mwj.hotims.com/16346-90 or use RS# 90 at www.mwjournal.com/info


FOR 60 YEARS
CUSTOMER SATISFACTION
HAS BEEN OUR GUARANTEE
3 Simple Reasons Why You Should Choose Dow-Key
1 PRODUCT INNOVATION
• 5 Million Cycle Products
• DC To 40 GHz Coaxial Switches
• 2.6 To 70 GHz Waveguide Switches
• PXI Broadband Modules
• High Power, PCB Mounted, Miniature Switches
• Switching Networks (Solid State, MEMS & Coaxial)
• Design Flexibilty for Custom Solutions
• Space Qualified High Power Switches
2 SHORT DELIVERY LEAD TIME
• Kanban System Offers Stock to 2 Week Delivery on Selected SPDT, DPDT And SP6T Switches
3 CUSTOMER FOCUS
• Superior Customer Support
• Customer Recognition as "Switch Supplier of Choice" for 5 Consecutive Years
• Star Supplier Award Recipient
(805) 650-0260
askdktmj2@dowkey.com
www.dowkey.com
Visit http://mwj.hotims.com/16346-39 or use RS# 39 at www.mwjournal.com/info
Dow-Key® Microwave
CORPORATION
A DOVER COMPANY

K&L MICROWAVE
A DOVER COMPANY

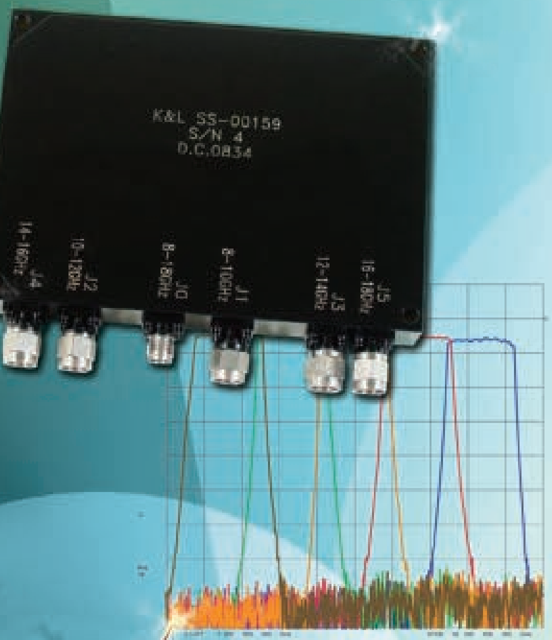
Filter Solutions

Passbands from 8 to 18 GHz

Combines Several Filters to a Common Port

Small Sizes and Custom Packages

Product Spotlight



8-18 GHz Multiplexer with Overlapping Bands

For wideband receiver applications, the 8 to 18 GHz spectrum is divided into 2 GHz segments prior to the amplification stage. The multiplexer passes each band with flat insertion loss of 1.25 dB and provides isolation of 70 dB between channels, directly affecting the dynamic range of signal detection equipment.

Other features of the multiplexer include:

- Overlapping Channels
- Resonators Machined Directly into the Housing for High Reliability
- Laser Welded Cover to Meet Fine Leak Requirements
- 4" x 3" x .5" with SMA Connectors on One Side

Filter Wizard℠

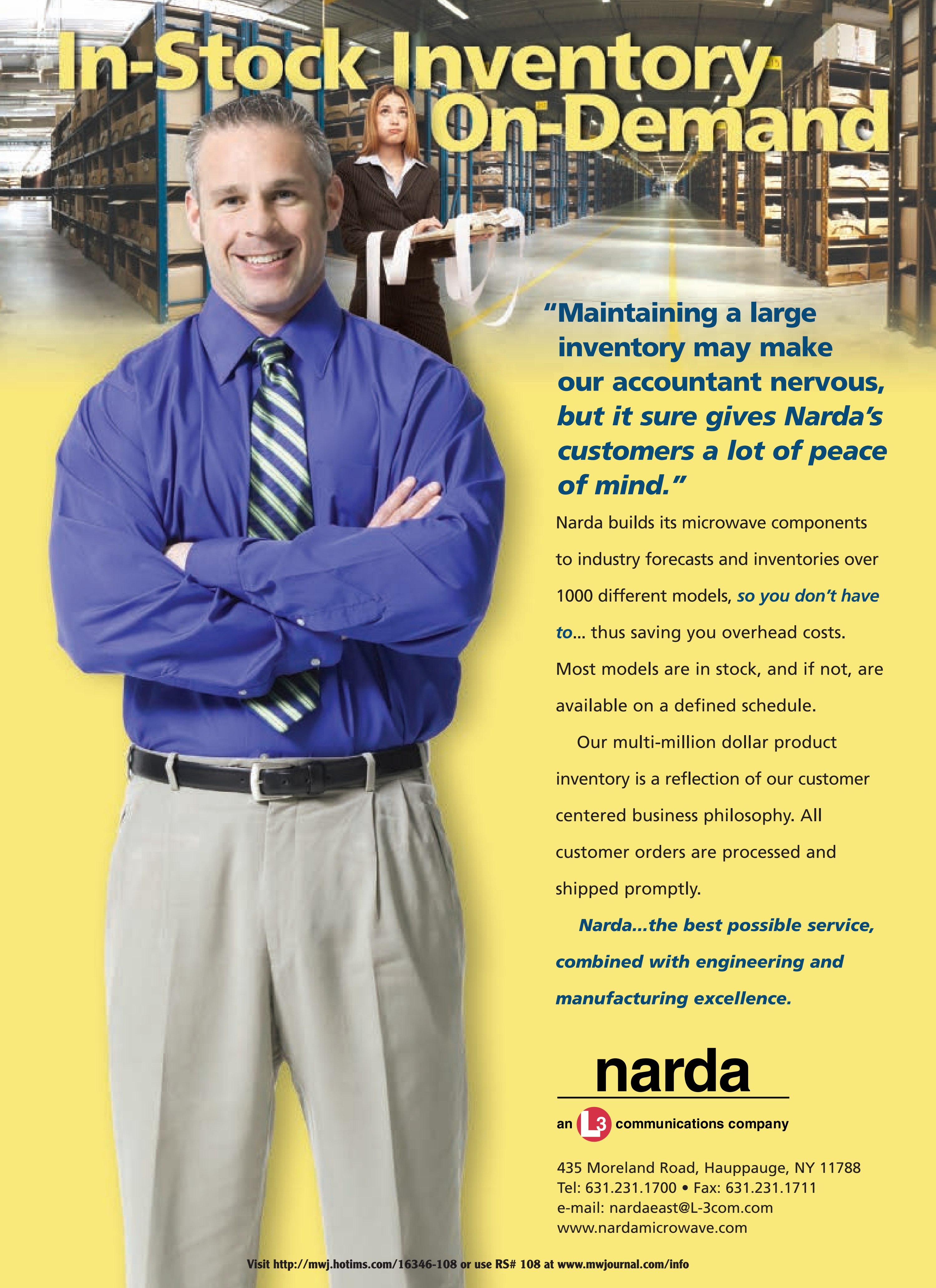
K&L Microwave's Filter Wizard℠ software simplifies selection of the right filter product for your application from a vast number of designs. Provide desired specifications, and Filter Wizard℠ returns response data, downloadable S-parameter data, and outline drawings for matching products. Visit www.klfilterwizard.com today!

microwave products group

QMI ISO 9001 Registered AS9100B

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 • sales@kleurope.com

Visit http://mwj.hotims.com/16346-68 or use RS# 68 at www.mwjournal.com/info

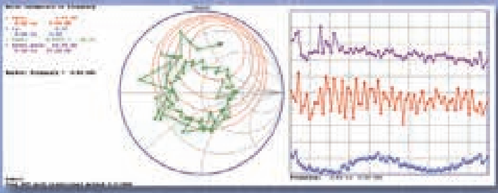

In-Stock Inventory
On-Demand
"Maintaining a large inventory may make our accountant nervous, *but it sure gives Narda's customers a lot of peace of mind."*
Narda builds its microwave components to industry forecasts and inventories over 1000 different models, *so you don't have to*... thus saving you overhead costs. Most models are in stock, and if not, are available on a defined schedule.
Our multi-million dollar product inventory is a reflection of our customer centered business philosophy. All customer orders are processed and shipped promptly.
Narda...the best possible service, combined with engineering and manufacturing excellence.
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
Visit http://mwj.hotims.com/16346-108 or use RS# 108 at www.mwjournal.com/info

Measure With Confidence!

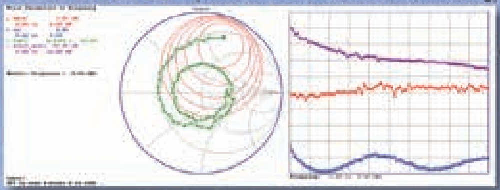
Maury & Agilent are Teamed Together for PNA-X Apps

100x Speed Improvement in Noise Parameter Measurement with Maury + PNA-X

Old Method

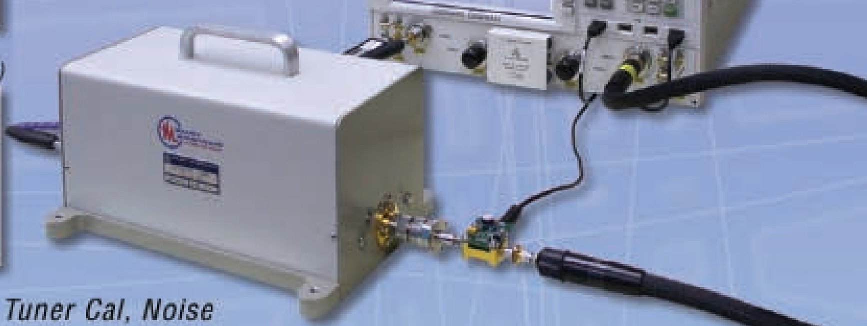


New Method* *(U.S. & International Patents Pending)*



- Simple Setup & Ultra-Fast Process
- Enhanced Measurement Accuracy
- Smoother Data with Less Scatter

Maury ATSv5.1 Software runs inside Agilent's PNA-X or on your Windows® Based PC.

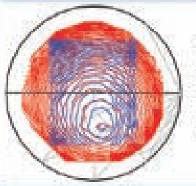


*Results in Just **8 Minutes** (Including Tuner Cal, Noise Receiver Cal, & DUT Measurements for 73 Frequencies!

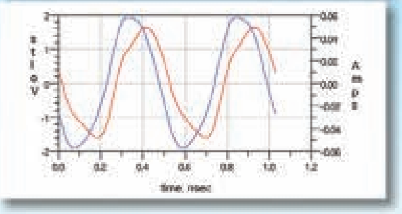
Maury Load Pull + PNA-X Provides Instant Large Signal Models for PA Design

NOW! Control Your Tuners From The PNA With **ATSv5.1** AUTOMATED TUNER SYSTEM SOFTWARE

Typical PAE (red) and Delivered Power (blue) contours from measurement-based load-dependent X-Parameters



Simulated (blue) and Independent Measured (red) Delivered Power Contours



- Automated Process from Measurement to Simulation with Simple Setup
- Start Simulation Immediately with PHD Large Signal Model Over the Entire Smith Chart
- Includes Magnitude & Phase Data as Non-linear Functions of Power, Bias and Load at Each Harmonic
- Includes Time Domain Data

Agilent Technologies
Channel Partner

MAURY MICROWAVE
WWW.MAURYMW.COM

Contact our Sales Department for Upgrade Options at:

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

Maury will be Exhibiting with our Representative **BSW Test Systems & Consulting AG** in Amsterdam, Netherlands Oct 27-31 2008 at the **EuMW 2008 Stand # 411**

OCTOBER 2008 VOL. 51 • NO. 10

COVER FEATURE: THEN AND NOW

TUTORIAL

SPECIAL REPORTS

TECHNICAL FEATURES

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 Wendelyn Bailey 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.

©2008 by Horizon House Publications Inc.

Posted under Canadian international publications mail agreement #0738654

Your declaration of independence

The new R&S®SMBV 100A vector signal generator – a stand-alone solution with unmatched flexibility

Where other mid-range signal generators make you buy add-ons to do common tasks, the new R&S®SMBV 100A comes fully equipped to do the job right out of the box. It supports all important digital standards, and has a wide 528 MHz modulation bandwidth as well as the highest output power up to 6 GHz in its class. It all means:

- Simpler testing – signal creation with no need to connect to a PC
- Faster testing, with big ARB memory and short switching times
- More accurate testing, with excellent RF performance

And much more than we can possibly tell you about here. To find out about everything this instrument can do, go to www.rohde-schwarz.com/ad/smbv

Hey Bill,
this looks like
a perfect fit
for us.

75 Years of Driving Innovation

ROHDE&SCHWARZ

Visit http://mwj.hotims.com/16346-141 or use RS# 141 at www.mwjournal.com/info

Microwave Journal

PRODUCT FEATURES

DEPARTMENTS

STAFF

Publisher: Carl Sheffres
Editor: David Vye
Managing Editor: Keith W. Moore
Technical Editor: Patrick Hindle
Associate Technical Editor: Dan Massé
Staff Editor: Jennifer DiMarco
Editorial Assistant: Barbara Walsh
Consulting Editor: Harlan Howe, Jr.
Consulting Editor: Frank Bashore
Consulting Editor: Peter Staecker
Consulting Editor: Dan Swanson
Web Editor: Samantha Bookman
Circulation Manager: Michelle Frazier
Traffic Manager: Edward Kiessling
Director of Production & Distribution: Robert Bass
Multimedia Designer: Greg Lamb
Web Site Production Designer: Michael O'Brien
DTP Coordinator: Janice Levenson
Graphic Designer: Sachiko Stiglitz

EUROPE

International Editor: Richard Mumford
Office Manager: Eugenie Hardy

CORPORATE STAFF

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

Editorial Review Board:

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

Executive Editorial Office:

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

European Editorial Office:

46 Gillingham Street, London SW1V 1HH, England
Tel: Editorial: +44 207 596 8730 Sales: +44 207 596 8740
FAX: +44 207 596 8749

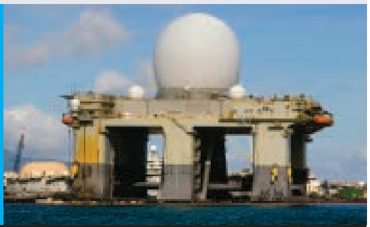
www.mwjournal.com

Printed in the USA

CARLISLE
INTERCONNECT TECHNOLOGIES
The combination of Tensolite and **CARLYLE INC.**

GOING THROUGH A PHASE?

Carlisle's family of precision coaxial phase adjusters is ideally suited for **Electronically Scanned Arrays** (ESAs) as well as other military and space applications.



FEATURES and **BENEFITS**:

- Multiple configurations include box models, coaxial airlines with mounting brackets and models that terminate at the end of a cable assembly.
- Carlisle offers a variety of interface options including SMA, TNC, SSMA, SMP and SSMP®.
- Covers frequency range from DC to 26 GHz.
- Allows for continuous adjustment of phase over the entire operating frequency range.
- All phase adjusters have mechanisms that allow for locking the device at a desired phase length.
- Phase adjustments are done in airlines to maintain 50-Ohm impedance and phase stability over temperature.

(866) 282-4708 Tel
(562) 494-0955 Fax

For more information:
rf@carlisleit.com

www.carlisleit.com

Visit http://mwj.hotims.com/16346-26 or use RS# 26 at www.mwjournal.com/info

Microwave Journal Online

Go to www.mwjournal.com

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

Free Webinars

50 Volt LDMOS Revitalizes Radar and Broadcast Markets

This must-see webinar will present an overview of the technology behind the device used in high power wireless infrastructure power amplifier applications.

Presented by **Freescale Semiconductor** and *Microwave Journal.*

Live webcast: October 23rd 11:00 am (EDT), October 24th 10:00 am Tokyo, 9:00 am Beijing

MWJ/Besser Associates Webinar Series

MMIC Design

This free webinar provides an overview of some of the practical strategies required to address MMIC lifetime, accurately model on-chip components and prevent unwanted oscillations.

Presented by **Besser Associates** and *Microwave Journal*.

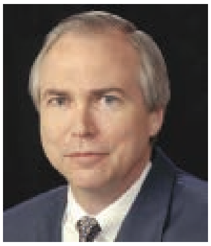
Sponsored by **AWR Corp.**

Live webcast: 10/21/2008, 11:00 am (EDT)

Expert Advice

Joel Kirschman, **AWR**, talks about the virtues of using a graphical interface for system-level design and the advantages of a system (communication) simulator over homegrown spreadsheets and back of the envelope approximations.

Executive Interview



Microwave Journal talks to **Rick Montgomery**, CEO, **Mimix Broadband**, about his company's history, the benefits of being fabless, the business outlook for microwave applications and their new Mimix SmartSet MMICs.

Retrospectives: An excerpt from the new book by Norman H. Pond, *The Tube Guys*. Pond was a tube guy for 30 years - with Hughes Aircraft, Sylvania, Microwave Electronics and eventually as president of Varian. The author of several articles on this topic for MWJ, Pond has now authored a truly fascinating history on this technology's evolution.

Events: European Microwave Week 2008 coverage continues with our Online Show Daily. Read our exclusive content from conference organizers, exhibitor perspectives, daily press releases, our editor's show wrap-up and the all new Virtual Trade Booths, featuring in-booth video interviews with exhibitors. (www.mwjournal.com/eumw2008)

MWJ Blog: MWJ editors share the information that comes across their desk by way of press releases and conversations with the product managers and engineers working in the trenches. Go beyond the headlines with these frequent updates on the news and our interpretation of how the industry might be affected. (microwavejournal.blogspot.com)

Online Technical Papers

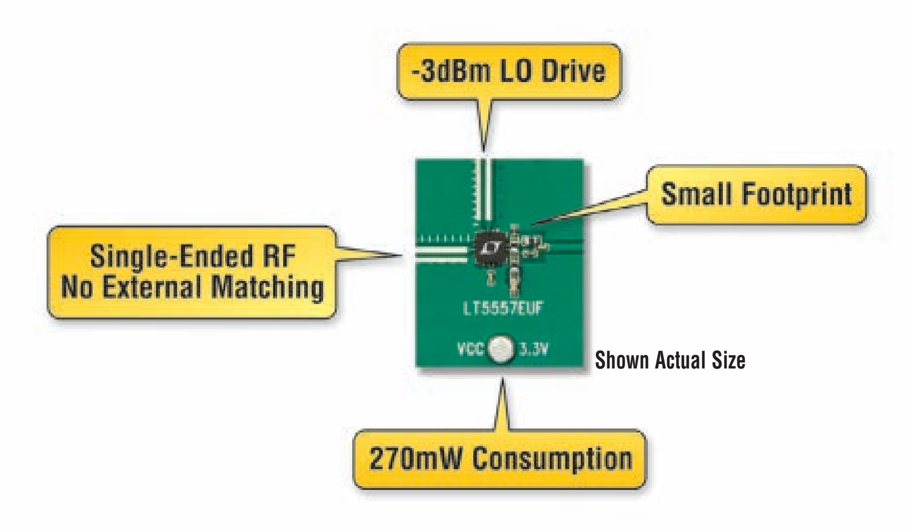
Novel Compact Monopole Antenna with a Parasitic Plate for WLAN Applications
Wen-Shan Chen and Ho-Yu Lin, Southern Taiwan University of Technology

Application Note: Designing GaAs Power Amplifiers for Femtocells
Joe Cozzarelli, Anadigics

RF Planning Speeds System-level Analysis
Joel Kirschman, AWR

Tutorial: VCO Design Explained
Joseph Andrews, RFVCO

+25dBm IIP3 Broadband Active Mixer



3.3V Receive Mixer Is Ideal for 3G and WiMAX

The LT®5557 delivers uncompromising performance in an active downconverting mixer that operates from 400MHz to 3.8GHz. Its superior linearity, low noise and high gain extend your receiver's dynamic range. Its 3.3V operation, easy-to-design features and our strong applications support reduce both time to market and production costs.

Features

- 3.3V Operation
- Wide Bandwidth: 400MHz to 3.8GHz
- -3dBm LO Drive
- 3.3dB Conversion Gain @ 900MHz
- 10.6dB NF @ 900MHz
- Single-Ended, 50Ω RF and LO Ports
- >40dB Isolation

Application	IIP3
900MHz	25.6dBm
1950MHz	24.7dBm
2600MHz	23.7dBm
3600MHz	23.5dBm

Info & Free Samples

www.linear.com/5557
1-800-4-LINEAR

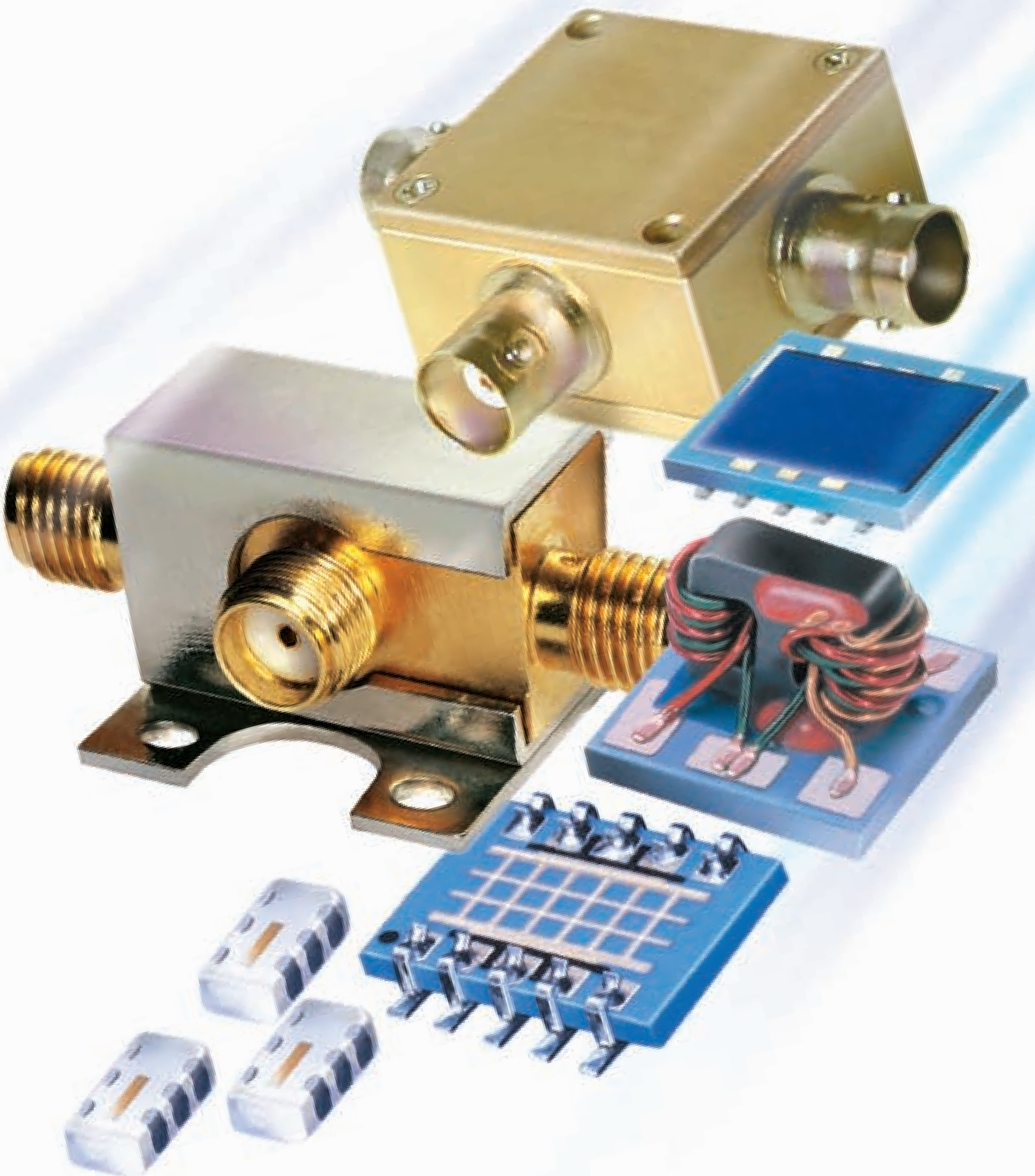
Free Wireless Solutions Brochure

www.linear.com/wireless

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

LINEAR TECHNOLOGY

Visit http://mwj.hotims.com/16346-71 or use RS# 71 at www.mwjournal.com/info



Directional/Bi-Directional

LTCC COUPLER FAMILY

RoHS COMPLIANT

IN STOCK From $ 1.69 ea. Qty.1000

Mini-Circuits LTCC coupler family offers versatile, low cost solutions for your ***5 to 4200 MHz*** 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 CERTIFIED

ALL NEW minicircuits.com

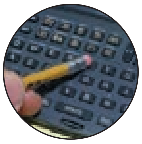
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661 For detailed performance specs & shopping online see Mini-Circuits web site

YONI2™ Patent Pending
The Design Engineers Search Engine *Provides ACTUAL Data Instantly From MINI-CIRCUITS At:* ***www.minicircuits.com***

RF/IF MICROWAVE COMPONENTS

396 Rev E

Visit http://mwj.hotims.com/16346-91 or use RS# 91 at www.mwjournal.com/info



COMING EVENTS

CALL FOR PAPERS

IEEE MTT-S International Microwave Symposium (IMS 2009)
by December 8, 2008

IEEE Radio Frequency Integrated Circuits Symposium (RFIC 2009)
by January 6, 2009

OCTOBER

AOC International Convention
October 19–23, 2008 • Reno, NV
www.crows.org

European Microwave Week
October 27–31, 2008
Amsterdam, The Netherlands
www.eumweek.com

NOVEMBER

WCA International Symposium
November 4–6, 2008 • San Jose, CA
www.wcai.com

electronica 2008
November 11–14, 2008 • Munich, Germany
www.electronica.de/en

AMTA 2008
November 16–21, 2008 • Boston, MA
www.amta2008.org

MILCOM 2008
November 17–19, 2008 • San Diego, CA
www.milcom.org

IME China 2008
November 18–20, 2008 • Shanghai, China
www.imwexpo.com

DECEMBER

ARFTG 72nd Microwave Measurement Symposium
December 9–12, 2008 • Portland, OR
www.arftg.org

Asia Pacific Microwave Conference (APMC 2008)
December 16–19, 2008 • Hong Kong, China
December 19–20, 2008 • Macau, China
www.apmc2008.org

JANUARY

IEEE Radio and Wireless Symposium (RWS 2009)
January 18–22, 2009 • San Diego, CA
http://rawcon.org

FEBRUARY

Mobile World Congress
February 16–19, 2009
Barcelona, Spain
www.mobileworldcongress.com

National Association of Tower Erectors (NATE 2009)
February 23–26, 2009 • Nashville, TN
www.natehome.com

MARCH

Satellite 2009
March 24–27, 2009 • Washington, DC
www.satellite2009.com

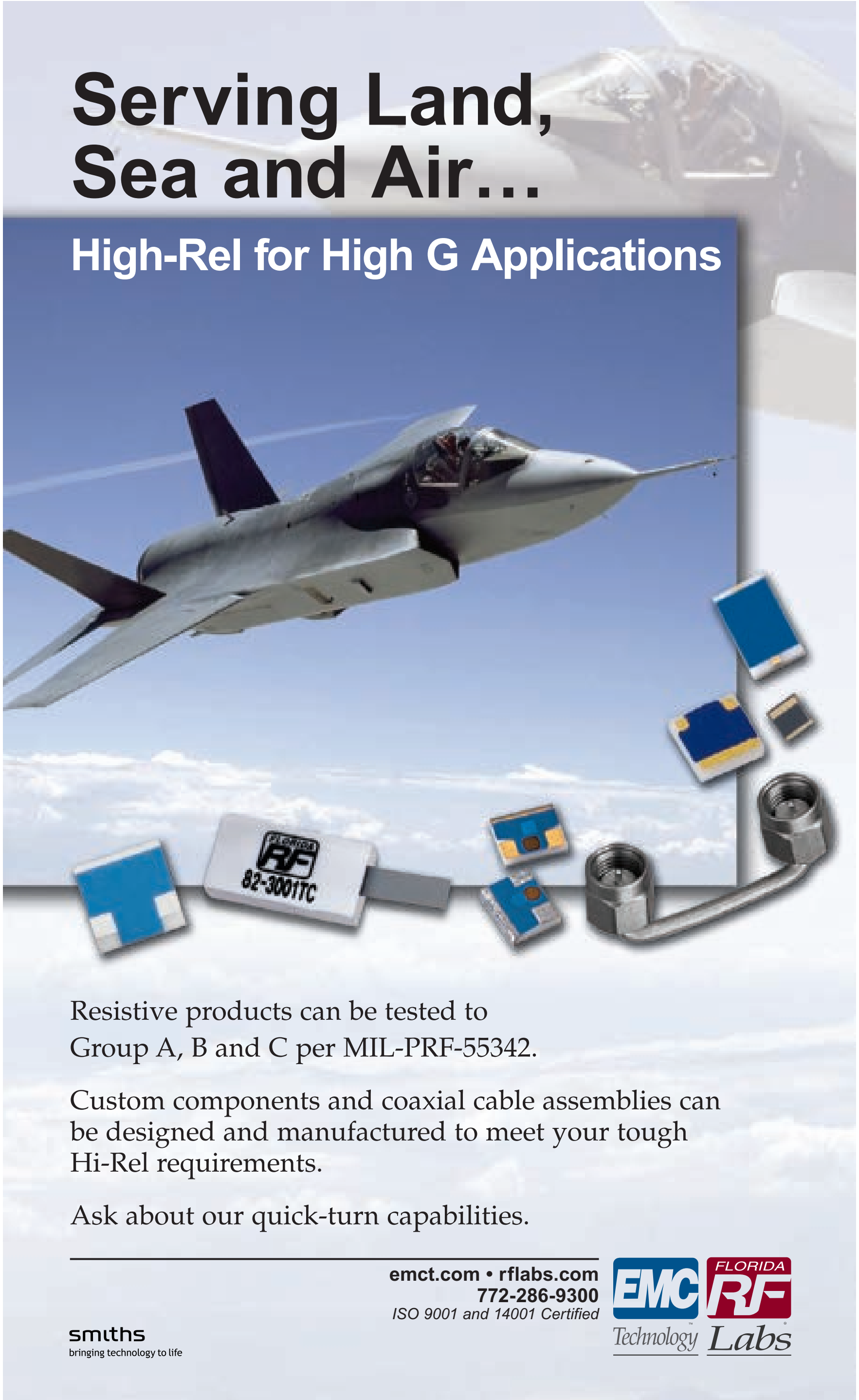
APRIL

CTIA with RF, Microwave and M2M Zones
April 1–3, 2009 • Las Vegas, NV
www.ctiawireless.com

JUNE

IEEE Radio Frequency Integrated Circuits Symposium (RFIC 2009)
June 7–9, 2009 • Boston, MA
www.rfic2009.org

IEEE MTT-S International Microwave Symposium (IMS 2009)
June 7–12, 2009 • Boston, MA
www.ims2009.org



Visit http://mwj.hotims.com/16346-45

Workshops & Courses

'Inspiring Engineering' Application Workshops

■ **Topics:** Ansoft's "Inspiring Engineering" application workshops for high-performance electronic design provide a unique opportunity that brings together designers, engineers, managers and technologists to discuss how applications of advanced electromagnetic and circuit simulation solve some of today's most challenging design problems. Topics include: signal- and power-integrity analysis; EMI/EMC; and RF, microwave and antenna system design.
■ **Site:** US, Asia and Europe
■ **Dates:** October 30–November 12, 2008
■ **Contact:** For more information, visit www.ansoft.com/ie.

Far-field, Anechoic Chamber, Compact and Near-field Antenna Measurement Techniques

■ **Topics:** Master the state-of-the-art far-field, anechoic chamber, compact and near-field measurements. Learn antenna measurement facility characterization and compensation techniques and microwave holography. Examine theory and optimal application of each technique. Concentrate on basic concepts, design, procedures and application. Focus on antenna measurements in the HF, VHF, UHF, microwave and millimeter-wave frequency ranges. Visit MI Technologies' compact range and demonstration facilities.
■ **Site:** Atlanta, GA
■ **Dates:** November 10–14, 2008
■ **Contact:** For more information, visit www.defense.gatech.edu/courses/.

Integrated Nonlinear Microwave and Millimeter-wave Circuits (INMMiC)

■ **Topics:** INMMiC offers a forum for promoting, discussing and spreading ideas in the field of nonlinear microwave and millimeter-wave circuits. Technical papers describing methodological and practical issues on active device characterization and modeling strategies, CAD analysis methods and design approaches are solicited, according to the conference topic list.
■ **Site:** Málaga, Spain
■ **Dates:** November 24–25, 2008
■ **Contact:** For more information, visit www.inmmic.org.

Power Seminar Tour

■ **Topics:** Fairchild's power experts bring you the latest in design techniques for optimizing system power. This one-day event provides insight into analog, discrete and optoelectric solutions. The registration fee includes lunch and a copy of all presentations and white papers. For more information, visit www.fairchildsemi.com.
■ **Site:** For location information, please visit url.
■ **Dates:** For date information, please visit url.
■ **Contact:** Fairchild Semiconductor Corp., 82 Running Hill Road, South Portland, ME 04106 (207) 775-8100.

Semiconductor Devices for IC Design

■ **Topics:** This course provides an in-depth and comprehensive understanding of the basic characteristics of semiconductor devices plus their second-order effects and device modeling that enable a circuit designer to cope with ever-increasing bandwidths of state-of-the-art designs. This course is intended for working professionals who are interested in understanding semiconductor devices and their modeling for integrated-circuit design. Many topics in BJT and MOS are covered.
■ **Site:** On-line course.
■ **Dates:** Open enrollment.
■ **Contact:** For more information, visit www.unex.berkeley.edu.

The Entrepreneurial Engineer

■ **Topics:** This short course is an introduction to the personal, interpersonal, business and organizational skills necessary to help engineers of applied science and mathematics perform at high levels in today's increasingly opportunistic organizations and enterprises. For more information, visit http://online.engr.uiuc.edu/shortcourses/tee/index.html.
■ **Site:** Archived on-line course.
■ **Dates:** Archived on-line for anytime viewing.
■ **Contact:** University of Illinois at Urbana-Champaign, 117 Transportation Bldg., 104 S. Mathews Avenue, Urbana, IL 61801 (217) 333-0897 or e-mail: deg@uiuc.edu.

GET THE LATEST GUIDE

RF engineers can find the latest GaAs, SAW and BAW devices in TriQuint Semiconductor's recently updated product selection guide.

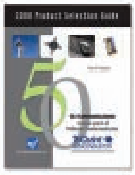
TriQuint has expanded its 2008 Product Selection Guide with new devices for GPS, base stations, auto radar, WLAN and many other applications.

We've also added hundreds of new products thanks to the recent acquisition of WJ Communications. Get both product guides by visiting www.triquint.com.

TriQuint's GaAs, LDMOS, SAW and BAW devices are inside the world's most popular RF products. Our newly-introduced Gallium Nitride (GaN) amplifier family offers greater power density and rugged dependability for applications up to 18 GHz. Buy with confidence from a product innovator.

Visit www.triquint.com/rf to register for our newsletter detailing the latest product and process updates.

WJ Communications is now a part of TriQuint Semiconductor. To download WJ's latest product selection guide, visit www.triquint.com.



VISIT US AT EuMW 2008 – STAND #407 - HALL 3 – PICK UP OUR LATEST PRODUCT SELECTION GUIDES AND ASK ABOUT OUR NEW FOUNDRY PROCESSES!

TriQuint® SEMICONDUCTOR

Phone: +1-503-615-9000 | Fax: +1-503-615-8900
E-mail: info-sales@tqs.com | Website: www.triquint.com

Connecting the Digital World to the Global Network®

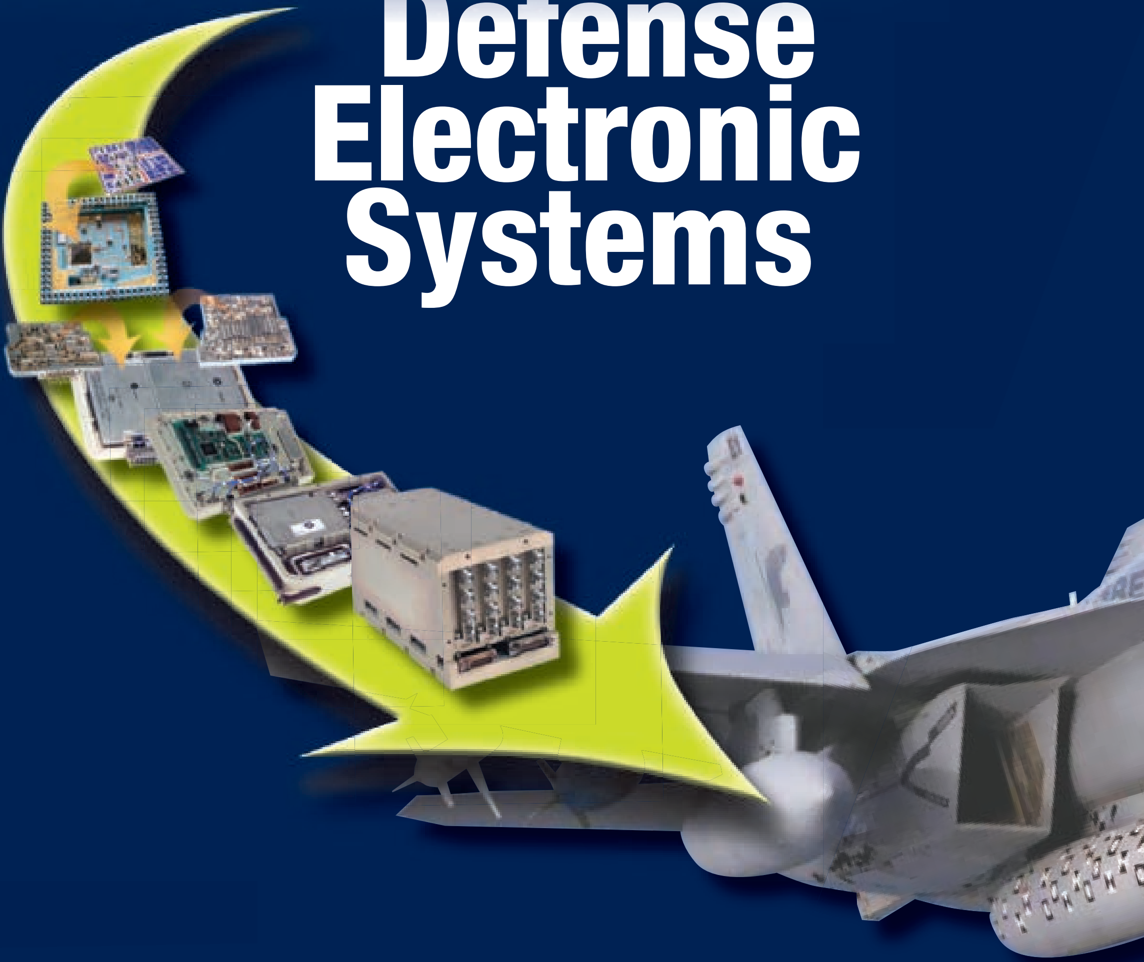
© 10-08 TriQuint Semiconductor, Inc.

Visit http://mwj.hotims.com/16346-167 or use RS# 167 at www.mwjournal.com/info

FOR
IMMEDIATE RELEASE

Cobham Defense Electronic Systems completes it's acquisition of M/A-COM's Radio Frequency components and subsystems business

Cobham Defense Electronic Systems

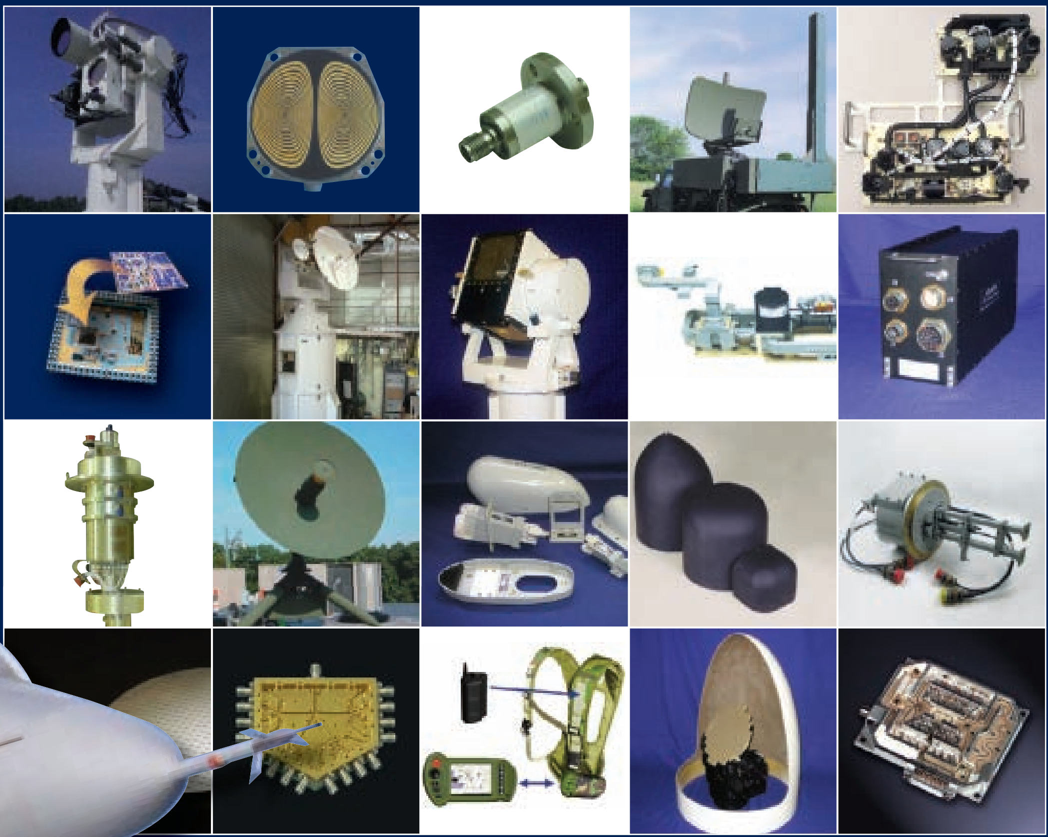


Cobham Defense Electronic Systems is...

Atlantic Microwave, Atlantic Positioning Systems, Cobham Defense Communications Ltd., Continental Microwave, Kevlin, Lansdale, M/A-COM, Nurad, REMEC Defense & Space, Sivers Lab AB

the power of integration

ELECTRONIC WARFARE RADAR GROUND AND MOBILE COMMUNICATIONS SATELLITE COMMUNICATION COMMERCIAL AVIATION SMART MUNITIONS AND MISSILES HOMELAND SECURITY SPACE SEARCH AND SURVEILLANCE OVERHAUL AND REPAIR



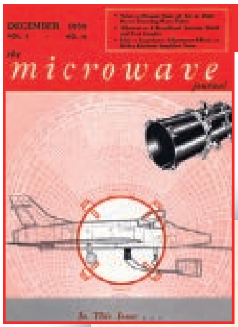
COBHAM

For more information, go to our website
www.cobhamdes.com

A Cobham plc subsidiary

ATLANTIC POSITIONING SYSTEMS www.atlanticpositioners.com 727.299.0150 ATLANTIC MICROWAVE www.atlanticmicrowave.com 978.779.6963
COBHAM DEFENSE COMMUNICATIONS Ltd. www.cobhamdcweb.com +44 0 1254 292020 CONTINENTAL MICROWAVE www.contmicro.com 603.775.5200
KEVLIN www.kevlin.com 978.557.2400 LANSDALE www.cobhamdes.com 215.996.2000 M/A-COM www.macom.com North America 800.366.2266
Europe +44 0 1908.574200 Asia / Pacific +81.44.844.8296 NURAD www.nurad.com 410.542.1700
REMEC DEFENSE & SPACE www.remecrds.com 858.560.1301 SIVERS LAB AB www.siverslab.se +46 8 477 6811

Visit http://mwj.hotims.com/16346-30 or use RS# 30 at www.mwjournal.com/info



PRESENT STATE OF ART IN HIGH POWER TRAVELING-WAVE TUBES

ERVIN J. NALOS
General Electric Co.
Microwave Laboratory
Palo Alto, California

ABSTRACT

The object of this paper is to outline the present state of art in the high power microwave field with special emphasis on linear beam circuits interacting with periodically loaded waveguides.

A number of interaction circuits are discussed, both for "O" and "M" type tubes and areas of advances and future trends are indicated.

I. INTRODUCTION

A. Historical Background

The present effort in the area of high power traveling-wave tubes finds its common root in both klystron development and the original low power helix TWT development. This is in a sense natural, since the achievement of megawatt-type microwave devices was first demonstrated in a klystron [1] whereas broadband amplification was first demonstrated in the low power helix TW tube.[2] Both types of devices use the velocity modulation principle, one in the form of standing waves, the other in the form of traveling-waves. In addition, many similarities in the design of both devices, such as beam formation, extraction of electromagnetic energy, and beam collection, serve to provide a common background of development. The discussion in this paper will deal primarily with linear beam devices with some reference to cross-field devices in order to give a fairly comprehensive picture of the state of art in high power microwave tubes.

The first effort designed to produce megawatts of pulsed microwave power was conducted on the high power pulsed klystron [1] at Stanford. This work conclusively demonstrated that large oxide-coated cathodes could be operated reliably at voltages of several hundred kilovolts, and provided the necessary impetus for further high power research directed toward the achievement of broader bandwidth at high power levels. Although prior to this work, a number of interaction circuits have been suggested by Pierce,[3] Field,[4] and others, their electrical characteristics were considered inferior to the simple helix at all but the highest voltages, where the helix becomes unsuitable. This is primarily due to its good radiating properties when stretched out to be in synchronism with a high velocity beam. With the demonstrated success of the high power pulsed klystron, a much greater interest developed in the utilization of traveling-wave devices in conjunction with high voltage electron beams. Unfortunately, in order to slow the electromagnetic wave down to synchronism with an electron beam, smooth transmission lines such as waveguides cannot be used directly; instead, some form of loading must be used. The periodically loaded waveguide provides a means of doing this.

the microwave journal for December, 1959 31

COAXIAL AND WAVEGUIDE SWITCHES

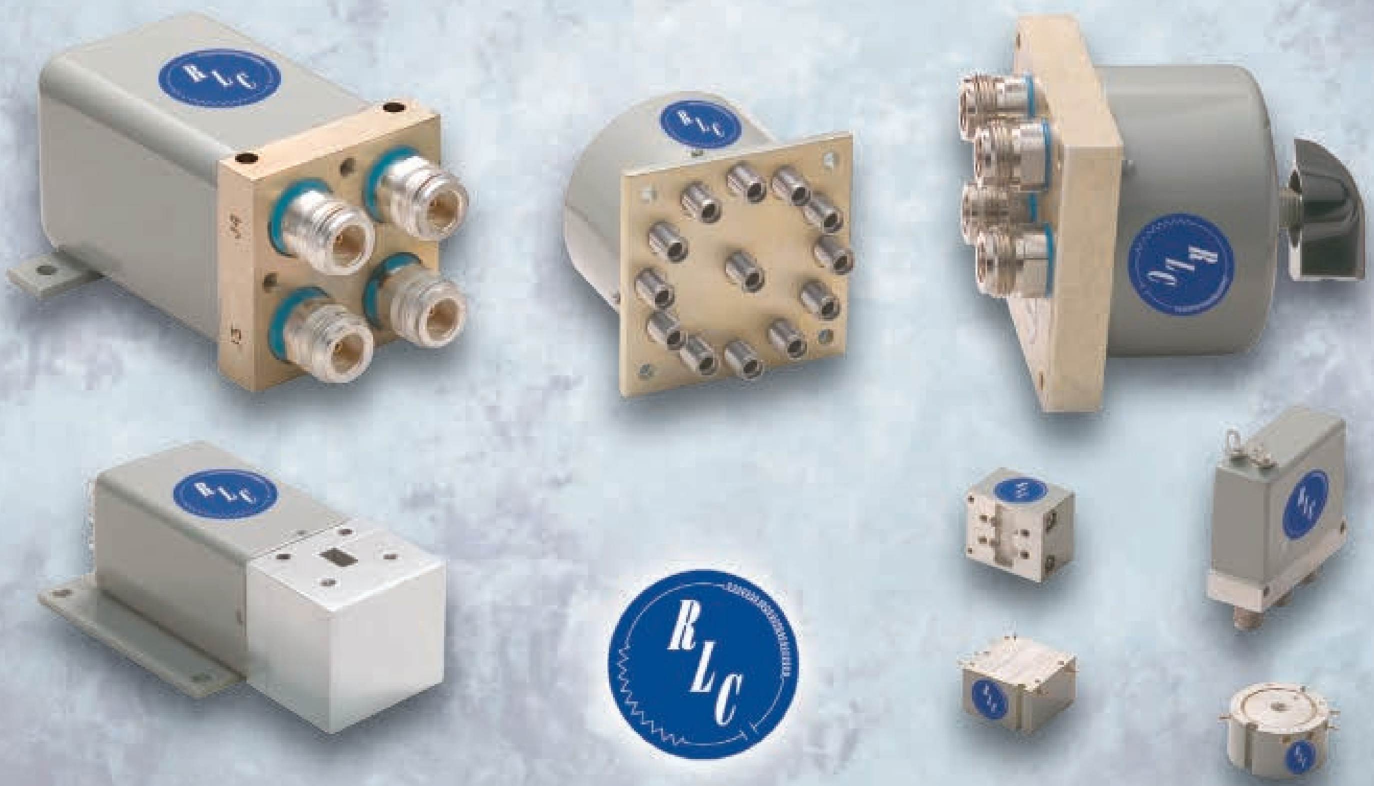
RLC has the exact solution you're looking for.

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

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

- SPDT to SP12T
- Transfer
- Low VSWR
- High Isolation
- Low Insertion Loss
- High Power
- Low Passive Intermodulation
- Surface Mount Options

For more detailed information on coaxial and waveguide switches, visit our web site.



RLC ELECTRONICS, INC.

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

ISO 9001:2000 CERTIFIED

VISA MasterCard

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

Visit http://mwj.hotims.com/16346-138 or use RS# 138 at www.mwjournal.com/info

B. General Discussions of High Power Microwave Tubes

Before proceeding with a detailed analysis of the periodically loaded waveguide, which has proved to be so important in the high power TW tube field, it is appropriate to discuss briefly the present state of art in all types of high power microwave tubes. This is outlined in Table I. Klystrons with their inherently high gain, low power TW tubes with their large bandwidth, and magnetron-like devices with their high efficiency, have all invaded the high power field. It is clear that keen competition between these devices will continue and that no single approach will satisfy all the foreseen needs. As indicated in Table I, hybrid devices exploiting the advantages of two or more different types of interaction may well provide a solution to some of the problems encountered to date.

	[illegible]		[illegible]		[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]		[illegible]		[illegible]		
[illegible]	[illegible]		[illegible]		[illegible]		
[illegible]	[illegible]						

Table 1 — High Power microwave tubes (S-Band).

The present effort to extend the state of art in these three fields has proceeded as follows:

1. The simple synchronously tuned multi-cavity klystron, capable of stable gains in excess of 60 db, has been adapted to provide means of detuning the intermediate cavities to give an increased bandwidth at some sacrifice in gain. Gains of 30-40 db have been obtained over a 3-5 per cent bandwidth at megawatt levels by stagger-tuning the initial cavities and broadbanding the output system by loading or the use of multiply-tuned cavities. Efficiencies of about 30 per cent are achievable in these types of tubes.

2. The crossed-field amplifier, with its inherently high efficiency (typically 40-50%) has given megawatts of peak power at the lower microwave frequencies, with CW capabilities in the range of hundreds of watts. Considerable effort is continuing to obtain better understanding of the complex interaction of the magnetron type with traveling-wave fields. A number of new slow-wave circuits for crossed-field devices are also being considered. There are no basic differences in the types of slow-wave circuits designed for linear-beam or crossed-field interaction except for the difference in synchronous voltage for a given power level. Perhaps the most distinguishing features of the crossed-field amplifier to date is its predominant operation on a backward-wave, whereas all broadband "O" type traveling-wave amplifiers interact with a forward-wave.

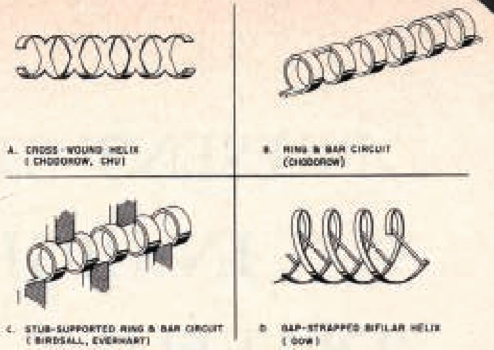


Figure 1 — Some helix modifications for high power applications.

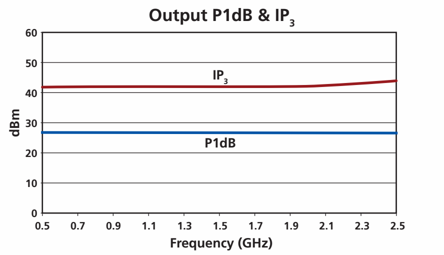
From the point of view of available current in the crossed field device, amplification can be achieved by either the use of an injected beam from outside of the r-f circuit, or by the use of a continuously emitting surface. The beam can be collected, or made re-entrant. It is not clear to date which of these two methods of current generation offer greater promise for higher power applications. Both types of injection have achieved stable gains in the 10-15 db region but the mechanism which limits the gain is not yet clearly understood.

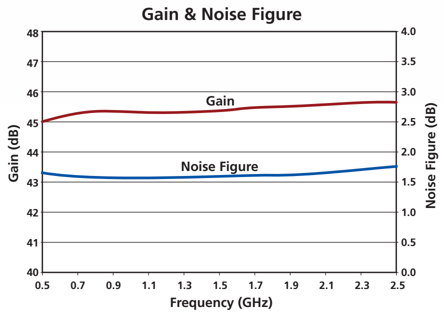
3. The simple helix is still the most frequently employed slow-wave circuit in TW tubes. It has been used in low noise applications, in medium power amplifiers, (with a CW capability as high as 10 watts at X-band), and in pulsed applications (as high as several kilowatts at S-band). In addition, it has found application in electronically tunable oscillators and amplifiers. Considerable work has been expended to modify the simple helix into circuits suitable for higher voltage interaction and higher average power capability. Some of these are shown in Figure 1. For example, a four helix circuit developed by Putz[3] has made it possible to develop 100 watts of CW power at X-band over an almost 2:1 frequency range (see Figure 2).

The evolution of the contrawound helix[5] (Figure 1A) and its close relative, the "ring and bar" circuit[6, 7, 8] (Figure 1B) have extended the useful range of operating voltages to the 20-70 kv range as well as allowing the use of larger transverse dimensions at a given frequency. Tens of kilowatts of peak power have been achieved with these circuits. The stub-supported helix (Figure 1C) appears capable of extending the average power range although at some sacrifice in bandwidth. Modified multifilar helices have also been suggested for high power TWT applications.[9] One such modification, thought promising for large bandwidth at high peak powers is the gap-strapped bifilar helix shown in Figure 1D. These devices are illustrative of the advances in the field of helix-derived circuits. It appears, however, that in the 10-30 per cent

High Linearity LNAs

Measured Data





- ***Innovative wideband LNA design***
- ***OIP_3 headroom >15 dB min over P1dB***
- ***Psat approaching +27 dBm***
- ***I/O return loss of 11 dB min***
- ***Gain of 35 dB or more***
- ***Low power dissipation***
- ***Optional gain/phase matching***
- ***Stable performance -54°C to +85°C***

Try our new amplifier search and inquiry tool.

www.endwave.com

High. And mighty.

New, high linearity, low noise amplifiers from Endwave possess a powerful combination of traits. Packing noise figures of 2 dB up through C-Band, saturated output powers approaching 0.5 Watt, and output IP_3 "headroom" over P1dB at unprecedented levels, there's hardly a challenge they can't stand up to. And for applications such as phased-array radar, our stringent DFM approach and high-precision automated assembly equipment enables them to be delivered in gain/phase matched sets for superior system-level performance.

Endwave. Plug us in.

Model	Frequency Range GHz	Gain dB Min	Gain Flatness +/- dB Max	Noise Figure dB Max	Output P1dB dBm Min	OIP_3 dBm Min	VSWR In & Out Max	DC Current @ +12 to +15VDC mA Typ	Package Type
JCA02-4000	0.5 to 2.0	40	1.00	1.8	24	40	1.8:1	450	K4
JCA24-4001	2.0 to 4.0	35	1.25	2.0	24	40	1.8:1	450	K4
JCA48-4000	4.0 to 8.0	35	1.50	2.2	24	40	1.8:1	450	K4

OPTIONS

Variable Gain Control	TTL Switching	Temperature Compensation
Input/Output Isolators	Waveguide Interface	Detector Output
Input Limiters	Phase Tracking	Gain Matching
Limiting Amplifiers	Low Phase Noise	Hermetic Packages
Environmental Screening	K-Connectors	Bias-T Output

endwave®

www.endwave.com

Visit http://mwj.hotims.com/16346-47 or use RS# 47 at www.mwjournal.com/info

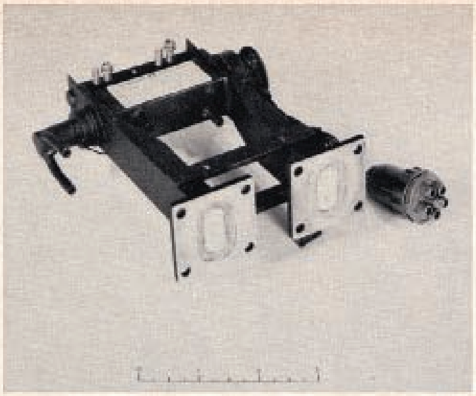


Figure 2—Z-5161 100 watt X-Band 4-Helix traveling-wave tube.

bandwidth region, the periodically loaded waveguide offers the greatest promise in achieving both high peak and average power simultaneously. The main emphasis of this paper lies in this area.

II. PERIODICALLY LOADED WAVEGUIDE CIRCUITS

A. General Considerations

The simple waveguide is basically a high pass filter, propagating energy with a phase velocity greater than light velocity at all frequencies. Any periodic loading of the circuit will result in cumulative reflections from the loading obstacles, which at some ranges of frequencies will cause total reflections, i.e., a stopband. The high pass filter thus becomes a bandpass filter, whose properties depend on the nature of the periodic loading. If the loading obstacles are small, little change from the waveguide characteristic will occur except near the regions of total reflections, curve 2, Figure 3. The new branches of the so-called "Brillouin" diagram (ω-β diagram) are required to fulfill the boundary conditions inside the composite circuit and are referred to as the spatial harmonics. They are mirror images of the fundamental passband and their amplitudes are determined by the detailed nature of the loading obstacles. If the loading is heavy, the waveguide passband is so greatly perturbed that it bears little relation to its original form. In many instances, it is convenient to visualize the slow-wave circuit as a set of resonant cavities coupled together by means of electric or magnetic fields. In the limit of zero coupling (no slots between cavities, or a resonant slot), the passband shrinks to zero, curve 4, Figure 3. With predominantly electric coupling (capacitive) the phase and group velocity in the first quadrant are of equal sign; giving curves 2 and 3, Figure 3; this is referred to as fundamental forward-wave interaction. With predominantly magnetic coupling (positive inductive coupling), the group velocity in the first quadrant is of the opposite sign to the phase velocity (curve 5, Figure 3), and a fundamental backward-wave results. In the last case, for the next quadrant, ($\pi - 2\pi$ phase shift), the group and phase velocities are of the same sign again, giving the so called spatial harmonic forward-wave interaction. The slope of the intersecting dotted line gives the Vp, while the slope of the ω-β curve itself at the operating point gives the Vg. In the forward wave, these are of the same sign. In the backward wave they are of opposite signs. For broadband operation, it is desirable to have the phase velocity nearly constant with frequency, i.e., low dispersion. It is seen in Figure 3, that in general, the fundamental forward-wave circuit is more dispersive than the spatial harmonic circuit, but the impedance is usually higher in the first quadrant since one is interacting with the main component of the r-f field.

A number of slow-wave circuits have evolved around the periodically loaded waveguide, both of the spatial harmonic type and of the fundamental forward-wave type. The first device of this type which employed interaction of a beam with a traveling-wave was the linear accelerator [10] developed by Hansen at Stanford. This circuit is composed of a cylindrical pipe, periodically loaded by capacitive discs, whose phase velocity has been slowed down to the velocity of light (at midband) for purposes of accelerating an electron beam, rather than extracting energy from it, i.e., converting microwave energy into pulsed high voltage d.c. energy. The circuit has the properties of a passband filter whose bandwidth depends on the size of the coupling aperture. For the linear accelerator application, this is made very narrow; to obtain broadband characteristics the detailed nature of the coupling between the periodic obstacles must be examined. As contrasted with the simple helix, the periodically loaded waveguide offers some attractive features: it is rugged physically, and for a given frequency it is larger in size. Both these features tend to enhance its ultimate average power capabilities. On the other hand, due to the dispersive nature of the slow-wave circuit, the bandwidth tends to be limited. Although considerable attention has been given to various filter type circuits by Pierce,[3] they were never seriously

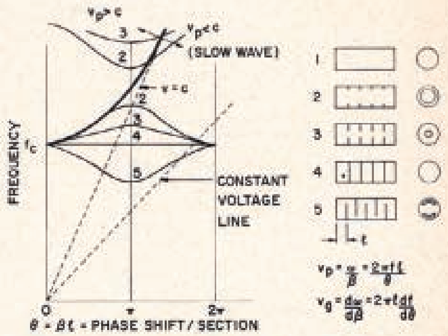
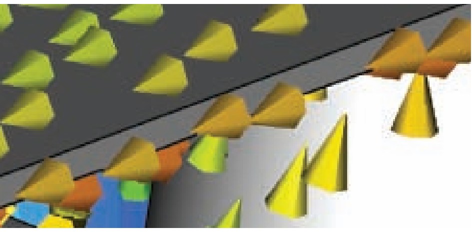


Figure 3 — Brillouin Diagram (ω-β Diagram) for periodically loaded circuits.

Experience the future
CST MICROWAVE STUDIO 2009



➤ Take a fresh look at next generation 3D EM solutions and choose the tool that matches your passion for design. CST MICROWAVE STUDIO® [CST MWS] offers accurate solutions at a speed that gives your designs a head-start in life.

Knowing that all designs and applications have different needs, CST has developed the technology to cover them all.

CST MWS is the market leading time domain tool for 3D EM simulation, but its advantages don't stop here. CST MWS is the first commercial HF 3D EM code to offer the advantages of time and frequency domain, hexahedral and tetrahedral meshing, united in one interface. This gives you the flexibility to choose the technology best suited to your application. Embedded in an advanced design environment, CST MWS can be coupled with all CST STUDIO SUITE™ solver technology including circuit and thermal simulation.

➤ Get passionate about simulation technology. There's more to CST MWS than meets the eye.

CST

CHANGING THE STANDARDS

Visit http://mwj.hotims.com/16346-34 or use RS# 34 at www.mwjournal.com/info

CST of America®, Inc. | To request literature or a free demo CD ✆ (508) 665 4400 | info: www.cst.com

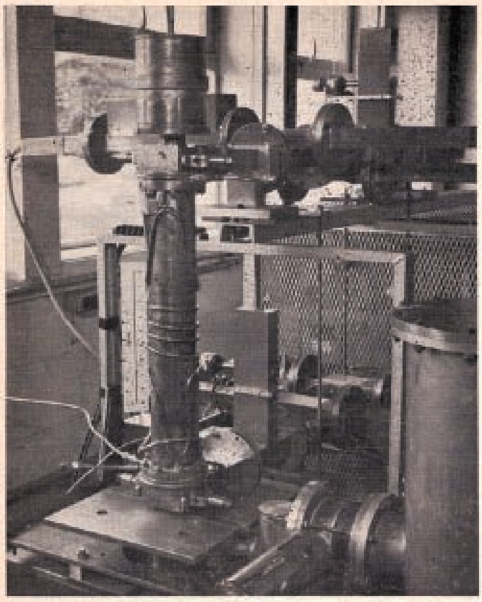


Figure 4 — First S-Band Megawatt-type disc loaded TW tube (Stanford).

considered for TW amplification until interest arose in higher peak and average powers than could be achieved with helix-type circuits. The first of these devices was a spatial harmonic type TW tube described by Chodorow and Nalos,[11] which gave in excess of 300 kw of pulsed power at S-band over a 10 per cent bandwidth (Figure 4). After the successful demonstration of the feasibility of this type of device, a great deal of interest was stimulated in a number of industrial and research institutions, leading to a wider exploitation of the periodically loaded waveguide as a slow-wave circuit. Both forward-wave circuits and spatial harmonic circuits were evolved and tried with the object of improving impedance and bandwidth. A comprehensive analysis of periodically loaded waveguide circuits for high voltage applications has been made by Craig,[12] pointing out the relative advantages of several classes of circuits. The selection of the circuit depends to a great degree on the desired voltage of operation and the desired bandwidth. Spatial harmonic circuits are usually characterized by relatively long field-free drift-spaces designed to hide the beam during periods at which it would be decelerated by the field, whereas the fundamental forward-wave circuits need not employ such drift tubes because the main component of the field is in synchronism with the beam. The energy stored per unit length, W, for a given amount of useful r-f field E, is given by

$$\frac{E^2}{W} = \left(\frac{E^2}{2\beta^2 P}\right) 2v_g\beta^2 \sim Kv_g$$

It is thus proportional to the r-f impedance K and the group velocity, v_g. For a typical set of parameters suitable for fundamental and spatial harmonic interaction, using a solid beam, a comparison of the energy storage factors at

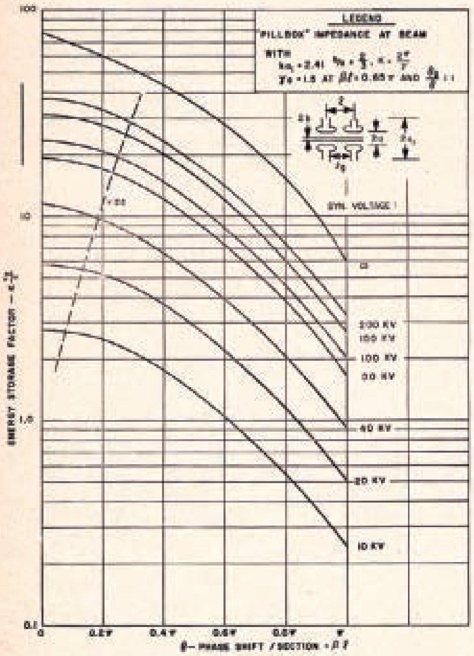


Figure 5a — Calculated energy storage factors: fundamental interaction.

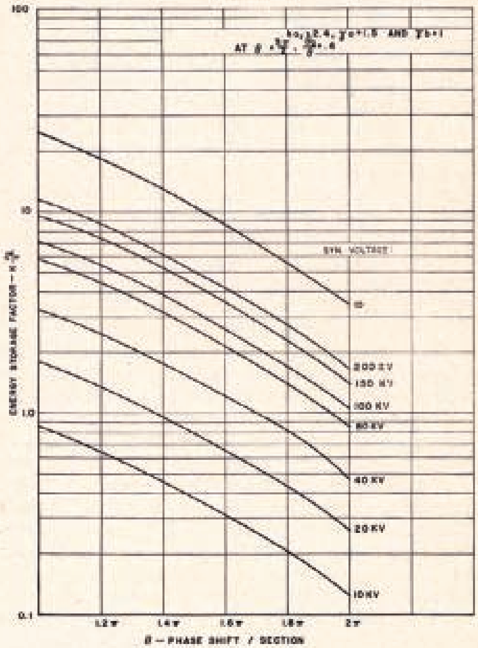
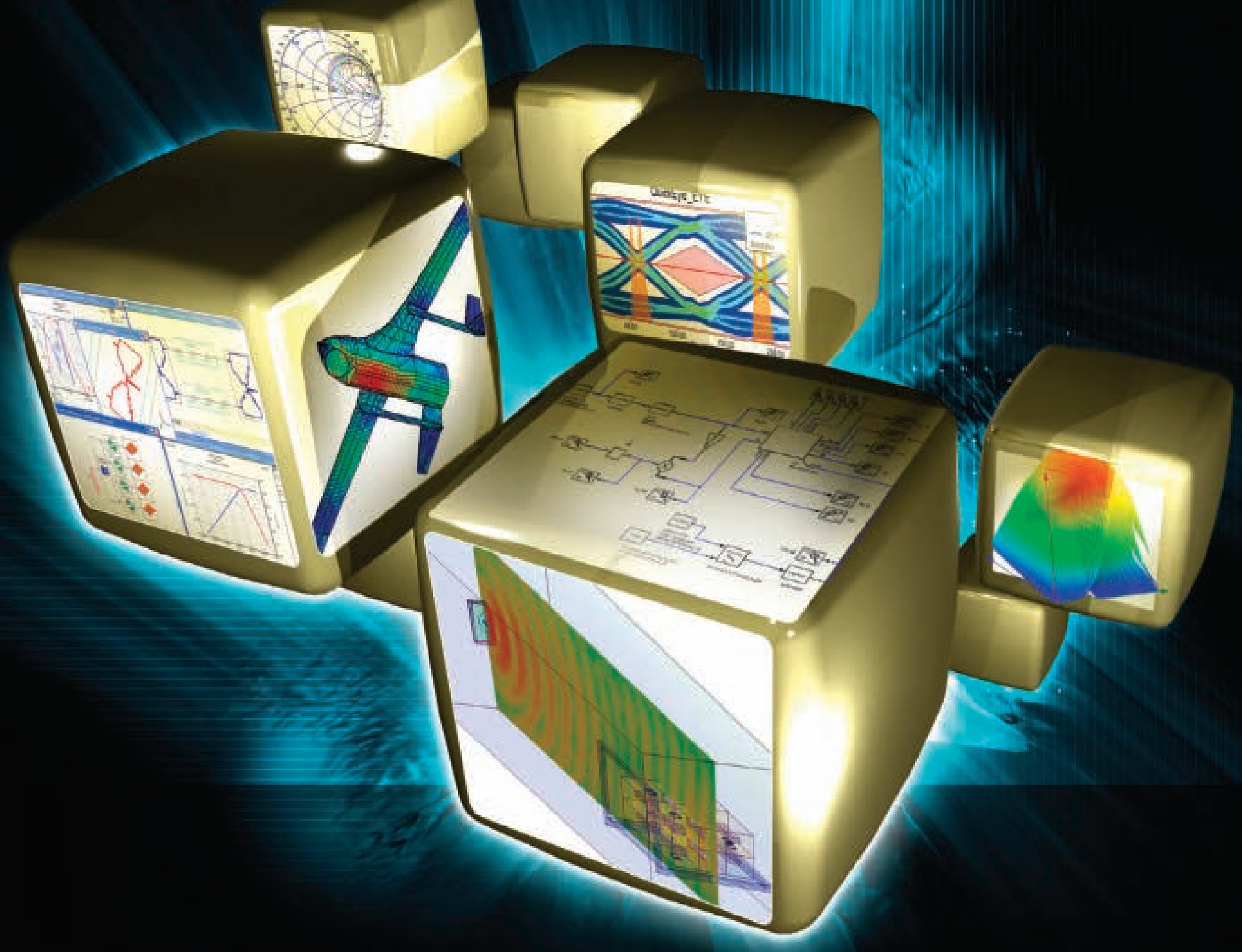


Figure 5b — Calculated energy storage factor: spatial harmonic interaction.

34 the microwave journal for December, 1959



FIRST-PASS SYSTEM SUCCESS

FOR RF & MICROWAVE DESIGN

Let Ansoft show you how to achieve first-pass system success when designing high-performance RF and microwave systems. Our unique two-way dynamic link between HFSS and Ansoft Designer allows you to combine high-fidelity component modeling with accurate system and circuit simulation to precisely predict performance, tune and optimize your designs before committing to hardware.

With Ansoft first-pass system success is possible.
Ask us. We will show you how.

ANSOFT.COM

ANSOFT

A subsidiary of ANSYS, Inc.

Visit http://mwj.hotims.com/16346-14 or use RS# 14 at www.mwjournal.com/info

various voltages is given in Figures 5A and 5B. It is seen that as far as impedance is concerned, a fundamental interaction is to be preferred.

In the following sections some applications of loaded-waveguide circuits will be described as used in present high power TW tubes, crossed-field devices and devices used for generation of high frequency waves. It will be seen that a wide range of both forward-wave and backward-wave circuits has been employed, depending not only on bandwidth and impedance considerations but also on adaptability to manufacture and compact focusing.

B. Circuits for High Power "O" Type TW Tubes

Both fundamental and spatial harmonic interaction has been employed for this application. Some circuits have employed a perturbation of the basic waveguide TM_{01} mode, whereas others have used a coaxial mode perturbed by the waveguide wall. It is possible to regard the field configurations of the slow-wave circuits as derived from several different basic transmission-line modes; the view presented here is one of convenience and usefulness to the author but is by no means the only one.

1. Fundamental Forward-Wave Circuits

Two types of forward-wave circuits will be discussed; one where capacitive coupling is obtained by means of an aperture near the axis of the circuit where strong electric fields exist, and the other, where negative inductive coupling is obtained by means of special slots in the region of the magnetic field.

a. Capacitively Coupled Circuits

Some typical fundamental forward-wave circuits are shown in Figure 6. The size of the capacitive aperture determines the bandwidth and the limitation of the circuit, Figure 6A, is given by the maximum size aperture allowed to obtain good r-f coupling to the beam. Obviously, if a hollow beam of adequate power capability can be employed, this limitation is removed because

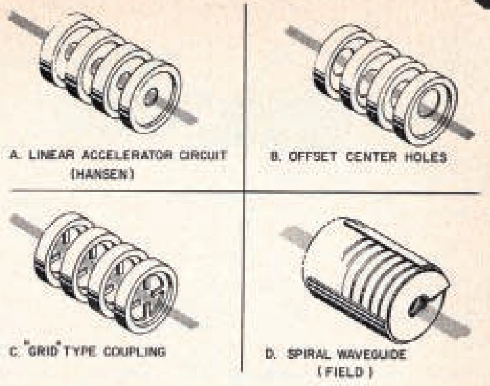


Figure 6—Some fundamental forward-wave circuits (capacitive coupling).

good r-f coupling can be maintained regardless of aperture size. Some methods to overcome this limitation are suggested in Figures 6B and 6C, where the coupling to the beam is achieved by grid-like vanes, or offset coupling holes.

b. Reversed-Loop Coupled Circuits

By means of a novel type of coupling, suggested by Chodorow and Craig,[13] it is possible to increase the bandwidth of the circuit with a fixed size center aperture using reversed loops, illustrated in Figure 7A. This type of coupling provides a microwave equivalent of a negative mutual inductance (i.e., a reactance of the same sign as that due to capacitive coupling) and has been successfully evolved at Stanford into slow-wave circuits of the "cloverleaf" type[12] and the "centipede" type[13] shown in Figures 7B and 7C.

A TW tube of the cloverleaf type which has given 2 megawatts of peak power at S-band over a 10 per cent frequency band is shown in Figure 8. Tubes of a similar type have been built at SERL (England), General Electric Microwave Laboratory, and Varian Associates.

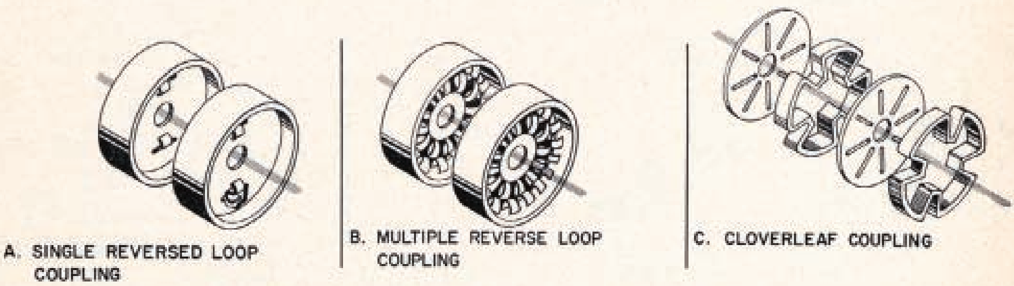
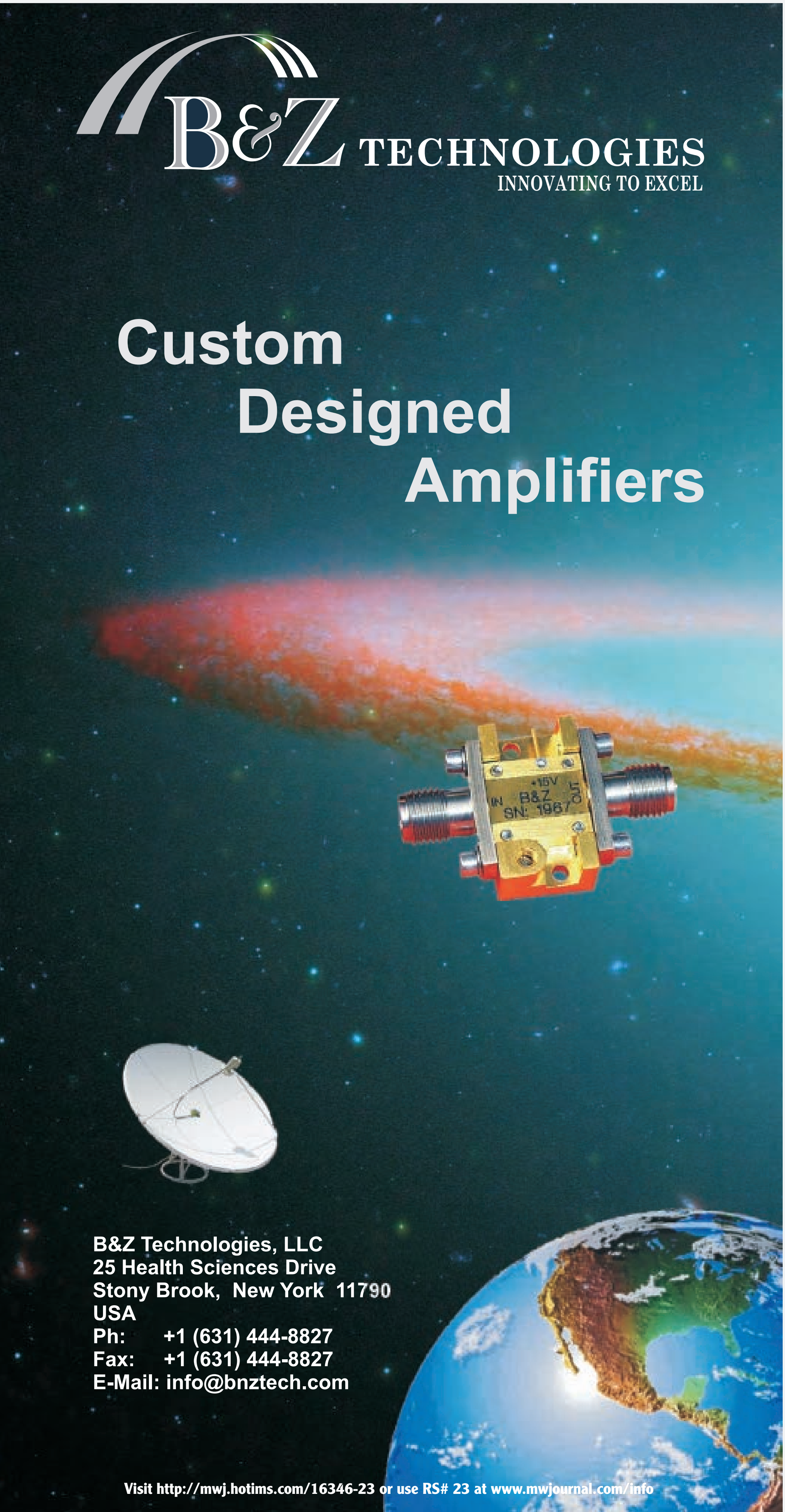


Figure 7—Circuits with negative inductive coupling (Craig, Chodorow).

the microwave journal for December, 1959 35

Please visit www.mwjournal.com to read this article in its entirety.
Also, look for our "Cover Feature: Then and Now" series every month this year in *Microwave Journal* as we celebrate our 50th anniversary.



Ultra Wideband
Low Noise

Wideband Low Noise

Wideband
Medium Power

Wideband High
Dynamic Range

Cryogenic

Waveguides

High Power

Features:

5 kHz to 70 Ghz

Noise Figures
from 0.35 dB

P1 dB >+30 dBm

Excellent Group Delay

Phase Matching <5°

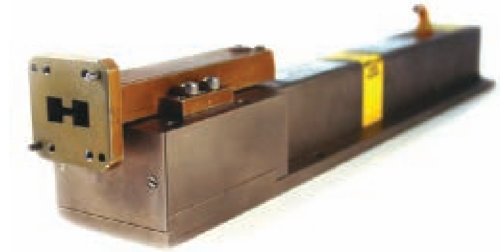
Gain Matching <0.5 dB

Up To 50 dB Gain

www.bnztech.com

COVER FEATURE
INVITED PAPER

TRAVELLING WAVE TUBES: MODERN DEVICES AND CONTEMPORARY APPLICATIONS



From its conception in 1943 by Dr. Rudolf Kompfner in England,[1] and later its development by Kompfner and John R. Pierce at the Bell Laboratories in the United States,[2] the travelling wave tube (TWT) has become the microwave amplifier of choice for many commercial and military systems. Originally developed for communication, these devices have become fundamental to many military applications, including radar, electronic counter measures (ECM) and electronic warfare (EW) systems.

In simple terms all types of TWTs consist of an electron gun, a slow wave structure, magnetic focussing system, RF input and output couplers, and a collector. With operating voltages applied, the electron gun (containing an emitter) produces an electron beam, which is injected into the slow wave structure (SWS). The magnetic focussing system constrains the electron beam, allowing it to travel longitudinally down the centre of the slow wave structure.

RF power of the appropriate frequency is injected through the input coupler onto the slow wave structure. The electron beam and the RF signal travel down the structure at similar speeds and an interaction between the two results in an energy transfer from the electron beam into the electromagnetic wave, thus achieving an amplification in the RF signal. The collector at the opposite end of the device to the electron gun is designed to collect the spent electron beam and dissipate the remaining energy efficiently.

TWT TECHNOLOGY

Developments in material and manufacturing technologies over the past 50 years have aided the advancement of TWT capabilities. Improvements in high purity vacuum-compatible materials such as nickel/copper alloys and pure oxygen-free, high-conductivity (OFHC) copper have been a major contributor to improvements in both life and reliability.

Advances in thermionic cathode technology, resulting in increased operating life, and the development of high-energy product mag-

BRIAN COAKER
e2v, Lincoln, UK
TONY CHALLIS
e2v, Chelmsford, UK

The #1 Synthesizer now comes with a full Two Year warranty!

Aeroflex is the #1 fast-switching synthesizer provider on the market today! We build the best synthesizers and even our most basic models are 30 times faster and 10 times cleaner than the closest competitor. Our synthesizers offer high speed, low noise and wide bandwidth all in one package.

We've built our synthesizer business reputation one installation at a time. Our installed base is one of the largest in the world with more than 5,000 Aeroflex fast-switching synthesizers installed to date.

2200 OEM Modular Frequency Synthesizer

- Spans frequency range from 10 MHz to 18.4 GHz
- Standard resolution of 1.0 Hz
- Can switch from any frequency (F1), to any other frequency (F2), up or down, in 1 µSec

2500 Frequency Synthesizer

- Spans frequency range from 0.3 to 26.5 GHz
- Standard resolution of 1.0 MHz (0.5 MHz with range 0.3 to 13.5 GHz)
- Can switch frequency in <200 ns

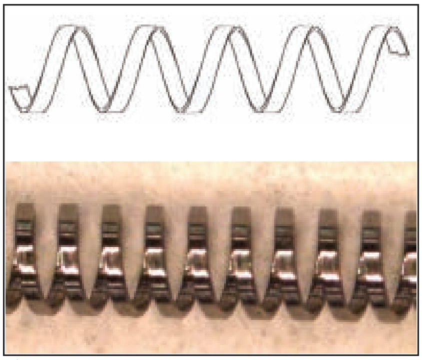
Find out more about our world-class Synthesizers and receive the latest data sheets by visiting:

www.aeroflex.com/mj1008

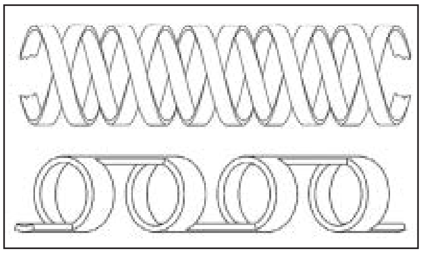
AEROFLEX
A passion for performance.

netic materials such as Samarium Cobalt, have enabled the reduction in size of magnetic circuits. The use of computer controlled processing systems and component-manufacturing machines have seen achievable tolerances reduce by an order of magnitude, along with a considerable reduction in unit cost.

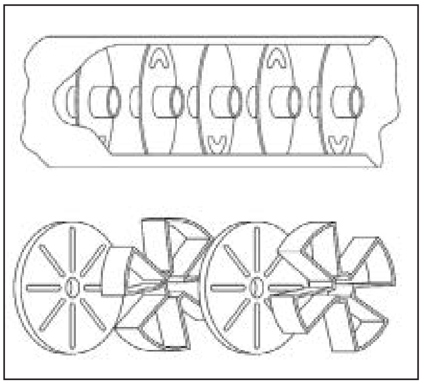
Numerous structure designs have been conceived since its original conception, offering various advantages to different applications. Ervin Nalos's paper, first published in the December 1959 issue of *Microwave Journal* (reprinted this month), focused primarily on high power travelling wave tubes.[3] Other circuit types were discussed, including the simple helix, ring-bar and bifilar, demonstrating the considerable understanding and capability of different slow wave structures 50 years ago.



▲ *Fig. 1 Simple helix slow wave structure (top) and photograph of a tungsten helix structure (bottom).*



▲ *Fig. 2 Bifilar contra-wound (top) and ring-bar (bottom) slow wave structures.*



▲ *Fig. 3 Slotted (top) and clover-leaf (bottom) coupled cavity slow wave structures.*

The major constraints to higher performance were materials technology, processing techniques and manufacturing capabilities. The 1959 paper discusses the simple helix, having the capability of continuous wave (CW) powers as high as 10 W at X-band. Today CW helix TWTs have achieved output power levels of several kilowatts at X-band, a considerable achievement, largely due to current material technologies and automated manufacturing processes.

THE HELIX

The 'simple' helix continues to be the most commonly used SWS in TWTs since its inception by Kompfner. In its simplest form, a wire or tape wound in the form of a helix, it exhibits the greatest potential of all SWSs, in terms of dispersion control and thus greatest operating bandwidth. Performance characteristics can be controlled through the design of simple and complex pitch tapering, to enhance both narrow and broadband operation, optimising gain, power and efficiency. ***Figure 1*** shows both a sketch of a simple helix structure and a photograph of a tungsten tape helix.

Dispersion characteristics can be controlled through design of helix supports, in terms of material choice and cross-sectional shape and electrically conductive dispersive vanes. Vanes offer the greatest opportunity for dispersion control and are commonly utilized within broadband TWTs of greater than an octave bandwidth.

BIFILAR CONTRA-WOUND AND RING-BAR TWTS

Variants on the simple helix include the bifilar helix (made up of two contra-wound helices of equal but reversed pitch), the ring-bar and the ring-loop structure. Sketches of both bifilar and ring-bar structures can be seen in ***Figure 2***. These types of structures enable higher power handling through both thermal capability and higher voltage operation without giving rise to backward wave oscillation (BWO), a major constraint in simple helix structures. The downsides to these types of structures (in relation to the simple helix) are the limitation of bandwidth due to the high dispersion characteristics of the SWS and the increased complexity in manufacture, which directly impacts the cost.

COUPLED CAVITY TWTS

The feature that distinguishes the coupled cavity TWT from other types is the SWS, which consists of a series of cavities, is coupled by slots. The benefits of this are that the cavities can be designed to operate with high voltage electron beams enabling peak output powers of 10s to 100s of kilowatts, with high average powers.

The space harmonic coupled cavity circuit, favoured by most users because of the high (up to 20 percent) instantaneous bandwidth achievable, is particularly suited to integration of periodic permanent magnetic (PPM) focussing. The result is a very compact device that is used in mobile radar systems. Very high average power and CW coupled cavity TWTs are available but these utilise solenoid focussing, which requires significant electrical power and weighs more than PPM focussed devices. ***Figure 3*** shows two of the more commonly used coupled cavity type structures: slotted and clover-leaf.

CATHODE TECHNOLOGY

Developments in the field of emitters, the electron source of travelling wave tubes, have enabled the development of devices capable of 10s and even 100s of thousands of hours of life. Fifty years ago the electron sources used in vacuum devices, including the early TWTs, would have been of the oxide-coated type emitter, restricted to pulsed or low current density CW applications, ideally suited to high-power pulsed devices, like the coupled cavity TWT, used for radar-type applications.

Today, with advances in cathode technology, materials and processing, a range of impregnated tungsten matrix cathodes are the cathode of choice. Capable of considerably higher mean currents, operating CW at high current densities (> 20 A/cm^2), the coated tungsten matrix (M-type) cathode is the most commonly used.

Other advantages over the oxide cathode include higher resistance to poisoning, increased life and improved manufacturing tolerances be-

CENTELLAX PRBS GENERATORS

Rates from 0.05Gbps to 56Gbps

56G PRBS SOURCE

- Operating range 40Gbps to 56Gbps
- Fixed-frequency internal clock (56Gb/s)
- Typical amplitude 1Vpp-d
- Model No. TG2P5A

40G PRBS SOURCE

- Operating range 21Gbps to 44Gbps
- Fixed-frequency internal clock (OC-768)
- Output amplitude 1Vpp-d
- Model no. TG1P4A

17G PRBS SOURCE

- Operating range 11Gbps to 21Gbps
- External clock required (11-21GHz)
- Output amplitude 1Vpp-d
- Model no. TG1P2A

10G PRBS SOURCE

- Operating range 50Mbps to 14Gbps
- Fixed-frequency internal clock [OC-192, 10GbE, others]
- Output amplitude 0.6Vpp-d or 1.6Vpp-d
- Model No. TG2P1A

CENTELLAX

3843 Brickway Blvd., Suite 100, Santa Rosa, CA 95403 USA
ph +1.707.568.5900 | fax +1.707.568.7647 | sales@centellax.com
toll free 866.522.6888 | www.centellax.com

For additional details, application notes, and assembly diagrams, please visit: www.centellax.com

VISIT US AT:
ITC 2008 - Booth #814, Oct. 28-30, Santa Clara, CA

Visit http://mwj.hotims.com/16346-27 or use RS# 27 at www.mwjournal.com/info

cause of the machined emitting surface. In addition to this, coupled with a potted heater assembly, cathodes have been manufactured to survive and function under the most severe vibration and shock levels.

Work continues towards making advances in cathode design and manufacture. Developments include mixed-matrix and reservoir cathodes, and more recently the field emitting cold cathode.[4] Although in its infancy, recent research has produced samples nearing the capabilities required for a TWT electron source.

TWT DESIGN AND VALIDATION

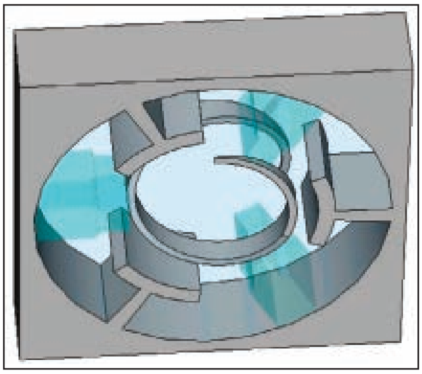
The introduction of computer modelling and its advances over the past three decades have had a marked impact on the vacuum electronics industry, taking design from long-hand calculations (sometimes only comprehendible to the most advanced mathematicians) to user-friendly computer simulation of all aspects (electronic, mechanical, thermal) of the device design.

3-D electron beam simulation programmes enable accurate simulation of beam entry, focussing systems and collection. ***Figure 4*** shows a plot from an electron gun model, using OPERA 2D. Together with the constant advances in computing power, designs can be realised in hours or even minutes, and once validated, the latest software is capable of previously unprecedented levels of accuracy.

Advances in Particle in Cell (PIC) and parametric codes, combined with complex optimisers, enables accurate simulation of the interaction between electron beam and the slow wave structure. Increases in computing power have enabled the simulation of complex slow wave structures and complete RF circuits. ***Figure 5*** is a cross-section of a helix SWS, showing dielectric helix support rods and dispersion vanes, typically used in broadband helix TWTs.

In addition to the advances in electrical design enabled by new codes and improved processing speeds, commercially available codes can be utilised for thermal and mechanical stress analysis. Thermal analysis of TWT collectors enables improved thermal management of new designs. ***Figure 6*** shows a simple thermal model of a single stage collector. The modern-day designer

▲ *Fig. 4 OPERA 2D finite element software —electron gun model.*



▲ *Fig. 5 Microwave Studio parametric model of a helix SWS.*

Introducing K band optical gate technology

MilliMeter Wave pHEMT Technology @ WIN = M²W

Parameter	Value
Small Signal Gain	14 dB
Ft	60 GHz
Vp	-1.2 V
Idss	360 mA/mm
Idmax	490 mA/mm
Vdg Breakdown	17.5 V
Ron	1.2 Ohm-mm
P1dB*	750 mW/mm
PAE (peak)*	51%
Gm (peak)	400 mS/mm

* f=10 GHz, Vdg=7 V, Ids=160 mA/mm

High performance microwave and millimeter wave technology is ready for your high volume applications.

www.winfoundry.com

WIN SEMICONDUCTORS

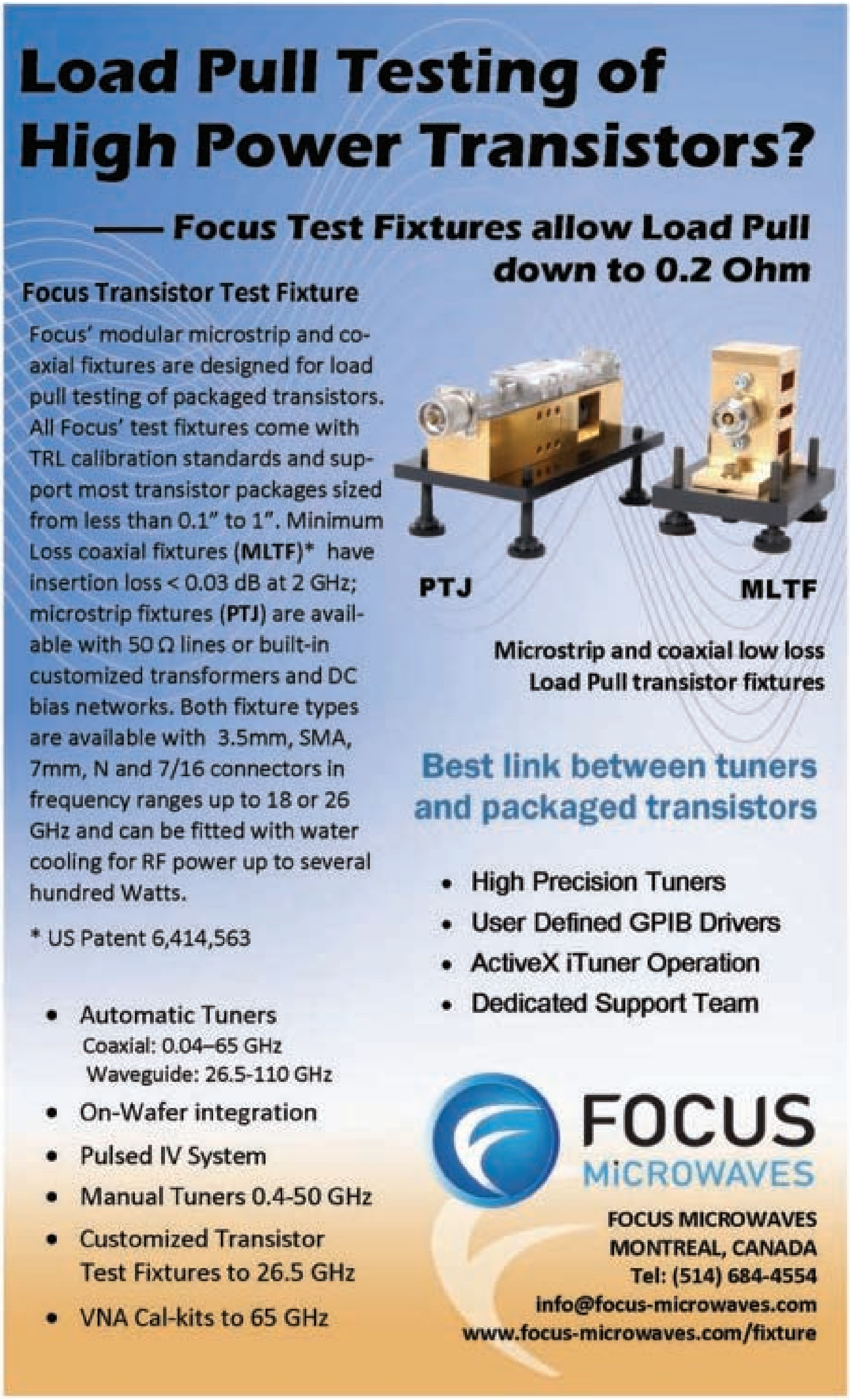
Visit http://mwj.hotims.com/16346-174 or use RS# 174 at www.mwjournal.com/info

now has a complete package of modelling and simulation codes that, when fully validated with real device data, enable a right-first-time design approach significantly reducing development times and costs.

PRESENT STATE OF THE TWT ART

TWT production is limited to a handful of manufacturers throughout the world; major suppliers include CPI, L-3 and Teledyne in the US, e2v, Thales and TMD in Europe, NEC in Japan, and several developing manufacturers in both India and China.

Determining the current state of the art is difficult; many government-funded programmes restrict the publication of data and commercial confidentiality is high due to the competitive markets. ***Table 1*** shows a cross-section of products from various manufacturers, giving a broad view of current capabilities.



HELIX TWTS

Satellite Communications (Ground-based)

Low cost, high reliability and high linearity are key in this commercially competitive market. Offerings are available from all the major manufacturers, whether it is earth stations, Satellite News Gathering (SNG) mobile systems, network hubs or small lightweight flyaway pack systems. Demands for bandwidth are forcing the move towards higher frequencies (Ka-band) and the onset of digital broadcasting requires higher powers.

Notable performance advances have been achieved by NEC and L-3 in the development of Ka-band helix TWTs for this market, with CW power levels as high as 500 W. Another growth area is in small lightweight amplifiers used in flyaway and hand portable systems. Reductions in luggage weight, by most airlines around the world, has forced demand for these systems to become smaller and lighter. In a market where solid state amplifiers and travelling wave tube amplifiers (TWTA) compete head to head, e2v has launched a range of TWTAs (StellarMini™) that are the smallest and lightest currently available.

Advances in multi-octave TWTs developed originally for military applications has lead to opportunities in multi-band TWTAs for both commercial and military communications. Dual- and tri-band devices have been developed by Teledyne, CPI and e2v.

Satellite Communications (Space)

Key attributes of the space TWT include long life (mission life greater than 20 years), high reliability, low power consumption (high efficiency) and low mass. The majority of all TWTs in space have been manufactured by Thales (France) or L-3 Electron Technologies Inc. (US; formerly Boeing/Hughes) with developments progressing at CEERI (India).

Future demand is moving up in frequency as advances in solid state technology capture the low frequency end of the operating spectrum (up to Ku-band) and the overcrowding of traditional bands forces the need for greater bandwidth utilization. The number of satellites being launched at Ka-band is growing fast and is set to continue.

Visit http://mwj.hotims.com/16346-51

TINY TOUGHEST MIXERS UNDER THE SUN

Rugged, tiny ceramic SIM mixers *from* 4^{95} *ea. qty. 1000* offer unprecedented wide band, high frequency performance while maintaining low conversion loss, high isolation, and high IP3.

0.2" x 0.18"

Over 21 models IN STOCK are available to operate from an LO level of your choice, +7, +10, +13, and +17 dBm. So regardless of the specific frequency band of your applications, narrow or wide band, there is a tiny SIM *RoHS* compliant mixer to select from 100 kHz to 20 GHz. Built to operate in tough environments, including high ESD levels, the SIM mixers are competitively priced for military, industrial, and commercial applications. Visit our website to view comprehensive performance data, performance curves, data sheets, pcb layouts, and environmental specifications. And, you can even order direct from our web store and have it in your hands as early as tomorrow!

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

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

Mini-Circuits®

ISO 9001 ISO 14001 CERTIFIED

minicircuits.com

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

YONI2™ *Patent Pending*

The Design Engineers Search Engine *Provides ACTUAL Data Instantly From MINI-CIRCUITS At:* ***www.minicircuits.com***

IF/RF MICROWAVE COMPONENTS

428 Rev A

Visit http://mwj.hotims.com/16346-92 or use RS# 92 at www.mwjournal.com/info

TABLE I

GLOBAL SELECTION OF CURRENT HELIX AND COUPLED CAVITY TWTs

Market	Product	Manufacturer	Frequency/ Band (GHz)	Output Power (W)
Satellite Comms (Ground)	TH3977[5]	THALES	Ku	750
	VTU-6397H1[6]	CPI	Ku	1200 (Peak)/ 600 (CW)
	MTG5338X[7]	TELEDYNE MEC	C/X/Ku	350/600/350
	LD7314[8]	NEC	Ka	350 (Peak)/ 250 (CW)
Satellite Comms (Space)	9100HR[9]	L-3	K	50 to 130
	TH4725B[5]	THALES	Ku	100 to150
	TH4626[5]	THALES	Ka	30 to 60
Radar	VTS5754F[6]	CPI	S Duty	130K, 8%
	N10570A[10]	e2v	X	20K, 8% Duty
	TL35038[5]	THALES	Ka	1K, 12% Duty
ECM/EW	L6049[11]	L-3	4.5 to 18	110
	N20160[10]	e2v	4.5 to 18	50
	TH3893[5]	THALES	6 to 16	1500

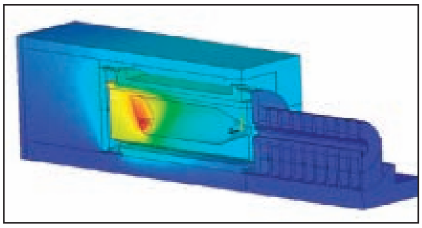


Fig. 6 3D thermal simulation model of TWT collector assembly.

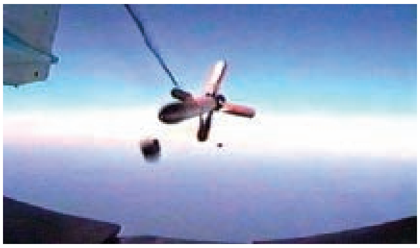


Fig. 7 Deployed fibre optic towed decoy.

Radar

Traditionally the realm of high peak power helix and coupled cavity TWTs, the development of active phased-array radar has seen a significant shift away from vacuum devices towards solid state technology, more suited to compact packaging required in an array system. Although as requirements become more demanding, requiring higher efficiency, lower thermal dissipation and greater reliability, customers of microwave amplifiers are turning back to TWTs as the preferred option. Over the past three decades TWT reliability has increased considerably; space TWTs have achieved MTBFs of six million hours with efficiencies reaching 50 percent, which makes the TWT a viable alternative to solid-state amplifiers (SSA). Advances in mini TWT technology, driven by airborne towed decoys and MPMs, has lead to compact high efficiency devices ideally suited to phased-array and Synthetic Aperture Radar (SAR) applications.

ECM and EW

The largest market for the helix TWT is in ECM and EW applications, which has seen tens of thousands of devices built into expendable decoy systems and ECM pods around the world. The demands on devices tend to be a combination of those for all other applications, with the added complexity of operation over multi-octave bandwidths. Current demands are for greater bandwidth and higher efficiency in smaller lighter weight packages that are able to operate over extreme temperature ranges and high altitudes. With the growth of unmanned air vehicle (UAV) applications, the military business for TWTs continues to grow.

Over the past decade, the likes of L-3, CPI, Thales and e2v have developed ranges of mini TWTs, predominantly for airborne applications with bandwidths of greater than 2 octaves covering 4.5 to 18 GHz and power levels now exceeding 100 W CW across the full band. Devices have been proven to survive and operate at temperatures ranging from –55° to > 150°C, altitude > 70 kft and shock levels in excess of 500 G.

Utilization of multi-stage depressed collectors has seen mid-band efficiencies top 50 percent, resulting in reduced thermal footprints and prime power requirements. CPI[12] has, over the past two decades, delivered many thousands of mini TWTs into the Raytheon[12] Goleta ALE-50 towed decoy programme, which is a notable

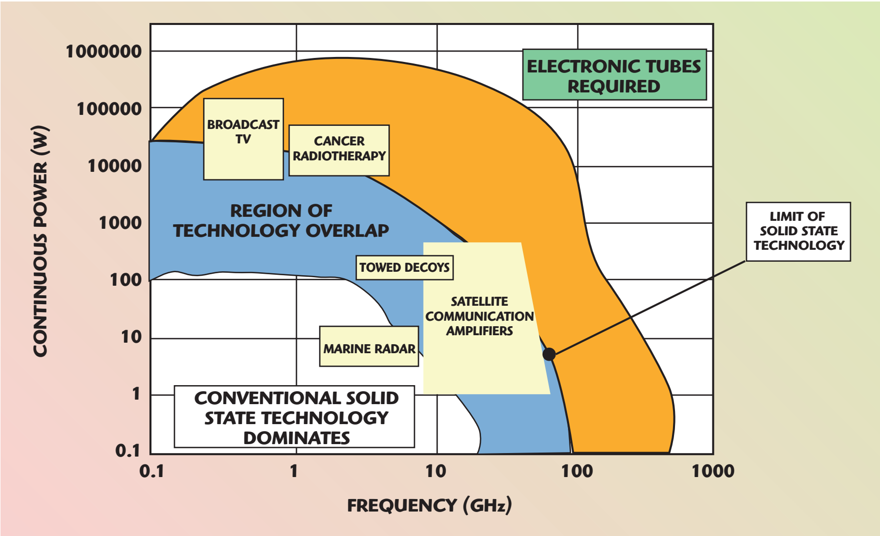
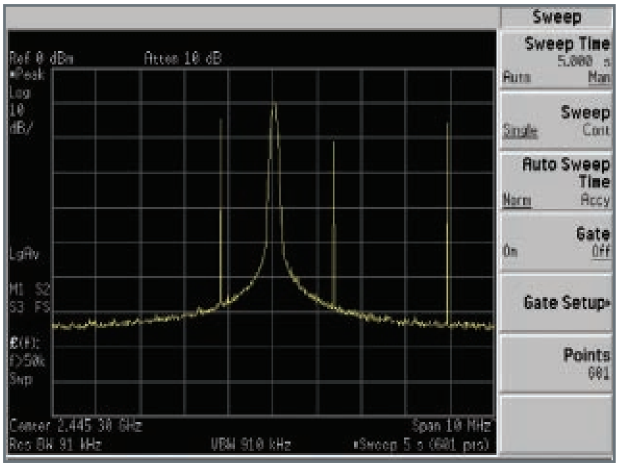
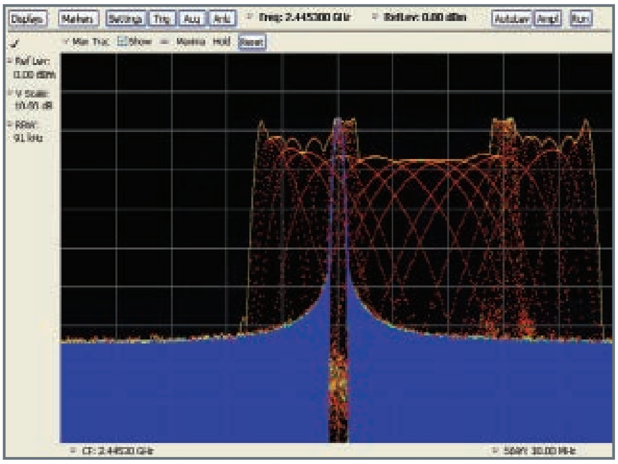


Fig. 8 Frequency and power capabilities of present amplifier technologies.



Traditional Spectrum Analyzer
5 seconds



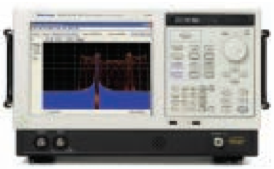
Tektronix
5 seconds

The two screens represent a traditional swept tuned spectrum analyzer and a Tektronix Real-Time Spectrum Analyzer running DPX™, each detecting an identical signal that changes every 1.28 seconds.

Tektronix DPX technology— see what you've been missing.

Discover what's real with Tektronix DPX™ technology. Now you can see your time-varying signals live with DPX technology, available on all Real-Time Spectrum Analyzers from Tektronix. DPX displays a live RF view of your signal changing over time. It shows you RF signal characteristics that are practically invisible with prior architectures.

See a live RF demo
www.tektronix.com/rtsa-dpx



Tektronix®
Enabling Innovation

© 2008 Tektronix. All rights reserved. Tektronix products are covered by U.S. and foreign patents, issued and pending. TEKTRONIX and the Tektronix logo are registered trademarks of Tektronix, Inc.

achievement. ***Figure 7*** shows a typical fibre optic towed decoy (FOTD) TWT platform being deployed.

Advances continue to be made at higher frequencies covering the 18 to 40 GHz band for countering and jamming new threats. With continually changing and advancing threats, plus the upgrades to existing systems, demands on the microwave amplifiers in this market are increasing, continuing to enhance efficiency and expand bandwidth will be necessary to keep ahead of the advancing SSA sector and meet the expectations of customers.

STATUS OF COUPLED CAVITY TWTS

Many modern radar systems, including new developments, continue to use coupled cavity TWTs. This is because, contrary to popular opinion, coupled cavity TWTs are often more robust, long-lived, reliable and efficient than the solid state alternative. Coupled cavity TWTs currently manufactured cover the frequency ranges from D-band up to M-band. Instantaneous bandwidth of 10 percent is required for most applications, but various techniques have been employed to increase this to 20 percent (normally compromising efficiency or power considerations).

The conventional manufacturing technique for coupled cavity TWTs employs individual cavities and coupling plates brazed together. At Ka-band and above, this technique becomes very expensive, as the machining tolerances become extremely tight.

Alternative methods of production for high frequency TWTs have been investigated, with the ladder structure used by CPI being the most popular. Modern computer aided design techniques have been used to redesign existing coupled cavity TWT designs; the result of this has been much higher manufacturing reproducibility, and hence yields.[13]

New radar transmitter specifications continue to demand more from the TWT designer; the areas of particular interest are higher mean power, faster warm-up time and higher efficiency. The use of computer aided design tools to investigate these areas has been successfully employed. Notably, e2v has developed and built RF circuits for high mean power that overcome the natural limitation of heat being conducted through iron pole pieces.[14] Other manufacturers have increased mean power by improving the electron beam confinement under RF conditions. There is no reason why both techniques cannot be combined to produce coupled cavity TWTs of higher mean power capability.

FUTURE DEVELOPMENTS

With the recent development of compound semiconductors into the power amplification domain, a number of power applications have now migrated from tube-based to solid state amplification. This is especially true of sub-kilowatt, narrow-band requirements, with recent developments in Silicon Carbide (SiC) and Gallium Nitride (GaN) extending these devices into multiple-kilowatt capability, to frequencies around 10 GHz and above.[15] ***Figure 8*** shows the current solid-state

Test from 2 MHz to 20 GHz with Anritsu's Site Master™ series.

Talley carries the full line Anritsu Site Master analyzers.

Anritsu

S332D Dual Port Site Master

Anritsu's Site Master™ series of handheld cable and antenna analyzers let you precisely measure return loss/VSWR, cable loss, distance-to-fault and other critical aspects of your applications, including VHF, broadcasting, paging, LMR, cellular, GPS, PCS/GSM, 3G, ISM, WLAN and WLL. Powerful menu-driven software makes it simple to perform measurements. And rugged construction will take you through many sites to come. We also offer Anritsu Site Master certification classes at each of our five distribution centers, and we're happy to bring the classes to your facility too. **Talley and Anritsu — ready when and where you are.**

800.949.7079

A family-owned business

sales@talleycom.com
www.talleycom.com

Shop our online store!

Talley COMMUNICATIONS®
You connect the world.
We make it easy.®

Visit http://mwj.hotims.com/16346-157

Stress Relief!

When the testing gets tough, your low-power amplifier could quickly begin folding back, losing power, and leaving you… powerless to perform your tests. You can never really be 100% sure that your RF or EMC test amplifier will hold up. Unless it's an AR amplifier.

AR amplifiers are designed and built to withstand even the harshest, most extreme test conditions. Our amplifiers have more or larger transistors than other amps, which means less stress per transistor, giving your amplifier a longer life. Plus, something no other amplifier offers: infinite VSWR tolerance.

That means that AR amplifiers continue to deliver full rated power to the load in all test circumstances. Even when the VSWR ratio is so high that other amplifiers fold back or diminish output to protect circuitry. AR amplifiers give you every watt of power you paid for. Every time.

Why take chances when AR makes it easy to get the power and frequency combination you need? AR supplies a multitude of unique RF solutions – and provides a competitive edge – to some of the best-known companies worldwide. Our products are backed by the strongest, most comprehensive warranty in the industry, and a global support network that's second to none.

To learn more, visit www.ar-worldwide.com or call us at 215-723-8181.

ISO 9001:2000
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 UK 441-908-282766 • ar France 33-1-47-91-75-30 • emv GmbH 89-614-1710 • ar Benelux 31-172-423-000

Copyright© 2008 AR. The orange stripe on AR products is Reg. U.S. Pat. & TM. Off.

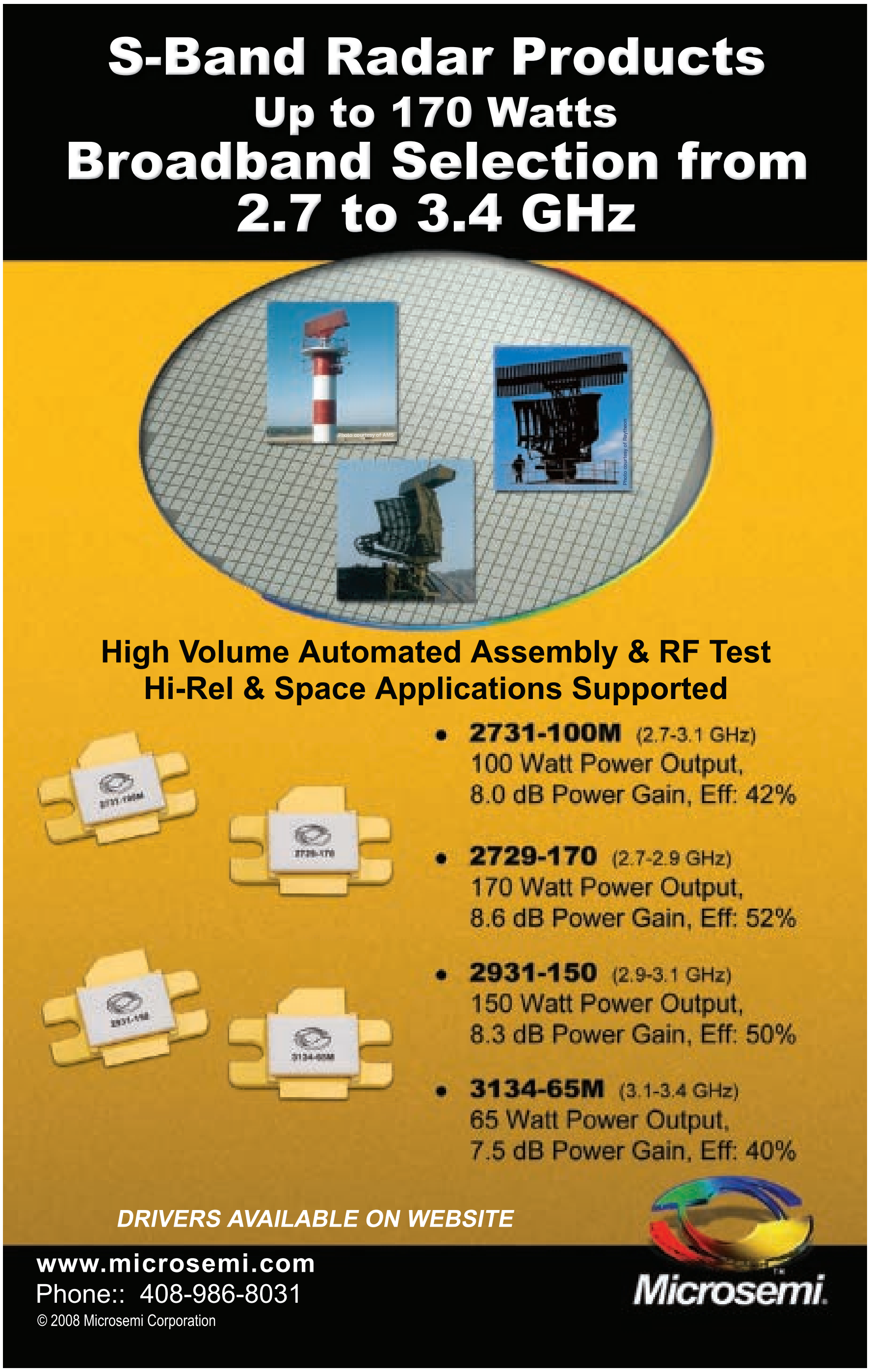
Visit http://mwj.hotims.com/16346-16 or use RS# 16 at www.mwjournal.com/info

and vacuum tube landscape, with respect to frequency and power.

As solid-state devices increase in capability, more applications will migrate from a tube to a transistor embodiment. However, for the present it is clear that travelling wave tubes continue to offer a compact and efficient amplifier solution, particularly under harsh operating environments. TWT amplifiers can also span a broad frequency bandwidth, approaching three octaves of coverage from a single tube.

FUTURE DIRECTION FOR TWTS

The future remains bright for TWTs, albeit in a tougher and more competitive market place. The continued progress of solid-state amplifiers will eat into the edges of the TWT domain, but there will remain to be requirements for the amplification of microwaves beyond the present capabilities of solid-state.



For systems with limitations on size, weight, power dissipation and consumption, there are, and will continue to be, numerous applications for vacuum electronic devices (VED). Higher power levels and higher frequencies are areas where tubes have no equal. The continued advances in VED technology will sustain growth.

In the commercial market, High Definition Television (HDTV) and the onset of the digital age are demanding higher powers and higher frequencies. These are major opportunity areas for the TWT.

The defence business worldwide continues to grow, upgrades to existing systems and new platforms, such as UAVs, require higher efficiencies, smaller lighter payload packages and improved reliability. Higher definition radar systems such as SARs and phased-array radar offer opportunities for small, lightweight, high-efficiency devices.

Also, government and defence funding is being made available to the industry to continue developing products for the future. An area of considerable interest at present is in the terahertz and sub mm-wave frequency regimes. Research and development in this area include CAD design of MEMS type structures, manufacturability, detection techniques and prototype manufacture. Programmes are as yet undefined but potential uses include UAV SAR for tactical targeting and terrain avoidance and security imaging.[16] ■

ACKNOWLEDGMENTS

Inputs on TWT product history and technology development have been provided by Alan Griggs (e2v principal TWT engineer) and Ian Milsom (e2v cathode development and test manager). The overview of current power amplifier technology was compiled by Dr. Cliff Weatherup (e2v strategic technology manager) and Dr. Trevor Cross (e2v chief technology officer). Product and application photographs were provided by Andy Bennett (e2v marketing).

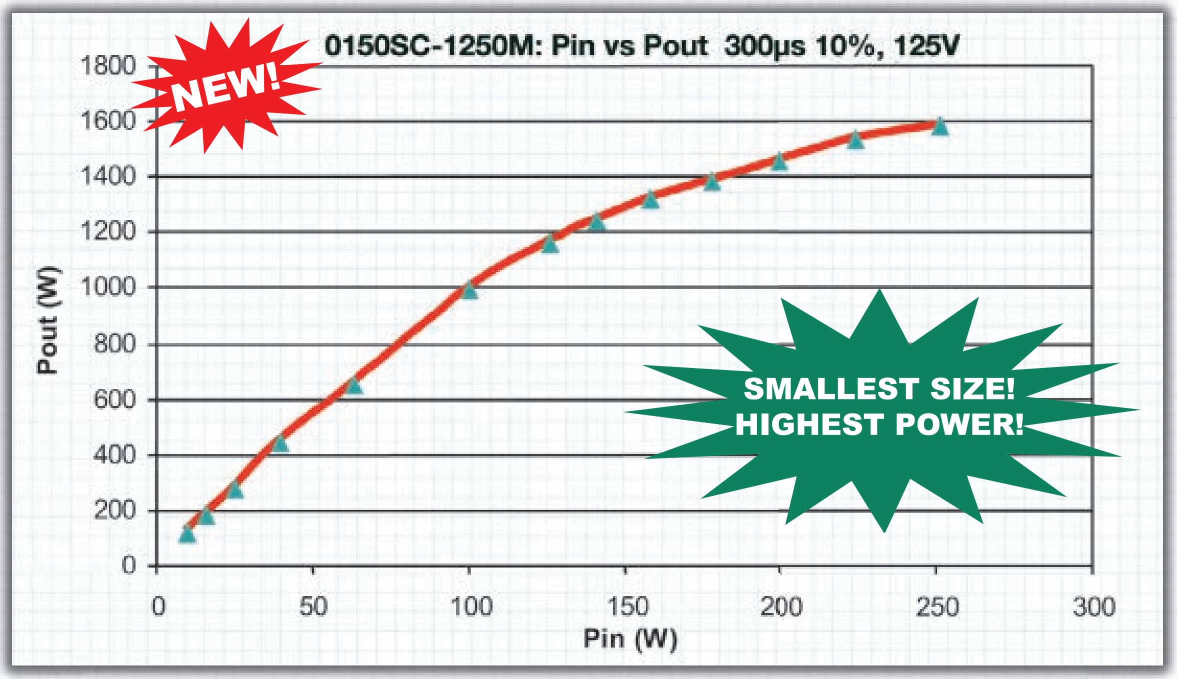
References

1. R. Kompfner, *Travelling Wave Electronic Tube*, US Patent no. 2630544, Filed 20th March 1948, Issued 3rd March 1953.
2. J.R. Pierce, "Travelling-wave Tubes," *Proc. IRE*, Vol. 35, No. 2, February 1947, pp. 108-111 .

 Visit http://mwj.hotims.com/16346-82

SiC • RF Power • SiC • RF Power

SILICON CARBIDE RF POWER DEVICES



Highest Peak Power In Smallest Package!

SiC™ Microsemi

	0150SC-1250M	*0405SC-1000M*
Freq:	156 MHz	405-450 MHz
Power Out:	1400 typ	1100 typ
Power Gain:	9 dB	8 dB
Pulse Width:	300 μs	300 μs
Duty Cycle:	10%	10%
VSWR-T:	10:1	10:1
Efficiency:	60%	45%
Bias:	125V	125V
Package:	0.9"x0.4"	0.9"x0.4"
Metallization:	all AU	all AU

Meet the first two SiC RF power devices launched from Microsemi. Ready *NOW* for your next generation VHF and UHF radar and ISM systems!

Check our specs for simplified solutions that can reduce your system size and part count. Our 0.9 x 0.4 inch package is 50% smaller than the highest power silicon BJT or LD/VDs you'll find anywhere.

- Single ended design
- Simple splitting & combining
- Extremely rugged for high system yield
- Low drain current to reduce noise
- High operating voltage for smaller power supplies
- Long term reliability

For detailed information contact us at: SiC@microsemi.com; or call 408-986-8031 x226.

Microsemi®

Microsemi and SiC logo are property of Microsemi Corporation. © 2008.

Visit http://mwj.hotims.com/16346-83 or use RS# 83 at www.mwjournal.com/info

3. E.J. Nalos, "Present State of Art in High Power Travelling-wave Tubes: Part I," *Microwave Journal*, Vol. 2, No. 12, December 1959, pp. 31-38.
4. D.R. Wahley, et al., "Operation of a Low Voltage High-transconductance Field Emitter Array TWT," *Proc. IEEE Vacuum Electronics Conference*, April 22-24, 2008, pp. 78-79.
5. Product data from Thales web site: http://components-subsystems.thales-catalogue.com.
6. Product data from CPI, Microwave Power Products Division web site: http://www.cpii.com/product.cfm/1/19/65.
7. Product data from Teledyne MEC web site: http://www.teledyne-mec.com/products/productCatalog.aspx.
8. Product data from NEC Microwave Tube web site: http://www.nec-mwt.com/english/products/twt/seihin/index.html.
9. Product data from L-3 Electron Technologies Inc. web site: http://www.l-3com.com/eti/product_lines_space_twt.htm.
10. Product Data from e2v.
11. Product Data from L-3, Electron Devices web site: http://www.l-3com.com/edd/products_mini_tubes.htm.
12. ALE-50 Contract reference, *Business Journal*, September 19, 2007, http://www.bizjournals.com/sanjose/stories/2007/09/17/daily44.html?ana=from_rss.
13. C. Ar, A.V. Piring and P. Tibbs, "F-Programs TWT Design Upgrades," *Proc. IEEE Vacuum Electronics Conference*, April 27-29, 2004, pp. 20-21.
14. A. Griggs, "A New Coupled Cavity Circuit for High Power Travelling-wave-Tubes," *IEEE Transactions on Electron Devices*, Vol. 38, No. 8, August 1991, pp. 1952-1957.
15. R. Trew, "Wide Bandgap Semiconductor Transistors for Microwave Power Amplifiers," *IEEE Microwave Magazine*, Vol. 1, No. 1, March 2000.
16. M.J. Rosker and H.B. Wallace, "Vacuum Electronics and the World Above 100 GHz," *Proc. IEEE Vacuum Electronics Conference*, April 22-24, 2008, pp. 5-7.

***Brian Coaker** joined the English Electric Valve Co. (a GEC subsidiary, later known as EEV, now e2v technologies), Lincoln, UK, as an Apprentice Technician Engineer. He then read BEng Physical Electronic Engineering at Lancaster University, before reading for a Total Technology PhD at the University of Aston in Birmingham. He is a Chartered Electrical Engineer (CEng) and Chartered Physicist (CPhys), member of the Institution of Engineering and Technology (MIET) and the Institute of Physics (MInstP), a Chartered Scientist (CSci) and is a Whitworth Scholar (WhSch). He is currently engaged as general manager of the microwave business of e2v technologies (UK) ltd., with particular interests in the military, commercial and maritime radar sectors. He has authored technical papers in the fields of microwave electronics and electrical breakdown phenomena in vacuum*

***Tony Challis** joined the English Electric Valve Co., Chelmsford, UK, as an Apprentice Technician Engineer in 1983. He received his HNC in electromechanical engineering from Anglia Polytechnic University (APU), Chelmsford, UK, in 1987. In 1988 he joined a team of development engineers within e2v, developing new products and re-engineering existing devices. With a strong background in mechanical engineering and experience gained in vacuum technology, he progressed to Technical Authority for Helix TWTs. Achievements in electron gun and PPM stack design led to his involvement in the successful development of a range of mini TWTs designed for airborne decoy applications. With this knowledge of TWT design and manufacture, allied with an appreciation for the vacuum electronics business, he is currently product manager for TWTs and microwave amplifier systems.*

Broadband Amplifiers by AML Communications

To Order Call: (805)388-1345 ext. 203

Model	Frequency (GHz)	Gain (dB)	Flatness (dB) max	NF (dB) max	P1dB (dBm) min	VSWR (In/Out)	DC Current @ +12/+15VDC
Broadband Low Noise Amplifiers							
AML016L2802	0.1 – 6.0	28	±1.25	1.3*	+7	2.0:1	190
AML48L3001	4.0 – 8.0	30	±1.0	1.2	+10	1.8:1	150
AML412L3002	4.0 – 12.0	30	±1.5	1.5	+10	1.8:1	150
AML218L0901	2.0 – 18.0	9	±1.0	2.2	+5	2.5:1	60
AML0518L1601-LN	0.5 – 18.0	16	±1.0	2.7	+8	2.2:1	100
AML0126L2202	0.1 – 26.5	22	±2.25	3.5*	+8	2.2:1	170
AML1226L3301	12.0 – 26.5	33	±2.0	2.8	+8	2.5:1	200
Broadband Medium Power Amplifiers							
AML0016P2001	0.01 – 6.0	21	±1.25	3.2*	+23*	2.0:1	480
AML26P3001-2W	2.0 – 6.0	28	±2.5	6	+33	1.8:1	1500
AML28P3002-2W	2.0 – 8.0	30	±2.0	5.5	+33	2.0:1	2000
AML218P3203	2.0 – 18.0	32	±2.5	4	+25	2.0:1	450
AML618P3502-2W	6.0 – 18.0	35	±2.5	4	+33	2.0:1	1850
Narrow Band Low Noise Amplifiers							
AML23L2801	2.8 – 3.1	28	±0.75	0.7	+10	1.8:1	150
AML1414L2401	14.0 – 14.5	24	±0.75	1.5	+10	1.5:1	130
AML1718L2401	17.0 – 18.0	24	±0.75	1.6	+10	1.8:1	150

Low Phase Noise Amplifiers — **Phase noise (dBc/Hz) at offset**

Part Number	Frequency (GHz)	Gain (dB)	Output Power (dBm)	100Hz	1KHz	10KHz	100KHz
AML811PN0908	8.5 – 11.0	9	17	-154	-159	-167	-170
AML811PN1808	8.5 – 11.0	18	18	-152.5	-157.5	-165.5	-168
AML811PN1508	8.5 – 11.0	15	28	-145.5	-153.5	-158.5	-164.5
AML26PN0904	2.0 – 6.0	9	20	-150	-165	-165	-178
AML26PN1201	2.0 – 6.0	11	15	-155	-160	-160	-175

High Dynamic Range Amplifiers

Part Number	Frequency (MHz)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	DC
AR01003251X	2 – 32	21	32	52	+28V @ 470mA
AFL30040125	50 – 500	23	28	53	+28V @ 700mA
BP60070024X	20 – 2000	32	30	43	+15V @ 1100mA

*Above 500MHz.

AML Communications
Camarillo, CA (805)388-1345 ext. 203

Over 1000+ amplifiers at
www.amlj.com

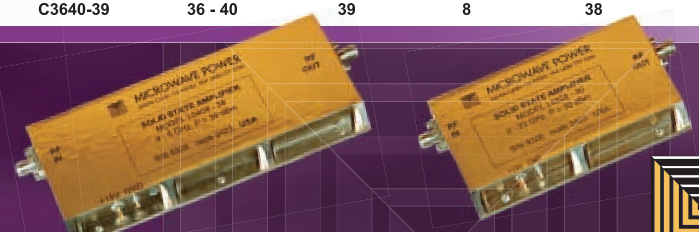
Power Amplifiers by Microwave Power

To Order Call: (408)727-6666 ext. 42

Model	Frequency (GHz)	Psat (dBm)	Psat (W)	P1dB (dBm)	Gain (dB)	DC Current(A) @ +12V or +15V
Broadband Microwave Power Amplifiers						
L0104-43	1 - 4	42.5	17.8	41.5	45	14
L0204-44	2 - 4	44	25	42.5	45	14
L0206-40	2 - 6	40	10	38.5	40	8.5
L0208-41	2 - 8	41	12	40	40	17
L0218-32	2 - 18	32	1.4	31	35	5
L0408-43	4 - 8	43	20	41.5	45	17
L0618-43	6 - 18	43	20	41.5	45	22
L0812-46	8 - 12	46	40	45	45	28
Millimeter-Wave Power Amplifiers						
L1826-34	18 - 26	34	2.5	33	35	4
L1840-27	18 - 40	27	0.5	26	30	2
L2240-28	22 - 40	28.5	0.7	27	30	3
L2630-39	26 - 30	39	8.0	38	40	15
L2632-37	26 - 32	37	5.0	36	38	10
L2640-31	26 - 40	31	1.2	30	30	5
L3040-33	30 - 40	33	2.0	32	33	9
L3337-36	33 - 37	36	4.0	35	40	12
L3640-36	36 - 40	36	4.0	35	40	10

High-Power Rack Mount Amplifiers

Model	Frequency (GHz)	Psat (dBm)	Psat (W)	P1dB (dBm)	Pac (kW)	Height (in)
C071077-52	7.1 - 7.7	52.5	170	51.5	1.8	10.25
C090105-50	9 - 10.5	50	100	49	1	8.75
C140145-50	14 - 14.5	50.5	110	49.5	2	10.25
C1416-46	14 - 16	46	40	45	0.35	5.25
C1820-43	18 - 20	43	20	41.5	0.25	5.25
C2326-40	23 - 26	40	10	39	0.25	5.25
C2630-45	26 - 30	45	30	44	0.45	5.25
C3236-40	32 - 36	40	10	39	0.25	5.25
C3640-39	36 - 40	39	8	38	0.24	5.25



Look for some serious power at
www.microwavepower.com

Microwave Power
An AML Communications Company
Santa Clara, CA (408)727-6666 ext. 42

Visit http://mwj.hotims.com/16346-10 or use RS# 10 at www.mwjournal.com/info

RF Amplifiers and Sub-Assemblies for Every Application

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

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

ISO 9001:2000 and AS9100B CERTIFIED

OCTAVE BAND LOW NOISE AMPLIFIERS

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

NARROW BAND LOW NOISE AND MEDIUM POWER AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
CA01-2111	0.4 - 0.5	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA01-2113	0.8 - 1.0	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3117	1.2 - 1.6	25	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3111	2.2 - 2.4	30	0.6 MAX, 0.45 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3116	2.7 - 2.9	29	0.7 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA34-2110	3.7 - 4.2	28	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA56-3110	5.4 - 5.9	40	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA78-4110	7.25 - 7.75	32	1.2 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA910-3110	9.0 - 10.6	25	1.4 MAX, 1.2 TYP	+10 MIN	+20 dBm	2.0:1
CA1315-3110	13.75 - 15.4	25	1.6 MAX, 1.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3114	1.35 - 1.85	30	4.0 MAX, 3.0 TYP	+33 MIN	+41 dBm	2.0:1
CA34-6116	3.1 - 3.5	40	4.5 MAX, 3.5 TYP	+35 MIN	+43 dBm	2.0:1
CA56-5114	5.9 - 6.4	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6115	8.0 - 12.0	30	4.5 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6116	8.0 - 12.0	30	5.0 MAX, 4.0 TYP	+33 MIN	+41 dBm	2.0:1
CA1213-7110	12.2 - 13.25	28	6.0 MAX, 5.5 TYP	+33 MIN	+42 dBm	2.0:1
CA1415-7110	14.0 - 15.0	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA1722-4110	17.0 - 22.0	25	3.5 MAX, 2.8 TYP	+21 MIN	+31 dBm	2.0:1

ULTRA-BROADBAND & MULTI-OCTAVE BAND AMPLIFIERS

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

LIMITING AMPLIFIERS

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

AMPLIFIERS WITH INTEGRATED GAIN ATTENUATION

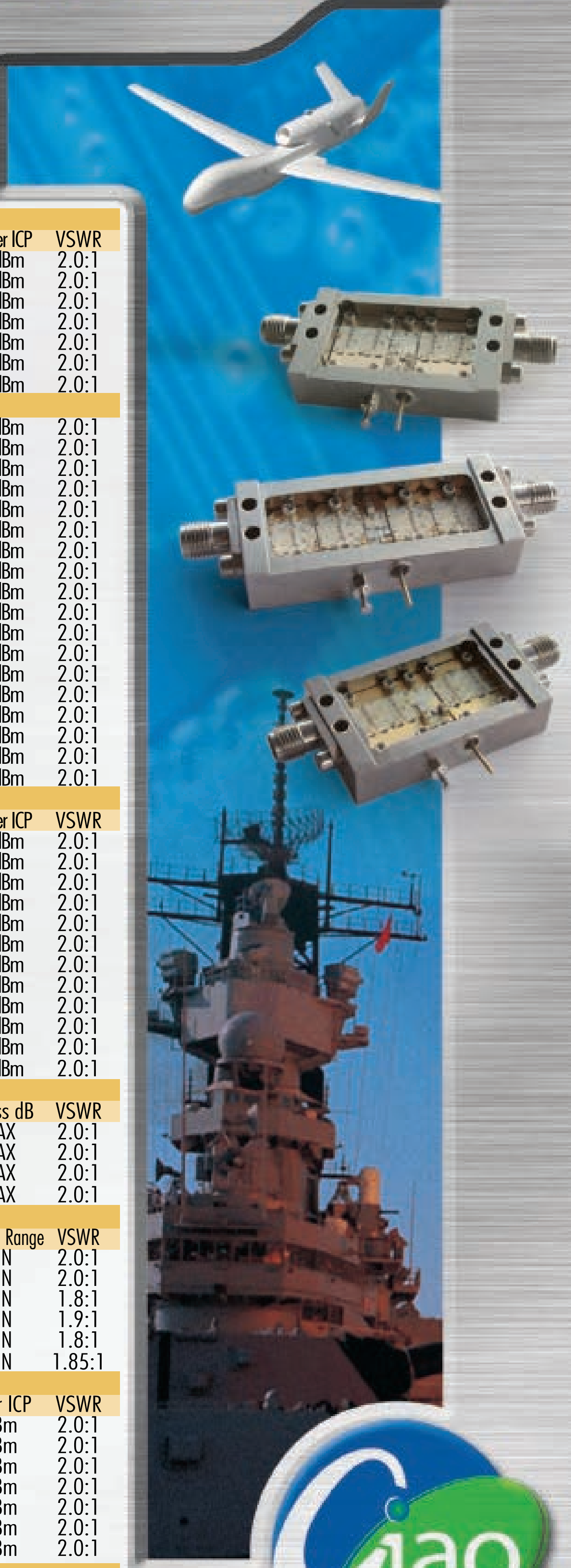
Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	Gain Attenuation Range	VSWR
CA001-2511A	0.025-0.150	21	5.0 MAX, 3.5 TYP	+12 MIN	30 dB MIN	2.0:1
CA05-3110A	0.5-5.5	23	2.5 MAX, 1.5 TYP	+18 MIN	20 dB MIN	2.0:1
CA56-3110A	5.85-6.425	28	2.5 MAX, 1.5 TYP	+16 MIN	22 dB MIN	1.8:1
CA612-4110A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

LOW FREQUENCY AMPLIFIERS

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

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

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



Ciao wireless

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

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

Visit http://mwj.hotims.com/16346-29 or use RS# 29 at www.mwjournal.com/info

General Dynamics Awarded $23 M for Digital Modular Radios

General Dynamics C4 Systems has been awarded a $23 M contract for AN/USC-61(C) Digital Modular Radios (DMR), the Navy's standard communication system for newly constructed ships and submarines. Deliveries are scheduled to begin in mid-2009 and continue through 2010. General Dynamics C4 Systems is a business unit of General Dynamics. The software-defined DMRs communicate with Ultra-High Frequency SATCOM, Single-Channel Ground and Airborne Radio Systems (SINCGARS), Line of Sight and High Frequency radios on Navy surface and subsurface platforms. General Dynamics has delivered more than 370 DMRs for use throughout the fleet and Navy shore sites, enabling secure short-range and global communications using US military standard waveforms. "By replacing what used to be racks of radios and encryption equipment, one DMR radio represents considerable savings in size, weight and power to the Navy," said Chris Brady, vice president of Assured Communications for General Dynamics C4 Systems. "The expertise we have gained from successfully executing on the DMR is particularly relevant now as we work with Lockheed Martin in the development of the Airborne and Maritime/Fixed Station component of the Joint Tactical Radio System." In March 2008, General Dynamics received a contract to develop and integrate the maritime and fixed-site joint tactical radio capabilities and provide information assurance services for the Lockheed Martin Airborne, Maritime and Fixed Site (AMF) Joint Tactical Radio System team. General Dynamics C4 Systems delivered the first Digital Modular Radio to the Navy in 1998; it was one of the first software-defined radios to be delivered under contract to the US military. In October 2004, the radio became the first software-defined radio certified by the National Security Agency for communications up to the Top Secret level. The DMR contracting office is the Space and Naval Warfare Systems Command, working on behalf of the Program Executive Office for Command Control Communications Computers and Intelligence, San Diego, CA.

Lockheed Martin Receives $61 M Contract for Guided MLRS Rockets

Lockheed Martin has received a $61 M follow-on contract for Guided Multiple Launch Rocket System (GMLRS) Unitary rockets. To date, more than 850 GMLRS rockets have been fired in the Global War on Terror. Work on the contract will be performed at the company's facility in Camden, AR, and Dallas, TX. Deliveries will begin in May 2010 and conclude in July of that year. "GMLRS delivers precision when warfighters need it most, especially effective in urban areas," said Lt. Col. Drew Clanton, the GMLRS product manager at the US Army's Precision Fires, Rockets and Missiles program management office in Huntsville, AL. "The system's readiness rates support the consistent quality we expect and its accuracy helps keep civilians out of harm's way."

GMLRS provides the US Army, US Marine Corps and the United Kingdom Defense Forces with a persistent, responsive, all-weather, rapidly-deployable, long-range, surface-to-surface, precision strike weapon. Reliability of US Army GMLRS missions exceeds 98 percent. "Soldiers continue to tell us how satisfied they are with GLMRS, because it is ready when it needs to be and can hit precision targets from 85 Km away, a new distance record recently recorded at tests at White Sands Missile Range," said Scott Arnold, vice president for Precision and Combat Maneuver Systems at Lockheed Martin Missiles and Fire Control. "Just as in previous orders, we are committed to delivering GMLRS to the quality and dependability on which our customers have come to rely." GMLRS is an all-weather, precision strike, artillery rocket system that achieves greater range and precision accuracy requiring fewer rockets to defeat targets and limiting collateral damage. GMLRS is a Future Force system that provides the joint warfighter with immediate precision fires to engage, destroy and deny terrain to the enemy.

Northrop Grumman Scores Success for Solid-state Laser Weapon

Northrop Grumman Corp. has set new industry records in all aspects of high-power solid-state laser production, demonstrating the readiness of these compact, portable, speed-of-light weapons to take their place on the battlefield. The company demonstrated the third critical milestone for the US military's Joint High Power Solid State Laser (JHPSSL) program, Phase 3. Operating from Northrop Grumman's one-of-a-kind laser factory, the system:

- Raised its demonstrated lethality by precisely combining two laser chains to produce a record power, 30 kW, in an excellent beam-beam quality of 2.1 times the theoretical limit.
- Operated at this performance level for more than five minutes continuously and more than 40 minutes total; and
- Achieved electrical-to-optical efficiency of greater than 19 percent.

"Our march towards providing compact, electrically powered, operationally scalable and affordable laser weapons for US military services continues to produce world-leading results," said Dan Wildt, vice president of Directed Energy Systems for Northrop Grumman's Space Technology sector. "We believe this sets a new solid-state record by simultaneously demonstrating tactically significant power and beam quality for more than five minutes," stated JHPSSL Phase 3 program manager Jay Marmo.

Just as it had in two previous milestone tests, the company's JHPSSL Phase 3 laser demonstrated its third milestone ahead of schedule. "We have achieved all our major milestones ahead of schedule as we continue to rev up the power and capability. By demonstrating our ability to combine two identical, modular laser chains into a single, high brightness beam, we have proven all aspects of our scalable design to 100 kW." The JHPSSL program is funded by the US Army Space and Missile Defense Command/Army Forces Strategic Command, Huntsville, AL; Office of the Secretary of Defense – Joint Technology Office, Albuquerque, NM; Air Force Research Laboratory, Kirkland Air Force Base, NM; and the Office of Naval Research, Arlington, VA.

Raytheon Systems Excel as LPD 20 Passes US Navy Acceptance Trials

Raytheon Co. announced satisfactory system performance onboard the USS Green Bay (LPD 20) as it completed its final acceptance trials. Raytheon Integrated Defense Systems (IDS) is the total ship electronics system integrator for the LPD 17 class of amphibious transport dock ships. The trials, which were held at Northrop Grumman Shipbuilding facilities in New Orleans and the Gulf of Mexico, demonstrated the performance and capabilities of Raytheon systems integrated onboard, including ship control and navigation, engineering control, voice and video communications, magnetic signature control systems and the Shipboard Wide Area Network. "The completion of these acceptance trials continues our legacy of reliability and proven performance as the Mission Systems Integrator for LPD 17 and our other Navy programs," said Robert Martin, IDS vice president and deputy of Seapower Capability Systems. "This milestone is a critical step toward delivering the advanced capabilities of the LPD 17 class to the Navy and our warfighters." The acceptance trials, conducted by the US Navy's Board of Inspection and Survey, represent the final construction milestone prior to ship delivery. The assessment consists of in-port and at-sea system testing and is conducted to demonstrate vessel performance and seaworthiness to the Navy. The USS Green Bay is the fourth ship of the advanced LPG class of amphibious transport dock ships. They provide the Navy's Expeditionary Strike Group with the technology and flexibility to launch and recover amphibious landing craft, such as the Landing Craft Air Cushion, operate an array of rotary-wing aircraft, as well as transport and launch the US Marine Corps' Expeditionary Fighting Vehicle.


RF & Microwave Filters
for the most advanced
Integrated
Assemblies
LORCH delivers custom solutions
for demanding applications
■ high-level integration capabilities
■ latest component technology
■ optimized for performance
and value
■ all hardware designed,
manufactured and assembled
in-house
■ time-tested baseline designs
ready for customization
LORCH
MICROWAVE
Salisbury, Maryland 21802 · USA
800.780.2169 · 410.860.5100
Brackenholme Y08 6EL. UK
Tel/Fax +44 (0) 1757 633 755
www.lorch.com
smiths
bringing technology to life
Visit http://mwj.hotims.com/16346-73 or use RS# 73 at www.mwjournal.com/info

Reactel, Incorporated
When Being the First to React Makes all the Difference in the World
Trust in Reactel's highly skilled engineers and technicians to quickly develop and produce the most reliable products for your filter requirements.
• RF & Microwave Filters
• Diplexers/Multiplexers
• Switched Filter Banks
• Cavity Filters
E-mail catalog@reactel.com to receive you new Reactel Product Catalog or go online to www.reactel.com to download your copy today.
FM Approvals
Reactel, Incorporated • 8031 Cessna Avenue • Gaithersburg, Maryland 20879
Phone: (301) 519-3660 • Fax: (301) 519-2447 • Email: reactel@reactel.com • www.reactel.com
Visit http://mwj.hotims.com/16346-126 or use RS# 126 at www.mwjournal.com/info

Thales Alenia Space and Inmarsat Sign EuropaSat ATP

Thales Alenia Space and Inmarsat have signed an Authorization To Proceed (ATP) for the development of the EuropaSat satellite to provide mobile broadcast and two-way telecommunications services in the S-band throughout Europe.

Thales Alenia Space will commence work on the satellite design, based on its Spacebus 4000C3 platform and develop it through timely Critical Design Review to support a fully compliant application for an EC-wide S-band spectrum allocation by Inmarsat, under the recently-announced European S-band Application Process. The spacecraft will carry a payload at 2 GHz generating nine S-band user spot beams in two polarizations, using a large S-band Tx antenna of 12 m diameter.

Designed with a lifetime of 15 years, the EuropaSat satellite is expected to be launched in early 2011, in compliance with the European Selection and Authorisation Process (ESAP). The spacecraft manufacturing programme supports Inmarsat's imminent application for an award of S-band spectrum, pursuant to the ESAP, which commenced on 7 August 2008 and is subject inter alia to a successful outcome of the ESAP for Inmarsat.

ST and Ericsson Provide Platform for Joint Venture

Ericsson and STMicroelectronics have agreed to merge Ericsson Mobile Platforms and ST-NXP Wireless into a joint venture. The 50/50 joint venture will have the industry's strongest product offering in semiconductors and platforms for mobile applications and will be an important supplier to Nokia, Samsung, Sony Ericsson, LG and Sharp. The fabless joint venture will employ almost 8,000 people with pro-forma 2007 sales of \$3.6 B. ST is expected to exercise its option to buy NXP's 20 percent of ST-NXP Wireless before the closing of the transaction.

In the joint venture, ST contributes its industry-leading multimedia and connectivity solutions as well as a complete world-class 2G/EDGE platform and strong 3G offering while Ericsson contributes its industry-leading 3G and LTE platform technology. The joint venture, staffed by proven professionals across all functional areas, is designed for long-term stability in its original structure, and is set to become an industry leader in product research, as well as design, development, and the creation of cutting-edge mobile platforms and wireless semiconductors. The joint venture will be headquartered in Geneva, Switzerland, and governance will be balanced between the companies.

Forum Adds New Members Worldwide

Eight organizations working within the advanced wireless market have recently joined the SDR Forum, bringing the total number of new members joining the Forum to 25. This growth represents a 20 percent increase in member organizations.

This rapid expansion can be attributed to the growing acceptance of software defined radio (SDR) and related technologies in the mainstream wireless markets, and the value that the SDR Forum brings to its members when operating within this dynamic environment.

The eight new member organizations demonstrate the diversity of companies involved in software defined radio development both in terms of activity and geographically with five being headquartered in the US and the other three in Europe.

They are: DRS Signal Solutions (US), a world leader in providing commercial-off-the-shelf products and custom-based SIGINT solutions; ENSTA (Paris, France), one of the top French institutes of higher education in engineering; Fraunhofer IIS (Erlangen, Germany) – as the inventor of mp3 and co-inventor of the MPEG AAC audio coding standard, the Fraunhofer IIS has achieved worldwide recognition; IMEC (Leuven, Belgium) is a world-leading independent research centre in nanoelectronics and nanotechnology; UC San Diego (US) – the California Institute for Telecommunications and Information Technology (Calit2) is a partnership of UC San Diego and UC Irvine. An area of research is software-defined radio; Reservoir Labs (US) provides leading-edge consulting and contract R&D; Xenotran (US) specializes in the analysis, design and implementation of digital communication components used in wireless communication systems; and VIP Mobile Inc. (US) provides research and development, software engineering and systems integration services.

Joint Venture to Develop UK Innovation Campus

The United Kingdom Atomic Energy Authority (UKAEA), the Science and Technology Facilities Council (STFC) and international property group, Goodman, have linked up to establish the Harwell Science and Innovation Campus in Oxfordshire, UK.

Under the agreement, UKAEA will provide land at Harwell for development and an existing business base. STFC will contribute involvement in major public sector science programmes and a proactive approach to ensuring fundamental research can be harnessed and exploited by innovators, entrepreneurs and industry. Goodman will offer market access to global businesses and expertise in long-term property ownership, development and management, as well as providing working capital for the joint venture.

Investment at the campus will encompass fundamental scientific research and the development of property, facilities and local infrastructure. A minimum of 100,000 m^2 of laboratory, high technology industrial and office accommodation will be developed in the first 20-year phase of the project. Up to 5,000 high value knowledge-based jobs are also expected to be created.

Indra Leads EGNOS Satellite Navigation System Study

Indra is heading the industrial group in charge of studying the feasibility and definition of the current EGNOS satellite navigation system towards a future Multiconstellation Regional System (MRS) for the European Space Agency (ESA). The team is composed of Astrium-EADS (Germany), Deimos Engenharia (Portugal), INECO (Spain), Novatel (Canada) and the Polytechnic University of Catalonia (Spain), in addition to Indra (Spain). The project budget is €1.5 M and the execution period is 18 months.

The EGNOS system currently provides air, sea and land information, using the North American GPS system. The objective of the study is to analyze how it should evolve so that it can take advantage of the greater number of satellites and constellations that will be in place in a few years' time, which will offer a greater volume and quality of information.

The industrial team will define the system requirements, technical specifications, design of the necessary navigation algorithms, both for the system and the end user application, features verification simulations and system architecture.

The aim is to analyze the possibility of evolving the current EGNOS system, turning it into a multiconstellation system, capable of improving regionally, within the European zone, the features offered on an individual basis by the different satellite systems separately. It will combine the signals of the future constellations of the American GPS, the Russian Glonass, the Chinese Compass/Beidou and the European Galileo systems to offer more advanced services to a greater number of users in critical, high-performance or commercial application areas. Once the study has been completed, the team will develop a preliminary prototype, based on a simulator of the various system components.

Pascall oscillators hit new lows

The **Phase Locked Dielectric Resonator** series has low power consumption and stays cool whilst delivering low phase noise, low microphony, high stability and reliability at low cost.

Pascall
thinking inside the box

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

www.pascall.co.uk

A subsidiary of Emrise Electronics

DC to 8 GHz

MMIC Amplifiers

SOT-89
Actual Size

from 99¢ ea. (qty. 25)

- Power output to 21 dBm
- High IP3 up to 38 dBm
- Transient and ESD protected
- Fixed voltage, GVA 84+
- Gain from 12-26 dB
- Noise figure from 2.7 dB
- InGaP HBT
- 2 year guarantee

These Tiny SOT-89 cascadable 50 ohm wideband gain blocks cover from below 10 KHz up to 8 GHz in a single model. Built to outlast the equipment it will be used in, these transient protected units are ruggedly constructed and will meet level 1 moisture sensitivity testing.
Check out our web site, over 24 models available with performance data, curves, environmental specs and easy downloading of S parameters from the web to your simulation software. Models are available to provide the performance you need from high gain, low noise, high IP3 or low DC current. Don't wait; choose the MMIC model that meets your performance/price requirements, ***Available from Stock***.

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

AMPLIFIER DESIGNER'S KITS

K3-Gali_GVA+: Only $99.95
Contains 10 Ea. of Gali 24+, 74+, 84+, GVA 84+ (40 pieces total)

K4-Gali+: Only $99.95
Contains 10 Ea. of Gali 1+, 2+, 3+, 4+, 5+, 6+, 21+, 33+, 51+ (90 pieces total)

K5-Gali+: Only $64.95
Contains 10 Ea. of Gali 4F+, 5F+, 6F+, 51F+, 55+ (50 pieces total)

Evaluation Boards Available, $59.95 ea.

All models protected under U.S. patent # 6,943,629.

RoHS compliant.

Mini-Circuits®
ISO 9001 ISO 14001 CERTIFIED

ALL NEW minicircuits.com

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

YONI2™ Patent Pending ***The Design Engineers Search Engine*** *Provides ACTUAL Data Instantly From MINI-CIRCUITS At:* ***www.minicircuits.com***

RF/IF MICROWAVE COMPONENTS

346 rev N

Visit http://mwj.hotims.com/16346-93 or use RS# 93 at www.mwjournal.com/info

NEW

CERAMIC HERMETICALLY-SEALED

RF SWITCHES

HIGH ISOLATION… 0.3 MHz to 6 GHz from $4.95 ea. (Qty.10-49)

On land, sea, and in the air, demanding critical applications call for a switch that is a cut above the rest. Mini-Circuits rugged CSWA2-63DR+ ceramic RF/microwave SPDT switch is that switch. From 0.5 to 6 GHz this switch operates in the absorptive mode (good output VSWR in off state). From 0.3 MHz to 500 MHz in the non absorptive mode (Output ports reflective in off state). The CSWA2-63DR+ at only 4 x 4 x 1.2 mm handles tight spaces; provide protection against high moisture environments, and offers outstanding performance. For tough RF/microwave switch requirements in commercial, industrial, or military applications, think Mini-Circuits' new ceramic switch. Visit our website to view comprehensive performance data, performance curves, data sheets, pcb layout, and environmental specifications. And, you can even order direct from our web store and have it in your hands as early as tomorrow!

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

CSWA2-63DR+ In Stock

- *Very High Isolation: 63 dB @ 1 GHz to 44 dB @ 6 GHz*
- *Low Insertion Loss: 1.2 dB*
- *High IP3: +45 dBm*
- *Integral CMOS Driver*
- *Supply current of only 18 micro amps*
- *23 ns typical rise/fall time*

4 mm Square Package

RoHs compliant

ALL NEW minicircuits.com

Mini-Circuits®

ISO 9001 ISO 14001 CERTIFIED

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

YONI2™ Patent Pending

The Design Engineers Search Engine** Provides ACTUAL Data Instantly From MINI-CIRCUITS At: **www.minicircuits.com

IF/RF MICROWAVE COMPONENTS

434 Rev A

Visit http://mwj.hotims.com/16346-94 or use RS# 94 at www.mwjournal.com/info

Sensors Take the Growth Baton in the Global MEMS Market

Driven by new demand from consumer electronics and wireless applications, the global market for Microelectromechanical Systems (MEMS) will expand to \$8.8 B in 2012, up from \$6.1 B in 2006, iSuppli Corp. predicts.

"The markets for mainstay MEMS actuator products—like inkjet heads and Digital Light Processor (DLP) chips from Texas Instruments Inc.—finally have passed the baton to MEMS sensors to drive the next growth wave in the market," said Jeremie Bouchaud, director and principal analyst, MEMS, for iSuppli. "The new wave is partly founded in the rapid rise of consumer electronics applications such as motion sensors for gaming, laptops and digital still cameras. Mobile handsets will also be a strong area, with MEMS sensor revenue in this area to rise at a 22.9 percent Compound Annual Growth Rate (CAGR) to reach \$925 M in 2012."

Four main segments collectively will account for slightly more than 60 percent of total MEMS market revenue in 2012: consumer electronics, mobile handsets, automotive and industrial process control. Aside from the consumer and wireless applications, market pull is being exerted by the automotive sector, an established area set to receive new impetus as a result of mandates for safety and new emissions standards. Demand also will be driven by a diverse range of applications in industrial processing and control.

The one bright spot for actuators is in Radio Frequency (RF) MEMS switches used in mobile handsets and test equipment. This market will grow at an annual rate of more than 100 percent from 2006 to 2012, and will account for \$261 M in actuator revenue in 2012, up from just \$6 M in 2007.

"The consumer electronics and mobile communications fields are much more dynamic than the previous mainstay markets for MEMS," Bouchaud said. "Existing companies have a great opportunity to ride this wave and new players have a chance to address a relatively open market. However, deep R&D pockets are essential to compete in this area, and the companies that will succeed will be those that bet on and invest in building dedicated mass-production facilities." Pioneering companies with brand new MEMS products tend to enjoy a lengthy monopoly in the market, such as Texas Instruments with its DLP chip or Knowles with MEMS microphones.

Meanwhile, in fast-moving markets like consumer electronics and automotive sensors—the latter driven by mandates—economies of scale will be the norm, with sensor companies attempting to address both sectors. iSuppli also expects the pace of mergers and acquisitions to accelerate in 2008 and 2009, concentrating MEMS market share among fewer players. Please visit page 212 of this month's issue of *Microwave Journal* for more market analysis from iSuppli Corp.

Wireless USB Enters into Competitive Market

Wireless USB refers to the Certified Wireless USB (WUSB) standard based on ultrawideband (UWB) technology that is compliant with WiMedia Alliance specifications. The subject of discussion for several years, WUSB finally hit the market in 2007 in notebook PCs from Dell and Lenovo, and in hub and dongle solutions from Belkin, IOGear and D-Link. The debut of these devices was a bit inauspicious, with relatively few devices shipping worldwide in 2007. However, the beginnings of a new wireless ecosystem have launched, and should lead to increased shipments in the years ahead.

Wireless USB is based on the same host/device architecture as wired USB, so the PC is the center of WUSB world. The Dell and Lenovo releases mark a promising start. But the question for WUSB is: Where next? In wired USB, there was a natural progression from PCs to PC peripherals to Consumer Electronics (CE) and mobile phones. However, wired USB was significantly less expensive than WUSB, which made it an easy decision to add for vendors of even the most price-sensitive PC peripheral and CE vendors. A WUSB chip solution, on the other hand, currently sells for over \$10, even in high volumes. This makes it very difficult for these same vendors to add, especially when there is no guarantee that WUSB will penetrate the vast majority of the PC market, as wired USB did. These relatively high ASPs will make WUSB adoption a relatively long-term process.

As UWB chip companies gear up production and ASPs decline, additional PC, PC peripheral and CE vendors will adopt the application. Notebook PCs will lead the adoption of WUSB. Within the PC peripheral market, there will be some interest from vendors for applications such as printers, multifunction peripherals and external hard disk drives. In the CE market, digital still cameras, digital camcorders and portable media players (PMP) should adopt WUSB in limited quantities over the next few years. However, significant WUSB adoption in these markets will not occur until WUSB chip solution ASPs come down to about half of their current levels. The competition for WUSB is fierce. It comes from other WiMedia UWB-based standards, such as Bluetooth over UWB and IP over UWB. However, the toughest competition for WUSB will come from Wi-Fi. A proven, inexpensive technology that has been through several generations, Wi-Fi is in every mobile PC shipping today, and has made inroads into many PC peripheral and CE applications, as well as into mobile phones. In addition, Intel's efforts to make Wi-Fi more Wireless PAN-friendly are directly aimed at WUSB. Ultimately though, UWB and WUSB will succeed because they solve problems that no other technology can; the ability to transmit large amounts of data over short distances from one device to another with relative power efficiency.

Online Social Networking Goes Mobile: 140 Million Users by 2013

Online social networking is huge and growing strongly, but what happens when all those virtual friends hit the road? Increasingly, they will be able to keep in touch via mobile versions of their favorite social networks, running on their cellular phones. ABI Research forecasts that in 2013, more than 140 million subscribers will share "anytime, anywhere" experiences this way, and they will generate subscription revenues in excess of $410 M.

"Subscriber numbers for mobile social networking will climb at a relatively modest rate for the next three or four years, but will then start to accelerate sharply," says research director Michael Wolf. "That uptick is based on assumed acceptance levels in the giant emerging markets such as Brazil, Russia, India and China. Those countries are wildcards, very difficult to estimate, so we are quite conservative in our forecasts."

Some mobile versions of social networks will follow the same model common to today's Internet-based groups such as MySpace and Facebook: free browser-based access. Such models pose a problem for mobile operators by limiting their slice of the revenue to a charge for data traffic. "The ideal scenario for the mobile operator includes a recurring revenue stream: a subscriber paying $1.99 or $2.99 a month to have this application on their handset," says Wolf.

Beyond the relatively modest subscription revenues that mobile social networking will generate, there will also be significant opportunities in mobile advertising as well as in mobile content sales. A recent end-user survey conducted by ABI Research showed that mobile users of social networks are likely to consume two or three times as much digital mobile content (pictures, music, videos and games) than their "asocial" peers. That would suggest a golden marketing and advertising opportunity yet, says Wolf, that is not happening: "They are not offering the right kinds of products for these users. The advertising is not that sophisticated yet. Social networking applications have to be uniquely mobile and not reliant entirely on advertising-based revenues, at least not initially."

ABI Research is a market research firm focused on the impact of emerging technologies on global consumer and business markets. For more information, visit www.abiresearch.com.

WHITEPAPER

Agilent Technologies

What You Should Know About MIMO Operation and Measurement

By: PETER CAIN
Wireless Solution Planner, Agilent Technologies
peter_cain@agilent.com

MIMO techniques are becoming a popular combination with OFDM radio formats because they offer the possibility of increased spectral efficiency. The first commercially available MIMO system was in WLAN, but the interest has spread to cellular formats including WiMAX and LTE. Each format has adopted slightly different techniques and terminology, sometimes making it a little difficult to be sure what is being discussed.

MIMO systems also introduce a new dimension in test - that of the cross coupling of signals between hardware transmit and receive paths. This gives rise to new performance measurement techniques to augment the single channel tests that remain the starting point.

A selection from Agilent's "Ten Things You Should Know About MIMO" are presented in this paper, with the intention of giving the user an overview of the operation of MIMO technology and test methodology. Each item uses an example to highlight the impact on the radio system or associated test. A poster that summarizes all ten points is available from Agilent on request (order information can be found at the end of this paper).

The distinction between MIMO spatial multiplexing and diversity

The term "Multi-Input Multi-Output" can sometimes be applied to other multi-antenna techniques, such as transmit and receive diversity, which do not directly increase the spectral efficiency of the radio link. In practice, diversity techniques will be just as important as the spatial multiplexing that does fundamentally increase capacity, and the two methods will often be combined. This explains why we will see base stations with four antennas, even though the mobile only has two.

Referring to *figure 1*, the key to spatial multiplexing is the simultaneous transmission of separate portions of the incoming user data. It is inevitable there will be some cross coupling as the signals

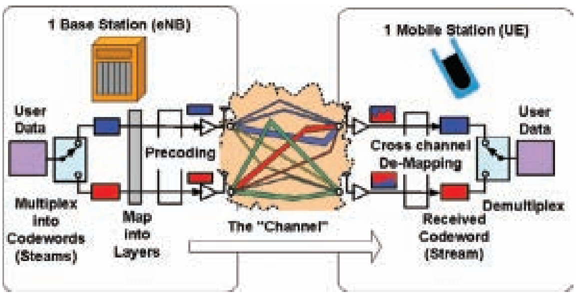


Figure 1 *Cellular style asymmetric MIMO operation.*

travel through the radio channel, which includes the antennas. The art of MIMO is to avoid the transmissions simply being interference to each other. Doing this means you have to know how the radiated signals are coupled, which requires there to be as many receivers as transmitters. This leads to the first item we should know.

Spatial multiplexing requires at least two transmitters and at least two receivers. The receivers need to be in the same place.

The receivers need to be in the same place because it is the combination of the information they recover about coupling that is used to separate the data streams, or what are called codewords in 3GPP LTE.

For measurements which post-process the signals, the constraint of the receiver hardware being in the same place is removed because the measurement software, like the Agilent 89600 VSA, can combine IQ data from multiple inputs and then perform the signal separation and analysis. Another special measurement case is where the signals are connected to the analyzer with cables and never coupled, i.e. direct mapped. It is then possible to recover each codeword (stream) by connecting a single input analyzer to each transmitter in turn.

If the signal being tested remains substantially constant from frame to frame, it is also possible to capture individual signals with a single switched input. An example of equipment using this technique for WLAN is the Agilent N4011A MIMO Multi-Port Adapter.

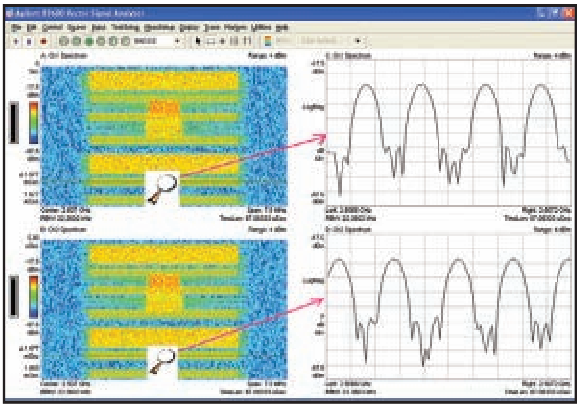


Figure 2 *The distinct MIMO channel training subcarriers in LTE.*

MIMO techniques are applied differently in the downlink and uplink of a cellular radio system.

In WLAN, the radio link is designed to allow symmetric operation. Figure 1 shows how this model has changed for cellular use, where the internet-led data downloading model results in the downlink being designed to have higher capacity than the uplink.

WiMAX and LTE base stations will have at least two transmitters. A number of designs have four or more transmitters, allowing the combination of MIMO and transmit diversity or phased array beamforming. All mobiles capable of supporting MIMO will have two receivers. The benefit of receive diversity is sufficient to mean mobiles would probably have two receivers even if MIMO is not initially implemented.

Figure 1 also shows the terms associated with the multiplexing of the incoming data signal into streams and layers. The incoming user data is separated into codewords (streams). If spatial multiplexing and diversity are being used in combination, there is a further step of mapping the codewords to layers, shown in the grey box. In this figure, direct mapping is shown, where no intentional cross coupling takes place before transmission.

In WLAN and WiMAX the incoming user data is multiplexed into streams which have the same modulation format (QPSK, 16QAM etc), but in LTE it is possible to have different modulation applied to each codeword. This points us to another of the MIMO fundamentals relating to the distinct difference between channel and data recovery.

MIMO signal recovery is a two-stage process.

Prior to demodulating the individual streams, the signals which were coupled as they travel through the channel have to be separated. To do this, the receivers look for channel training information which is unique to each transmitter. The generic term for a method using a special training mechanism is "non-blind".

In WiMAX and LTE this part of the signal can be made clearly visible. Channel estimation subcarriers are split among the different transmitters, so that no transmitter is using the same frequency at any one time. 802.11n originally considered this method, but settled on the use of orthogonal codes to distinguish the transmitters.

Figure 2 shows the spectrograms of two signals measured directly from LTE transmitters, and the zoomed-in spectral component for one of the training symbols. The LTE reference signal (RS) subcarriers can clearly be seen to be using different frequencies. Unlike the WiMAX pilots, the RS is only transmitted every 3rd or 4th symbol. The power level of all the subcarriers is the same, and their phase and timing relationship is known, which means it is possible to create a vector representation of the channel. This in turn provides the coefficients required to separate the data streams.

Phase differences don't affect open loop MIMO.

Open loop MIMO means the transmit signals are direct mapped. No feedback from the channel is used to couple (precode) the MIMO aspect of the signals.

Another way of saying this is that phase only matters when you couple different signals twice, which is most easily explained using the coupling of two CW signals on different frequencies. The first time they are combined there may or may not be a known phase relationship between them. It doesn't matter; the amplitude and phase of the two components will not be affected. If, however, they are coupled again, part of each signal will be common, and they will sum as vectors. The result will be changes in both amplitude and phase dependant on the combination of the original phase and the coupling factor. Complete cancellation could be one result.

This simple vector addition example explains why open loop MIMO, where the transmit signals have not been coupled, are not affected by the phase of the transmitted or received signals. The signals are only coupled once - in the channel. It also explains why uplink MIMO operation using two physically separated mobiles can work. Incidentally, precoding cannot be applied in this case, both because the input data is only available separately in each mobile, and also because the phase between mobiles cannot be controlled.

Figure 3 shows a test configuration for UL multi-user, MU, (collaborative) MIMO. The dashed line indicates the process that would take place in a real system, where the base station controls the transmission timing and power of each mobile such that the signals arrive aligned at the base station receiver. The mobiles themselves tune their frequency to match the base-station reference. In a test configuration, cables can be used and timing, power and frequency offsets can be applied with other impairments to ensure the receiver algorithms are sufficiently robust.

Cross-channel measurements can be made using a single input analyzer.

Most engineers will start with single input measurements because they are simple and provide much of the basic information about how well the components in the radio are working using available

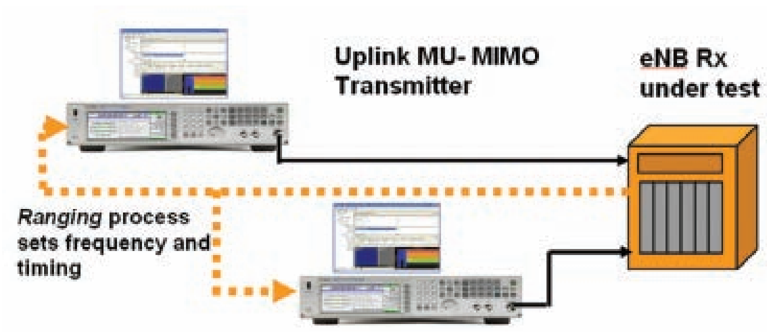


Figure 3 *Operation of multi-user (collaborative) MIMO in the uplink relies on the system working with only approximate power, frequency and timing alignment. The Agilent MXG with signal studio software–based test configuration shown here allows these parameters to be varied individually.*

equipment. The presence of the subcarriers used for MIMO channel training in LTE and WiMAX allows a significant extension to what can be done with a single input analyzer.

As part of the measurement demodulation process, the isolation between channels can easily be measured. This assumes the signals have not been coupled in the transmitter. In LTE, the reference signal is not precoded, so even when precoding is applied it does not affect the measurement. For WLAN and WiMAX, direct mapping should be used.

Signals using transmit diversity only require a single receiver, so they can be fully analyzed with one input. Even MIMO signals that are direct mapped can be individually analyzed, although it will not be possible to remove any unwanted coupling. The single input analyzer should be connected to each transmitter output in turn, and the analysis configured for the appropriate codeword (stream).

The most precise RF phase and timing measurements can be made with a single input analyzer. If a power combiner is used to feed multiple inputs into the single input analyzer, as shown in *figure 4*, relative timing and RF phase measurements may be made by demodulating the signals and comparing the symbol alignment. This method entirely removes any effect of additional equipment, and can offer sub-nanosecond and degree-measurement resolution.

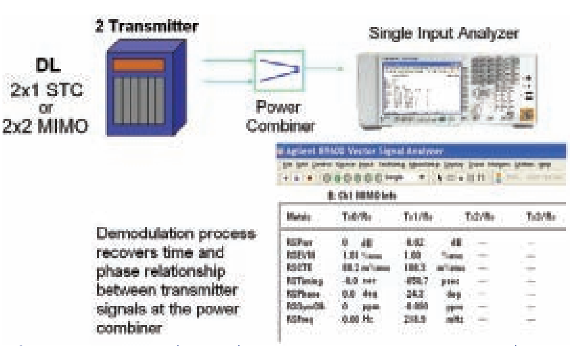


Figure 4 *Cross-channel measurements using a single-input MXA spectrum analyzer and power combiner include RF frequency and phase*

Antenna configuration has a major impact on the channel-path correlation.

After the receiver has been proven with static channels, fading according to different pedestrian and vehicular speed profiles can be added, using equipment such as Agilent's new PXB MIMO Receiver Tester. As noted earlier, the channel includes the antennas at both transmitter and receiver. There has been a lot of effort to model how changes in the antenna configuration affect the path correlation.

For certification, a subset of the possible antenna configurations is chosen, but during design or more thorough performance comparisons, it is important to assess performance using a much wider range of scenarios. The Agilent PXB MIMO Receiver Tester provides the flexibility needed to do this, calculating the correlation factors as it does so.

Agilent's N5106A PXB MIMO Receiver Tester

MIMO needs a better carrier-to-noise ratio than SISO.

MIMO offers improved spectral efficiency over SISO because, under the right circumstances, the channel capacity increases linearly with the number of transmit-receive pairs. But it doesn't come entirely for free. When comparing the performance of SISO and MIMO, the first step is to give the total transmitted signals equal power. With a direct mapped MIMO signal, this equates to requiring the carrier-(signal) -to-noise ratio, CNR, for each MIMO transmitter signal to be at least 3dB better for the same demodulation performance. This represents the point on the left hand axis in the graph of *figure 5*.

By introducing cross coupling, moving left to right in the graph, we can see how the CNR has to further improve as the condition number of the MIMO channel gets higher. The matrix condition number is a standard mathematical concept that indicates the potential increase in capacity for a particular MIMO channel. The poster associated with this article provides more details on how it is calculated.

In-phase (0°) coupling is a starting point for testing a MIMO receiver, as the step beyond single channel sensitivity testing. It will verify how well the channel recovery operates when the training signal has noise. For example, when a lot of coupling is applied,

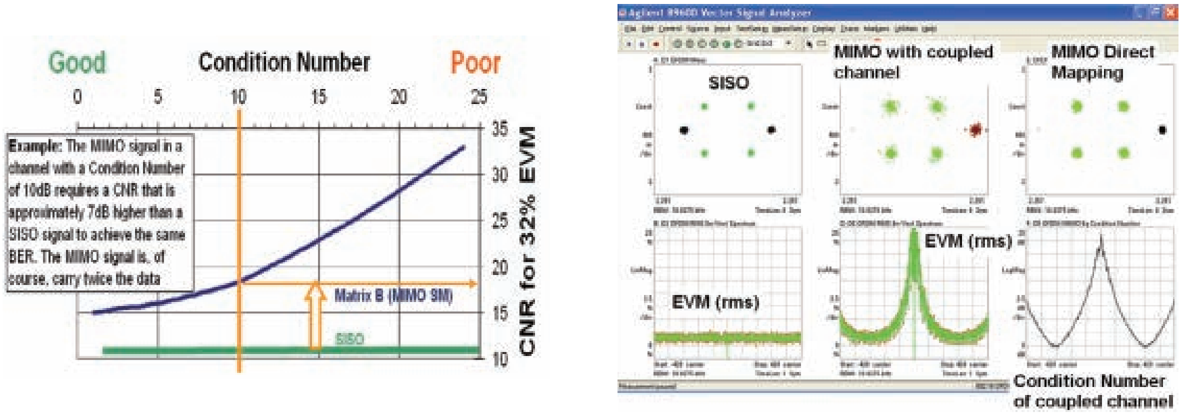


Figure 5 *Results demonstrating MIMO needs a better CNR than SISO.*

excess errors in the receivers' channel estimation due to insufficient processing resolution will cause receiver performance to degrade faster than expected. A further step in testing is to add a delay in the coupling, which introduces a phase variation proportionate to the OFDMA subcarrier.

The EVM trace in the Agilent 89600 VSA display of *figure 5* shows a V-shape indicating a time delay in an OFDM signal. In this example, the signal amplitude was first adjusted to ensure there was measurement noise, resulting in a raised level of EVM (RCE). The match between the increase in EVM and the worsening condition number is clearly seen in the bottom, center and right traces.

Distortion in one component degrades all coupled codewords (streams).

In a direct-mapped configuration, where the measurement is made on individual transmitter outputs, distortion from an analog component such as an amplifier or mixer will only affect the data codeword (stream) it is carrying. If however the data signal is precoded, such as with codebook 1 or 2 in LTE, the codewords share analog components and are affected by distortion in any of them.

To create the measurements in *figure 6*, a MIMO signal was subject to the 1,1,1,-1 precoding known as codebook 1 in LTE, or spatial expansion in WLAN. The gain of one of the receiver amplifiers was set to clip the ADC.

The left-hand column shows the individual signals before the coupling was removed. One of the curious MIMO measurement effects due to correlated interference can be seen. QPSK appears as a 3*3 constellation. It is called the "constellation of constellations". Despite this, it's clear the lower signal is suffering some distortion not seen on the upper signal.

In the center column, the signals have been separated so both are QPSK, but note how both are suffering some of the distortion previously only seen on one half. Finally, the right-hand column is a transmit diversity signal fed through a system where one transmitter was distorted. The point to note is that neither signal appears distorted; indicating that only measuring fully decoded diversity signals can mask physical hardware problems.

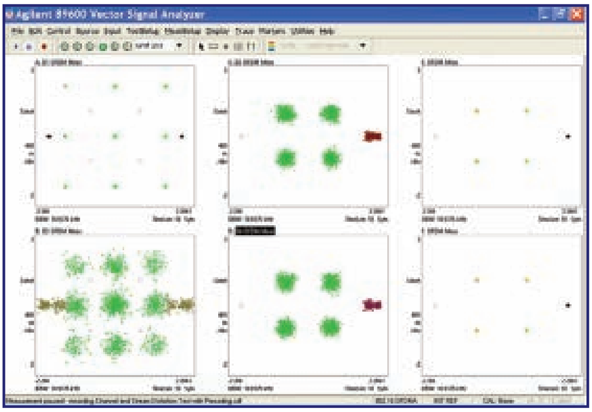


Figure 6 *In the left-hand column, distortion in one channel component is seen to only affect the lower trace. The spatially multiplexed signal in the center shows both streams impaired. The right-hand trace shows how the impairment is hidden when diversity, rather than spatial multiplexing, is applied.*

Summary

MIMO is an exciting addition to the transmission methods available to the radio engineer. This article has provided information relating to the key aspects of MIMO operation and measurement – showing how Agilent's design and test solutions help you ensure your receivers and transmitters are operating correctly.

Useful Resources from Agilent

To order your free copy of Agilent's new MIMO Poster "Ten Things You Should Know about MIMO" please visit **www.agilent.com/find/mimo-mwj**.

To view archives of Agilent's MIMO webcasts, please visit **www.agilent.com/find/webcasts**.

For more information on Agilent's suite of MIMO design and test solutions, please visit **www.agilent.com/find/mimo**.

2009 International Microwave Symposium

June 7 - 12, Boston Convention & Exhibition Center

IEEE Microwave Theory and Techniques Society

www.ims2009.org

IEEE MTT-S

Call for Papers

In the 1940's the best and brightest scientists formed the MIT Radiation Laboratory near Boston to study the electromagnetic properties of matter and microwave communication principles in defense of the free world.

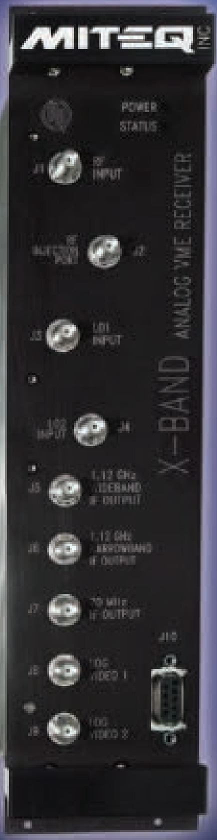
In June 2009, today's generation of leading technologists will descend once again upon Boston to advance the state of microwave knowledge. Will you be among them?

Keep the tradition alive – submit your paper today.

- Gain Prestige
- Share your expertise
- Network with Colleagues
- Visit Historic Boston

Visit www.ims2009.org for Details

INTEGRATED ASSEMBLIES



The VME Based Receiver SYS1000N01U is a multi-stage superhetrodyne design that will translate an X-band signal with the frequency excursion of 1,000 MHz to an IF center frequency of 70 MHz with an instantaneous bandwidth of 20 MHz. The receiver functionality includes automatic gain control (AGC) attenuator with analog sampling, channel gain balance attenuator, channel phase balance phase shifter, signal injection point, peak detected signals (available via VME interface) and RF signal monitoring points. The receiver is fabricated into a three-slot wide VME module. Control of the receiver components is done using standard VME-64 bus protocol.

VME Receiver

- S, C and X-band dual conversion radar receiver
- Bandwidths up to 1,000 MHz
- Receiver functions:
  - Automatic gain control (AGC) attenuator with analog sampling
  - Channel gain and phase trimmers
  - Peak pulse sampling
  - 3-slot wide VME module
  - Receiver control, BIT and monitoring using VME-64 bus protocol

Switched Output Variable Gain Amplifier

- 11 to 21 GHz frequency range
- +20 dBm output 1 dB compression point
- 30 dB gain
- 4 BIT 15 dB digital gain control
- 4 switched selectable outputs
- High reliability miniature hermetic MIC construction

6-Channel Log Receiver

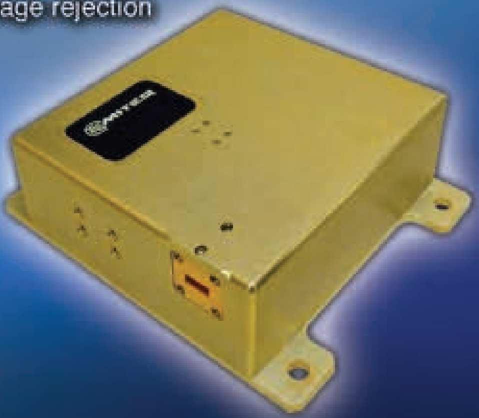
- 2 to 18 GHz RF bandwidth
- 500 MHz IF bandwidth
- 65 dB log range
- 20 mV/dB log slope
- 2 dB channel-to-channel tracking
- Tangential system sensitivity (TSS) -70 dBm

3-Channel Receiver with Limiter

- RF input frequency 11 GHz
- IF frequency range 25 to 50 MHz
- 28 dB conversion gain
- 3.3 dB noise figure
- 20 dB image rejection
- High and low gain selectable

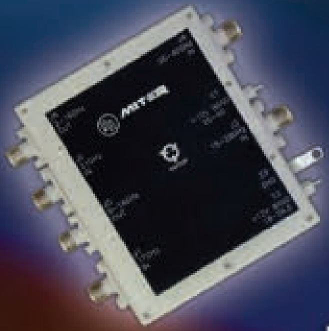
Low Noise Block Downconverter

- RF input range 18 to 22 GHz
- Internal LO 17 GHz
- IF output 1 to 5 GHz
- Noise figure 2.9 dB
- 60 dB image rejection



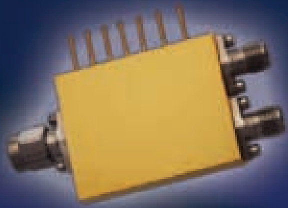
Integrated Dual-Channel Block Converter

- RF input frequency range 18 to 40 GHz
- IF output frequency range 2 to 16 GHz
- Integrated LO multipliers and filters
- Integrated RF and IF filters



Sub-Harmonic Upconverter and Power Amplifier Module

- RF output range 36 to 37 GHz
- LO input frequency 17.5 GHz
- Output 1 dB compression point +24 dBm
- Conversion gain 20 dB
- Carrier suppression 40 dB
- High reliability miniature hermetic MIC construction



Low Noise Block Converter with Fiber Optic IF Output

- RF input frequency range 24 to 40 GHz
- IF output frequency range 2 to 18 GHz
- Instantaneous bandwidth 16 GHz
- Noise figure 4 dB typical
- Conversion gain 50 dB including fiber optic receiver

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

MITEQ

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

www.miteq.com

Visit http://mwj.hotims.com/16346-104 or use RS# 104 at www.mwjournal.com/info

INDUSTRY NEWS

■ **Terabeam/HXI**, also known as the Harmonix Division of **Terabeam Corp.**, was sold by its parent company, **Proxim Wireless**, to **Renaissance Electronics Corp.** (REC), Harvard, MA. Going forward, the new company name will be **HXI LLC** and HXI will be a wholly-owned subsidiary of REC. Proxim will retain the use of the Terabeam name and it will no longer be used by HXI. All management, engineering, technical, administrative and direct sales personnel have remained with HXI through the acquisition. HXI also retained all relevant intellectual property, patents and component/subsystems designs that they had previous to the acquisition. HXI will remain in the same facility and will have all the same contact information, with the exception of e-mail addresses and web site address. The company can be reached at HXI LLC, a wholly-owned subsidiary of Renaissance Electronics Corp., Ward Hill Business Park, 22 Parkridge Road, Haverhill, MA 01835; ph: (978) 521-7300; fax: (978) 521-7301 or visit: www.hxi.com.

■ **Ceralta Technologies Inc.** announced the launch of a combined direct Sales Force to support the strategic direction and valued customer base of Ceralta and its subsidiaries **TRU Corp.** and **Sage Laboratories Inc.** TRU and Sage are radio frequency and microwave solution providers that garner significant brand recognition in the marketplace due to the individual technological innovations and growing value to their customers since each was founded in the early 1950s. Ceralta's combined Sales Force will be jointly directed by Michael Wisner and Ed Kersten.

■ **Harris Corp.**, an international communications and information technology company, announced that it will integrate technology from **Freescale Semiconductor**, a global-leader in the design and manufacture of embedded semiconductors, into its new TV transmitters for terrestrial broadcasters. Using Freescale's laterally diffused MOS (LDMOS) UHF technology will enable Harris to produce its most compact and power-efficient UHF transmitters.

■ **Acceleware® Corp.**, a developer of high performance computing applications, and **Computer Simulation Technology** (CST), a supplier of electromagnetic (EM) simulation software, announced a new Compute Unified Device Architecture (CUDA)-based Acceleware solution for accelerating EM simulations with CST MICROWAVE STUDIO® (CST MWS). Trial tests of this new acceleration product have delivered performance gains of up to 40 percent compared to the current product.

■ **Peregrine Semiconductor Corp.**, a supplier of high performance RF CMOS and mixed-signal communications ICs, and **Rubicon Technology**, a manufacturer of sapphire substrates and other advanced technology materials, announced that Rubicon has begun initial production of 8" sapphire wafers for supply to Peregrine for its UltraCMOS™ Silicon-on-Sapphire (SOS) semiconductor processing.

■ **TriQuint Semiconductor**, an RF front-end product manufacturer and foundry services provider, was recognized by **Northrop Grumman Corp.** Electronic Systems (NGES) at its 2008 Supplier Conference with an award for bulk acoustic wave (BAW) innovation. At the same event, TriQuint also received a Strategic Supplier Award for its dedication to the success of NGES programs. TriQuint was one of 32 companies recognized by Northrop Grumman at the event and the only company to win two awards.

■ **Astrolab** has received its AS9100 B certification as a manufacturer of RF and microwave applications for the aerospace industry. AS9100 B is a Quality Management System that specifies aerospace industry quality and manufacturing standards. In addition to receiving this new certification, the company was re-certified to the ISO 9001:2000 standard maintained since 1994.

CONTRACTS

■ **Skyworks Solutions Inc.**, an innovator of high performance analog and mixed-signal semiconductors enabling mobile connectivity, announced that it has signed a five-year, multi-million dollar contract with **Lockheed Martin** to supply high-precision technical ceramic toroids and inserts for the Aegis Weapon System. This contract win reflects the company's increasing diversification into adjacent markets within its Linear Products business.

■ **Nitronex**, a developer and manufacturer of high performance RF power transistors for wireless infrastructure, broadband and military markets, has received Phase II Small Business Technology Transfer (STTR) funding to further develop its GaN technology for military and aerospace applications. The two-year Phase II STTR program began in the first quarter of this year. The primary program objective is to deliver high power X-band GaN monolithic microwave integrated circuits (MMIC) that address Ballistic Missile Defense radar needs of the Missile Defense Agency (MDA).

■ **MI Technologies** has completed installation of a very large planar near-field antenna measurement system at the Naval Surface Warfare Center (NSWC Crane), located in Crane, IN. NSWC Crane provides comprehensive support for complex military systems spanning development, deployment and sustainment in three mission areas: Electronic Warfare/Information Operations, Special Missions and Strategic Missions.

NEW MARKET ENTRY

■ **RF VCO** provides training and design services for integrating custom voltage-controlled oscillators (VCO) onto a customer's PCB. Depending on customer's needs, RF VCO can provide either a turn-key VCO design ready for PCB layout or VCO design training for engineers seeking to learn VCO design. RF VCO empowers engineers and companies to take control of their own VCO require-

WIDEBAND TRANSFORMERS

Features

> Low Cost
> Wide Bandwidth
> Good Amplitude / Phase Unbalance
> Rugged Welded Construction
> RoHS Compliant
> REL-PRO® Technology
> 0.150" x 0.150" x 0.150"

Model #	Z Ratio (50:Z)	Frequency (MHz)	Schematic
TM1-1	1:1	0.4 - 500	
TM4-0	1:4	0.2 - 350	
TM1-0	1:1	0.30 - 1000	
TM2-1	1:2	1 - 600	
TM4-GT	4:1	5 - 1000	
TM8-GT	8:1	5 - 1000	
TM2-GT	2:1	5 - 1500	
TM1-6	1:1	5 - 3000	
TM1-8	1:1	800 - 4000	
TM4-1	1:4	10 -1000	
TM4-4	1:4	10 - 2500	
TM1-2	1:1	20 - 1200	

SYNERGY® MICROWAVE CORPORATION

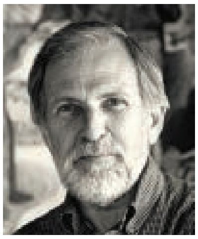
For additional information, contact Synergy's sales and application team.
Phone: (973) 881-8800 Fax: (973) 881-8361 E-mail: sales@synergymwave.com
Visit Our Web Site At WWW.SYNERGYMWAVE.COM

Visit http://mwj.hotims.com/16346-154 or use RS# 154 at www.mwjournal.com/info

ments for performance and cost optimization. Visit the company's web site at: www.rfvco.com.

PERSONNEL

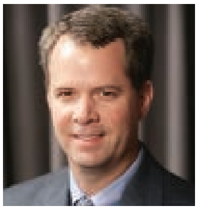
■ The publishing and defense industries lost a respected veteran recently with the death of **Hal Gershanoff**. Hal joined Horizon House in 1978 and served as publisher of the *Journal of Electronic Defense* until his retirement in 2002, after which he continued to work with the Association of Old Crows (AOC). He travelled extensively for business and pleasure, establishing personal relationships around the globe. He leaves his wife of 35 years, Mary Dana, and a strong legacy in the industry.


▲ *Harry Rutstein*

■ **Harry Rutstein** has retired from the presidency of Dorado International and left the telecommunication industry for his new calling as an explorer and writer. In 1948 he started as a research engineer at Johns Hopkins University and over the next 60 years established and managed many marketing and manufacturing enterprises. Now as a writer, Rutstein announced the September publication release of *The Marco Polo Odyssey: In the Footsteps of a Merchant Who Changed the World.* The book is a personal narrative of his 13,000 mile overland journey to become the first person to follow the voyage of Marco Polo from Venice to Beijing. Rutstein can be reached via e-mail at hrutstein2@aol.com.


▲ *Joe Bottenfield*

■ Crane Aerospace & Electronics, a segment of Crane Co., has announced the appointment of **Joe Bottenfield** as the vice president of microwave systems solutions, which includes both the Beverly, MA and Chandler, AZ sites. Crane's Microwave Systems provide RF and microwave solutions for the defense, space and communications industries for use in electronic countermeasures, missiles, radar, intelligence and guidance systems. Prior to Crane, Bottenfield was director of avionics, North America for Barco Inc.


▲ *Greg Baker*

■ Mimix Broadband Inc. announced that it has appointed **Greg Baker** as senior vice president sales and marketing. Baker will focus on managing the sales cycle, acquiring new customers and expanding relationships with existing customers, and launching new products to the marketplace. Most recently with Sirenza Microdevices as vice president international sales, Baker brings more than 20 years experience in RF and microwave component design, marketing and sales to Mimix.

■ Renaissance Electronics Corp. announced the appointment of **Charles Nashef** in charge of the company's In-

VERY LOW DISTORTION

MIXERS

+36 dBm IP3... 2.0 to 3100 MHz from 9^{95} ea. qty. 1000

Mini-Circuits shielded RoHS 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.

Check these features!

- ✓*Very wide band, 2 to 3100 MHz*
- ✓*Ultra high IP2 (+60 dBm) and IP3 (+36 dBm)*
- ✓*Super high isolation, up to 52 dB*
- ✓*High 1 dB compression, up to +23 dBm*
- ✓*Extremely low conversion loss, from 6.3 dB*

U.S. Patent Number 6,807,407 *RoHS compliant*

With a wide selection of models, you'll find a Lavi mixer optimized for your 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 provided.

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

Mini-Circuits®
ISO 9001 ISO 14001 CERTIFIED

ALL NEW minicircuits.com

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

YONI2™ Patent Pending ***The Design Engineers Search Engine*** *Provides ACTUAL Data Instantly From MINI-CIRCUITS At:* ***www.minicircuits.com***

IF/RF MICROWAVE COMPONENTS

451 Rev Org.

Visit http://mwj.hotims.com/16346-95 or use RS# 95 at www.mwjournal.com/info

Integrated

ANTENNAS
MICROWAVE CIRCUITS
AND RADAR
CROSS SECTION
ANALYSIS
SOFTWARE

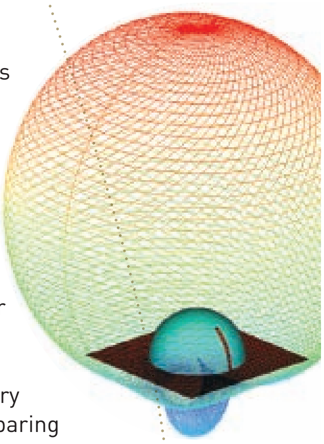
INTEGRATED's tools provide solutions to a wide variety of electromagnetic field models, which can be obtained based on the Method of Moments **(MoM)** approach for open region problems and Finite Element Method **(FEM)** for closed region problems.

Fast. Accurate. Easy-to-use.

- Link to CAD packages for true representation of complex geometric shapes
- Powerful parametric solvers

Other benefits:

- Incorporated Physical Optics (PO) along with the Moment Method
- Only tool in the market that handles Highly Lossy Materials
- Built-in FFT solver, for electrically large problems
- Accurate calculation of near field distribution
- Field distribution with any arbitrary, free form geometry
- Excellent match when comparing software results with experimental results



TRY OUR SOFTWARE FOR 30 DAYS!

CALL FOR A **FREE EVALUATION** AND START IMPROVING PRODUCTIVITY TODAY.

A **LIVE DEMO** IS ALSO AVAILABLE.

INTEGRATED
ENGINEERING SOFTWARE

Call **+1.204.632.5636**
email **info@integratedsoft.com** or visit **www.integratedsoft.com**

HYBRID SIMULATION TOOLS FOR ELECTROMAGNETIC DESIGN ANALYSIS

Visit http://mwj.hotims.com/16346-62

ternational Sales Development and Marketing Campaign. Nashef has over 16 years in business development for manufactured components on a national and international level with extensive experience working with the aerospace, defense, telecom, industrial and medical industries. Nashef will manage and develop the international markets for all of Renaissance product offerings along with spearheading the marketing campaign for both national and international. Nashef can be reached at (978) 772-7774.

■ KOR Electronics announced that **Bruce Quinn** has joined the company as director of sales. In his role as sales director, Quinn oversees KOR Electronics' sales activities with major prime contractors and Asian customers. Prior to joining KOR Electronics, Quinn was director of sales for Crane Aerospace and Electronics. He comes to KOR Electronics with over 30 years of experience in the microwave industry.

▲ *Bruce Quinn*

REP APPOINTMENTS

■ **MITEQ Inc.** announced the appointment of **TriTex Technical Sales Inc.** as the company's exclusive sales representative in Texas. TriTex Technical Sales Inc. will represent MITEQ's Component division of products. TriTex Technical Sales Inc. can be contacted at (972) 492-2621 or e-mail: dpgrand@worldnet.att.net or tritex@austin.rr.com.

■ **Micro-Coax** announced the appointment of **Northern Technical Sales** as sales representative in the Upstate New York territory. Northern Technical Sales has been providing solutions for demanding test and measurement applications since 1988.

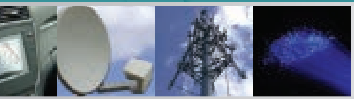
■ **Planar Monolithics Industries Inc.** (PMI), a manufacturer of RF and microwave amplifiers, filters, log amps, phase shifters and many other components, subsystems and systems, announced the appointment of **Altaix Electronica** of Madrid as its representative in Spain. To reach Altaix, visit www.altaix.com.

■ **California Eastern Laboratories** (CEL) has signed **Elexience** to represent its growing line of IEEE 802.15.4/ZigBee radio modules. Based in Verrières-le-buisson, Elexience will be the exclusive source for these CEL products throughout France.

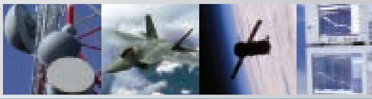
■ **Presidio Components Inc.** announced the appointment of **Southeastern Sales RF LLC** (SES RF), headquartered in Stuart, FL. SES RF will provide technical, sales representation for the Southeastern US utilizing extensive technical expertise to solve customer problems. Presidio Components manufactures quality ceramic capacitors serving commercial, defense and space markets, with unique capabilities in compact, high voltage and/or high frequency ceramic capacitors. Contact SES RF directly at (321) 431-1503 or visit them on the web at www.sesrf.com, or contact Presidio at (858) 578-9390.

POWER DETECTORS

FOR FIXED WIRELESS, WIMAX, & CELLULAR INFRASTRUCTURE!



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



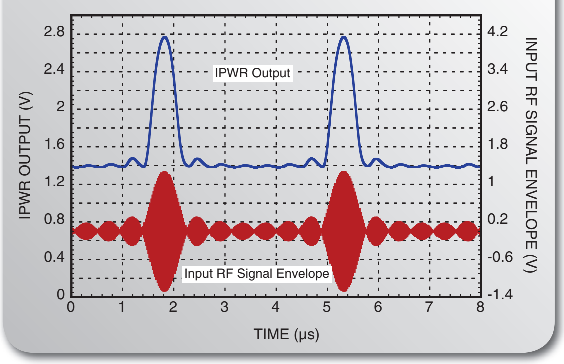
New!

4x4mm SMT

HMC614LP4E RMS/PAR Power Detector, 100 MHz to 3.9 GHz

- *Instantaneous Power & Crest Factor Measurement*
- *RF Signal Wave Shape & Crest Factor Independent*
- *Excellent Temperature Stability*
- *Power Down Mode*
- *Supports Controller Mode*

RMS / PAR Output & Input RF Signal Envelope vs. Time for an Input Crest Factor of 12.04 dB



V_{TGT} 2V, Average Input Power = 0 dBm

6 NEW POWER DETECTORS RELEASED: LOG, RMS & SDLVA

	Frequency (GHz)	Function	Dynamic Range (dB)	RSSI Slope (mV / dB)	RF Threshold Level (dBm)	Bias Supply	Package	Part Number
NEW!	50 Hz - 3.0	Log Detector	74 ± 3	+19	-66	+3.3V @ 29mA	LP4	**HMC612LP4E**
	0.001 - 8.0	Log Detector	70 ± 3	-25	-61	+5V @ 113mA	LP4	**HMC602LP4E**
	0.001 - 10.0	Log Detector	70 ± 3	-25	-65	+5V @ 106mA	LP4	**HMC611LP4E**
NEW!	0.001 - 10.0	Log Detector	73 ± 3	-25	-65	+5V @ 103mA	Chip	**HMC611**
	0.01 - 4.0	Log Detector	74 ± 3	19	-68	+3.3V @ 30mA	LP4	**HMC601LP4E**
	0.05 - 4.0	Log Detector	70 ± 3	19	-69	+3.3V @ 29mA	LP4	**HMC600LP4E**
NEW!	0.1 - 3.9	RMS / PAR Power Detector	71 ±1	37	-58	+5V @ 75mA	LP4	**HMC614LP4E**
	DC - 3.9	True RMS Detector	69 ± 1	37	-60	+5V @ 65mA	LP4	**HMC610LP4E**
NEW!	0.1 - 20	SDLVA	62	14	-57	+3.3V @ 83mA	LC4B	**HMC613LC4B**
	Connectorized Power Detector Modules							
NEW!	0.01 - 2.0	True RMS Detector	70 ±1	37	-58	+12V @ 95mA	C-6 / SMA	**HMC-C054**
NEW!	1 - 20	SDLVA	59	14	-67	+12V @ 86mA	C-10 / SMA	**HMC-C052**

See www.hittite.com for Our Complete Power Detectors Product Line!

Hittite MICROWAVE CORPORATION

Hittite Microwave Corporation
Corporate Headquarters Ph 978-250-3343 sales@hittite.com
HMC Europe, Ltd. Ph +44-870-7664355 europe@hittite.com
HMC Deutschland GmbH Ph +49-8031-97654 germany@hittite.com
HMC Nordic AB Ph +46-8-56020120 nordic@hittite.com
HMC Asia Co., Ltd. Ph +82-2-559-0638 korea@hittite.com
HMC Co., Ltd. Shanghai Ph +86-21-6209-8809 china@hittite.com
Hittite KK Ph +81-3-6853-6854 japan@hittite.com

Order On-Line
www.hittite.com

ISO/TS 16949 TÜV SÜD ISO 9001

Visit http://mwj.hotims.com/16346-55 or use RS# 55 at www.mwjournal.com/info

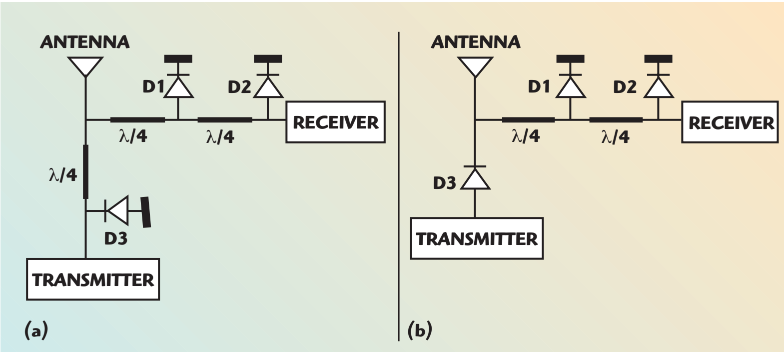
TRANSCEIVER DUPLEXER DESIGN CONSIDERATIONS

The transceiver duplexer is a key element in avionics systems, radars, antenna arrays and wireless communication systems. The duplexer provides protection of the receiver and transmitter from unwanted parasitic signals. This article discusses several duplexer schematics, their development flow and a trade-off design.

DUPLEXER SCHEMATICS

An RF transceiver duplexer connecting a single antenna to the transceiver is often the key component in phase arrays, radar, communications and navigation systems. A duplexer directs the transmitter energy to a single antenna during the transmit mode and the energy received by the antenna to the receiver during the receive mode.

Fig. 1 TX/RCV switch/limiter duplexer schematics.



The RF duplexers can be classified according to the timing of the transmit and receive operations: Full duplexer when the transmitter and receiver are operating simultaneously and half duplexer when the transmitter and receiver are operating at different times. In pulse systems, the transmit and receive time are separated. In CW systems (for instance, Doppler radars, CW altimeters, etc.), the transmit and receive modes are implemented at the same time. The duplexer is not a frequency-selective device like a diplexer and must be designed for operation in the frequency band used by the receiver and transmitter.

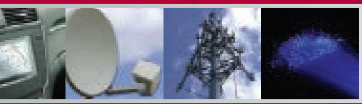
The duplexers should meet the following objectives:

- reduce the number of antennas (a single antenna for transmitting and receiving)
- reduce the number of cables connecting the transceiver with the single antenna
- reduce the potential transmitter pulling,

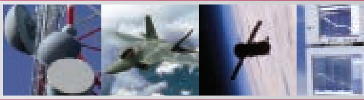
LEO G. MALORATSKY
Rockwell Collins, Melbourne, FL

Synthesizer ICs

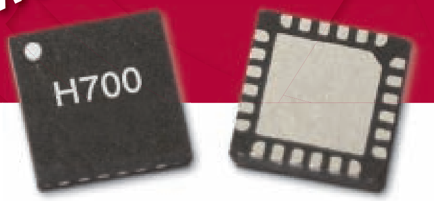
Superior Phase Noise Performance Covering 100 MHz to 8 GHz!



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



New!

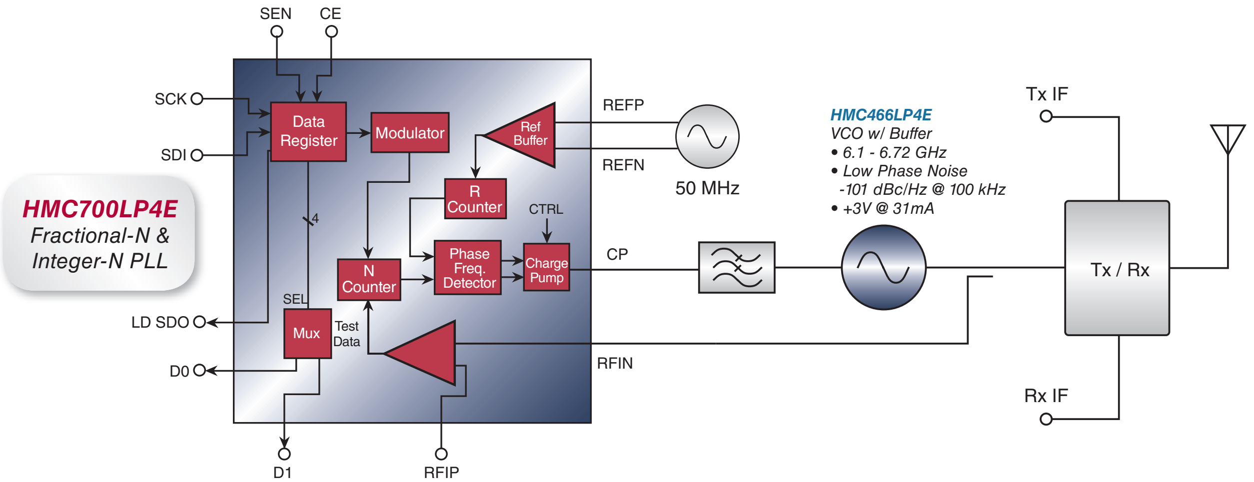


4x4mm SMT

HMC700LP4E Fractional-N & Integer-N PLL Synthesizer IC

- *8 GHz Fractional & 9 GHz Integer Modes*
- *16-Bit Prescaler*
- *Low Phase Noise (Frac / Integer, 50 MHz PFD): -103 / -108 dBc/Hz @ 6 GHz*
- *-227 dBc/Hz FOM (Integer) @ 1 GHz, 200 kHz PFD*
- *Cycle Slip Prevention & Direct FSK Modulation*

Typical PLL Loop for Microwave Radio



IN-STOCK FRACTIONAL-N & INTEGER-N SYNTHESIZER ICs

	Frequency (GHz)	Function	Maximum PFD Frequency (MHz)	Maximum Reference Frequency (MHz)	Figure of Merit (Frac / Int) (dBc/Hz)	Frequency Resolution @ 50 MHz Ref. (Hz)	Bias Supply	Package	Part Number
NEW!	0.1 - 8.0	Fractional-N & Integer-N	100	200	-221 / -226	3	+5V @ 95mA	LP4	**HMC700LP4E**
NEW!	0.08 - 7.0	Integer-N	1300*	1300	- / -233	10	+5V @ 310mA	LP5	**HMC698LP5E**
NEW!	0.08 - 7.0	Integer-N	1300*	1300	- / -233	10	+5V @ 310mA	LP5	**HMC699LP5E**

* Maximum frequencies may be limited by available counter division ratio.

Ideal for Cellular Infrastructure, Fixed Wireless Communications, Test Equipment, Military Communications & Sensors

Hittite
MICROWAVE CORPORATION

Hittite Microwave Corporation

Corporate Headquarters	Ph 978-250-3343	sales@hittite.com
HMC Europe, Ltd.	Ph +44-870-7664355	europe@hittite.com
HMC Deutschland GmbH	Ph +49-8031-97654	germany@hittite.com
HMC Nordic AB	Ph +46-8-56020120	nordic@hittite.com
HMC Asia Co., Ltd.	Ph +82-2-559-0638	korea@hittite.com
HMC Co., Ltd. Shanghai	Ph +86-21-6209-8809	china@hittite.com
Hittite KK	Ph +81-3-6853-6854	japan@hittite.com

Order On-Line
www.hittite.com

ISO/TS 16949 TÜV SÜD ISO 9001

Visit http://mwj.hotims.com/16346-56 or use RS# 56 at www.mwjournal.com/info

intermodulation and noise due to antenna mismatch
- protect the receiver from unwanted (parasitic) synchronous and non-synchronous signals
- reduce cost, maintenance and mechanical complexity

The transceiver duplexer has to provide the following electrical performance:

- low transmission loss to maximize the radiated power
- minimum receive loss for low receiver noise figure and maximum receiver sensitivity
- sufficient isolation between transmitter and receiver
- proper impedance match between transmitter, antenna and receiver
- suppression of the unwanted parasitic signals in the receiver and transmitter passes
- high transmitter peak and average power

There are three main types of duplexer in common use. The first duplexer consists of an SPDT transmit/receive (TX/RCV) switch/limiter. The second type includes a ferrite circulator, while the third includes a ferrite circulator and a transceiver protector.

TX/RCV SWITCH/LIMITER DUPLEXER

Figure 1 illustrates a duplexer that includes a TX/RCV switch/limiter. Practically any PIN diode can be used in a limiter. The main difference between switch and limiter designs is the reflection transients. Several PIN diode switch architecture options should be considered. The most important circuit configurations include: series, shunt or series-shunt PIN diodes. One of the limiters shown includes one shunt switch PIN diode D3 in the transmit pass and two shunt limiter diodes D1 and D2 in the receive pass. The other includes one series switch PIN diode D3 in the transmit pass and two shunt limiter diodes D1 and D2 in the receive path. The shunt diode switches are commonly used for systems with high isolation and are capable of handling higher power because the heat dissipation in a shunt diode (which has one grounded end) is much better than for a diode in a series-type switch due to good heat sinking. Series diode switches are commonly used in broadband circuits. The series-shunt configuration provides greater isolation than the previous version, but requires a bias current from both positive and negative sources that would significantly increase the DC power dissipation.

During the transmit mode, the biased limiter diodes provide active suppression of the synchronous transmitter leakage into the receiver. Also, during the receive mode, the limiter diodes of both schematics provide passive limitation of the unwanted and potentially damaging high-power non-synchronous signals received by the antenna from nearby systems.

The TX/RCV switch/limiter duplexer is characterized by:

- low insertion loss in order to minimize transmitter power delivered to the antenna and receiver input noise figure
- high TX-RCV isolation
- high switching speed
- low harmonic and intermodulation products
- low cost
- small physical dimensions
- good temperature stability

The TX-RCV isolation is achieved by a switch that disconnects either the transmitter or the receiver. The TX/RCV switch/limiter duplexer may not be electrically symmetrical. For example, 20 dB of isolation in the transmit arm is sufficient to prevent any variation in the output impedance of the transmitter from affecting the performance of the receiver, while more than 40 dB of isolation in the receiver arm is necessary to protect the receiver from the strong transmit signal.

A single-stage switch/limiter can typically produce approximately 20 dB of isolation, depending on the PIN diode characteristics. For a greater than 40 dB transmit-receive isolation, multi-stage limiters, such as the two-stage switch/limiter, can be used in the receive pass. The isolation of one shunt PIN diode is given by

$$a_{iso} \approx 10 \log \frac{Y^2}{4} \qquad (1)$$

where $Y = 1/R_F$ is the shunt diode normalized susceptance and R_F is the diode series resistance.

For the ON diode mode, the relationship between the isolation of the two-diode shunt-iterated switch and diode resistance R_F or susceptance Y can be found[1]

$$a_{iso} = 10 \log \frac{Y^2}{4} + 10 \log \frac{Y^2}{4} + 10 \log 4 \qquad (2)$$

Comparing Equations 1 and 2, it can be seen that the isolation of the two shunt-iterated diodes separated by a spacing of $l = \lambda_0/4$ is double that of a single device, plus 6 dB (10 log 4) extra. The isolation of an n-diode shunt-iterated SPST switch is

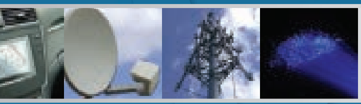
TABLE I

PERFORMANCE OF HIGH POWER SM PIN DIODES

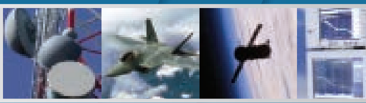
Performance	M/A-COM 4P505-1072T	MICROSEMI G C42405-M1	Test Conditions
Breakdown voltage (min) (V)	500	500	I_R=10 µA
Series resistance R (max) (Ω)	0.45	0.8	I_F= 100mA, F=100 MHz
Total capacitance C_j (max) (pF)	0.65	0.55	F=1 MHz, V_R100 V V_R=50 V, F = 1 MHz
Minority carrier life time (at 50% recovery) (max) (µS)	1.1	1.5	I_F= 10mA, I_r= 6mA
Minority carrier life time (at 90% recovery) (max) (µS)	2.2	3.0	I_F= 10mA, I_r= 6mA

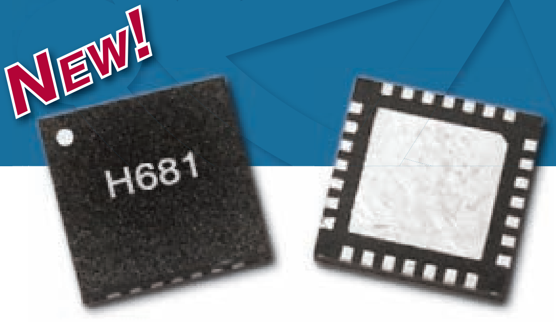
VARIABLE GAIN AMPLIFIERS

FOR CELLULAR/3G, WiMAX/4G, TEST & MEASUREMENT & MILITARY!



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

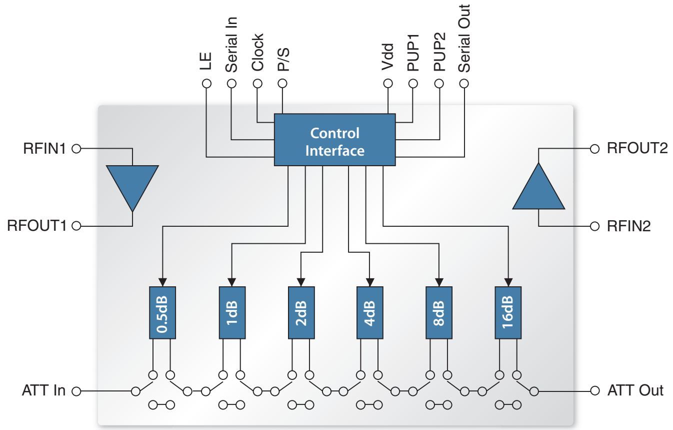




5x5mm SMT

HMC681LP5E 6-Bit Digital, Serial Control, DC - 1.0 GHz

- ♦ *Up to +36 dBm Output IP3 in All States*
- ♦ *Variable Gain: Up to 45 dB in 0.5 dB Steps*
- ♦ *3-Wire Serial Control Interface*
- ♦ *Serial Output for Cascaded Applications*
- ♦ *Noise Figure as Low as 2.7 dB*
- ♦ *User Defined Power-Up States*



Optimal Integration!

IN STOCK VARIABLE GAIN AMPLIFIERS - ANALOG & DIGITAL

	Frequency (GHz)	Function	Gain Control Range (dB)	NF * (dB)	OIP3 (dBm)	P1dB (dBm)	Bias Supply	Package	Part Number
	0.4 - 3.0	Analog VGA	-25 to +20	5	40	23	+5V @ 265mA	LP5	**HMC640LP5E**
NEW!	6 - 17	Analog VGA	+1 to +23	5	30	22	+5V @ 170mA	Chip	**HMC694**
	0.05 - 0.8	5-Bit Digital	-8 to +15	5	35	18	+5V @ 65mA	LP4	**HMC628LP4E**
	DC - 1	6-Bit Digital, Serial & Parallel Control	-11.5 to +20	4.3	36	20	+5V @ 90mA	LP5	**HMC627LP5E**
	DC - 1	6-Bit Digital, Parallel Control	+8.5 to +40	4	36	20	+5V @ 176mA	LP5	**HMC626LP5E**
NEW!	DC - 1	6-Bit Digital, Serial Control	+13.5 to +45	2.7	36	20	+5V @ 176mA	LP5	**HMC681LP5E**
	DC - 6	6-Bit Digital, Serial & Parallel Control	-13.5 to +18	6	33	19	+5V @ 88mA	LP5	**HMC625LP5E**

** Maximum Gain State*

See www.hittite.com for Our Complete Variable Gain Amplifier Product Line!

Hittite MICROWAVE CORPORATION

Hittite Microwave Corporation

Corporate Headquarters	Ph 978-250-3343	sales@hittite.com
HMC Europe, Ltd.	Ph +44-870-7664355	europe@hittite.com
HMC Deutschland GmbH	Ph +49-8031-97654	germany@hittite.com
HMC Nordic AB	Ph +46-8-56020120	nordic@hittite.com
HMC Asia Co., Ltd.	Ph +82-2-559-0638	korea@hittite.com
HMC Co., Ltd. Shanghai	Ph +86-21-6209-8809	china@hittite.com
Hittite KK	Ph +81-3-6853-6854	japan@hittite.com

Order On-Line www.hittite.com

ISO/TS 16949 TÜV SÜD ISO 9001

Visit http://mwj.hotims.com/16346-57 or use RS# 57 at www.mwjournal.com/info

$$a_{iso} = n \times 10 \log \frac{Y^2}{4} + (n-1) \times 6 \text{ (dB)} \qquad (3)$$

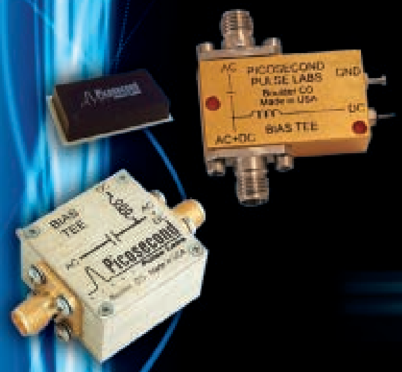
The TX/RCV switch duplexer has the following disadvantages:

- no protection to the transmitter from the transmitter power reflected from the antenna mismatch and from other elements in the TX/RCV common channel
- power-handling capability limit
- switching speed limit
- necessity of control signals
- possible harmonics and intermodulation product

The three quarter-wavelength sections narrow the bandwidth to approximately 10 percent. The operating bandwidth can also be limited by the diode bias network, which is a filter network that isolates the DC bias current from the RF network. To increase the bandwidth and minimize the transmit insertion loss, the distance from the series diode D3 to the common junction should be an absolute minimum. There are different switch modifications with greater bandwidth. The Hewlett Packard network,[2] which includes additional transformers with other than 50 Ω

The *Gold Standard* in high performance

Bias Tees



Picosecond Pulse Labs offers a variety of models with a wide range of capabilities, all with the same ***high performance standards*** you have come to expect from our products.

High Performance

- Bandwidths to 50GHz
- Low f cutoff down to 3.5kHz
- DC voltages to 1.5kV
- DC currents to 7A
- Coaxial and SMT packages

BIAS TEE PRODUCT SPECIFICATIONS

Model	Bandwidth	Low Frequency 3dB	Max DC Voltage	Max DC Current
5530A	12.5 GHz	20 KHz	200 V	10 mA
5531	10 GHz	750 KHz	1.5 KV	20 mA
5541A	>26 GHz	80 kHz	50 V	100 mA
5542	50 GHz	10 kHz	16 V	100 mA
5542K	40 GHz	12 KHz	16 V	100 mA
5542LL	>40 GHz	12 kHz	16 V	100 mA
5545	20 GHz	65 kHz	50 V	500 mA
5546	7 GHz	3.5 KHz	50 V	500 mA
5547	15 GHz	5 kHz	50 V	500 mA
5550B	18 GHz	100 kHz*	50 V	500 mA*
5575A	12 GHz	10 kHz*	50 V	500 mA*
5580	15 GHz	10 kHz	50 V	2 Amp
5585	18 GHz	2 GHz	100 V	6 Amps
5586	5 GHz	1 GHz	100 V	8 Amps
5587	2 GHz	200 MHz	100 V	6 Amps
5589	2.8 GHz	300 MHz	100 V	7 Amps
SM100	13 GHz	14 kHz	16 V	500 mA
SM101	15 GHz	7 kHz*	16 V	500 mA

Excellent for Applications

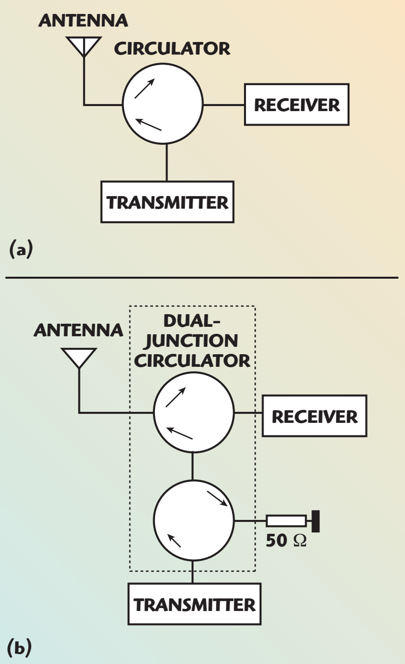
- Serial data testing
- Broadband RF applications
- General purpose lab use
- Broadband component test

The Technology Leader in High-Speed Analog Signals

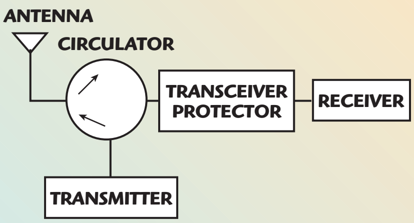
Picosecond Pulse Labs

www.picosecond.com

2500 55th Street, Boulder, CO 80301 • Tel: (303) 209-8100 • Fax: (303) 447-2236



▲ *Fig. 2 TX/RCV duplexers using circulators.*



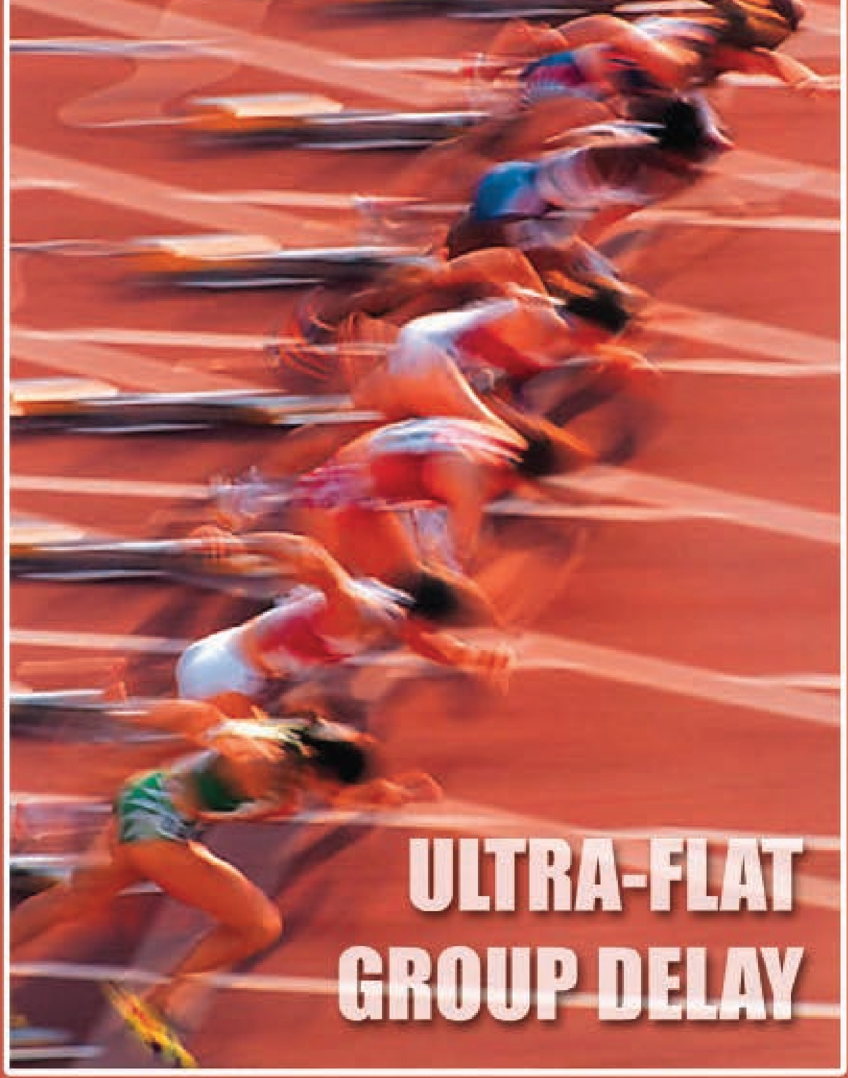
▲ *Fig. 3 TX/RCV duplexer using a circulator and a transceiver protector.*

WAVEFADE™

MARKI MICROWAVE LOW-PASS WAVEFADE™ FILTERS

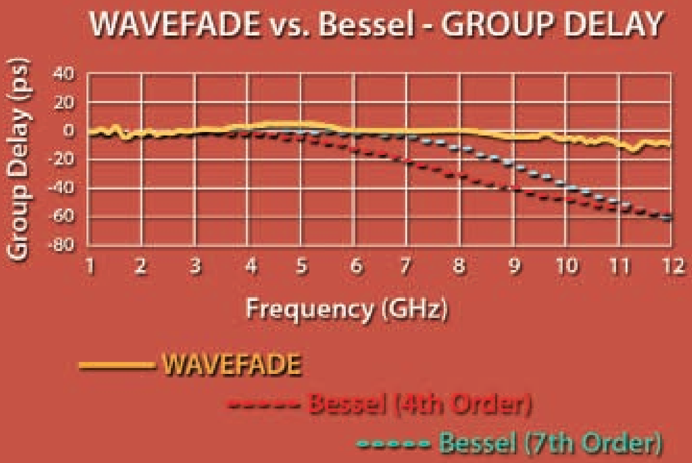
WAVEFADE™ filters utilize state-of-the-art filter technology to achieve ultra-flat group delay as compared to conventional Bessel-Thomson filters.

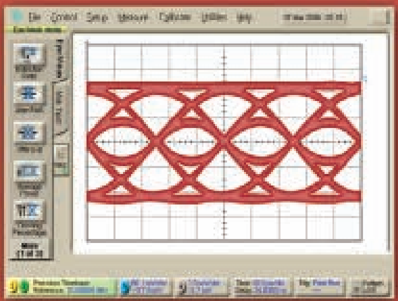
These filters are optimized for high data rate, high sensitivity digital receivers; SONET/SDH optical reference receiver compliance testing, and advanced optical modulation formats.



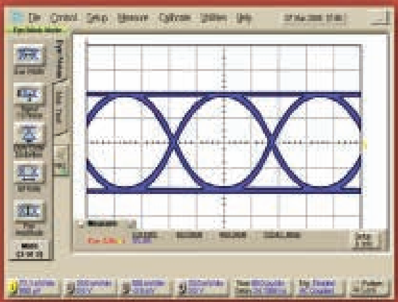
KEY FEATURES

- Bessel Shaped Magnitude Response
- Ultra-flat Group Delay Response
- 3dB Frequency Range 1 GHz to 30 GHz
- Standard and User Defined Cutoff
- Absorbtive-type Filter
- Yields Symmetrical Eye Diagrams with Minimal Jitter





40 Gb/s duobinary signal created using a 12 GHz WAVEFADE™ filter.



WAVEFADE™ filter yields symmetrical eye diagram with minimal ringing and group delay distortion.

Marki microwave

MARKI MICROWAVE, INC.
215 Vineyard Court, Morgan Hill, CA 95037 USA
Ph +1.408.778.4200 | Fax +1.408.778.4300
WAVEFADE@markimicrowave.com
www.markimicrowave.com

ISO 9001

Visit http://mwj.hotims.com/16346-76 or use RS# 76 at www.mwjournal.com/info

impedances, provides a bandwidth greater than 30 percent. Also, to improve bandwidth, a series-shunt diode network can be used.

The conventional narrow-band shunt diode switch topology with quarter-wave diode spacing is too large at low frequencies. A defected ground structure (DGS)[3] can provide reduction of size and harmonic signal. A DGS switch shows results very comparable to a conventional switch, in spite of being half the size.

For a good switch performance, the PIN diodes should have a low resistance at low forward current and low capacitance at zero bias. ***Table 1*** illustrates the performance of two high-power surface-mount PIN diodes.

The TX/RCV switch must rapidly disconnect the transmitter and connect the receiver to the antenna. The switching speed limit depends on the PIN diode carrier life time. PIN diode switches can generate harmonics and intermodulation products since PIN diodes are fundamentally nonlinear devices. All distortions are strongly influenced by the lifetime of a PIN diode, as well as the transmitter RF power which is applied to the diode. The contradictory requirements for the switch diode will be discussed later.

CIRCULATOR DUPLEXER

The duplexers in ***Figures 2*** and ***3*** include a circulator whose principal role is to protect the expensive, high power, TX RF power amplifier from variation in loading conditions.

The circulator network provides:

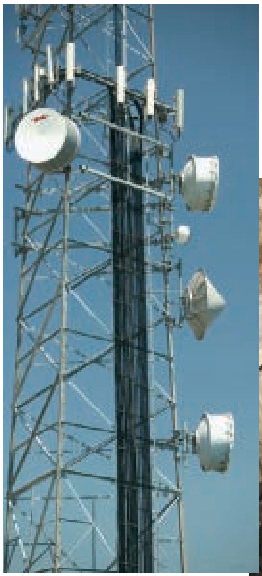
- greater maximum power
- no need for electrical switching
- additional attenuation (approximately 6 to 8 dB) to the different harmonics[4]

In the full duplexer, transmission and reception can occur simultaneously. The main problem is that the isolation of a circulator is poor. Therefore, an antenna mismatch results in poor transmitter-receiver isolation and transmitter pulling due to the signal reflected from the mismatched receiver.

To improve circulator isolation, different options can be used. Dual-junction circulators are used in high-power systems requiring high receive-transmit isolation (up to 50 dB) and transmitter stability. With the isolator installed in the network, any reflected power will flow into the 50 Ω load of the isolator and is dissipated into heat. A three-dimensional dual-junction circulator[1] provides a high integration level in the horizontal plane and low cost as compared with traditional multi-junction circulators.

Another circulator duplexer option is a network with a three-port circulator and a transceiver protector that provides:

- greater isolation
- protection of RCV from synchronous and non-synchronous signals
- protection of TX from reflection signal from antenna and other elements in the TX/RCV common channel

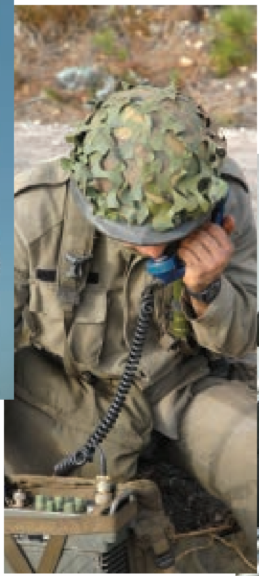


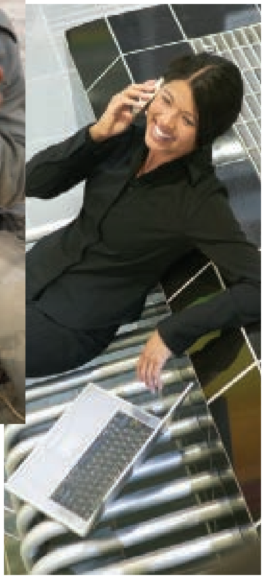
AVAGO
TECHNOLOGIES

Introducing the industry's ***smallest*** packaged amplifiers

New VMMK products

- **Ultra Small**
- **High Performance**
- **Low Cost**





Manufactured using Avago's revolutionary "WaferCap" chip scale package technology, these ultra small, low-profile low noise devices occupy less than 5% of the space of standard SOT-343 packages without sacrificing performance. The 0402 package-size VMMK products are designed to operate up to 26 GHz and are priced up to 3 times less than comparable devices from other manufacturers.

VMMK devices are suitable for a variety of wireless applications, including:

- Cellular/PCS and WCDMA Base Stations
- Military Radar, Radio and ECM Systems
- WLAN and WiMAX
- Instrumentation
- Satellite Communications
- Broadband Wireless Access Systems

	Bias Condition			Specifications @ 50 Ohms match					
Part No.	Freq (GHz)	Vd (V)	Id (mA)	Test Freq	NF (dB)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	
VMMK-1218	DC - 18	3	20	10	0.71	9	+12	+22	GaAs FET
VMMK-1225	DC - 26	2	20	12	0.87	11	+8	+23	GaAs FET
***Coming Soon in Q4 2008!**									
VMMK-2103*	0.5 - 6.0	5	25	3	2.4	14	—	+23	50 ohm RFIC with built-in bypass switch
VMMK-2203*	1.0 - 10	5	28	5	2.4	16	—	+15	50 ohm RFIC
VMMK-2303*	0.5 - 6.0	1.8	20	6	2.2	13	+10	+24	50 ohm RFIC
VMMK-2403*	2.0 - 4.0	5	50	3	2.5	15	+20	+32	50 ohm RFIC
VMMK-2503*	1.0 - 12	5	60	3	3.7	14	+17	+28	50 ohm RFIC

Request samples and more information from your local Richardson Electronics sales engineer or logon to:
www.rell.com/Avago

Your Global Source for RF, Microwave & Power Conversion Components

Richardson Electronics

Visit* www.rell.com/locations.asp *for a complete listing of our worldwide locations.

Call 800-737-6937 (USA/Canada) • 630-208-3637 • rfwireless.rell.com • rwc@rell.com

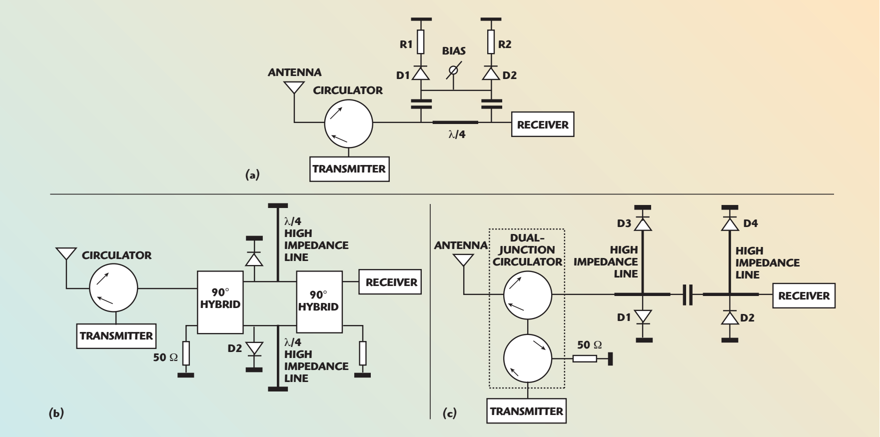
MK090055

Visit http://mwj.hotims.com/16346-137 or use RS# 137 at www.mwjournal.com/info

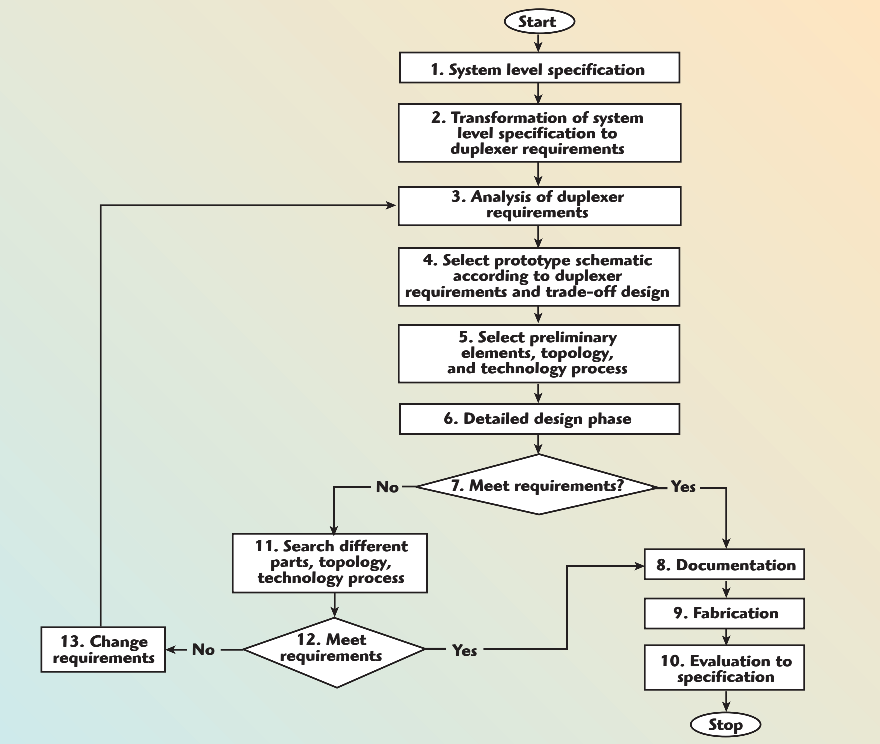
TABLE II

DROP-IN 3 PORT CIRCULATORS

Model Number	Company	Ins. Loss (dB) max	ISO (dB) min	VSWR max	Operating Temp. (°C)	Size (in)
C096012/DA	Trak	0.5 0.5	19 18	1.3 1.3	-25 to +85 -40 to +85	1.5 x 1.5 x .50 1.5 x 1.5 x .50
3G2NF	REC	0.4 0.3	18 20	1.3 1.25	-55 to +24 +25 to +85	1.25 x 1.25 x.35
JID0960T1215G1	JQL	0.4 0.6	20 18	1.25 1.3	-30 to +70 -55 to +85	1.00 x 1.122 x .472
DFN2540-T0001	MICA Microw.	0.6	17	1.35	-55 to +85	1.00 x 1.00 x .50
SDC-0913	SMT	0.4	20	1.25	-55 to +85	1.00 x 1.00 x .30
CD-1090-S	UTE Microw.	0.6	20	1.3	-30 to +85	1.00 x 1.00 x .25



▲ *Fig. 4 Three types of transceiver protector configurations.*



▲ *Fig. 5 Duplexer development flow.*

- greater maximum RF power

It is possible to maintain high circulator isolation by using an additional compensation network[1,5] where the parasitic leakage signal is compensated for by an input signal sample. Emerging new principles and technologies offer possibilities of fabricating low cost nonreciprocal devices without using ferrites. Several designs utilizing an active circulator have been described in the literature.[1,6-8] However, these devices possess power handling limitations.

Table 2 illustrates the performance of different L-band high-power ferrite drop-in circulators for the frequency range 960 to 1215 MHz, which can be used as duplexers in several pulsed avionics systems: DME, TCAS, Transponder and UAT.

These circulators are characterized by:

- insertion loss less than 0.5 dB
- isolation greater than 18 dB
- VSWR<1.3
- peak power handling of 600 W min

COMPARISON OF DIFFERENT DUPLEXERS

Table 3 illustrates the performance of the three kinds of duplexer. According to the table, the networks with circulators have the following disadvantages as compared to the PIN diode switch duplexer:

- higher cost
- greater dimensions
- poor temperature performance
- greater insertion loss
- required magnetic shielding

The duplexers with TX/RCV switch/limiter have the following disadvantages:

- no protection of transmitter from reflected synchronous signals
- lower peak power
- required switching control network

TRANSCEIVER PROTECTOR

The transceiver protector provides:

- protection of the receiver from large input signals while allowing the receiver to function normally when these large signals are not present
- protection of the transmitter from signals reflected from the

receiver due to receiver and antenna mismatch

In the duplexer with a circulator, the transmitter power may leak into the receiving system due to non-ideal circulator isolation, antenna port reflection paths, as well as to mutual coupling from adjacent antenna array elements. This can cause such problems as saturation, gain compression of the receiving system and increased FM-AM noise. Any losses between antenna and low noise amplifier (LNA) directly degrade the receiver sensitivity. Also, sometimes unwanted and potentially damaging high-power signals from nearby systems (non-synchronous signals) received by the antenna pass to the receiver. The transceiver protector is primarily used to protect the power-sensitive receiver components and devices (LNA, mixer) from these high-power sources. The transceiver protector can also suppress the unwanted signals reflected from the antenna and the mismatched receiver to prevent transmitter pulling and possible damage. Therefore, the transceiver protector provides protection of both the receiver and the transmitter from the unwanted signals.

There are three types of the transceiver protector configurations,[1] as shown in ***Figure 4***. The active limiter works on a separate current source (a). To protect the transmitter from the signal reflected from the active limiter, a non-reflective network can be used. For this network, the terminating impedance is developed by the non-reflective (absorptive) switch including the series combination of the diode and the terminating load to ground. Parasitic signals from mismatches at the antenna and TX leakage are absorbed by the limiter with 50 Ω loads. The required 50 Ω terminating impedance is achieved by the series combination of the PIN diode and terminating resistance to ground. The non-reflective (absorptive) limiter with 50 Ω loads can protect the transmitter from the reflection signals. But in the absorptive switches, the power-handling ability is limited by the ability of the diodes and resistors to dissipate RF power. The active transceiver protector can only protect against signals that are synchronous with the transmitter pulse. Protection against non-synchronous, external

TABLE III

PERFORMANCE OF THE THREE DUPLEXERS

Performance	TX/RCV SPDT Switch (Fig. 1)	Circulator (Fig. 2,b)	Circulator with Transceiver Protector (Fig. 3)
	Duplexer Schematic		
TX insertion loss max (dB)	0.2	0.4	0.4
RCV insertion loss max (dB)	0.4	0.4	0.8
TX-RCV isolation min (dB)	50	20	50
RCV-TX isolation min (dB)	20	40	40
VSWR max	1.3	1.3	1.3
Protection of TX from unwanted reflected synchronous signals	No	Yes	Yes
Protection of RCV from non-synchronous RF signals	Yes	No	Yes
Transmit power peak max (W)	800	1500	1500
Electrical switching	Yes	No	Yes
Switching speed limitation	Yes	No	Yes
EMI shielding problem	No	Yes	Yes
Temperature limits @-55° to +85°C	No	Yes	Yes
Package	Surface-mount	drop-in	Surface-mount diodes & drop-in circulator
Size	small	large	medium
Cost	low	high	medium

TABLE IV

PERFORMANCE OF THE THREE TYPES OF TRANSCEIVER PROTECTORS

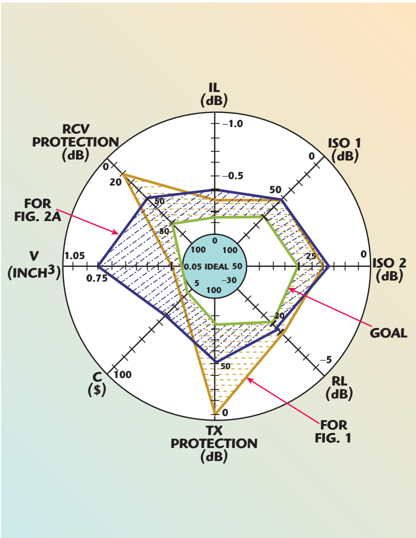
Transceiver Protector Configuration	Advantages	Disadvantages
Passive (Fig. 4, b)	No power supplies required Protection from synchronous and non-synchronous RF pulses Protection from TX pulling High reliability	Switching speed limitation Large size High cost Bandwidth limitation
Active (Fig. 4, a)	Protection from synchronous RF pulses Protection from TX pulling High switching speed	DC power supplies required No protection from non-synchronous RF pulses Less reliabilty due to driver circuit components Bandwidth limitation
Quasi-Active (Fig. 4, c)	No power supplies required Protection from synchronous and non-synchronous RF pulses High switching speed Protection from TX pulling	Large size Less reliability due to Schottky diodes

signals is provided by the passive limitation of diodes D1 and D2. Absorptive switches exhibit slower switching speed. In some duplexers, the broadband matching is more important than the switching speed.

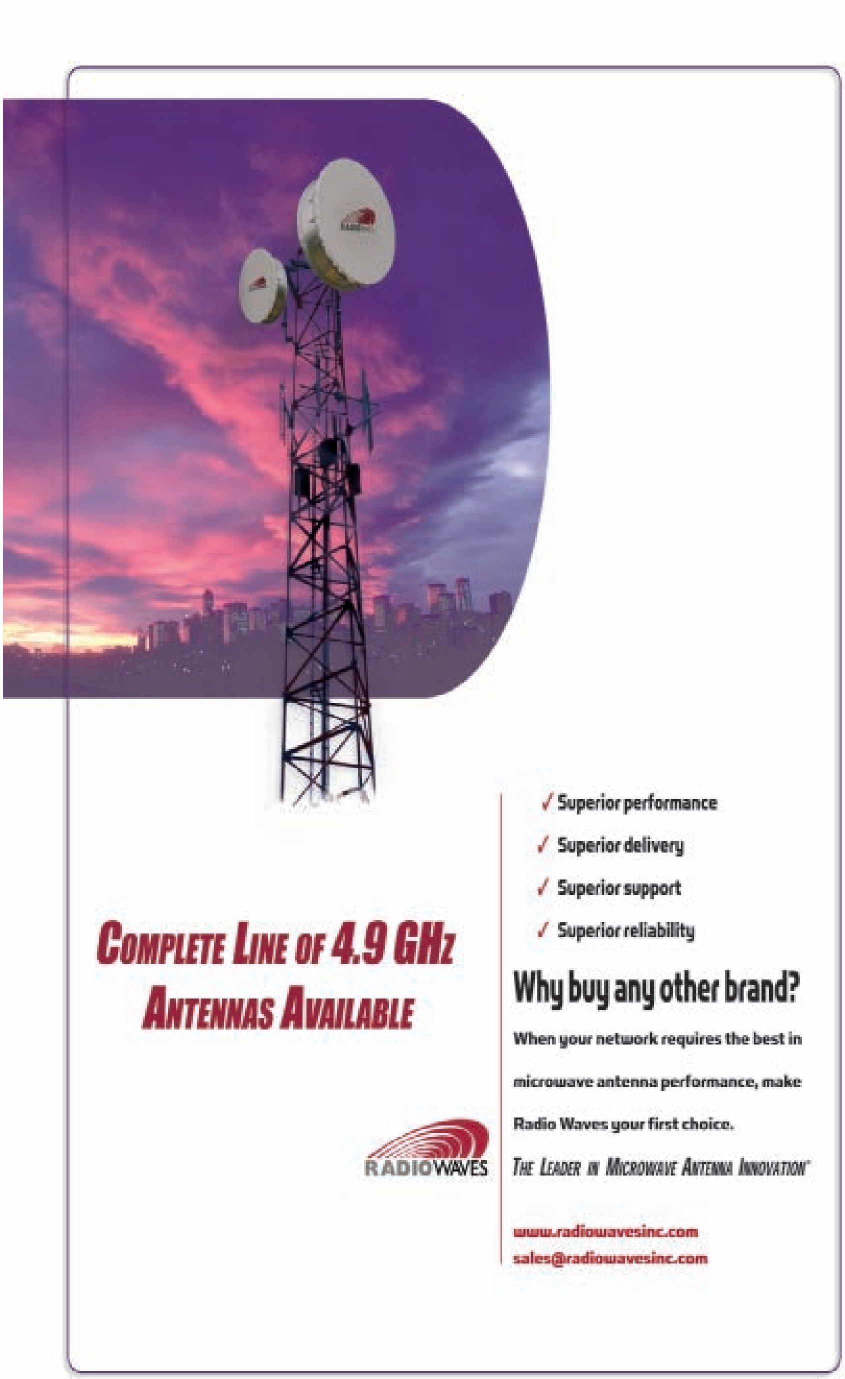
A duplexer with a circulator and a balanced passive limiter,[9] which provides better switching speed performance, is also shown (b). The balanced limiter makes use of the features of two 3 dB hybrids, in combination with limiter diodes placed between two 90° hybrids, to control the power flow. The input splitter divides the input RF signal equally between two limiter diodes. The output combiner recombines the output signals from the splitter. The balanced limiter is a non-reflective network because the reflected signals are dissipated in the input hybrid 50 Ω loads, which prevents transmitter load pulling. The hybrids of the balanced configuration provide a good input and output match at all power levels and a route for the reflected power to the 50 Ω load. The limiter diodes are turned on by the RF signal itself. The passive limiter can include an RF choke inductor as well as a quarter-wave shorted high impedance transmission line. This structure allows a DC signal to pass through, but not an RF signal. In most limiter circuits, DC blocking capacitors are included at the input and the output of the circuit. These series capacitors have low series reactance at the RF frequency and allow to separate the DC current along a transmission line.

A passive limiter is a self-activated switch that is activated by a high-level incident power. The speed of this process depends on the diode lifetime (see Table 1). This relatively slow process leads to a high dissipation power on the diode. The maximum signal RF power that a limiter diode can handle is limited by either the diode's breakdown voltage or its power-dissipation capability. The absorptive passive limiter usually exhibits somewhat slower switching speeds.

To eliminate the limiter diode speed problem, a quasi-active limiter (c) can be used. Also, the quasi-active limiter provides both synchronous and non-synchronous protection of the receiver. A two-stage quasi-active limiter with limiter diodes D1 and D2 and two Schottky detector diodes D3 and D4[1] is shown. The Schottky diodes D3 and D4 are cou-



▲ *Fig. 6 Circle diagram of the duplexer parameters.*



Big and Small,

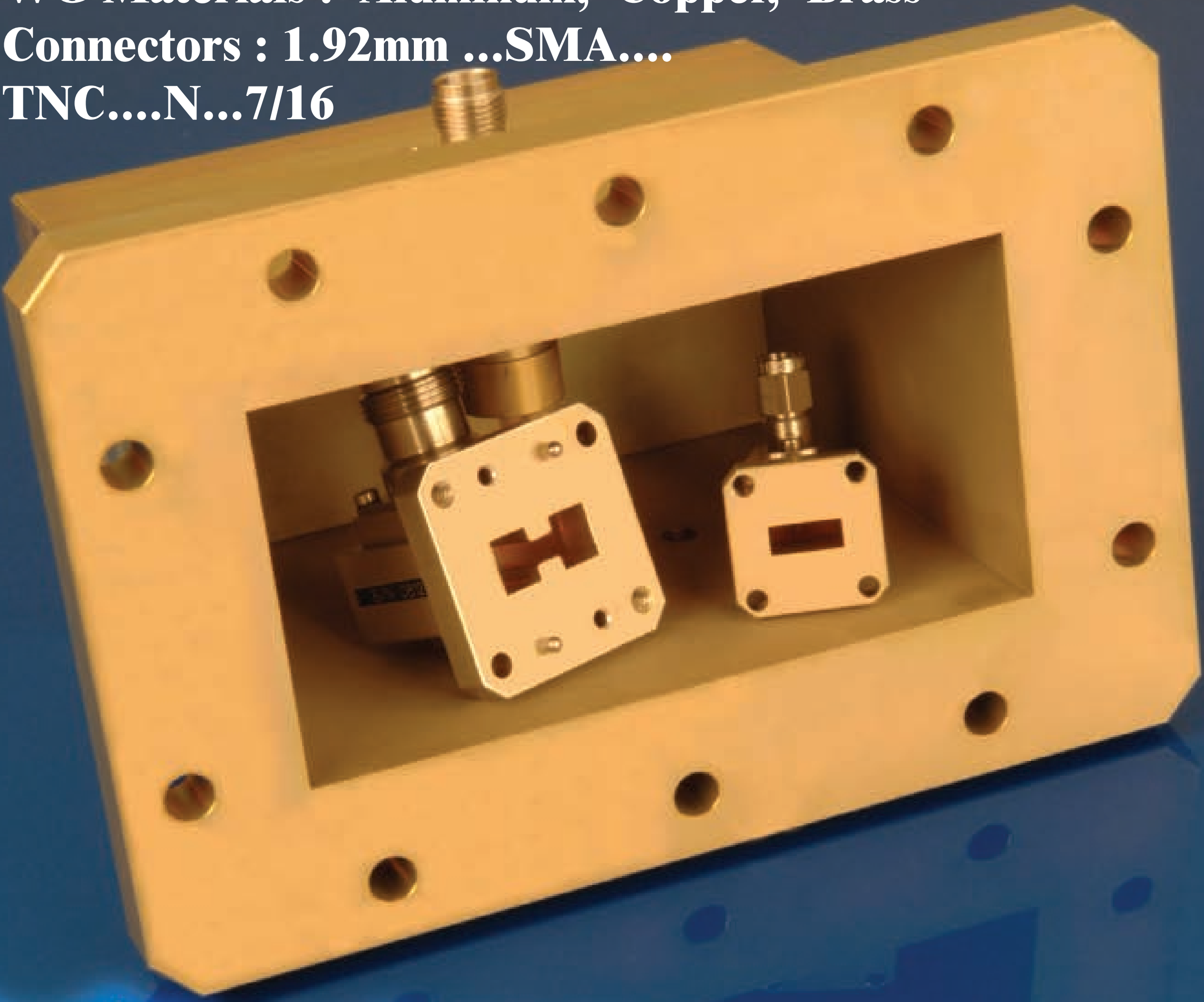
we have 'em all

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

P.O. Box 450533

Telephone: +49-89-3548-040

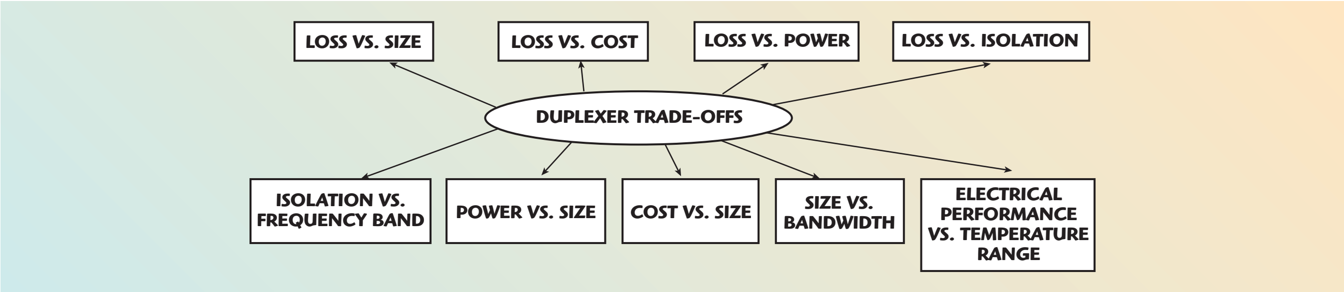
Facsimile: +49-89-3548-0490

WWW.SPECTRUM-ET.COM

Email: Sales@Spectrum-et.com

WG-Big&SmallE4

Visit http://mwj.hotims.com/16346-148 or use RS# 148 at www.mwjournal.com/info



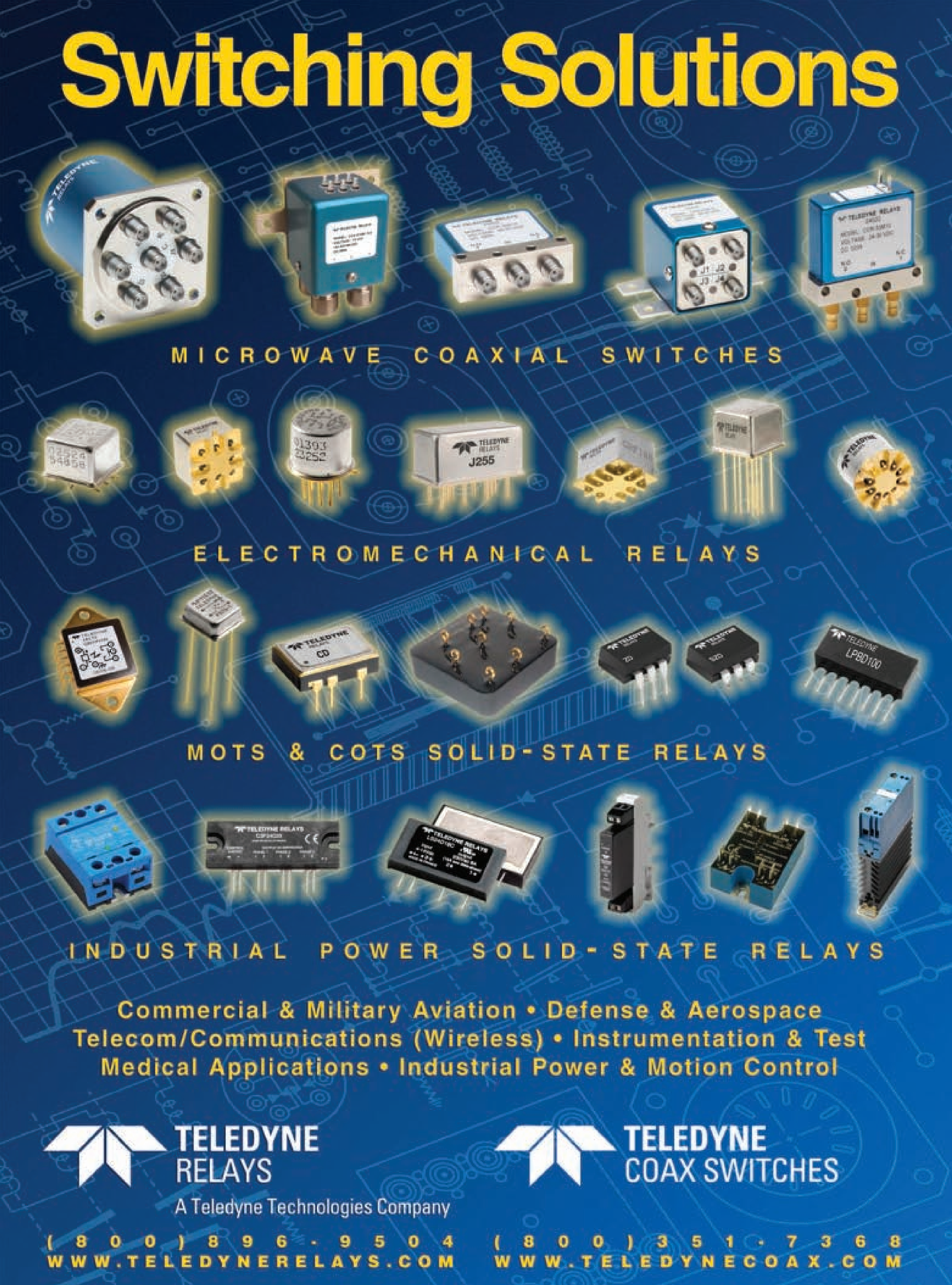
▲ *Fig. 7 Different duplexer trade-offs.*

pled (~20 dB) with the main 50 Ω transmission line through a high-impedance (~120 Ω) transmission line or can be connected through a directional coupler. The limiter diodes D1 and D2 are turned on primarily by the external bias current from the Schottky detector diodes D3 and D4, which are sensitive to the incident signal. Diodes D3 and D4 detect the incident RF power and rapidly apply self-rectified current to the limiter diodes D1 and D2 respectively, causing a rapid increase in attenuation and protection from synchronous and non-synchronous signals. The first Schottky diode D3 starts activating the first high-power limiter diode D1 at approximately 15 dBm incident power. Diode D1 is used as a prelimiter of the high-incident RF power. The second low-power limiter diode D2 has a faster response and, therefore, provides protection during the initial stages of pulse rise time. The parasitic signals reflected from the limiter are dissipated in the dual-junction circulator 50 Ω load. This network prevents transmitter load pulling and leakage of unwanted high RF power to the receiver. ***Table 4*** illustrates the performance of the three transceiver protectors.

DUPLEXER DEVELOPMENT FLOW

Figure 5 illustrates the ANT/TX/RCV duplexer design flow. The system level specification is the first step in a duplexer design flow. The second step is the transformation of system level specification into the duplexer requirements. Some duplexer requirements should be similar to the system requirements; for example, frequency range, maximum power and temperature range. Other duplexer requirements are specific to the duplexer and depend on system requirements; for example, TX and RCV pass insertion loss, TX-RCV iso-

Visit http://mwj.hotims.com/16346-114



Visit http://mwj.hotims.com/16346-160 or use RS# 160 at www.mwjournal.com/info

lation and RCV-ANT isolation.

Analysis of RF duplexer requirements (third step) includes the definition of fixed and variable characteristics. Fixed duplexer characteristics are similar to the system requirements and include center frequency, bandwidth, power, etc. The variable duplexer parameters may be flexible and depend on system requirements, performance of other subsystems and devices, and physical implementation of the duplexer network. The variable duplexer characteristics are insertion loss, isolation, matching, cost and size. A designer has to choose the weighting coefficients k_i for each duplexer parameter to provide multi-parameter optimization.

The fourth step is the selection of a prototype schematic according to duplexer requirements, analysis of the schematic and the optimum topology trade-off design. After that, the layout can be prepared. The fifth step includes selection of elements (parts), topology and technology process. The sixth step is the detailed design phase that includes calculation and simulation over the specified temperature range and manufacturing tolerances. The final steps (8, 9 and 10) are preparation of documentation, fabrication and evaluation to specification.

Analysis of the duplexer includes multi-parameter optimization for the following major characteristics:

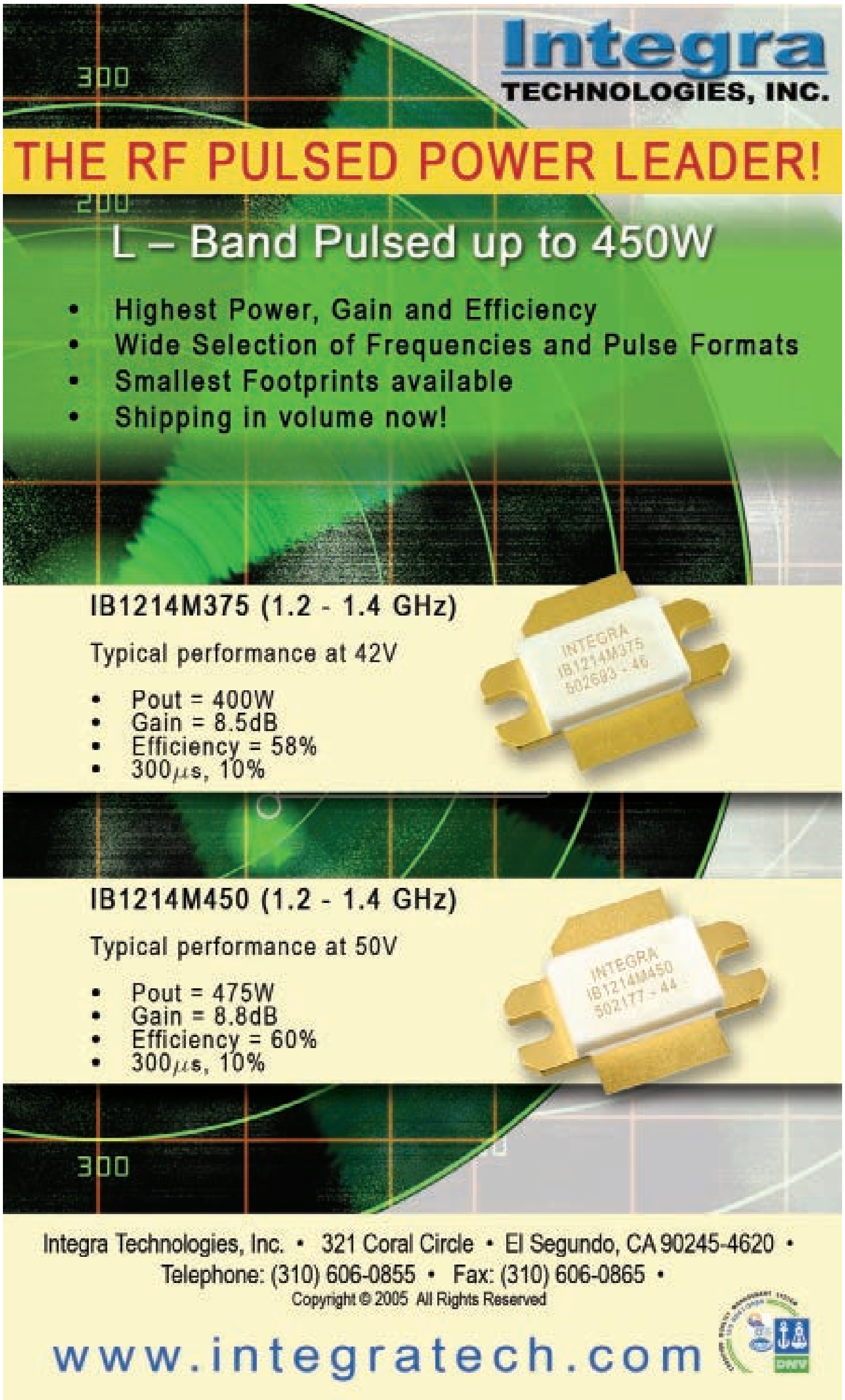
- TX Insertion Loss (IL)
- TX-RCV Isolation (ISO1)
- RCV-TX Isolation (ISO2)
- Matching (VSWR or Return Loss RL)
- RCV and TX protection
- Cost (C)
- Volume (V)

Figure 6 illustrates the circle diagram of these parameters with goal values (green) for the two options: 1) SPDT TX/RCV switch shown in brown and 2) circulator with transmitter-receiver protector shown in blue. To optimize the duplexer network, the area between real and goal performance should be minimized. The comparison of the two networks using the circle diagram showed that the SPDT TX/RCV switch corresponded to a smaller area and, therefore, a better performance than the circulator with transmitter-receiver protector. These preliminary results should be corrected using the weighting coefficients for each parameter. A designer has to choose the weighting coefficients k_i for each parameter from k=1 (most important) to k= max (least important). The circle diagram should be corrected by using different scales for each parameter according to the weighting coefficients and final decision about the optimal network should be based on a new circle diagram.

DUPLEXER TRADE-OFF DESIGN

The most contradictory duplexer parameters include (see ***Figure 7***):

- loss vs. isolation, power, volume and cost
- isolation vs. frequency band
- size vs. power, cost and bandwidth
- electrical performance vs. temperature range



Visit http://mwj.hotims.com/16346-61

Now! MULTIPLY UP TO 20 GHz

Frequency Multipliers from 5^{95} qty. 10-49

For your leading-edge synthesizers, local oscillators, and Satellite up/down converters, Mini-Circuits offers a large selection of ***broadband doublers, triplers, quadruplers, and x12 frequency multipliers.***

Now generate output frequencies from 100 kHz to 20 GHz with excellent suppression of fundamental frequency and undesired harmonics, as well as spurious. All featuring low conversion loss and designed into a wide array of, off-the-shelf, rugged coaxial, and surface mount packages to meet your requirements.

Visit our website to choose and view comprehensive performance curves, data sheets, pcb layouts, and environmental specifications. And you can even order direct from our web store and have a unit in your hands as early as tomorrow! *Mini-Circuits...we're redefining what VALUE is all about!*

Mini-Circuits®
ISO 9001 ISO 14001 CERTIFIED

minicircuits.com

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

YONI2™ Patent Pending ***The Design Engineers Search Engine*** *Provides ACTUAL Data Instantly From MINI-CIRCUITS At:* ***www.minicircuits.com***

IF/RF MICROWAVE COMPONENTS

455 rev. org.

Visit http://mwj.hotims.com/16346-96 or use RS# 96 at www.mwjournal.com/info

The most important electrical parameter of the transceiver duplexer is insertion loss (IL). The trade-off design can satisfy contradictory parameters: insertion loss versus volume. The integration quality of these two parameters is characterized by the insertion loss – volume integration index:[1]

$$i = \frac{IL}{k_1} \times \frac{V}{k_2} \left(dB \times inch^3 \right) \quad (4)$$

where IL is the total insertion loss in dB, k_1 is the weighting coefficient of the insertion loss, V is the volume in $inch^3$ and k_2 is the volume weighting coefficient. The optimum duplexer has the minimum integration index i_{min}, which means the smallest physical dimensions and the minimum insertion loss. It is important to keep in mind that the integration index varies linearly with frequency.

Size (volume) of the duplexer depends on electrical requirements, transmission line type, dielectric substrate parameters, component dimensions and the structure of the duplexer. The integration strategy of a duplexer is based on the optimum schematic and design. A number of different transmission lines are generally used in RF and microwave integrated circuits. The trade-off design showed that the combination of different transmission lines offers certain advantages in both cost and insertion loss.[1]

The main trends in integrated technology are smaller size and lower cost. Integrated circuits can be divided into three categories: hybrid microwave integrated circuits (HMIC), monolithic microwave integrated circuits (MMIC), and combination of hybrid and monolithic MICs. Two categories, including monolithic MICs, have high cost. The printed circuit board (PCB) technology has advantages of low cost, low loss and ease of manufacture. The disadvantage of the PCB technology is the use of plastic dielectric substrates with relatively low dielectric constant leading to greater dimensions.

The guidelines that provide the network cost reduction are listed below:

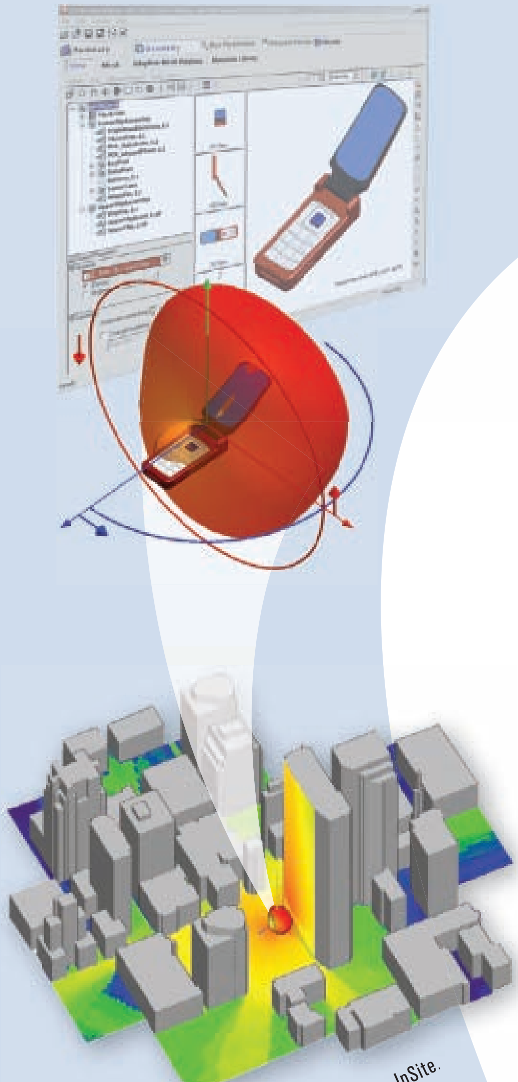
- use the cheapest technology process (PCB)
- use a low cost carrier substrate
- choose the simplest transmission line (for instance, microstrip line)
- keep the assembly as simple as possible
- avoid using expensive components
- design the TX/RCV network with minimum interconnections

For the high power circulator duplexer, requirements for very low insertion loss and high peak power are frequently in conflict. The important factor is the amount of power that the circulator can handle before nonlinearity is produced in the ferrite, which causes an increase in insertion loss. Therefore, a trade-off in the ferrite material selection is required.4 According to Table 2, circulators with tighter electrical performance necessarily have reduced operating temperature ranges.

Remcom Inc.

EM Simulation **PRECISION.** The **FASTEST** Calculations. Remcom Has the **COMPLETE SOLUTION.**

Cell phone antenna simulation in **XFdtd** . . .



. . . and subsequent propagation analysis in **Wireless InSite**.

Turn to **Remcom** for electromagnetic simulation expertise with **XFdtd**® and **Wireless InSite**®. Our products are designed to work together to provide complete and accurate results when simulating real-world devices in real-world scenarios.

XF

XFdtd: General purpose, full-wave 3D EM analysis software

- Acceleration via computer clusters or GPU hardware

WI

Wireless InSite: Radio propagation analysis tool for analyzing the impact of the physical environment on the performance of wireless communication systems

- Complex urban, indoor and rural environments
- Wideband applications

Remcom focuses on building customer needs into every innovation and new feature. Our business philosophy is to satisfy our customers by delivering exceptional quality, unmatched reliability and state-of-the-art software and services, all backed by our expert customer support.

Visit **www.remcom.com** or call us to learn how Remcom can add precision and speed to your simulation projects.

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

AMERICA'S FASTEST-GROWING PRIVATE COMPANIES Inc. 5000

Visit http://mwj.hotims.com/16346-127 or use RS# 127 at www.mwjournal.com/info

For the TX/RCV switch/limiter and the TX/RCV using a circulator and transceiver protector duplexers, the PIN diodes and Schottky diodes are selected using the trade-off design with respect to the following conflicting performance factors: power handling, bandwidth, loss-isolation and switching speed.[10] There is a direct trade-off between isolation and insertion loss in PIN diode switches: the higher isolation, the higher the insertion loss. A designer has to specify the minimum acceptable isolation to get the lowest insertion loss. For good switching speed performance, the PIN diodes should have low capacitance at zero bias and low resistance at low forward current. To handle the high power, the limiter diode should have a high breakdown voltage and large junction area. The large area leads to high capacitance, causing a poorer isolation than a low power device. The higher the operating frequency of the diode, the smaller the percentage of bandwidth over which high performance can be maintained. There are contradictory conditions for the diode power handling versus frequency: the junction capacitance should be at a minimum (smaller junction area) to provide low loss at high frequency. However, reducing junction area increases thermal resistance and hence reduces power handling capability. ■

References

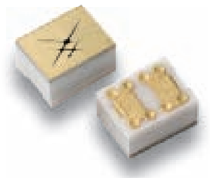
1. L.G. Maloratsky, *Passive RF & Microwave Integrated Circuits*, Elsevier, St. Louis, MO, 2003.
2. *Broadbanding the Shunt PIN Diode SPDT Switch*, Hewlett Packard Application Note 957-1, 1996.
3. D.W. Kim, "Small-sized High-power PIN Diode Switch with Defected Ground Structure for Wireless Broadband Internet," *ITRE Journal*, Vol. 1, February 2006, pp. 84-86.
4. R.O. Collado, "Learn to Specify High-power Ferrite Circulators," *Microwaves & RF*, November 1987, pp. 107-114.
5. Y.K. Chan, et al., "Transmitter and Receiver Design of an Experimental Airborne Synthetic Aperture Radar Sensor," *Progress in Electromagnetics Research*, PIER 49, pp. 203-218, 2004.
6. S. Tanaka, N. Shimommura and K. Ohtake, "Active Circulators: The Realization of Circulators Using Transistors," *Proceedings of the IEEE*, Vol. 53, No 3, March 1965, pp. 260-267.
7. I.J. Bahl, "The Design of a 6-port Active Circulator," *1988 IEEE MMT-S International Microwave Symposium Digest*, pp. 1011-1014.
8. P. Katzin, Y. Ayasli, L. Reynolds, Jr. and B. Bedard, "6 to 18 GHz MMIC Circulators," *Microwave Journal*, Vol. 35, No. 5, May 1992, pp. 248-256.
9. R.Z. Jones and B.A. Kopp, "Duplexer Consideration for X-band T/R Modules," *Microwave Journal*, Vol. 43, No. 5, May 2000, pp. 348-352.
10. P. Sahjani and J.F. White, "PIN Diode Operation and Design Trade-offs," *Applied Microwave*, Spring 1991, pp. 68-78.

Leo G. Maloratsky *received his MSEE degree from the Moscow Aviation Institute and his PhD degree from the Moscow Institute of Communications in 1962 and 1967, respectively. In 1962, he joined the Electrotechnical Institute where he was involved in the research, development and production of RF and microwave integrated circuits and was an assistant professor. From 1992 to 1997, he was a staff engineer at Allied Signal. In 1997, he joined Rockwell Collins, where he works on RF and microwave integrated circuits for avionics systems.*

SKYWORKS®
BREAKTHROUGH SIMPLICITY

High performance and high reliability RF and microwave diodes for your demanding applications

Schottky, PIN and Varactor Diodes



- LTCC packaging technology
- Offered in hermetic surface mount packaging
- Suitable at frequencies as high as 24 GHz

- Beam leads and chips for space / military applications

For data sheets, design kits, samples and pricing visit:

www.skyworksinc.com

Visit http://mwj.hotims.com/16346-146 or use RS# 146 at www.mwjournal.com/info

MICROWAVES IN EUROPE: HISTORICAL MILESTONES AND INDUSTRY UPDATE, PART II

Part I of this report last month focused on individual countries and their contributions and achievements related to the microwave industry. But the continent as a whole plays a key role in all sectors including industrial, biomedical, military, aerospace and emerging wireless technologies. Since there is such a broad range of sectors, in Part II we will only focus on the technological development in Europe of two sectors: Satellite communications from the launch of Sputnik to the use of satellites for mobile communication and broadcast TV; and microwave radar, which has developed to span the vastly differing demands of conflicts from WWII to the fight against terrorism to more peaceful applications such as automotive.

SATELLITE COMMUNICATIONS IN EUROPE: A HISTORICAL PERSPECTIVE

JOSEF MODELSKI
Warsaw University of Technology, Poland

Satellite communications is an important part of telecommunications, and the main function of satellite-based commercial systems, alongside navigation and Earth observation. A satellite placed in a geostationary orbit (GEO) fixed above the Earth has the capability to cover up to a quarter of the Earth's surface (except for the polar regions) and to realize long distance transmissions between users separated by a distance of several thousands of kilometres.

Satellite communication systems offer many different services for different groups of users, independently from the terrestrial telecommunications infrastructure. In general, these services can be divided into two groups:

Services for stationary users

- Two-way transmission Fixed Satellite Services (FSS) and broadcast applications - Direct Broadcast Services (DBS)
- Broadcast of digital TV programmes in DVB-S and DVB-S2 standard
- International telephony connections
- Data transmission networks - i.e. Very Small Aperture Terminals (VSAT) networks
- Occasional transmissions
- Back-up for terrestrial systems

Services for mobile users - Mobile Satellite Services (MSS)

- Voice and low rate data transmission
- Broadcasting of radio programmes (XM Radio and Sirius in US)
- Future broadband interactive services - to realize communications, "anywhere and at any time"

Broadcasting of TV programmes to individual users—Direct To Home (DTH)—is a major driving force for satellite communications. Conversion to High Definition TV (HDTV) will be an additional impulse to growth as will multimedia broadband services for mobile users. Currently there are over 200 active communications satellites in GEO, with more than 100 in Low Earth Orbit (LEO).

RICHARD MUMFORD
Microwave Journal *International Editor*

ROG Solves Your Most Advanced High Frequency & Thin Dielectric Material Needs.

From wireless base stations, defense and auto-telematics to high speed digital, portable communications and beyond... Rogers delivers the material you need with the technical resources and experience to handle even the most challenging designs. For the best performance over the widest range of applications, start with ROG!

For more information, visit
www.rogerscorporation.com/acm

USA +1-480-961-1382 • EUROPE +32-9-235-3611 • ASIA +886-2-8660-8056

ROGERS CORPORATION

Visit http://mwj.hotims.com/16346-140 or use RS# 140 at www.mwjournal.com/info

www.jqlelectronics.com

TECHNOLOGY ON THE MOVE™

JQL

i•n•s•p•i•r•a•t•i•o•n

Newly Designed Solid State Power Amplier

- High Power Solution Designed for RF Testing
- From 400Mhz to 4Ghz
- Maximum 200W Output Power
- Broadband, Low IMD
- Build-in Siginal Generator Option Upon Request

- Isolator
- Circulator
- Combiner
- Directional Coupler
- Power Divider
- Ceramic Filter

JQL ELECTRONICS INC

Tel:1(888)236-9828(US&Canada)
(630)930-9917 (International)
Fax:(630) 823-2902 / (630)756-0017
Email:sales@jqlelectronics.com

Designed and Created by Garfield-Loves-Fish Studio

SATELLITE COMMUNICATIONS DEVELOPMENT

The new satellite era dawned on 4th November 1957, when the first satellite, Sputnik-1, was launched by the USSR. From the very beginning, the use of satellites for military and commercial telecommunications was considered to be an important and promising application. Initial investigations were carried out both in the US and the USSR. The first experimental communications satellite SCORE, which stood for Signal Communications by Orbiting Relay Equipment, was launched in 1958.

Echo-1 satellite, a passive reflector realized as a 30 m balloon coated with aluminium and launched in 1960, was the first intercontinental satellite transmitting between stations in the US and Western Europe. However, Telstar-1, launched in 1962, was the first true communications satellite, with an active transponder working in C-band. This satellite was used to realize the first transmission of a TV signal between ground stations in the US and in Europe (the UK and France).

Because a satellite in low orbit moves above the Earth's surface, and many satellites are necessary to provide continuous services, the next step was to investigate the use of satellites placed in GEO. In 1964, Syncom-3 was the first geostationary communications satellite to be launched, which was used to transmit TV signals from the Summer Olympic Games in Tokyo, Japan.

In 1964, the International Telecommunications Satellite Organization (INTELSAT) was established as an inter-governmental organization with 12 participating countries, but the number of members grew rapidly over the next few years. The main task of this organization was to design, develop, construct, establish, maintain and operate the space segment of global commercial satellite systems.

In 1965, Early Bird (Intelsat-1) was the first commercial communication satellite launched in GEO, and the new era of commercial satellite communications began. Early Bird was 38.5 kg spin stabilized spacecraft with 2 transponders with the capacity of 240 telephone channels or one TV channel for point-point connections between ground stations placed in the US and Europe. Due to the low power signal transmitted by the satellite, in the ground station, a very large parabolic antenna had to be used. In subsequent years, new generations of Intelsat satellites increased the number of available transponders.

At the same time the USSR developed its own satellite communications system to distribute TV programmes. Because a large part of the USSR territory lay in the polar region where GEO satellites cannot be operated, satellites placed in elliptical orbits were used—Molnia satellites.

The enormous growth in demand for satellite communications resulted in a plethora of operational satellites. In the 1970s, the regional satellite operators were established: INTERSPUTNIK for the USSR and Eastern Europe, and EUTELSAT for Western Europe. Also, the first national communications satellites were launched.

Technical developments of the 1970s and 1980s, which resulted in the increase of the satellite weight and supply power and the realization of low noise and high power microwave components, made it possible to use Ku-band and facilitate the significant reduction of antenna dimensions in the ground stations. Hence, the broadcasting of TV programmes, firstly to head-ends of cable television networks and then directly to individual users equipped with receiving terminals.

In 1991, SES ASTRA realized a new concept of collocation of many satellites in the same orbit position in order to increase the number of TV programmes accessible to the user without changing the orientation of the receiving antenna.

Digital transmission of TV programmes in the 1990s using the MPEG-2 compression standard was the next stage of development. It enabled the transmission of several digital programmes in the single transponder channel instead of one analogue programme, with comparable reception quality. This seriously increased the number of transmitted programmes available for the user.

With regards to the use of satellite communications to provide services for mobile users, 1979 saw the International Maritime Satellite Organiza-

Europe's Premier Microwave, RF, Wireless and Radar Event

EuMW 2009

S.P.Q.R. Science, Progress and Quality at Radiofrequencies

EUROPEAN MICROWAVE WEEK

Rome

28 September - 2 October 2009

www.eumweek.com

28 September - 2 October 2009
Nuova Fiera di Roma, Rome, Italy

SUBMIT YOUR PAPER ONLINE NOW!

To electronically submit a technical paper for one or more of the four conferences, all you have to do is:

1. Log on to www.eumweek.com
2. Click on 'Conference Information' to view the individual conference topics
3. Click on 'Paper Submission' for author's instructions on how to submit a summary

That's all there is to it, so log on now!

www.eumweek.com

Co-sponsored by: MTT-S, GAAS

Supported by: IET (A new Institution from the IEE and IIE)

Endorsed by: IEEE, AP-S, Electron Devices Society, a e s s, EurAAP

Organised by: horizon house

EuMA European Microwave Association

Official Publication: Microwave Journal

39th European Microwave Conference 2009

The 39th European Microwave Conference

EuWiT 2009 — The 2nd European Wireless Technology Conference

EuRAD 2009 — The 6th European Radar Conference

EuMIC 2009 — The 4th European Microwave Integrated Circuits Conference

Visit http://mwj.hotims.com/16346-50 or use RS# 50 at www.mwjournal.com/info

tion (INMARSAT) established to realize communication with ships using GEO satellites operating in L-band.

At the beginning of the 1990s, investigations into the development of satellite mobile telephony systems were launched and specifically the use of constellations of satellites placed in Low Earth Orbit (LEO) and Medium Earth Orbit (MEO), in order to improve the power budget of the radio link between the satellite and handheld user terminal, in comparison with GEO satellites.

Two systems: IRIDIUM and GLOBALSTAR started commercial services in 1999 and 2000, respectively. However, these systems hit financial problems caused by the high cost of system development and short predicted life time in comparison to GEO systems plus a severe lack of user take-up. As a result, the implementation of other systems using LEO and MEO orbits were terminated.

This coincided with developments in satellite technology at the end of the 1990s whereby high power satellites with large deployable antennas could be built, meaning that mobile satellite telephony systems could be realized using GEO satellites. Thus, two systems—THURAYA and ACES—were built.

SATELLITE COMMUNICATIONS IN EUROPE

After the experimental tests of satellite communications in the US at the beginning of the 1960s, it was evident that telecommunications could be one of the most promising commercial applications of satellite systems. However, European activity was non-existent in comparison to the US and the USSR, and at the beginning of the satellite communication era, the European effort was virtually insignificant, being limited to the building of ground stations in the UK and France and then in Germany and Italy.

To change this situation, two major initiatives were instigated, namely international projects coordinated by the European Space Agency (ESA) and its predecessors, the European Space Research Organization (ESRO) and European Launcher Development Organization (ELDO) and national projects.

In 1967 ESRO began studies on the technical feasibility and economic aspects of a European satellite communications system. It was deemed that going into competition with INTELSAT would be difficult so special applications for Europe were considered: intra-continental telephone connections (for the European Conference of Postal and Telecommunications Administrations - CEPT), distribution and exchange of TV programmes (for the European Broadcasting Union - EBU) and maritime communications.

In the early 1970s, a satellite communication system project was launched to consider the realization of an experimental satellite for the transmission of telephone calls and TV programmes [Orbital Test Satellite (OTS)] and a satellite for maritime communications [Maritime Orbital Test Satellite (MAROTS)].

At the same time, some countries started national or joint venture experimental communications satellite projects: SKYNET in the UK in cooperation with the US for military applications, SYMPHONY in Germany and France, and SIRIO in Italy. SYMPHONY-1, with two C-band transponders, was the first European communications satellite placed in GEO in 1974. In 1977, the ESA OTS-2 satellite was launched. This was the first communications satellite with Ku-band transponders capable of handling 7,200 telephone connections.

The first commercial European communications satellites were launched in 1981 [Maritime European Communication Satellite 1 (MARECS-1)] and in 1983 [European Communications Satellite 1 (ECS-1)]. MARECS-1 was the continuation and re-definition of the MAROT experimental programme and was used by INMARSAT. ECS-1 was the first of five satellites built by ESA and after the launch transferred to EUTELSAT as EUTELSAT I satellites.

In the 1980s and the 1990s, the next generations of EUTELSAT satellites, and also national communications satellites were launched, and European satellite communications began to play a significant role in the everyday life of citizens.

In the 1980s, the satellite broadcasting of TV programmes using telecommunications satellites with medium power transponders entered

 Visit http://mwj.hotims.com/16346-63

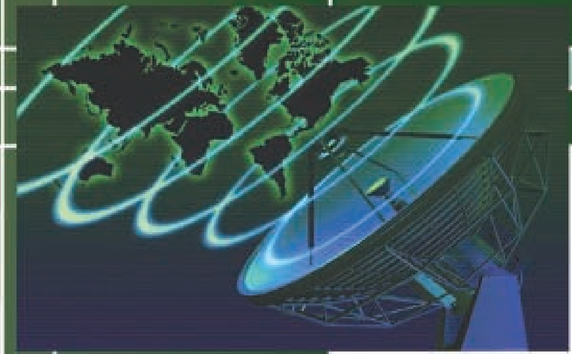
High Performance Radar Components

X-Band switching assemblies

High ENR broadband noise sources 1 - 18 GHz

High power X, Ku band 300W switches

High power X-band 1000W power limiters



Micronetics has been manufacturing an extensive line of RF/ microwave components and subassemblies suited for military and commercial radar applications for over 30 years.

phased array early warning radar
- voltage variable attenuators for signal leveling
- limiters for receiver protectors

fire control radar
- noise sources for built-in-test
- low loss, fast switching for BIT circuit enabling

weather radar
- high power transmit/receive switches
- noise sources for built-in calibration

instrumentation radar
- high power, high speed, transmit/receive switches
- phase shifters

Visit http://mwj.hotims.com/16346-80 or use RS# 80 at www.mwjournal.com/info

divisions of Micronetics:

ENON

Micro-Con

Stealth Microwave

MICA Microwave

MVS Micronetics

VMC Vectronics Microwave Corporation

amplifiers
attenuators
build-to-print services
carrier/noise generators
combiners
dividers
ferrites
high power limiters
high power switches
mixers
multifunction modules
noise sources
oscillators (vco, cro, pll)
phase shifters
power meters
switches
switch filter banks
test equipment

MICRONETICS
www.micronetics.com
26 Hampshire Drive, Hudson NH 03051
Tel: 603-883-2900 Fax: 603-882-8987
email: controlsales@micronetics.com
ISO 9001 Certified

ISOLATORS AND CIRCULATORS

M2 Global: a leading supplier of RF isolators and circulators and passive microwave components to the telecommunications and defense industries. Applications include TETRA, TV broadcast, cellular, GSM, PCS, UMTS, WiMAX, IFF, satellite base stations, microwave radio, and radar in coax, drop-in and waveguide configurations. For additional information contact us at sales@m2global.com or visit our Web site at www.m2global.com.

THE SOLUTION SOURCE FOR THE WIRELESS & MICROWAVE INDUSTRY

- Standard and Custom Designs
- Low IMD and Insertion Loss
- Dual Junctions
- Proven Reliability
- Non-BeO Options
- ISO 9001 Certified
- Veteran Owned

nsai I.S. EN ISO 9001

WE HAVE MOVED

5714 Epsilon Drive
San Antonio, TX 78249
Phone: (210) 561-4800
Fax: (210) 561-4852
www.m2global.com

Europe by the back-door, avoiding the decisions of WARC 77, with the use of high power Ku-band broadcasting satellites. Only a few broadcast satellites were launched and used, with the bulk of satellite TV programmes being transmitted using Ku-band transponders of telecommunication satellites. Increases in the number of satellites and the transponders they carried increased the volume of programmes available to users. In 1985, SES ASTRA, the first European private satellite operator in Europe, was established, launching the ASTRA-1 satellite and offering TV programmes to individual users, thus becoming a rival to EUTELSAT.

The great success of European satellite communications operators was connected to the broadcasting of digital TV programmes using DVB-S standards. The family of DVB standards were proposed by the European Broadcasting Union (EBU) and the European Telecommunications Standard Institute (ETSI) in 1995 to realize the transmission of digital television in different media (satellite, cable and then terrestrial) in Europe. Over the next few years DVB-S, based on the MPEG-2 compression method, became the worldwide standard. In 1996, satellite digital television based on this standard was launched in Europe, and now over 1,000 digital TV programmes and several hundred digital radio programmes are transmitted by ASTRA's satellites and EUTELSAT's HotBirds.

The DVB-S standard is also used for data transmission, i.e. realization of access to Internet via satellite, supported by a return channel realized by terrestrial telephone networks or by a satellite in Ka-band using the DVB-RCS standard.

In 2003, the next version of the DVB-S2 standard, based on the MPEG-4 image compression method, and adaptive spectrum effective modulation schemes was announced and implemented. Using this standard, a larger number of TV programmes can be transmitted in a single transponder channel. This transition to the digital television standard is related to the increasing number of programmes and the introduction of HDTV services in Europe. The DVB-SH standard relates to the provision of multimedia data broadcasting services to mobile users.

As for the near future, the new satellite applications of interactive broadband transmissions, operating in S- and Ka-bands, will be offered to mobile and fixed users, respectively. Also, new satellites will be equipped with multi-beam antennas and advanced modern transponders operating at increased power levels.

MICROWAVE RADAR IN EUROPE: A HISTORICAL PERSPECTIVE

YVES BLANCHARD
Consulting engineer and author

When *Microwave Journal* was first published in July 1958, European electronics had scarcely recovered from the devastation of World War II. The industry needed to make up for lost time, be innovative and build on significant pre-war technological breakthroughs. These can be traced back to as early as the 1920s when European scientists were attracted by 'Ultra High Frequencies' and the unexplored world opening up beyond the 1 GHz border.

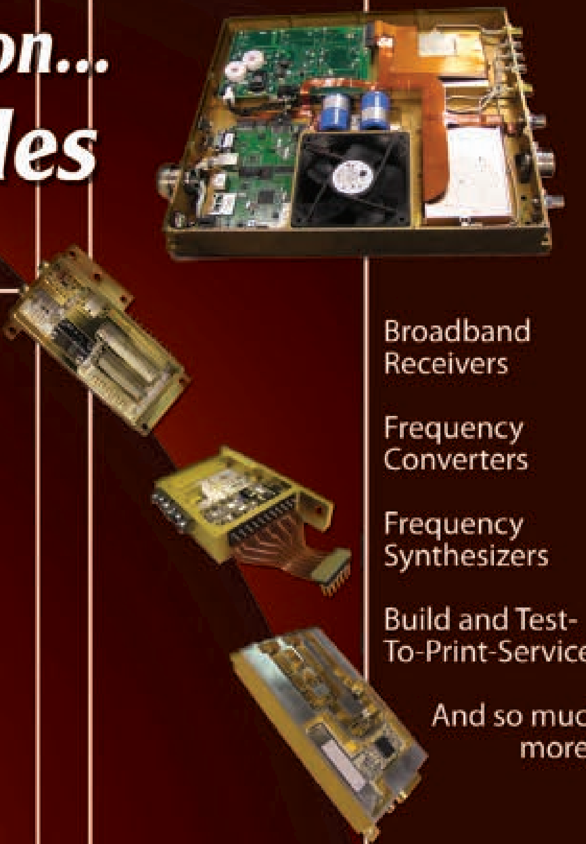
In 1923, Professor René Mesny went down to wavelengths of 1.2 m (250 MHz), and with his colleague, Pierre David, he organized a public demonstration of a radio link using such 'short' waves at the Physics and Wireless Telegraphy Exhibition in Paris, France. David had other applications in mind too, and as early as 1926 he started trials to detect airplanes by their electromagnetic radiation.

Next came Professor Heinrich Barkhausen of the Technical University of Dresden, Germany, who, with his colleague Kurz, reached the magical 30 cm limit with a triode fed in an unusual way: for their Positive Grid Tube they applied the high voltage to the grid instead of the traditional plate. This Barkhausen-Kurz oscillator is considered to be the first microwave oscillator.

In 1927, using a modified Barkhausen scheme, Professor Emile Pierret at the University of Nancy, France, reduced the wavelength to a new 12 cm record. During his tests he observed many effects of reflections in the cluttered yard of the faculty. Henri Gutton, a student who assisted him, would later remember these effects and deduce that a ship could be detected in this way. I shall

 Visit http://mwj.hotims.com/16346-75

From Concept to Production...
Multifunction Modules



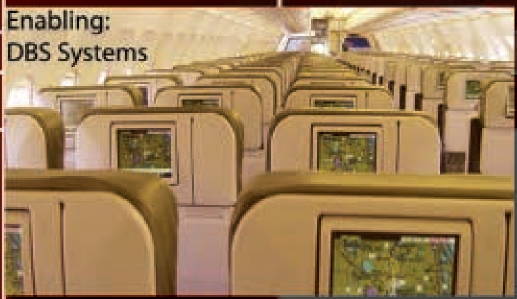
Broadband Receivers

Frequency Converters

Frequency Synthesizers

Build and Test-To-Print-Services

And so much more...



From Concept-to-Production
Micro-Con has extensive experience designing, developing, and manufacturing state-of-the-art, highly reliable, broadband (multi-octave) microwave components and complex integrated subassemblies used in military and high-reliability commercial applications.

Our Design Expertise Includes:
- Complex Multi-function Modules such as Receivers, Frequency Converters, RF Distribution Networks, & Frequency Synthesizers
- Single Function MIC Devices such as Broadband & Ultra-Low Noise Amplifiers & Frequency Multipliers
- Custom MMIC Chips
- Multi-layer RF/Microwave Substrates (LTCC & Softboard Materials)
- Complete RF Subsystems and more...

Build and Test-To-Print-Services
Our strong design and manufacturing expertise enables us to offer build and test-to-print services for your existing subassemblies and subsystems that, because of their complexity, cannot be easily outsourced to other contract manufacturers.

Micro-Con
MICROWAVE CONCEPTS, INC.
A Division of Micronetics, Inc.
12 Gardner Road, Fairfield, NJ 07004
Tel: 973-244-1040 Fax: 973-244-1188
email: sales@micro-con.com
www.micro-con.com

MICRONETICS
divisions of Micronetics:
ENON
Micro-Con
Stealth Microwave
MICA MICROWAVE
MVS

amplifiers
attenuators
build-to-print services
carrier/noise generators
combiners
dividers
ferrites
high power limiters
high power switches
mixers
multifunction modules
noise sources
oscillators (vco, cro, pll)
phase shifters
power meters
switches
switch filter banks
test equipment

Visit http://mwj.hotims.com/16346-81 or use RS# 81 at www.mwjournal.com/info

explain later how he turned this idea into a radar reality.

The most spectacular achievement, however, was undoubtedly the link set up in 1931 across the Channel by an Anglo-French team from ITT, led by André Clavier. They demonstrated a focused beam—which they named a micro-ray—at 18 cm. Thus the advent of the European microwave pioneer was confirmed.

MAGNETRON: A EUROPEAN SUCCESS STORY

In 1904, the German Christian Hülsmeyer failed in his project to provide shipping companies with his patented Telemobiloskop, which incidentally, could have saved the Titanic eight years later. For almost 30 years there were no significant microwave radar developments, all things being confined to the metric field due to the lack of sufficient powerful centimetric sources. However, in 1940 the definitive solution arrived in the form of the magnetron.

This valve had been envisaged in 1918 by the American A.W. Hull as a Lee de Forest's triode competitor, but it was not used as an RF source until 1924 when the Czech August Žaček and the German Erich Habann succeeded in bringing it into oscillation. In his Praha laboratory, Žaček got a 29 cm wave with a sort of Barkhausen mounting, and Habann took it one step further at the Jena University by suggesting that Barkhausen's negative resistance effect could be produced with a cylindrical fenced anode. This opened the way to a field of research that focused around three eminent European scientists: E.C.S. Megaw at GEC, UK, Klaas Posthumus at Philips NatLab, Netherlands, and Maurice Ponte at SFR-CSF, France.

Ponte began his magnetron research in 1932, with the aim of higher emitted levels and reduced magnetic fields. Pursuing Habann's idea he found that cutting the anode in multiple paired segments divided the magnetic field required by the number of segments. Over the next five years he continued his anode geometry trials with Henri Gutton. In 1937 they reached a peak power of 10 W at 16 cm with a tube they named M-16.

Ponte was in contact with Megaw who was mostly involved in the theoretical question of multi-modes coexistence in a given valve. He pursued this work in open competition with Posthumus, author of a new theory that he had named rotating field oscillations. Apart from their theoretical debates, Posthumus also set up a split anode magnetron that delivered about 10 W at 30 cm in 1933.

These 'first generation' magnetrons, despite their limited performance, found immediate applications as radar sources. In Germany in 1933 the trials for a naval radar by Rudolf Kühnhold used a Posthumus magnetron giving 40 W at 48 cm. In France, a decimetric radar (16 cm) was installed on board the liner Normandy by Gutton, first (1935) with a positive grid triode and later (1937) with his M-16 magnetron. In Holland in 1936 detection tests ordered to C.H. Staal by the Koninklijke Marine used a 10 W, 30 cm Philips magnetron. With the levels available, only large targets—civil liners or warships—could be considered for these attempts. All these research programmes proved the need for improved power sources.

It is well documented that, in England, Robert Watson-Watt had deliberately, and for a time successfully, excluded microwaves to set his Chain Home on a decametric basis. But when the enemy turned to bombing by night, Chain Home was not accurate enough to direct night-fighters within their interception range, and the need for efficient AI radars quickly resumed the interest in centimetric waves.

The decisive turnaround came from Professor John Randall and his student Henry Boot at Birmingham University, UK, who in 1939 had the bright idea to substitute cylindrical cavities in place of the external oscillating circuits of traditional magnetrons and to cut those cavities in a large copper ring used as the anode. On February 21, 1940, a six cavity prototype gave 400 W at 9.9 cm. Their next magnetron (E-1188), produced on May 16, was calibrated to give at least 1 kW.

Its only defect was a very short lifespan, due to the fast evaporation of the directly heated tungsten filament they used as the cathode. The last word lay with Ponte, who on May 9, 1940, only two days before the


When components have
to be combat ready...
think Narda West
Military Qualified Components, including:
Power Dividers / Combiners
Switchable / Notch Filters
Multifunctional Assemblies
Filters / Multipliers
Cable Amplifiers
narda
microwave-west
an L3 communications company
We have been a leading supplier of high-performance, combat-ready products for over 35 years. Our highly skilled technical staff and modern production facility make it possible to respond to our customer's mission critical requirements. When your military-qualified projects demand the best, think Narda West for the highest quality components and assemblies possible...all delivered on time and within budget. To learn more about partnering with Narda West, contact us today.
107 Woodmere Road
Folsom, CA 95630
Tel: 916.351.4500
Fax: 916.351.4550
e-mail: nmw.sales@l-3com.com
www.nardamicrowave.com/west
nqa. AS9100 Registered
ANAB ACCREDITED
nqa. ISO 9001 Registered
Visit http://mwj.hotims.com/16346-109 or use RS# 109 at www.mwjournal.com/info

German army broke through the front line and rushed to Paris, crossed the Channel with two samples of a new M-16 using an oxide coated and indirectly heated cathode. Bringing together the principles of the anode cavities and the oxide cathode, Megaw on June 26 achieved a 15 kW level, which exceeded all expectations. The cavity magnetron, disclosed three months later to the American allies by the Tizard mission, opened the way to the centimetric radar revolution, which was claimed to have changed the course of WWII.

POST-WAR EUROPEAN RADAR

Directly after WWII and for the next three decades, radar together with microwave radio links, supported the revival of the European microwave industry. British companies such as Marconi, GEC, Plessey and Ferranti had the privilege of priceless experience acquired during the war. In 1948 Marconi was charged with a study for the complete overhaul of the RAF radar chain round the whole of the UK. However, this favourable period was followed by two decades without any significant public orders. British companies, without major government procurements, struggled against US and new European competitors on the export market. The success of the privately-developed Martello in the 1980s came probably too late, when the dramatic restructuring of the European defence industry arose after the fall of the Berlin Wall.

In other countries, companies such as CFTH (France) or Microlambda (Italy) entered the field without any radar background, and chose to start on a US licensed basis. CFTH's first radars (a Precision Approach Radar, replica of the AN/MPN-1, and COTAL, a gun control radar issued from the SCR-584) were successful enough to give the company a solid position for markets of gun guidance (NATO Hawk programme, 1958); spatial trajectography (Aquitaine, 1955); and long-range 3D air surveillance systems. In 1963 CFTH won the NATO competition for equipping the NADGE long-range stations with its Palmier/ARES.

Microlambda opened in 1951 at Fusaro near Napoli in a pre-war torpedo factory, as a joint venture between the Italian holding Finmeccanica and Raytheon, to start a radar production business. The first apparatus transferred to Fusaro was the TPS-1D. The successful completion of the contract opened the way for Microlambda to develop in an autonomous way. It became Selenia, which received the Italian part of the NATO Hawk programme.

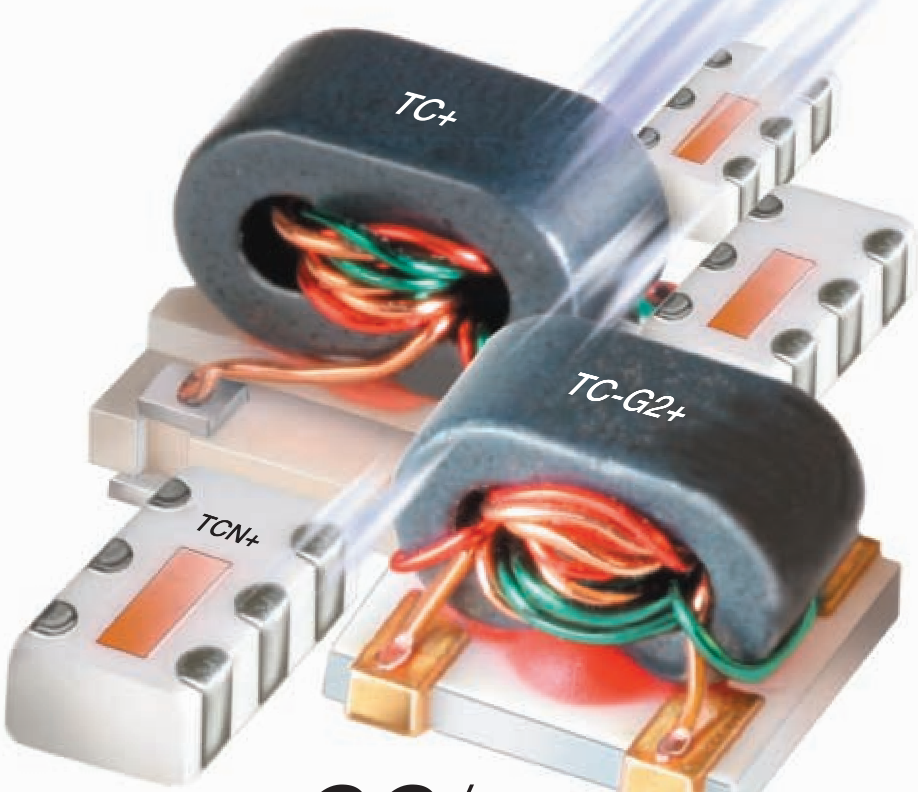
In the Netherlands Signaalapparaten (opened in 1922 at Hengelo) was a manufacturer of gun guidance systems. Captured by the Germans, and harshly damaged by allied raids, the factory reopened in 1945 to restart its original business. In the meantime radar had become a required element of Gun Laying systems. The task was given to Max Staal, who had installed, before the war, a 70 cm radar prototype on board the Dutch destroyer Isaac Sweers. As general manager of Signaal, Staal later produced a large range of successful radars for the Dutch Navy and for a worldwide export.

Named head of CSF, Ponte created a Radar Application Department in 1950 to take advantage of the pre-war experience of Gutton's decimetric radars, and acquired know-how in magnetron applications. CSF was the first to respond to French government requests for Naval radars, but its most significant success occurred in the airborne radar domain, after it won the bid for the fighter Mirage 3C radar with its famous Cyrano (1958), from which more than 1,000 sets were sold over the next 20 years.

For many years all these companies were confronted by the lack of microwave components, which they had to develop themselves, or buy from new specialist companies such as EEV in the UK. Until the mid 1960s progress in radar meant longer ranges (more powerful transmitters), and increased resolution (larger antennas). In 1957 CFTH achieved a world record with an S-band klystron delivering 30 MW peak power. This trend slowed down when advances in signal processing gave priority to wideband components. In 1968 the same CFTH laboratory succeeded in reaching a 10 percent bandwidth at 200 kW average power.

In the meantime, Doppler filtering and pulse compression had been

TINY RF & MICROWAVE
TRANSFORMERS



.3-3000 MHz as low as 99¢ IN STOCK each (qty. 100)

Mini-Circuits wide selection of broadband transformers demonstrates excellent VSWR with impedance ratios from 1:1 up to 16:1, covering from 300 KHz to 3 GHz. To meet your demanding size, performance, and environmental requirements Mini-Circuits offers three package styles to accommodate your transformer Microwave & RF needs.

TCN+ *mini-packaged Low Temperature Co-fired Ceramic transformers deliver outstanding thermal stability high reliability, and permit fast high volume manufacturing.*

TC+ *models have compact open case design, all-welded construction, and offer high-strength plastic base for low cost commercial applications.*

TC-G2+ *ceramic base with gold plated terminations, for military and high reliability requirements*.

These low cost transformers are the best price/performance buy in the business! For detailed specifications, full data, and *Designer Kits* see our Website.

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

Available as RoHS compliant.


.12" x .06"


.15" x .15"

Mini-Circuits®
ISO 9001 ISO 14001 CERTIFIED

ALL NEW minicircuits.com

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

YONI2™ Patent Pending *The Design Engineers Search Engine* *Provides ACTUAL Data Instantly From MINI-CIRCUITS At:* ***www.minicircuits.com***

RF/IF MICROWAVE COMPONENTS

377 Rev L

Visit http://mwj.hotims.com/16346-97 or use RS# 97 at www.mwjournal.com/info

Part No.	Gain (dB)	P1dB (dBm)	P3dB (dBm)	OIP3 (dBm)	Pkg
RT233N	15	34	37	45	WQ-22
RT233C	15	34	37	45	WP-22
RT240N	14	40	43	50	WQ-22
RT240C	14	40	43	50	WP-22
RT243N	12	43	45	52	WQ-12
RT243C	12	43	45	52	WP-12
RT440N	14	43	46	53	Push-pull
RT440C	14	43	46	53	Push-pull
RT443N	12	46	49	55	Push-pull

* Up to 6 GHz

Are you looking for better efficiency in higher or wider frequency bands?

Maybe thinking of new technology such as GaN, but think its high cost wouldn't meet the price target?

Check out the new thermally enhanced GaN from RFHIC with equivalent cost of GaAs.

Application

Communication Equipments,
CATV & Broadcasting,
Wireless Communication,
Medical Equipments,
Multiband, Wideband applications,
Military applications,
Radar communications.

RFHIC
www.rfhic.com

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

Manufacturer of high frequency components for wired & wireless telecommunication
RFHIC is in compliance with EU's Standard RoHS regulations

Come see us at EuMW2008
in Amsterdam / Oct.27–31 / Booth #107

implemented. Pulse compression was patented during WWII by the German engineer E. Huttman (1940) but remained unapplied. In 1954, Charles E. Cook revived it at the US Sperry Co. for the AN/FPS35. It was not long before the idea came back to Europe: in March 1959, M.H. Carpentier at STTA, France, tested a laboratory model, which is said to be the second recorded in the world. In 1962 it was applied by CFTH to the experimental Conrad radar.

ACTIVE ANTENNAS: KEY TO THE NEW MULTI-FUNCTION SYSTEMS

In the '80s, R&D efforts considered the new concepts of phased arrays and electronic scanning, one major technical gap in radar development. It was not exactly a new idea, insofar as the WWII German Mammut was already an electronically scanned phased array. The concept was revived when size and weight of ABM early warning radars made mechanical scanning impracticable, and progressively it extended to complete radar families.

Three decades were necessary for making it technically workable, with two main ways of implementation:

- Passive Electronically Scanned Antennas (PESA) are powered by a single source sharing its output between many phase shifters plus transmitters modules. Power may be distributed to the radiating elements by a more or less complicated net of waveguide feeders, as implemented in the '80s French DRBJ11 or 22XX. In a more advanced architecture the power source may face an array of multiple phased reflectors (reflect array), or send its waves through an electronic lens. This solution, combined with a fast mechanical rotation, has been adopted both by Thales (Arabel) for the French SAAM anti-missile system and Selex (Empar) for the Horizon frigates PAAMS system.
- Active Electronically Scanned Antennas (AESA) feature the most advanced architecture. They use a large number of solid-state transmit/receive (T/R) modules, instead of the PESA single source. This improves beam agility and flexibility, saves energy and increases reliability. AESAs are specially suitable for multifunctional systems (to make a ground radar evolve from a general Air Defence mission to an extended Air and Missile Defence mission, for example.) First implementations were limited to an elevation '1D' e-scanning, with a classical rotating mode for azimuths: MASTER-A (Thales, 1995) or RAT-31DL (Selex, 1999) are both fitted with horizontal rows of radiating elements, fed with a vertical column of solid-state phase-controlled transmit amplifiers.

Getting full '2D' scanning required major investment. The UK Multi-function Electronically Scanned Adaptive Radar (MESAR) research programme was launched in 1982 jointly by Plessey and DERA. It resulted in an array of 1,264 elements, each delivering 10 W, quad-packed on a total of 316 T/R-modules. MESAR has initiated Sampson, an S-band Multi-Function Radar (MFR) produced by BAE Systems Insyte to be fitted to the PAAMS missile system of the Royal Navy's Type 45 destroyers.

Sampson's closest competitor is the Thales-NL X-band MFR Active Phased Array Radar (APAR), evolving from a Netherlands, Germany and Canada joint programme. As opposed to the Sampson's two rotating arrays, it uses a four array fixed structure.

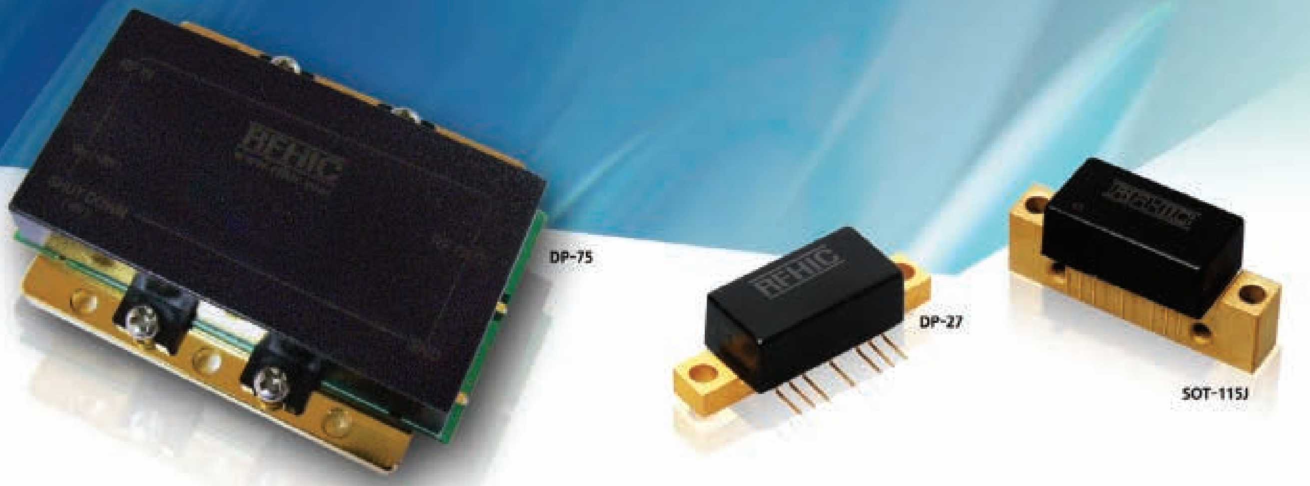
Other projects have been in conjunction with US companies: Counter Battery Radar (COBRA) was a 1997 tripartite programme for equipping French, British and German armies with battlefield AESA C-band radar. It was developed in just two years by the Euro-ART (Advanced Radar Technology) consortium including Thales Air Defence, EADS Deutschland GmbH, Thales Defence Ltd., and Lockheed-Martin, which brought its T/R solid-state GaAs technology. Today Thales works in association with Raytheon in a 50/50 joint venture, Thales-Raytheon Systems, which develops the M3R project, a very flexible system with a fully modular architecture of octopacks (8 T/Rs).

Airborne radars are basically multifunction systems; ensuring air surveillance, air-to-ground and weapon control missions, and AESA should logically be the most suitable choice. But it has suffered for some time from the lack of mass-produced X-band T/R modules. The Airborne Multirole Solid-state Ac-

NEW VALUE STANDARD IN TOWN.

Are you looking for wideband amplifiers with
great performance & value?
Broadcasting, Wireless communications, Airborne & Military
customers are all surprised at the performance & the value they get.

YOU DESERVE IT BY NOW.



Part Number	RFW2500H10-28	RFW1G35H20-28	RFW7735H20-28	RFW5035H40-28	RFW8835H40-28	RFW1G33H40-28
Frequency (MHz)	20 ~ 2500	20~1000	450~ 770	20 ~ 500	450 ~ 880	20 ~ 1000
Power Gain (dB)	13	35	35	35	35	34
P3dB (dBm)	36	41	43	46	46	44
OIP3 (dBm)	41	46	50	53	53	50
Supply Voltage (V)	28	28	28	28	28	28
Current (A)	0.9	1.8	1.8	2.5	2.5	3.1

* Custom design available.

Other Wideband Amplifiers

Part Number	Freq. (MHz)	Pout (dBm)	OIP3 (dBm)	Pkg
1F5500	5~500	31	49	DP-27
RFC041	400~800	30	47	DP-27
RFC092	800~1000	30	50	DP-27
RFC1G22-24	20~1000	30	50	DP-27
RFC1G18H4-24	20~1000	36	46	DP-27
RFC1G18H4-24S	20~1000	36	46	SOT-115J
Under Development	500~2600	40~50		
Under Development	2500~6000	40~47		

With much experience on Hybrid and Pallet PA design, custom solution can be provided within a week just for you.
Listed products are just a few of our capability, so contact us now for wider bandwidth power amplifiers.

RFHIC
www.rfhic.com

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

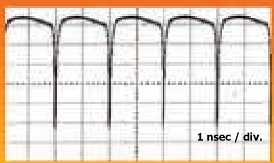
RFHIC, Innovative Solutions for RF System Design.

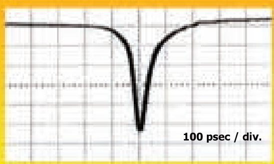
Manufacturer of high frequency components
for wired & wireless telecommunication
RFHIC is in compliance with EU's Standard RoHS regulations

Visit http://mwj.hotims.com/16346-134 or use RS# 134 at www.mwjournal.com/info

Impulse Generators 100 - 2000 MHz

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



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

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

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

Herotek

The Microwave Products Source

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

Visa MasterCard Accepted

tive Array (AMSAR) programme was launched in 1992 in order to set up a technology demonstrator within GTDAR [a consortium between Thomson-CSF, GEC-Marconi Avionics and Daimler Benz Aerospace (now EADS)]. This tripartite programme began in 2003 with flight trials beginning in 2008.

However, markets don't wait. To fit in with the Typhoon and Rafale fighter programmes, radar manufacturers had to provide interim solutions, respectively CAPTOR with a mechanical slotted antenna for the first, and RBE2 with an electronic lens PESA for the second. At the same time Thales studied a new 1000 T/R active antenna, based on AMSAR experience, featuring a 'plug and play' antenna to be included in a new RBE2-AA. Simultaneously, a Euroradar consortium, with Selex Sensors & Airborne Systems, Galileo Avionica —both united since May 2005 as Selex Galileo—EADS Defence Electronics, and INDRA made CAESAR, a 1425 T/R array to be plugged in an upgraded Captor-E CAESAR. AESA technology had become the de-facto standard for the radars of all advanced European fighters.

Technologically, active modules of an AESA are implemented with a limited number of monolithic integrated circuits, performing functions of phase shifter, microwave mixing, high power amplification, low noise amplification and T/R high frequency switching. More often HPA, LNA, attenuator and phase shifters use GaAs and the T/R switch uses a circulator. Today efforts lay in packaging, cooling, and compatibility with 'tile' antenna architectures. In the next five years, new components like GaN (which support higher power density and wider bandwidth) should be introduced for HPA and LNA, SiGe for phase shifters, and MEMS for power switching.

Providing radar manufacturers with adequate AESA components has become a top priority for the European microwave industry. It is a good opportunity to enforce Europe's position in the highly competitive market of GaAs and other MMIC technologies. In return, radar should benefit to some extent from the mass production techniques developed for the consumer electronics market.

CONCLUSION

This Report began by relating the state of the European microwave industry in the early 1960s and posed questions as to how it had changed and developed during the intervening years. Of course, there are no definitive answers apart from the fact that the continent has had to adapt to political change, particularly in Eastern Europe and the expansion of the EU, economic pressures and competition from emerging markets such as India and China.

A stark reality is that against the background of changing markets and increased competition, companies have undergone rationalisation, merged or made acquisitions. In recent years the landscape of European microwave companies has changed with many of the household names that were synonymous with the industry being renamed, merged or gone completely. Now, companies are rarely single country flagships, but more likely part of large international organisations.

However, what has not changed and what has been illustrated in this Report is the wealth of industrial and academic expertise that is not only a part of Europe's history, but is also its present and its future. Europe is at the forefront of technological development in many sectors. Through Europe-wide initiatives such as the Framework Programme (now in its 7th stage) and the associated Networks of Excellence Programmes, microwave research is taking an interdisciplinary and collaborative approach enabling system capabilities to guide the selection of new technologies. This is being backed up with financial investment and commercial development in an environment of coordination and cooperation at academic, industrial and political levels. Europe has a rich and valuable microwave history. That can continue if it focuses on exploiting its core competencies of a highly skilled research and development capability and the production of added value products and services. ■

ACKNOWLEDGMENTS

The author would like to thank Józef Modelski and Yves Blanchard for their time and effort, and for sharing their knowledge and expertise.

High Dynamic Range Amplifiers

An amplifier's True Dynamic Range (TDR) is the range of input signals in which spurious outputs are below the noise level of the output. Engineers can choose from Teledyne Cougar's standard catalog solutions, or talk directly to a Cougar application engineer for custom performance capabilities.

Model	Freq. Range (MHz)	Small Signal Gain (dB) Typ.	Noise Figure (dB) Typ.	Power Output at 1dB Comp. (dBm) Typ.	Dyn. Rng.* (dB) Typ.	Intercept Pt. 3rd/2nd (dBm) Typ.	D.C. V Nom.	D.C. mA Typ.
AP1207	10-1200	11.0	2.8	25.5	98	43/66	15	188
AP1053	10-1000	11.0	1.5	26.0	97	39/58	15	100
ARJ109	0.5-200	10.8	4.5	28.5	96	44/75	15	235
AR1096	600-1000	14.2	2.1	28.0	96	42/58	15	230
AP348	10-250	13.5	3.2	25.0	95	42/57	15	108
AP2009	10-2000	11.0	3.5	28.0	95	40/50	15	188
AP1051	10-1000	11.5	1.5	23.0	94	35/52	8	89
AP2079	10-2000	10.3	3.1	24.5	94	38/54	15	125
AC652	10-600	10.8	1.3	18.8	93	32/45	5	48.5
A2CP6008	2000-6000	11.0	3.0	24.0	92	34/50	12	250
AC5079	100-5000	7.5	4.7	20.5	91	33/55	15	115

Typical and guaranteed specifications vary versus frequency; see detailed data sheets for specification variations.

Teledyne Cougar is your one-stop source for catalog and custom high dynamic range amplifiers, RF and Microwave components, integrated assemblies, subsystems, and value-added service needs.

TELEDYNE COUGAR RF & MICROWAVE PRODUCTS • QUALITY • PERFORMANCE • ON TIME

TELEDYNE COUGAR
A Teledyne Technologies Company

ISO 9001:2000 • 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: Amp@teledyne.com

Visit http://mwj.hotims.com/16346-159 or use RS# 159 at www.mwjournal.com/info

A MICROWAVE JOURNEY, PART IV: THE 1980s

This six-part series looks at five decades of the microwave industry recorded in *Microwave Journal*. In this fourth installment, we focus on the 1980s, a decade marked by such notable events as the birth of MTV, punk rock and "new wave," the marriage of Prince Charles and Diana, the Cosby Show, the fall of the Berlin Wall and disasters such as the bombing of Flight 103 over Lockerbie, Scotland, the Challenger explosion, and industrial accidents at a chemical plant in India and a nuclear facility at Chernobyl in the former USSR.

The decade also saw dramatic social, economic and political change. Economic liberalization among western countries came with the rise of right-wing politics in the US and the "Reagan Revolution" along with other world leaders such as Margaret Thatcher, Helmut Kohl, Brian Mulroney and Carlos Salinas. Among eastern countries, hostility toward authoritarianism put pressure on the economies of communist states, bringing about policies such as perestroika and glasnost, while developing countries felt the crushing economic burdens brought on by a debt crises, drought, food shortages and war.

During the Reagan years, the Cold War would heat-up and spawn renewed investment in the US military with a particular focus on R&D. Once again, the microwave industry was a beneficiary of this government spending. The money led to significant advances for microwave components used in EW, ECM, guided tactical weapons, and tactical communications systems for command and control architecture. Commercially, the huge demand for voice and data transmission led to major advances in digital modulation techniques, satellite communication continued to advance, providing links for the distribution of content to local cable TV operators. GaAs and MMIC technology, driven by the needs of the military experienced great technical gains, yet also experienced a disastrous start in the commercial world and test & measurement showed significant advances due to microprocessors while computer aided design moved from the research lab to the microwave designer, aided by the personal computer.

DAVID VYE
Editor, Microwave Journal

Your Source for Programmable Step Attenuators

Aeroflex / Weinschel offers an extensive range of PIN, GaAs, Edge-line, and Relay based programmable attenuators to support your test and subsystem applications. Our wide selection of attenuators offers exceptional repeatability and performance for all applications. Aeroflex / Weinschel designs offer...

- Wide Selection of Attenuation Ranges & Steps Sizes
- Choice of Frequency Ranges: dc – 1, 2, 3, 4, 6, 18, 26.5, 40 GHz
- Built-In TTL\CMOS Interface or SmartStep®, Driver Circuitry available.
- High Quality Construction & Connectors
- Phase Compensated & 75 Ohm Designs
- Multi-channel and High Power Attenuator Units
- Custom designs our specialty!

Aeroflex / Weinschel attenuators operate across multiple frequency bands and support applications that include military and commercial satellite, ground communications systems, cable modem and cellular telephone testing, telecommunications, radar, and precision microwave test instrumentation.

Multi-channel attenuation subsystems are available for cable and mobile wireless test applications, including RF simulation, multi-path and fading, high-power hot-switching attenuation, RF signal conditioning and production testing.

Aeroflex / Weinschel, Inc.
800-638-2048, 301-846-9222
www.aeroflex.com/weinschel
weinschel-sales@aeroflex..com
www.aeroflex.com/microwave

Wide range of Models and Designs available Off-The-Shelf

Model	Frequency Range (GHz)	Attenuation Range (dB)	Notes	Model	Frequency Range (GHz)	Attenuation Range (dB)	Notes
150-11	dc-18.0	0-11/1		3200-1	dc-2.0	0-127/1	
150-75-3	dc-18.0	0-75/5		3200-2	dc-2.0	0-63.75/.25	
150-70	dc-18.0	0-70/10		3200-1E-2	dc-3.0	0-127/1	
150-70-1	dc-18.0	0-70/10		3200-2E-2	dc-3.0	0-63.75/.25	
151-11	dc-4.0	0-11/1		3201-1	dc-2.0	0-31/1	
152-90-3	dc-26.5	0-90/10		3201-2	dc-2.0	0-120/10	
150T-11	dc-18.0	0-11/1	◆	3206-1	dc-2.0	0-63/1	
150T-15	dc-18.0	0-15/1	◆	3200T-1	dc-2.0	0-127/1	◆
150T-31	dc-18.0	0-31/1	◆	3206T-1	dc-2.0	0-63/1	◆
150T-62	dc-18.0	0-62/2	◆	3250T-63	dc-1.0	0-63/1	◆ X
150T-70	dc-18.0	0-70/10	◆	3406-55	dc-6.0	0-55/1	*New*
150T-75	dc-18.0	0-75/5	◆	3408-55.75	dc-6.0	0-55.75/0.25	*New*
150T-110	dc-18.0	0-110/10	◆	3408-103	dc-6.0	0-103/1	*New*
151T-110	dc-4.0	0-110/10	◆	4216-63	0.8-3.0	0-63/1	
152T-55	dc-26.5	0-55/5	◆	4218-127	0.8-3.0	0-127/1	
153-70	dc-40	0-70/10	*New*	4238-103	.01-2.5	0-103/1	
153-110	dc-40	0-110/10	*New*				

Notes: ◆ SmartStep® Control Circuitry, X = 75 Ohm Model
For a complete list of available models/designs, visit our website @ www.aeroflex.com/weinschel-programmables

Visit http://mwj.hotims.com/16346-6 or use RS# 6 at www.mwjournal.com/info

AEROFLEX
A passion for performance.

RF Microwave Filters & Components
Standard & Custom Designs Available to meet your Specifications

Microwave Filter Company, Inc.
800-448-1666
315-438-4700
E-mail: mfcsales@microwavefilter.com
Web: www.microwavefilter.com
Made in the USA
ISO 9000:2001 Registered Company

THE 1980S

February 1980

While the first issue of the new decade may have included a broader range of application topics (e.g. "Microwave Communications from the Outer Planets: The Voyager Project;" "A Rotating Directional Antenna Feed System for a Microwave Oven"; "Microwave Apparatus for the Treatment of Cancer by Hyperthermia;" and "A Synthesized Approach to Satellite-TV Reception"), February was focused on defense electronics. In a special report, Lynwood Cosby of Naval Research Labs wrote about the microwave challenges for EW applications in the '80s. His two principle observations were that "A broad technology base must consistently exist to support the wide range of equipment development options." The author described several past wartime events where a gap in electronic technology between combatants significantly influenced the outcome. He cautioned readers that "We must not fall in the trap of believing that EW is a mature technology." The author's other main observation (and by his accord—even greater significance") was that "it is better to take a high-risk long-shot R&D approach rather than stay with a tried and proven approach." Again the author used examples from history to lobby for what we frequently refer to now as "disruptive" technology. In presenting his case for taking a high risk approach to component design for EW, the author explicitly mentions solid-state technology. The defense department's interest in solid-state technology and GaAs devices in particular is evident in numerous articles appearing in this issue and others throughout the '80s.

Other defense related articles this month included a special report on the 1979 DoD/AOC (Association of Old Crows) EW Symposium, Principles of EW: Radar and EW; and a look at Navy Microwave Component Contracts by Eliot Cohen of NRL. The author looked specifically at contract programs to develop S-band power GaAs FETs, FET amplifiers (including low noise amplifiers), Schottky barrier mixer diodes (for use in 94 GHz systems) and monolithic integrated circuits. Contract winners mentioned by name included Avantek, Hughes Aircraft, Microwave Associates and Texas Instruments.

March 1980

Either by intent or coincidence, the following month was dedicated to the theme of microwave solid-state. In the guest editorial, "The First Thirty Years" by Lawrence Thielen of Avantek, the author congratulated *Microwave Journal* founder William Bazzy for predicting that "the microwave industry would come of age at the dawning of the '80s." The author cited the yearly revenue of the average mid-sized microwave component manufacturer and the value of a typical contract and concluded that the industry was too prosperous for the investment community to ignore. "These investors have come to realize that our once-fledgling cottage industry—largely DoD supported—is today an industry with great depth and breadth, and one with remarkable growth potential and staying power." Another interesting comment from the author of this article, nearly 30 years old: "Our technology is even helping to reduce the debilitating effects of high-priced petro-energy—inexpensive, effective communications eliminates the need for many auto and airline trips."

Theme-related articles included a special report from Keith Kennedy of Watkins-Johnson on the then recent technical advances and projections for continued improvements to microwave and millimeter-wave solid-state devices. Seeing solid-state as critical to reducing costs and forcing standardization, the author specifically called attention to advances in Gunn and IMPATT diode technology. Taking more of the spotlight than these two device types was the GaAs MESFET. Fellow W-J engineer, Karl Niclas wrote a technical article on GaAs MESFET feedback amplifiers. Ira Drukier of Microwave Semiconductor Corp. (MSC) discussed the "Design of a 15 GHz High Power GaAs FET." The performance of this device from the early '80s showed a peak output power of 30 dBm, 6.7 dB gain at 17.0 percent PAE. Raytheon technical guru and author of microwave device text books, Robert Pucell wrote an article entitled "Per-

Aethercomm salutes our armed forces!

Another industry first from Aethercomm:
a 20 MHz to 6000 MHz 10 Watt
RF amplifier in a single module!

Aethercomm thanks the U.S. Military for a job well done.

We design & manufacture RF amplifiers and systems used for Force Protection and other life saving missions. Aethercomm products are combat proven and operate in the harshest environments on the earth.

Featured Product : SSPA 0.02-6.00-10

- *GaN technology*
- *20 MHz to 6000 MHz bandwidth*
- *10 Watts PSat output power typical*
- *50 dB small signal gain typical*
- *28 Vdc operation*
- *+/- 3 dB gain flatness typical*
- *-40C to +85C base plate operation*
- *2.5" (w) x 6.4" (l) x 1.0" (h)*

Applications:
- *EW Jamming*
- *Broadband Communications*
- *Test and Measurement*

Contact Aethercomm with your RF amplifier requirements.

BSI REGISTERED
ISO 9001:2000
FM 89386

Tel 760.598.4340
Fax 760.598.4342
sales@aethercomm.com
www.aethercomm.com

Aethercomm®

RF & Microwave Components

The right solution. Right now.

Immediate delivery of quality components from stock.

- DC-18GHz Fixed Attenuators
- Wilkinson Power Dividers
- 3GHz Manual Variable Attenuators
- Programmable Attenuators
- DC-18GHz terminations
- Solid-State Multi-throw switches 10MHz – 4.2GHz

TRILITHIC
INNOVATIVE ENGINEERING

To find out more, call **(800) 344-2412** *or visit* **www.trilithic.com.**

formance of GaAs MESFET Power Combiner" in which he described a four FET combiner that delivers over 2 W of output power at 10 GHz. Meanwhile, contributing editor Joseph White wrote a special report entitled "Why Go to MTT?"

May 1980

Microwave Journal dedicated its May issue to the MTT-S Symposium with the magazine cover showing the conference location (Washington, DC). The magazine included a listing of the complete technical guide and exhibitor list, and map of the exhibition floor plan. Editor Joseph White wrote the second of *Microwave Journal's* annual "Attending the Conference" article. The format of the "show issue" and our extensive coverage began the year before in April 1979 and will go mostly unchanged right through today. Starting in 1980, however, the show issue is published every May up to the present.

January 1983

The January issue is dedicated to communication systems and featured articles describing an industry grappling with how to improve the capacity and efficiency of voice and data transmission. While cell phone technology is not among the challenges mentioned, the digital modulation techniques that will make cell phones feasible are the focus of several articles. The communication systems written about were concerned with applications such as common-carrier digital point-to-point terrestrial radios for long haul telecommunications, satellite relay links, privately owned digital switches and microwave links for industry and point-to-multipoint inter-city communication networks to mention a few.

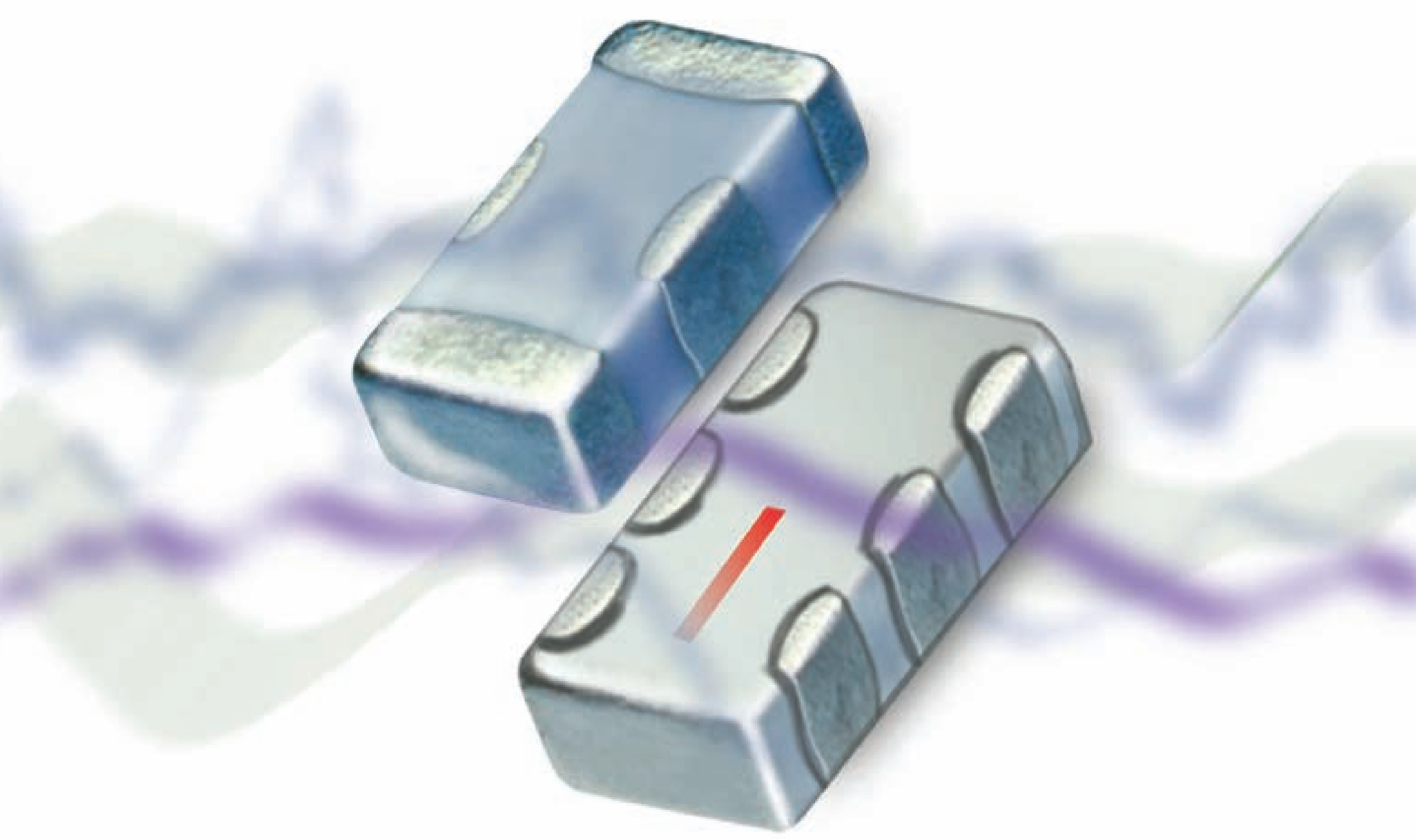
By 1983, digital technology was being heavily investigated by the microwave world, made evident in a business/special report by guest editor Harold Sobol of Rockwell International (Collins Transmission Systems Division). In his article, "Progress in Microwave Communication Systems," Sobol brings the reader up to speed on the state-of-the-art in communications equipment. "Digital radios for PCM voice and data transmission, interconnections of electronic digital switches and wideband encrypted messages have been in service during the last five years," wrote Sobol. "Earth stations for satellite relay stations are undergoing enormous changes and direct broadcast video systems for residential use are just around the corner."

Sobol described the primary factors responsible for changing microwave communications equipment to be "the growth of telecommunications in the public, private and government sectors and the demand for new types of service." The goal then (and now) was to increase channel capacity within FCC allocated channels. Sobol wrote about analog long haul FM radios (6 GHz, 30 MHz BW, 2700 voice circuit capacity per channel) being replaced with SSB radios with 6000 voice circuit capacity (a significant improvement in spectrum utilization), the capacity of high density microwave digital radios (employing 8 PSK, 16 and 64 QAM modulation schemes) and the promise of fiber optics to address the channel capacity challenge. At the time of this editorial, new digital radio technology based on 64 QAM showed an increase in capacity of 50 percent at 6 GHz compared to the 8 PSK radios, which was the modulation technique in the majority of digital radios in use at the time. This put 64 QAM on par with analog FM, but still a far cry from the analog SSB radios.

May 1983

The Boston skyline at dusk graces the cover of the *Journal* in honor of the location of MTT-S in 1983. That year's conference was projected to be the largest to date with 250+ exhibitors (an increase of 25 percent over the previous high). Guest Editorial included MTT-S Adcom president Charlie Rucker who wrote about the engineer supply problem. Technical Program Chair Ralph Levy and Consulting Editor Joe White who was also serving as Chair of Special Events wrote pre-show articles. Future *Microwave Journal* publisher/editor Harlan Howe served as the chairman of that year's Steering Committee.

It was also a big year for microwave instrumentation equipment to appear on *Microwave Journal* covers, reflecting the developments oc-



CERAMIC FILTERS

LOW PASS AND HIGH PASS

Over 120 models... 80 MHz to 13 GHz from **99¢** ea. (Qty.1000)

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!

RoHS compliant
U.S. Patent 6,943,646

NEW! ***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!*

Mini-Circuits®
ISO 9001 ISO 14001 CERTIFIED

minicircuits.com

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

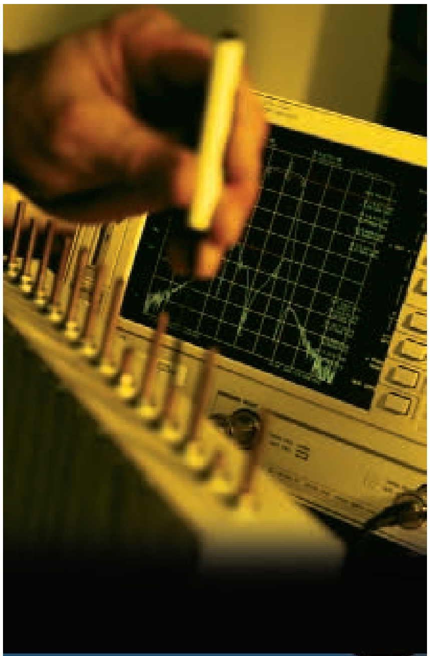
YONI2™ Patent Pending

The Design Engineers Search Engine** Provides ACTUAL Data Instantly From MINI-CIRCUITS At: **www.minicircuits.com

IF/RF MICROWAVE COMPONENTS

432 Rev B

Visit http://mwj.hotims.com/16346-98 or use RS# 98 at www.mwjournal.com/info



RF & Microwave Solutions

Fast.
Flexible.
For you.

Whether it's custom filters or stock components, you need solutions tailored for your unique requirements. And you need them fast.

At Trilithic, innovation is about more than engineering and technology. It's about listening to your needs and expectations. So together we can create solutions that work for you – today and tomorrow.

TRILITHIC
INNOVATIVE ENGINEERING

To find out more, call **(800) 344-2412** *or visit* **www.trilithic.com.**

curring in the automation of test & measurement systems. These new capabilities were made possible in part through the recent advances in microprocessors. A fourth generation Hewlett-Packard scalar network analyzer was featured on the cover of March's "microelectronics" issue, Wiltron's 5669 ANA with a measurement sweep range up to 40 GHz was featured on the cover of the June "millimeter-wave" issue, a Marconi power meter that "exploits microprocessor capabilities to enhance the speed and accuracy of its average and peak power measurements" appeared on the April "microwave instrumentation" issue, another power meter appears on the November "super-components" issue (this time the "new" 438A dual sensor power meter from HP) and in December, a photo of a Wavetek model 952 1 to 4 GHz microwave source. This focus on instrumentation on the cover spills over into 1984 with the January cover featuring the new vector "real-time" network analyzer also from HP.

January 1988

Digital communication is again the focus of the January issue and in the five years since the editorial by Sobol, Ferdo Ivanek of Communications Research reports that the effort to match and eventually surpass the spectral efficiency of SSB via digital radio is about half the way to its goal with a system using 256 QAM (not yet in commercial operation). However, work is already under way to double the spectral efficiency through frequency re-use with orthogonal polarizations. The gap continued to close between analog and digital radios.

The author mentioned that achieving greater spectral efficiency would come at the cost of system complexity, which in turn would require higher-levels of circuit integration. At the time, high level integration was beyond the state-of-the-art for GaAs MMICs, but was well within the reach of CMOS. An additional challenge for multilevel modulation methods used by these digital radios was the serious performance degradation of nearly saturated solid-state power amplifiers due to nonlinear behavior. The hope of achieving greater capacity through digital modulation would depend on advances in developing RF integrated circuit technology. Of the other papers that month addressing digital microwave communications, three are system related dealing with high capacity transmission using 16 QAM, 64 QAM and 256 QAM, and the other two are on microwave components—power amplifiers and oscillators.

Several times that year, the state of GaAs technology and the GaAs market comes under scrutiny. The first article dealing with this topic is "The Elusive GaAs MMIC Market" by Jeff Montgomery of ElectroniCast Corp. Since Frank Brand wrote in *Microwave Journal* 10 years earlier that the promise of GaAs could be threatened by a shortage of material suppliers, 30 laboratories worldwide had made major investments in the technology (partially with US government support). Investments of $91 M in 1987 were expected to reach $194 M by 1992 in pursuit of business projected to be within the range of $500 M to over a $1 B by 1991. Nice return. Unfortunately, at the time of this article, the author reported that the enthusiasm of almost every laboratory manager was in decline as they were beginning to conclude that high volume use of GaAs MMIC was much further out than originally projected. Why? The earlier studies were based on the consensus views of the researchers themselves rather than the markets they would be selling into. Because most labs were captive, MMIC researchers and manufacturers could not see past their own needs. The importance of high volume production and low cost was initially off everyone's radar.

A similar outlook was shared by editor Joe White in his April article "GaAs: The Bumpy Road." White wrote that the market for GaAs devices could be met by two firms; the remainder represented manufacturing overcapacity. Still, speed performance including that of the relatively new HEMT devices fueled the remaining optimism for the technology. Various individuals provided their predictions as to who would succeed and who would fail. Some would re-coup their investment by offering foundry services

NEW

ATC 800 Series High RF Power Multilayer Capacitors

Building On The Excellence Of Our 100 Series...

- Optimized Form Factor
- Lowest ESR @ Wireless Frequencies
- Highest Self Resonance
- Rugged, Reliable NPO Dielectric
- High RF Power Applications
- Superior Thermal Performance
- Ideal for Large and Small Signal Applications

800 SERIES Case A	Capacitance Range	Electrical Specifications
.055" x .055" (1.4 mm x 1.4 mm)	0.1 pF to 100 pF	Voltage Rating: Up to 250 WVDC • IR: 10^5 MΩ @ 25°C • TCC: 0 ±30 PPM/°C
800 SERIES Case B	**Capacitance Range**	**Electrical Specifications**
.110" x .110" (2.79 mm x 2.79 mm)	0.1 pF to 1000 pF	Voltage Rating: Up to 500 WVDC • IR: 10^5 MΩ @ 25°C • TCC: 0 ±30 PPM/°C

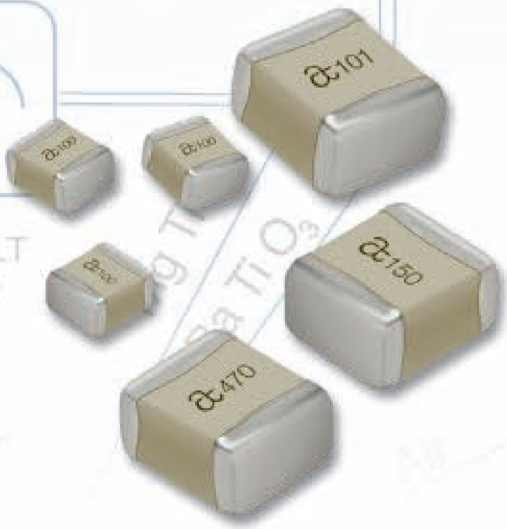
NEW

ATC 100 A/B & 700 A/B Porcelain MLCs for the Broadest Range of Extended Voltage Ratings to 1500 WVDC

Supports a wide range of critical large and small signal applications including:

- MRI Imaging Coils
- High RF Power Amplifiers and associated devices
- High RF Power Switching
- Matching Networks
- Filter Networks
- Antenna Matching
- Transceiver Modules

100A/700A		
Capacitance Range	Standard WVDC	Extended WVDC
0.1 to 56 pF	150 WVDC	250 WVDC
62 to 100 pF	150 WVDC	200 WVDC
100B/700B		
Capacitance Range	Standard WVDC	Extended WVDC
0.1 to 47 pF	500 WVDC	1500 WVDC
51 to 100 pF	500 WVDC	1000 WVDC
110 to 200 pF	300 WVDC	1000 WVDC



AMERICAN TECHNICAL CERAMICS

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

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

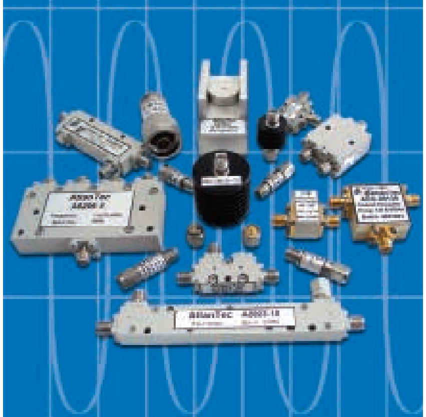
ATC Asia
+86-755-8366-4318
sales@atceramics-asia.com

THE ENGINEERS' CHOICE™

www.atceramics.com

Visit http://mwj.hotims.com/16346-9 or use RS# 9 at www.mwjournal.com/info

"Passives" by AtlanTecRF



Adapters
Attenuators
Cable Assemblies
Circulators
Coaxial Cable
Connectors
Couplers
Filters - Low Pass
Filters - High Pass
Isolators
Mixers
Power Dividers
Switches
Terminations

Bookmark your favorites @ AtlanTecRF.com

offering MMIC circuit realization (three to five wafer execution over six months at a cost between $50,000 and $100,000) while others would succeed by finding the right niche markets best suited for the benefits of GaAs devices and not hampered by any technical or production-related downside. The losers would likely be captive fabs with only a military customer to cover their expenses.

Nineteen eighty-eight saw new activity on the computer simulation front with an ad from Compact Software depicting a new nonlinear simulator for microwave frequencies based on a technique known as harmonic balance. The simulator called Microwave Harmonica is portrayed as a race car, speeding past another race car labeled SPICE. Microwave Harmonica would be the cover story ("New Design Workstation Simplifies the Design Process") of the July issue that year. EEsof, which introduced the PC platform-based Touchstone circuit design product in 1983, introduced Omnisys. This simulator specifically for microwave system designers made its *Journal* debut as an insert in the May Show issue and in a technical feature that month. Hewlett Packard (now Agilent) would acquire EEsof to compliment its design software product called Microwave Design System (MDS) and eventually both products would be replaced by the familiar ADS product still in use today.

January 1989

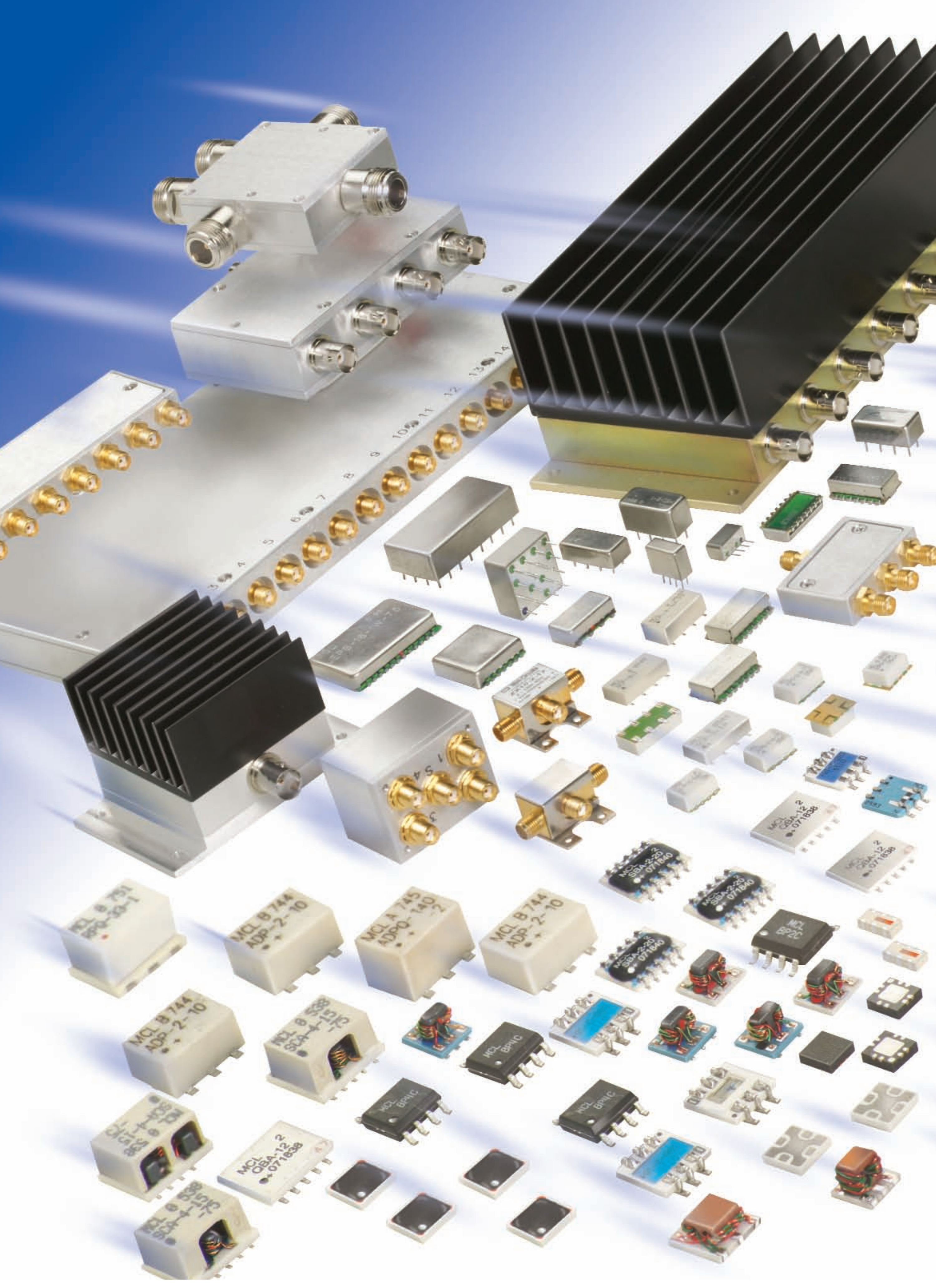
In the first issue closing out the decade, *Microwave Journal* Staff Editors Martin Stiglitz and Lloyd Resnick provided a report on the government program that, unlike any other, tied together all the advances in solid-state processing and design development, test and measurement techniques and computer-aided design and would propel these technologies to the next level. Their article—"The MIMIC Program: A Technology Impact Report"—gave an excerpt on the MIMIC program, including its goals, structure, program phases, and the targeted military and commercial applications. This program epitomized the convergence of technical advances that took place over this phenomenal decade in microwave technology. MIMIC was a R&D effort sponsored by the DoD and conducted by DARPA and the military services. Together, they would be responsible for developing a family of monolithic analog integrated circuits and modules that could be used in the front-end of military electronic systems operating at microwave or mm-wave frequencies.

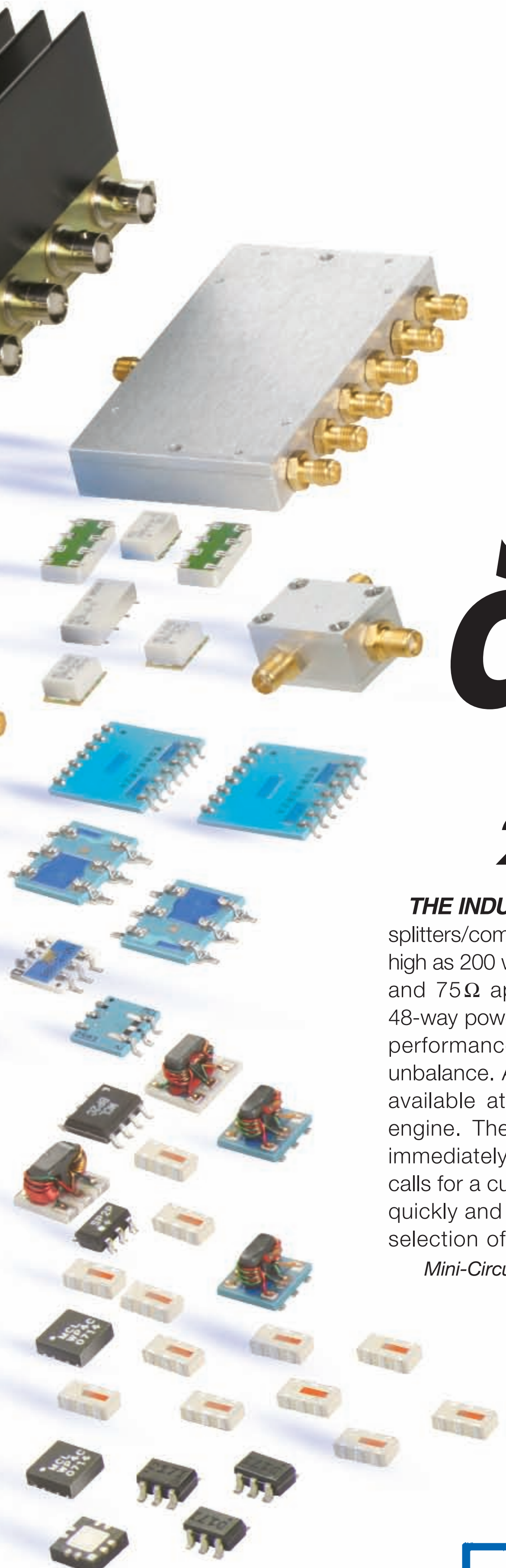
The program was modeled after the very high-speed IC (VHSIC) program and would be largely responsible for inter-company cooperation and technical developments that would not likely be pursued by civilian companies because of the limited commercial potential. However, the resulting advances would create new markets and opportunities similar to those created by the development of the Internet (another DARPA project). It is hard to imagine how today's mobile communication would have been possible without the influence of this program. It may also be equally hard to find a microwave engineer over the age of 40 who was not somehow connected to this program directly.

CONCLUSION

Driven by social and political activity, which was responsible for increased investment in military R&D, significant advances in solid-state processing and design for RF/microwave devices, modules and integrated circuits took place. Along with high-frequency device technology, advances in digital ICs provided the technology that would forever change the capabilities of test & measurement equipment and the computers that would host the new computer-aided design software that was becoming more abundant for microwave design. The industry would also be focused on developing methods to improve spectral efficiency to address the growing demand for data transmission. All these developments of the 1980s and the ending of the Cold War would provide the perfect alignment of resources, technology and need for new markets that would help our industry take on and achieve commercial success of an unprecedented scale—the wireless revolution of the 1990s. ■

Visit http://mwj.hotims.com/16346-33 or use RS# 33 at www.mwjournal.com/info


MCL B 744
ADP-2-10
MCL
BPNC



POWER SPLITTERS/ COMBINERS

2 kHz to 12.6 GHz as low as 79¢

THE INDUSTRY'S LARGEST SELECTION Mini-Circuits offers thousands of power splitters/combiners for applications from 2 kHz to 12.6 GHz and with power handling as high as 200 watts. Choose from coaxial, flat-pack, and surface-mount housings, for 50Ω and 75Ω 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 1year 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...we're redefining what VALUE is all about!

RoHS Compliant
Product availability is listed on our website.

Mini-Circuits®
ISO 9001 ISO 14001 CERTIFIED

ALL NEW minicircuits.com

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

Yoni2™ Patent Pending ***The Design Engineers Search Engine*** *Provides ACTUAL Data Instantly From MINI-CIRCUITS At:* ***www.minicircuits.com***

IF/RF MICROWAVE COMPONENTS

448 Rev Org

Visit http://mwj.hotims.com/16346-99 or use RS# 99 at www.mwjournal.com/info

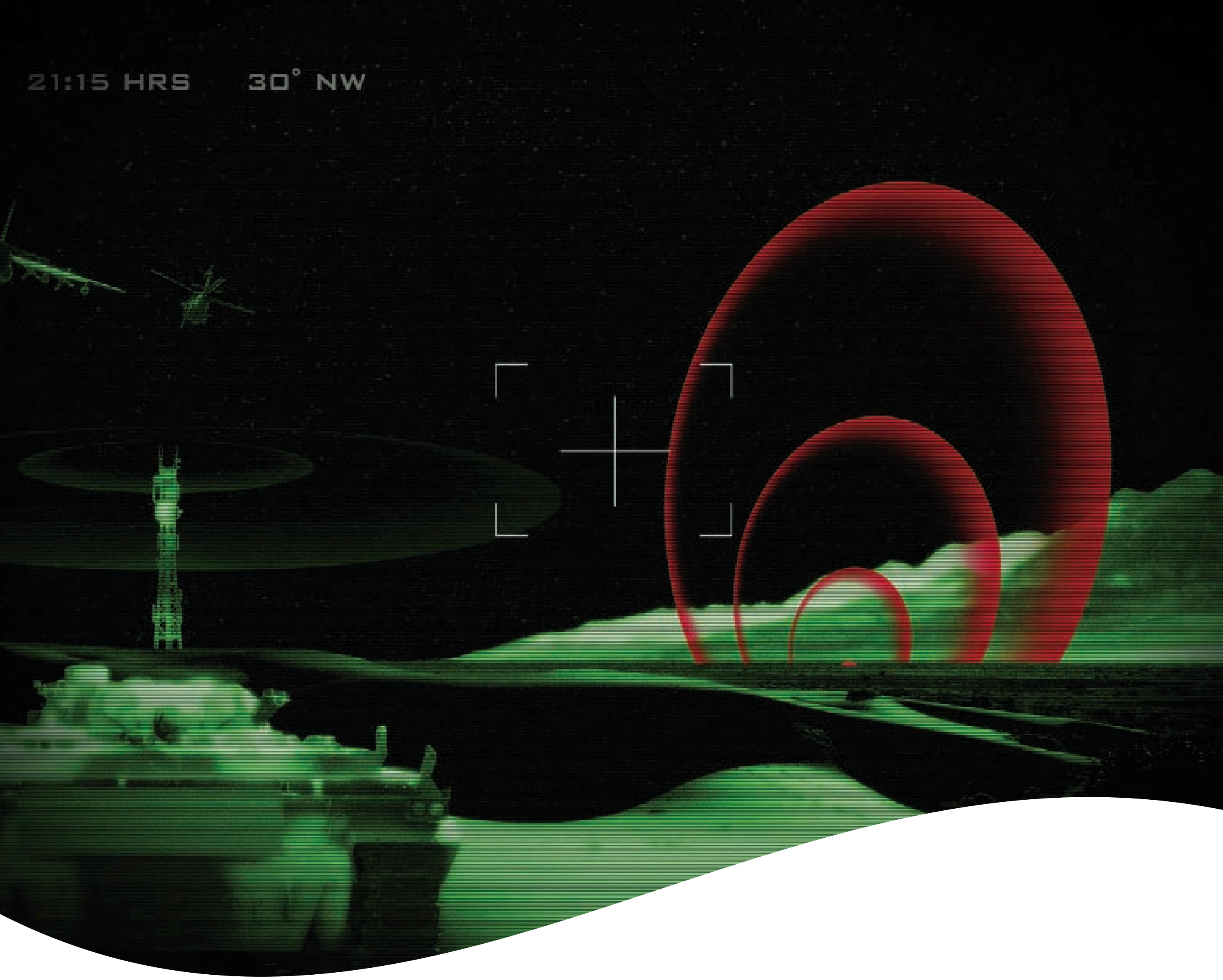
AN APPROACH FOR DETERMINING MOSFET SMALL-SIGNAL CIRCUIT MODEL PARAMETERS

A simple method for the extraction of the small-signal model parameters of a MOSFET is proposed. The intrinsic elements determined are described as functions of the extrinsic resistances. The parasitic elements are iteratively determined using the variance of the intrinsic elements as an optimization criterion. Good agreement is obtained between simulated and measured results over a wide range of bias points up to 30 GHz.

For the fabrication of high-performance CMOS RF/microwave IC modules, suitable IC design and device characterization technologies for high-frequency applications should be well established. A critical issue in the technologies is the development of a physically acceptable small-signal MOSFET model and an accurate parameter extraction technique, which are crucial to design linear RF ICs such as low noise amplifiers and develop a large-signal model for nonlinear RF IC design. In addition, this small-signal modeling is increasingly important because the device characteristic data used for optimizing RF device performance during the development cycle of process integration can be provided through the extraction of small-signal model parameters.[1]

An accurate procedure for extraction of the extrinsic resistances is extremely important for silicon MOSFETs. Optimization methods have conventionally been used for the determination of these parameters. However, the accuracy of the numerical optimization methods that minimizes the difference between measured and modeled S-parameters versus frequency can vary, depending upon the optimization method and starting values, and may result in nonphysical and no unique results for the extracted elements.[2] For the direct extraction of small-signal MESFET equivalent circuits from S-parameters, parasitic inductances and resistances are initially determined and subsequently the rest of the parameters are extracted from formulations.[3,4] However, this

QIAN WANG, CHENG YUAN AND YASEN HUANG
Southeast University, Nanjing, PR China
JIANJUN GAO
East China Normal University Shanghai, PR China



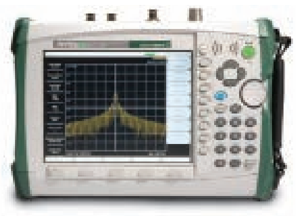
Distinguish the signals that matter

With unmatched dynamic range (101 dB), receiver sensitivity (-159 dBm), phase noise (-104 dBc/Hz), and full control of the RBW (1 Hz – 3 MHz), plus unprecedented frequency range (9 kHz – 20 GHz), Anritsu's 20 GHz Spectrum Analyzer gives you the power to detect any signal, no matter how well it's hidden. And because it delivers lab-quality performance in a lightweight, field-tested tool, you can take the Spectrum Master MS2724B wherever you need to secure communications—and protect lives.

Learn more. Download our White Paper, *Solving Your Radio Frequency Interference Problems*. To find out more about our specialized training courses, please visit www.anritsu.us/MS2724B824

Get a quote now at www.anritsu.us/S824

9 kHz to
20
GHz



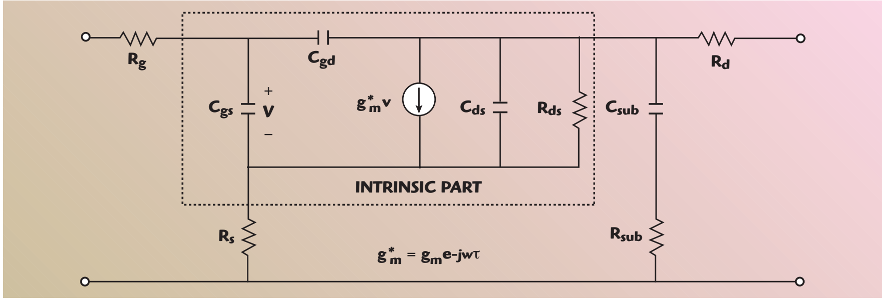
The Anritsu MS2724B
Spectrum Master

Anritsu

Sales Offices: USA and Canada 1-800-ANRITSU, Europe 44 (0) 1582-433433, Japan 81 (46) 223-1111, Asia-Pacific (852) 2301-4980, South America 55 (21) 2527-6922, www.us.anritsu.com ©2008 Anritsu Company

Visit us at MILCOM 2008 in San Diego, Booth #2036

Visit http://mwj.hotims.com/16346-13 or use RS# 13 at www.mwjournal.com/info



▲ *Fig. 1 Equivalent circuit of a MOSFET.*

cold-FET method cannot be applied to extract these resistances for Si MOSFETs because the DC gate current cannot flow due to the isolation between the gate and the rest of device. As a modified approach[5] for Si MOSFETs, extrinsic resistances have been extracted from S-parameters at zero bias condition (VGS = VDS = 0). This method may produce uncertainties due to possible bias dependences in the extraction of source and drain resistances.[6] Because of these difficulties, the values of the extrinsic resistances are often guessed or set to zero.[7]

In this article, an improved method to determine a MOSFET equivalent circuit, including the substrate-related parameters, is proposed. This method combines the advantages of the analytical and optimization extraction methods, and extracted results that are more accurate can be obtained. The intrinsic elements determined are expressed as functions of the extrinsic resistances. Assuming that the equivalent circuit is valid over the whole frequency range of the measurement, the parasitic elements are iteratively determined using the variance of the intrinsic elements as an optimization criterion.

ANALYTICAL DETERMINATION OF THE EQUIVALENT CIRCUIT

Parameters Extraction

Figure 1 shows the equivalent circuit of a short-channel MOSFET, whose intrinsic behavior is properly modeled by means of a quasi-static (QS) approach. Once the extrinsic resistances are determined, the intrinsic elements can be determined after de-embedding the open and short structures by using four steps as follows:

1) Subtraction of R_g and R_d:

$$Z_1 = Z_{DUT} - \begin{bmatrix} R_g & 0 \\ 0 & R_d \end{bmatrix} \tag{1}$$

Where Z_{DUT} is the matrix obtained from conversion of the de-embedded S-parameters to the corresponding Z-parameters.

2) Subtraction of the substrate parasitics:

 Visit http://mwj.hotims.com/16346-24

HUBER+SUHNER
Excellence in Connectivity Solutions

SUCOFLEX 400
The loss revolution

- Applicable up to 26.5 GHz
- Lowest loss on the market
- Best phase stability vs. temperature and bending
- Excellent VSWR

The new SUCOFLEX 400 family meets your highest demands.

HUBER+SUHNER AG Degersheimerstrasse 14 CH-9100 Herisau T +41 71 353 4111 hubersuhner.com

Visit http://mwj.hotims.com/16346-58 or use RS# 58 at www.mwjournal.com/info

$$Y_2 = Z_1^{-1} - \begin{bmatrix} 0 & 0 \\ 0 & \dfrac{\omega^2 C_{jd}^2 R_b}{1+\omega^2 C_{jd}^2 R_b^2} + \dfrac{j\omega C_{jd}}{1+\omega^2 C_{jd}^2 R_b^2} \end{bmatrix} \quad (2)$$

For the case of the substrate elements (R_{sub} and C_{sub}), the extraction is also biased on the MOSFET's equivalent circuit model at $V_{ds} = V_{gs} = 0$.[8] The real part of $1/Z_{22}$ at $V_{ds} = V_{gs} = 0$ is given by

$$\frac{\omega^2}{Re(1/Z_{22})} = R_{sub}\omega^2 + \frac{1}{C^2_{sub} R_{sub}} \quad (3)$$

R_{sub} can be determined from the slope m_0 of the linear regression of the $\omega^2/Re(1/Z_{22})$ versus ω^2 data, whereas C_{sub} is determined from the intercept with the abscissa b_0 by applying:

$$C_{sub} = \frac{1}{\sqrt{m_0 \times b_0}} \quad (4)$$

3) Subtraction of R_s:

$$Y_3 = \left(Y_2^{-1} - \begin{bmatrix} R_s & R_s \\ R_s & R_s \end{bmatrix}\right)^{-1} = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} = \begin{bmatrix} j\omega(C_{gs} + C_{gd}) & -j\omega C_{gd} \\ g_m e^{j\omega\tau} - j\omega C_{gd} & R_{ds}^{-1} + j\omega(C_{gd} + C_{ds}) \end{bmatrix} \quad (5)$$

4) Intrinsic Elements

The intrinsic elements can be obtained from the intrinsic Y-parameters.

$$C_{gd} = -\frac{Im(Y_{12})}{\omega} \quad (6)$$

$$C_{gs} = \frac{Im(Y_{11}) + Im(Y_{12})}{\omega} \quad (7)$$

$$C_{ds} = \frac{Im(Y_{12}) + Im(Y_{22})}{\omega} \quad (8)$$

$$R_{ds} = -\frac{1}{Re(Y_{22})} \quad (9)$$

$$g_m = \left|Im(Y_{21}) - Im(Y_{12})\right| \quad (10)$$

$$\tau = -\frac{1}{\omega}\tan^{-1}(Im(Y_{21}) - Im(Y_{12}), Re(Y_{21}) - Re(Y_{12})) \quad (11)$$

CRITERION OF CIRCUIT VALIDITY

The intrinsic elements can be determined by solving Equations 6 to 11 as functions of the extrinsic elements as well as frequency:

$$R_{sub} = f_0(\omega_i, R_g, R_d, R_s) \quad (12)$$

$$C_{sub} = f_1(\omega_i, R_g, R_d, R_s) \quad (13)$$

$$C_{gd} = f_2(\omega_i, R_g, R_d, R_s) \quad (14)$$

$$C_{gs} = f_3(\omega_i, R_g, R_d, R_s) \quad (15)$$

26 to 65 GHz
High Frequency Components

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

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

Ideal for
Test and Measurement
Optical Communications
Microwave Radio Links

Pictured left to right:
2.4mm DC Block 7 kHz - 50 GHz
2.92mm Attenuator DC - 40 GHz
2.92mm Bias Tee 7 kHz - 40 GHz
2.92mm Termination DC - 40 GHz
2.4mm Termination DC - 50 GHz
1.85mm Attenuator DC - 50 GHz

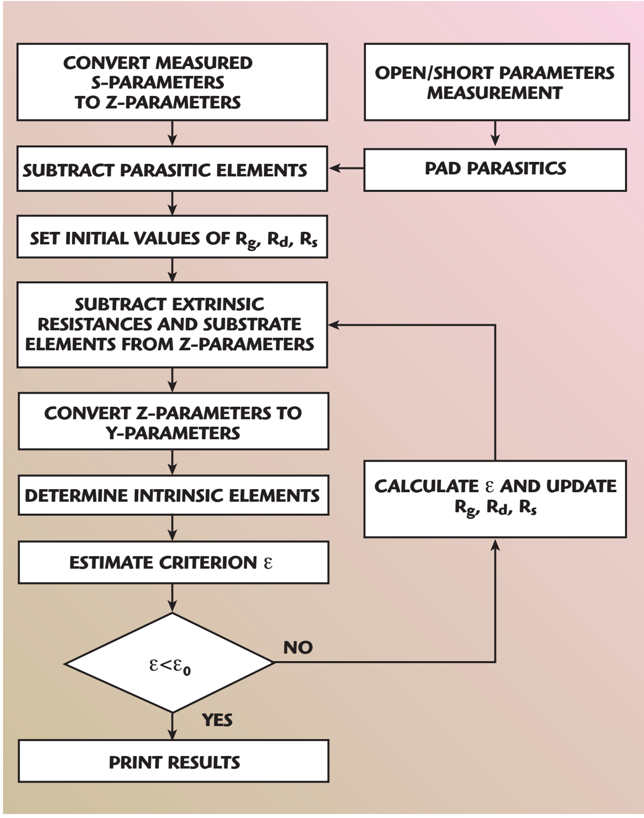
Aeroflex / Inmet
Ann Arbor, Michigan
www.aeroflex-inmet.com

AEROFLEX
A passion for performance.

AEROFLEX INMET
An ISO 9001 Certified Company

Visit http://mwj.hotims.com/16346-4


Voltronics Corp
Chip Trimmer Capacitors
are the Smart Choice!
Our Chip
Trimmer
Capacitors
Stability Better Than ±1%
RoHS Compliant
Immediate Delivery
JZ
JR
JV
Actual
Size
JQ
JN
Delivery:
Up to 50,000 pieces
stock to 4 weeks
on most parts!
Voltronics
CORPORATION
The Trimmer Capacitor Company
A DOVER COMPANY
RoHS
COMPLIANT
100 Ford Road, Denville, NJ 07834
973.586.8585 • Fax: 973.586.3404 • e-mail: info@voltronicscorp.com
www.VoltronicsCorp.com
Visit http://mwj.hotims.com/16346-170 or use RS# 170 at www.mwjournal.com/info



▲ *Fig. 2 Flow chart of the iterative process.*

$$C_{ds} = f_4\,(\omega_i, R_g, R_d, R_s) \tag{16}$$

$$R_{ds} = f_5\,(\omega_i, R_g, R_d, R_s) \tag{17}$$

$$g_m = f_6\,(\omega_i, R_g, R_d, R_s) \tag{18}$$

$$\tau_m = f_7\,(\omega_i, R_g, R_d, R_s) \tag{19}$$

where ω is the angular frequency and I (=0, 1 … N-1) is the number of sampling points.

Assuming that the equivalent circuit is valid for all frequency measurement points and making use of the intrinsic elements for optimization criteria, the appropriate values for extrinsic elements can be determined by iteration without complicated additional measurements.

The first candidates for criteria are the derivatives of intrinsic elements with respect to frequency, but they sometimes suffer from numerical and measurement errors. Therefore, variances are chosen as criteria.[9] That is:

$$\varepsilon_1^k = \frac{1}{N-1}\bullet \sum_{i=0}^{N-1}\left| f_k(\omega_i, R_g, R_d, R_s) - \overline{\sum_{i=0}^{N-1} f_k(\omega_i, R_g, R_d, R_s)} \right|^2 \tag{20}$$

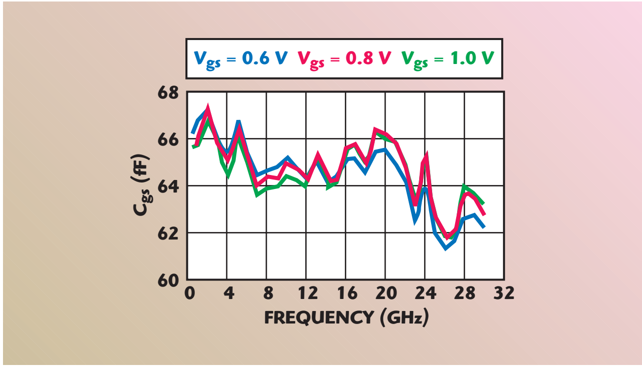
$(k = 0, 1, \ldots, 7)$

Moreover, for stable calculation, the discrepancy between the measured and calculated S-parameters is considered as a loose constrait. The mean values of intrinsic elements are used to calculate the S-parameters.

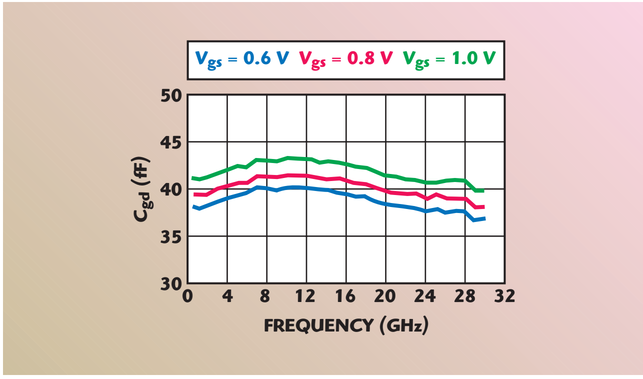
$$\varepsilon_2 = \frac{1}{N} W_{pq} \sum_{p=1}^{2}\sum_{q=1}^{2}\sum_{i=0}^{N-1} \left| \frac{\left|\mathrm{Re}(S_{ij}^s) - \mathrm{Re}(S_{ij}^m)\right| + \left|\mathrm{Im}(S_{ij}^s) - \mathrm{Im}(S_{ij}^m)\right|}{S_{ij}^{"}} \right|^2 \tag{21}$$

where
S^s= Modeled S-parameters
S^m=Measured S-parameters
W_{pq} (Fixed at 0.25)=Weight Factors
The extended error vector is then composed as follows:

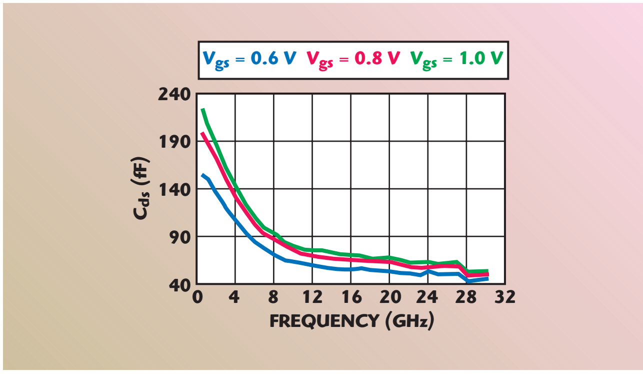
$$\varepsilon = \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix} \tag{22}$$



▲ *Fig. 3 C_{gs} frequency characteristics (V_{ds} = 1.0 V).*



▲ *Fig. 4 C_{gd} frequency characteristics (V_{ds} = 1. 0 V).*



▲ *Fig. 5 C_{ds} frequency characteristics (V_{ds} = 1.0 V).*


RF MOSFETs
Richardson Electronics & SEMELAB
SML
DMD1029
SML
DMD1006
SEME
LAB
SEMELAB's new
MOSFET packaging offers:
• Higher gain
• Reduced source inductance
• Exceptional linearity
• BeO-free
• Improved thermal resistance
• Full RoHS compliance
Your Global Source for RF, Microwave
and Power Conversion Products
Richardson Electronics
Call 1-800-737-6937 (USA/Canada) • rfwireless.rell.com • rwc@rell.com

SEMELAB's new MOSFET packaging offers:

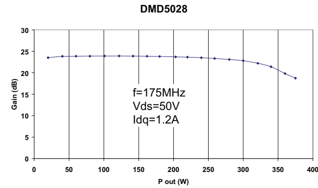
- Higher gain
- Reduced source inductance
- Exceptional linearity
- BeO-free
- Improved thermal resistance
- Full RoHS compliance

SEMELAB provides one of the broadest lines of Silicon RF Power MOSFETs for all of your HF, VHF and UHF applications.

Contact your Richardson sales engineer to identify the best SEMELAB solution for your next amplifier design.

Connect to the latest SEMELAB products and information at **www.rell.com/SEMELAB**

D1 and A1 Package



D2 and A2 Package

Device	Min. Output Power (W)	Minimum Efficiency (%)	Minimum Gain (dB)	Test Frequency (MHz)	Operating Voltage (V)	Single-Ended/ Push-Pull
DMD1006	120	50	16	175	28	SE
DMD1009	150	50	12	400	28	PP
DMD1010	125	50	13	400	28	PP
DMD1012	100	50	13	500	28	PP
DMD1020	150	50	13	400	28	PP
DMD1028	300	60	16	175	28	PP
DMD1029	350	60	16	175	28	PP
DMD1037	140	50	13	175	28	SE
DMD5010	125	60	13	400	50	PP
DMD5012	100	65	15	500	50	PP
DMD5028	300	60	20	175	50	PP
DMD5029	350	60	20	175	50	PP

Your Global Source for RF, Microwave and Power Conversion Products

Richardson Electronics

Visit www.rell.com/locations.asp for a complete listing of our worldwide locations.
Call 1-800-737-6937 (USA/Canada) • rfwireless.rell.com • rwc@rell.com

Radio Wireless Week

http://www.radiowirelessweek.org/

18 - 22 January 2009, San Diego, CA

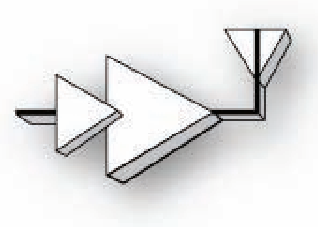
Register Now! **http://www.radiowirelessweek.org/**

Join us for a week long wireless event
At the heart of wireless valley
Omni Hotel, San Diego, CA, USA

Oral presentations - posters - workshops - panels - exhibitions

IEEE Radio & Wireless Symposium
18 - 22 January 2009
San Diego, CA USA

RWS is a leading interdisciplinary forum for the latest results in wireless technology, providing unique comprehensive view of wireless field from system level design to implementation, particularly for commercial and civilian/military wireless communication systems, such as 3G/4G, WLAN, SDR, 802.xx, and UWB using enabling technologies that span from RF to optical frequencies.

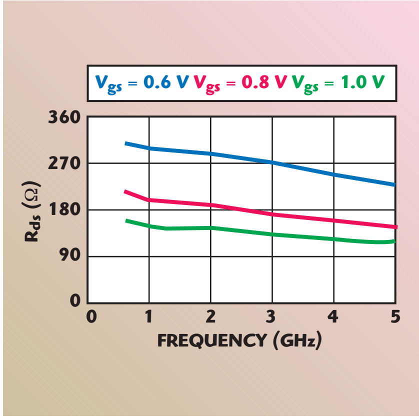


The Power Amplifier Symposium is a forum for the presentation and discussion of innovative research and development in the broad area of power amplifiers. Topics of interest include high efficiency design approaches, linearization and predistortion, linear & nonlinear characterization, device and system modeling, narrow- and broad-band amplifier architectures, base-station and handset applications, practical PA realizations, and measured results.

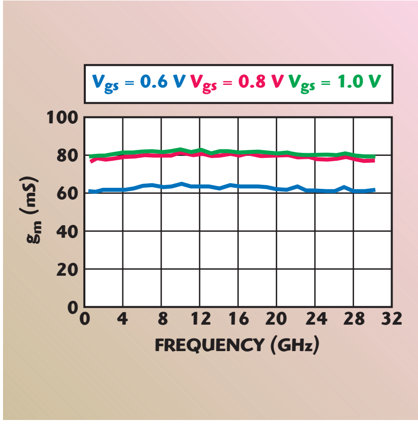
SiRF is the only conference devoted to Si-based devices, passives, integrated circuits, and applications for high-frequency systems. Over three days, papers and sessions will highlight the significant technological advances of this dynamic field, as well as provide a unique forum for the presentation of new ideas and candid exchange on the emerging challenges and opportunities. Invited talks from international experts will be presented in key topical areas. A student paper competition will be held, and prizes will be given at the conference banquet.

Platinum Sponsorship by RFMD

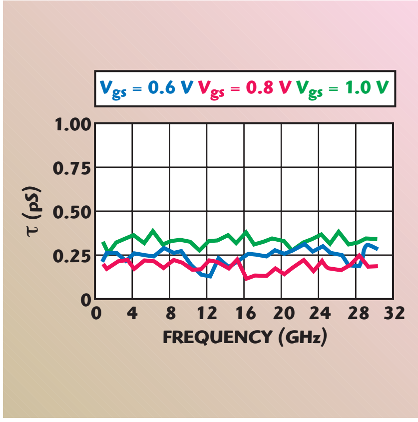
HTTP://WWW.RADIOWIRELESSWEEK.ORG/



▲ *Fig. 6 R_{ds} frequency characteristics (V_{ds} = 1.0 V).*



▲ *Fig. 7 g_m frequency characteristics (V_{ds} = 1.0 V).*



▲ *Fig. 8 τ frequency characteristics (V_{ds} = 1.0 V).*

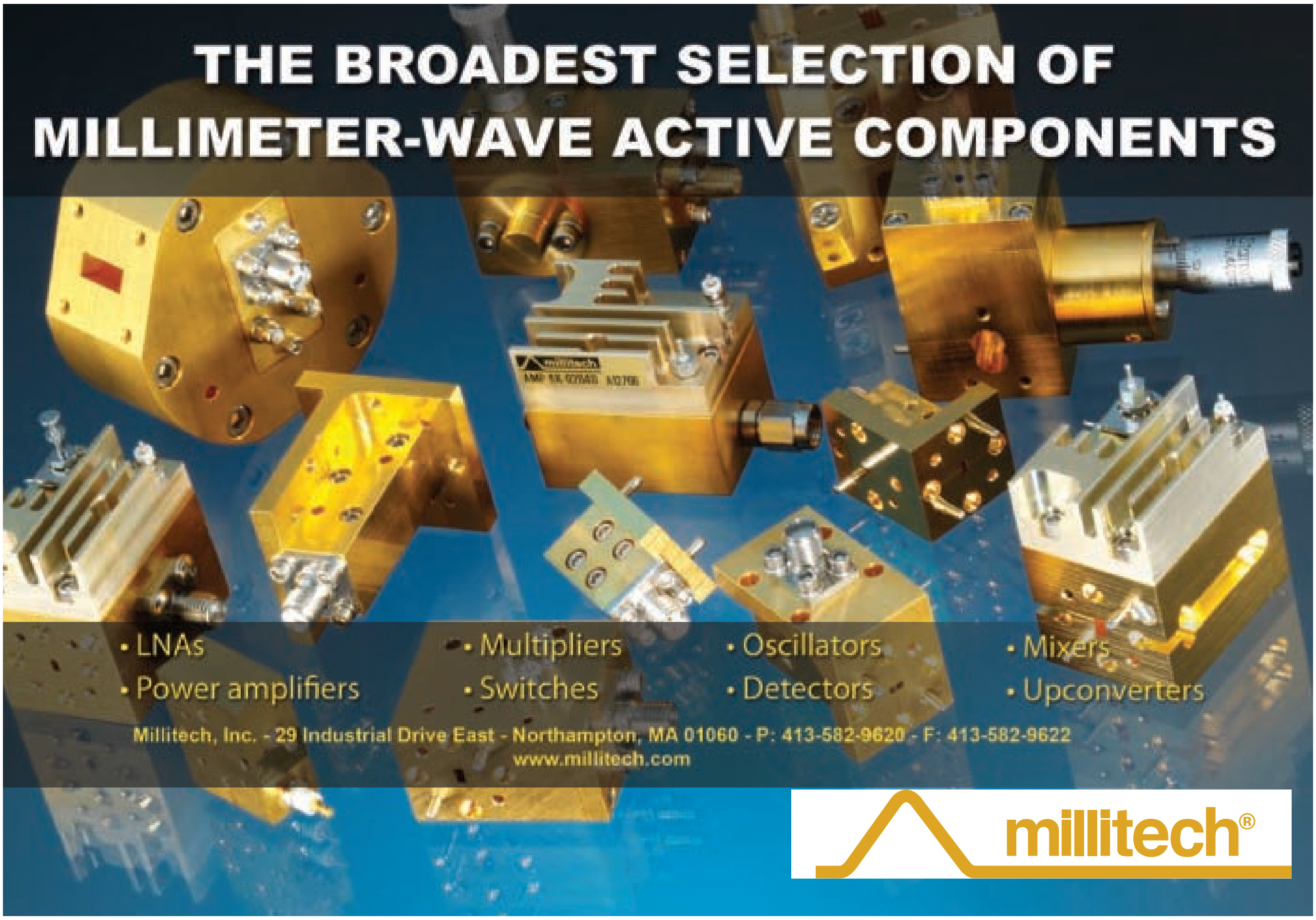
EXTRACTION PROCESS

A flowchart of the iterative process is shown in ***Figure 2***. First, the initial extrinsic resistances and substrate elements are subtracted from the Z-parameters. The reduced Z-parameters are then converted to Y-parameters and the values of intrinsic elements are determined using Equations 14 to 19. Next, the extended error vector ε is estimated from Equation 22. The values of R_g, R_d and R_s are updated to reduce ε using the Powell method.

EXPERIMENT

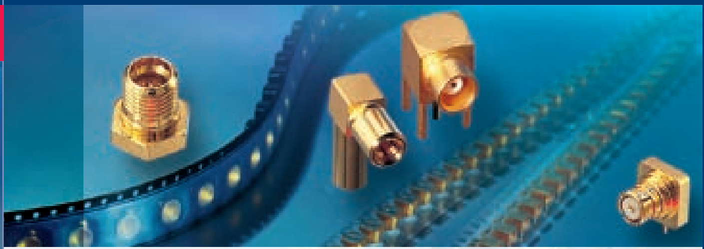
The MOSFET device has a channel mask length, L = 0.13 μm, a finger width, W = 5 μm, and a number of gate fingers, N = 16. Once the extrinsic elements are known, it is easy to determine the intrinsic elements for all biases. ***Figures 3*** to ***8*** show the intrinsic elements dependence on the gate and drain biases.

The results show that the extracted parameters remain almost constant with frequency. However, it also can be found that frequency dispersion effects exist in the extraction of R_{ds} and C_{ds}. This verifies that those components are frequency independent and the



Rosenberger
50
1958-2008

Rosenberger®



Well connected

Rosenberger Coaxial Connectors and Cable Assemblies

play a key role in many high-tech-applications – such as telecommunications, automotive electronics, test & measurement applications, aerospace engineering, modern data networks, medical electronics etc.

Our comprehensive product range covers RF-coaxial connectors, e.g. SMP, Mini-SMP, SMA, QMA, 1.6-5.6, N or 7-16, automotive connectors, adaptors or test & measurement products such as high-precision connectors, calibration kits and many more.

New:

- QN Connectors – QLF qualified
- SnapN Connectors – quick-lock connectors, compatible with standard N.
- FMC – compensate misalignments with repeatable electrical characteristics.
- SMA+ and RFlex™ cable assemblies

Exploring new directions

Ask us for more information:

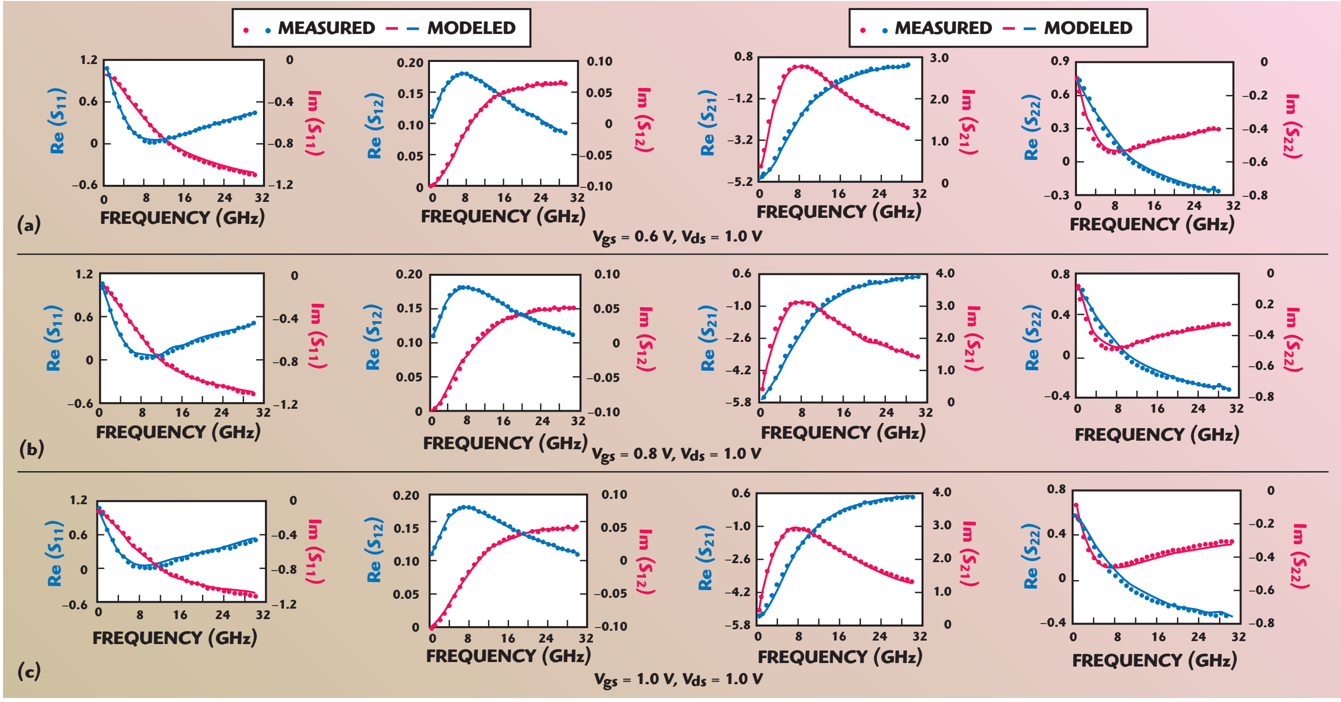
North America:

Rosenberger of North America, LLC
Greenfield Corporate Center
P.O.Box 10113 · USA – Lancaster, PA 17605-0113
Phone: 717-290-8000 · Fax: 717-399-9885
info@rosenbergerna.com · www.rosenbergerna.com

Europe:

Rosenberger Hochfrequenztechnik GmbH & Co. KG
P.O.Box 1260
D-84526 Tittmoning
Phone: +49-86 84-18-0 · Fax: +49-86 84-18-499
info@rosenberger.de · www.rosenberger.de

Visit http://mwj.hotims.com/16346-142 or use RS# 142 at www.mwjournal.com/info



▲ *Fig. 9 Comparison of modeled and measured S-parameters for different biases.*

method is accurate and reliable. ***Figure 9*** compares the measured and modeled S-parameters for the MOSFET in the frequency range of 0.5 to 30 GHz under different bias conditions (V_{ds} = 1.0, V_{gs}= 0.6, 0.8, 1.0). The modeled S-parameters agree very well with the measured ones.

Field Replaceable SMA

2 Hole, .625", with Ground Plane

4 Hole, .500", with Ground plane

2 Hole Diamond with Ground Plane

2 Hole, .550" with EMI Gasket

4 Hole, .500" x .375" with EMI Gasket

2 Hole, .625", Male, with EMI Gasket

Female Thread Mount

Male Thread Mount

Many other configurations available. Please specify .012", .015", .018" or .020" pins.

Performance

Frequency Range:	DC to 27 GHz
Voltage Rating:	335 V RMS (sea level)
Nominal Impedance:	50 ohms
DWV:	1000 V RMS @ 60 Hz (sea level)
Insulation Resistance:	10,000 megohms
Temperature Range:	-65°C to +165°C

Materials

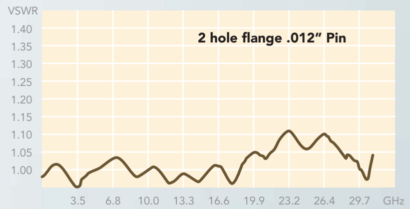
Dielectrics:	PTFE Fluorocarbon
Center Contacts:	Beryllium copper
Bodies:	SS303
EMI gaskets:	Silver filled Fluorosilicone rubber

Plating

Center Contacts:	Gold
Bodies:	Passivated

Pimp your components

Trick out your next design in one easy step with new, innovatively engineered field replaceable SMAs from San-tron. This simple switch will give you a boost in available frequency range—in some cases up to 31 GHz! When combined with VSWR performance of 1.07:1 from DC to 18 GHz and 1.25:1 or better through 26.5 GHz, your circuits will be fueled like never before.



See for yourself by visiting our Web site and requesting a free sample.

San-tron

ISO 9001

www.santron.com

978-356-1585

ROHS compliant

Visit http://mwj.hotims.com/16346-143 or use RS# 143 at www.mwjournal.com/info


Signal Integrity testing and expertise

EXPERIENCED INNOVATION.

Superior engineering made simple.

Gore offers a family of proven test solutions that provide reliable and repeatable results to meet your requirements.

Excellent phase and amplitude stability

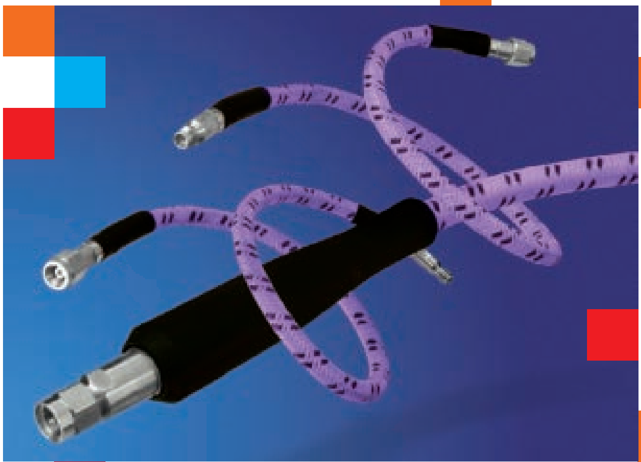
Precision time matching

High density solutions

Rugged and durable


GORE™ VNA Microwave Test Assemblies


GORE™ Ultra High Density Interconnect Systems


GORE™ PHASEFLEX® Microwave Test Assemblies

Proven solutions for your high data rate, RF, and microwave applications through 110 GHz

W.L. Gore & Associates

gore.com

North America:
1 (800) 445 4673
International
1 (302) 292 5100

Europe:
+49 91 44 6010
+44 1382 561511

GORE Creative Technologies Worldwide

GORE, PHASEFLEX, and design are trademarks of W.L. Gore & Associates. ©2007 W.L. Gore & Associates, Inc.

Visit http://mwj.hotims.com/16346-171

CONCLUSION

An improved extraction technique for MOSFET small-signal model parameters is developed. The approach is based on a combination of analytical and optimization methods. ADS is then used to optimize only the parasitics with very small dispersion of initial values. Good agreement is obtained between the simulated and measured results over a wide range of bias points up to 30 GHz. ■

ACKNOWLEDGMENTS

This work is supported in part by the Jiangsu Natural Science Foundation of China and Infineon Technologies.

References

1. S. Lee, C.S. Kim and H.K. Yu, "A Small-signal RF Model and Its Parameters Extraction for Substrate Effects in RF MOSFETs," *IEEE Transactions on Electron Devices*, Vol. 48, No. 7, July 2001, pp. 1373-1379.
2. J. Gao, "An Approach for Determining PHEMT Small-signal Circuit Model Parameters up to 110 GHz," *International Journal of Infrared and Millimeter*, Vol. 26, No. 7, July 2005, pp. 1017-1029.
3. 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.
4. R. Anholt and S. Swirhun, "Equivalent-circuit Parameter Extraction for Cold GaAs MESFETs," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 39, No. 7, July 1991, pp. 1243-1247.
5. D. Lovelace, J. Costa and N. Camilleri, "Extracting Small-signal Model Parameters for Silicon MOSFET Transistors," *1994 IEEE MTT-S International Microwave Symposium Digest*, Vol. II, pp. 865-868.
6. G.J. Hu, C. Chang and Y.T. Chia, "Gate-voltage-dependent Effective Channel Length and Series Resistance of LDD MOSFETs," *IEEE Transactions on Electron Devices*, Vol. 34, No. 12, December 1987, pp. 2469-2475.
7. I. Kwon, M. Je, K. Lee and H. Shin, "A Simple and Analytical Parameter-extraction Method of a Microwave MOSFET," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 50, No. 6, June 2002, pp. 1503-1509.
8. R. Torres-Torres and R. Murphy-Arteaga, "Straightforward Determination of Small-signal Model Parameters for Bulk RF-MOSFETs," *5th International Caracas Conference on Devices, Circuits and Systems Proceedings*, Vol. 1, November 2004, pp. 14-18.
9. K. Shirakawa, H. Oikawa, T. Shimura, Y. Kawasaki and T. Saito, "An Approach to Determining an Equivalent Circuit for HEMTs," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 43, No. 3, March 1995, pp. 499-503.

TRAK

Mission-Critical Solutions

Electronic Warfare

Homeland Security

Radar

C4ISR

Space

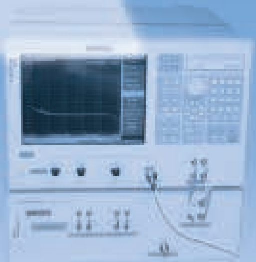
Ultra Low Phase Noise

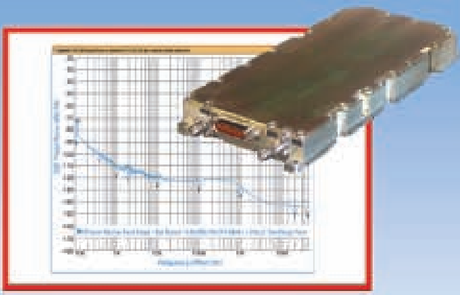
Products:

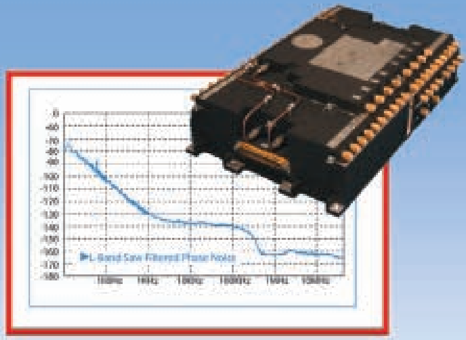
- Converters
- Signal Generators
- Synthesizers
- Transceivers (T/R) Modules

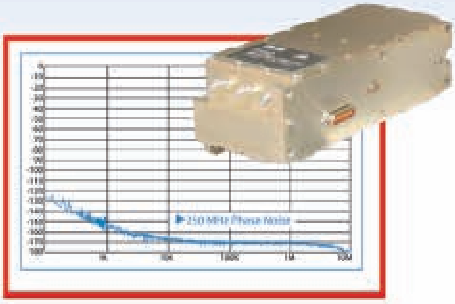
Capabilities:

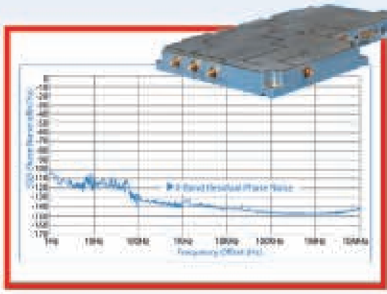
- 45 Years of Low Phase Noise Design Experience
- Mechanical and Electrical Software Modeling/Simulation
- Proprietary Microphonics Control
- World Class Test and Measurement Equipment (Dynamic Test Under Vibration)











www.trak.com

smiths

bringing technology to life

Visit http://mwj.hotims.com/16346-164 or use RS# 164 at www.mwjournal.com/info

WIDEBAND 400 W PULSED POWER GaN AMPLIFIER

A 400 W pulsed output power GaN HEMT amplifier operating over the 2.9 to 3.5 GHz band (17 percent bandwidth) has been developed. Under pulsed RF drive, with 10 percent duty cycle and 100 µs pulse width, the amplifier delivers an output power in the range of 401 to 446 W over the band, with a drain efficiency of 48 to 55 percent when biased at a drain voltage of 65 V. The amplifier uses AlGaN/GaN HEMTs with a total device periphery of 44.4 mm and advanced source-connected field plates for high breakdown voltage. These wideband high power amplifiers are suitable for use in frequency agile pulsed applications such as military radar, air traffic control radar and communications jamming.

The high power and wide bandwidth potential of GaN HEMT devices is well known.[1] RFMD has been developing high power amplifiers using GaN HEMTs for various applications. A 250 W amplifier in the 2.14 to 2.5 GHz band for wireless infrastructure applications in the WCDMA and WiMAX bands was reported previously.[2] Such wide bandwidth is essential for the next-generation frequency agile software-defined radio (SDR) architectures that use reconfigurable radios to support multiple frequency bands and various standards.[3]

The military and commercial communities require high power and broadband modules for pulsed radar surveillance and air traffic control applications. The market is looking for the next-generation of devices that provide higher power and broader bandwidth and are able to support 1.2 to 1.4 GHz L-band for IFF, TACAN and TCAS pulsed applications and 2.7 to 3.5 GHz S-band pulsed applications.

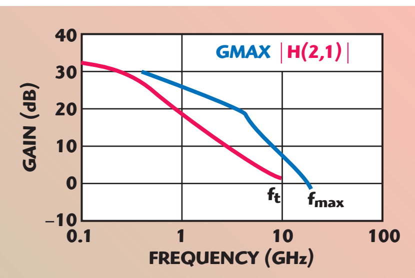


Fig. 1 GaN unit cell current and power gain performance.

These devices will enable suppliers to power combine fewer devices and reduce the size and weight power modules of greater than 1 kW for use in radar systems.

To obtain high power in existing power amplifier technologies, such as silicon laterally diffused metal oxide semiconductor (Si LDMOS) and gallium arsenide pseudomorphic high electron mobility (GaAs PHEMT), large periphery devices are required. The resulting inherent large device parasitic capacitances per watt of output power lead to low device input and output impedances. Matching such low impedance to a 50 Ω system severely limits the bandwidth achievable. This also limits the maximum power obtainable in a package and further power combining is needed on the board. Wide band-gap material systems like gallium nitride (GaN) can be operated at high drain voltage and have low parasitic capaci-

M.J. POULTON, K. KRISHNAMURTHY, J. MARTIN, B. LANDBERG, R. VETURY AND D. AICHELE
RF Micro Devices Inc., Greensboro, NC

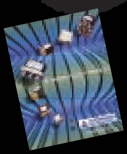
Products to Solutions...

Ducommun Technologies provides superb quality components and integrated sub-assemblies. Ducommun's heritage includes legacy companies like Dynatech, DB Products and Jay-El Microwave. With the recent addition of WiseWave, Ducommun's component products now include Coaxial Switches, Couplers, Power Combiners, Power Dividers, and Filters, along with other active and passive components.

Our system engineers take these components to develop integrated solutions to meet a variety of applications for avionics, defense, telecommunications and satellite communications requirements.

Contact Ducommun Technologies today to discuss your specific requirement.

DC to 110 GHz



To request a copy of our brand new catalog for Millimeter Wave and Microwave Products go to www.ducommun.com/mwjcat

Ducommun Technologies
23301 Wilmington Avenue
Carson, CA 90745-6209
Tel: 310.513.7214

www.ducommun.com

Ducommun Technologies

Visit http://mwj.hotims.com/16346-40 or use RS# 40 at www.mwjournal.com/info

TABLE I
SUMMARY OF GaN PROCESS DC PARAMETERS

Parameter	Typical Value	Units
Idss	800	mA/mm
Id-max	900	mA/mm
Peak gm	225	mS/mm
Vp	-4.5	V
V_{br}(GD)	>150	V

tances per watt of output power. A combination of wider bandwidth and high output power can be achieved in a small package. This simplifies the design of kW transmitters for radar and jamming applications by reducing the number of devices required and minimizing losses in external combining networks.

THEORY

In theory, purely real impedances can be matched to a 50 Ω system over any bandwidth using an infinite number of matching elements. However, actual devices have optimum impedances with a reactive component. Complex loads can be matched only over a limited bandwidth as defined by Fano's limit.[4] The maximum bandwidth ratio achieved using an infinite lossless matching network is given by

$$\frac{F_{high} - F_{low}}{F_o} = \frac{\Pi}{-Q_L \ln(\Gamma)} \qquad (1)$$

where Q_L is the Q-factor of the device optimum source or load impedance to be matched and Γ is the minimum reflection coefficient needed across the band. This bandwidth is further limited in practice due to the finite number of matching sections and the matching network losses. Hence, low Q-factors for the optimum source and load impedances are critical to obtaining a broad bandwidth. A suitable figure of merit, for high power broadband capability of a device technology, is a low pF/W gate and drain capacitance.

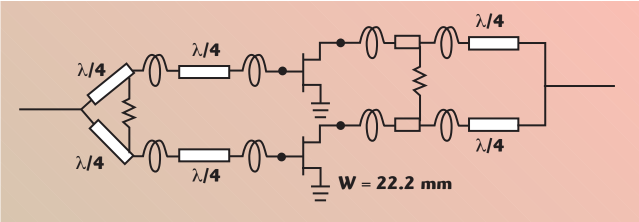


Fig. 2 Schematic of the amplifier circuit.

GaN HEMT TECHNOLOGY

RFMD's baseline AlGaN/GaN HEMT technology is based on devices with a standard 0.5 µm gate length and an advanced source connected field plate to obtain breakdown voltages in excess of 150 V. To be able to handle high-power densities in excess of 10 W/mm, a SiC substrate is used that provides excellent thermal conductivity and minimizes temperature dependent memory effects. The device topology and the baseline fabrication process are detailed in an earlier publication.[5]

Typical DC characteristics for the gallium nitride HEMT process are provided in ***Table 1***. A typical device, biased at a drain voltage of 65 V, exhibits a peak current density of 0.9 A/mm. The current and power gain cut-off frequencies (f_t and f_{max}), as measured from small periphery devices, are 11 and 18 GHz respectively, as shown in ***Figure 1***.

Under class AB bias and CW operation at 3.3 GHz, a typical 2.2 mm unit cell device obtains 56 percent peak power added efficiency (PAE) and a peak output power of 21.9 W. This corresponds to a power density of 9.9 W/mm. This is about three times the 3.2 W/mm power density obtained at 28 V drain bias from a device without the field plate. The series equivalent optimum source and load impedances are Z_s= 3.8 +j10.5 Ω and Z_l=30 +j47 Ω, respectively. These indicate low gate and drain capacitances of approximately 0.46 pF/W and 0.07 pF/W, respectively, which is about one fifth of that of equivalent silicon devices. Using this series equivalent source impedance, the theoretical maximum bandwidth ratio for a 15 dB return loss can be calculated to be 57 percent. These low capacitances contribute to the higher bandwidth obtained, compared to other device technologies.

CIRCUIT DESIGN

The amplifier circuit, seen in ***Figure 2***, uses two 22.2 mm periphery devices, combined using a Wilkinson power divider/combiner[6] on the input and output, respectively. This topology achieves a wider bandwidth than would be obtained using a single 44.4 mm device. Along with the power division/combination function, the Wilkinson combiners also perform the impedance transformations required to provide the optimum source and load impedance to the devices.

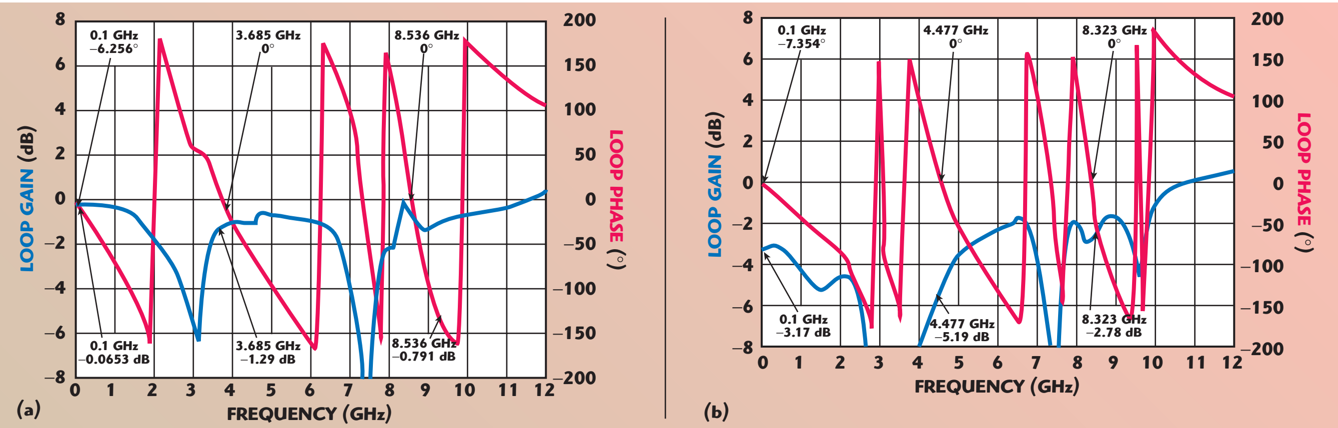
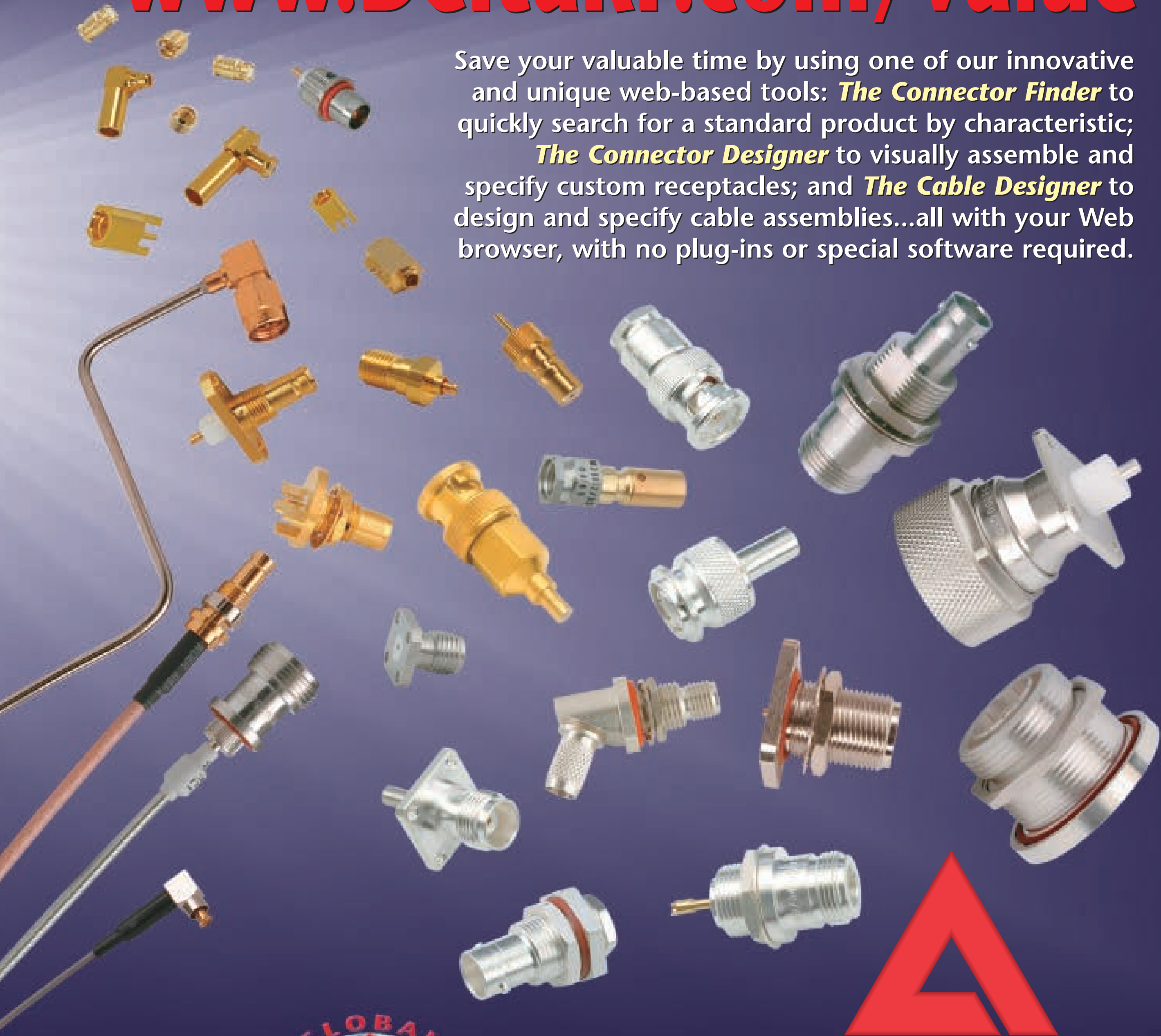


Fig. 3 Loop gain and phase analysis (a) without isolation resistor and (b) with isolation resistor.

Value Added Here:
www.DeltaRF.com/value

Save your valuable time by using one of our innovative and unique web-based tools: ***The Connector Finder*** to quickly search for a standard product by characteristic; ***The Connector Designer*** to visually assemble and specify custom receptacles; and ***The Cable Designer*** to design and specify cable assemblies...all with your Web browser, with no plug-ins or special software required.



GLOBAL MANUFACTURER

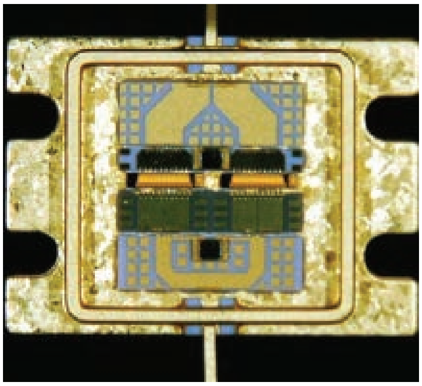
DELTA
ELECTRONICS MFG. CORP.
Connect Here.

(978) 927-1060
www.DeltaRF.com

FAX (978) 922-6430
Email: sales@DeltaRF.com
P.O. Box 53, Beverly, MA 01915

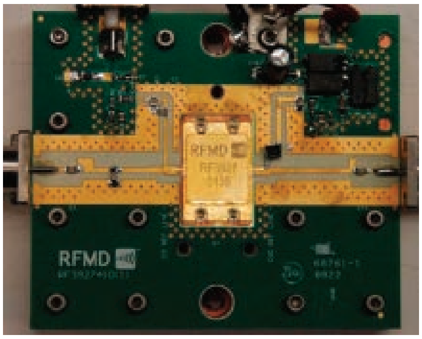
ISO 9001:2000 CERTIFIED
RoHS COMPLIANT
SOMWBA Woman-Owned CERTIFIED

Visit http://mwj.hotims.com/16346-37 or use RS# 37 at www.mwjournal.com/info



▲ *Fig. 4 Photograph of the 400 W GaN HEMT amplifier.*

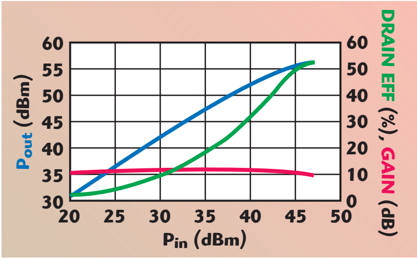
The unit cell source and load pull impedance measurements were used to estimate the large periphery device's source and load optimum impedances. Due to the higher gate capacitance, a two-stage impedance transformation was used at the gate to obtain a broader bandwidth. The drain section consists of an inductive element to provide the reactance needed for the optimum load and a single stage Wilkinson combiner/transformer. Electromagnetic field models were used extensively to



▲ *Fig. 5 Photograph of the 400 W 50 Ω test fixture.*

model the frequency performance of the combiner transformer elements.

Additionally, extensive stability analysis and odd-mode oscillation loop analysis were conducted. This type of combining network is prone to the formation of out of frequency band oscillation loops. Therefore, the design needs significant analysis over a wide frequency range to determine if any potential odd-mode oscillation loops exist. A previous work[7] provides a detailed description of applying stability analysis to multi-device amplifiers, using linear analysis and S-para-



▲ *Fig. 6 RF output power at the mid-point of the pulse, drain efficiency and gain measured at 3.4 GHz.*

meters. Applying this methodology to gallium-nitride-based amplifiers, an extensive analysis of odd-mode oscillation loops is provided by Yanamaka, et al.[8] For an odd-mode loop to cause stability issues, the following conditions must be met

Loop phase angle $(\Gamma)=0°$ (2)
Loop gain magnitude $(\Gamma)>1$ (0 dB) (3)

Generally, however, to provide adequate design margin, loop gain less than -2 dB should be maintained across a frequency band where G_{max} is greater than 0 dB.

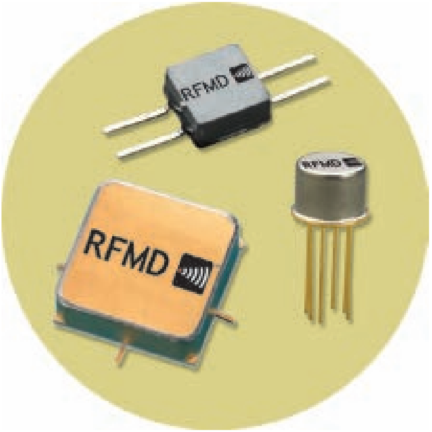
A similar methodology was applied to this amplifier design; an example of the loop analysis is shown in ***Figure 3***. The amplifier's loop gain and phase, using Wilkinson combiner networks not using an isolation resistor between the ports, is shown. It can be seen that the loop phase angle meets the criteria for oscillation at two distinct frequencies 3.685 and 8.536 GHz. Additionally, the loop phase is close to the criterion at low frequency. In all three cases the loop gain requirement is not met. However, the loop gain margin is less than the adequate limit defined. The figure also shows how the loop stability can be

TABLE II
SUMMARY OF THE AMPLIFIER RF PERFORMANCE

Frequency (GHz)	Pk Pout (W)	Drain Eff (%)	PAE (%)
2.9	446.4	55.5	49.1
3.0	432.9	55.1	49.0
3.1	414.8	50.8	44.6
3.2	419.3	54.0	47.3
3.3	405.4	48.4	42.4
3.4	434.1	52.6	46.5
3.5	401.5	53.8	47.9

High-Reliability Ruggedized Components

Hermetic Signal Source and Signal Processing Hybrid Modules



RFMD® delivers a broad portfolio of high-reliability components designed to fit a variety of Aerospace & Defense applications, such as:

VOLTAGE CONTROLLED OSCILLATORS (VCOs): RFMD's portfolio of VCOs operates from 25 MHz to 10 GHz for ruggedized military, aerospace and space-born applications, which demand the highest level of reliability.

REPRESENTATIVE PART

Part Number	Frequency	Phase Noise at 100 kHz	Output Power	Tuning Voltage
VCO-550TC	Min: 6500, Max: 8000 MHz	-94 dBc/Hz	-1.5 dBm	Min: 0, Max: 16 V

PASSIVE MIXERS: RFMD's line of high-reliability mixers are housed in a rugged, compact package and deliver excellent performance.

REPRESENTATIVE PART

Part Number	LO RF Frequency	IF	LO Drive Level	Isolation L-R	Isolation L-X	Isolation R-X
DBM-700	1 - 3500 MHz	5 - 2500 MHz	10 - 20 dBm	42 dB	33 dB	30 dB

POWER DIVIDERS: The family of multiway power dividers from RFMD is also ideal for broadband applications. They are designed to meet their specifications in conditions over -55 degrees Celsius to +100 degrees Celsius.

REPRESENTATIVE PART

Part Number	Frequency	IL	Isolation	VSWR
PS-2-4000F	20 - 4000 MHz	0.4 dB	25 dB	1.3:1

FEATURES

- Custom designs available
- Qualification and screening testing for Class H and Class K
- Package options include TO-8, SMT, SMT2, SMA and FP
- In-house reliability and analysis lab

For sales or technical support, contact RFMD at 336.678.5570, Ext. 1 or sales-support@rfmd.com
For customer service, contact RFMD at 336.678.5570, Ext. 2 or customerservice@rfmd.com

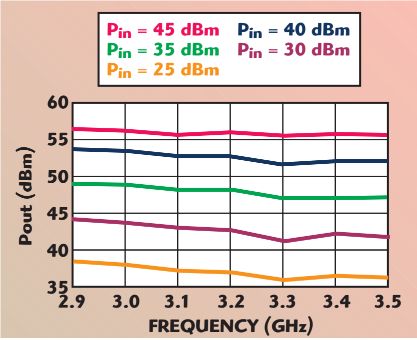
7628 Thorndike Road, Greensboro, North Carolina 27409-9421 USA • Phone 336.664.1233 • Fax 336.931.7454

RFMD® is a registered trademark of RFMD, LLC. All other trade names, trademarks and registered trademarks are the property of their respective owners. ©2008 RFMD.

RFMD®

rfmd.com

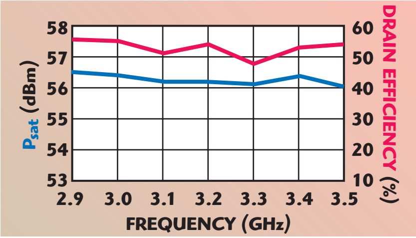
Visit http://mwj.hotims.com/16346-135 or use RS# 135 at www.mwjournal.com/info



▲ *Fig. 7 RF output power at the mid-point of the pulse over the 2.9 to 3.5 GHz band.*

increased by adding an isolation resistor to the Wilkinson combiner and by optimizing the gallium nitride device layout. The loop gain has been reduced to levels meeting the design margin requirements at all three frequency points.

The devices are packaged in a 15 x 17 mm package (see ***Figure 4***).[9] The combiner/dividers were implemented on high dielectric constant substrates to achieve the small dimensions required to fit inside the package. The quarter-wave transformations were designed to obtain a 35 Ω impedance

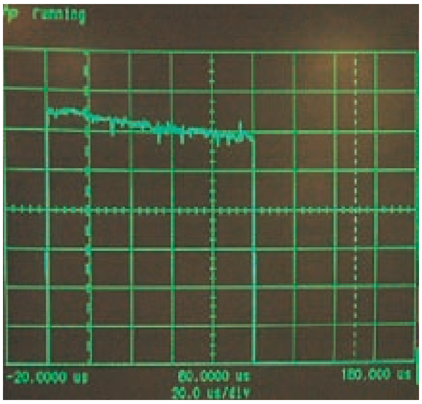


▲ *Fig. 8 Measured saturated output power and drain efficiency over the 2.9 to 3.5 GHz frequency band.*

at the package leads. The evaluation board used for testing further transforms the impedance to 50 Ω and is shown in ***Figure 5***.

PULSE POWER PERFORMANCE

The RF performance of the device was evaluated after optimizing the on-board matching. The amplifier was biased in class AB mode at a fixed drain voltage of 65 V and a drain current of 440 mA. The RF input was pulsed using a 100 µs wide pulse with a 1 ms period and the output power was measured at the center of the pulse. The drain current pulse waveform was monitored to calculate the drain efficiency. The amplifier was tested over the frequency range of 2.9 to 3.5 GHz.



▲ *Fig. 9 Measured power droop of 0.25 dB over a 100 µs pulse at 56.4 dBm output power (at the center of the pulse) with 10% duty cycle.*

Figure 6 shows the measured output power at the mid-point of the pulse, the drain efficiency and the gain at 3.4 GHz as a function of the input power. A peak output power of 434 W was obtained at 3.4 GHz with a drain efficiency of 52.6 percent. ***Figure 7*** shows the measured output power over frequency for a range of input power. The broadband power capability of the device is apparent from the plot.

Figure 8 shows the peak saturated output power and drain efficiency over the frequency band, while ***Table 2*** summarizes the data. An output power in excess of 401.5 W was obtained over the entire band, with better than 48.4 percent drain efficiency.

The pulse droop performance at 56.4 dBm output power (see ***Figure 9***) shows approximately a 0.25 dB droop over the complete 100 µs pulse, and less than 0.15 dB across the middle 50 percent of the pulse. This confirms the excellent thermal capability of the GaN on SiC dies in the package, even under the high power density at which they are operating.

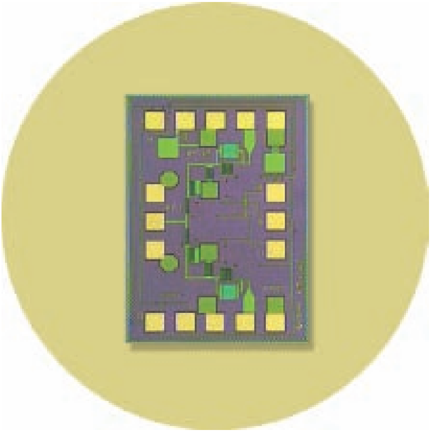
CONCLUSION

A compact, greater than 400 W, wideband, AlGaN/GaN HEMT power amplifier has been demonstrated, operating at 65 V with better than 48.4 percent drain efficiency over a 600 MHz bandwidth from 2.9 to 3.5 GHz, under pulsed condition with a 10 percent duty cycle and 100 µs pulse width.

Visit http://mwj.hotims.com/16346-43

RFMD® pHEMT Broadband Switches

Low-Loss, High-Isolation, DC to 20 GHz SPST and SPDT Switch MMIC Die



The portfolio of low-loss, high-isolation broadband single-pole-single-throw (SPST) and single-pole-double-throw (SPDT) gallium arsenide (GaAs) switches are designed on the 0.5 µm pHEMT switch process from RFMD®. The FMS2023, FMS2027 and FMS2029 offer absorptive properties from both ports (50 ohms terminations). This process technology offers leading-edge performance optimized for switch applications in the military, SATCOM, broadband communications, test and measurement, and fiber optics markets.

SPECIFICATIONS

	Insertion Loss at 10 GHz				Isolation at DC-20 GHz				P1dB at 10 GHz			
Part Number	Min	Typ	Max	Units	Min	Typ	Max	Units	Min	Typ	Max	Units
FMS2023	-0.9	-0.7	-	dB	-	-50	-43	dB	25	27	-	dBm
FMS2024	-1.6	-1.1	-	dB	-	-37	-34	dB	22	24	-	dBm
FMS2027	-1.5	-1.3	-	dB	-	-42	-40	dB	21	22.5	-	dBm
FMS2029	-1.65	-1.4	-	dB	-	-60	-45	dB	23.5	25.2	-	dBm

FEATURES

- Low insertion loss
- High isolation
- Absorptive output in off-state (FMS2023, FMS2027, FMS2029)
- All reflective design (FMS2024)
- Excellent low-control voltage performance
- Available in die form

For sales or technical support, contact RFMD at 336.678.5570, Ext. 1 or sales-support@rfmd.com
For customer service, contact RFMD at 336.678.5570, Ext. 2 or customerservice@rfmd.com

7628 Thorndike Road, Greensboro, North Carolina 27409-9421 USA • Phone 336.664.1233 • Fax 336.931.7454

RFMD® is a registered trademark of RFMD, LLC. All other trade names, trademarks and registered trademarks are the property of their respective owners. ©2008 RFMD.

RFMD

rfmd.com

The combination of GaN HEMT device technology and the impedance matching topology achieves high power and broad bandwidth in a small package. The design incorporates Wilkinson combiner/transformers that provide excellent low loss, wide bandwidth performance in a compact design. The loop stability is a critical design consideration that was addressed to ensure stability over all frequencies.

These amplifiers are well suited for pulsed applications, including advanced radar systems. The small size and high power obtained in a single package greatly simplifies the design of kW transmitters by reducing the number of devices needed in parallel. In addition, improvement to overall system bandwidth and efficiency is achieved as the combiner losses are further reduced. Additional savings in inventory and critical real estate needs are further advantages of using this device. ■

ACKNOWLEDGMENT

The authors wish to acknowledge their colleagues at RFMD for their continued and timely support in device fabrication and assembly.

References

1. L.F. Eastman, et al., "The Toughest Transistor Yet [GaN Transistors]," *IEEE Spectrum*, Vol. 39, No. 5, May 2002.
2. K. Krishnamurthy, M.J. Poulton, J. Martin, R. Vetury, J.D. Brown and J.B. Shealy, "A 250 W S-band GaN HEMT Amplifier," *2007 IEEE Compound Semiconductor Integrated Circuit Symposium Digest*, pp. 1-4.
3. W. Koenig, S. Walter, U. Weiss and D. Wiegner, "A Multi-band Front-end for a Medium Range Base Station: An Important Step Towards SDR," *Third Karlsruhe Workshop on Software Radios, WSR'04*, March 17-18, 2004.
4. R.M. Fano, "Theoretical Limitations on the Broadband Matching of Arbitrary Impedances," *Journal of the Franklin Institute*, January 1950.
5. R. Vetury, Y. Wei, D.S. Green, S.R. Gibb, T.W. Mercier, K. Leverich, P.M. Garber, M.J. Poulton and J.B. Shealy, "High Power, High Efficiency, AlGaN/GaN HEMT Technology for Wireless Base Station Applications," *2005 IEEE MTT-S International Microwave Symposium Digest*, June 2005, pp. 487-490.
6. E. Wilkinson, "An N-way Hybrid Power Divider," *IRE Transactions on Microwave Theory and Techniques*, Vol. 8, No. 1, January 1960, pp. 116-118.
7. M. Ohtomo, "Stability Analysis and Numerical Simulation of Multidevice Amplifiers," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 41, No. 6/7, June/July 1993, pp. 983-991.
8. K. Yamanaka, K. Iyomasa, H. Ohtsuka, M. Nakayama, Y. Tsuyama, T. Kunii, Y. Kamo and T. Takagi, "S- and C-band Over 100 W GaN HEMT 1 Chip High Power Amplifiers with Cell Division Configuration," *2005 European Gallium Arsenide and Other Semiconductor Application Symposium Digest*, pp. 241-244.
9. K. Krishnamurthy, J. Martin, B. Landberg, R. Vetury and M.J. Poulton, "Wideband 400 W Pulsed Power GaN HEMT Amplifiers," *2008 IEEE MTT-S International Microwave Symposium Digest*, June 2008, pp. 303-306.

Matthew Poulton *received a BSc in Physics from University of Birmingham, Birmingham, UK, an MSc in Microwave Solid State Physics from University of Portsmouth, Portsmouth, UK and has 14 years of experience in microwave product and IC development, and engineering management. He is currently a principal engineer at RFMD's Aerospace and Defense business unit, based in Charlotte, North Carolina. For the last seven years Mr. Poulton has contributed to GaN HEMT device development and high power amplifier design using RFMD's gallium nitride HEMT technology.*

Karthik Krishnamurthy *received the B.Tech. degree from the Indian Institute of Technology, Chennai, in 1995, and the M.S. and Ph.D. degrees from the University of California, Santa Barbara (UCSB), in 1996 and 2000, respectively. He is currently a staff design engineer at the Aerospace and Defense business unit of RF Micro Devices, Charlotte Design Center. His current work focuses on circuits and devices for high power and ultra-broadband efficient RF/microwave power amplifiers in AlGaN/GaN HEMT technology.*

James Martin *received a Bachelor of Engineering in Electrical Engineering from Vanderbilt University in Nashville, TN and has 13 years of experience in the design of RF and MW integrated circuits and engineering management. He is currently an Engineering Manager within RFMD's Aerospace and Defense business unit, based in Charlotte, North Carolina. Current areas of focus include GaN and GaAs based products for military communications, Radar, jamming, and other general purpose amplifier applications in the defense sphere.*

Bart Landberg *is a product engineer who specializes in test and measurement automation at RFMD. He holds a BSEET from UNC-Charlotte.*

Ramakrishna Vetury *received his B.Tech degree from the Indian Institute of Technology, Madras and his MSEE and PhD degrees from the University of California at Santa Barbara. He has published in the areas of solid state devices and circuits and is currently working in the development of gallium nitride based FET technologies at RFMD.*

David Aichele *is Director, Business Development with the Aerospace & Defense Business Group of RFMD. David has been with RFMD for the past 4 years and prior to that held strategic positions with Tessera Technologies (formerly Digital Optics) and Tyco Electronics. David holds a MBA focus on Technology Innovation from University of Colorado and a BSEE from Ohio University.*

Integrated Microwave Assemblies

Advanced Technology - Extensive Experience - Superior Performance

CPI
Communications & Power Industries

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

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

Communications & Power Industries
Beverly Microwave Division

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

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

Visit http://mwj.hotims.com/16346-31 or use RS# 31 at www.mwjournal.com/info

LOW FREQUENCY 3-D ELECTROMAGNETIC ANALYSIS OF ANECHOIC CHAMBER PERFORMANCE

The advantages of anechoic chambers utilized for antenna measurements, as compared with conventional outdoor antenna test ranges, such as security, interference-free radiation and immunity to weather, are well known. Typical anechoic chambers comprise a shielded enclosure with the internal metallic surfaces covered by absorbing materials, a source antenna to illuminate the device under test (DUT), and positioning equipment on which the DUT is installed and rotated to acquire antenna pattern data. The dimensions of the shielded enclosure are primarily determined by the lowest operating frequency, and thus the required size will be significantly increased if the chamber operation is required down to VHF and/or UHF frequency bands. This in turn increases the construction and absorbing material costs. As a result, the advantage of an indoor chamber is often questioned when considering the VHF or UHF band as the lowest operating test frequency range. The main concern in this case is the projected amount of real estate required for construction of the chamber. A trade-off exists between the desire to lower the cost by reducing chamber size and the desire to ensure minimum performance levels by increasing the chamber size.

In order to achieve a minimum level of accuracy in the antenna measurement, a corresponding minimum level of DUT test zone illumination quality and overall chamber reflectivity needs to be achieved. This requires that turn-key chamber suppliers need to be able to accurately analyze the chamber performance. The ability to accurately characterize chamber performance results in an optimum design implemented at minimum cost.

To date, the method most often implemented in the industry to analyze anechoic chambers has been based on ray tracing. This method suffers from poor accuracy in cases where the room dimensions are only a few wavelengths at the lowest operating frequency. Several factors contribute to poor accuracy for these cases:

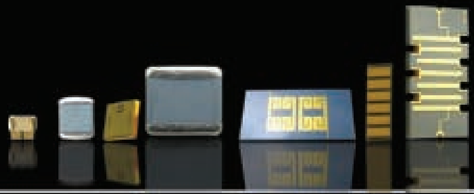
• The specular region, where reflections significantly impact the quality of the DUT test zone, has characteristic dimensions that encompass a few wavelengths of the wall surface covered by the absorbing materials, which at VHF and UHF frequencies may exceed side wall, floor and ceiling characteristic dimensions.

MARK WINEBRAND AND JOHN AUBIN
ORBIT/FR Inc., Horsham, PA

DLI DIELECTRIC LABORATORIES
A DOVER COMPANY
CPG

We wouldn't say our advancements are as impressive as landing on the Moon...

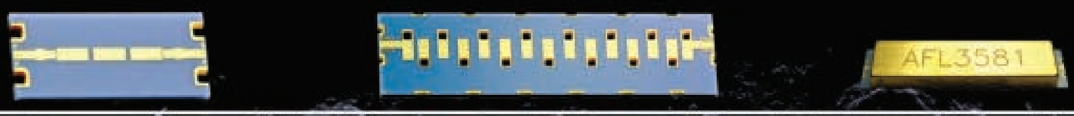
but our customers are continuously impressed.



Dielectric Laboratories www.dilabs.com

Let DLI be your portal to the Moon and beyond.

- Programs such as Venus Probe, Mars Science Laboratory, and Juno are testaments to our Filter technologies. Our Filters are miniature, lightweight, and have outstanding temperature stability.
- Most space programs around the world have been using our Single-Layer Capacitors (SLC) for decades.
- Our Resonators have survived a megarad of total radiation with no degradation.



2777 Route 20 East Cazenovia, New York, USA 13035-9433 (315) 655-8710

DLI is the premier source for microwave, RF, and millimeter-wave components that enable smaller and lighter systems with stable performance in any environment.

Visit http://mwj.hotims.com/16346-38 or use RS# 38 at www.mwjournal.com/info

• As the effective specular area is large, it is difficult to define the correct incidence angle of the specular illumination for the ray tracing analysis.
• It is difficult to accurately predict or measure the reflection coefficient of the wall absorber at off-normal incidence at low frequencies.
• The phase of the reflection coefficient of the absorber material is difficult to accurately measure. Hence, only RMS or RSS fields can be calculated in the DUT test zone, thus delivering only approximate analysis results.
• In some cases assumptions are made for the reflectivity at off-normal incidence angles at VHF and UHF bands, based on similarity to reflectivity degradation curves at off-normal incidence at higher frequencies (> 2 GHz).[1] However, this extrapolation has proven to be inaccurate at a number of installed anechoic chambers.

A useful improvement to the ray tracing method is the aperture integration method, in which the fields reflected from side walls into the test zone are calculated using Kirchhoff integration over apertures (portions of the side walls, floor or ceiling), and the field in the test zone is obtained as a sum of these reflected fields together with the direct radiation of the source antenna.

Although this method is better suited for analysis of anechoic chambers, the available accuracy is still limited and is determined by the information available on the reflectivity (magnitude and phase for two orthogonal polarizations) of the absorbing materials used in the chamber at both normal and off-normal incidence, which is (as indicated earlier) too problematic at the VHF and UHF bands. In addition, neither the aperture integration nor ray tracing methods take into account multiple reflections within the chamber, which is typically a significant effect at these frequencies.

IMPACT OF INACCURATE CHAMBER ANALYSIS

Lack of accuracy in chamber performance prediction may lead to non-optimum chamber design. However, less than optimum performance is not always easy to identify. For example, field probing of the test zone may not show the full extent of field variations and ripples originating from reflections within the chamber interior due to the long period of the interference pattern produced by the reflections and direct radiation at low frequencies.

In order to ensure adequate chamber performance, field probing should be performed over as broad a frequency range as possible. Smooth changes of the field in the test zone over a broad frequency range are a positive sign, indicating that the chamber performs well. Small variations of the recorded signal over a broad frequency range for multiple matched transmit/receive polarizations is another positive sign of excellent chamber performance.

3-D ELECTROMAGNETIC SIMULATION

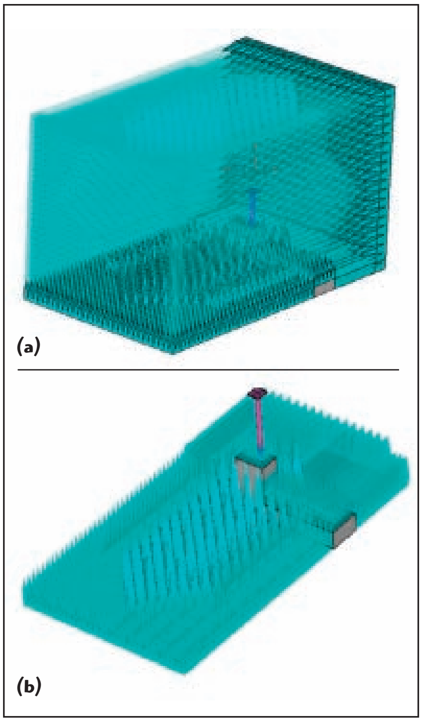
Given the limitations stated above for the aforementioned analysis techniques at low frequencies, it is obvious that a more rigorous and comprehensive analysis is required. An appropriate analysis is a 3-D electromagnetic simulation as described below.

A short time ago, no standard software package could be utilized to solve the problem of analyzing an anechoic chamber for comprehensive 3-D field quality. Recently, thanks to significant steps made in PC technology and advances in 3-D electromagnetic computer simulation packages utilizing time-domain techniques,[2] such analysis is now possible.

ORBIT/FR has implemented a full 3-D simulation for anechoic chambers at low frequencies using a commercial transient solver package available from CST. Typical simulation results are presented below to illustrate the effectiveness of the 3-D time domain technique as applied to the analysis of anechoic chambers at low frequencies.

The primary analyses performed for the chamber include field uniformity over a volume of interest within the chamber, such as the DUT test zone, including subsequent determination of amplitude taper and ripple; phase variation; and induced cross-polarization levels in the chamber fields. These metrics are a function of the following parameters:

- Absorbing material layout and grades



▲ *Fig. 1 Isometric view of the anechoic chamber design (a) and absorber layout on the floor (b).*

- Source antenna/DUT separation
- Operating frequency
- Source antenna beamwidth
- DUT positioning equipment
- DUT supporting structure geometry and materials

The analysis can provide information leading to the proper selection of source antenna, source antenna/DUT separation, absorber layout and minimum chamber size required to achieve desired performance levels.

CHAMBER MODELING METHODOLOGY

The most efficient way to model the anechoic chamber is to create a database of standard components, including absorbing materials of different types such as pyramids, wedges, hybrids (a combination of pyramids backed by ferrite tiles), walkways, etc. Each type of material may contain different size models. For example, pyramids may be produced with various heights ranging from 2 to 96 inches or more. For UHF and VHF applications the larger heights are utilized, typically from 36 to 96 inches.

Material loading levels are input and stored in the database. These are based on measurements of the material properties ε'(f), ε"(f) , μ'(f), μ"(f)

What's *your* hot button?

Wire-wound baluns had their day. But tomorrow belongs to the new generation of low-profile, ultra-miniature, and ferrite-free components from Anaren's consumer-electronics team.

Utilizing an innovative and RoHS-compliant softboard, multi-layer technology – and measuring a mere .04 x .04 x .022" – Anaren baluns offer excellent performance in a world-class form factor. Are suitable for WiFi, WiMAX, Bluetooth®, GSM, GPS, Zigbee, and other apps. And are 100% RF-tested via a proprietary Anaren QC system.

To request an engineering kit (refer to Part No. CCGkit1) and more information on our fast-growing line of consumer-electronics sized baluns, filter baluns, couplers, power dividers, and RF crossovers – email ccg@anaren.com or contact Richardson Electronics.

Insist on the truly "wireless" balun: Even at a glance, you can see our "0404" baluns offer tremendous form-factor advantages over traditional wirewound models. They outperform on key performance specs, too, like insertion loss, temperature stability, IMD, and CMRR.

Part Number	Frequency (Ghz)	Insertion Loss (dB)	Common Mode Rejection Ratio (dB, typical)
B0011E75300A00	0.04-1.1	1.6	28
BD0810J50100A00	0.8-1.0	0.85	39
BD0810J50150A00	0.8-1.0	1.1	33
BD0810J50200A00	0.8-1.0	1	26
BD0826J50200A00	0.8-2.6	1.3	26
B0922J7575A00	0.9-2.2	1.2	26
B0922J7575A50	0.9-2.2	1.1	25
BD1222J50200A00	1.2-2.2	0.6	30
BD1631J50100A00	1.6-3.1	1	33
BD1722J50100A00	1.7-2.2	1	26
BD1722J50150A00	1.7-2.2	0.7	30
BD1722J50200A00	1.7-2.2	0.7	30
BD2130J5050A00	2.1-3.0	1.2	37
BD2425J5050A00	2.4-2.5	0.9	37
BD2425J50100A00	2.4-2.5	0.75	42
BD2425J50200A00	2.4-2.5	0.8	37
BD2326L50150A00	2.3-2.6	1.1	29
BD2326L50200A00	2.3-2.6	1.1	29

Part Number	Frequency (Ghz)	Insertion Loss (dB)	Common Mode Rejection Ratio (dB, typical)
BD3150L50100A00	3.1-5.0	1.1	28
BD3150L50200A00	3.1-5.0	1.2	25
BD4859L5075A00	4.8-5.9	1.3	31
BD4859L50100A00	4.8-5.9	1.1	30
BD4859L50150A00	4.8-5.9	1	28
BD4859L50200A00	4.8-5.9	1.4	26
B4859A53	4.8-5.9	0.9	27
BD2425N5075A00	2.4-2.5	0.9	35
BD2425N50100A00	2.4-2.5	0.7	37
BD2425N50200A00	2.4-2.5	0.7	29
BD3150N50100A00	3.1-5.0	0.7	26
BD4859N5050A00	4.8-5.9	0.7	27
BD4859N5075A00	4.8-5.9	0.5	28
BD4859N50100A00	4.8-5.9	0.6	26
BD4859N50150A00	4.8-5.9	0.6	26
BD4859N50200A00	4.8-5.9	0.5	29

To order a free engineering/sample kit – request Part No: CCGkit1

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)

Richardson Electronics
Engineered Solutions

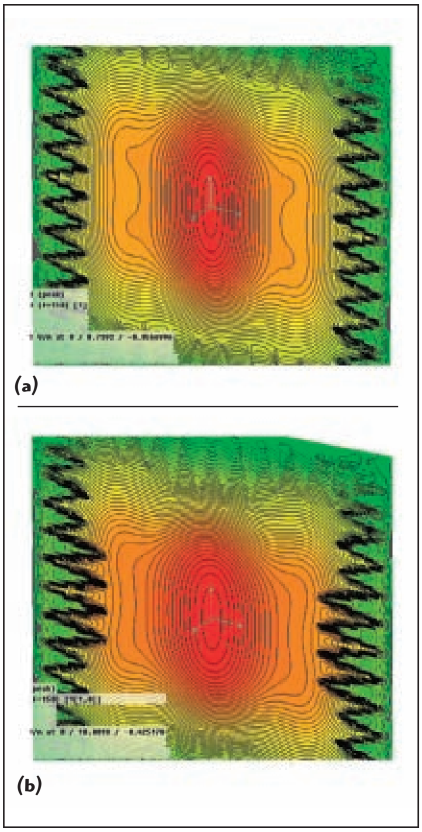
Visit http://mwj.hotims.com/16346-12 or use RS# 12 at www.mwjournal.com/info

over the desired frequency range. Accurate characterization of the material using these parameters is critical for an acceptable simulation.

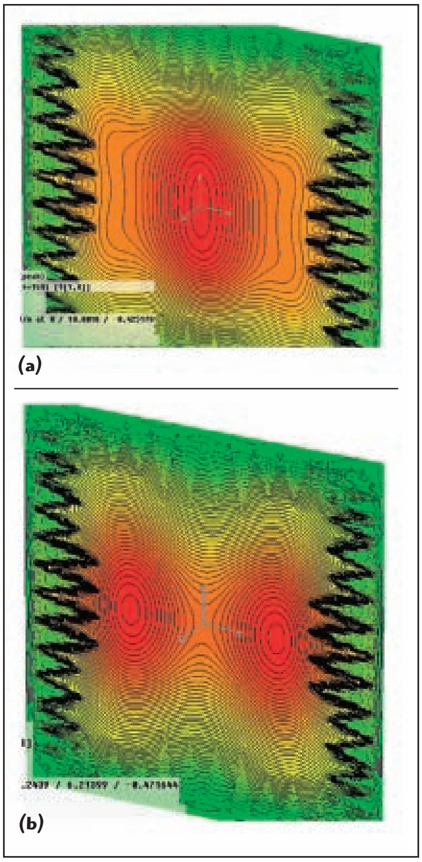
Typically, the absorber layout contains different types and different grades of absorbing materials, as shown in ***Figure 1***. The design shown is for an anechoic chamber size of H = 6 m, W = 6 m W, L = 10 m, intended to operate down to 150 MHz. The floor contains a "diamond patch" of diagonally oriented pyramidal pieces of absorbing material located in the "specular" region of the floor, and is surrounded by lower grades of pyramids and wedge absorbing materials at the far end of the floor. The positioning system, a fiberglass tower supporting the DUT and walkway are also shown in the layout, and are accounted for in the simulations.

OPTIMAL SELECTION OF ABSORBER LAYOUT AND GRADES

Here, the effect of the absorber layout and absorber grades on the test zone performance is discussed. It is assumed that the basic chamber layout is similar to the one shown. A study and comparison of the test zone performance are made for two cases in which the receive wall and the "diamond patch" are made of 36 and 48 inches high pyramidal absorbers, respectively. The test zone fields for the two cases are presented in ***Figure 2*** in the form of contour plots of the fields in the central cross-section of the test zone. It is evident upon inspection that the field in case b) is more uniform than in case a), indicating that the performance is superior using the 48 inch pyramids.



▲ *Fig. 2 Test zone field contour at center of the test zone (a) 36-inch pyramidal absorber; (b) 48-inch pyramidal absorber.*



▲ *Fig. 3 Test zone field contour as a function of source antenna/DUT separation: (a) 3 m separation; (b) 6 m separation.*

It is also readily observed that the reflectivity of the side walls (H-plane of the incident field) is inferior to that of the floor and ceiling (E-plane of the incident field), yielding the "ellipse" like field distribution in the test zone.

Not all synthesizers are created equal.

Broadband, Fast Tuning Mini Synthesizer
- Model No. SMS-B120
- 1 to 20 GHz, Single Output
- <50 μsec Tuning Speed
- -60 dBc Spurious
- Only 4.5W Power Consumption
- Internal 1.0ppm 10 MHz Reference
- Smallest 3"x 3"x 0.7" Package

Direct Digital Up-Converter Synthesizer
- Model No. SMS-DU1020
- Up to 500 MHz DDS 'Chirp' Modulation
- 10 to 20 GHz, Single Output
- 50 dBc Spurious
- 50 nS Tuning Speed (In-Band)
- Low-Cost Integrated Module
- Small 4.5"x 4.5"x 1.2" Package

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 – military, industrial or commercial.

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***

RF Solutions from JFW Industries

- Programmable Attenuation Systems
- Fixed Attenuators & Terminations
- Programmable Attenuators
- RF Test Accessories
- RF Matrix Switches
- Rotary Attenuators
- RF Power Dividers
- RF Switches

JFW Industries, Inc.

Call Toll Free 877-887-4539 or 317-887-1340

E-mail: sales@jfwindustries.com

www.jfwindustries.com

Visit http://mwj.hotims.com/16346-66 or use RS# 66 at www.mwjournal.com/info

EFFECT OF SOURCE ANTENNA/DUT SEPARATION ON TEST ZONE PERFORMANCE

The separation between the source antenna and the DUT is an important parameter at VHF and UHF frequency bands and can strongly influence the test zone performance. It is well known that at microwave frequencies (> 2 GHz) the absorbing materials perform reasonably well for large incident wave angles such as 65°. However, at VHF and UHF frequencies, the absorber performance at large off-normal angles is sharply reduced. The examples shown in ***Figure 3*** illustrate field contour plots calculated for the following:

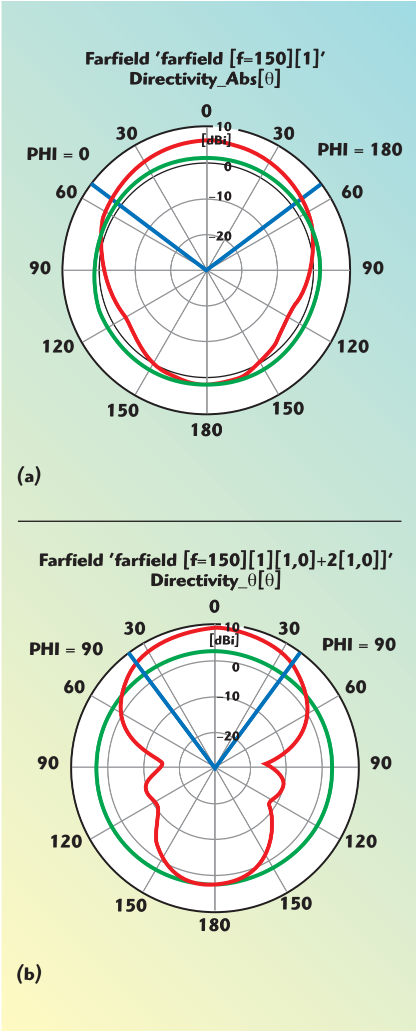
- A 3 m source antenna/DUT separation, where the incident wave angle to the side walls, floor and ceiling is approximately 27°.
- A 6 m source antenna/DUT separation, where the incident wave angle to the side walls, floor and ceiling is approximately 45°.

As is readily observed, the longer separation leads to an unexpected and undesired field distribution across the test zone. The field structure results in a local minimum in the center of the test zone, which represents an unstable condition that tends to change rapidly with frequency, and, therefore, results in poorly controlled field uniformity in the test zone.

EFFECT OF SOURCE ANTENNA BEAMWIDTH (BW) ON TEST ZONE PERFORMANCE

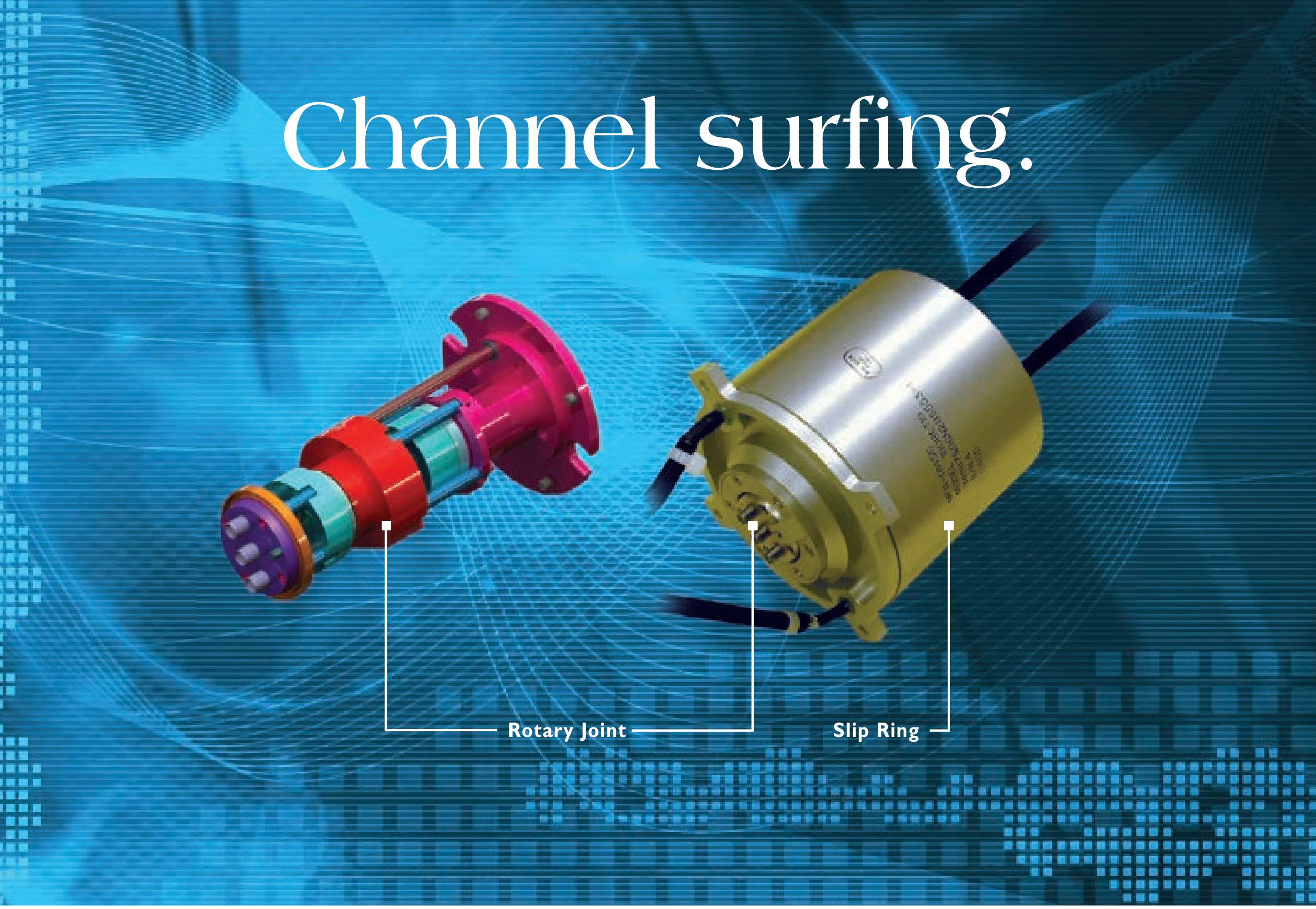
Another important parameter in the design of the anechoic chamber is the beamwidth of the source antenna. As mentioned previously, the reflectivity in the H-plane of the chamber is typically worse than in the E-plane. Poor reflectivity can be improved to some degree by reducing the beamwidth of the source antenna. However, too large of a beamwidth reduction leads to increased amplitude taper and reduction in the size of the test zone. Moreover, beamwidth reduction is not easy to achieve at VHF and UHF frequencies, since this requires increased dimensions of the source antenna, which is not always practical in an anechoic chamber. Electromagnetic simulation is thus an important tool in analyzing the optimum choice of source antenna prior to anechoic chamber construction.

The simulation examples represent the test zone field contour plots obtained with a source antenna composed of a single log-periodic dipole (LPD) antenna as well as with a pair of LPD antennas separated by a half wavelength. The difference in H-plane patterns of the two source antennas is shown in ***Figure 4***. Inspection of the contour plot lines in ***Figure 5*** reveals that the dual LPD array produces a more uniform field, exhibiting fields with nearly circularly symmetric contour lines.



▲ *Fig. 4 H-plane patterns of LPD-based source antenna (a) single LPD antenna, 3 dB BW, ≈ 106° and (b) pair of LPD antennas, 3 dB BW, ≈ 73°.*

Visit http://mwj.hotims.com/16346-48



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*

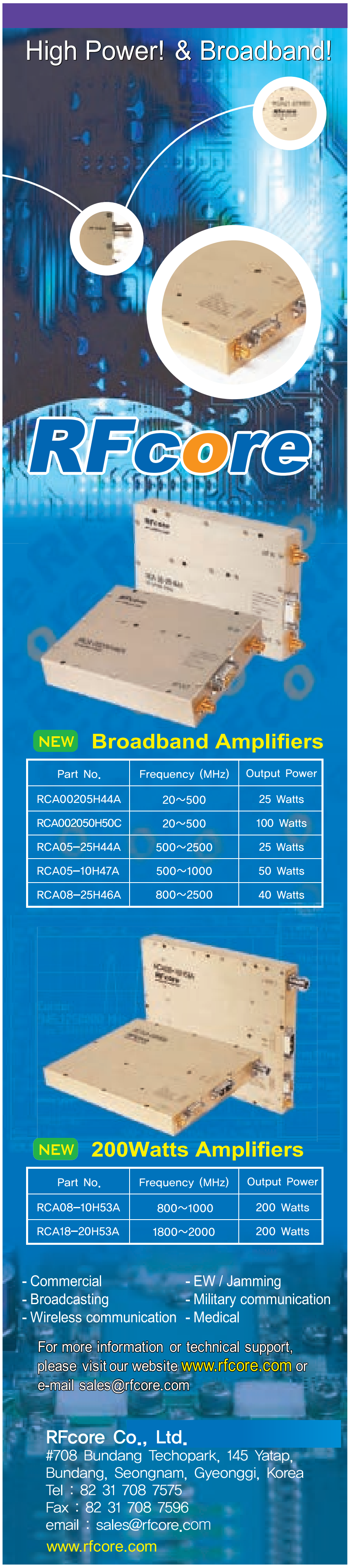
Slip Ring Assembly	
Isolated Contacts:	*30*
Voltage:	*20-300 Volts*
Current:	*.1 - 5 Amps*

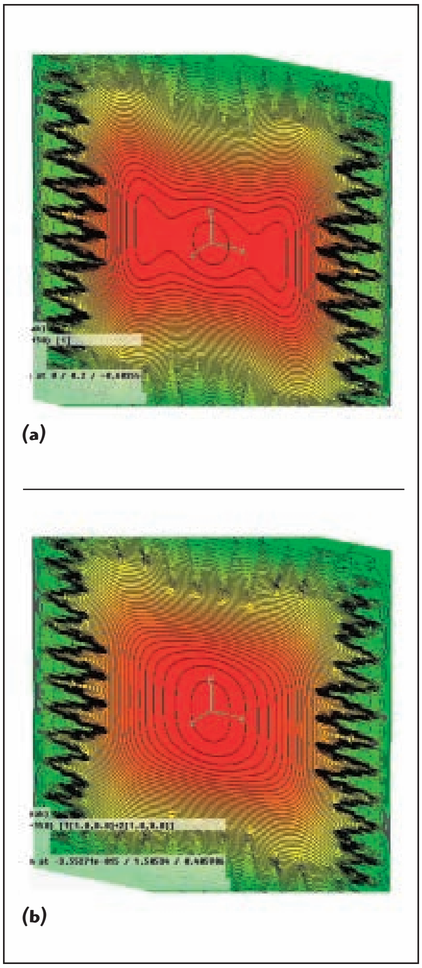
WAVEGUIDE CAST BENDS & TWISTS
WAVEGUIDE FEED ASSEMBLIES
MONOPULSE COMPARATORS
ROTARY JOINTS
MICROWAVE FILTERS
ROTARY SWITCHES
WAVEGUIDE TO COAX ADAPTERS
WAVEGUIDE PRESSURE WINDOWS
COMMERCIAL WAVEGUIDE ASSEMBLIES

MDL

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

Visit http://mwj.hotims.com/16346-85 or use RS# 85 at www.mwjournal.com/info

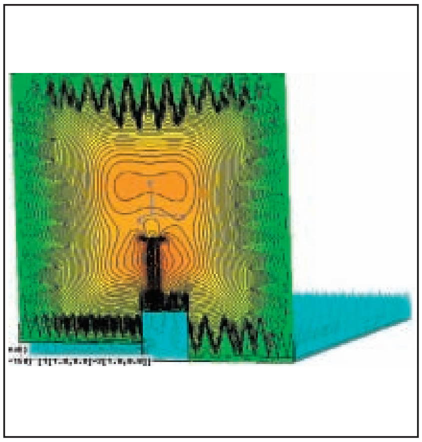




▲ *Fig. 5 Contour plots of test zone fields obtained using different source antennas: (a) single LPD antenna, 3 dB BW ≈ 106°; (b) pair of LPD antennas, 3 dB BW ≈ 73°.*

EFFECT OF POSITIONING EQUIPMENT ON TEST ZONE PERFORMANCE

Positioning equipment and a walkway absorber path for operator access to the DUT are required elements in any anechoic chamber. As a result of their close proximity to the test zone, both may cause undesired and uncontrolled test zone field perturbations, especially at low frequencies. The effects of these elements on test zone performance are often hard or impossible to estimate prior to their installation. Electromagnetic 3-D computer simulation is a tool capable of taking these elements into account and to estimate the overall test zone performance in advance, prior to the chamber construction. ***Figure 6*** shows how the positioner and fiberglass tower that supports the DUT may affect the test zone field distribution. As is evident, the field may lose important symmetry properties and the peak of the field (or the center of the test zone) moves higher, sometimes above the DUT mounting location. Addition of absorbers on the positioner assembly can often reduce this effect.



▲ *Fig. 6 Fields in the test zone with positioner, walkways and fiberglass tower included.*

CONCLUSION

Electromagnetic 3-D analysis of anechoic chambers at low frequencies such as the VHF and UHF bands, executed with the aid of time domain software, delivers significant advantages over previously utilized analysis methods, resulting in a much more accurate characterization of test zone fields, thus allowing a more cost-effective and higher performance chamber design.

The performance factors that may be evaluated include:

- Broadband analysis of the effects produced by absorber material layout and various absorber grades on test zone performance
- Definition of the optimal source antenna/DUT separation as a function of frequency
- Optimal choice of the source antenna(s)
- Analysis of the effects produced by DUT positioning equipment and mounts, as well as walkway absorber, on test zone performance. ■

References

1. L.H. Hemming, *Electromagnetic Anechoic Chambers: A Fundamental Design and Specification Guide*, Wiley-Interscience, Hoboken, NJ, 2002.
2. CST Studio Suite 2008.


See the Light...
CCS
Cosite Communication Solutions
Carefully designed communications links may fall short – interference eats away at your link margin. Co-sited transmitters emit broadband noise, your receiver is overloaded with out of band signals, and even rusty bolt effects result in unintended interference in your system. Can you hear? Are you being heard?
Pole/Zero can analyze your system and apply its vast database of knowledge and extensive line of range-restoring solutions. Selective agile filters and high dynamic range amplifiers, in carefully chosen configurations, clear the interference haze. For HF to microwave, transmit, receive, duplex, multicoupled, airborne, ground, maritime, SINCGARS, HAVEQUICK, SATURN, custom systems…
Recover your range – clear the haze by contacting one of our cosite communications engineers today!
COMM LINES
POLE ZERO
A DOVER COMPANY
CORPORATION
513.870.9060
fax 513.870.9064
www.polezero.com
microwave products
group
Visit http://mwj.hotims.com/16346-117
or use RS# 117 at www.mwjournal.com/info

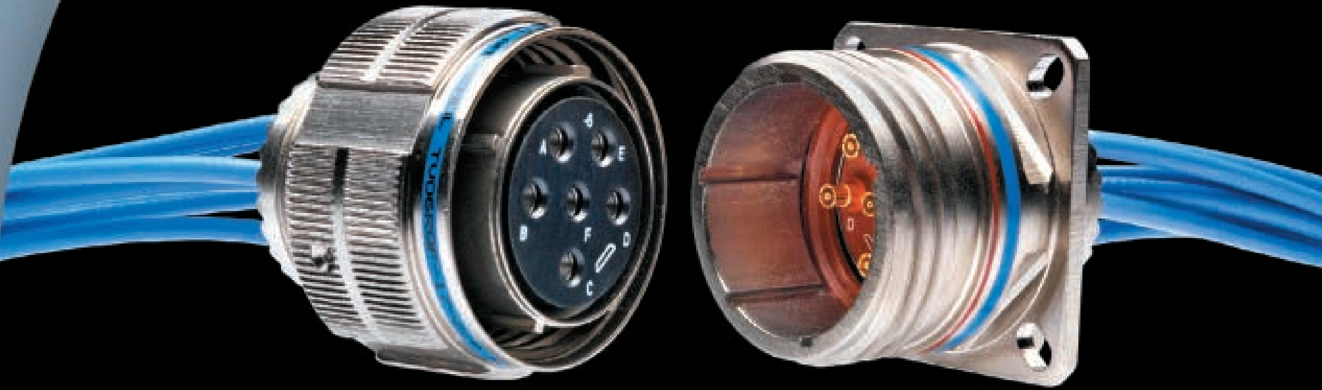
A COMPACT CPW-FED RECTANGLE-TRAPEZOID-RECTANGLE SHAPED MONOPOLE ANTENNA FOR ULTRA-WIDEBAND SYSTEMS

A novel CPW-fed rectangle-trapezoid-rectangle shaped monopole antenna composed of a trapezoid and two rectangles is presented. In this context, the flat monopole structure improves the impedance bandwidth and reduces the size of the antenna dramatically. The ultra-wideband (UWB) antenna design plays a role as a filter. The coplanar waveguide grounds are beveled and the impedance transformer patch (ITP) performs a 50 to 100 Ω impedance transformation. The impedance and radiation characteristics of this antenna are studied. The measured bandwidth, defined by a 10 dB return loss, is from 2.78 to 10.71 GHz. The overall size of the printed antenna is 31.45 × 31.45 × 0.8 mm, which is very compact, low profile and can be integrated within an ultra-wideband transceiver. The proposed antenna also has the advantages of a very simple geometric structure, good radiation characteristics, almost omni-directional radiation patterns and smooth gain characteristics. Therefore, it is a good candidate for ultra-wideband applications.

Ultra-wideband technology has been widely used in various wireless communications and has attracted much attention recently for communication systems. UWB is suitable for high-speed wireless communications within Wireless Personal Area Network (WPAN), because of its short-range, high data-rates, low-cost and low-power technology, utilizing the unlicensed radio spectrum from 3.1 to 10.6 GHz. The design of a UWB antenna is one of the most exciting tasks in these systems. Some coplanar waveguide (CPW) antennas have been proposed for wideband applications.[1–11]

One of the critical issues in UWB system design is the size of the antenna for portable devices, because the size affects the wide impedance bandwidth, gain and omni-directional radiation pattern. Therefore, to miniaturize an

WEN-SHAN CHEN AND
KAI-CHENG YANG
Southern Taiwan University
Tainan Hsien, Taiwan, ROC

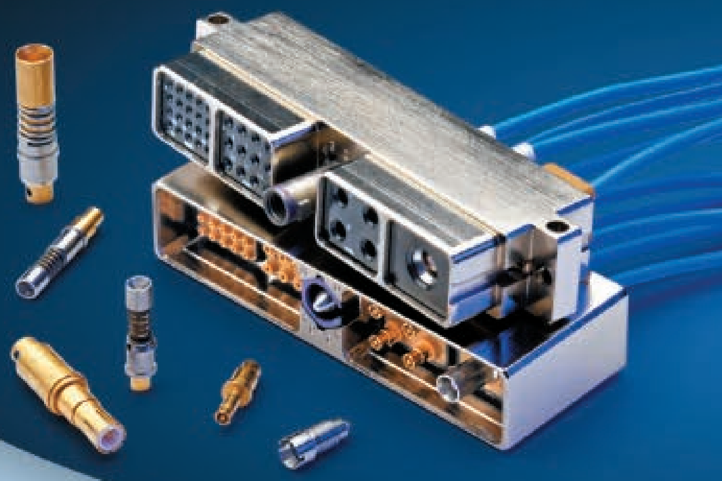


Varoom to move

Performance and flexibility. SV's latest multiport contacts and cable assemblies deliver shielded connections up to 40 GHz while offering the benefits of our robust blindmate contacts and innovative float mount technology. Choose from D38999, ARINC and Micro-D styles and select the perfect tension in the float for your application.

D38999 contacts are available in Size 8, 12, and 16 configurations and are interchangeable with any D38999 insert. So now you can expand the use of your assemblies into the microwave range without the need for a custom connector.

A little wiggle room never felt so good. To learn more about our RF Multiport contacts and assemblies visit **www.svmicrowave.com/multiportcontacts**



Electrical

Frequency Range:	
Size 8 standard interface:	DC-18 GHz
Size 8 custom interface:	DC-40 GHz
Size 12 and 16:	DC-40 GHz
Nominal Impedance:	50 ohms
VSWR:	1.07 + .01 (f) GHz
Insertion Loss:	.06 x square root (f) GHz
Insulation Resistance:	10,000 Mohms

Materials and Finishes:

Body:	Stainless steel per AMS-5640, UNS-S30300, Type 1
	Gold plated per ASTM-B-488 over nickel per SAE AMS-QQ-N-290, or passivated
Contacts:	Beryllium copper per ASTM-B-195
	Gold plated per ASTM-B-488 over nickel per SAE AMS-QQ-N-290
Insulators:	PTFE per ASTM D-1710

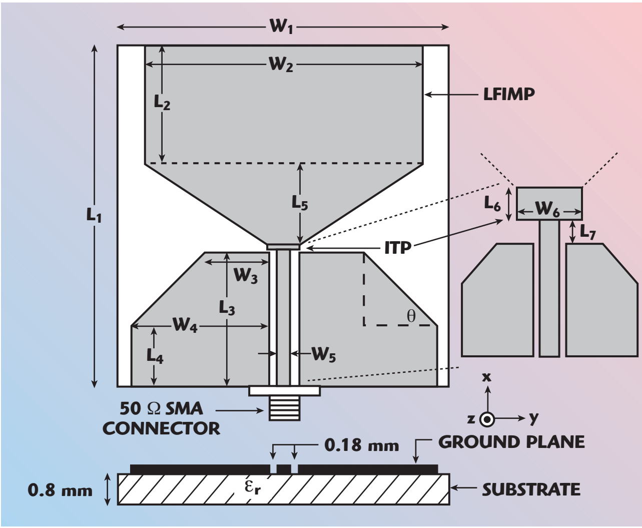
Amphenol®
SV MICROWAVE
RF Connectors & Components

www.svmicrowave.com | 561-840-1800 x128

Visit http://mwj.hotims.com/16346-152 or use RS# 152 at www.mwjournal.com/info

antenna capable of providing a broad impedance matching bandwidth and an acceptable gain is a challenging task.[4] To increase the bandwidth, such techniques as constructing a simple bevel,[5] using a smooth rounded element[6] or using a shorting pin[7] have been reported. In addition, CPW-fed monopoles[1–4] have also been introduced for their compact size, simple structure and ease of integration with microwave circuits.

In this article, a small size antenna is proposed using a CPW feedline for UWB systems. Compared to the printed folded flared monopole antenna[8] and the improved U-shaped stub rectangular slot antenna with a tuning pad for UWB applications,[9] the proposed antenna can produce better gain and good radiation performance. This novel CPW-feed rectangle-trapezoid-rectangle shaped monopole antenna is composed of a trapezoid and a tangential rectangle. This monopole structure reduces the size, improves the impedance bandwidth and offers a smooth gain and almost omni-directional patterns. The detailed design and experimental results are presented and discussed in the following sections.



▲ *Fig. 1 Geometry of the printed CPW-fed UWB antenna.*

ANTENNA DESIGN

The proposed antenna has a simple structure, with one layer of dielectric and metal. The antenna is fabricated on a low-cost FR-4 substrate with a dielectric constant $\varepsilon_r = 4.4$ and thickness h = 0.8 mm. The following design method has been used to develop the proposed CPW-feed antenna knowing the lowest frequency of the UWB operation (f_L = 3.1 GHz) and the effective dielectric constant of the transmission line (ε_{reff}). Excluding the feeder, the width (W_1) and length (L_1) of the antenna structure can be calculated using Equations 1 and 2

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} \tag{1}$$

$$W_1 = L_1 = \frac{c}{2f_L\sqrt{\varepsilon_{reff}}} \tag{2}$$

where

c = speed of light in free space

The rectangle-trapezoid-rectangle shape is printed on a substrate L_1 = 31.45 mm (0.3249 λ) by W_1 = 31.45 mm (0.329 λ) substrate, where λ is the free space wavelength at the 3.1 GHz frequency. The monopole antenna is fed by a 50 Ω CPW line with width W_5 = 1.5 mm and a spacing gap G_1 = 0.18 mm between the center conductor and the ground plane. The geometry of the proposed antenna is shown in ***Figure 1***. The bevels in the ground plane enhance the operating bandwidth. The flare angle is θ = 45°.

In this article, the impedance transformer patch (ITP) is designed to obtain a well-matched wideband antenna. Recognizing that the center frequency for UWB operation is f_r = 7.85 GHz and the dielectric constant is ε_r, the major ITP length (W_6) and the width (L_6) are chosen according to the following equations:

$$W_6 = \frac{c}{8f_r}\left(\frac{\varepsilon_{reff}+1}{2}\right)^{\frac{1}{2}} \tag{3}$$

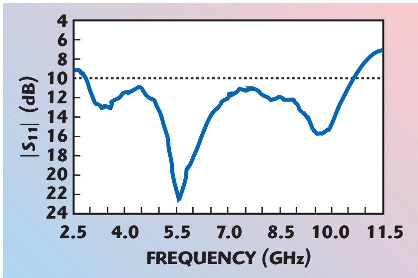
$$L_6 = \frac{1}{W_6} = \frac{1}{\dfrac{c}{8f_r}\left(\dfrac{\varepsilon_{reff}+1}{2}\right)^{\frac{1}{2}}} \tag{4}$$

The ITP is formed by setting W_6 = 4 mm. When the length of the W_6 section increases, the ITP becomes a rectangle and the bandwidth increases gradually. The length of W_6 controls the effective area of the rectangle and is the primary parameter to determine the coupling between the antenna element and the ground plane.

The rectangle-trapezoid-rectangle shaped patch is the radiator of the proposed design. The parameter $L_T = (L_2 + L_5 + L_6 + L_7)$ is used to control the impedance matching of the patch (LFIMP) at the lower frequency of operation and the width W_2 influences the impedance bandwidth at the lower frequencies. The major length (L_T) is chosen according to the following equation

$$L_T = L_2 + L_5 + L_6 + L_7 = \frac{c}{4f_L}\sqrt{\frac{2}{\varepsilon_{reff}+1}} \tag{5}$$

Table 1 lists the antenna parameters of the proposed design. This antenna was constructed and experimentally studied.



▲ *Fig. 2 Measured return loss of the proposed antenna.*

TABLE I

DIMENSIONS OF THE CPW-FED RECTANGLE-TRAPEZOID-RECTANGLE MONOPOLE

Antenna Parameter	L_2	L_3	L_4	L_5	L_6	L_7	W_2	W_3	W_4	W_6	θ
Unit (mm)	9.99	14	9	6.61	0.2	0.65	19	5	10	4	45°

TUSONIX

A Subsidiary of CTS Electronic Components

A World Leader in Ceramic EMI/RFI Components

...and a broad range of fixed and variable ceramic capacitors

- **Technology**...EMI/RFI Components based on extensive Ceramic Dielectric Technology.
- **Innovation**...Our coaxial resonators are produced utilizing a proprietary metalization process.
- **Delivery**...We meet customer needs with proven on-time performance & in-demand products.
- **Quality**...Quality Management System adheres to ISO 9001.
- **Value**...Cost Effective Solutions are a priority.

www.tusonix.com

TUSONIX
A Subsidiary of CTS Electronic Components

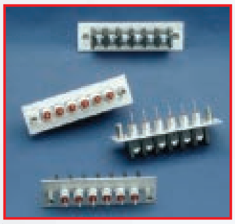
- 7741 N. Business Park Drive
  Tucson, Arizona 85743
- 520-744-0400 FAX: 520-744-6155
- email: sales@tusonix.com

TUSONIX Featured Products

Ceramic Coaxial Resonators

- High quality factor Q
- Excellent Solderability
- Easy to fine tune or adjust SRF
- Rugged, thermally stable ceramics
- Wide frequency range w/ high tolerance
- Superior metalization offers great adherence

Back Plane Filtered Terminal Blocks



- Cost Effective & Sturdy
- Filters recognized to UL standard 1283 and terminal blocks recognized to UL standard 1059
- Insertion loss range from 10 MHz to 10GHz
- Custom Design Options

Visit http://mwj.hotims.com/16346-168 or use RS# 168 at www.mwjournal.com/info

Visit Us On-Line at www.tusonix.com

- On-line, we offer an Information Request page, a Stock Check page, Product Information and Specifications info, PDF Format Catalogs and much more. For more info, call Customer Service at 520-744-0400.

Visit http://mwj.hotims.com/16346-21

Call for Book and Software Authors

You can enhance your professional prestige and earn substantial royalties by writing a book or software package. With over 500 titles in print, Artech House is a leading publisher of professional-level books in microwave, radar, communications and related subjects. We are seeking to publish new microwave engineering books and software in areas such as microwave and RF device design, wireless communications, advanced radar and antenna design, electromagnetic analysis, RF MEMS, and more.

We are currently seeking potential authors among engineers and managers who believe that they can make a contribution to the literature in their areas of expertise. If you have published technical papers, conducted professional seminars or solved important real-world problems, then you are an excellent candidate for authorship.

We invite you to submit your manuscript or software proposal for review. For a complete publications catalog and Author's Questionnaire please contact:

Mark Walsh
Editor
Artech House
685 Canton St.
Norwood, MA 02062

1-800-225-9977
mwalsh@artechhouse.com

Dr. Simon Plumtree
Senior Publishing Editor
Artech House
46 Gillingham Street,
London SW1V 1AH, UK

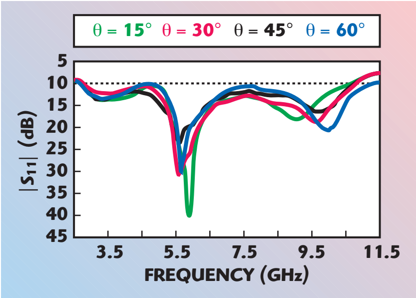
Tel: +44(0) 207 596 8750
splumtree@artechhouse.co.uk

ARTECH HOUSE | www.artechhouse.com

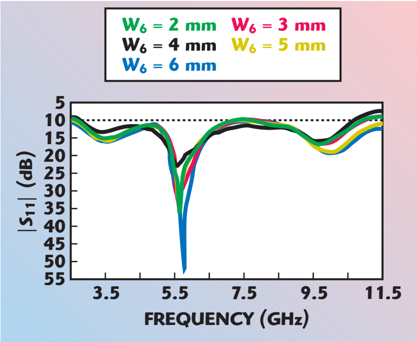
EXPERIMENTAL RESULTS AND DISCUSSION

To verify the performance of the proposed antenna, the prototype of the UWB antenna was measured after fabrication. The impedance bandwidth has been measured using the Agilent-8720ES vector network analyzer (VNA).

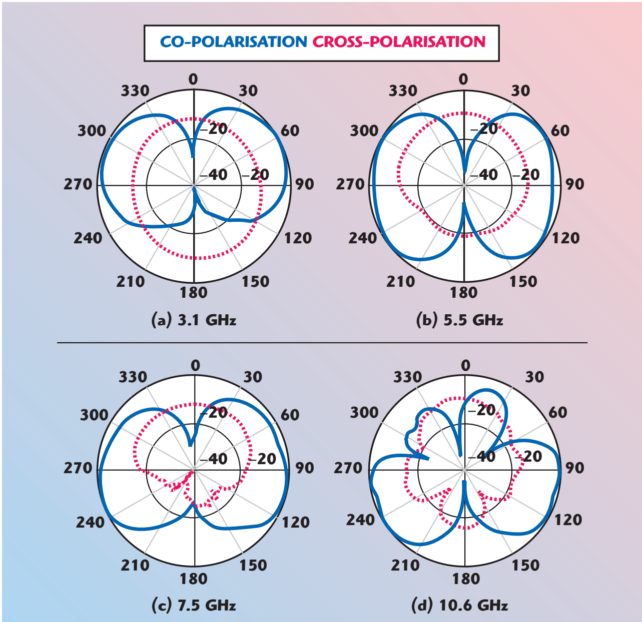
Figure 2 shows the measured return losses of the proposed antenna, which shows that a 10 dB bandwidth of 2.78 to 10.71 GHz has been achieved. The broadband of the rectangle-trapezoid-rectangle shaped monopole antenna is evident. This antenna has a matching impedance bandwidth that meets the requirements of the UWB band of 3.1 to 10.6 GHz. From the measured results shown, the length L_2 of the LFIMP is approximately 0.1 times the operating center wavelength. In ***Figure 3***, the impedance bandwidth is measured as a function of θ when the other antenna dimensions, $L_1 = 31.45$ mm, $L_2 = 9.99$ mm, $L_3 = 14$ mm, $L_4 = 9$ mm, $L_5 = 6.61$ mm, $L_6 = 0.2$ mm, $L_7 = 0.65$ mm, $W_1 = 21.86$ mm, $W_2 = 19$ mm, $W_3 = 5$ mm, $W_4 = 10$ mm, $W_5 = 1.5$ mm, $W_6 = 4$ mm, $G_1 = 0.18$ mm, $h = 0.8$ mm and $\varepsilon_r = 4.4$ are kept con-



▲ *Fig. 3 Measured return loss as a function of the ground plane bevel angle.*



▲ *Fig. 4 Measured return loss as a function of W_6.*



▲ *Fig. 5 Measured radiation patterns in the x-z plane (E-plane).*

Meeting Tomorrow's Challenges

Test & Measurement Solutions for Aerospace and Defense

75 Years of Driving Innovation

ROHDE&SCHWARZ

The R&S®ESU test receiver breaks new ground for testing MIL-STD-461/462 EMI, with fully compliant test for MIL-STD-461 A-F and DO 160.

- Frequency coverage from 20 Hz to 40 GHz
- High sensitivity across the entire frequency range (built-in preamplifier)
- Built-in preselector (single-box solution)
- FFT-based time domain scan for extremely fast overview measurements
- Onboard report generator
- Removable mass storage for use in secure areas

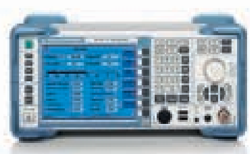
The R&S®ZVA network analyzer is a high-end instrument for challenging R&D tasks. It sets new standards in numerous areas and is well suited for measurements on active and frequency-converting devices.

- Pulsed measurements including pulse profile measurements with wide bandwidth and high time resolution
- Arbitrary frequency conversion measurements including mixer measurements
- Four-port architecture with integrated second source
- Coherent sources with adjustable phase offset
- Removable mass storage for use in secure areas

The R&S®ZVA-Z75, R&S®ZVA-Z110 and R&S®ZVA-Z325 external frequency converters facilitate network analysis in the V band from 50 GHz to 75 GHz, in the W band from 75 GHz to 110 GHz or in the J band from 220 GHz to 325 GHz, respectively, in combination with an R&S®ZVA or R&S®ZVT network analyzer.

The R&S®UPV audio analyzer is a universal instrument for audio and low frequency analysis, with generator and analyzer functionality in the analog domain, and optionally in the digital domain.

- Linear and non-linear distortion measurements
- FFT and waveform analysis
- Protocol and interface measurements in the digital domain



The R&S®EVS300 ILS/VOR analyzer is a portable level and modulation analyzer designed specifically for starting up, checking and maintaining ILS, VOR and marker beacon systems.

Its numerous software options enable users to analyze the frequency and time domains of received signals without having to take along extra T&M equipment.

- High-precision level and modulation measurements
- GPS, trigger and remote control interfaces
- Realtime data logging
- Two independent measurement channels (option)
- Support for the R&S®NRT and R&S®NRP power sensors

The R&S®NRP-Z power sensors provide top accuracy and ease of use.

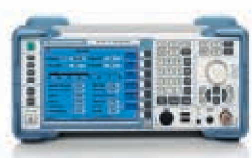
- Highest precision at fast measurement speed
- Operable from the R&S®NRP base unit, a signal generator, or spectrum or network analyzer, or standalone when connected directly to a PC via USB

The R&S®ESU test receiver breaks new ground for testing MIL-STD-461/462 EMI, with fully compliant test for MIL-STD-461 A-F and DO 160.
- Frequency coverage from 20 Hz to 40 GHz
- High sensitivity across the entire frequency range (built-in preamplifier)
- Built-in preselector (single-box solution)
- FFT-based time domain scan for extremely fast overview measurements
- Onboard report generator
- Removable mass storage for use in secure areas

The R&S®ZVA network analyzer is a high-end instrument for challenging R&D tasks. It sets new standards in numerous areas and is well suited for measurements on active and frequency-converting devices.
- Pulsed measurements including pulse profile measurements with wide bandwidth and high time resolution
- Arbitrary frequency conversion measurements including mixer measurements
- Four-port architecture with integrated second source
- Coherent sources with adjustable phase offset
- Removable mass storage for use in secure areas

The R&S®ZVA-Z75, R&S®ZVA-Z110 and R&S®ZVA-Z325 external frequency converters facilitate network analysis in the V band from 50 GHz to 75 GHz, in the W band from 75 GHz to 110 GHz or in the J band from 220 GHz to 325 GHz, respectively, in combination with an R&S®ZVA or R&S®ZVT network analyzer.

The R&S®UPV audio analyzer is a universal instrument for audio and low frequency analysis, with generator and analyzer functionality in the analog domain, and optionally in the digital domain.
- Linear and non-linear distortion measurements
- FFT and waveform analysis
- Protocol and interface measurements in the digital domain



The R&S®EVS300 ILS/VOR analyzer is a portable level and modulation analyzer designed specifically for starting up, checking and maintaining ILS, VOR and marker beacon systems.

Its numerous software options enable users to analyze the frequency and time domains of received signals without having to take along extra T&M equipment.
- High-precision level and modulation measurements
- GPS, trigger and remote control interfaces
- Realtime data logging
- Two independent measurement channels (option)
- Support for the R&S®NRT and R&S®NRP power sensors

The R&S®NRP-Z power sensors provide top accuracy and ease of use.
- Highest precision at fast measurement speed
- Operable from the R&S®NRP base unit, a signal generator, or spectrum or network analyzer, or standalone when connected directly to a PC via USB

The R&S®ESU test receiver breaks new ground for testing MIL-STD-461/462 EMI, with fully compliant test for MIL-STD-461 A-F and DO 160.

- Frequency coverage from 20 Hz to 40 GHz
- High sensitivity across the entire frequency range (built-in preamplifier)
- Built-in preselector (single-box solution)
- FFT-based time domain scan for extremely fast overview measurements
- Onboard report generator
- Removable mass storage for use in secure areas

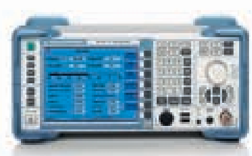
The R&S®ZVA network analyzer is a high-end instrument for challenging R&D tasks. It sets new standards in numerous areas and is well suited for measurements on active and frequency-converting devices.

- Pulsed measurements including pulse profile measurements with wide bandwidth and high time resolution
- Arbitrary frequency conversion measurements including mixer measurements
- Four-port architecture with integrated second source
- Coherent sources with adjustable phase offset
- Removable mass storage for use in secure areas

The R&S®ZVA-Z75, R&S®ZVA-Z110 and R&S®ZVA-Z325 external frequency converters facilitate network analysis in the V band from 50 GHz to 75 GHz, in the W band from 75 GHz to 110 GHz or in the J band from 220 GHz to 325 GHz, respectively, in combination with an R&S®ZVA or R&S®ZVT network analyzer.

The R&S®UPV audio analyzer is a universal instrument for audio and low frequency analysis, with generator and analyzer functionality in the analog domain, and optionally in the digital domain.

- Linear and non-linear distortion measurements
- FFT and waveform analysis
- Protocol and interface measurements in the digital domain



The R&S®EVS300 ILS/VOR analyzer is a portable level and modulation analyzer designed specifically for starting up, checking and maintaining ILS, VOR and marker beacon systems.

Its numerous software options enable users to analyze the frequency and time domains of received signals without having to take along extra T&M equipment.

- High-precision level and modulation measurements
- GPS, trigger and remote control interfaces
- Realtime data logging
- Two independent measurement channels (option)
- Support for the R&S®NRT and R&S®NRP power sensors

The R&S®NRP-Z power sensors provide top accuracy and ease of use.

- Highest precision at fast measurement speed
- Operable from the R&S®NRP base unit, a signal generator, or spectrum or network analyzer, or standalone when connected directly to a PC via USB

From multimode radar to the network-centric battlefield, mission success depends on the performance of electronic systems for detection, interception, encryption, dissemination, communication, and interdiction. These systems must all perform flawlessly, and tomorrow's challenges must be anticipated and met today.

Rohde & Schwarz plays an integral role in meeting the challenges tomorrow will bring. We're one of the world's leading innovators in electronic test & measurement, radiocommunications, and radiomonitoring and radiolocation. The scope and performance of our technologies is second to none.

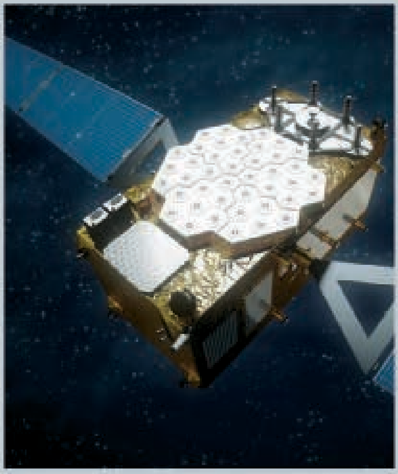
Aerospace and defense programs rely on the unsurpassed performance and quality of Rohde & Schwarz solutions. Since we keep all manufacturing in-house, we can maintain the tight control on quality that only co-located engineering and manufacturing can provide. We also provide a unique level of support. With facilities in over 70 couwntries, comprehensive service, and the ability to serve any need including custom solutions and systems, we not only win on performance – we win on support too.

The force behind innovation

Rohde & Schwarz has been developing test & measurement solutions for 75 years, starting with our first frequency meter in 1933. We've been instrumental in moving the technological benchmark – with developments such as state-of-the art TOI performance and 120 MHz modulation bandwidth in our high performance spectrum analyzers. True four-port 50 GHz network analysis, highly innovative signal generators with up to two signal paths in one instrument (including 2 x 2 MIMO realtime fading), power meters with smart sensor technology, the R&S®FSMR one-box test receiver, and the industry-leading new R&S®PR 100 handheld radiomonitoring receiver are further examples of pacesetting Rohde & Schwarz products.

For decades, Rohde & Schwarz solutions have been in use by military services and government agencies. Aerospace and defense contractors use our test & measurement solutions in cutting-edge R&D, production, and operational support programs alike. We work collaboratively with the aerospace and defense industry to bring focused solutions that meet our customers' exacting requirements. Our developments are integral parts of many of the most cutting-edge defense programs in the world today. Confidence in Rohde & Schwarz solutions is underscored by the numerous direct government contracts won over the last decade. As an example, the U.S. Army awarded Rohde & Schwarz a 4000-unit contract for the R&S®SMB signal generator, which will replace their legacy analog signal generators.

Test & measurement technology is key to the proper functioning of electronic systems in all branches of the military



Customer Support

Europe, Africa, Middle East | +49 1805 124242
customersupport@rohde-schwarz.com
North America | +1 888 837 8772
customer.support@rsa.rohde-schwarz.com
Latin America | +1 410 910 7988
customersupport.la@rohde-schwarz.com
Asia/Pacific | +65 65 130488
customersupport.asia@rohde-schwarz.com

www.rohde-schwarz.com

R&S® is a registered trademark of Rohde&Schwarz GmbH&Co. KG · Trade names are trademarks of the owners · Printed in Germany (Pe bb)
PD 5214.1965.62 V01.00 · July 2008 · Data without tolerance limits is not binding · Subject to change

AMTA is coming...

AMTA is coming...

Boston, Massachusetts
November 16-21, 2008

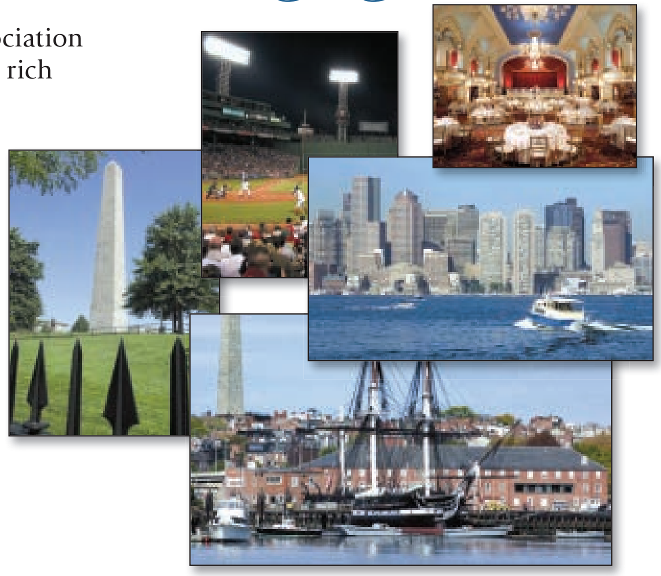
Come join us where American history began!

The 30th Annual Antenna Measurement Techniques Association Symposium offers a strong technical program as well as a rich historical and cultural experience and many professional networking opportunities.

Registration is available online at www.amta2008.org.

Take advantage of early registration discount rates by registering before October 10th.

Accommodations at the Boston Park Plaza Hotel must be made separately.
Call 617.426.2000 to make your reservation by the October 10 cutoff date. Tell them you will be attending the AMTA 2008 Symposium to get the discounted rate of $199 USD, plus tax, for single or double occupancy.



For more information on AMTA 2008,
visit: www.AMTA2008.org

Highlights of AMTA 2008 will be:

- Sunday Short Course presented by Professor Rahmat-Samii of UCLA
- Monday opening of technical sessions – the high number of excellent abstracts received promises an outstanding technical program
- Monday's exhibitor's lunch (the great meet and eat event)
- Monday night dinner cruise on the Odyssey in the scenic Boston Harbor
- Tuesday "Student Day" includes attendance at paper sessions and exhibits, and culminates with a casual dinner and a panel discussion in the evening
- Wednesday evening annual awards banquet
- Thursday evening Blue Man Group performing at the Charles Playhouse.
- Friday visit the Boston Museum of Science for a unique technical tour
- Daily Companion tours including: the Freedom Trail, the world champion Red Sox Fenway Park, Boston's North End (Italian district), the Museum of Fine Arts, the Isabella Stewart Gardner Museum, a guided tour of Harvard Square, and a visit to the JFK Library.

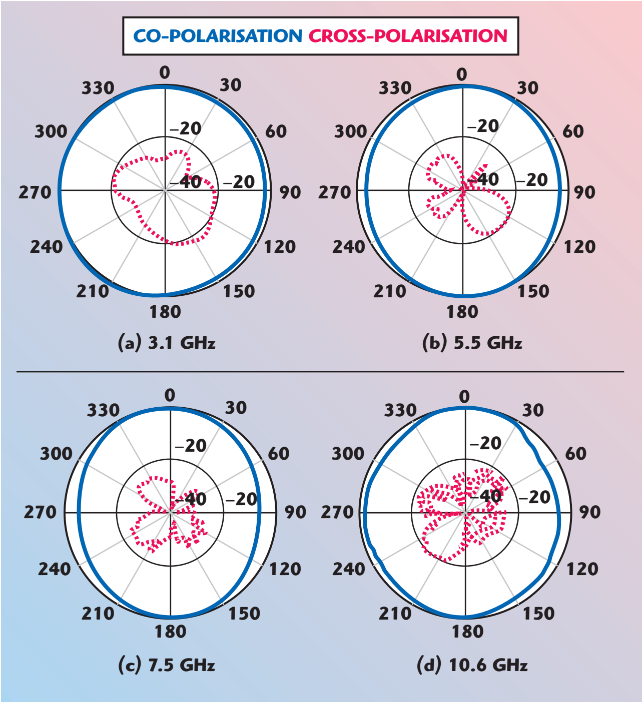
AMTA 2008 IS HOSTED BY:

SAIC® From Science to Solutions

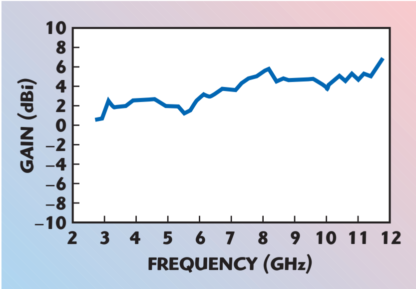
CASCA Center for Advanced Sensor and Communication Antennas

Sponsorship opportunities are available. Contact Yvonne Grosek at yvonne@amta2008.com or 714-540-8638.

Visit http://mwj.hotims.com/16346-11 or use RS# 11 at www.mwjournal.com/info



▲ *Fig. 6 Measured radiation patterns in the y-z plane (H-plane).*



▲ *Fig. 7 Measured gain of the proposed antenna.*

stant. It shows how the return loss of the rectangle-trapezoid-rectangle shaped monopole varies with different ground plane bevel angles θ. It can be observed that this arrangement of the design leads to the enhancement of the impedance matching bandwidth as the bevel angle θ increases. It is observed that the angle of θ determines the impedance matching in the band of 4 to 5.5 GHz.

Figure 4 shows the return loss for different ITP lengths (W_6), all other dimensions being identical to the previous figure. It is observed that the length of W_6 determines the impedance matching in the band of 6.5 to 9 GHz. The radiation patterns of the proposed antennas at 3.1, 5.5, 7.5 and 10.6 GHz were also measured. ***Figures 5*** and ***6*** show the x-z plane (E-plane) and y-z plane (H-plane) patterns, respectively. It is obvious that the radiation patterns are nearly omni-directional patterns and suitable for UWB applications. ***Figure 7*** shows that the measured antenna gain, within the operating frequency band, is 2.5 to 5.6 dBi. The gain flatness of the proposed antenna is suitable for UWB applications.

CONCLUSION

A novel CPW-fed printed rectangle-trapezoid-rectangle shape antenna has been proposed. The proposed

Herley New England
Custom High Power Capability

Qualified to airborne EW standards

- Switches
- Limiters
- Integrated Assemblies
- 0.5 to 18 GHz
- Up to 10 KW typical peak power handling
- Complete in house testing facility
- MIC and waveguide technologies available

Contact Herley New England for all of your high power applications.

Sales@herleynewengland.com
Telephone: 781-729-9450
Facsimile: 781-729-9547

Visit http://mwj.hotims.com/16346-53

HERLEY Industries, Inc.

Proven Microwave Performance
www.herley.com

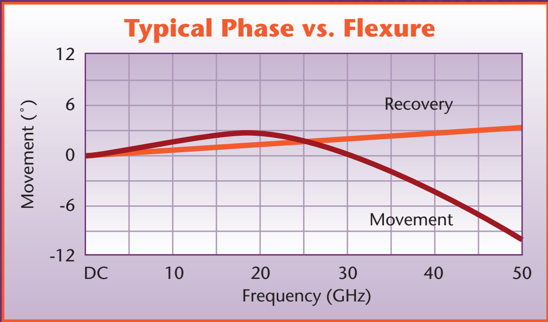
Herley New England, 10 Sonar Drive, Woburn, MA 01801 • **Telephone:** 781-729-9450
FAX: 781-729-9547 • www.herley.com • **E-Mail:** sales@herleynewengland

MegaPhase® GrooveTube® Technology

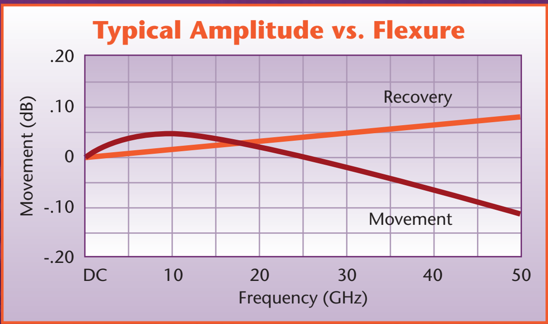
Use GrooveTube® for your ATE or VNA:

For **Consistent Measurements**. Every Time, All The Time.
The **Best Phase and Amplitude Stability**. Period.
Save Money Over OEM Test Cables.

Typical Phase vs. Flexure



Typical Amplitude vs. Flexure



GrooveTube® Test Cable Products

Your Application ➧	VNA High Performance Test Cable	MegaRED™ Bench Test Cable	SightLine™ Field & Prod. Test Cable	Superflex Low Loss Test Cable
MegaPhase® Series	**VN Series**	**TM Series**	**SL Series**	**SF Series**
DC - 4 GHz	VN4	TM4	SL4	SF4
DC - 8 GHz	VN8	TM8	SL8	SF8
DC - 18 GHz	VN18	TM18	SL18	SF18
DC - 26 GHz	VN26	TM26	SL26	SF26
DC - 40 GHz	VN40	TM40	SL40	-
DC - 50 GHz	VN50	TM50	SL50	-
Max. Frequency	50 GHz			26.5 GHz
Inner Conductor	Solid			Stranded
Dielectric	Solid PTFE			PTFE Tape
Outer Conductor	Super-Flexible Copper GrooveTube® by MegaPhase®			
Finished Outer Diameter	0.625 in. 15.88 mm	0.285 in. 7.24 mm	0.500 in. 12.70 mm	0.285 in. 7.24 mm
Ruggedization	Metal Braid over Metal Armor	Metal Braid	Metal Braid over Metal Armor	Metal Braid
Outer Jacket	PET Braid	Polyolefin	Neoprene	Polyolefin
Bend Radius	1.5 in. 38.1 mm	0.5 in. 12.7 mm	1.5 in. 38.1 mm	0.5 in. 12.7 mm
Flexibility Rating – Highest = 5.0	4.0	4.5	4.0	5.0

Repeatable & Consistent Measurements:
GrooveTube® is a super-flexible copper outer conductor that maintains its geometry – flexure after flexure. GrooveTube® doesn't cage, kink and fatigue like traditional braid/foil outer conductors. As a result calibrations won't degrade over time.

Superior Phase & Amplitude Stability to 67 GHz:
GrooveTube® outer conductor is the industry's best phase & amplitude performance vs. flexure. When flexed, the inner conductor stays dead center.

Cost Savings vs. OEM Test Cables:
Save your budget dollars – GrooveTube® test cables eature the lowest cost per measurement: fewer calibrations, longer life and less procurement. MegaPhase® rugged test cables feature precision connectors, ISO-level quality, and fast deliveries.

Broadband Probe Station Adapter

For data on the full line of MegaPhase® products:
MegaPhase.com
1-877-MegaPhase / 570-424-8400
GrooveTube@MegaPhase.com

MegaPhase®

Testing, Connecting, and Enabling Electronic Systems from DC-67 GHz.

Visit http://mwj.hotims.com/16346-79 or use RS# 79 at www.mwjournal.com/info

antenna, with a compact size of 31.45 × 31.45 × 0.8 mm, was implemented. It has a simple geometry, an effective feeding structure, an adequate operational bandwidth, a nearly smooth gain and has almost omni-directional radiation patterns. These features are very attractive for UWB applications and the antenna can be integrated in transceivers. ■

References

1. H.D. Chen and H.T. Chen, "A CPW-fed Dual-frequency Monopole Antenna,"*IEEE Transactions on Antennas and Propagation*, Vol. 52, No. 4, April 2004, pp.978–982.
2. D.C. Chang, J.C. Liu and M.Y. Liu, "A Novel Tulip-shaped Monopole Antenna for UWB Applications," *Microwave and Optical Technology Letters*, Vol. 48, No. 2, December 2005, pp. 307–312.
3. W.C. Liu and P.C. Kao, "CPW-fed Triangular Monopole Antenna for Ultra-wideband Operation," *Microwave and Optical Technology Letters*, Vol. 47, No. 6, October 2005, pp. 580–582.
4. S.W. Su, K.L. Wong and C.L. Tang, "Ultra-wideband Square Planar Monopole Antenna for IEEE 802.16a Operation in the 2 to 11 GHz Band," *Microwave and Optical Technology Letters*, Vol. 42, No. 6, July 2004, pp. 463–466.
5. M.J. Ammann, "Control of the Impedance Bandwidth of Wideband Planar Monopole Antennas Using a Beveling Technique," *Microwave and Optical Technology Letters*, Vol. 30, No. 4, July 2001, pp. 229–232.
6. N.P. Agrawall, G. Kumer and K.P. Ray, "Wideband Planar Monopole Antennas," *IEEE Transactions on Antennas and Propagation*, Vol. 46, No. 4, April 1998, pp. 294–295.
7. M.J. Ammann and Z.N. Chen, "A Wideband Shorted Planar Monopole with Bevel," *IEEE Transactions on Antennas and Propagation*, Vol. 51, No. 4, April 2003, pp. 901–903.
8. R.B. Waterhouse and D. Novak, "Printed Folded Flared Monopole Antenna," *Electronics Letters*, Vol. 42, No. 3, February 2006, pp. 141–142.
9. D.C. Chang, J.C. Liu and M.Y. Liu, "Improved U-shaped Stub Rectangular Slot Antenna with Tuning Pad for UWB Applications," *Electronics Letters*, Vol. 41, No. 20, October 2005, pp. 1095–1097.
10. C.H.K. Chin, Q. Xue, H. Wong and X.Y. Zhang, "Broadband Patch Antenna with Low Cross-polarisation," *Electronics Letters*, Vol. 43, No. 3, February 2007, pp. 137–138.
11. K.P. Ray, Y. Ranga and P. Gabhale, "Printed Square Monopole Antenna with Semi-circular Base for Ultra-wide Bandwidth," *Electronics Letters*, Vol. 43, No. 5, March 2007, pp. 13–14.

Wen-Shan Chen *received his BSc degree in electronic engineering of technology from the National Taiwan Institute of Technology (now known as the National Taiwan University of Technology) and his PhD degree from National Sun Yat-Sen University, Kaohsiung, Taiwan, ROC, in 2001. From 2001 to 2002, he was an assistant professor at the Chien-Kuo Institute of Technology, Changhua, Taiwan, ROC. He is currently an assistant professor in the department of electronic engineering of Southern Taiwan University, Tainan, Taiwan, ROC. His research interests include antenna design, RF and microwave circuits.*

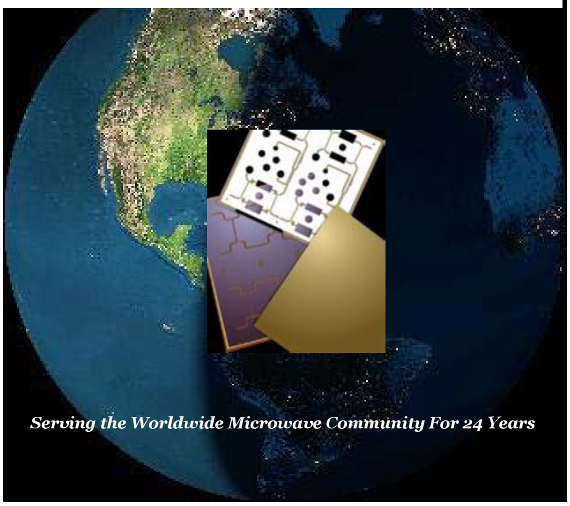
Kai-Cheng Yang *received his MSc degree from the Southern Taiwan University of Technology, Taiwan, ROC, in 2005. He is currently a PhD student in the department of electronic engineering at Southern Taiwan University, Tainan Hsien, Taiwan, ROC. He is currently engaged in the development of ultra-wideband antennas and ultra-wideband systems. He has conducted research on ultra-wideband antenna characteristics in frequency and time domains. His current research interests focus on ultra-wideband antennas design, mobile small antennas and ultra-wideband systems.*

Ion Beam Milling, Inc.

Ultra Precision Thin Film Circuits Since 1982

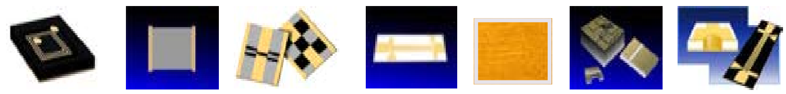
The benefits of Ion Beam Milling, Inc. are cut and dry.

An ISO Certified Company



Visit us at www.ionbeammilling.com

- *An ISO Certified Company*
- *Custom Circuits with Quick Turn Response*
- *Unsurpassed stability and repeatability only available with the ion milling process*
- *3 micron lines and spaces*
- *Design Engineering Kits available with various inductors and/or attenuators– READY TO SHIP*
- *Standard Products: Inductors, Attenuators, Heat Spreaders, Transmission Lines*
- *Services: Ion Etching, Photopattern Processing, Dicing, Testing and Measurement, Engineering Consultation Available*
- *A Complete line of Off The Shelf Components*
- *Wafer Processing– Large Ion Miller Capacity for Same Day Turnaround*
- *Custom Thin Film Circuits: Laser Diode Submounts, Filters, Lange Couplers, Tantalum Nitride Resistors*
- *Product Development and Solutions for wide array of Biomedical, Optical and Magnetic Applications*
- *We Welcome Low Volume Jobs and Design Prototypes*



Ion Beam Milling, Inc.

Ion Beam Milling, Inc. 1000 East Industrial Park Drive Manchester, NH 03109 Telephone: 603.644.2326 Fax: 603.647.6889
Email us at: info@ionbeammilling.com or sales@ionbeammilling.com Visit our website: ***www.ionbeammilling.com***

SUPER ULTRA WIDEBAND
AMPLIFIERS

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

Simply calling the ZVA-183X and ZVA-213X "wideband" amplifiers doesn't begin to describe them. The super ultra wideband ZVA-183X amplifier operates from 0.7 to 18.0 GHz while the ZVA-213X amplifier covers even more "spectral ground," with a range of 0.8 to 21.0 GHz. Both super ultra wideband amplifiers deliver +24 dBm typical output power at 1 dB compression by merit of 26 dB typical small-signal gain with ±1 dB typical gain flatness. Both provide wide dynamic range along with the bandwidth, with typical noise figure of 3 dB and typical IP3 of +33 dBm. These versatile amplifiers are ideal for broadband commercial and military applications, from radar systems to test equipment. The ZVA-183X and ZVA-213X amplifiers are unconditionally stable. In fact, they are so rugged, they can even withstand load mismatches as severe as an open or short circuit at full 1dB compression output power.

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

TYPICAL SPECIFICATIONS

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

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

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

All models IN STOCK! *RoHS compliant*

Mini-Circuits®
ISO 9001 ISO 14001 CERTIFIED

ALL NEW minicircuits.com

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

YONI2™ Patent Pending ***The Design Engineers Search Engine*** *Provides ACTUAL Data Instantly From MINI-CIRCUITS At:* ***www.minicircuits.com***

IF/RF MICROWAVE COMPONENTS

440 Rev A

Visit http://mwj.hotims.com/16346-100 or use RS# 100 at www.mwjournal.com/info

MIMIX SMARTSETS: COMPLETE QFN CHIPSET SOLUTIONS

EXECUTIVE INTERVIEW SERIES

MWJ speaks with Rick Montgomery, Founder and CEO, Mimix Broadband. Visit www.mwjournal.com to read this in-depth interview.

Sustained growth in wireless communications and greater demands for bandwidth place tremendous pressure on component manufacturers to provide high performance, surface-mount technology (SMT) packaged products. The market is seeking low-cost, standard SMT components for high volume printed circuit board (PCB) assembly flow, in particular for applications such as point-to-point (PTP) digital radio and commercial satellite communications systems (VSAT) at microwave and millimeter-wave frequencies. The drivers for industry growth in the PTP market are next generation data services and the rapid expansion of cellular usage in developing nations such as China and India. In order to meet the performance, cost and time to market requirements of these systems, OEMs are turning to complete SMT chipset solutions. Mimix SmartSet devices are highly integrated chipsets that are housed in standard plastic QFN packages that offer a number of advantages including low cost, ease of handling and assembly, as well as suitability for mass production. Among these devices are unique, high linearity power amplifier technologies that house integrated power detectors and broadband, high performance receivers in small 4x4 mm packages.

MIMIX SMARTSET SOLUTIONS

Mimix recently launched its new "Mimix SmartSet" product line, which offers complete QFN chipset solutions to meet the requirements for next generation wireless communications. These Mimix SmartSet solutions give design engineers the ability to create complete SMT radio boards that can be manufactured by sub-contractors at very low prices and faster time to market, while still meeting the performance demands for higher linearity and

MIMIX BROADBAND INC.
Houston, TX

Need Millimeter Wave Spectrum Analysis?

OML has provided customers with 1000 millimeter wave harmonic mixers over the past 15 years.

OML harmonic mixers feature:

Waveguide bands WR-42 to WR-03 (18 to 325 GHz)
Rugged construction
Compatibility with analyzers requiring two or three port mixers
Conversion loss data provided up to 110 GHz
On-going conversion loss performance verification available

OML harmonic mixers are available for:

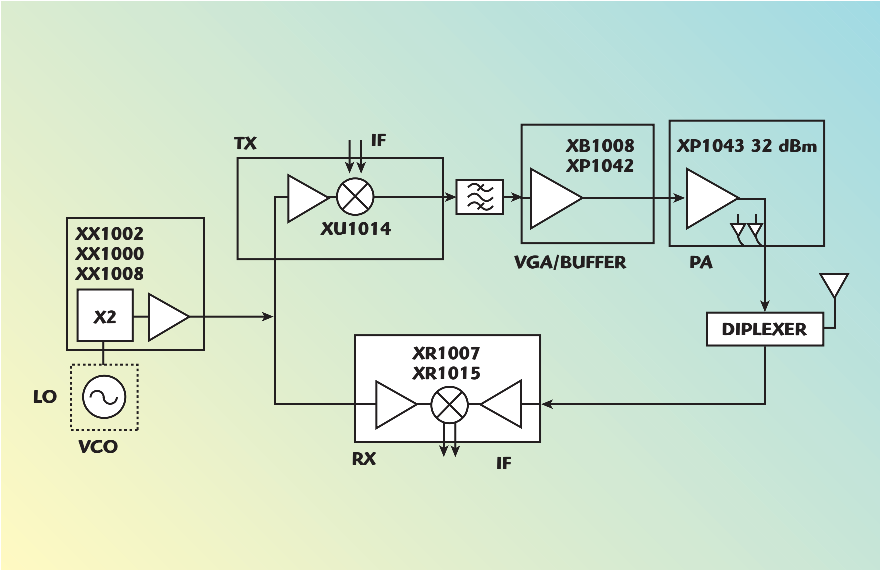
Advantest R3172
Agilent* E4407B, E440A/46A/47A/48A, 856xEC
Anritsu MS2667C, MS2668C, MS2687B
R & S ESIB26/40, FSP40, FSQ26/40, FSU26/40/50, FSUP26/40
Discontinued** Advantest Agilent, Anritsu, IFR* & Tektronix models

*Requires OML diplexer
**Contact factory for available models

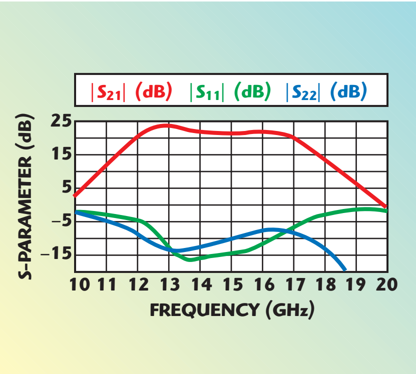
OML Inc.

300 Digital Drive • Morgan Hill, CA 95037 • Tel: (408) 779-2698 • Fax: (408) 778-0491 • email: info@omlinc.com • www.omlinc.com
Outside US: Radar Systems Technology • Tel: (650) 949-8041 • Fax: (650) 949-8082 • email: sales@rst-radar.com

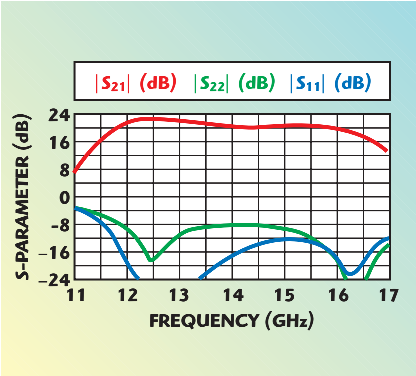
Visit http://mwj.hotims.com/16346-113 or use RS# 113 at www.mwjournal.com/info



▲ *Fig. 1 Mimix 10 to 16 GHz chipset.*



▲ *Fig. 2 XP1042-QT small-signal parameter response vs. frequency (V_{dd} = 5 V, I_{d1} = 125 mA, I_{d2} = 125 mA, I_{d3} = 250 mA).*



▲ *Fig. 3 XP1043-QH small-signal response vs. frequency (V_d = 7 V, I_{d1} = 60 mA, I_{d2} = 120 mA, I_{d3} = 240 mA).*

bandwidth applications. The key to this technology is the integration of four functions or more into a single MMIC, which reduces the chip-count, simplifies the design, minimizes the board layout, reduces cost and speeds up the design process. Therefore, these Mimix SmartSet QFN chipsets are ideally suited to meet the needs for next generation wireless communications design.

12 TO 16 GHZ MIMIX SMARTSET

The Ku-band QFN Mimix chipset is shown in ***Figure 1***. The block diagram is based on a common LO feed to the receive and transmit paths. On the receiver side, a single device, XR1015-QH, integrates an LNA, image reject mixer and LO buffer amplifier within a 4x4 mm standard QFN package. The device includes on-chip ESD protection structures and DC-bypass circuitry to improve yields and ease handling during assembly. On the transmit path, the upconverter feeds into a buffer amplifier, XB1008-QT, which is a high gain, miniature device in a 3x3 QFN package. The buffer amp in turn feeds into a driver amplifier, XP1042-QT, followed by a power amplifier, the XP1043-QH. The XP1043-QH is the company's flagship product for the SmartSet chipset and it sets a new industry standard for performance for GaAs in a miniature 4x4 mm QFN package. The driver and PA pair can be bias adjusted to provide stable power and gain regulation over 30 dB of dynamic range with little degradation in the linearity performance. Furthermore, the XP1043-QH PA includes a directional on-chip temperature compensated power detector for output power monitoring and gain power control mechanisms.

XP1042-QT "MINIATURE HIGH LINEARITY DRIVER AMPLIFIER"

The 12 to 16 GHz driver amplifier, XP1042-QT, is offered in a 3x3 mm QFN package and offers superior power handling and linearity. The device delivers high performance with 38 dBm OIP3, 25 dBm P1dB and 21 dB gain. ***Figure 2*** shows small signal parameter response over the frequency range. The device is highly efficient requiring only 5 V and 500 mA to provide high linearity with 38 dBm OIP3. The bias can be controlled to achieve linear gain control by reducing the drain current. This lower drain current also improves the DC power consumption of the radio in the turn-down mode. The unique offering for this product is the very high IP3 to P1dB ratio of 13 dB, which makes the device an ideal candidate for very high linearity driver applications.

XP1043-QH "HIGH LINEARITY AND DC EFFICIENCY WITH POWER DETECTION"

The 12 to 16 GHz power amplifier, XP1043-QH, is the Mimix SmartSet flag-ship product. The device is offered in a standard 4x4 mm QFN package and offers a set of unique features making it ideally suited to large volume linear radio requirements. Firstly, it provides 30 dBm P1dB and 41 dBm OIP3 in the linear, DC efficiency mode with 5 W DC power consumption. ***Figure 3*** shows the small signal response over the frequency range, which shows that the packaged device has greater than 20 dB gain and is fully matched across the band. The device is also rated to be biased up to 10 V and 1000 mA, which enables it to provide over 2 W of saturated RF power. The XP1043-QH also includes an on-chip temperature-compensated power detector and offers power and gain control through bias adjustment. The integrated power detector allows the user to control the linear output power without needing to use a discrete power detector and attenuator, and

Solid State Tetrode Tube and Combination Amplifiers

Model Number	Freq Range (MHz)	Min Pwr Out (Watts)	Min Sat Gain (dB)
M/TCCX/SCCX Series • *.01-220 MHz*			
SCCX300	.01-220	300	55
SCCX500	.01-220	500	57
M404	.01-220	500	57
M406	.01-220	1000	60
TCCX2000	.01-220	2000	63
TCCX2200	.01-220	2200	63
TCCX2500	.01-220	2500	64
CMX/SMX Series • *.01-1000 MHz*			
SMX301	.01-1000	300/100	55/50
SMX302	.01-1000	300/200	55/53
SMX303	.01-1000	300/300	55/55
SMX501	.01-1000	500/100	57/50
SMX502	.01-1000	500/200	57/53
SMX503	.01-1000	500/300	57/55
CMX10001	.01-1000	1000/100	60/50
CMX100010	.01-1000	1000/1000	60/60

Microwave Solid State and TWT Amplifiers

Model Number	Freq Range (GHz)	Min Pwr Out (Watts)	Min Sat Gain (dB)
T-200 Series • *200-300 Watts CW 1-21.5 GHz*			
T251-250	1-2.5	250	54
T82-250	2-8	250	54
T188-250	7.5-18	250	54
T2118-250	18.0-21.7	250	54
T-500 Series • *500 Watts CW 1-18 GHz*			
T251-500	1-2.5	500	57
T7525-500	2.5-7.5	500	57
T188-500	7.5-18	500	57
MMT Series • *5-150 Watts, 18-40 GHz*			
T2618-40	18-26.5	40	46
T4026-40	26.5-40	40	46
S/T-50 Series • *40-60 Watts CW 1-18 GHz*			
S21-50	1-2	50	47
T82-50	2-8	50	47
T188-50	8-18	50	47

Solid State Amplifiers

Model Number	Freq Range (MHz)	Min Pwr Out (Watts)	Min Sat Gain (dB)
SMCC Series • *200-1000 MHz*			
SMCC350	200-1000	350	55
SMCC600	200-1000	600	58
SMCC1000	200-1000	1000	60
SMCC2000	200-1000	2000	63
SMC Series • *80-1000 MHz*			
SMC250	80-1000	250	54
SMC500	80-1000	500	57
SMC1000	80-1000	1000	60
SMX-CMX Series • *.01-1000 MHz*			
SMX100	.01-1000	100	50
SMX200	.01-1000	200	53
SMX500	.01-1000	500	57
SVC-SMV Series • 100-1000 *MHz*			
SVC500	100-500	500	57
SMV500	500-1000	500	57

Visit IFI.com for additional amplifier models and products.

INSTRUMENTS FOR INDUSTRY

903 South Second Street • Ronkonkoma, NY 11779
Tel: 631-467-8400 • Fax: 631-467-8558 • E mail: sales@ifi.com • www.ifi.com

Visit http://mwj.hotims.com/16346-60 or use RS# 60 at www.mwjournal.com/info

Digital Signal Source

Digitally Accurate RF Tester (DART-40)

- Store up to 200 profiles
- Up-convert I/Q data (max 1024 points)
- Eight states for FSK, ASK or PSK
- Stream states: file, UART or random
- Lightweight and battery powered
- SCPI control over RS-232

Syndetix Core Expertise:
- Analog & digital design
- RF design
- Mechanical design and fabrication
- Software design and development

Syndetix Incorporated
2820 North Telshor Blvd.
Las Cruces, NM 88011
Tel: (575) 522-8762, Fax: (575) 521-1619
Email: dart@syndetix.com
www.syndetix.com

Visit http://mwj.hotims.com/16346-153

Locus Microwave

High Performance & Custom Amplifiers and Converters HF to 30 GHz

- High Performance Amplifiers
  - LNAs
  - SSPAs
  - High Dynamic Range
- Frequency Converters
- Government & Commercial
- Specialists in MIL SATCOM apps

Frequency Bands

	L	S	C	X	Ku	K	Custom
LNAs	✔	✔	✔	✔	✔	✔	✔
SSPAs	✔	✔	✔	✔	✔	✔	✔
LNBs				✔			✔
BUCs				✔			✔

✔ = New

176 Technology Dr., Suite 200
Boalsburg, PA 16827
Tel: 814.466.6275 Fax: 814.466.1104
www.LocusMicrowave.com
email: info@LocusMicrowave.com

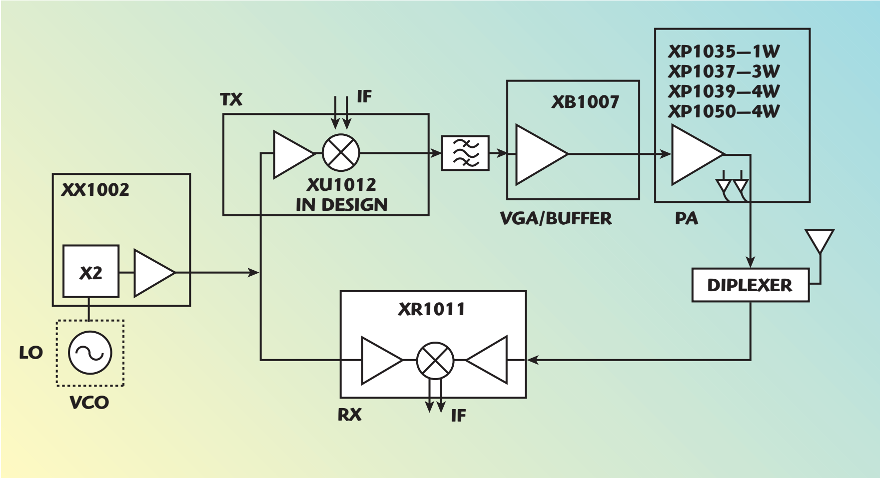


Fig. 4 Mimix 5 to 10 GHz QFN chipset.

this enhanced functionality simplifies the design requirements and lowers cost for transmit applications.

5 TO 10 GHZ MIMIX SMARTSET

The 5 to 10 GHz QFN chipset is shown in ***Figure 4*** with a common LO feed configuration. On the receiver side, a single device, XR1011-QH, integrates an LNA, image reject mixer and LO buffer amplifier within a 4x4 mm standard QFN package. The device includes unique active on-chip ESD protection structures, which are 'disabled' once the device is biased up for use. During handling and assembly, the ESD structures actively shunt possibly damaging static charge away from the most sensitive circuit structures. Furthermore, the device has sufficient DC-bypass circuitry to simplify the board layout and bias design. On the transmit path the RF is fed into a buffer amplifier, XB1008-QT, which is a high gain, miniature device in a 3x3 QFN package. The buffer amplifier in turn feeds into a driver amplifier with 29 dBm P1dB, XP1035-QH, followed by a number of options for high power linear amplifiers, which deliver up to 4 W of saturated RF power and 50 dBm OIP3. The high power amplifiers (HPA) employ HFET GaAs technology, which provides high power and linearity at high DC efficiencies and increased thermal reliability, allowing these devices to be offered in standard 6x6 mm QFN packages. These new 4 W devices are the industry's first fully molded 6x6 mm QFN power amplifier MMICs that provides a viable alternative to discrete power FETs.

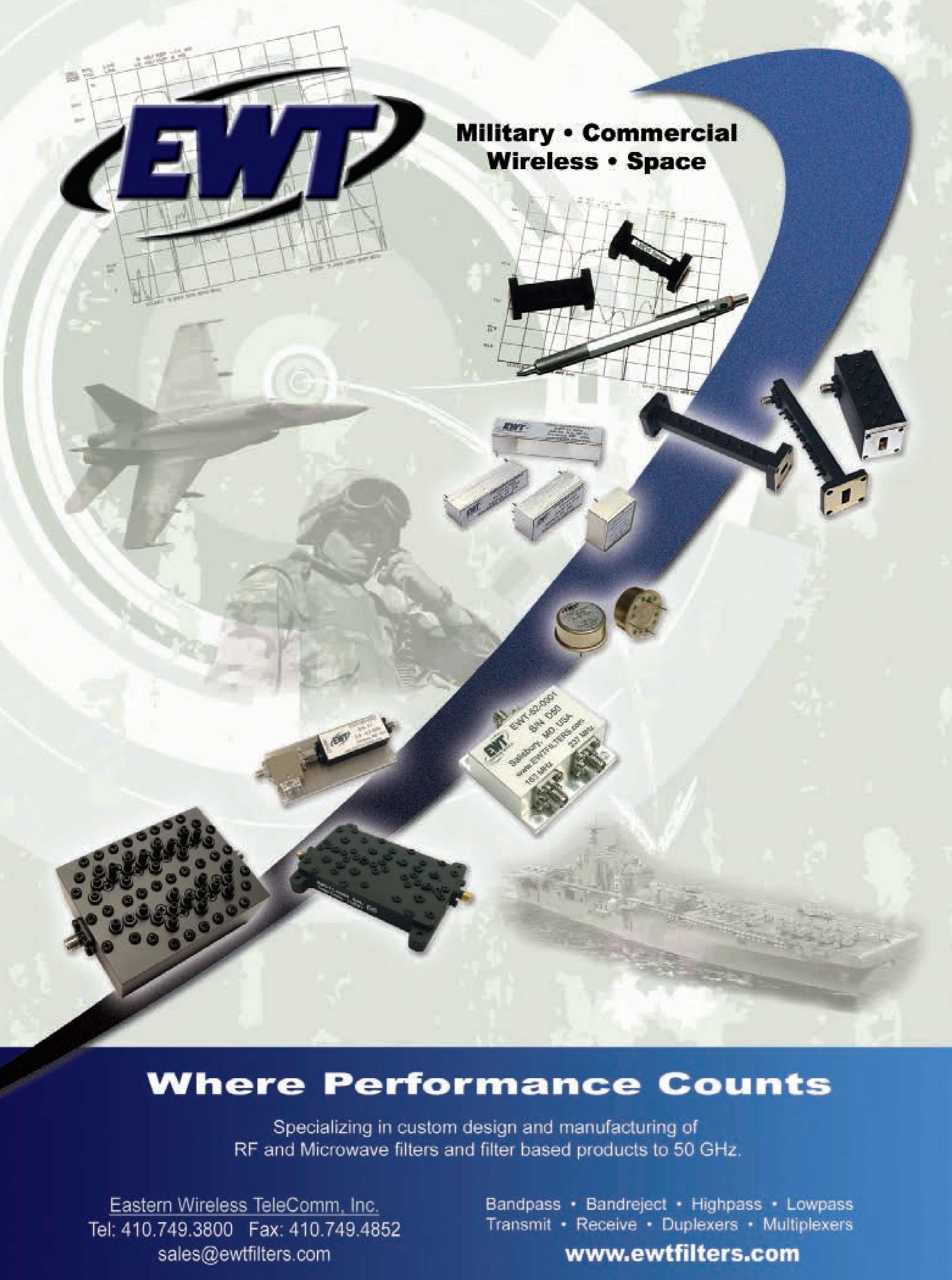
XR1011-QH "HIGH PERFORMANCE BROADBAND OPERATION"

The XR1011-QH is the industry's first fully molded 4x4 mm QFN packaged receiver covering the frequency range of 4.5 to 10.5 GHz. The part is distinguished by its high performance; combining low noise figure, high conversion gain and excellent linearity across the entire band. The device integrates an image reject mixer, an LO buffer amplifier, and a low noise amplifier within a fully molded 4x4 mm QFN package that is RoHS compliant. ESD protection structures and DC-bypass are all included on-chip to provide high yields and ease the handling, board design and implementation in assembly. The conversion gain is shown in ***Figure 5***. The NF shows very good performance across the band with better than 2 dB at room temperature and little variation in temperature from -40° to +85°C. The device offers high conversion gain of 14 dB and IIP3 of +3 dBm, making it a market leader in integrated, packaged receiver technology.

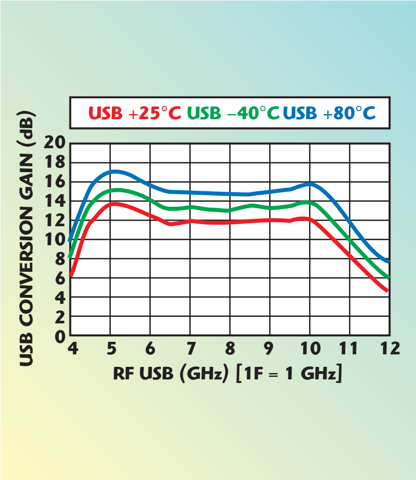
XP1035-QH "VERSATILE BROADBAND POWER AMPLIFIER"

The XP1035-QH is a packaged linear power amplifier that operates over the 5.9 to 9.5 GHz frequency band. The device provides high gain of 26 dB gain (see ***Figure 6***) and linearity of 39 dBm OIP3 across the band. The packaged amplifier is comprised of a three-stage power amplifi-

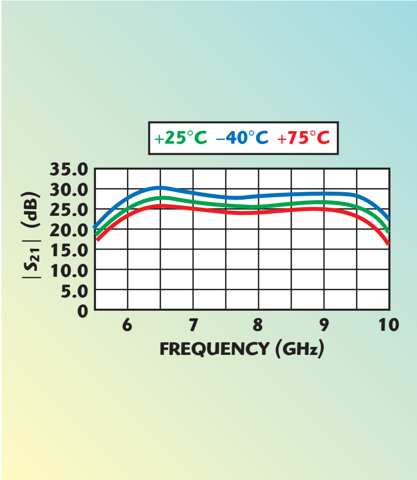
Visit http://mwj.hotims.com/16346-72



Visit http://mwj.hotims.com/16346-42 or use RS# 42 at www.mwjournal.com/info



▲ *Fig. 5 XR1011QH USB conversion gain (4 V @ 130 mA, P_{LO} = 5 dBm).*

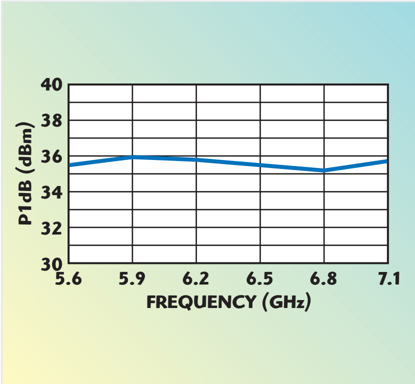


▲ *Fig. 6 XP1035-QH gain vs. frequency (V_d = 6 V, I_d = 500 mA).*

er with an integrated, temperature compensated on-chip power detector and is offered in an industry standard, fully molded 4x4 mm QFN package. The device includes on-chip ESD protection structures and DC bypass capacitors to ease the implementation and volume assembly of the packaged part. The combination of broadband performance and strong drive level with standard QFN packaging make the device highly versatile for a wide range of applications.

XP1039-QJ "4 W POWER IN STANDARD QFN PACKAGE"

Mimix now offers very high linearity packaged power amplifiers for the 5.6 to 8.5 GHz frequency bands in standard 6x6 mm QFN packages. These new devices are the industry's first high power amplifiers in standard 6x6 mm packages and present an attractive alterative to discrete power FETs due to some key advantages. Firstly, the devices provide plenty of linearity with up to 50 dBm OIP3 using HFET wafer technology and they operate at lower DC power consumption levels. Secondly, the devices are high gain with up to 16 dB gain, thus greatly reducing the power requirements for driver amplifiers and hence lowering DC power consumption and overall BOM cost. Thirdly, the components are fully matched and broadband in performance, which further reduces the BOM count and simplifies the board design. Finally, the power amplifiers are offered in standard 6x6 mm QFN packages, an industry first to offer such high linearity and power with all the advantages associated with standard QFN packaging. The gain of the XP1039-QJ is greater than 16 dB from 5.6 to 7.1 GHz and ***Figure 7*** shows the P1dB performance as a function of frequency, which shows the device is capable of delivering up to 4 W of RF power at P1dB.



▲ *Fig. 7 XP1039 – QJ P1dB vs. frequency (V_d = 8 V, I_d = 1400 mA).*

Mimix Broadband has developed Mimix "SmartSets" for the bands between 5 to 16 GHz and chipsets for the 16 to 32 GHz band are in development. These Mimix SmartSet QFN chipsets are ideally suited to meet the needs for next generation wireless communications design.

Mimix Broadband Inc., (281) 988-4600 info@mimixbroadband.com, www.mimixbroadband.com.

RS No. 303

Mission Critical PERFORMANCE

EW System Interconnects from ***TIMES MICROWAVE SYSTEMS***

Integrated Device Assemblies
- Flat, Equalized, Filtered, Attenuated, Amplified
- Platform-Independent System Design
- Dramatically Boosts System Performance
- Broadband Performance

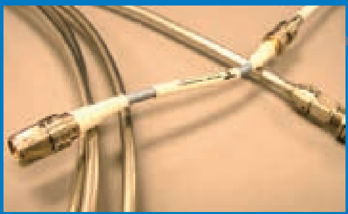
Multi-Port Interconnects
- 38999 size 8, 12; M8; P8; MMP Contacts
- Blind-Mating, ARINC, Rack & Panel, Custom Shells
- Easy Insertion/Removal, Field Replaceable Contacts
- Rugged, Sealed, Extreme Environment Qualified

Vehicle Mounted/Deployed Antenna
Feeder Cables
- Excellent Long-Term Electrical Performance
- Resists Harsh Treatment and Environments
- NBC Compliant Ruggedization Options
- Suited to COMM, COMMINT, IED, More

PhaseTrack™ for Critical Phase Applications
- Superior Electrical Phase Stability (vs LD PTFE)
- <1.5 ppm/°C
- TF4 Dielectric Technology (no PTFE "Knee")
- Ruggedization Options Available

Blind Mate Antenna Solutions
- Convert Antennas to Blind Mate
- Improve Reliability, Maintainability and Serviceability
- Simplify Mission Equipment Role Changes
- Reduce Loss, Eliminate Cable Loop

Military Low Smoke Cables
- Ideal for Shipboard, Vehicle, Manned Area Use
- Low Loss, Light Weight, Superior RF Shielding
- Fire Retardant (non-halogen), Flexible
- MIL-DTL-17H Qualified



SiO2 (Silicon Dioxide) Cable Assemblies
- Exceptional Phase Stability
- Temperature: -273°C to +600°C
- Hermetically Sealed to 10E-9
- Resistance to Harsh/Extreme Environments

MilTech™ Microwave Transmission Lines
- Flexible, Hermetically Sealed Cables
- Low Loss to 20 dB/100 ft. at 18 GHz
- Replaceable Standard and Self-Locking Connectors
- Aircraft Qualified Worldwide

TIMES MICROWAVE SYSTEMS

ISO 9001

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 Fax: +44(0)1592653162
China Sales: 16F, United Plaza, 1468 West Nanjing Road, Shanghai, China 200040 • Tel: 86-21-32224506 Fax: 86-21-62898980

www.timesmicrowave.com

Visit http://mwj.hotims.com/16346-163 or use RS# 163 at www.mwjournal.com/info

MID-RANGE VECTOR SIGNAL GENERATOR WITH INTERNAL SIGNAL GENERATION

The world of telecommunications has experienced an accelerated period of change in recent years. In the past, many terminals such as mobile telephones and PDAs were only capable of transmitting and receiving signals based on a few different standards such as GSM and WCDMA. However, increasing numbers of functions and standards are now being integrated into terminal equipment (e.g. GSM, WCDMA, WLAN, WiMAX, GPS, FM radio and mobile TV).

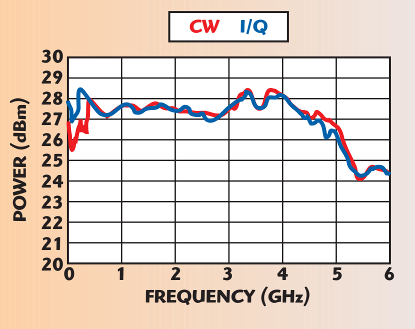
In addition, the data rate to be transmitted has increased from a few kbit/s in GSM to target data rates of 100 Mbit/s in LTE, while the transmission bandwidth has grown from several hundred kHz to as much as 40 MHz in 802.11n. Modulation methods such as OFDM/OFDMA and other techniques such as MIMO have found a place in all of the new communications standards.

All of these advances are presenting new test and measurement challenges. For instance, developing and manufacturing equipment requires signal generators with all-round qualities and the capability of keeping up with the rapid development of modern technology. However, such generators must also be scalable so that users only have to invest what is necessary to meet their current test requirements.

It is a tough task for a mid-range vector signal generator to satisfy all of these different criteria, but the new, compact R&S SMBV100A vector signal generator is up to the challenge. Its RF characteristics are paired with a flexible baseband architecture and many useful add-on functions.

It is available for frequency ranges from 9 kHz to 3.2 GHz or from 9 kHz to 6 GHz. The vector signal generator is characterized by high output power of typically +24 dBm across its entire frequency range (see ***Figure 1***). This is particularly advantageous with complex test set ups. Components such as cables, switches and couplers often cause significant

Fig. 1 Measured maximum output power vs. frequency.



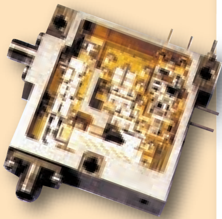
ROHDE & SCHWARZ
Munich, Germany

Whenever legacy systems are upgraded, whether to address new threats or to benefit from improved technology, you can count on CTT's twenty-five years of experience in microwave amplification and subsystem integration.

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 SiC.

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.

- Multi-Band Communications
- Simulators
- Line Test Equipment
- EW: ECM, ECCM & ESM
- Jammers: Radar & IEDs
- Radar Systems



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

- ❖ **Low-Noise Amplifiers**
  - **NEW** Compact Low-Noise
  - 0.5–20 GHz
  - Broadband 0.2–20 GHz
  - Broadband 17–40 GHz
  - Narrowband Up to 18 GHz
- ❖ **Custom Engineered Options**
- ❖ **Hi-Reliability Capability**
- ❖ **Power Amplifiers**
  - **NEW** GaN Broadband
  - Broadband 0.2–100W
  - Narrowband Up to 100W
  - Rack-Mount 0.5–40 GHz
- ❖ **Special Purpose Amplifiers**
  - Equalizer Amplifiers
  - Frequency Doubler/Triplers
  - Limiting Amplifiers
  - Temperature Compensated
- ❖ **Subsystems**
- ❖ **Contract Manufacturing**

USA-based thin-film microwave production facility

NSAI
ISO 9001:2000 QUALITY

CTT INC.

241 East Java Drive • Sunnyvale • California 94089

Phone: 408-541-0596 • Fax: 408-541-0794 • www.cttinc.com • E-mail: sales@cttinc.com

Visit http://mwj.hotims.com/16346-35 or use RS# 35 at www.mwjournal.com/info

TABLE I

APPLICATION-SPECIFIC BASEBAND CONFIGURATION

Baseband Option	*Baseband Generator*	*RF Bandwidth*	*Recommended Use*
R&S SMBV-B10	Baseband coder with realtime functionality and ARB (32 Msample or 256 Msample)	120 MHz	R&D, service
R&S SMBV-B50	ARB only (32 Msample or 256 Msample)	120 MHz	Production
R&S SMBV-B51	ARB only (32 Msample or 256 Msample)	60 MHz	Production

TABLE II

SELECTION OF INTERNALLY SUPPORTED SIGNALS (WITH ADDITIONAL OPTIONS)

3GPP FDD including HSPA/HSPA+
TD-SCDMA
CDMA2000®[1]
1xEV-DO
EUTRA/LTE (FDD+TDD)
GSM/EDGE
WiMAX
WLAN IEEE 802.11a/b/g/n
DVB-H/DVB-T
XM Radio waveforms
HD Radio™[2] waveforms
Multi-carrier CW
Custom digital modulation
AWGN
ARB waveform playback (including multi-carrier and multi-segment waveform generation)

[1] *CDMA2000® is a registered trademark of the Telecommunications Industry Association (TIA – USA)*

[2] *HD Radio™ is a proprietary trademark of iBiquity Digital Corp.*

TABLE III

SPECIFICATIONS IN BRIEF

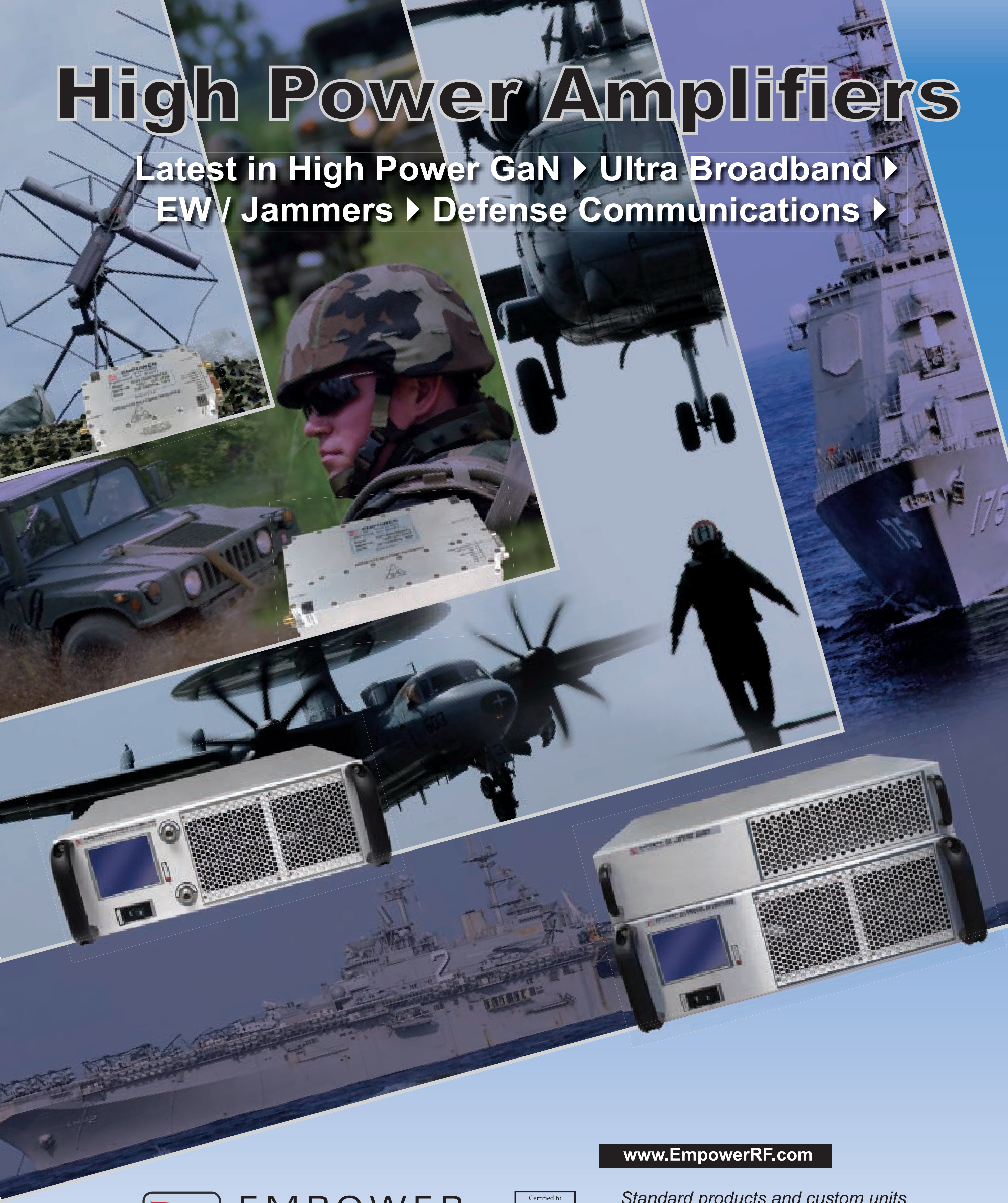
Frequency		
Frequency range	R&S SMBV-B103/R&S SMBV-B106	9 kHz to 3.2 GHz/6 GHz
Setting time	SCPI mode, ALC state ON, CW mode	<3 ms
	List mode	<1 ms
Power Level		
Maximum output power	1 MHz < f ≤ 6 GHz	>+18 dBm (PEP)
Setting time	SCPI mode, ALC state ON, CW mode	<2.5 ms
	List mode	<1 ms
Spectral Purity		
Harmonics	f > 1 MHz; CW, level ≤ 8 dBm	<–30 dBc
Non-harmonics	CW, level > –10 dBm, >10 kHz carrier offset, f ≤ 1500 MHz	<–70 dBc (nominal <–85 dBc)
SSB phase noise	f = 1 GHz, 20 kHz carrier offset, 1 Hz measurement bandwidth, CW	<–122 dBc (nominal –128 dBc)
Wideband noise	attenuator mode AUTO CW, level > 5 dBm, >10 MHz carrier offset, 1 Hz measurement bandwidth	<–142 dBc (nominal –152 dBc)
Supported Analog Modulation Modes		
AM/FM/PM		standard
Maximum FM/φM deviation	f > 3 GHz	16 MHz/160 rad
Pulse modulation		optional with R&S SMBV-K22
On/off ratio		>80 dB
Rise/fall time	10% to 90% of RF amplitude	<20 ns, typ. 4 ns
Minimum pulse width	using the optional R&S SMBV-K23 pulse generator	10 ns
I/Q Modulation		
ACLR	WCMDA 3GPP FDD, TM 1/64	typ. 67 dBc
EVM	WCMDA 3GPP FDD, TM 1/64	typ. 0.6%
	WiMAX IEEE 802.16e	typ. 0.4%
	EUTRA/LTE	typ. 0.4%

power loss that requires adequate compensation. With the R&S SMBV100A, the use of external amplifiers can be avoided. This minimizes the overall uncertainty of the test set up and helps to avoid additional costs.

The new instrument also offers very good signal purity. The SSB phase noise has a nominal value of 128 dBc/Hz (20 kHz offset) at f = 1 GHz (see ***Figure 2***). Non-harmonics undergo nominal suppression of better than 85 dB and the wideband noise has a nominal value of 152 dBc. The error vector magnitude (EVM) for signals such as WiMAX IEEE 802.16e and LTE is typically 0.4 percent, while the level repeatability has a nominal value of 0.05 dB.

MODULATION BANDWIDTH UP TO 528 MHZ

Today's communications standards require more and more transmission bandwidth to handle the growing complexity of multimedia applications and the R&S SMBV100A is well equipped to



EMPOWER
RF SYSTEMS, INC.

Certified to ISO 9001:2000
TÜVRheinland
Precisely Right.

316 W. Florence Avenue, Inglewood, CA 90301 U.S.A.
Phone: +1 (310) 412-8100, Fax: +1 (310) 412-9232
sales@empowerrf.com

RENO AOC
Booth722

www.EmpowerRF.com

Standard products and custom units designed and delivered as

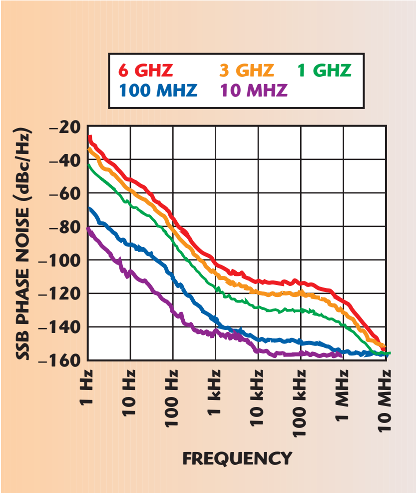
- *Modules*
- *Rack mount amplifiers*
- *Multi-function PA assemblies*

Visit http://mwj.hotims.com/16346-46 or use RS# 46 at www.mwjournal.com/info

meet the challenge. With internal signal generation, RF bandwidths of 60 or 120 MHz can be selected. Even multicarrier signals for wideband wireless communications standards such as WLAN IEEE 802.11n and LTE can be generated.

With external I/Q modulation, the maximum RF modulation bandwidth of the R&S SMBV100A is 528 MHz. This allows up-conversion of UWB signals, which can be generated using the R&S AFQ100B baseband generator (see ***Figure 3***, for example). At the same time, the large I/Q bandwidth ensures high time resolution for the signals.

Very fast baseband frequency hopping as used in military applications and generation of steep-edged radar pulses with complex modulation are thus feasible in conjunction with an external I/Q source such as the R&S AFQ100B. Thus, the R&S SMBV100A can replace more expensive vector signal generators, which are utilized solely for their large bandwidth and not any other capabilities.



▲ *Fig. 2 Measured SSB phase noise with internal OCXO (R&S SMBV-B1 option).*

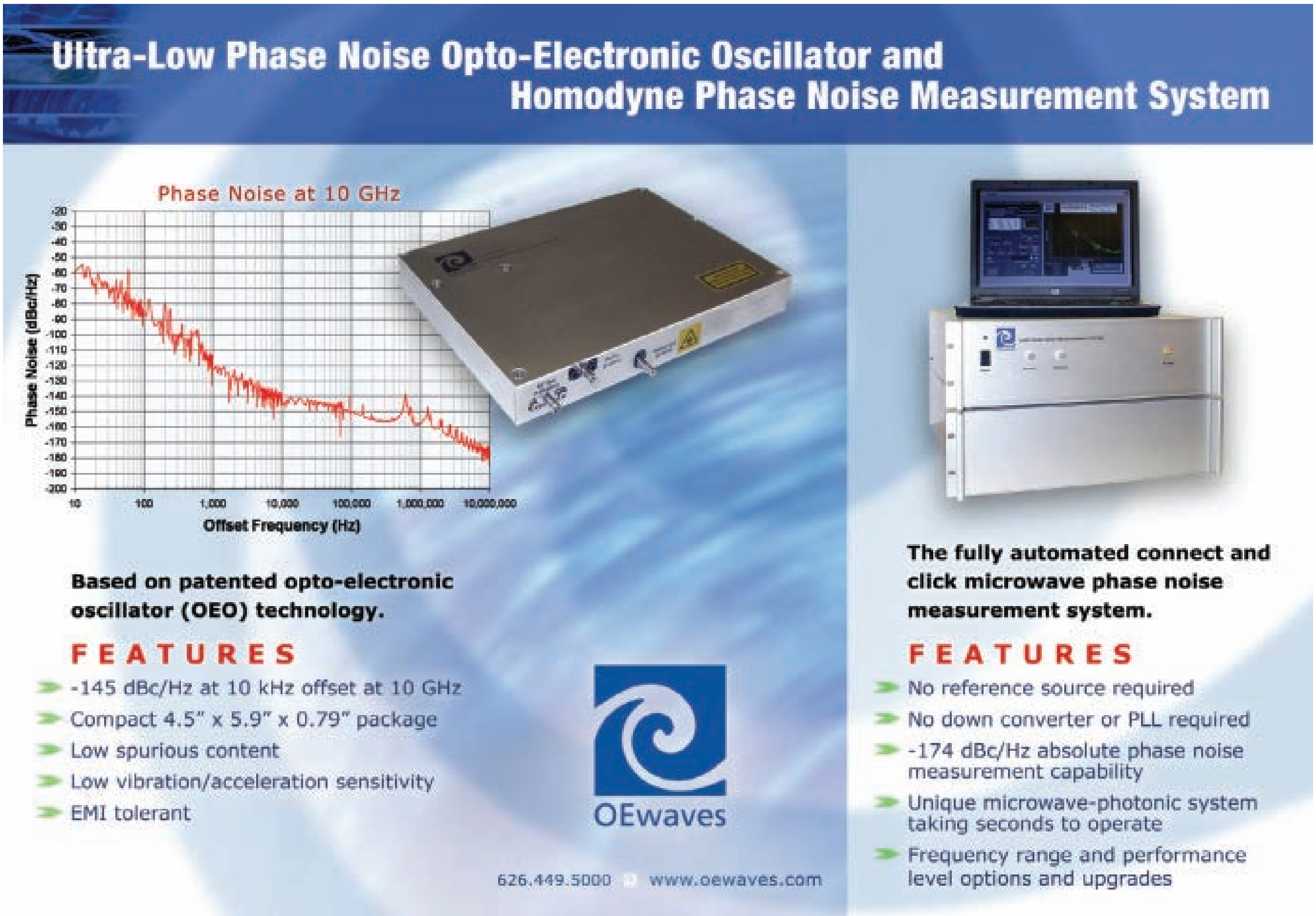
CUSTOMIZED INTERNAL SIGNAL GENERATION

Customizing test instruments to fit the application is more or less a standard practice nowadays. However, the R&S SMBV100A implements this feature in an unusual way, being unique in its class by being equipped with a real time baseband coder for direct signal generation.

Alternatively, it allows selection between different versions of an arbitrary waveform memory from which pre-calculated waveforms can be played back. This means that a single platform can provide a solution that can be optimally adapted to requirements in production and development.

In production applications, standardized test sequences are required along with fast frequency and level setting times that the R&S SMBV100A also ensures with a value of <1 ms in the List mode. For playing back these test signals (which are generally pre-calculated), a total of four different versions of the arbitrary waveform memory (ARB) are available. Depending on the configuration, the instrument offers a bandwidth of 60 MHz or 120 MHz and an I/Q memory size of 32 Msamples or 256 Msamples (see ***Table 1***).

This makes it possible to easily play back even long test sequences, which is a requirement for digital radio standards, for example. Addition-



Visit http://mwj.hotims.com/16346-112

2 W & 5 W
DC to 18 GHz ATTENUATORS

from 29^{95} ea. (1-49)

Rugged Stainless Steel Construction, High Repeatability, Miniature Size, Low Cost, and Off-The-Shelf Availability are some of the features that make Mini-Circuits "BW" family of precision fixed attenuators stand above the crowd! This extremely broad band DC to 18 GHz series is available in 5 watt Type-N and 2 & 5 watt SMA coaxial designs, each containing 15 models with nominal attenuation values from 1 to 40 dB. Built tough to handle 125 watts maximum peak power, these high performance attenuators exhibit excellent temperature stability, 1.15:1 VSWR typical, and cover a wealth of applications. So contact Mini-Circuits today, and capture this next generation of performance and value! *Mini-Circuits…we're redefining what VALUE is all about!*

MODELS (Add Prefix BW-)

2 W SMA	5 W SMA	5 W Type-N	Attenuation (dB)	
$29.95	$44.95	$54.95	Nominal	Accuracy*
S1W2	S1W5	N1W5	1	±0.40
S2W2	S2W5	N2W5	2	±0.40
S3W2	S3W5	N3W5	3	±0.40
S4W2	S4W5	N4W5	4	±0.40
S5W2	S5W5	N5W5	5	±0.40
S6W2	S6W5	N6W5	6	±0.40
S7W2	S7W5	N7W5	7	-0.4, +0.9
S8W2	S8W5	N8W5	8	±0.60
S9W2	S9W5	N9W5	9	-0.4, +0.8
S10W2	S10W5	N10W5	10	±0.60
S12W2	S12W5	N12W5	12	±0.60
S15W2	S15W5	N15W5	15	±0.60
S20W2	S20W5	N20W5	20	-0.5, +0.8
S30W2	S30W5	N30W5	30	±0.85
S40W2	S40W5	N40W5	40	-0.5, +1.5

*At 25°C includes frequency and power variations.

***Now Available!* Adapters** (Prices: qty. 1-49)

Type-N to SMA **DC-18 GHz** 22^{95} ea.
SMA to SMA **DC-18 GHz** *from* 4^{95} ea.
QUICK CONNECT SMA
SMA to BNC **DC-2 GHz** 3^{95} ea.
Type-N to Type-N **DC-6 GHz** 9^{95} ea.

Pb RoHS COMPLIANT

To order Attenuators as RoHS, add + to base model No. *Example: BW-S1W2+*
Adapters available as RoHS, see web site.

Mini-Circuits®
ISO 9001 ISO 14001 CERTIFIED

ALL NEW **minicircuits.com**

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

YONI2™ Patent Pending ***The Design Engineers Search Engine*** *Provides ACTUAL Data Instantly From MINI-CIRCUITS At:* ***www.minicircuits.com***

RF/IF MICROWAVE COMPONENTS

331 Rev K

Visit http://mwj.hotims.com/16346-101 or use RS# 101 at www.mwjournal.com/info

ally, the large I/Q memory enables the storage of different signals as part of a multi-segment waveform and switching between the individual signals in just a few microseconds. This is especially useful during production tests on multi-standard modules that are designed to support a wide variety of digital standards, e.g. GSM and UMTS. The test signals can be pre-calculated using either the R&S WinIQSIM2 signal generation software or third-party programs.

In research and development environments, the R&S SMBV100A is useful due to its optional real time baseband coder. Test signals for all major digital communications standards can be configured directly on the instrument (see ***Table 2***). Users can also avoid the hassle of having to pre-calculate the signals on an external PC and transfer them to the signal generator. This makes it possible to modify individual parameters quickly and easily while directly examining the effects on the device under test. Everyday work in the lab is accelerated, helping to shorten development time and design cycles.

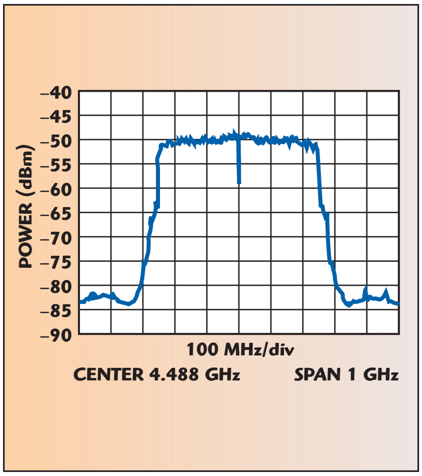


Fig. 3 Frequency response of the IQ modulator with a bandwidth of > 500 MHz.

The real time coder also enables generation of infinitely long test sequences, e.g. for simple digitally modulated signals as well as for internally generated digital standards such as GSM/EDGE and 3GPP FDD (downlink). Such long test sequences serve as a reliable basis for performing bit error rate tests, particularly in cases where long bit sequences are needed to ensure statistically meaningful results.

A TRUE ALL-ROUNDER

A signal generator is only as good as its interfaces. This applies to the interfaces for connecting to the device under test, for synchronizing with different test instruments and for handling remote control, as well as to the user interface itself.

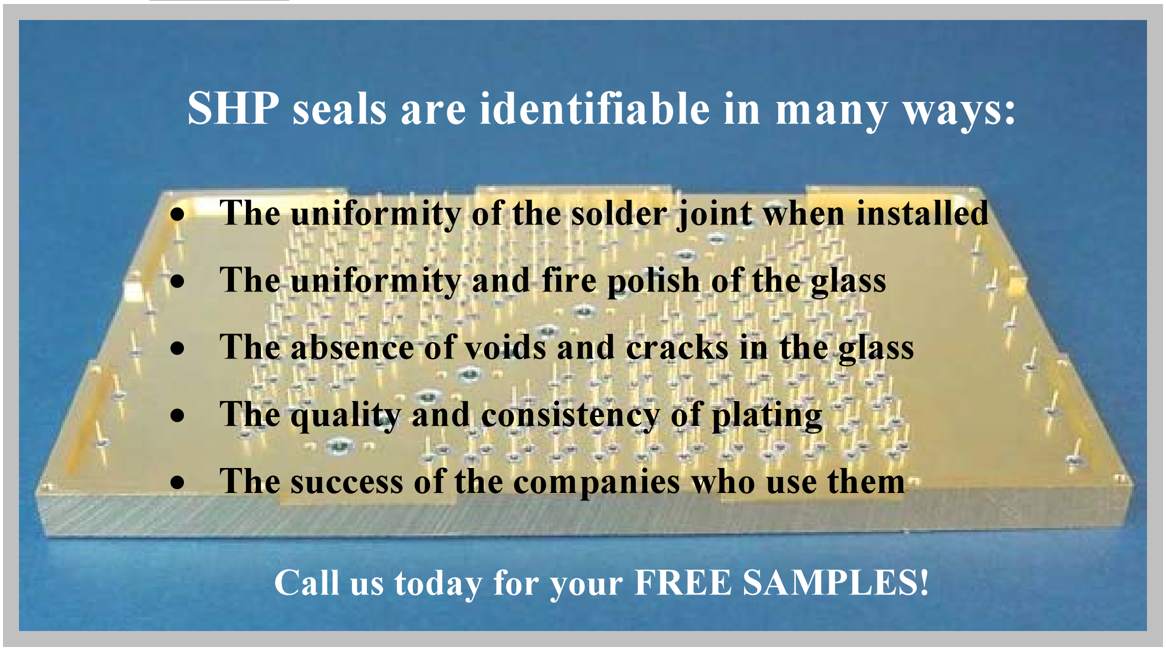
In addition to the RF interface, the R&S SMBV100A also includes analog differential I/Q outputs as a standard feature, while an optional digital I/Q output will be available in the first quarter of 2009 (enabled via software). This makes the vector signal generator suitable for tests at the RF and in the baseband.

For the baseband generator, a wide range of trigger and marker functions are available to ensure accurate synchronization with the device under test. In the RF range, multiple signal generators can be

SHP

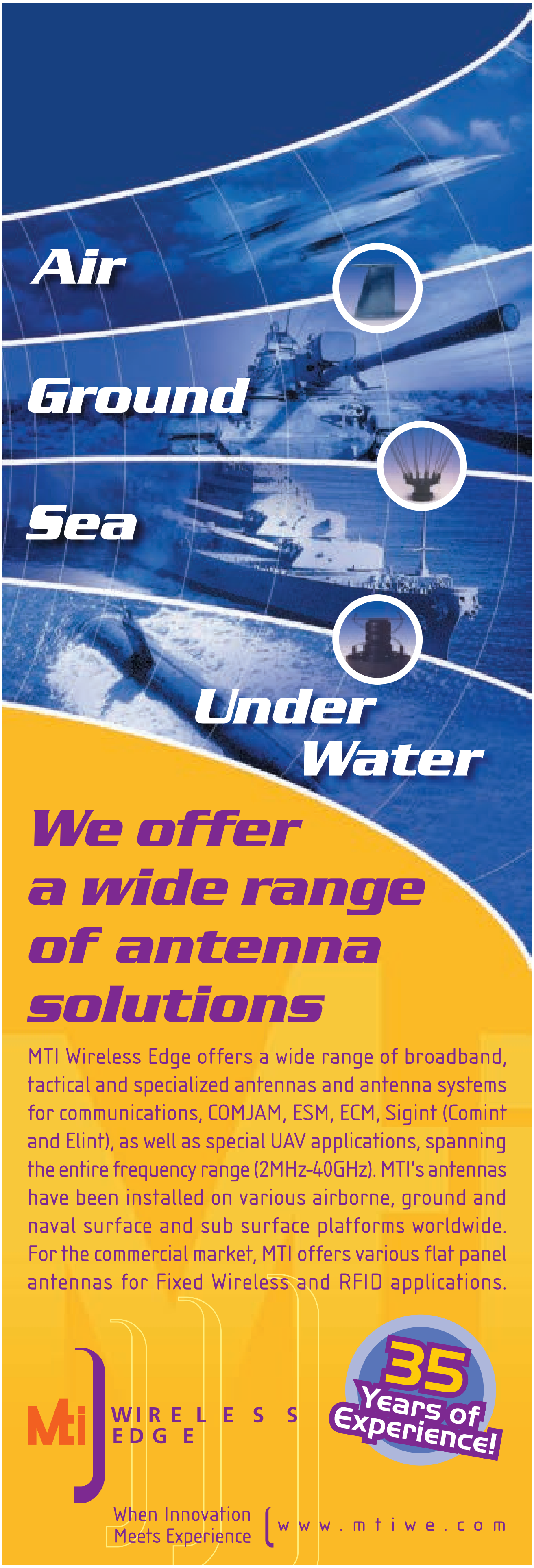
SPECIAL HERMETIC PRODUCTS, INC.

Hi-Rel By Design



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


THE MILITARY AND AEROSPACE INDUSTRIES RELY ON ACC ADVANCED SWITCH TECHNOLOGY.
Our complete line of switch products include:
• PIN Diode and GaAs FET Design
• "Unlimited" Number of Throws
• Frequency capability up to 40Ghz
• Switching Speed under 10 nSec available
• Up to 120db isolation
• High power models available to 150W CW and beyond
PACKAGING
• Connectorized • Drop-in
• Surface mount
ALSO AVAILABLE:
Custom Switches, Switch Matrices and Switch Filters
Advanced Control Components Inc.
611 Industrial Way West, Eatontown, NJ 07724 • Tel 732 460-0212 • Fax 732 460-0214
www.advanced-control.com
Visit http://mwj.hotims.com/16346-1 or use RS# 1 at www.mwjournal.com/info



interconnected using the phase coherence option. Usage of a common local oscillator (LO) signal ensures the phase coherence needed to make, for example, measurements on phased-array antenna systems (beamforming) or components with differential RF (e.g. amplifiers).

In the area of remote control, the instrument meets all needs; USB, LAN and GPIB interfaces are available along with the appropriate software drivers. An integrated VNC server also enables convenient remote control of the instrument via a web browser.

The R&S SMBV100A is Rohde & Schwarz' first vector signal generator that uses Linux as its operating system, which helps to safeguard against viruses. Passwords can be set or the USB interfaces in the instrument can be disabled if necessary. The instrument also offers an optional removable 80 GB hard disk, which is useful for keeping critical data secure while being able to transport the instrument as required. This helps to avoid costly sanitizing procedures otherwise needed before an instrument can be removed from a secure area. If required, however, sanitizing can be performed easily.

The R&S SMBV100A also incorporates a convenient user interface that will be familiar from the company's other signal generators. The block diagram enables intuitive operation while the integrated transient recorder (graphics block) enables visual monitoring of the signals that are generated (I/Q diagram, spectrum, constellation, CCDF, eye diagram, etc.). The context-sensitive online help facility provides useful background information about all setting parameters of the signal generator.

CONCLUSION

When designing a new all-round vector signal generator, the trick is to meet today's requirements while also leaving room to satisfy future requirements and the R&S SMBV100A provides sufficient reserves. It combines the benefits of purely analog signal generators with those of a powerful vector signal generator. The instrument contains features that are normally only found in high-end signal generators (see ***Table 3***). At the same time, it offers a good price/performance ratio. This is due to the three-year calibration cycle, the high-quality technical implementation and the user-friendly service concept that makes it possible to quickly repair instruments on-site if necessary.

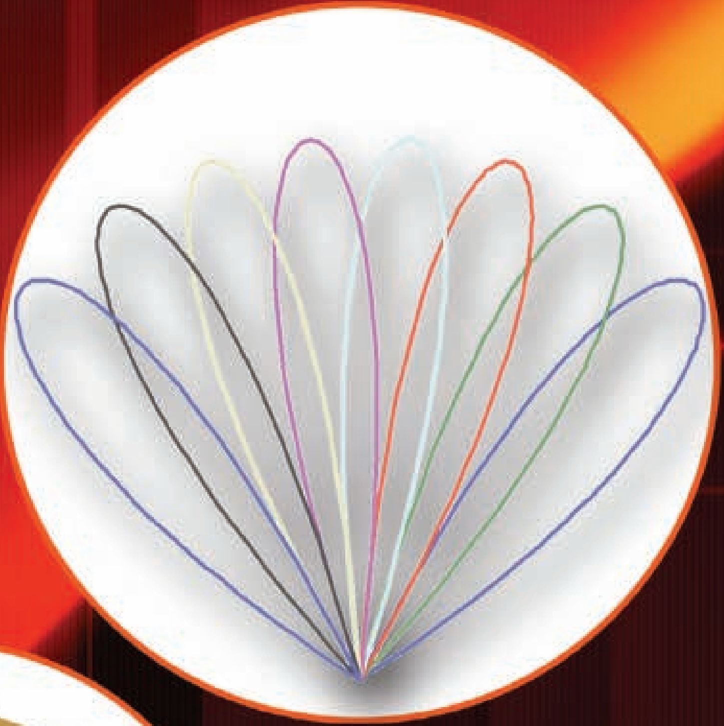
Rohde & Schwarz, Munich, Germany,
+49 1805 12 4242,
customersupport@rohde-schwarz.com;

Americas: Rohde & Schwarz,
+1 888 837 8772,
customer.support@rsa.rohde-schwarz.com;

Asia: Rohde & Schwarz,
+65 65130 488,
customersupport.asia@rohde-schwarz.com.

RS No. 302

10 MHz to 65 GHz Components



Antenna Beamforming Networks

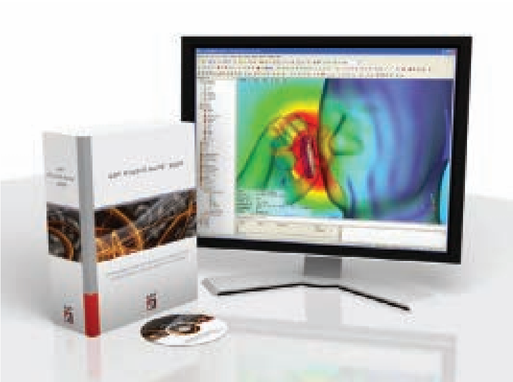
et Industries

www.etiworld.com

50 Intervale Road, Boonton , NJ 07005 U.S.A. : Tel 973-394-1719 : Fax. 973-394-1710

E-mail: sales@etiworld.com

Visit http://mwj.hotims.com/16346-49 or use RS# 49 at www.mwjournal.com/info



EFFICIENT, ACCURATE, RELIABLE EM SIMULATION TOOL

In the ongoing race for reduced design costs and faster time to market, simulation efficiency remains the most important factor in electromagnetic field analysis. Simulation efficiency can be determined by the time taken to reach the final design, which is strongly influenced by the level of workflow integration, the versatility in manipulating the model, the choice of solver type, the method's accuracy, the implementation's efficiency and, of course, the hardware speed. The new CST STUDIO SUITE™ 2009, incorporating the CST MICROWAVE STUDIO® (CST MWS) 3D electromagnetic field simulator for microwaves and RF, has been specifically designed to meet these requirements.

USABILITY

For this new version, the modeling interface has undergone a complete makeover. Besides changes that simplify user access to functionality, there are improvements in user interaction. Transformations such as translation, rotation and scaling can now be performed using mouse control. In addition, version 2009 features a special interactive alignment mode that allows geometrical objects in the model to be positioned easily with a few mouse clicks. The new alignment mode is automatically activated when copying objects between two projects by standard copy [Ctrl-c] and paste [Ctrl-v] operations, or when importing sub-projects into the main project.

Conformal modeling is often required, particularly for antenna applications. Version 2009 offers an interactive bending feature. ***Figure 1*** shows the 3D model of an antenna carrier. The antenna itself is modeled as a planar structure, which is then imported in a separate step. The two objects are aligned (see Figure 1; top), then the bending process is started by selecting individual faces (see Figure 1; middle, highlighted red) of the carrier onto which the antenna should be bent. Eventually the entire antenna is fitted perfectly to the carrier (see Figure 1; lower). This is actually very similar to the real procedure, where the antenna is printed onto a flexible foil and then attached to the carrier.

Perhaps the most important among all the improvements to the modeling front-end is

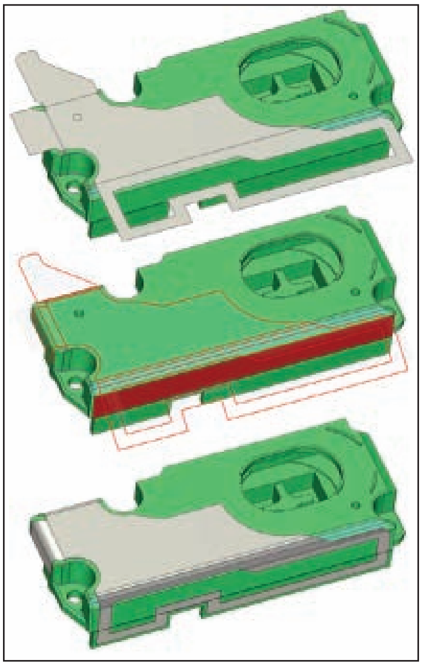
CST OF AMERICA
Framingham, MA

Visit http://mwj.hotims.com/16346-123 or use RS# 123 at www.mwjournal.com/info

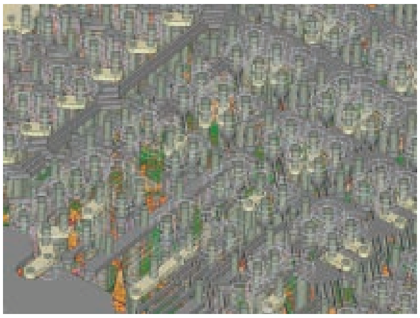
not visible at all; the entire user interface has been ported to 64-bit in order to serve the demand for dealing with increasingly complex models.

INTEROPERABILITY

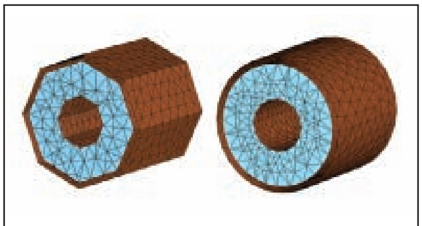
Workflow integration has always been a key concern in CST's development. All import filters available in the CST STUDIO SUITE are characterized by their robustness and ability to deal with flaws in the imported models. Besides updating the CAD kernel and the existing import filters, the palette of available imports/exports is being continuously extended. Version 2009 now features Nastran, GDSII and Gerber exports.



▲ *Fig. 1 Interactive bending of a fictitious antenna onto a carrier.*



▲ *Fig. 2 Complex EDA import for signal integrity analysis.*



▲ *Fig. 3 Coaxial waveguide after traditional (left) and true surface (right) mesh adaptation.*

Particular attention has been directed to the imports from EDA tools, e.g. from Cadence®, Mentor Graphics® and Zuken®, since the investigation of signal integrity is becoming an increasingly important application area for 3D EM simulation. These EDA interfaces can also deal with importing lumped circuit components. A completely new feature is the Mentor Graphics PADS® import.

SIMULATION PERFORMANCE

Computers are getting faster every year. But while CST has seen a performance increase for desktop workstations of about a factor 25 for a simple scalar textbook FDTD implementation in the last 10 years, the increase in average model complexity is actually greatly outweighing this. Factor increases of 1000 in numerical model size are not uncommon (see ***Figure 2***). For a mobile phone simulation, 10 years ago it was acceptable to replace the actual mobile phone by a metallic block and focus on the antenna. Today the entire mobile phone, its antennas, PCB, cameras, etc., have to be simulated, while also considering the presence of the phone user's head, hand, perhaps even the entire body, and the environment it is in.

Improvements in both the algorithms and hardware concepts must be leveraged. The neglect of one of these aspects necessarily leads to decreased performance. On the algorithmic side, CST takes the complete technology approach. An Allen screw can be tightened much quicker with an Allen key than with any other kind of screwdriver. Similarly, users can choose the tool within CST MWS that best suits their application.

On the next level, technologies like the Perfect Boundary Approximation (PBA)®, the Thin Sheet Technology (TST)™ and the Multilevel Subgridding Scheme (MSS)™ can improve performance dramatically. Improvements in implementation have also led to significant performance gains in the frequency domain solver.

Improvements on the hardware side are taking place at various levels. Together with Intel®, performance on desktop workstations has been further improved. In collaboration with Acceleware, GPU-based hardware acceleration has been made available to CST MWS users. Currently one-, two- and four-card solutions are available. Compared to high-end desktop workstations, speed-ups of up to a factor 19 have been achieved for typical applications. The upcoming realizations of GPU-based hardware acceleration using Nvidias Compute Unified Device Architecture (CUDA) programming language promise further performance improvements.

MPI FOR CST MWS

Hardware acceleration solutions for CST MWS are currently limited to a maximum of 96 million mesh nodes. Very complex structures such as multilayered PCB boards or electrically large models can easily exceed this limit. They will benefit most from the company's latest development: A message passing interface (MPI)-based parallelization of the CST MWS transient solver. By decomposing the calculation domain into several parts and distributing these parts to computers in a cluster, the simulation of models with several hundreds of millions of mesh nodes becomes feasible. At the same time the simulation is sped up by using several CPUs and memory interfaces in each individual computer.

TRUE SURFACE MESH ADAPTATION

As an additional algorithmic advance, the mesh adaptation of CST MWS's tetrahedral frequency domain solver has been entirely revised. Traditionally, adaptive refinement of HF frequency domain solvers based on a tetrahedral grid does not improve on the initial facetted representation of the structure. The originally created tetrahedra are simply divided further where necessary. The mesh adaptation will converge, not to the results of the actual structure (e.g. S-parameters), but to those of the initial segmented model (see ***Figure 3***; left). CST's mesh adaptation approach is different. After every adaptation step the proposed refinement is projected back onto the original model. This leads to an improved geometry approximation and to a convergence to the real results of this structure (see Figure 3; right).

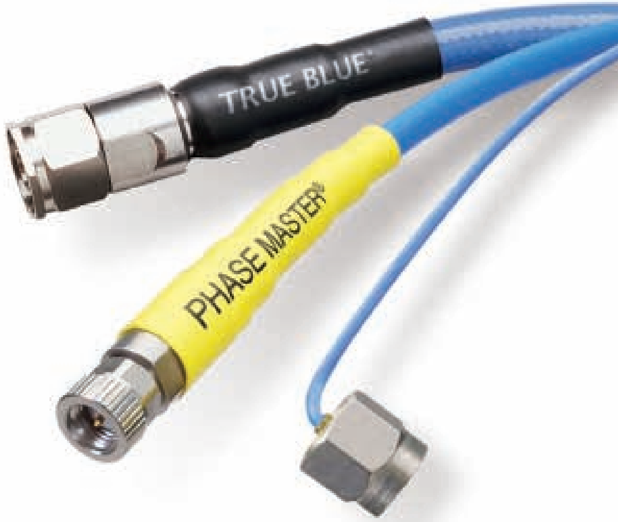
TELEDYNE
STORM PRODUCTS

Your Source for Military Interconnect Solutions

With **over 30 years experience** providing solutions for challenging defense applications, **Teledyne Storm's heritage is your heritage.**

We understand your needs for high performance microwave assemblies specifically engineered for military radar and EW applications and offer a product line that includes:

- ***True Blue®*** *low loss flexible assemblies*
- ***Phase Master®*** *phase stable flexible assemblies—superior phase stability, exceptional value*
- ***Storm Flex™*** *assemblies—durable, compact, superior electrical performance*
- ***Maximizer Gold™*** *phase stable semi-rigid assemblies*
- *Miniature blindmate assemblies*



Put our reputation for **technical expertise and outstanding customer service** to the test.

Contact us today to discuss how Storm Products can combine **high quality, performance, & value** in a product solution that works for you.

TELEDYNE
STORM PRODUCTS
A Teledyne Technologies Company

Teledyne Storm Products - Microwave
10221 Werch Drive ▪ Woodridge, Illinois 60517
Tel 630.754.3300 ▪ Fax 630.754.3500
Toll Free 888.347.8676
microwave@stormproducts.com

www.teledynestorm.com/mil1008

Visit http://mwj.hotims.com/16346-161 or use RS# 161 at www.mwjournal.com/info

INTEGRAL EQUATION SOLVER

Introduced for the solution of electrically large structures in CST MWS version 2008, the integral equation solver, based on the multilevel fast multipole method (MLFMM), is catching up with the rest of the company's solvers with respect to available features. The performance improvements over the previous version are dramatic. Besides MLFMM, an iterative MoM solver is available for solving structures that are electrically not very large, i.e. in the range of about 5 to 20 wavelengths. The memory efficiency is also good (N log(N) compared to N^3 for normal MoM).

TRUE TRANSIENT EM/CIRCUIT CO-SIMULATION

Particularly beneficial for engineers working in signal integrity, CST STUDIO SUITE 2009 additionally features true transient EM/circuit co-simulation. In standard EM/circuit co-simulation, the circuitry and 3D structures are solved separately, and S-parameter models represent the 3D EM structure in a circuit simulator [e.g. CST DESIGN STUDIO™ (CST DS)], which then solves the entire set-up.

CST MWS models, for example, can also be used within Agilent ADS or AWR Microwave Office. Although this is not co-simulation in the sense that 3D EM fields and circuit components influence each other, it is very useful to analyze and optimize a system in a way that also accounts for full 3D effects.

The new scheme available in version 2009 follows a different path, although the principal set-up looks very similar. A full 3D structure is represented by a block in a schematic, and circuit components are attached to its ports. The transient 3D EM/circuit co-simulation exchanges currents and voltages continuously at the ports between the CST MWS EM simulation and the circuit simulation in CST DS, while the signal propagates through the model (see ***Figure 4***).

There are two major advantages of transient compared to standard EM/circuit co-simulation:

- The full S-matrix of the 3D EM structure is no longer required since the circuit elements are directly interacting with the electromagnetic field simulation. This is advantageous particularly for PCBs with many ports and many lumped elements because the full S-matrix derivation of such a device can be extremely time consuming and is not always necessary for the investigation of critical parts.
- Transient EM/circuit co-simulation can also simulate the transient electromagnetic fields that result from the interaction with non-linear elements such as diodes. The broadband nature of the transient simulation means that many harmonics are automatically taken into account (see Figure 4).

TRANSIENT THERMAL SIMULATION

The thermal analysis of electromagnetic losses is a natural augmentation of EM simulation tools. In previous versions, a stationary heat equation solver was available. In version 2009 its capabilities are extended to simulate the transient behavior of the heating process. For the benefit of

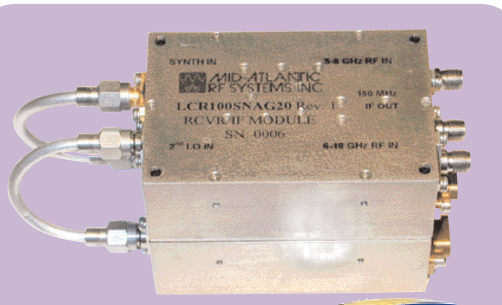
Void free fused metal PCB-to-pallet bonding. Planar, multilevel, two sided and in cavity designs. Reduce or eliminate associated RF tuning to lower total cost for critical designs. To learn more about advanced fabrication of printed circuit boards call 319-295-3673 or email: cpcsales@rockwellcollins.com

Rockwell Collins

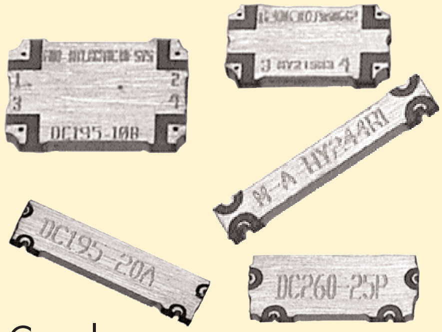
Building trust every day

www.rockwellcollins.com/flash

CHALLENGING CONCEPTS
CREATIVE SOLUTIONS

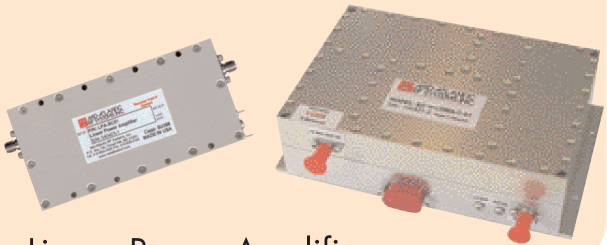


Tuner/Receiver
0.1 to 18 GHz



Couplers

UMTS Signal Generator



Linear Power Amplifier

- **A low cost solution for multi-carrier power amplifiers burn-in testing**

The most challenging design concepts require the most creative solutions. At Mid-Atlantic RF Systems, Inc. our goal is to provide cost-effective solutions for all microwave and RF applications. We design and manufacture a variety of couplers, switches, amplifiers, assemblies and low-cost receivers for both the commercial and military markets. Value-Added assembly (contract manufacturing) offers a fast and precise way to fulfill complex microwave and RF assembly requirements from prototyping to short run. For more information on product specifications, call Mid-Atlantic RF today!

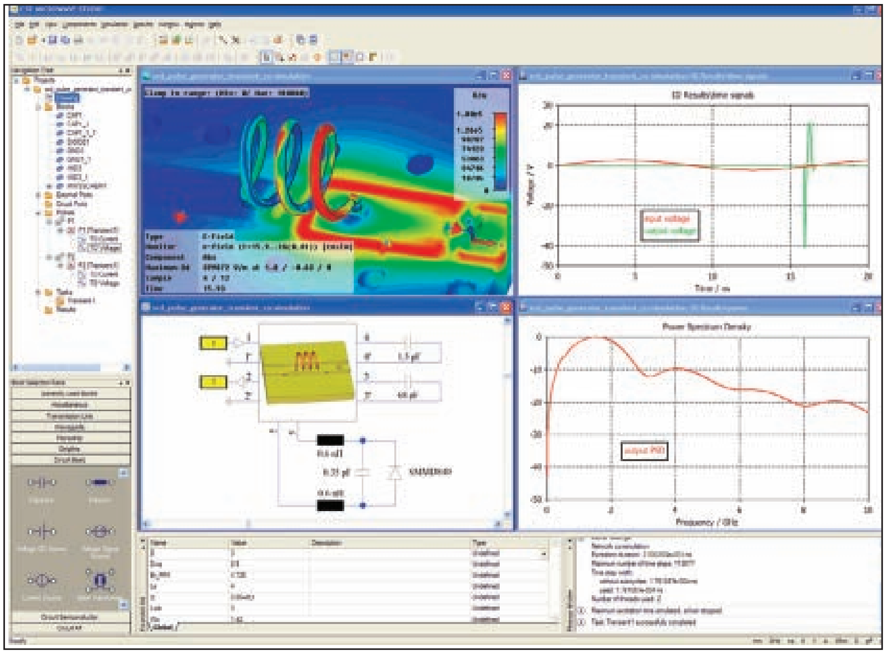
- **1,000 hop/sec**
- **No Reference Spurs**
- **Programmable**

Synthesizer

MID-ATLANTIC RF SYSTEMS, INC.
PO Box 745, Forest Hill, MD 21050
Tel:410/893-2430 • Fax:410/638-5193
E-mail:info@midatlanticrf.com
Web:www.midatlanticrf.com

MID-ATLANTIC RF SYSTEMS, INC.

Visit http://mwj.hotims.com/16346-87 or use RS# 87 at www.mwjournal.com/info



▲ *Fig. 4 Transient EM/circuit co-simulation.*

modeling biological tissues, both thermal solvers have been extended to include the bio-heat equation.

NEW PRODUCTS

Version 2009 features two entirely new products: CST PCB STUDIO™ (CST PCBS) and CST CABLE STUDIO™ (CST CS). Both are based on SimLab technology and are fully integrated in the CST DESIGN ENVIRONMENT™. CST CS simulates fields on cable harnesses while CST PCBS focuses on PCBs. Signal integrity and conducted emissions can be directly evaluated in these tools, and calculated surface currents can be used to conduct a radiation analysis in CST MWS.

CONCLUSION

Version 2009 efficiently leverages new technologies to reduce simulation times and increase interoperability offering improved usability and simulation capabilities, as well as two new products. As a result users benefit from an accurate and reliable tool that speeds up their design process and smoothly integrates into existing design flows.

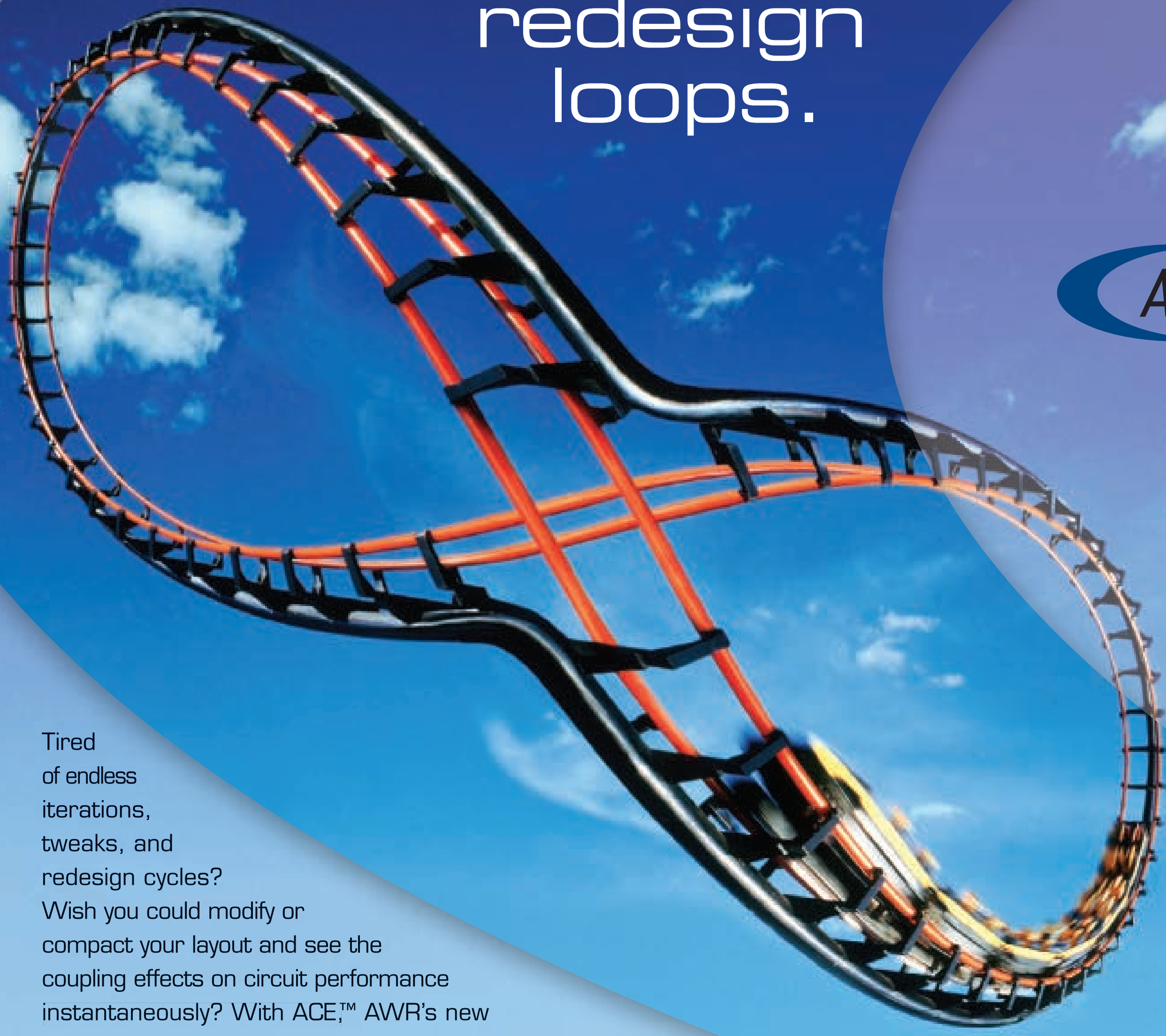
CST of America, Framingham, MA (508) 665-4400, www.cst.com.

RS No. 300

Visit http://mwj.hotims.com/16346-124 or use RS# 124 at www.mwjournal.com/info

www.awrcorp.com

Break free of infinite redesign loops.



AWR

Tired of endless iterations, tweaks, and redesign cycles? Wish you could modify or compact your layout and see the coupling effects on circuit performance instantaneously? With ACE,™ AWR's new automated circuit extraction technology, you can. ACE extracts layout-driven effects — including coupling in multilayered RF modules and ICs — in seconds and stops the monotony of brute force EM analysis or schematic-driven manual fracturing techniques. Test drive it today at www.awrcorp.com/ACE.

Microwave Office

ACE. Interconnect modeling in seconds

© 2008 Applied Wave Research, Inc. All rights reserved.

Visit http://mwj.hotims.com/16346-22 or use RS# 22 at www.mwjournal.com/info

GET IN THE ZONE!

Visit
mwjournal.com/info
to request

FREE

Product Information
From advertisers and featured products in this issue
at

Info Zone

Where you can:
Request information by RS number, company name or product category
or
Link directly to hundreds of manufacturer's Websites

It's FAST, EASY and FREE!

Microwave Journal

FREE
Product Information

Available Online
at

Info Zone

The Web-based
product information system

from

Microwave Journal

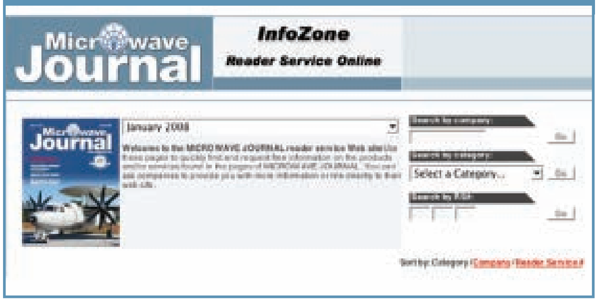
Just visit
mwjournal.com/info
and enter the RS number from the ad or editorial item
or
request information by company name or product category

It's Easy

It's Fast

It's FREE

GET IN THE ZONE!



IME2008
November 18-20 China

The 3th

China International Conference & Exhibition on Microwave

—— The largest RF/ Microwave Component & Instrument Event in China

Date: November 18-20, 2008
Venue: Shanghai Everbright Convention & Exhibition Center, China

COME TOGETHER

As the largest and professional microwave exhibition in China, IME/China will be a good platform and channel for technical exchanges, business cooperation and trade promotion between world microwave products & technology suppliers and China microwave customers.

IME/China 2008 has two parts: exhibition and conference.

ViewTran
Exhibition Service

For more information, please find in our website：
www.imwexpo.com
or please contact us:
Mr. Xu Yimin / Project Manager
Viewtran Exhibition Service Co., Ltd.
Tel: +86-21-62477218
Fax: +86-21-62475839
E-mail: expo@vtexpo.com.cn

Visit http://mwj.hotims.com/16346-59 or use RS# 59 at www.mwjournal.com/info

A MICROWAVE CABLE FAMILY WITH ULTRA LOW INSERTION LOSS

In 1983, the SUCOFLEX 100 microwave cable family from HUBER+SUHNER impacted greatly on the market and to this day continues to hold its own as a leading product family. Its extensive product range and electrical and mechanical characteristics, allied to high reliability, has enabled the family to be widely used worldwide. The new SUCOFLEX 400 cable family has been designed with new features that will enable it to continue the tradition and set new standards for microwave cable assemblies, particularly in the test and measurement, defense, instrumentation and space markets.

TABLE I

ELECTRICAL CHARACTERISTICS OF THE SUCOFLEX 404

Impedance	50 ± 1 Ω
Operating frequency	26.5 GHz
Diameter	5.5 mm
Capacitance	74.8 pF/m (22.8 pF/ft)
Velocity of propagation	89%
Signal delay	3.74 ns/m (1.14 ns/ft)
Nominal phase	1347°/GHz/m (410.5°/GHz/ft)
Phase stability vs. temperature	See graph 1+2
Insertion loss stability vs. temperature	< 0.0023 /°C
Insertion loss stability vs. bending	< 0.05 dB
Screening effectiveness up to 18 GHz	> 90 dB
Attenuation	See table 1
CW power	See table 1
Return loss with straight SMA connectors	Min. 20.0 dB up to 18.0 GHz

NEW REQUIREMENTS

In recent years, the requirements that cable assemblies must meet have changed and become increasingly demanding. For example, vibration, shock, the need for the lowest phase change in relation to temperature, RF-leakage, moisture and chemical resistance, weight, etc., are of enormous importance in defense technology. In the test and measurement market, requirements such as Flex-Life, small phase change versus bending and torsion, and high loss stability in the case of bending and shaking are priority considerations.

To better meet specific market needs, HUBER+SUHNER initiated a major initiative with the goal of designing future products, each with a market focus—basically providing a tailor-made solution for each target group. The first result of this initiative was the development of the SUCOFLEX 300 family for aerospace applications; the SUCOFLEX 400 is the latest range to be produced.

LOW INSERTION LOSS

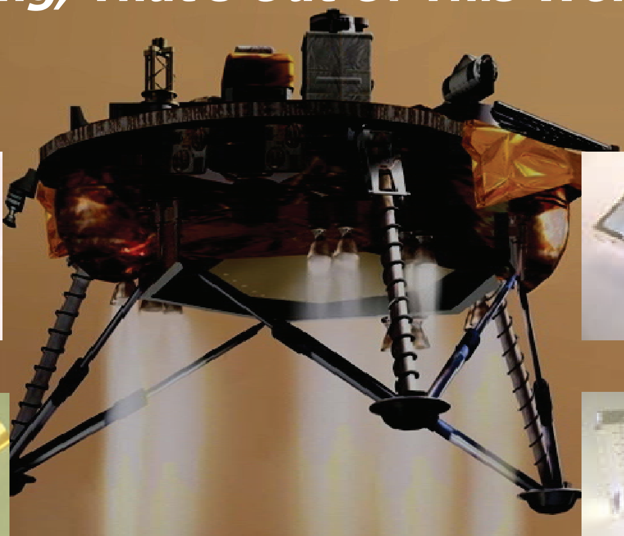
The SUCOFLEX 400's construction (shown in ***Figure 1***) is a solid silver-plated copper wire center conductor, encased by an extruded ultra low density PTFE dielectric, with a silver-plated copper tape inner shield, a silver-plated copper braid outer shield and a Fluorinated Ethylene Propylene (FEP) jacket.

Of particular significance is the new, extruded ultra low density PTFE dielectric, with a dielectric constant of 1.26, giving the SUCOFLEX 400 the lowest insertion loss

HUBER+SUHNER AG
Herisau, Switzerland

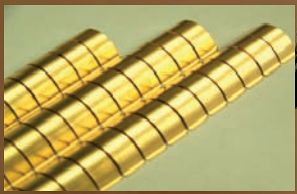
Purecoat International, LLC & Purecoat North, LLC

Plating, That's Out Of This World !



Plated to your specifications

Tin or Tin/Lead



Plated to your specifications

Gold and Silver

With over forty years of experience, Purecoat Int. & Purecoat North have made their mark on the aerospace, electronics, transportation & microwave industries. Our unique ability to plate aluminum alloys, copper alloys, nickel alloys, stainless steel, titanium and zinc, have made us one of the fastest growing job shops in the country.

High Rel **is our forte; we service some of the most prestigious connector/filter houses in the nation, providing them with the highest standards in quality and customer service. We pride ourselves in knowing that many orbital and communications satellites contain parts plated at our facility.**

Typical Applications

Amplifiers	Circulators	Filter Housings	RoHS & Non-RoHS
Attenuators	Connectors	EMI Shielding	Thick & Thin Film Products
Waveguides	Contacts	Kovar Carriers	Glass & Ceramic Products
Masking Available		PC Board Hardware	Glass To Metal Seals

For a quote, or a complete list of our plating capabilities and specifications, look us up on the web.

PCI *Servicing the Worlds Metal Finishing Needs* PCN

Purecoat International, LLC
3301 Electronics Way
West Palm Beach, Florida 33407
Ph (561) 844-0100 Fax (561) 845-7480
www.purecoat.com

Purecoat North, LLC
39 Hittinger St
Belmont, Massachusetts 02478
Ph (617) 484-8870 Fax (617) 484-9105
www.purecoatnorth.com

Visit http://mwj.hotims.com/16346-120 or use RS# 120 at www.mwjournal.com/info

currently available. And, despite the proportion of air, the proven mechanical stability and reliability of the extruded dielectric has been preserved. The cable's electrical characteristics are shown in ***Table 1***.

Another highlight of the very low dielectric constant is that the Continuous Wave (CW) power capability has been increased together with a very significant improvement in phase stability versus temperature (shown in ***Figures 2a*** and ***2b***). This is a great advantage in applications such as phased-array antenna systems and also helps to simplify the adjustment of radars. The attenuation/CW power is shown in ***Table 2***.

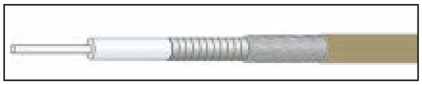
The new family of microwave cables has been specifically developed for applications on the ground for defense technology, medical and space measurement technology applications, where the lowest loss, highest performance, best phase stability versus temperature and phase stability versus bending, good return loss and mechanical stability are of the utmost importance.

DIVERSE APPLICATIONS

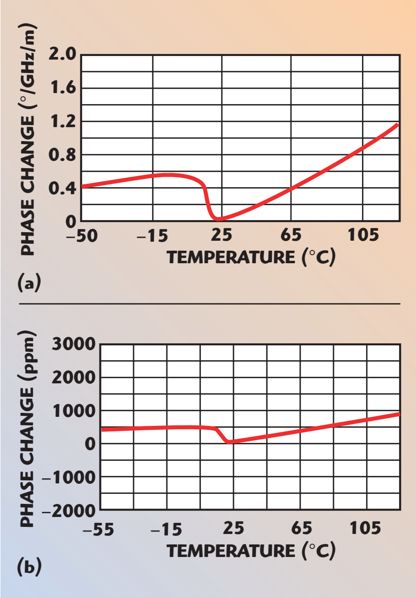
The new microwave cable assembly is suitable for different applications. In defense technology, its primary use is in tactical and strategic communications and in electronic warfare (radar systems, etc.). In particular, phase-matched cable assemblies are required for radar applications. Complete sets of phase-matched, time-delay-matched or amplitude-matched SUCOFLEX 400 cable assemblies are available.

The special characteristics of the new cable assembly family are also likely to make it the preferred solution for thermal vacuum tests for satellite components or for entire satellites, as well as for applications in medical systems such as high frequency ablations of cancerous ulcers or connections between high frequency generators and probes.

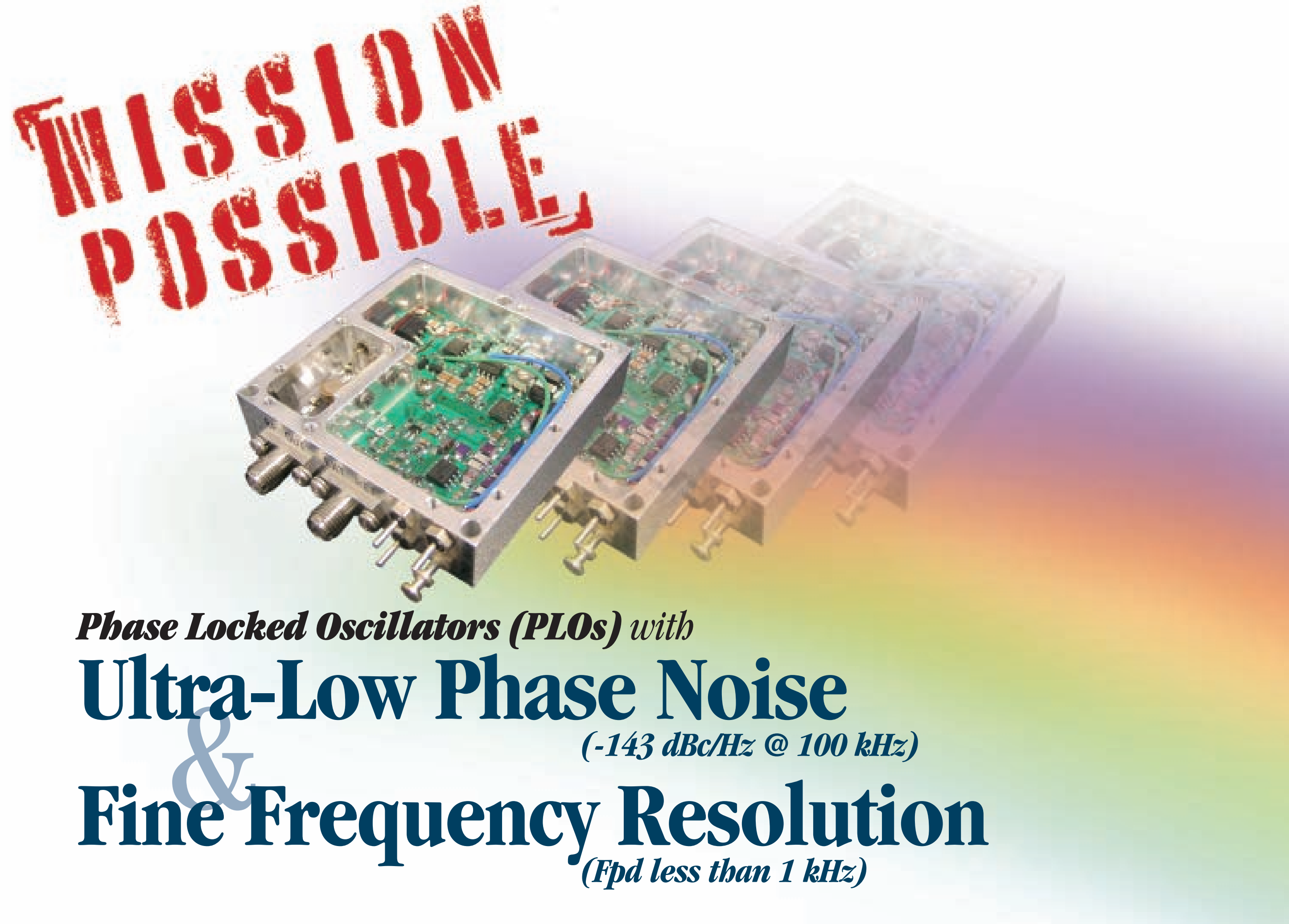
The cable assemblies have been tested in accordance with the relevant MIL specifications and standards and, as a result, are suitable for numerous applications in defense technology. The



▲ *Fig. 1 A graphical illustration of the construction of the SUCOFLEX 400.*



▲ *Fig. 2 Phase stability vs. temperature (°/GHz/m vs. °C) (a); phase stability vs. temperature (ppm vs. °C) (b).*



products will also be subjected to a special TVAC test program for thermal vacuum applications.

PRODUCT LAUNCH

There will be a steady roll-out of SUCOFLEX 400 products for specific relevant markets starting with the SUCOFLEX 404 (diameter 5.5 mm) with a straight male SMA connector, which will be available this month (October 2008). The SUCOFLEX 406 (diameter 7.9 mm) including N and TNC straight male connectors will follow at the beginning of 2009. This cable will have the lowest loss of the family and thus be the lowest loss product up to 18 GHz on the market. During the course of 2009, the connector range will be expanded and followed by additional thinner versions with the lowest losses for frequencies up to 40 GHz, as well as additional jackets and armor for all kinds of applications.

CONCLUSION

The SUCOFLEX 400 family of microwave cable assemblies is identical in design with the familiar SUCOFLEX 100 products, which have proven their reliability and stability for a wide range of applications for more than 20 years. The latest innovation though, is the new ultra low density PTFE dielectric, which has been completely redesigned and, as a result, has improved the electrical performance of the new cable. The connectors, likewise developed by HUBER+SUHNER, have been adjusted to the cable in order to preserve the excellent return loss (VSWR) on the assembly.

TABLE II

ATTENUATION/CW POWER

Frequency (GHz)	Attenuation (dB/m)	Attenuation (dB/ft)	CW Power (W) sea level, 40°C
2.0	0.30	0.09	689
4.0	0.42	0.13	488
6.0	0.52	0.16	398
8.0	0.61	0.19	345
10.0	0.68	0.21	308
12.0	0.75	0.23	281
14.0	0.82	0.25	260
16.0	0.88	0.27	243
18.0	0.95	0.29	230
26.5	1.15	0.35	189

Current HF systems for defense, medical and space applications must comply with the highest demands, so it is essential that the accompanying connection components meet the highest standards too. The new SUCOFLEX 400 family meets these demands.

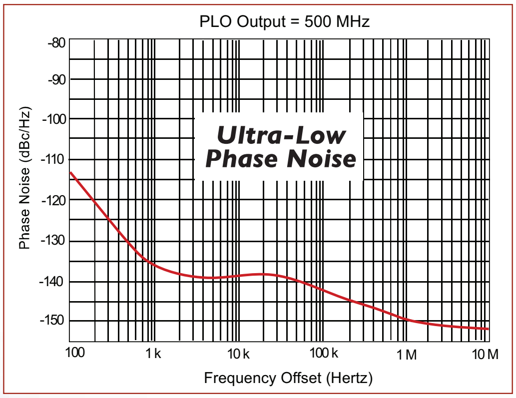
HUBER+SUHNER AG, Herisau, Switzerland, +41 71 353 41 11, www.hubersuhner.com.

RS No. 301

We Offer More Standard Features…
to give you the highest performing PLOs & DROs

Phase Locked Oscillators (PLOs) and Dielectric Resonator Oscillators (DROs) delivering ULTRA-Low Phase Noise and Upgraded with all the features your design needs ... Spectrum Microwave can make your MISSION POSSIBLE. We'll review power supply noise, load impedances and other system considerations to recommend a design loaded with features that will fully integrate into your system.

- Integral voltage regulator for Improved Phase Noise and Reduced Spurious Signals
- TTL lock alarm… Standard
- Phase lock integrator output for test or error detection
- Low Loss Isolators for improved pulling and added isolation from bad load VSWR
- Standard Oscillators from 500 MHz to 21 GHz



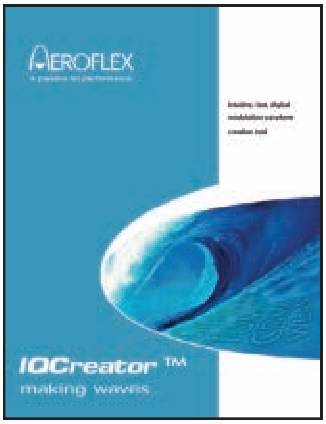
See how we can make your optimized PLO MISSION POSSIBLE, call 888.553.7531 or visit SpectrumMicrowave.com

Ask for our New Integrated RF & Microwave Solutions Brochure Available Online

SPECTRUM MICROWAVE INC.
A Spectrum Control Business

EMF Systems • Q-Bit

Visit http://mwj.hotims.com/16346-149



Capabilities Brochure

Learn about all capabilities of Aeroflex IQCreator™ software in this new product brochure. Designed for use with Aeroflex's digital RF signal generators, including the 3410 and PXI-based 3000 Series, IQCreator enables you to create waveforms that emulate digitally modulated RF and analog baseband I and Q transmission formats. IQCreator is an easy to use, Windows™-based software application that enables a user to set up a modulation scheme and then create an Arbitrary Waveform Generator (ARB) file.

Aeroflex,
Plainview, NY (800) 835-2350, www.aeroflex.com.

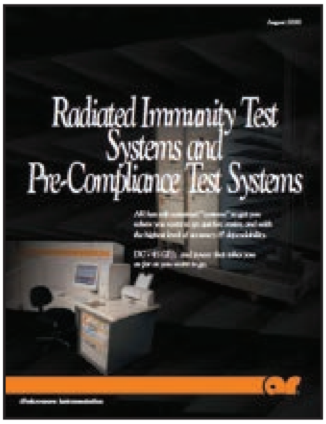
RS No. 310

Switch Selection Guide

Agilent's new "RF and Microwave Switch Selection Guide" provides comprehensive information on the company's entire portfolio of switches. The guide provides an overview of electromechanical and solid-state switches and switch drivers. Characteristic switch parameters such as switching speed, isolation and insertion loss including typical applications and configuration are provided. To download a free copy, visit www.agilent.com/find/switches.

Agilent Technologies,
Santa Clara, CA (800) 829-4444, www.agilent.com.

RS No. 311



AR Systems Brochure

AR RF/Microwave Instrumentation's newest brochure highlights its systems' capabilities and AR-Cell Precompliance Test Systems. AR has the capabilities to customize systems to solve your RF and EMC test problems with the power and frequency you need – from 10 kHz to 45 GHz. The AR-Cell systems are out-of-the-box immunity and emissions test systems that perform precompliance testing to IEC 61000-4-3 requirements as well as other industry specific standards.

AR RF/Microwave Instrumentation,
Souderton, PA (215) 723-8181, www.ar-worldwide.com.

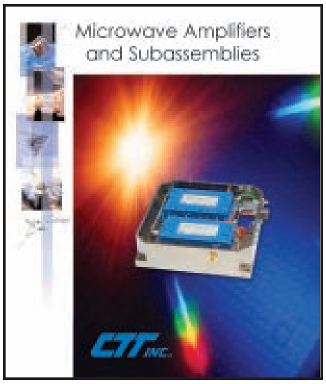
RS No. 312

Enhanced Catalog

With 62 pages the new 2008 AtlanTecRF catalog is bigger than ever. It features many new additions to the product ranges, most notably: synthesized local oscillators, a new phase-locked oscillator with internal TCXO reference (APL-04), mixers, terminations, medium power attenuators, filters, PIN switches and cable assemblies. The catalog offers detailed specifications for each product, including dimensional diagrams, etc. It also contains information on the ranges of custom equipment and components.

AtlanTecRF,
Braintree, Essex, UK +44 1376 550220, www.atlantecrf.com.

RS No. 313



Product Catalog

This 36-page catalog features 175 all-new amplifier products, including lightweight and compact LNAs based on GaAs PHEMT active devices. CTT's extended product offering includes Gallium Nitride (GaN)-based power amplifiers for wideband jammer applications (25 W from 0.5 to 2.0 GHz), as well as narrowband radar applications (80 W from 8.5 to 9.6 GHz). In addition, several new subsystem offerings have been introduced including a VMEbus-compatible two-channel IF conditioner.

CTT Inc.,
Sunnyvale, CA (408) 541-0596, www.cttinc.com.

RS No. 314

Interactive Product Catalog

This web site provides a comprehensive, user-friendly selection of the company's products and functionality to configure and submit quote requests. The site features a parametric search engine and a collection of RF engineer's applets such as a watts-to-dBm converter, gain calculator and links to contact Empower's sales team. There is also a mobile-friendly version accessible from devices such as a RIM Blackberry. The mobile site has a product selector, contact information and driving directions from Los Angeles Airport.

Empower RF Systems Inc.,
Inglewood, CA (310) 412-8100, www.empowerrf.com.

RS No. 315

With Our Newly Expanded Diode Line, You Have Even More Reasons to Smile

More diodes, more application assistance, more custom options. Microwave engineers want it all, and Aeroflex Metelics is delivering. After the recent acquisition of MicroMetrics, we're now more equipped than ever to service all your diode requirements. From east coast to west coast. From GaAs to silicon. No one provides a more comprehensive approach to handling all your requests for standard and custom Schottkys, PINs, NIPs, varactors, detectors, limiters, capacitors, resistors, inductors, attenuator pads, and so much more. And they come delivered every way imaginable, from wafers to plastic surface mount.

Give us a call at 888-641-SEMI (7364) and let our customer service team make you smile.

aeroflex-metelics.com

AEROFLEX

A passion for performance.

RF Systems and Components

The new 2008 product folder from eubus GmbH combines all detailed data sheets of the RF systems and RF components product portfolio. The RF systems part contains all network attenuator module (NAM) products and the handover and coupling unit (HCU). The RF components part shows all power dividers/combiners, solid-state programmable attenuators, RF switch modules as well as directional couplers.

eubus GmbH,
München, Germany +49 (0) 89 4522 578 11, www.eubus.net.

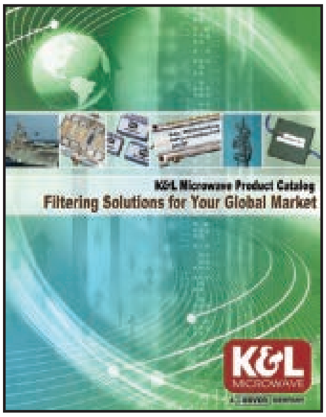
RS No. 316

Test Systems Catalog

This test systems catalog features programmable attenuator assemblies, handover test systems, transceiver test systems, switch assemblies, matrix switches, Ethernet, RS-232 and GPIB command information. To download the catalog or request a printed catalog, visit www.jfwindustries.com.

JFW Industries Inc.,
Indianapolis, IN (317) 887-1340, www.jfwindustries.com.

RS No. 317

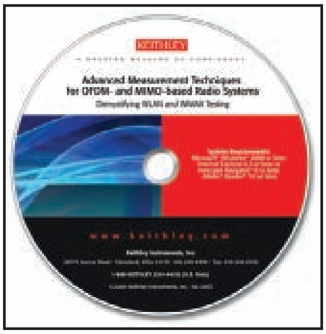


RF and Microwave Filter Catalog

K&L Microwave's new catalog features RF and microwave filter products that are essential for defense electronics and telecommunication systems. Integrated assemblies and a wide assortment of lumped component, cavity, ceramic and suspended substrate filters are among the many types of products included in this 128-page catalog.

K&L Microwave,
Salisbury, MD (410) 749-2424, www.klmicrowave.com; www.klfilterwizard.com.

RS No. 318



Wireless and RF Testing Guide

Advanced Measurement Techniques for OFDM- and MIMO-based Radio Systems: Demystifying WLAN and WiMAX Testing gives test engineers a broad range of information on the fast changing wireless communication and RF testing field for a wide array of applications, including spectrum analyzer power averaging, as well as the most challenging testing of the most complex signals, such as OFDM, MIMO and WiMAX. This CD contains useful and informative RF testing resources, including application notes, articles and white papers.

Keithley Instruments Inc.,
Cleveland, OH (440) 248-0400, www.keithley.com.

RS No. 319

Selection Guide

The electromechanical relays selection guide has been modified into an easy-to-use guide for engineers to quickly choose a product through a comprehensive part number development tool for each relay family. The new 24-page EMR selection guide features RF, commercial, military, special environment and Teledyne's Established Reliability relays. Screening levels for the Military and Established Reliability relays are also included.

Teledyne Relays,
Thousand Oaks, CA (805) 373-4545, www.teledynerelays.com.

RS No. 320

Product Brochure

This brochure provides a brief, descriptive overview of the LMR® family of cables and connectors, including the acclaimed Advantage™ series. The brochure also includes T-RAD® leaky feeder cable for interior coverage solutions, SilverLine™ test cables including SilverLine QMA and SilverLine TuffGrip™ and also TCOM® flexible low-PIM cables. LMR cables are flexible, non-kinking low loss RF transmission line cables that utilize easy-to-install connectors.

Times Microwave Systems,
Wallingford, CT (203) 949-8400, www.timesmicrowave.com.

RS No. 321


RF/Microwave Switching
Customized within your budget
Whether you choose the customizable Racal Instruments™ 1257 or the fully configurable Racal Instruments™ 1256, we can supply the ideal switching system for your RF or Microwave switching requirement.
1257: fully customizable, larger, powerful
1256: fully configurable, more compact
Whatever you have in mind, we'll deliver a finely crafted, fully documented, fully supportable solution. Should you need another system, either next week or five years from now, it will match the first. And all of this at commercial off-the-shelf prices.
For state-of-the-art, cost effective RF/μW switch systems, contact:
EADS North America Test and Services
800.722.2528 | www.ts.eads-na.com
info@ts.eads-na.com
Visit http://mwj.hotims.com/16346-156
or use RS# 156 at www.mwjournal.com/info
EADS
NORTH AMERICA

Buyer's Guide &

GLOBALSPEC®
The Engineering Search Engine®

The MWJ Buyer's Guide is the source for over 1000 RF/Microwave Companies delivering the latest products and services to our industry. The MWJ Buyer's Guide and VendorViews let engineers sort technologies by category to browse through company listings, products and related information. Now featuring specification-based product search from GlobalSpec - the leaders in engineering component search engines.

Locate:

- Product Information
- Company News
- Technical Articles
- Events
- Downloads
- Parts by performance specifications

Visit:

http://www.mwjournal.com/BuyersGuide/

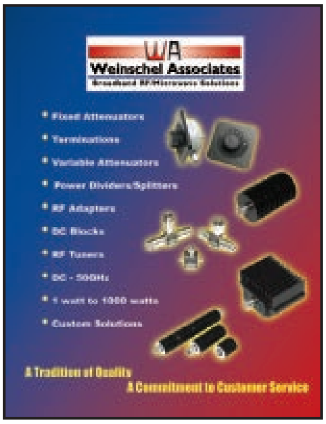
CATALOG UPDATE

Product Catalog

Valpey Fisher Corp. specializes in low noise timing solutions. From discrete high precision crystal oscillators to highly integrated low noise timing modules, Valpey Fisher offers a broad array of frequency control products needed in advanced timing applications including wireless and wireline infrastructure, avionics, test and measurement, and military communications. The product catalog is filled with the latest innovative timing and frequency control products. Visit the company's web site for a digital copy of the catalog. Products include: timing modules, OCXOs, TCXOs, VCXOs, XOs and hi-rel COTS.

Valpey Fisher Corp.,
Hopkinton, MA (800) 982-5737, www.valpeyfisher.com.

RS No. 322

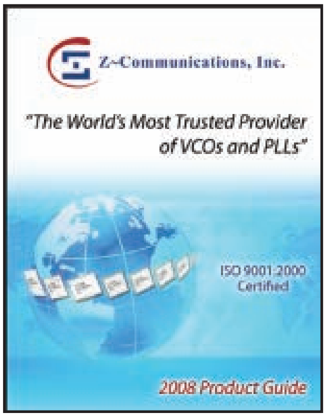


Product Catalog

Weinschel Associates, a manufacturer of high-quality broadband RF and microwave products for commercial and military markets both domestic and international, has just released the 2009 edition of its full-line catalog. The company's goal is to serve you, the customer, with an ever increasing usefulness of product line.

Weinschel Associates,
Gaithersburg, MD (301) 963-4630,
www.weinschelassociates.com.

RS No. 323



Product Guide

Z-Communications Inc. announced the release of the company's 2008 product guide. This short form catalog includes a wide variety of surface-mount voltage-controlled oscillator (VCO) and phase-locked loop (PLL) synthesizer modules ranging from 40 MHz to 10 GHz. In addition to high performance parts and specifications, the guide features detailed outline drawings, footprints and test fixtures. Users can download an electronic version of the product guide on-line at www.zcomm.com or contact the company at sales@zcomm.com for a hard copy version.

Z-Communications Inc.,
San Diego, CA (858) 621-2700, www.zcomm.com.

RS No. 324

Innovative GaAs integration technologies without compromise

HBT + pHEMT @ WIN = H²W

e-Mode + d-Mode pHEMT @ WIN = e/d

It's a **whole new world** for designers with breakthrough integration technologies from WIN Semiconductors.
Combining GaAs HBT, enhancement and depletion pHEMT technologies on a single wafer enables innovative, highly integrated product solutions.

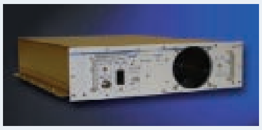
www.winfoundry.com

WIN
SEMICONDUCTORS
CORP.

Visit http://mwj.hotims.com/16346-175 or use RS# 175 at www.mwjournal.com/info

High Power GaN Amplifier

The model SSPA 3.1-3.5-1300-RM is a high power, pulsed RF amplifier that operates from 3.1 to 3.5 GHz in a rack-mounted configuration. This PA is ideal for S-band military radars. It is packaged in a 3U high, 19 inch rack-mounted enclosure. This amplifier has a minimum peak output power of 1300 W at a 5 percent duty cycle with a 64 uSec pulse width. This amplifier offers a typical saturated gain of 38 dB with a typical power flatness of ± 1.0 dB with an input drive of 24 dBm ± 1.0 dB. Input and output VSWR is 1.5 maximum. This RF rack-mounted amplifier operates from 208 to 220 VAC. There is a forward power RF sample port along with an output forward detected voltage pulse available.



Aethercomm Inc., San Marcos, CA (760) 598-4340, www.aethercomm.com.

RS No. 249

Low Noise Synthesizers

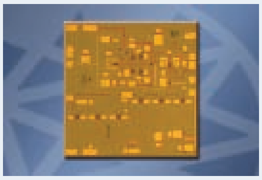
The ESP-1100 and ESP-1700 were designed for use as local oscillators in converters for fading channel simulators, operating at fixed-frequencies (1100 MHz and 1700 MHz), with extremely low phase noise of <-143 dBc/Hz at 100 kHz and <-138 dBc/Hz at 100 kHz, respectively. The ESP series features output powers up to +14 dBm, external or internal frequency references, in a small connectorized package, 2.25" x 2.25" x 0.6". Originally configured for laboratory and ground-based applications, this part is extremely robust, will handle high levels of shock and vibration, and can be hermetically-sealed for use in high-rel military applications.

EM Research Inc., Reno, NV (775) 345-2411, www.emresearch.com.

RS No. 216

Active x2 Multiplier

The HMC598 active x2 frequency multiplier utilizes GaAs PHEMT technology, and is offered in bare die form. The device is comprised of an input amplifier, a low conversion loss frequency doubler, and an output buffer amplifier. When driven with a +5 dBm input signal, this frequency multiplier provides +15 dBm typical output power from 22 to 46 GHz, and the Fo and 3Fo isolations are 25 dBc and 15 dBc respectively at 30 GHz. This multiplier is ideal for clock generation, microwave radio and test equipment applications.



Hittite Microwave Corp., Chelmsford, MA (978) 250-3343, www.hittite.com.

RS No. 217

TWT Amplifier

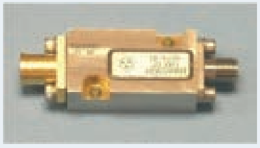
The model 8923H is a dual-band 300 W 30 GHz/175 W 45 GHz Traveling Wave Tube (TWT) amplifier. Designed for military SATCOM uplink applications, this TWT has a remarkably small footprint and weighs less than four pounds. L-3 ETI's model 8923H TWT operates in a frequency range from 30 to 45.5 GHz, including the 33 to 36 GHz radar band, and incorporates focus electrode modulation to allow both CW and pulsed operation. This product introduction complements L-3 ETI's existing 8926HB 500 W Ka-band TWT (27.5 to 31 GHz) and 8925HP 200 W Q-band TWT (43.5 to 45.5 GHz).

L-3 Electron Technologies Inc., Torrance, CA (310) 517-6000, www.l-3com.com.

RS No. 218

High Power Limiter

The model CCS33060 is a high power, self-biased limiter that operates from 10 MHz to 18 GHz. The input power specification is 180 W CW, 600 W peak. The flat leakage is 17 dBm maximum, and the insertion loss is 0.8 dB maximum. This device has a VSWR of 1.35 maximum and a recovery time of 5 uSec maximum. The input connector is a JGMS and the output connector is a removable SMA. This device uses a self-biased PIN/Schottky input stage with a PIN clean-up stage.



Cobham Defense Electronic Systems, REMEC Defense and Space East, Manchester, NH (603) 518-2700, www.remecrds.com.

RS No. 219

4 W Linear Power Amplifier

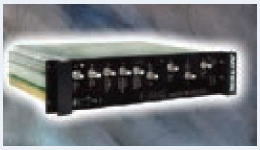
The model SM06927-36H is a 690 to 2700 MHz solid-state GaAs FET amplifier designed for multi-purpose use in multiple wireless and military markets. This module provides a minimum of +36 dBm of output power at P1dB with an OIP3 of +48 dBm. The gain flatness over the entire 2.1 GHz bandwidth is ±0.75 dB. The unit uses the latest surface-mount technologies to provide numerous features, while maintaining a minimal size. Price: $1200 (1-3). Delivery: three to four weeks.

Stealth Microwave Inc., Trenton, NJ (609) 538-8586, www.stealthmicrowave.com.

RS No. 220

VME-based Receiver

The model SYS1000N01U is a VME-based receiver that features a multi-stage superheterodyne architecture design. The design will translate an X-band signal with the frequency excursion of 1,000 MHz to an IF center frequency of 70 MHz with an instantaneous bandwidth of 20 MHz. The receiver functionality includes automatic gain control (AGC) attenuator with analog sampling, channel gain balance attenuator, channel phase balance phase shifter, signal injection point, peak detected signals (available via VME interface) and RF signal monitoring points. The receiver is fabricated into a three-slot wide VME module. Control of the receiver components is done using standard VME-64 bus protocol.



MITEQ Inc., Hauppauge, NY (631) 436-7400, www.miteq.com.

RS No. 242

Monitoring Receiver

The model RMR-818-77-NRL is an 8 to 18 GHz radar/microwave monitoring receiver for laboratory applications. The receiver uses an extended range detector log video amplifier (DLVA), a preamplifier and RF bandpass filtering. It also offers a dynamic range of 75 dB with a typical TSS of -80 dBm. It can be supplied with either individually removable bandpass filters or various switched filter bank options. The basic model offers a log video output for analysis through external test equipment. These microwave monitoring receivers are available in frequency ranges from 0.5 to 20 GHz as well as different sizes and capabilities.

Planar Monolithics Industries Inc., Frederick, MD (301) 631-1579, www.planarmonolithics.com.

RS No. 243

Calibrated Noise Source

The NW-CS-I series is a high level calibrated noise source equipped with an internal isolator allowing high output noise to be generated with an excellent VSWR. Standard output levels are 30 to 35 dB ENR with units as high as 40 dB available. These units are ideal for built-in test application in early warning radar systems and satellite test systems to calibrate receivers. Due to their high output levels they can be injected via couplers and into high loss networks. The unit is integrated into a small package saving space.

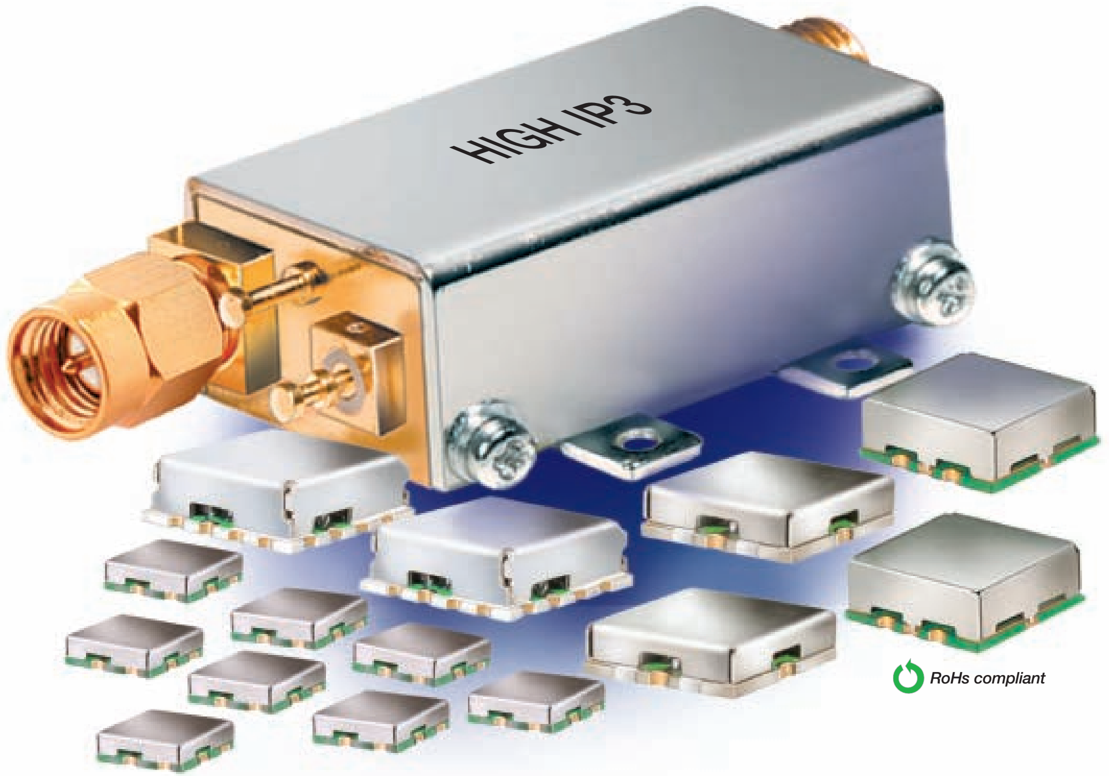
NoiseWave, East Hanover, NJ (973) 386-1119, www.noisewave.com.

RS No. 246

Constant Impedance

VVAs

10 to 3000 MHz



RoHs compliant

from $3.95 ea. qty.10-49

Voltage Variable Attenuators (VVAs) deliver as high as 40 dB attenuation control over the 10 MHz through 3.0 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...we're redefining what VALUE is all about!

Mini-Circuits®

ISO 9001 ISO 14001 CERTIFIED

ALL NEW minicircuits.com

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

YONI2™ Patent Pending

The Design Engineers Search Engine *Provides ACTUAL Data Instantly From MINI-CIRCUITS At:* ***www.minicircuits.com***

IF/RF MICROWAVE COMPONENTS

449 rev org

Visit http://mwj.hotims.com/16346-102 or use RS# 102 at www.mwjournal.com/info

Expand your safety portfolio...

It's up to you.

Invest in safety and make your plans today to attend NATE 2009 in Nashville, Tennessee, February 23-26.
NATE encourages everyone involved in the tower industry to play their part in worker safety.

National Association of Tower Erectors • www.natehome.com • 605-882-5865 • 888-882-5865 (U.S.)

Visit http://mwj.hotims.com/16346-110 or use RS# 110 at www.mwjournal.com/info

Active Components

Temperature-compensated Crystal Oscillator

The model VFTX312 is a temperature-compensated crystal oscillator (TCXO) with a voltage control option suitable for FEMTO CELL reference timing. The output frequency of 26 MHz and the tight temperature stability of 0.1 ppm is specifically designed for 3GPP (Femto Cell) system timing. This TCXO is a fundamental mode crystal oscillator with low power consumption. Available in a 5x7 mm surface-mount hermetically-sealed package that is fully RoHS 6/6 compliant.

Valpey Fisher Corp., Hopkinton, MA
(508) 435-6831, www.valpeyfisher.com.
RS No. 221

Low Phase Noise Frequency Multiplier

The Holzworth HX4110 frequency multiplier is a laboratory grade reference multiplier that can be used for any 10 to 100 MHz conversion. The HX4110 has a unique circuit architecture that maintains the low phase noise and low jitter characteristics of precision oscillators and RF sources. With typical additive phase noise performance of -174 dBc/Hz (input referred), the HX4110 is an excellent choice for sensitive laboratory applications as well as high performance transmitter/receiver applications. Holzworth products are 100 percent final performance tested for phase noise verification.

Holzworth Instrumentation, Boulder, CO
(303) 325-3473, www.holzworth.com.
RS No. 222

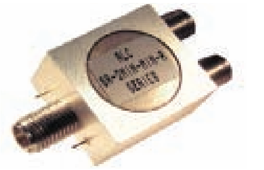
Voltage-controlled Oscillators

These economical voltage-controlled oscillators (VCO) offer low phase noise in the industry-standard one half inch square package. Model MD111MST operates in a frequency range from 950 to 980 MHz and is rated -119 dBc at 10 kHz offset. Many other catalog models are available and custom designs can be supplied with no NRE.

Modco Inc., Sparks, NV (775) 331-2442,
www.modcoinc.com.
RS No. 223

Micro-miniature SMA Switch

This micro-miniature SMA switch is a single-pole two position type. The switch incorporates SMA connectors to allow high density packaging and excellent electrical performance through 26.5 GHz. The switch is available in failsafe and latching configurations with a choice of three different frequency ranges and three different coil voltages.



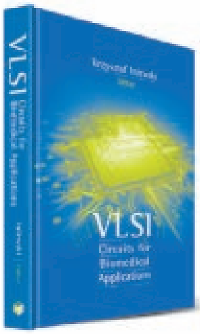
RLC Electronics Inc., Mount Kisco, NY
(914) 241-1334, www.rlcelectronics.com.
RS No. 224

Voltage-controlled Oscillator

The model ZRO0743B2LF is a coaxial resonator based voltage-controlled oscillator (VCO) that operates in a frequency range from 738 to 748 MHz with a tuning voltage range of 0 to 6 VDC. This VCO features an excellent typical phase noise of -131 dBc/Hz at 10 kHz offset and a typical tuning sensitivity of 2 MHz/V. The ZRO0743B2LF is designed to deliver a typical output power of 9 dBm at 8 VDC supply while drawing 23 mA (typical) over the temperature range of -40° to 85°C. The ZRO0743B2LF has a typical phase noise value of -104 dBc/Hz at 1 kHz offset and -151 dBc/Hz at 100 kHz offset. This VCO features typical second harmonic suppression of -20 dBc and comes in Z-COMM's newly developed

ArtechHouse.com

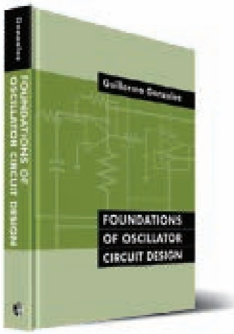
Your Complete Source for RF & Microwave Design Know-How



New!
VLSI Circuits for Biomedical Applications
Krzysztof Iniewski, *Editor*

Written by top-notch international experts in industry and academia, this groundbreaking resource presents a comprehensive, state-of-the-art overview of VLSI circuit design for a wide range of applications in biology and medicine. Supported with over 280 illustrations and over 160 equations, the book offers cutting-edge guidance on designing integrated circuits for wireless biosensing, body implants, biosensing interfaces, and molecular biology.

• Hardcover • 430 pp. • 2008 • ISBN: 978-1-59693-317-0
• Order Book No. MW083178 • $139 £75



Bestseller
Foundations of Oscillator Circuit Design
Guillermo Gonzalez

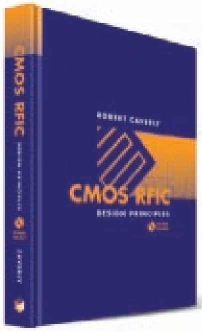
Offering broader coverage than other oscillator design books on the market, this comprehensive resource considers the complete frequency range, from low-frequency audio oscillators to more complex oscillators found at the RF and microwave frequencies. Packed with over 1,200 equations, the book gives you a thorough understanding of the principles and practice of oscillator circuit design and emphasizes the use of time-saving CAD simulation techniques.

• Hardcover • 500 pp. • 2007 • ISBN: 1-59693-162-0
• Order Book No. MW081628 • $139 £84

Designing Bipolar Transistor Radio Frequency Integrated Circuits
Allen A. Sweet

If you're looking for an in-depth and up-to-date understanding bipolar transistor RFIC design, this practical resource is a smart choice. Unlike most books on the market that focus on GaAs MESFET or silicon CMOS process technology, this unique volume is dedicated exclusively to RFIC designs based on bipolar technology. Until now, critical GaAs HBT and SiGe HBT process technologies have been largely neglected in reference books. Finally, this book offers a detailed treatment of this increasingly important topic.

• Hardcover • 334 pp. • 2008 • ISBN: 978-1-59693-128-2
• Order Book No. MW071288 • $119/£66



CMOS RFIC Design Principles
Robert Caverly

Turn to this practical resource for comprehensive, expert guidance on designing CMOS RF integrated circuits. You get complete design details on elemental and advanced CMOS RF circuits, from low noise amplifiers, general gain amplifiers, mixers, and oscillators, to voltage controlled oscillators, phase lock loops, frequency synthesizers, and power amplifier architectures. The book discusses ideal circuit topologies and then looks at non-ideal CMOS circuit elements to provide insight into circuit modifications needed to achieve design specifications.

• Hardcover • 456 pp. • 2007 • ISBN: 978-1-59693-132-9
• Order Book No. MW081328 • $129 £72

Find complete book descriptions and order at the Artech House Online Bookstore www.artechhouse.com

• Special discounts on forthcoming titles • Secure ordering with email confirmation • "Special Offers" page with great ways to save
• Sample chapters and demonstration software • Ability to check status of your order • In-stock orders ship within 24 hours

Order at www.artechhouse.com or contact the office nearest you: **US** **FAX** Purchase orders and credit card orders to 1-781-769-6334 **PHONE** Toll-Free 1-800-225-9977, ext. 4030 or 1-781-769-9750 **E-MAIL** artech@artechhouse.com **UK** **FAX** Purchase orders and credit card orders 24 hours a day to +44 (0)20 7630-0166 **PHONE** +44 (0)20 7596-8750 **E-MAIL** artech-uk@artechhouse.com **All orders plus shipping/handling and applicable taxes.**

Also available from major online retailers and at fine bookstores where professional-level high-tech books are sold.

ARTECH HOUSE BOSTON | LONDON

685 Canton Street, Norwood, MA 02062 USA
46 Gillingham Street, London, SW1V 1AH, UK

Visit http://mwj.hotims.com/16346-18 or use RS# 18 at www.mwjournal.com/info

ZMX-14-SM package, measuring 0.75" x 0.75" x 0.22". Delivery: stock to six weeks.
Z-Communications Inc., San Diego, CA (858) 621-2700, www.zcomm.com.
RS No. 226

Amplifier

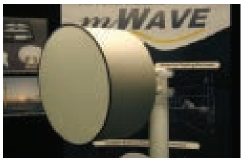
Low Noise Amplifiers

The model ZX60-0916LN+ is an ultra-low noise amplifier that boasts a noise figure of only 0.55 dB, while delivering 18 dB gain and a high output power of up to 16.5 dBm. Ultra reliable and packaged in a rugged patented unibody housing, using SMA connectors, these amplifiers provide for a broad range of applications from 824 to 960 MHz, including: CDMA: 824 to 894 MHz, GSM Rx: 880 to 915 MHz and GSM Tx: 925 to 960 MHz. Price: $39.95 (1-9). Delivery: available from stock.
Mini-Circuits, Brooklyn, NY (718) 934-4500, www.minicircuits.com.
RS No. 227

Antenna

WLAN Antenna

The model HRP2-54-N antenna is a 2' (0.6 m) diameter high performance single linear polarized design and operates in the 4.94 to 4.99 GHz public safety band and the unlicensed frequency bands of 5.25 to 5.85 GHz. Antenna gain is 26.7 to 28.5 dBi. HPBW's are 7.0 to 6.2 degrees. VSWR is 1.5 maximum. F/B is 43 dB or better. RF input is type N female. The antenna offers manual polarization adjustment for vertical and horizontal polarization settings. The antenna incorporates a sturdy aluminum parabolic main reflector and aluminum shroud with a UV stabilized planar radome.



mWAVE Industries LLC, Windham, ME (207) 892-0011, www.mwavellc.com.
RS No. 229

Passive Components

In-phase Splitter

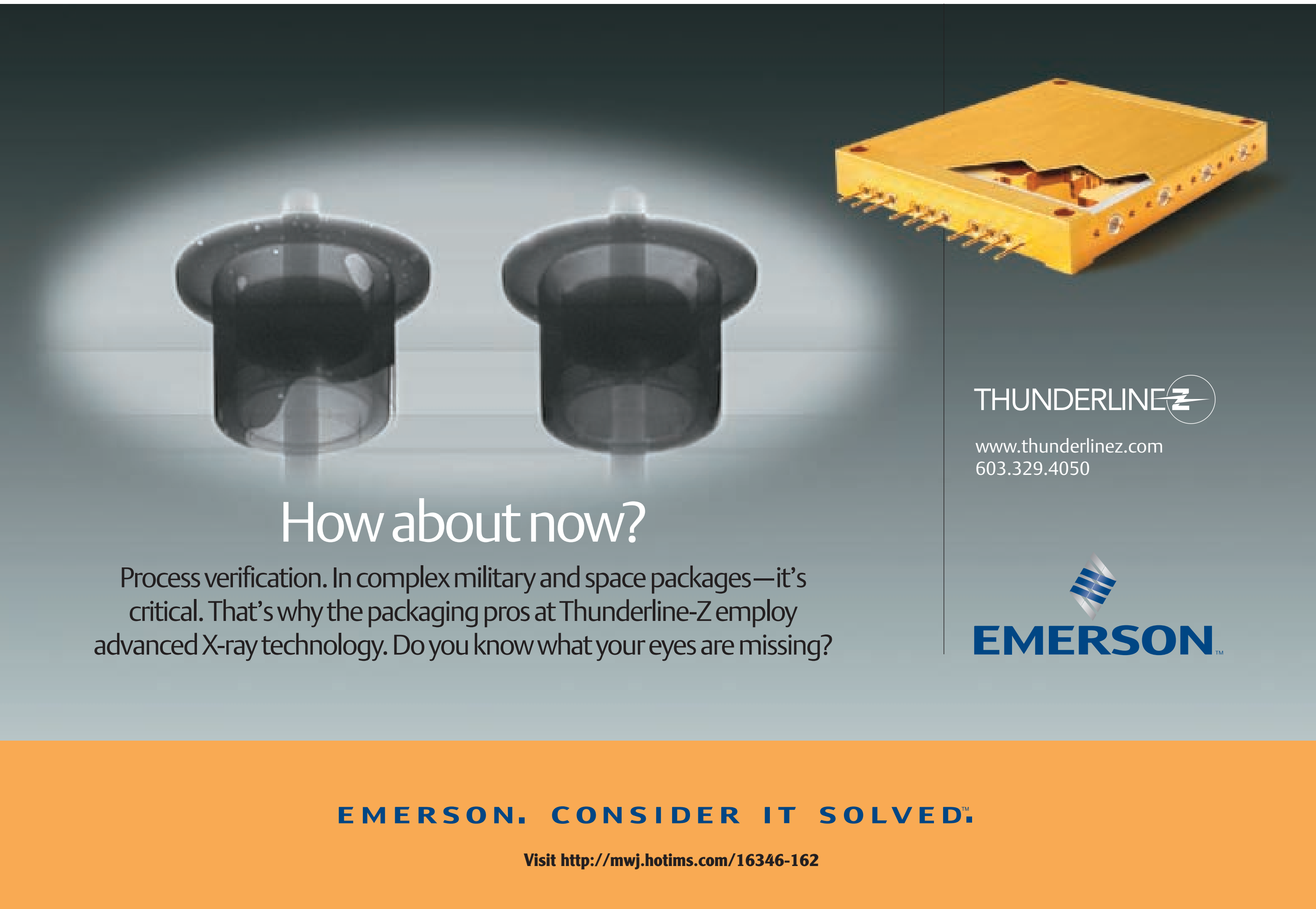
The model SPD-90-210 is an L-band, four-way in-phase splitter for SATCOM applications. This low loss splitter spans the frequency band of 900 to 2100 MHz while maintaining tight phase and amplitude tracking, typically within 3 degrees and 0.2 dB of signal unbalances respectively within specified frequency band. This product replaces stripline splitters and saves critical board space when splitting local oscillator signals and when used as receiver antenna combiners. Size: 0.8" x 0.4" x 0.2". Prices start at $20.00 for low quantities, with deliveries ranging from stock to six weeks.
Synergy Microwave Corp., Paterson, NJ (973) 881-8800, www.synergymwave.com.
RS No. 225

Phase Invariant Attenuator

The model APD3-0080G-0180G-111A is an 8 to 18 GHz phase invariant digital programmable attenuator. A double-balanced arrangement of quadrature couplers and PIN diodes gives phase invariant attenuation. It has an attenuation range of 32 dB, insertion loss of < 5.5 dB and VSWR of 2.0. This model offers attenuation accuracy of ±0.5 dB, flatness of ±0.8 dB from 0 to 20 dB and ±1.0 dB from 20 to 32 dB. Switching speed is < 350 ns. Size: 2.5" × 2" × 0.5".
American Microwave Corp., Frederick, MD (301) 662-4702, www.americanmicrowavecorp.com.
RS No. 230

Low Pass Filters

Designed for reduction and removal of unwanted spurious signals, harmonics and sidebands, the AFL Series of coaxial low pass filters provides microwave design engineers and technicians with an 'off-the-shelf' solution to



Visit http://mwj.hotims.com/16346-162

GaN Power Amplifiers GA Series

Low Cost GaN FET Amplifiers

Need Power Amp? Ask R&K!

Model Number	Frequency (GHz)	Power
GA0538-4540-M	0.5~3.8	10W(min)
GA0538-4540-R	0.5~3.8	10W(min)
GA0830-4344-M	0.8~3.0	25W(min)
GA0830-4344-R	0.8~3.0	25W(min)
GA0830-4747-M	0.8~3.0	50W(min)
GA0830-4747-R	0.8~3.0	50W(min)
GA0827-4552-M	0.8~2.7	150W(min)
GA0827-4552-R	0.8~2.7	150W(min)
GA0827-4754-R	0.8~2.7	250W(min)
CON0827-150W-R	0.8~2.7	150W Peak

* Suffix "-M" is Module type, "-R" is Rack type.

R&K Company Limited
info@rkco.jp
http://www.rk-microwave.com
Country in Origin

SEKI TECHNOTRON USA
A subsidiary of SEKI TECHNOTRON CORP.
sfumo@sekitech.com
http://www.sekitechusa.com
US Sales Partner

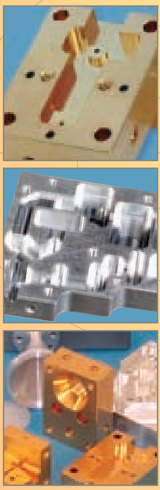
Visit http://mwj.hotims.com/16346-121

Microtool, INC.

913-492-1588

www.microtoolinc.com

Specializing in precision machining for the millimeter wave industry.



- Aluminum
- Brass
- Copper
- Plastic
- Rexolite
- Stainless Steels

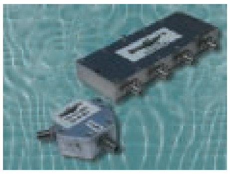
ISO 9001 PLATING:
– highly qualified services available –
Chromate • Gold • Nickel • Silver

many spectral purity problems. These suspended substrate filters, which are available with standard cut-off frequencies from 1 to 18 GHz, can be quickly installed in communications equipment according to operating needs and as 'select-on-test' components prior to commissioning. The quasi-elliptical function provides typical insertion loss in the passband of 1.2 dB with stopband attenuation in excess of 50 dB and power handling of 15 W CW.

AtlanTecRF, Braintree, UK
+44 1376 550220, www.atlantecrf.com.
RS No. 231

WiFi/WiMAX Power Dividers

The model 151-173-002 is a two-way, 50 Ω, DC to 6 GHz, 1 W unit with SMA female connectors. Insertion loss is ±0.5 dB maximum DC to 4 GHz and ±0.8 dB maximum 4 to 6 GHz with maximum VSWR 1.50. Model 151-231-004 is a four-way, 50 Ω, DC to 6 GHz, 5 W unit with SMA female connectors. Insertion loss is ±1.0 dB nominal with maximum VSWR 1.50. These devices are ideal for dividing signals for in-building wireless, WiFi, WiMAX and Homeland Security/Public Safety systems.



BroadWave Technologies Inc., Franklin, IN
(317) 346-6101, www.broadwavetech.com.
RS No. 232

High Power Band Reject Filter

The model WSN-00198 is a high power band reject filter positioned at the output of a VHF-UHF amplifier. The filter attenuates an undesired harmonic by 60 dB, while maintaining low loss passbands utilizing special features to extend the upper passband to 500 MHz.

K&L Microwave, Salisbury, MD
(410) 749-2424, www.klmicrowave.com.
RS No. 233

PCS High Power Cavity Duplexer

The model WP-D00001 is a duplexer that covers the full Personal Communication System (PCS) frequencies. This duplexer exhibits less than 0.8 dB of insertion loss across the passbands of 1850 to 1910 MHz and 1930 to 1990 MHz while providing greater than 60 dB of rejection. The unit will handle 500 W average power and 10 kW peak power. This unit is designed for mounting on a 3U – 19" rack with a depth of 6.00" and is available from stock.

Lorch Commercial and Wireless,
Salisbury, MD (410) 860-5100,
www.lorch.com.
RS No. 234

High Power Directional Coupler

The model C50-109-481/1N is a high power directional coupler that operates in a frequency range from 1 to 100 MHz with an insertion loss of 0.2 dB, coupling of 50±1 dB and directivity of 20 dB. The coupling is flat within ±1.0 dB across the band and the VSWR is 1.20. Maximum input power is 500 W. Outline dimensions are 3" × 4" × 1.5" and connectors are type N female.

Pulsar Microwave Corp., Clifton, NJ
(973) 779-6262, www.pulsarmicrowave.com.
RS No. 235

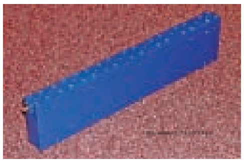
RF Coaxial Relay

This newly configured inline five-port 2P2T coaxial relay offers the flexibility of independently operating each of the two sets of switching contacts. The center RF connector port is common to the adjacent output connectors and allows signal path for backup or redundancy mode configuration. Available in 12 and 24 V failsafe with excellent RF performance and power handling capabilities from DC to 18 GHz. Relay measures 2.25" x 0.52" x 1.75". Options include aux contacts, suppression diodes, DC header and logic.

RelComm Technologies Inc.,
Salisbury, MD (410) 749-4488,
www.relcommtech.com.
RS No. 236

Dual Notch Filter

This narrowband dual notch filter attenuates both L1 and L2 GPS frequencies. It is the perfect unit for applications that need to eliminate both of these GPS bands simultaneously, yet can only tolerate a two-port device. A high power option is available. The company manufactures many different varieties of GPS filters; please contact Reactel with your specific need.



Reactel Inc., Gaithersburg, MD
(301) 519-3660, www.reactel.com.
RS No. 237

6 GHz Fixed Attenuators

This XFP-6 series of 2 W fixed attenuators operates in a frequency range from DC to 6 GHz, with attenuation values from 1 to 40 dB. VSWR is excellent and specified at 1.25 and the attenuation accuracy is typically ±0.5 dB depending on the dB value. The body and SMA connectors are passivated stainless steel. This series is an ideal solution for test fixtures and signal

Visit http://mwj.hotims.com/16346-84

leveling applications in UMTS and WiMAX test environments.
Trilithic Inc., Indianapolis, IN (317) 895-3600, www.trilithic.com.
RS No. 238

30 dB Dual Directional Coupler

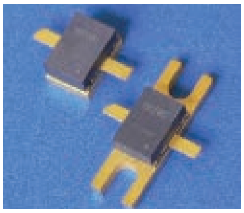
The model C3063 is a 30 dB dual directional coupler designed for high power, HF applications. This coupler is rated at 3000 W CW and exhibits exceptional flatness across its entire 0.5 to 32 MHz operating band. Specifications include 0.1 dB insertion loss, 1.05 VSWR, 25 dB directivity and ±0.25 dB coupling flatness. Size: 6.46" x 2.52" x 1.2".

Werlatone Inc., Brewster, NY (845) 279-6187, www.werlatone.com.
RS No. 239

Semiconductors/ICs

Thermally-enhanced GaN 30 W Devices

Models RT233, RT240 and RT243 are thermally-enhanced gallium nitride devices that offer 36, 43 and 45 dBm measured Psat output power each, from DC to 6 GHz applications. Patent-pending thermally-enhanced technology has been used to improve high temperature reliability and provide added power when used at pulsed applications or Class A amplification. The RT233, RT240 and RT243 transistors are packaged in a thermally-enhanced package, and are available with standard (RT233C, RT240C and RT243C: C-series), or earless type (RT233N, RT240N and RT243N: N-series) designs. Wideband capable characteristics can give 50 to 2500 MHz wideband applications and other design opportunities.



RFHIC Corp., Suwon, Korea 82-31-250-5011, www.rfhic.com.
RS No. 240

Software

IC Package Tool

The VeloceWired™ is a powerful IC package tool that accelerates bondwire design and simulation and enables optimization of high-speed leadframe packages and co-design with analog and mixed-signal ICs. With this tool the bondwire design becomes an integral part of the IC tool flow. It features an efficient and flexible bondwire editor that operates seamlessly in Cadence Virtuoso®. Bondwires are created in 2-D through a simple point-and-click procedure, while their 3-D properties can be edited on-the-fly. Die-to-die and stacked-die configurations are supported.
Helic, Athens, Greece +30 210 9949390, www.helic.com.
RS No. 241

Test Equipment

RF Conducted Immunity Test System

AR RF/Microwave Instrumentation has introduced a new RF conducted immunity test system to test to MIL-STD 461D & E CS114, DO160D & E, EN/IEC 61000-4-6, IEC 60601-1-2, EN 50130-4, EN 61000-6-1/2 and EN 55024 standards. Model CI00400 (10 kHz to 400 MHz) is a fully self-contained unit and includes a signal generator, power meter, 100 W AR amplifier, directional coupler and control software.
AR RF/Microwave Instrumentation, Souderton, PA (215) 723-8181, www.ar-worldwide.com.
RS No. 244

56 Gb/s Multiplexer and Demultiplexer

The 56 Gb/s 4:1 multiplexer and 56 Gb/s 1:4 demultiplexer is designed to meet current high-speed market needs. The MS4S1V2M is a SiGe 4-to-1 multiplexer designed for use in telecom applications up to 56 Gb/s. The module accepts input data rates from 0.5 to 14 Gb/s with an input sensitivity better than 100 mV. The broad bandwidth of the input allows operation from 2 to 56 Gb/s. The MD1S4V2M is a SiGe 1-to-4 demultiplexer designed for use in 100G applications operating at transmission speeds within the demultiplexer's 2 to 56 Gb/s input rate. The demux has a very broad input rate, and can be used for a wide range of applications from 2 to 56 Gb/s.
Centellax Inc., Santa Rosa, CA (866) 522-6888, www.centellax.com.
RS No. 250

Pre-matching Tuners

The MT902A series of pre-matching tuners operate in a frequency range from 8 to 50 GHz and are highly stable, low loss wafer probe mounts used in on-wafer device characterization applications. By extending a wafer probe away from the tuner body, these mounts create additional clearance for proper probe alignment. The ultra high stability inherent in their design eliminates the possibility of undesired movement during operation.

Maury Microwave Corp., Ontario, CA (909) 987-4715, www.maurymw.com.
RS No. 245

Microwave Signal Generator Upgrades

The capabilities of the R&S SMF100A microwave signal generator has been expanded with two new options. The R&S SMF-K27 option allows users to configure pulse trains for radar specific devel-

RF Power Amplifiers ALM Series

Low Cost GaAs FET Amplifiers

Need Power Amp? Ask R&K!

Model Number (Module Type)	Frequency (MHz)	Power
ALM000110-2840FM-SMA(F)	1 ~ 1000	10W(min)
ALM00110-2840FM-SMA(F)	10 ~ 1000	10W(min)
ALM1015-2840FM-SMA(F)	1000 ~ 1500	10W(min)
ALM1520-2840FM-SMA(F)	1500 ~ 2000	10W(min)
ALM1922-2840FM-SMA(F)	1900 ~ 2200	15W(min)
ALM00505-4546-SMA	50 ~ 500	40W(min)
ALM0105-4748-SMA	100 ~ 500	60W(min)
ALM0510-3846-SMA	500 ~ 1000	25W(min)
ALM2527-4547-SMA	2500 ~ 2700	50W(min)

* A bench top type is also available that features 100-240V AC.

R&K Company Limited
info@rkco.jp
http://www.rk-microwave.com
Country in Origin
SEKI TECHNOTRON USA
A subsidiary of SEKI TECHNOTRON CORP.
sfumo@sekitech.com
http://www.sekitechusa.com
US Sales Partner

Visit http://mwj.hotims.com/16346-122

Variable Attenuators

Solid-state Variable Attenuators from 10Mhz to 19Ghz. Current Controlled, Linearized Voltage Controlled, or Linearized Digital Controlled.

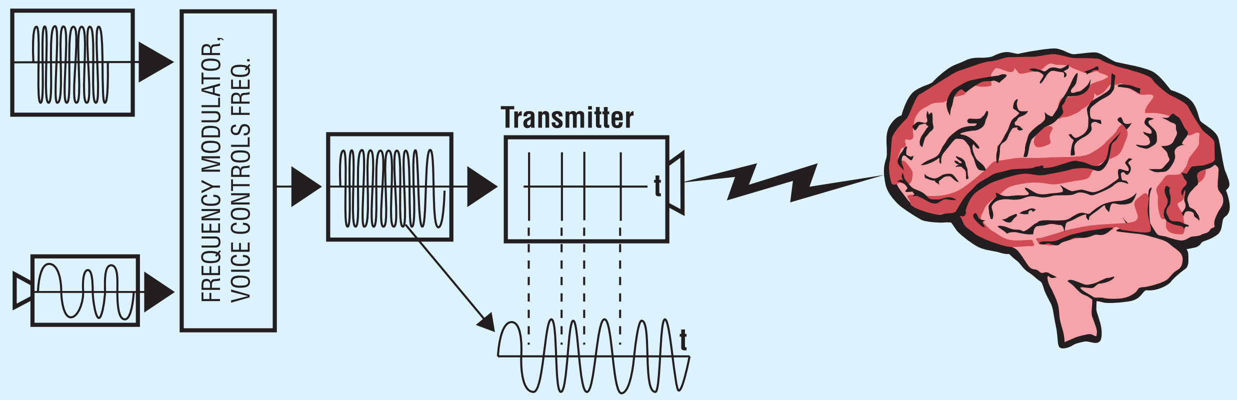
Product Line:
- Solid State Variable Attenuators
- Solid State Switches
- Directional Couplers
- Hybrid Couplers (90°/180°)
- Power Dividers / Combiners
- DC-Blocks & Bias Tee's

Universal Microwave Components Corporation
5702-D General Washington Drive
Alexandria, Virginia 22312
Tel: (703) 642-6332, Fax: (703) 642-2568
Email: umcc @ umcc111.com
www.umcc111.com

Visit http://mwj.hotims.com/16346-169

Fill your brain with Microwave Information

fig. #1



The Microwave Journal/Besser Associates Free 2008 Webinar Series

Microwave Journal teams with Besser Associates, the leader in RF/microwave training, in this series of on-line courses in RF/microwave principles for working professionals. Each hour-long installment is presented by an instructor from Besser Associate and includes a Q&A session.

Register at www.mwjournal.com/rftraining

Upcoming Webinars

October 21st – MMIC Design

November 20th – EMC Shielding

December 16th – Balanced Amplifiers

Previous Sponsors:

Analog Devices
AWR Corp.
CST
DLI
Endwave
Mimix Broadband
K&L Microwave
Pole/Zero
Rogers Corporation
Tyco Electronics
Tektronix

Microwave Journal

Sponsorship opportunities available.
Contact webinars@mwjournal.com for details.

Besser Associates
The Worldwide Leader in RF & Wireless Training

opments and tests, while the R&S SMF-K28 option makes the R&S SMF100A the first signal generator to handle power analysis. The R&S SMF-K27 option allows users to generate pulse trains with very short rise and fall times. It makes use of the full dynamic range and speed of the pulse generator and modulator that can be integrated as options into the R&S SMF100A. The R&S SMF-K28 option offers the alternative of performing power analyses such as compression point measurements using an R&S SMF100A microwave signal generator. The results can be read, stored and also displayed as a diagram.

Rohde & Schwarz GmbH & Co. KG, Munich, Germany +49 89 4129-13779, www.rohde-schwarz.com.

RS No. 247

Transmission-line Component

Coaxial Terminations

These coaxial terminations operate in a frequency range from DC to 18 GHz with power handling of up to 10 W. These components have been over-produced by the company's production department and are ready for immediate delivery at greatly discounted prices. If your termination needs are not covered by these specifications, please contact a MCLI sales representative to learn about the company's complete product line.

Microwave Communications Laboratories Inc. (MCLI), Saint Petersburg, FL (727) 344-6254, www.mcli.com.

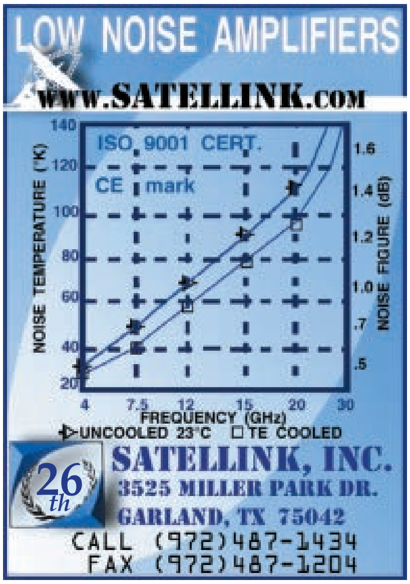
RS No. 248

RS 2

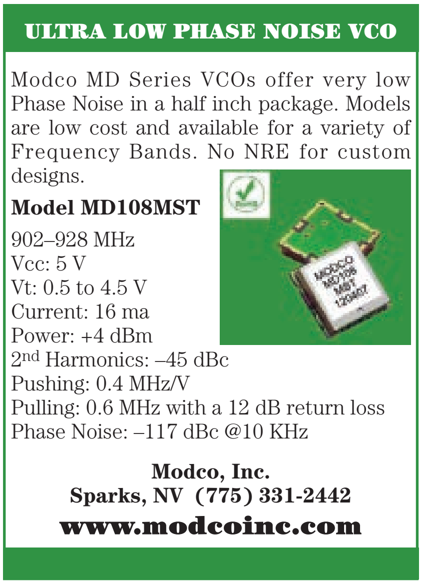
RS 69

RS 129

RS 36

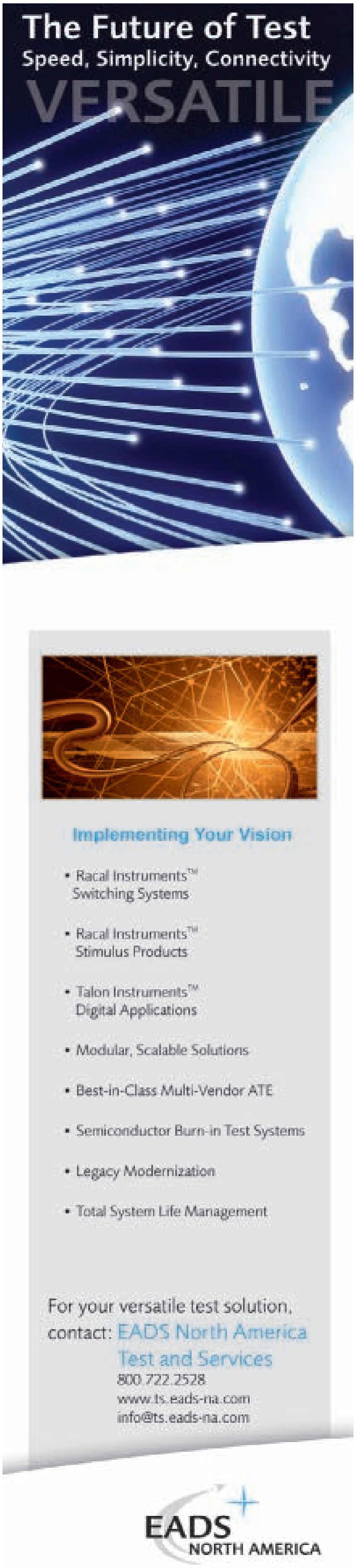


RS 144



RS 106

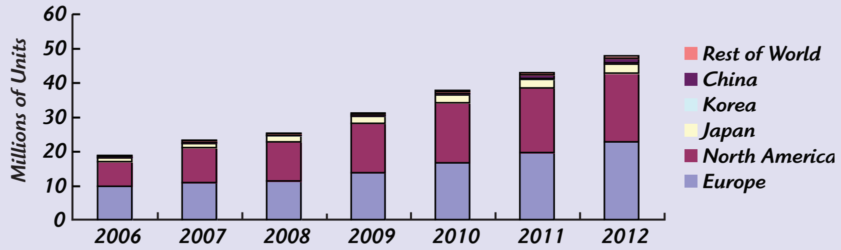
RS 145



MANDATES RESHAPE MARKET FOR AUTOMOTIVE ELECTRONIC STABILITY CONTROL SYSTEMS

Driven by new government mandates, global market revenue for Microelectromechanical System (MEMS) sensors used for automotive Electronic Stability Control (ESC) is set to nearly double from 2006 to 2012, according to iSuppli Corp. Worldwide revenue for MEMS ESC sensors will rise to $715 M in 2012, up from $378 M in 2006. Global shipments of complete ESC systems are expected to rise to 47.7 million units in 2012, up from 23.1 million in 2007.

Shipments of ESC Systems by Global Region 2006-2012 (Millions of Units)

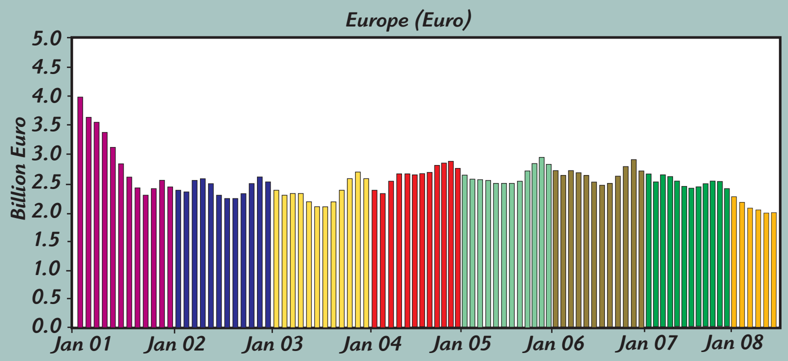


Source: iSuppli Corp., 1700 East Walnut Avenue, Suite 600, El Segundo, CA 90245

EUROPEAN SEMICONDUCTOR MARKET

Worldwide sales of semiconductors of $21.6 B in June were 8% higher than the $20.0 B reported for June 2007, the World Semiconductor Trade Statistics (WSTS) reports. A flat growth rate can be observed if June sales are compared with the $21.5 B reported for May 2008. Year-to-date (YTD) sales of $127.5 B are 5.4% higher than in the first half of the year 2007 when sales were $121 B.

On the basis of the same comparison, the figures also show that the performance of the European semiconductor market followed a similar positive trend to the world market with a growth rate of 5.1%. Looking at product categories, strong growth was observed for Optoelectronics (31.7%) mainly for industrial, automotive and mobile phones applications, Micro Processing Unit (MPU) (13.2%) for PCs and notebooks but also special purpose ICs for industrial (28.5%), communication (15%) and automotive (9.9%) applications. More in detail, European semiconductor sales in June 2008 amounted to $3.369 B according to WSTS, up 1.2% versus the previous month. This corresponds to an increase of 5.1% compared to the same month last year. On a YTD basis semiconductor sales increased by 1.9% versus the same period in the year 2007.



Monthly European Semiconductor Sales in Billion Euro (3-month-average Data)

Source: European Electronic Component Manufacturers Association, Diamant Building-Bd. A. Reyers 80, B1030 Brussels, Belgium (www.eeca.org)

Gallium Nitride, 2 to 6 GHz Amplifier Range

- Easily extends current 2 GHz capability
- Minimum linear power levels of 30W, 50W and 100W available
- Designed with 21st century transistor technology
- Ease of power upgrade within the range

Continuing amplifier innovation From MILMEGA

Designed to bring the intrinsic benefits of Gallium Nitride transistor technology to the lab environment while extending current lab capability with the minimum of fuss. The new range of innovative microwave amplifiers from MILMEGA delivers exceptional reliability, embedded intelligence and portability in a 21st century response to the challenge of microwave power provision.

With the flexibility and ease of use that you would expect from a MILMEGA product, the new 2 to 6 GHz range further enhances our reputation for going the extra mile to deliver what customers want, with the quality and reliability competitors aspire to.

Find out more at www.milmega.co.uk/AS0206

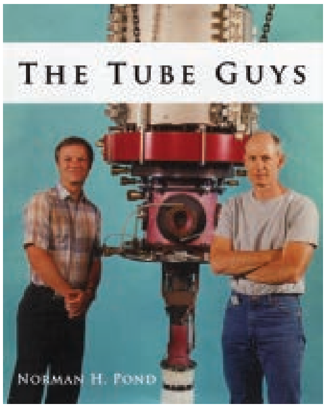
Designers and Manufacturers of High Power Microwave and RF Amplifiers

MILMEGA

MILMEGA Limited Ryde Business Park, Nicholson Road, Ryde, Isle of Wight, PO33 1BQ United Kingdom
Tel. +44 (0) 1983 618004 Fax. +44 (0) 1983 811521 sales@milmega.co.uk www.milmega.co.uk

Visit http://mwj.hotims.com/16346-89 or use RS# 89 at www.mwjournal.com/info

The Tube Guys

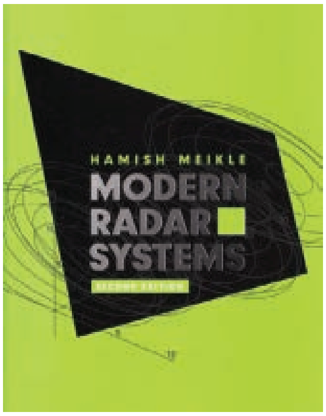


Norman H. Pond
447 pages; $29.95 • Russ Cochran, Publisher
ISBN: 978-0-9816923-0-2

To order this book, contact:
Russ Cochran, Publisher
4 Court Square
West Plains, MI 65775
www.russcochran.com

Microwave tubes, a largely unrecognized technology invented at the onset of World War II, have changed the world. Magnetrons and klystrons made radar practical, giving the Allies great advantages in detecting and targeting enemy aircraft. Over the past 70 years, a small group of dedicated people have made continued improvements to this technology and the resulting products affect many aspects of our lives. The purpose of the book is to record its remarkable story and to answer the questions: How did the inventions occur? Who did it? Who were these guys? How did businesses develop? Why did some companies fall by the way side while others flourished? And finally, what does the future hold for this technology? The first chapter traces the roots of the tube industry to Edison light bulb and the first attempts to develop a radio tube by Fleming in the UK and de Forest in the US. The next four chapters are dedicated to the invention and development of magnetrons and klystrons, which were of such importance during World War II. Then, the inventions of other tubes, such as the travelling tube, the backward wave tube, the Ubitron and Gyrotron are described in four chapters. Two chapters describe the state of the tube industry from the end of World War II to 2007. Non-military uses of microwave tubes, such as linear accelerator, broadband communications and microwave ovens are covered in three chapters. The next 26 chapters consider the formation and consolidation of microwave tube companies and the history of 25 different companies, many of which are no longer operating or have been merged with others. In three chapters, the microwave tube activity in Japan, the former USSR and Germany is described. The final chapter considers the future of microwave tube and the concurrence offered by solid-state technology.

Modern Radar Systems: Second Edition



Hamish Meikle
712 pages; $159, £88 • Artech House
ISBN: 978-1-59693-242-5

To order this book, contact:
Artech House
685 Canton St.
Norwood, MA 02062
(781) 769-9750 ext. 4030; or
46 Gillingham St.
London SW1V 1HH, UK
+44 (0) 207-8750

The second edition of *Modern Radar Systems* is an extensively revised and expanded version of the successful first edition, published in 2001. Chapter 1 presents the fundamentals of radar, including both primary and secondary radar. Chapter 2 introduces the fundamental methods of vector presentation, modulation polyphase signals and noise, and the probability distributions that are used to represent them. The discussion of radar subsystems starts with Chapter 3 on transmitters, where new material has been included on solid-state devices. Chapter 4 on waveguides and transmission lines now includes material on stripline technology and the description of the many types of microwave components has been updated. An expanded Chapter 5 describes antennas, including a discussion and plots of low-sidelobe monopulse patterns. Chapter 6 covers factors outside the radar: propagation, scattering and clutter. Continuing with radar subsystems, Chapter 7 is dedicated to the receiver, followed by Chapter 8 on matched and matching filters. Chapter 9 covers detectors and Chapter 10 discusses analog to digital conversion. Here, material on the techniques of conversion at intermediate frequency has been added. Signal processing is the subject of Chapter 11. New material includes detailed mathematics of the log-FTC circuit response to clutter and on the operation of range-cell-averaging constant-false-alarm-rate (CFAR) processing. Threshold and detection issues are discussed in Chapter 12, with plots and graphs covering the steady target and the four Swerling models. Chapter 13 covers the determination of position, with equations for the errors for different measuring procedures. A section on the display of position has been added. Chapter 14 discusses radar performance, including the range equation, accuracy, resolution, stability considerations and operation in jamming.

TWT Broadband Power Amplifiers

Ideal For: Radar, EW & EMI/EMC Testing

2.5 – 7.5 GHz 500W
2.0 – 8.0 GHz 370W
6.0 – 18.0 GHz 250W
7.5 – 18.0 GHz 250W
18.0 – 26.5 GHz 45W
26.5 – 40.0 GHz 35W
18.0 – 40.0 GHz 45W

Features Include:

- Compact Size
- Forced Air Cooling
- Quiet Operation
- Extensive Diagnostic With Ethernet Interface
- Advanced Thermal Design

Indoor & Outdoor Applications

For additional information, please contact:
MCL Sales Department at (630) 759-9500 or sales@mcl.com
MITEQ's Component Sales Department at (631) 439-9220 or components@miteq.com

MITEQ

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

MCL INC — A MITEQ COMPANY

501 South Woodcreek Drive
Bolingbrook, IL 60440-4999
TEL.: (630) 759-9500 • FAX: (630) 759-5018
www.mcl.com

Visit http://mwj.hotims.com/16346-105 or use RS# 105 at www.mwjournal.com/info

LORCH MICROWAVE

RF/Microwave Design Engineer

This individual will be responsible for design and test of integrated assemblies and switched filter banks. The applicant should be familiar with filters, amplifiers, switches and other RF components. A working knowledge of filter design is a plus but not required.

Responsibilities will include reviewing and evaluating customer requirements, working with sales in acquiring new business, product design and "hands on" activity to support production engineering and manufacturing.

An EE degree and/or a strong background in RF and microwave products is necessary.

Lorch Microwave offers a peak salary with proven experience and a complete benefits package, which includes medical, dental, prescription drug plan, company paid life insurance, 401K plan with matching contribution, and 100% paid tuition assistance. Many benefits start on first day of employment.

Lorch Microwave is an Equal Opportunity-Affirmative Action Employer M/F/D/V., and offers a drug free working environment.

Interested applicants should apply online at www.lorch.com, or apply in person at:

Lorch Microwave, Inc.
1725 N. Salisbury Blvd.
Salisbury, MD 21801

Career Corner

Branding for RF Engineering Talent

In times when the vacant positions compete on limited RF engineering resources, preparation can help. In here I present the term Branding in the Job Market context as the logical preparation to projected recruiting needs. The more recognized a company is among its technology niche, the more likely it is to gain attention to its recruiting efforts. Branding works here the same way it works in the sales & marketing arena.

RF engineering talent and knowhow (among few other analog fields) is a scarce commodity these days. It is also hard to estimate the cost of an understaffed project. In today's conditions the marketing task imposed on employers and recruiters "selling" their RF engineering positions is not simple. Unlike some other engineering fields, RF engineering projects are typically not tolerant to "on-the-job-training". RF engineering skills are built over many years of hands-on experience. On the other hand, some skill-sets are very hard to come by, and the wait time for the ideal candidate can extend to months and more.

Branding is a way for a company to build recognition among potential customers. Similarly, promoting a company for its technologically challenging career opportunities (in addition to the generic employment appeal factors), increases the attention that later recruiting efforts by that company will receive (e.g. online job postings). Perceived image improves the rate of response to later ads for specific positions. It also encourages RF engineers to make inquiries unrelated to a specific vacancy, serving to build up a database for future use.

People make their career moves for a variety of reasons and the decision process is typically long (months and years). Building recognition in the industry as a viable career alternative, the recruiter captures the attention of those in the midst of that decision process – occasionally before they start their job search. It is a known fact that many of the top-notch engineers never reach the public job market when switching between jobs.

Moreover, this type of promotion in the RF and microwave engineering media reaches customers' engineers and decision makers as well, and hence contributes to the company's sales & marketing efforts.

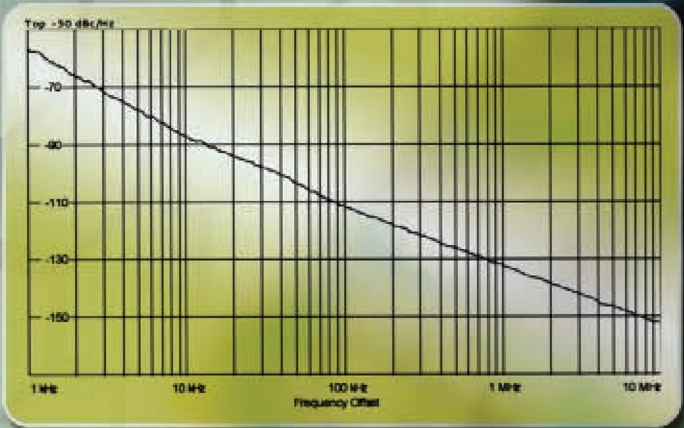
Conclusions: The core industry media channels can be used to highlight and promote a company for its career offerings, reach both engineers and customers. Branding a company as a desired career option in the RF engineering community prepares the cognitive grounds complementing and supporting efforts filling specific RF engineering positions.

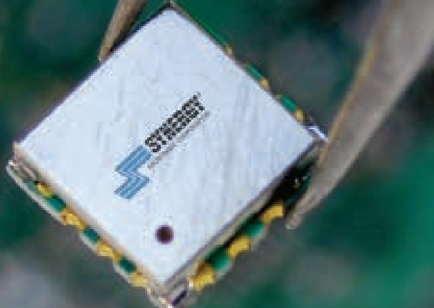
Isaac Mendelson
ElectroMagneticCareers.com
Isaac@ElectroMagneticCareers.com

MINIATURE C-BAND & X-BAND VCO'S

SYNERGY® MICROWAVE CORPORATION

DCO & DXO Features
- Exceptional Phase Noise
- Miniature Footprint: 0.3" x 0.3" x 0.1"
- Excellent Tuning Linearity
- Models Available from 4 to 11 GHz
- Optimized Bandwith (Approx. 1 GHz)
- High Immunity To Phase Hits
- Lead Free RoHS Compliant





DCO & DXO SERIES

Model #	Frequency Range (MHz)	Tuning Voltage (V)	Supply Voltage (V)	Supply Current (mA Max.)	Phase Noise @ 10 kHz (dBc/Hz Typ.)	Operating Temp. Range (°C)	Size (Inch)
DCO Series							
DCO490517-5 *	4900 - 5175	0.5 - 5	+5	22	-88	-40 to +85	0.3 x 0.3 x 0.1
DCO495550-5 *	4950 - 5500	0.5 - 12	+5	22	-87	-40 to +85	0.3 x 0.3 x 0.1
DCO615712-5 *	6150 - 7120	0.5 - 18	+5	22	-85	-40 to +85	0.3 x 0.3 x 0.1
DXO Series							
DXO810900-5 *	8100 - 9000	0.5 - 24	+5	25	-80	-40 to +85	0.3 x 0.3 x 0.1
DXO10351090-5 *	10350 - 10900	0.5 - 25	+5	25	-75	-40 to +85	0.3 x 0.3 x 0.1

Additional models to be released. Our applications engineering team can help you with your specific requirements.

** Preliminary Specification.*

RoHS COMPLIANT

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 http://mwj.hotims.com/16346-155 or use RS# 155 at www.mwjournal.com/info

Visit Our Website At WWW.SYNERGYMWAVE.COM

RS No.	Advertiser	Page No.	Phone	Fax	Web Address
1	Advanced Control Components Inc.	175	732-460-0212	732-460-0214	http://mwj.hotims.com/16346-1
2	Advanced Switch Technology	211	613-384-3939	613-384-5026	http://mwj.hotims.com/16346-2
3	Aeroflex	33	516-694-6700	516-694-2562	http://mwj.hotims.com/16346-3
4	Aeroflex / Inmet, Inc.	120	734-426-5553	734-426-5557	http://mwj.hotims.com/16346-4
5	Aeroflex / Metelics, Inc.	197	888-641-7364	408-733-7645	http://mwj.hotims.com/16346-5
6	Aeroflex / Weinschel, Inc.	105	800-638-2048	301-846-9116	http://mwj.hotims.com/16346-6
7	Aethercomm	107	760-598-4340	760-598-4342	http://mwj.hotims.com/16346-7
8	American Microwave Corporation	126	301-662-4700	301-662-4938	http://mwj.hotims.com/16346-8
9	American Technical Ceramics	111	631-622-4700	631-622-4748	http://mwj.hotims.com/16346-9
10	AML Communications Inc.	47	805-388-1345	805-484-2191	http://mwj.hotims.com/16346-10
11	AMTA 2008	155	425-868-2558		http://mwj.hotims.com/16346-11
12	Anaren Microwave	143	800-411-6596	315-432-9121	http://mwj.hotims.com/16346-12
13	Anritsu Company	117	800-ANRITSU	972-671-1877	http://mwj.hotims.com/16346-13
14	Ansoft Corporation	29	412-261-3200	412-471-9427	http://mwj.hotims.com/16346-14
15	Antenna Research Associates	86	301-937-8888	301-937-2796	http://mwj.hotims.com/16346-15
16	AR Worldwide	43	215-723-8181		http://mwj.hotims.com/16346-16
17,18	Artech House	154,206	800-225-9977	781-769-6334	http://mwj.hotims.com/16346-17
19	Association of Old Crows	184	703-549-1600	703-549-2589	http://mwj.hotims.com/16346-19
20	Atlantic Microwave Ltd.	112	44-1376-550220	44-1376-552145	http://mwj.hotims.com/16346-20
21	Aviel Electronics, a Division of RF Industries	154	702-739-8155	702-739-8161	http://mwj.hotims.com/16346-21
22	AWR	186	310-726-3000		http://mwj.hotims.com/16346-22
23	B&Z Technologies, LLC	31	631-444-8827	631-444-8825	http://mwj.hotims.com/16346-23
24	Barry Industries, Inc.	118	508-226-3350	508-226-3317	http://mwj.hotims.com/16346-24
25	Bird Technologies Group	84	866-695-4569		http://mwj.hotims.com/16346-25
26	Carlisle Interconnect Technologies	13	866-282-4708	562-494-0955	http://mwj.hotims.com/16346-26
27	Centellax	35	707-568-5900	707-568-7647	http://mwj.hotims.com/16346-27
28	Cernex, Inc.	18	408-541-9226	408-541-9229	http://mwj.hotims.com/16346-28
29	Ciao Wireless, Inc.	48	805-389-3224	805-389-3629	http://mwj.hotims.com/16346-29
30	Cobham Defense Electronic Systems	20-21	603-775-5200	603-775-5201	http://mwj.hotims.com/16346-30
31	CPI Beverly Microwave Division	139	978-922-6000	978-922-2736	http://mwj.hotims.com/16346-31
32	Crane Aerospace & Electronics	64	480-961-6269		http://mwj.hotims.com/16346-32
33	Crystek Corporation	113	800-237-3061		http://mwj.hotims.com/16346-33
34	CST of America, Inc.	27	508-665-4400	781-576-5702	http://mwj.hotims.com/16346-34
35	CTT Inc.	169	408-541-0596	408-541-0794	http://mwj.hotims.com/16346-35
36	Damaskos Inc.	211	610-358-0200	610-558-1019	http://mwj.hotims.com/16346-36
37	Delta Electronics Mfg. Corp.	133	978-927-1060	978-922-6430	http://mwj.hotims.com/16346-37
38	Dielectric Laboratories Inc.	141	315-655-8710	315-655-0445	http://mwj.hotims.com/16346-38
39	Dow-Key Microwave Corporation	6	805-650-0260	805-650-1734	http://mwj.hotims.com/16346-39
40	Ducommun Technologies	131	310-513-7214	310-513-7298	http://mwj.hotims.com/16346-40
156,41	EADS North America Test and Services	199,212	800-722-2528		http://mwj.hotims.com/16346-156
42	Eastern Wireless TeleComm, Inc.	165	410-749-3800	410-749-4852	http://mwj.hotims.com/16346-42
43	Elcom Technologies	136	201-767-8030	201-767-6266	http://mwj.hotims.com/16346-43
44	Electro Magnetic Careers	216			http://mwj.hotims.com/16346-44
45	EMC Technology Inc.	17	772-286-9300	772-283-5286	http://mwj.hotims.com/16346-45
46	Empower RF Systems, Inc.	171	310-412-8100	310-412-9232	http://mwj.hotims.com/16346-46
47	Endwave	25	408-522-3180	408-522-3181	http://mwj.hotims.com/16346-47
48	ESM Cable Corporation	146	209-892-3347	209-892-3348	http://mwj.hotims.com/16346-48
49	ET Industries	177	973-394-1719	973-394-1710	http://mwj.hotims.com/16346-49
50	EuMW 2008	91	+ 44 20 7596 8742	+ 44 20 7596 8749	http://mwj.hotims.com/16346-50
45	Florida RF Labs Inc.	17	800-544-5594		http://mwj.hotims.com/16346-45
51	Focus Microwaves Inc.	38	514-684-4554	514-684-8581	http://mwj.hotims.com/16346-51
52	GGB Industries, Inc.	3	239-643-4400	239-643-4403	http://mwj.hotims.com/16346-52
53	Herley New England	156	781-729-9450	781-729-9547	http://mwj.hotims.com/16346-53
54	Herotek, Inc.	102	408-941-8399	408-941-8388	http://mwj.hotims.com/16346-54
55,56,57	Hittite Microwave Corporation	67,69,71	978-250-3343	978-250-3373	http://mwj.hotims.com/16346-55
58	Huber + Suhner AG	119	+41 71 353 41 11	+41 71 353 44 44	http://mwj.hotims.com/16346-58
	IEEE MTT-S International Microwave Symposium	59			www.ims2009.org
	IEEE Radio Wireless Week 2008	123			www.radiowirelessweek.org
59	IME China 2008	191	+86-21-62477218	+86-21-62475839	http://mwj.hotims.com/16346-59
60	Instruments for Industry Inc.	163	631-467-8400	631-467-8558	http://mwj.hotims.com/16346-60
61	Integra Technologies, Inc.	82	310-606-0855	310-606-0865	http://mwj.hotims.com/16346-61
62	Integrated Engineering Software	66	204-632-5636		http://mwj.hotims.com/16346-62
63	International Manufacturing Services, Inc.	92	401-683-9700	401-683-5571	http://mwj.hotims.com/16346-63
64	Ion Beam Milling, Inc.	158	603-644-2326	603-647-6889	http://mwj.hotims.com/16346-64
65	ITT Microwave Systems	58	978-441-0200		http://mwj.hotims.com/16346-65

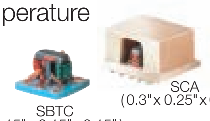
world's smallest

2 WAY & 4 WAY SPLITTERS

5 to 2500 MHz from $1.69 ea. (qty. 1000) IN STOCK

Mini-Circuits tiny SBTC 2 way-0° and SCA 4 way-0° power splitters are the ***world's lowest priced*** and smallest size splitters operating within 5 to 2500 MHz band. But that's not all. Patented LTCC technology provides outstanding performance features including low insertion loss down to 0.3 dB typical, excellent 0.2 dB amplitude and 1 degree phase unbalance (typ), and ***superior temperature*** stability. Pads are solder plated, and connections are assembly welded for high temperature reflow reliability. As demand for smaller gets bigger, blow away the competition with Mini-Circuits space saving, ***money saving*** SBTC and SCA power splitters.

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



Model	Frequency (MHz)	Z	Price $ea. (Qty. 25)
SBTC-2-10+	5-1000	50 Ω	2.49
SBTC-2-20+	200-2000	50 Ω	3.49
SBTC-2-25+	1000-2500	50 Ω	3.49
SBTC-2-10-75+	10-1000	75 Ω	3.49
SBTC-2-15-75+	500-1500	75 Ω	3.49
SBTC-2-10-5075+	50-1000	50/75 Ω	3.49
SBTC-2-10-7550+	5-1000	50/75 Ω	3.49
SCA-4-10+	5-1000	50 Ω	6.95
SCA-4-10-75+	10-1000	75 Ω	6.95
SCA-4-15-75+	10-1500	75 Ω	7.95
• SCA-4-20+	1000-2000	50 Ω	7.95

• LTCC construction

U.S. Patent No. 6,963,255

All models are RoHS compliant

Mini-Circuits®

ISO 9001 ISO 14001 CERTIFIED

ALL NEW minicircuits.com

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

YONI2™ Patent Pending ***The Design Engineers Search Engine*** *Provides ACTUAL Data Instantly From MINI-CIRCUITS At:* ***www.minicircuits.com***

IF/RF MICROWAVE COMPONENTS

354 Rev J

Visit http://mwj.hotims.com/16346-103 or use RS# 103 at www.mwjournal.com/info

Advertising Index

RS No.	Advertiser	Page No.	Phone	Fax	Web Address
66	JFW Industries, Inc.	145	317-887-1340	317-881-6790	http://mwj.hotims.com/16346-66
67	JQL Electronics Inc.	90	888-236-9828	630-823-2902	http://mwj.hotims.com/16346-67
68	K&L Microwave, Inc.	7	410-749-2424	443-260-2268	http://mwj.hotims.com/16346-68
69	KR Electronics, Inc.	211	732-636-1900	732-636-1982	http://mwj.hotims.com/16346-69
70	Labtech Microwave	166	+44 (0)1544 260093	+44 (0)1544 260310	http://mwj.hotims.com/16346-70
71	Linear Technology Corporation	15	800-454-6327		http://mwj.hotims.com/16346-71
72	Locus Microwave, Inc.	164	814-466-6275	814-466-1104	http://mwj.hotims.com/16346-72
73,74	Lorch Microwave	51,216	800-780-2169	410-860-1949	http://mwj.hotims.com/16346-73
75	M2 Global Technology, Ltd.	94	210-561-4800	210-561-4852	http://mwj.hotims.com/16346-75
76	Marki Microwave, Inc.	73	408-778-4200	408-778-4300	http://mwj.hotims.com/16346-76
77	Maury Microwave Corporation	9	909-987-4715	909-987-1112	http://mwj.hotims.com/16346-77
78	MECA Electronics, Inc.	COV 2	973-625-0661	973-625-9277	http://mwj.hotims.com/16346-78
79	MegaPhase	157	877-MegaPhase		http://mwj.hotims.com/16346-79
80	Micronetics CSE Division	93	603-883-2900	603-882-8987	http://mwj.hotims.com/16346-80
82,83	Microsemi	44,45	408-986-8031		http://mwj.hotims.com/16346-82
84	Microtool, Inc.	208	913-492-1588	913-492-1591	http://mwj.hotims.com/16346-84
81	Microwave Concepts, a division of Micronetics	95	973-244-1040	973-244-1188	http://mwj.hotims.com/16346-81
85	Microwave Development Laboratories	147	781-292-6680/6684	781-453-8629	http://mwj.hotims.com/16346-85
86	Microwave Filter Company, Inc.	106	800-448-1666	315-463-1467	http://mwj.hotims.com/16346-86
	Microwave Journal	200,210,221	800-225-9977	781-769-5037	www.mwjournal.com
87	Mid-Atlantic RF Systems, Inc.	183	410-893-2430	410-638-5193	http://mwj.hotims.com/16346-87
88	Millitech	124	413-582-9620	413-582-9622	http://mwj.hotims.com/16346-88
89	Milmega Limited	213	+44 (0) 1983 618004	+44 (0) 1983 811521	http://mwj.hotims.com/16346-89
90,91,92, 93,94,95, 96,97,98, 99,100,101, 102,103	Mini-Circuits	4-5,16,39, 55,56,65, 83,99,109, 114-115,159,173, 203,219	718-934-4500	718-332-4661	http://mwj.hotims.com/16346-90
104,105	MITEQ Inc.	60-61,215	631-436-7400	631-436-7430	http://mwj.hotims.com/16346-104
106	Modco, Inc.	211	775-331-2442	775-331-6266	http://mwj.hotims.com/16346-106
107	MTI Wireless Edge	176	+972-3-9025050	+972-3-9025051	http://mwj.hotims.com/16346-107
108	Narda Microwave-East, an L3 Communications Co.	8	631-231-1700	631-231-1711	http://mwj.hotims.com/16346-108
109	Narda Microwave-West, an L3 Communications Co.	97	916-351-4500	916-351-4550	http://mwj.hotims.com/16346-109
110	National Association of Tower Erectors	204	605-882-5865	605-886-5184	http://mwj.hotims.com/16346-110
111	Networks International Corporation	36	913-685-3400	913-685-3732	http://mwj.hotims.com/16346-111
112	OEwaves	172	626-449-5000		http://mwj.hotims.com/16346-112
113	OML Inc.	161	408-779-2698	408-778-0491	http://mwj.hotims.com/16346-113
114	Orbit/FR Inc.	80	215-674-5100		http://mwj.hotims.com/16346-114
115	Pascall Electronics Limited	54	+44(0) 1983 817300	+44(0) 1983 564708	http://mwj.hotims.com/16346-115
116	Picosecond Pulse Labs Inc.	72	303-209-8100	303-447-2236	http://mwj.hotims.com/16346-116
117	Pole/Zero Corporation	149	513-870-9060	513-870-9064	http://mwj.hotims.com/16346-117
118	Prewell Corporation	138	82-31-420-8362	82-31-420-8369	http://mwj.hotims.com/16346-118
119	Programmed Test Sources, Inc.	COV 3	978-486-3400	978-486-4495	http://mwj.hotims.com/16346-119
120	Purecoat International, LLC	193	561-844-0100	561-845-7480	http://mwj.hotims.com/16346-120
121,122	R&K Company Limited	208,209	+81-545-31-2600	+81-545-31-1600	http://mwj.hotims.com/16346-121
123,124	Radiall	179,185	33-1-49-353535	33-1-48-546363	http://mwj.hotims.com/16346-123
125	Radio Waves, Inc.	78	978-459-8800	978-459-3310	http://mwj.hotims.com/16346-125
126	Reactel, Incorporated	52	301-519-3660	301-519-2447	http://mwj.hotims.com/16346-126
127	Remcom	85	814-861-1299	814-353-1420	http://mwj.hotims.com/16346-127
128	REMEC Defense & Space	50	858-560-1301		http://mwj.hotims.com/16346-128
129	RF TEC Mfg., Inc.	211	770-487-2187	770-486-9499	http://mwj.hotims.com/16346-129
130	RFcore Co., Ltd.	148	82 31 708 7575	82 31 708 7596	http://mwj.hotims.com/16346-130
131,132, 133,134	RFHIC	96,98, 100,101	82-31-250-5011	82-31-250-5088	http://mwj.hotims.com/16346-131
135,136	RFMD	135,137	336-678-5570	336-931-7454	http://mwj.hotims.com/16346-135
137	Richardson Electronics, Ltd.	75	800-737-6937	630-208-2550	http://mwj.hotims.com/16346-137
138	RLC Electronics, Inc.	23	914-241-1334	914-241-1753	http://mwj.hotims.com/16346-138
139	Rockwell Collins	182	319-295-3673		http://mwj.hotims.com/16346-139
140	Rogers Corporation	89	480-961-1382	480-961-4533	http://mwj.hotims.com/16346-140
141	Rohde & Schwarz GmbH	11	+49-1805-124242	+49-89-412913777	http://mwj.hotims.com/16346-141
142	Rosenberger	125	+49-8684-18-0	+49-8684-18-499	http://mwj.hotims.com/16346-142
143	Santron Inc.	127	978-356-1585	978-356-1573	http://mwj.hotims.com/16346-143
144	Satellink, Inc.	211	972-487-1434	972-487-1204	http://mwj.hotims.com/16346-144
145	Sector Microwave Industries, Inc.	211	631-242-2300	631-242-8158	http://mwj.hotims.com/16346-145
146	Skyworks Solutions, Inc.	87	781-376-3000		http://mwj.hotims.com/16346-146

FREE
Product Information

Now Available Online
at

Info Zone

The new Web-based reader service system
from

Microwave Journal®

Just visit
mwjournal.com/info
and enter the RS number from
the ad or editorial item
or
request information by company
name or product category

It's Easy

It's Fast

It's FREE

GET IN THE ZONE!

ADVERTISING INDEX

RS No.	Advertiser	Page No.	Phone	Fax	Web Address
147	Special Hermetic Products, Inc.	174	603-654-2002	603-654-2533	http://mwj.hotims.com/16346-147
148	Spectrum Elektrotechnik GmbH	79	+49-89-3548-040	+49-89-3548-0490	http://mwj.hotims.com/16346-148
149	Spectrum Microwave, Inc.	194-195	888-553-7531	302-727-3729	http://mwj.hotims.com/16346-149
150	Spinnaker Microwave, Inc.	144	408-732-9828	408-732-9793	http://mwj.hotims.com/16346-150
151	State of the Art, Inc.	46	800-458-3401	814-355-2714	http://mwj.hotims.com/16346-151
152	SV Microwave, Inc.	151	561-840-1800 x128	561-842-6277	http://mwj.hotims.com/16346-152
153	Syndetix Incorporated	164	575-522-8762	575-521-1619	http://mwj.hotims.com/16346-153
154,155	Synergy Microwave Corporation	63,217	973-881-8800	973-881-8361	http://mwj.hotims.com/16346-154
157	Talley Communications	42	800-949-7079		http://mwj.hotims.com/16346-157
158	Tektronix, Inc.	41	800-426-2200		http://mwj.hotims.com/16346-158
159	Teledyne Cougar	103	408-522-3838	408-522-3839	http://mwj.hotims.com/16346-159
160	Teledyne Relays	81	800-896-9504		http://mwj.hotims.com/16346-160
161	Teledyne Storm Products	181	630-754-3300	630-754-3500	http://mwj.hotims.com/16346-161
162	Thunderline-Z	205,207	603-329-4050		http://mwj.hotims.com/16346-162
163	Times Microwave Systems	167	203-949-8400	203-949-8423	http://mwj.hotims.com/16346-163
164	TRAK Microwave Corporation	129	813-901-7200		http://mwj.hotims.com/16346-164
165,166	Trilithic Inc.	108,110	800-344-2412	317-895-3612	http://mwj.hotims.com/16346-165
167	TriQuint Semiconductor, Inc.	19	503-615-9000	503-615-8900	http://mwj.hotims.com/16346-167
168	Tusonix	153	520-744-0400	520-744-6155	http://mwj.hotims.com/16346-168
169	Universal Microwave Components Corporation	209	703-642-6332	703-642-2568	http://mwj.hotims.com/16346-169
170	Voltronics Corporation	121	973-586-8585	973-586-3404	http://mwj.hotims.com/16346-170
171	W.L. Gore & Associates, Inc.	128	800-445-GORE		http://mwj.hotims.com/16346-171
172	Weinschel Associates	134	877-948-8342	301-963-8640	http://mwj.hotims.com/16346-172
173	Werlatone, Inc.	COV 4	845-279-6187	845-279-7404	http://mwj.hotims.com/16346-173
174,175	Win Semiconductors Corp.	37,201	310-530-8485	310-530-8499	http://mwj.hotims.com/16346-174
176	Winchester Electronics Corporation	74	203-741-5400	203-741-5500	http://mwj.hotims.com/16346-176

Visit **Microwave Journal** *on the Web at* **www.mwjournal.com**

Visit mwjournal.com/info and enter RS# to request information from our advertisers

Microwave Journal

NOVEMBER 2008 ISSUE

Microwave Filter Design Techniques

What's New with Filters

Microwaves in Asia

SALES REPRESENTATIVES

microwave journal

CARL SHEFFRES, PUBLISHER

ED KIESSLING, TRAFFIC MANAGER

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

Pacific and Mountain Time Zones
Wynn Cook
Western Reg. Sales Mgr.
PO Box 23200
San Jose, CA 95153
Tel: (408) 224-9060
FAX: (408) 224-6106
wcook@mwjournal.com

International Sales
Richard Vaughan
International Sales Manager
46 Gillingham Street
London SW1V 1HH, England
Tel: +44 207 596 8742
FAX: +44 207 596 8749
rvaughan@horizonhouse.co.uk

Germany, Austria, and Switzerland (German-speaking)
Brigitte Beranek
Wissling Marketing Services
Riedstrasse 5
72813 St. Johann-Wuertingen
Germany
Tel: +49 7122 828140
FAX: +49 7122 828145
bberanek@horizonhouse.com

Israel
Oreet Ben Yaacov
Oreet International Media
15 Kineret Street
51201 Bene-Berak, Israel
Tel: +972 3 570 6527
FAX: +972 3 570 6526
obenyaacov@horizonhouse.com

Korea
Young-Seoh Chinn
JES Media International
2nd Floor, ANA Bldg.
257-1, Myungil-Dong
Kangdong-Gu
Seoul, 134-070 Korea
Tel: +82 2 481-3411
FAX: +82 2 481-3414
yschinn@horizonhouse.com

Japan
Katsuhiro Ishii
Ace Media Service Inc.
12-6, 4-Chome,
Nishiiko, Adachi-Ku
Tokyo 121-0824, Japan
Tel: +81 3 5691 3335
FAX: +81 3 5691 3336
amskatsu@dream.com

If you have to ask how much it costs.....

you <u>can</u> afford it

for frequency sources from PTS, you don't even have to ask,

all our technical information, (web, catalog, data sheets) shows the price of our units. PTS produces fast switching, low noise synthesizers with the best performance/price ratio on the market. Our total installed base, first in the ATE industry, confirms this fact.

Are there ... that have eve... bsolutely. If you ... hose cost... know t... story...

anything from a 10 MHz slot to a 6.4 GHz band, covered with numerous models

If you should need information on our products, you're free to ask. We shall gladly answer your questions about specs and price.

PTS THE FASTER SOURCE NOW TO 6400 MHz

INDUSTRY'S LARGEST INSTALLED BASE

synthesized

LO sources

with:

- → crystal control
- → ultra-low phase noise
- → µs-switching
- → multi-octave coverage
- → fine resolution
- → 0.1 MHz - 6.4 GHz

PTS FREQUENCY SYNTHESIZERS

PROGRAMMED TEST SOURCES, INC.
9 Beaver Brook Road
Littleton, MA 01460

Tel: 978 486-3400
Fax: 978 486-4495
http://www.programmedtest.com
e-mail: sales@programmedtest.com

PROGRAMMED TEST SOURCES, INC.

Visit http://mwj.hotims.com/16346-119 or use RS# 119 at www.mwjournal.com/info

Wide bandwidth, HIGH POWER DEVICES

Unsurpassed quality + on-time delivery, is the Werlatone promise

WERLATONE

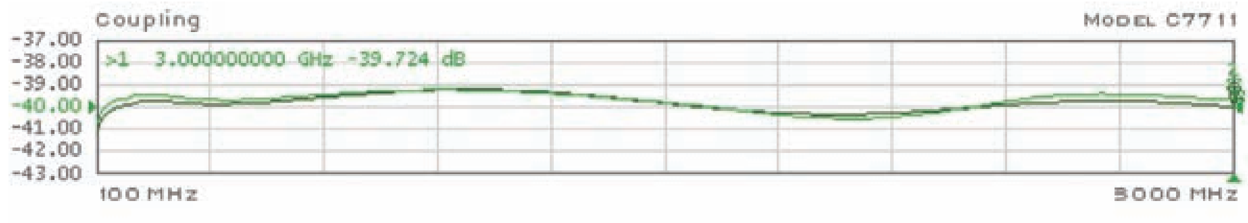
QUADRATURES COMBINERS DIVIDERS HYBRIDS

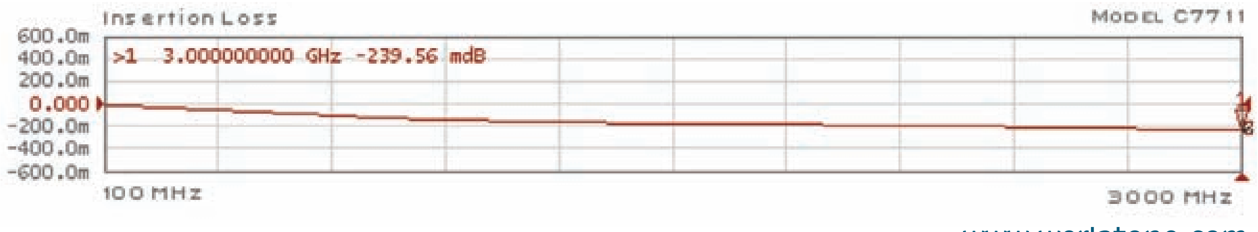
Breaking all the Rules

10:1+ Bandwidth Lowest Loss Directional Couplers

COUPLERS

- Superior performance starting at 3:1 bandwidth
- Newly Patented!
- No exotic materials needed
- 3X thicker center boards for more power and producability
- More sections per bandwidth for better coupling flatness
- Electrically shorter and physically smaller
- Stripline designs invade traditional lumped element territory





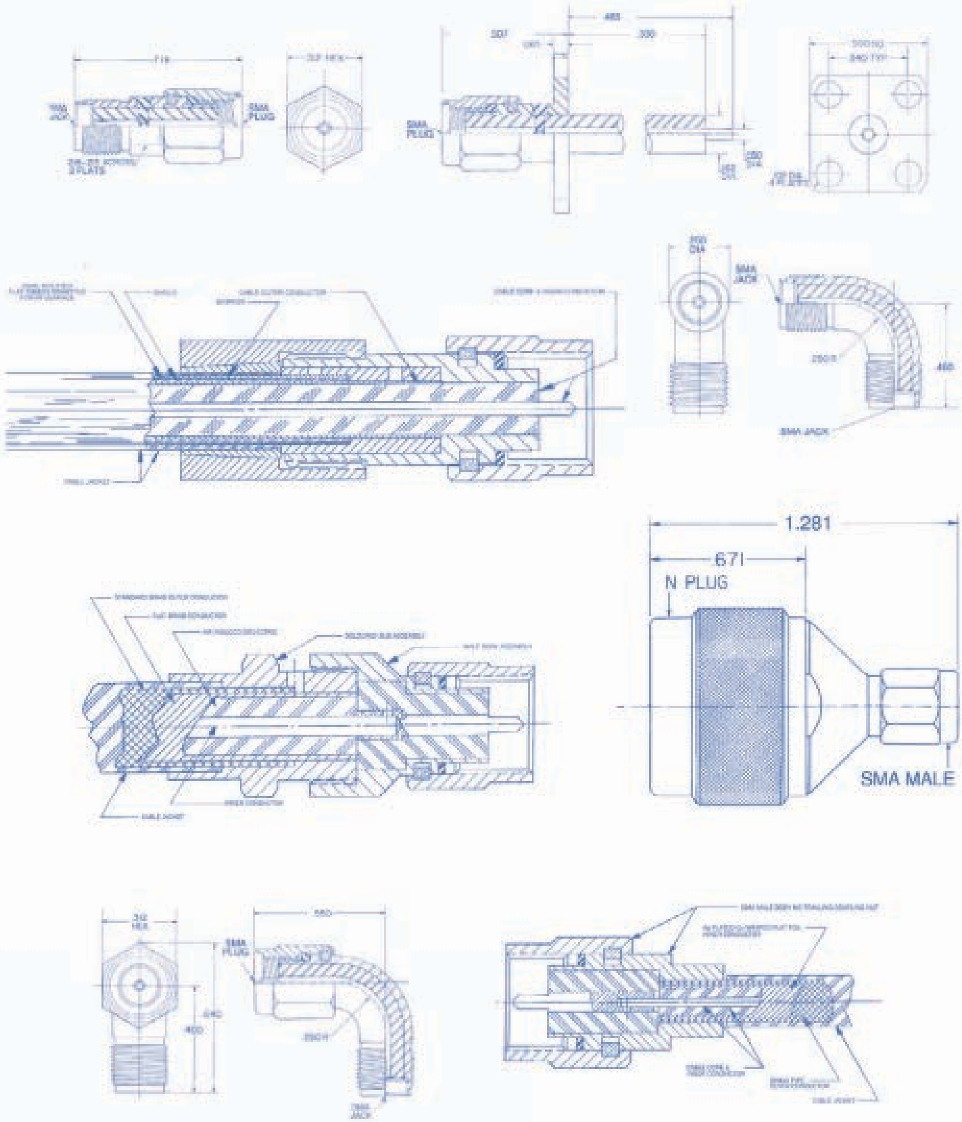
www.werlatone.com

Model	Coupler Type	Frequency (MHz)	Power CW (Watts)	Coupling (dB)	Flatness (±dB)	Insertion Loss (dB)	VSWR (Mainline)	Directivity (dB)	Size (Inches)
C7734	Dual Directional	30-2500	100	43	±1.5	0.35	1.25:1	18	3.5 x 2.6 x 0.7
C7148	Bi Directional	60-600	200	10	±1.0	0.35	1.20:1	20	6.0 x 4.0 x 0.75
C7711	Dual Directional	100-3000	100	40	±1.0	0.35	1.25:1	18	3.0 x 2.2 x 0.7
C7783	Bi Directional	200-1000	200	20	±0.75	0.2	1.20:1	20	3.0 x 1.5 x 0.53
C6600	Bi Directional	200-2000	200	20	±1.2	0.25	1.25:1	18	4.0 x 2.0 x 0.72
C7152	Bi Directional	300-3000	100	20	±1.0	0.35	1.20:1	15	3.7 x 2.0 x 0.75
C7811	Dual Directional	500-2500	100	40	±0.5	0.2	1.25:1	20	3.0 x 2.0 x 0.6
C7753	Bi Directional	700-4200	100	20	±1.0	0.35	1.25:1	18	1.8 x 1.0 x 0.6

Visit http://mwj.hotims.com/16346-173 or use RS# 173 at www.mwjournal.com/info

UNITED MICROWAVE PRODUCTS INC

http://www.unitedmicrowave.com



MICROWAVE CABLES & CONNECTORS

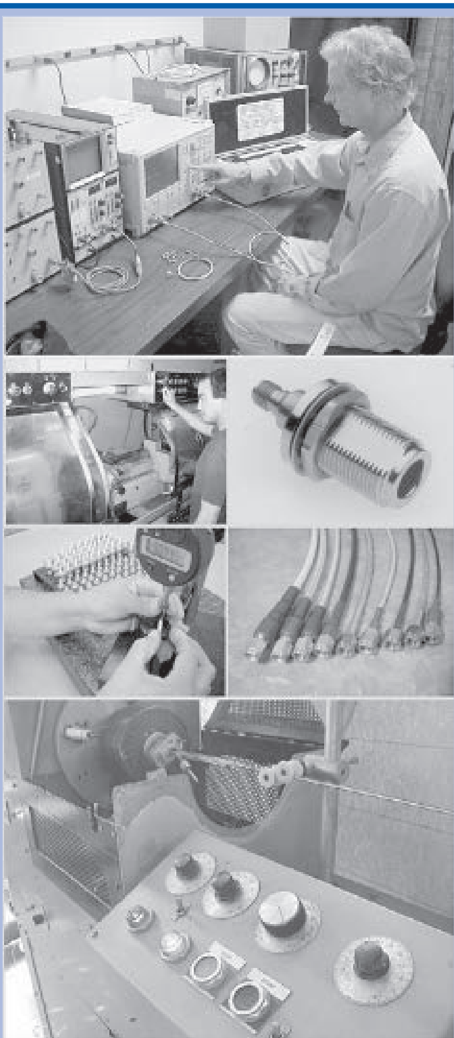
TABLE OF CONTENTS

Prices listed effective as of 1 July 2008 and subject to change at any time.

United Microwave Products Inc.
Direct Sales, Tech Support and Current Order Status

 22129 S.Vermont Ave. Torrance CA. 90502 Phone (310) 320-1244 Fax (310) 320-9729 Email umpinc@pacbell.net

United Microwave
Products Inc.



United Microwave Products, Inc. was founded in 1975 and since then has become a leader in innovative connector design. Our commitment was and still is to price competitively, manufacture quality parts and deliver to negotiated dates.
United Microwave rates our customers number one knowing that they significantly contribute to our success.
Originally, United Microwave Products Inc. started designing and manufacturing special RF connectors, cable assemblies, and associated microwave products. This specialization along with continued investment in high quality equipment makes United Microwave a viable source for all RF connector applications. We offer every product listed in this catalog at competitive prices and deliveries to meet customer requirements.
Please contact us or our representatives for additional product information and design applications.

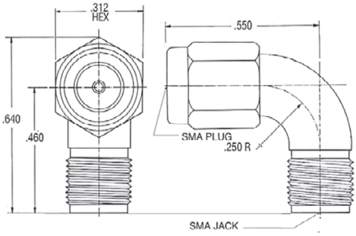
WARRANTY

UNITED MICROWAVE WARRANTS PRODUCTS OF ITS MANUFACTURE TO BE FREE FROM DEFECTS IN MATERIAL AND WORKMANSHIP FOR A PERIOD OF ONE YEAR UNDER NORMAL USAGE CONDITIONS

PRECISION 90 ADAPTERS AT AFFORDABLE PRICING

STANDARD SMA
PERFORMANCE DC to 18 GHz

MAX VSWR 1.20:1

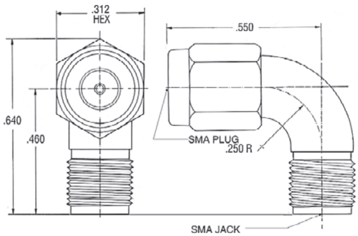


RADIUS RIGHT ANGLE SMA PLUG TO SMA JACK ADAPTER

PART NO	1-9	10-24	25-49	50-99	100+
370	$28.50	$26.75	$25.25	$23.50	$22.75

HIGH PERFORMANCE SMA
DC to 26.5 GHz

MAX VSWR 1.25:1

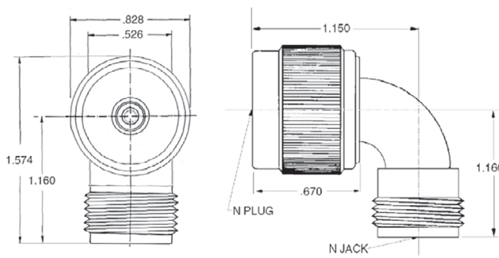


HIGH PERFORMANCE RADIUS RIGHT ANGLE SMA PLUG TO SMA JACK ADAPTER

PART NO	1-9	10-24	25-49	50-99	100+
370-26	$37.50	$34.50	$31.75	$29.25	$27.50

HIGH PERFORMANCE TYPE "N"
DC to 18 GHz

MAX VSWR 1.20:1

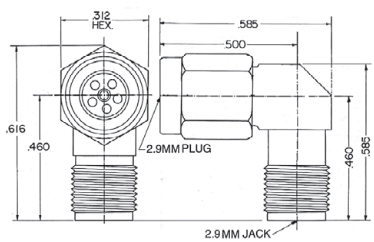


RADIUS RIGHT ANGLE TYPE "N" PLUG TO TYPE "N"JACK ADAPTER

PART NO	1-9	10-24	25-49	50-99	100+
1521	$142.00	$135.00	$127.00	$119.00	$112.00

STANDARD PERFORMANCE 2.9mm
DC to 40.0 GHz

MAX VSWR 1.25:1



RADIUS RIGHT ANGLE 2.9MM PLUG TO 2.9MM JACK ADAPTER

PART NO	1-9	10-24	25-49	50-99	100+
370-40	$121.00	$116.00	$111.00	$107.00	$105.00

United Microwave Products Inc.
Direct Sales, Tech Support and Current Order Status
3 22129 S.Vermont Ave. Torrance CA. 90502 Phone (310) 320-1244 Fax (310) 320-9729 Email umpinc@pacbell.net 3

SMA Connectors

The SMA Series Connectors listed on the following pages are available primarily of stainless steel construction. The stainless steel is normally gold plated. However, all connectors are available in passivated stainless steel and may be ordered by adding the suffix SF to the part number (SF = Stainless Finish). Almost all female panel mount and bulkhead connectors are available with captivated contacts. If captivation is required, add the letters CC to the part number (CC = Captive Contact). Figure 1.2 show Greater than 18GHz performance is possible at United Microwave (26 = 26GHz High performance)

Figure 1.1

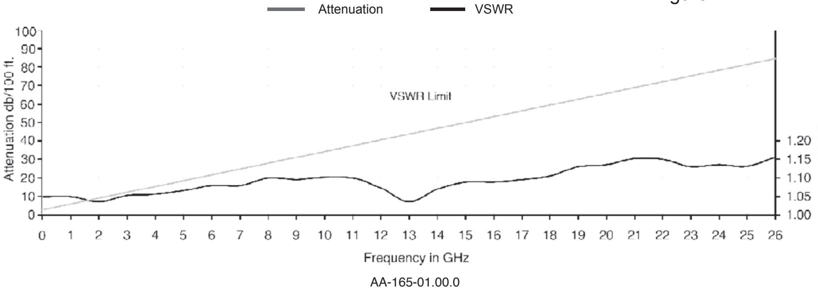
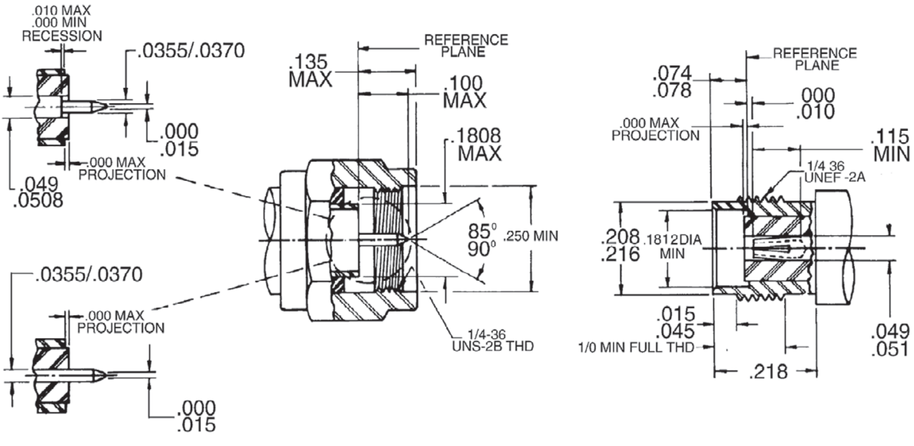


Figure 1.2 SMA PLUG to SMA PLUG ONE FOOT MICROFLEX 165 CABLE

Figure 1.3

SMA Interface Dimensions Per MIL-C-39012



SMA Specifications Per MIL-C-39012

REQUIREMENT	MIL-C-39012 PARA	SPECIFICATIONS
MATERIAL	**3.3**	Steel corrosion resistant per QQ-S-763, class 303, Beryllium Copper per QQ-C-530 condition HT Silicone Rubber per ZZ-R-765, class II B, Grade 65-75 TFE Fluorocarbon per L-P-403 Soft copper per QQ-B-825
FINISH	**3.31**	Center contacts: 0.00005 min. gold per MIL-G-45204 type II Grade C over 0.0001 min. copper per MIL-C-14550. Other Metal parts: Sufficient to meet corrosion requirements PARA 3.14 of MIL-C-39012.
DESIGN	**3.4**	Mating dimensions are in accordance with Figure 1.3
INSULATION RESISTANCE	**3.11**	5,000 MEGOHMS minimum per MIL-STD-202, Method 302.
DIELECTRIC WITHSTANDING VOLTAGE AND RF HIGH POTENTIAL	**3.18**	MIL-STD 202, Method 301.
CONTACT RESISTANCE (Millivolt Drop)	**3.17**	**Maximum millivolt drop**
VOLTAGE STANDING WAVE RATIO (VSWR)	**3.14**	**Straight Plugs and Jacks** / **Right Angle Plugs and Jacks**
INSERTION LOSS	**3.29**	Straight plugs and jacks, dB Max. = .05 x√GHz Freq. Right Angle plugs, dB Max. = .15x√GHz Freq.
FORCE TO ENGAGE AND DISENGAGE	**3.51**	Longitudinal force is not applicable. torque 2 in-lbs. maximum.
COUPLING NUT PROOF TORQUE	**3.6**	15 inch-pounds minimum.

DIELECTRIC WITHSTANDING VOLTAGE AND RF HIGH POTENTIAL (3.18)

CABLES	VRMS @ 60CPS	VRMS @5MHz
RG-I78, 122, 174, 179, 316,	500	335
.085 SR	750	500
RG-58, 142, 223, 303, .141.S, R,	1,000	670

CONTACT RESISTANCE (3.17) — Maximum millivolt drop

Initial	After
Center Contact 3.0	4.0
Outer Contact 2.0	Not applicable
Braid to Body 0.5	Not applicable

VSWR (3.14) — Straight Plugs and Jacks

CABLES	VSWR	
RG-178	1.20+0.025	(F) GHz
RG- 122, 174, 179 & 316	1.15+0.02	(F) GHz
RG-58, 142, 223 & 303	1.15+0.01	(F) GHz
085 DIA. S.R. (RG-401)	1.15+0.01	(F) GHz
.141 DIA. S.R. (RG-402)	1 .05+0.005	(F) GHz

Right Angle Plugs and Jacks

CABLES	VSWR	
RG-178	1.20+0.030	(F) GHz
RG- 122, 174, 179 & 316	1.15+0.03	(F) GHz
RG-58, 142, 223 & 303	1.15+0.02	(F) GHz
085 DIA. S.R. (RG-401)	1.15+0.015	(F) GHz
.141 DIA. S.R. (RG-402)	1 .05+0.01	(F) GHz

Prices listed effective as of 1 July 2008 and subject to change at any time.

SMA Specifications Per MIL-C-39012

REQUIREMENT	MIL C 39012 PARA	SPECIFICATIONS
CONNECTOR DURABILITY	**3.16**	Insertion and withdrawal **500** cycles min. at 12 Cyclmin. max Connector shall show no evidence of mechanical failure and shall meet the mating characteristics requirements.
CABLE RETENTION FORCE	**3.26**	See Table I

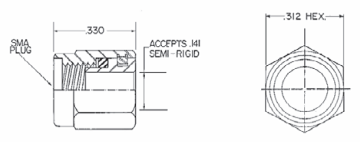
TABLE 1 -Cable retention force.

Cable dielectric Outer diameter	Non crimp Single braid		Crimp Single braid	
	Center contact		Center contact	
Inches (max)	Captive Pounds (max)	Non Captive Pounds (max)	Captive Pounds (max)	Non Captive Pounds (max)
,036	13	10	13	10
,066	25	20	25	20
,110	35	30	35	30
,122	45	40	45	40

REQUIREMENT	MIL C 39012 PARA	SPECIFICATIONS
MATING CHARACTERISTICS	**3.7**	Contacts with spring members Center contact (female) Oversize test pin - **.0375 inches** minimum diameter Test pin finish - **16** Insertion depth - **.030/.045 inches** Number of insertions - **3** Insertion force test: Steel test pin Diameter - **.0370 inches** minimum diameter Insertion depth - **.050/.075 inches** Test pin finish - **16** Insertion force - **3 Pounds** maximum Withdrawal **force test: Steel test** pin Diameter - **.0355 inches** maximum diameter Insertion depth - **.050/.075 inches** Withdrawal force - **1 Ounce** minimum Test pin finish - **16**
VIBRATION	**3.18**	MIL-STD-202, method 204, test condition B. No discontinuities.
SHOCK	**3.19**	MIL-STD-202, method 213, test condition I. No discontinuities.
THERMAL SHOCK	**3.20**	Refer to applicable military slash sheet or consult factory.
CORROSION SALT SPRAY	**3.13**	MIL-STD-202, method 101, test condition **B,** the salt solution shall be 5 percent.
MOISTURE RESISTANCE	**3.23**	MIL-STD-202, method 106. Insulation 200 MEGOHMS min. within 5 minutes after removal from humidity.
CABLE RETENTION	**3.24**	Refer to applicable military slash sheet or consult factory.
CORONA LEVEL	**3.22**	Refer to applicable military slash sheet or consult factory.

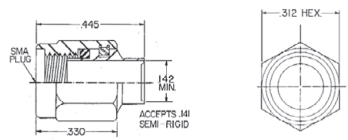
Prices listed effective as of 1 July 2008 and subject to change at any time.

SMA Connectors to Semi-Rigid Cable



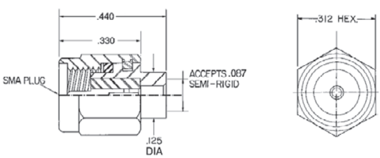
STRAIGHT PLUG .141 SEMI-RIGID

PART NO	1-9	10-24	25-49	50-99	100+
300-1	$4.25	$4.00	$3.75	$3.50	$3.25



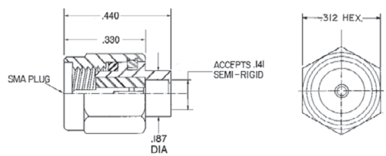
STRAIGHT PLUG .141 SEMI-RIGID IMPROVED SOLDER TYPE

PART NO	1-9	10-24	25-49	50-99	100+
300	$4.25	$4.00	$3.75	$3.50	$3.25



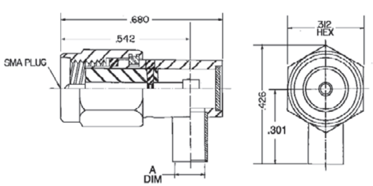
STRAIGHT PLUG .085 SEMI-RIGID WITH CONTACT

PART NO	1-9	10-24	25-49	50-99	100+
301-1	$4.75	$4.50	$4.25	$4.00	$3.75



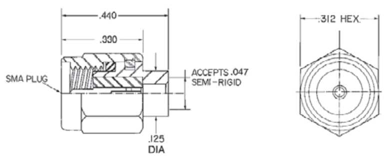
STRAIGHT PLUG .141 SEMI-RIGID WITH CONTACT

PART NO	1-9	10-24	25-49	50-99	100+
300-7	$4.75	$4.50	$4.25	$4.00	$3.75



RIGHT ANGLE PLUG DC-12.4 GHZ

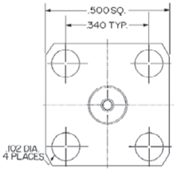
PART NO	(A) DIM	CABLE	1-9	10-24	25-49	50-99	100+
305	.143	RG-402	$15.00	$14.75	$13.75	$12.75	$12.50
305-1	.0875	RG-405	$15.00	$14.75	$13.75	$12.75	$12.50



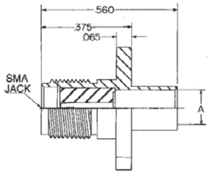
STRAIGHT PLUG .047 SEMI-RIGID WITH CONTACT

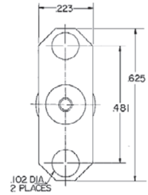
PART NO	1-9	10-24	25-49	50-99	100+
301-3	$12.75	$12.50	$12.25	$12.00	$11.75

SMA Connectors to Semi-Rigid Cable



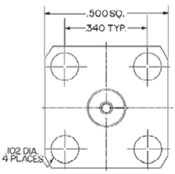
303
4 HOLE JACK SEMI-RIGID SOLDER TYPE



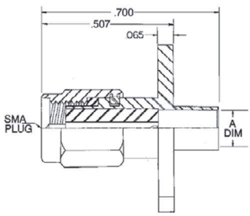


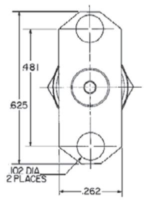
307
2 HOLE JACK SEMI-RIGID SOLDER TYPE

PART NO	(A) DIM	CABLE	1-9	10-24	25-49	50-99	100+
303	.143	141 SR	$9.25	$9.00	$8.75	$8.50	$8.25
303-1	.0875	085 SR	$9.25	$9.00	$8.75	$8.50	$8.25
303-3	.051	047 SR	$10.25	$10.00	$9.75	$9.50	$9.25
307	.143	141 SR	$9.75	$9.50	$9.25	$9.00	$8.75
307-1	.0875	085 SR	$9.75	$9.50	$9.25	$9.00	$8.75
307-3	.051	047 SR	$10.75	$10.50	$10.25	$10.00	$9.75



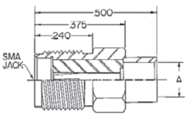
303-M
4 HOLE PLUG SEMI-RIGID SOLDER TYPE

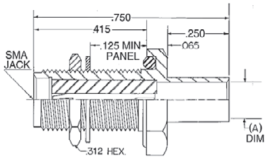


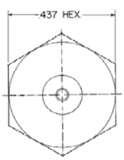


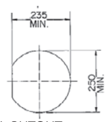
307-M
4 HOLE JACK SEMI-RIGID SOLDER TYPE

PART NO	(A) DIM	CABLE	1-9	10-24	25-49	50-99	100+
303M	.143	141 SR	$20.00	$19.75	$18.75	$17.75	$17.50
303-1M	.0875	085 SR	$21.00	$20.75	$20.50	$20.25	$19.25
303-3M	.051	047 SR	$22.75	$22.50	$22.25	$22.00	$21.75
307M	.143	141 SR	$20.75	$20.50	$20.25	$20.00	$19.75
307-1M	.0875	085 SR	$22.75	$22.50	$22.25	$22.00	$21.75
307-3M	.051	047 SR	$23.75	$23.50	$23.25	$23.00	$22.75









PANEL CUTOUT

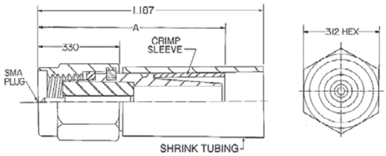
STRAIGHT JACK SEMI-RIGID IMPROVED SOLDER TYPE

PART NO	(A) DIM	CABLE	1-9	10-24	25-49	50-99	100+
302	.143	141 SR	7.50	7.25	7.00	6.75	6.50
302-1	.0875	085 SR	7.50	7.25	7.00	6.75	6.50
302-3	.051	047 SR	18.25	17.50	16.75	16.25	15.75

D MOUNT BULKHEAD JACK SEMI-RIGID SOLDER TYPE

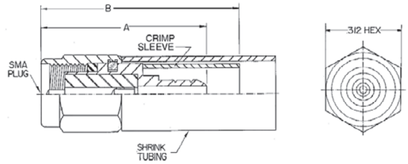
PART NO	(A) DIM	CABLE	1-9	10-24	25-49	50-99	100+
304	.143	141 SR	$8.25	$8.00	$7.75	$7.50	$7.25
304-1	.0875	085 SR	$8.25	$8.00	$7.75	$7.50	$7.25
304-3	.051	047 SR	$24.50	$23.50	$23.25	$23.00	$22.50

SMA Connectors to Flexible Cables



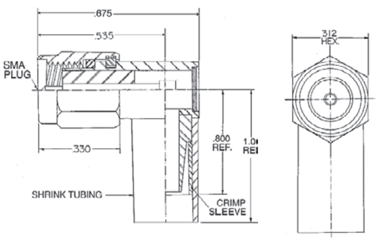
STRAIGHT CABLE PLUG SOLDER ATTACHMENT

PART NO.	A DIM.	CABLE	1-9	10-24	25-49	50-99	100+
351-1	.725\.775	RG-55/U, 58, 141, 142, 223, 303, 400	$7.49	$6.97	$6.49	$5.99	$5.49
351-3	.750\.775	RG-174/U, 179, 187, 188, 316	$7.49	$6.97	$6.49	$5.99	$5.49



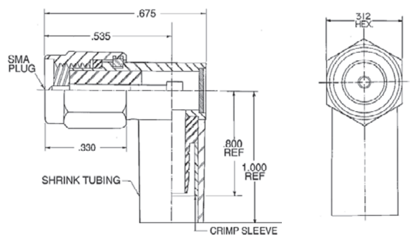
STRAIGHT CABLE PLUG CRIMP OR SOLDER ATTACHMENT

PART NO.	A DIM.	B DIM.	CABLE	1-9	10-24	25-49	50-99	100+
352-1	.690	.945	RG-55/U,142, 223	$7.49	$6.97	$6.49	$5.99	$5.49
352-2	.690	.945	RG-58, 141, 303, 400	$7.49	$6.97	$6.49	$5.99	$5.49
352-3	.655	.815	RG-174/U, 179, 187, 188, 316	$7.49	$6.97	$6.49	$5.99	$5.49



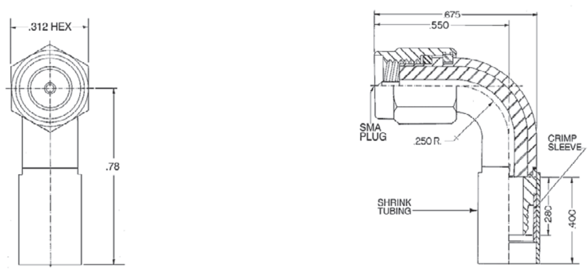
RIGHT ANGLE PLUG SOLDER ATTACHMENT

PART NO.	CABLE	1-9	10-24	25-49	50-99	100+
308-1	RG-55/U, 58, 141, 142, 223, 303, 400	$15.00	$14.75	$13.75	$12.75	$12.50
308-3	RG-174/U, 179, 187, 188, 316	$15.00	$14.75	$13.75	$12.75	$12.50



RIGHT ANGLE PLUG CRIMP OR SOLDER ATTACHMENT

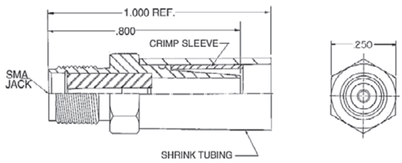
PART NO.	CABLE	1-9	10-24	25-49	50-99	100+
309-1	RG-55/U 142, 223	$15.00	$14.75	$13.75	$12.75	$12.50
309-2	RG-58, 141, 303, 400	$15.00	$14.75	$13.75	$12.75	$12.50
309-3	RG-174/U, 179, 187, 188, 316	$15.00	$14.75	$13.75	$12.75	$12.50



SMA RADIUS RIGHT ANGLE PLUG SOLDER/CRIMP ATTACHMENT FOR RG-55/U, 58, 141, 142, 223, 303 & 400 CABLES

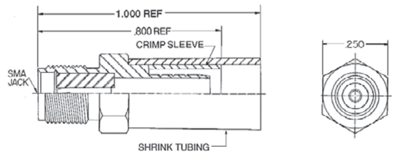
PART NO.	CABLE	1-9	10-24	25-49	50-99	100+
314	RG-55/U, 58, 141, 142, 223, 303, 400	$42.75	$39.50	$37.25	$34.50	$29.50

SMA Connectors to Flexible Cables



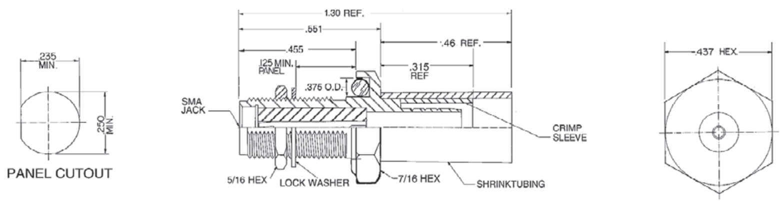
STRAIGHT CABLE JACK SOLDER ATTACHMENT

PART NO.	CABLE	1-9	10-24	25-49	50-99	100+
368-1	RG-55/U, 58, 141, 142, 223, 303, 400	$10.50	$10.00	$9.50	$9.00	$8.25
368-3	RG-174/U, 179, 187, 188, 316	$10.50	$10.00	$9.50	$9.00	$8.25



STRAIGHT CABLE JACK CRIMP OR SOLDER ATTACHMENT

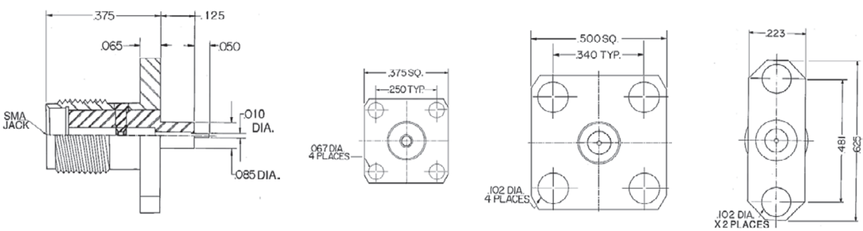
PART NO.	CABLE	1-9	10-24	25-49	50-99	100+
373-1	RG-55/U, 58, 141, 142, 223, 303, 400	$10.50	$10.00	$9.50	$9.00	$8.25
373-3	RG-174/U, 179, 187, 188, 316	$10.50	$10.00	$9.50	$9.00	$8.25



D MOUNT BULKHEAD CABLE JACK CRIMP/SOLDER ATTACHMENT

PART NO.	CABLE	1-9	10-24	25-49	50-99	100+
386-1	RG-55/U 142, 223	$12.20	$11.59	$11.01	$10.46	$ 9.41
386-2	RG-58, 141, 303, 400	$12.20	$11.59	$11.01	$10.46	$9.41
386-3	RG-174/U, 179, 187, 188, 316	$12.20	$11.59	$11.01	$10.46	$9.41

SMA Flange Mount Jack Captive Contact • .010 Microstrip Terminal



SMA 2 or 4 HOLE FLANGE JACK CAPTIVE CONTACT .010 MICROSTRIP

PART NO	FLANGE	1-9	10-24	25-49	50-99	100+
344-CC	SMA .500 SQ.	$8.75	$8.50	$8.25	$7.50	$7.00
344-2-CC	SMA 2 HOLE	$9.25	$9.00	$8.75	$8.00	$7.50
344-375-CC	SMA .375 SQ.	$8.75	$8.50	$8.25	$7.50	$7.00

SMA • Panel Panel Mount • Solder Pot Terminal • Captive Contact

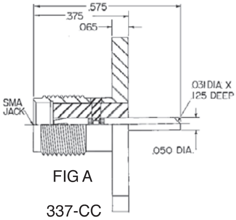


FIG A

337-CC

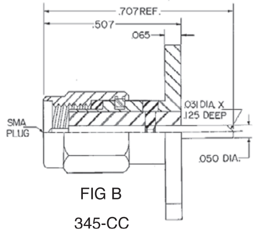


FIG B

345-CC

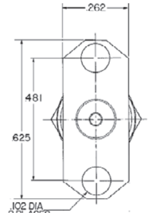


FIG C

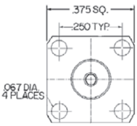


FIG D

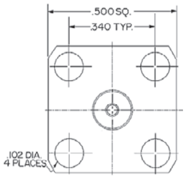


FIG E

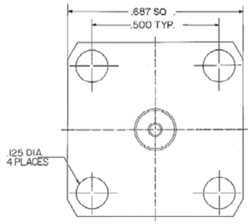


FIG F

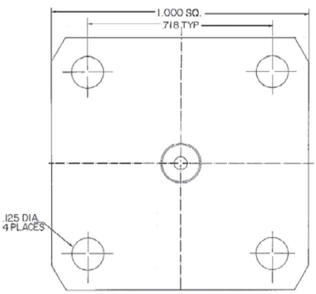
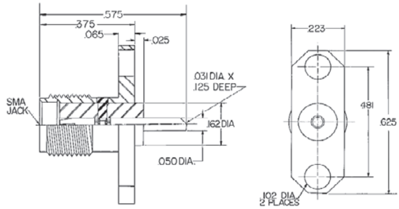


FIG G



341-CC 2 HOLE FLANGE MOUNT JACK
SOLDER POT TERMINAL CAPTIVE CONTACT

FIG H

SMA JACK FLANGE MOUNT SOLDER POT TERMINAL CAPTIVE CONTACT

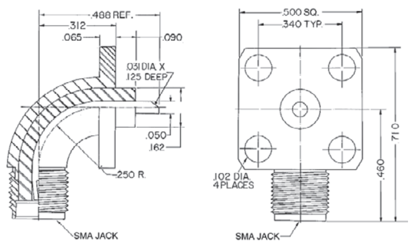
345CC FIG - B (SMA PLUG)							
PART NO.	FLANGE SIZE	FIGURE	1-9	10-24	25-49	50-99	100+
345-CC-375	.375 SQ.	D	$9.50	$9.05	$8.50	$7.95	$7.35
345-CC-2	2 HOLE	C	$10.25	$9.80	$9.25	$8.75	$8.25
345-CC	.500 SQ.	E	$9.50	$9.05	$8.50	$7.95	$7.35
345-CC-687	.687 SQ.	F	$17.50	$16.75	$15.50	14.75	$14.25
345-CC-1.00	1.000 SQ.	G	$21.75	$20.75	$20.25	$20.10	$19.95
337CC FIG - A (SMA JACK)							
PART NO.	FLANGE SIZE	FIGURE	1-9	10-24	25-49	50-99	100+
337-CC-375	.375 SQ.	D	$6.45	$5.81	$5.23	$4.71	$4.24
341-CC	2 HOLE	H	$6.95	$6.31	$5.73	$5.21	$4.74
337-CC	.500 SQ.	E	$6.45	$5.81	$5.23	$4.71	$4.24
320-CC-S	.687 SQ.	F	$7.45	$6.75	$6.25	$5.75	$5.25
325-CC-S	1.000 SQ.	G	$11.75	$10.75	$10.25	$10.10	$9.95

For non-captive contact, delete the “CC” designator.
Add the suffix SF for passivated stainless finish.
Suffix BR for brass body with a Hard Nickel Finish.

BR (brass body) unavailable for
ALL SMA MALE (PLUG) CONNECTORS!

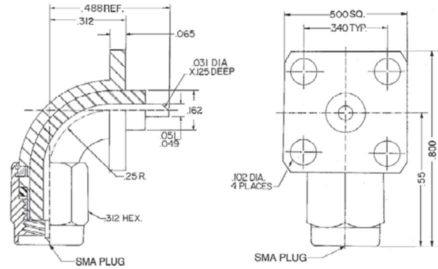
ALL PRICES STATED ARE FOR GOLD FINISH PLEASE CONSULT FACTORY FOR STAINLESS FINISH OR BRASS BODY STYLE.

SMA Right Angle Panel Mount Solder Pot Terminal



4 HOLE RADIUS RIGHT ANGLE JACK

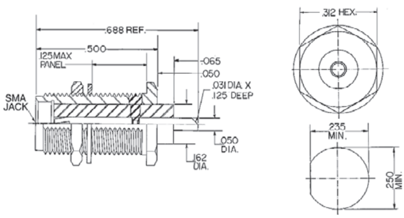
PART NO	1-9	10-24	25-49	50-99	100+
377	$35.50	$33.70	$32.04	$30.45	$27.50



4 HOLE RADIUS RIGHT ANGLE PLUG

PART NO	1-9	10-24	25-49	50-99	100+
372	$41.17	$39.06	$37.11	$35.26	$31.73

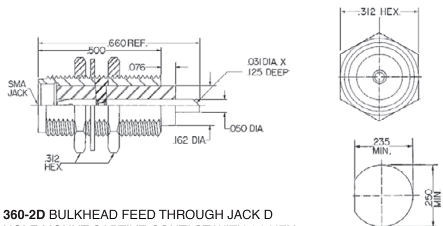
SMA Bulkhead Mount Solder Pot Terminal



PANEL CUTOUT

BULKHEAD FEED THROUGH JACK D HOLE
MOUNT CAPTIVE CONTACT

PART NO	1-9	10-24	25-49	50-99	100+
362-CC	$6.75	$6.50	$6.25	$5.75	$5.50
362-CC-SF	$6.25	$6.00	$5.75	$5.25	$5.00

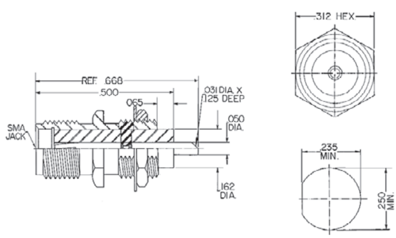


PANEL CUTOUT

360-2D BULKHEAD FEED THROUGH JACK D HOLE MOUNT CAPTIVE CONTACT WITH (2) HEX NUTS & (1) WASHER **360-D** SUPPLIED WITHOUT ANY HARDWARE **360** SUPPLIED WITH SINGLE NUT & WASHER

PART NO	1-9	10-24	25-49	50-99	100+
360-2D-CC	$8.00	$7.75	$7.50	$7.25	$6.75
360-2D-CC-SF	$7.50	$7.25	$7.00	$6.75	$6.25
360-D-CC	$7.90	$7.65	$7.40	$7.15	$6.65
360-D-CC-SF	$7.40	$7.15	$6.90	$6.65	$6.15
360-CC	$7.80	$7.65	$7.30	$7.05	$6.55
360-CC-SF	$7.30	$7.15	$6.80	$6.45	$6.05

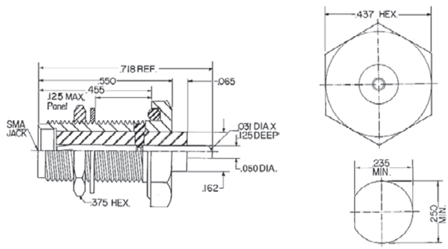
The suffix SF is for passivated stainless finish. Or consult factory for brass body nickel finish pricing.



PANEL CUTOUT

BULKHEAD FEED THROUGH JACK D HOLE
MOUNT FRONT CAPTIVE CONTACT

PART NO	1-9	10-24	25-49	50-99	100+
363-CC	$6.75	$6.50	$6.25	$5.75	$5.50
363-CC-SF	$6.25	$6.00	$5.75	$5.25	$5.00



PANEL CUTOUT

BULKHEAD FEED THROUGH JACK D HOLE
MOUNT “O” RING CAPTIVE CONTACT

PART NO	1-9	10-24	25-49	50-99	100+
361-CC	$10.25	$10.00	$9.75	$9.00	$8.25
361-CC-SF	$9.75	$9.50	$9.25	$8.50	$7.75

SMA Plug SMA Jack Flange Mount Slot Terminal Captive Contact

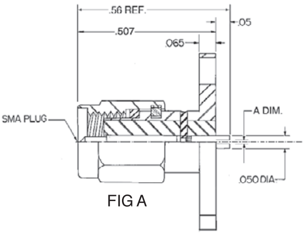


FIG A

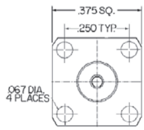


FIG B

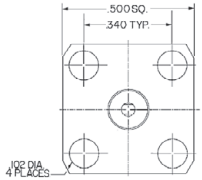


FIG C

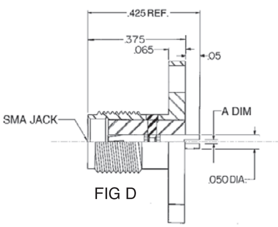


FIG D

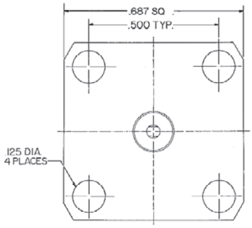


FIG E

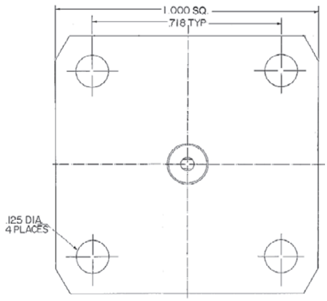


FIG F

The suffix SF is for passivated stainless finish.
For non-captive contact connectors or brass connectors with a Hard Nickel Finish consult factory for pricing
BRASS IS UNAVAILABLE FOR ALL SMA MALE PLUG CONNECTORS!

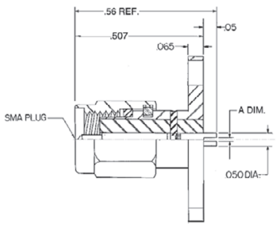
(FIG A) SMA PLUG BODY								
PART NO	FIG	A DIM	FLANGE	1-9	10-24	25-49	50-99	100+
348-1CC-375	FIG B	.012	.375	$9.50	$9.05	$8.50	$7.95	$7.35
348-1CC-375-SF	FIG B	.012	.375	$9.00	$8.55	$8.00	$7.45	$6.85
348-2CC-375	FIG B	.018	.375	$9.50	$9.05	$8.50	$7.95	$7.35
348-2CC-375-SF	FIG B	.018	.375	$9.00	$8.55	$8.00	$7.45	$6.85
348-3CC-375	FIG B	.028	.375	$9.50	$9.05	$8.50	$7.95	$7.35
348-3CC-375-SF	FIG B	.028	.375	$9.00	$8.55	$8.00	$7.45	$6.85
348-1CC	FIG C	.012	.500	$9.50	$9.05	$8.50	$7.95	$7.35
348-1CC-SF	FIG C	.012	.500	$9.00	$8.55	$8.00	$7.45	$6.85
348-2CC	FIG C	.018	.500	$9.50	$9.05	$8.50	$7.95	$7.35
348-2CC-SF	FIG C	.018	.500	$9.00	$8.55	$8.00	$7.45	$6.85
348-3CC	FIG C	.028	.500	$9.50	$9.05	$8.50	$7.95	$7.35
348-3CC-SF	FIG C	.028	.500	$9.00	$8.55	$8.00	$7.45	$6.85
348-1CC-T	FIG E	.012	.687	$18.00	$17.45	$16.00	$15.25	$14.75
348-1CC-T-SF	FIG E	.012	.687	$17.50	$16.95	$15.50	$14.75	$14.25
348-2CC-T	FIG E	.018	.687	$18.00	$17.45	$16.00	$15.25	$14.75
348-2CC-T-SF	FIG E	.018	.687	$17.50	$16.95	$15.50	$14.75	$14.25
348-3CC-T	FIG E	.028	.687	$18.00	$17.45	$16.00	$15.25	$14.75
348-3CC-T-SF	FIG E	.028	.687	$17.50	$16.95	$15.50	$14.75	$14.25
348-1CC-N	FIG F	.012	1.000	$21.75	$20.75	$20.25	$20.10	$19.95
348-1CC-N-SF	FIG F	.012	1.000	$21.25	$20.25	$19.75	$19.60	$19.45
348-2CC-N	FIG F	.018	1.000	$21.75	$20.75	$20.25	$20.10	$19.95
348-2CC-N-SF	FIG F	.018	1.000	$21.25	$20.25	$19.75	$19.60	$19.45
348-3CC-N	FIG F	.028	1.000	$21.75	$20.75	$20.25	$20.10	$19.95
348-3CC-N-SF	FIG F	.028	1.000	$21.25	$20.25	$19.75	$19.60	$19.45

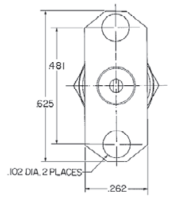
(FIG D) SMA JACK BODY								
PART NO	FIG	A DIM	FLANGE	1-9	10-24	25-49	50-99	100+
318-1CC-375	FIG B	.012	.375	$6.95	$6.31	$5.73	$5.21	$4.74
318-1CC-375-SF	FIG B	.012	.375	$6.45	$5.81	$5.23	$4.71	$4.24
318-2CC-375	FIG B	.018	.375	$6.95	$6.31	$5.73	$5.21	$4.74
318-2CC-375-SF	FIG B	.018	.375	$6.45	$5.81	$5.23	$4.71	$4.24
318-3CC-375	FIG B	.028	.375	$6.95	$6.31	$5.73	$5.21	$4.74
318-3CC-375-SF	FIG B	.028	.375	$6.45	$5.81	$5.23	$4.71	$4.24
318-1CC	FIG C	.012	.500	$6.95	$6.31	$5.73	$5.21	$4.74
318-1CC-SF	FIG C	.012	.500	$6.45	$5.81	$5.23	$4.71	$4.24
318-2CC	FIG C	.018	.500	$6.95	$6.31	$5.73	$5.21	$4.74
318-2CC-SF	FIG C	.018	.500	$6.45	$5.81	$5.23	$4.71	$4.24
318-3CC	FIG C	.028	.500	$6.95	$6.31	$5.73	$5.21	$4.74
318-3CC-SF	FIG C	.028	.500	$6.45	$5.81	$5.23	$4.71	$4.24
320-1CC	FIG E	.012	.687	$7.95	$7.25	$6.75	$6.25	$5.75
320-1CC-SF	FIG E	.012	.687	$7.45	$6.75	$6.25	$5.75	$5.25
320-2CC	FIG E	.018	.687	$7.95	$7.25	$6.75	$6.25	$5.75
320-2CC-SF	FIG E	.018	.687	$7.45	$6.75	$6.25	$5.75	$5.25
320-3CC	FIG E	.028	.687	$7.95	$7.25	$6.75	$6.25	$5.75
320-3CC-SF	FIG E	.028	.687	$7.45	$6.75	$6.25	$5.75	$5.25
325-1CC	FIG F	.012	1.000	$12.25	$11.45	$10.75	$10.60	$10.45
325-1CC-SF	FIG F	.012	1.000	$11.75	$10.95	$10.25	$10.10	$9.95
325-2CC	FIG F	.018	1.000	$12.25	$11.45	$10.75	$10.60	$10.45
325-2CC-SF	FIG F	.018	1.000	$11.75	$10.95	$10.25	$10.10	$9.95
325-3CC	FIG F	.028	1.000	$12.25	$11.45	$10.75	$10.60	$10.45
325-3CC-SF	FIG F	.028	1.000	$11.75	$10.95	$10.25	$10.10	$9.95

SMA 2 Hole Plug Flange Mount Slot Terminal Captive Contact

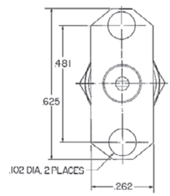
348 TABULATED

For non-captive contact, passivated stainless finish or brass body with a hard nickel finish body type. consult factory for pricing.





VERTICAL



HORIZONTAL

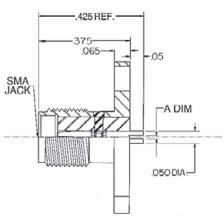
SMA 2 HOLE PLUG PANEL MOUNT SLOT

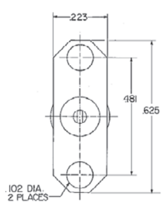
PART NO.	SLOT WIDTH A	SLOT POSITION	1-9	10-24	25-49	50-99	100+
348H-1CC	.012	HORIZONTAL	$9.75	$9.27	$8.85	$8.25	$7.55
348H-2CC	.018	HORIZONTAL	$9.75	$9.27	$8.85	$8.25	$7.55
348H-3CC	.028	HORIZONTAL	$9.75	$9.27	$8.85	$8.25	$7.55
348V-1CC	.012	VERTICAL	$9.75	$9.27	$8.85	$8.25	$7.55
348V-2CC	.018	VERTICAL	$9.75	$9.27	$8.85	$8.25	$7.55
348V-3CC	.028	VERTICAL	$9.75	$9.27	$8.85	$8.25	$7.55

SMA 2 Hole Jack Flange Mount Slot Terminal Captive Contact

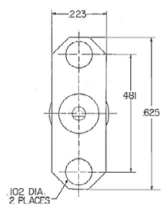
318 TABULATED

For non-captive contact, passivated stainless finish or brass body with a hard nickel finish body type. consult factory for pricing.





VERTICAL



HORIZONTAL

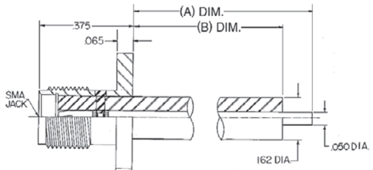
SMA 2 HOLE JACK PANEL MOUNT SLOT

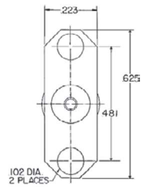
PART NO.	SLOT WIDTH A	SLOT POSITION	1-9	10-24	25-49	50-99	100+
318H-1CC	.012	HORIZONTAL	$6.75	$6.10	$5.70	$5.20	$4.75
318H-2CC	.018	HORIZONTAL	$6.75	$6.10	$5.70	$5.20	$4.75
318H-3CC	.028	HORIZONTAL	$6.75	$6.10	$5.70	$5.20	$4.75
318V-1CC	.012	VERTICAL	$6.75	$6.10	$5.70	$5.20	$4.75
318V-2CC	.018	VERTICAL	$6.75	$6.10	$5.70	$5.20	$4.75
318V-3CC	.028	VERTICAL	$6.75	$6.10	$5.70	$5.20	$4.75

SMA Jack Flange Mount Extended Terminal Captive Contact

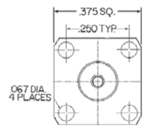
336-CC-CC 80 through 88 TABULATED

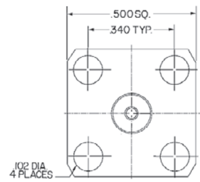
For non-captive contact, passivated stainless finish or brass body with a hard nickel finish body type. consult factory for pricing.

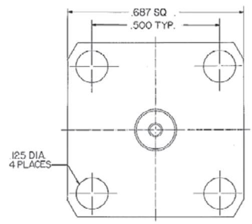


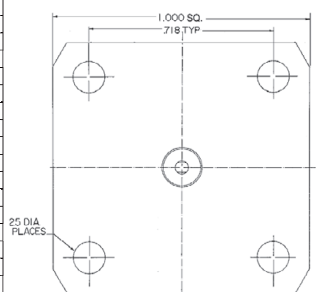


SMA 4 HOLE AND 2 HOLE FLANGE PANEL MOUNT EXTENDED STRAIGHT TERMINAL







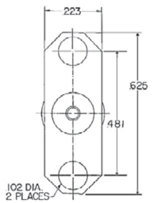


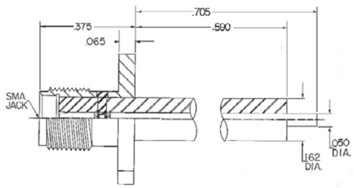
336-CC-2 TAB							
FLANGE SIZE SMA 2 HOLE							
PART NO.	A DIM.	B DIM.	1 - 9	10 - 24	25 - 49	50 - 99	100 +
336-CC-2-80	.300	.090	$7.50	$7.25	$7.00	$6.50	$6.25
336-CC-2-81	.230	.110	$7.50	$7.25	$7.00	$6.50	$6.25
336-CC-2-82	.245	.110	$7.50	$7.25	$7.00	$6.50	$6.25
336-CC-2-83	.300	.145	$7.50	$7.25	$7.00	$6.50	$6.25
336-CC-2-84	.375	.175	$7.50	$7.25	$7.00	$6.50	$6.25
336-CC-2-85	.260	.200	$7.50	$7.25	$7.00	$6.50	$6.25
336-CC-2-86	.290	.210	$7.50	$7.25	$7.00	$6.50	$6.25
336-CC-2-87	.290	.240	$7.50	$7.25	$7.00	$6.50	$6.25
336-CC-2-88	.475	.375	$7.50	$7.25	$7.00	$6.50	$6.25
336-CC-375 TAB							
FLANGE SIZE .375 SQUARE							
336-CC-375-80	.300	.090	$7.25	$7.00	$6.75	$6.25	$5.75
336-CC-375-81	.230	.110	$7.25	$7.00	$6.75	$6.25	$5.75
336-CC-375-82	.245	.110	$7.25	$7.00	$6.75	$6.25	$5.75
336-CC-375-83	.300	.145	$7.25	$7.00	$6.75	$6.25	$5.75
336-CC-375-84	.375	.175	$7.25	$7.00	$6.75	$6.25	$5.75
336-CC-375-85	.260	.200	$7.25	$7.00	$6.75	$6.25	$5.75
336-CC-375-86	.290	.210	$7.25	$7.00	$6.75	$6.25	$5.75
336-CC-375-87	.290	.240	$7.25	$7.00	$6.75	$6.25	$5.75
336-CC-375-88	.475	.240	$7.25	$7.00	$6.75	$6.25	$5.75
336-CC-500 TAB							
FLANGE SIZE .500 SQUARE							
336-CC-500-80	.300	.090	$7.25	$7.00	$6.75	$6.25	$5.75
336-CC-500-81	.230	.110	$7.25	$7.00	$6.75	$6.25	$5.75
336-CC-500-82	.245	.110	$7.25	$7.00	$6.75	$6.25	$5.75
336-CC-500-83	.300	.145	$7.25	$7.00	$6.75	$6.25	$5.75
336-CC-500-84	.375	.175	$7.25	$7.00	$6.75	$6.25	$5.75
336-CC-500-85	.260	.200	$7.25	$7.00	$6.75	$6.25	$5.75
336-CC-500-86	.290	.210	$7.25	$7.00	$6.75	$6.25	$5.75
336-CC-500-87	.290	.240	$7.25	$7.00	$6.75	$6.25	$5.75
336-CC-500-88	.475	.375	$7.25	$7.00	$6.75	$6.25	$5.75
336-CC-687 TAB							
FLANGE SIZE .687 SQUARE							
336-CC-687-80	.300	.090	$7.95	$7.50	$7.25	$6.75	$6.25
336-CC-687-81	.230	.110	$7.95	$7.50	$7.25	$6.75	$6.25
336-CC-687-82	.245	.110	$7.95	$7.50	$7.25	$6.75	$6.25
336-CC-687-83	.300	.145	$7.95	$7.50	$7.25	$6.75	$6.25
336-CC-687-84	.375	.175	$7.95	$7.50	$7.25	$6.75	$6.25
336-CC-687-85	.260	.200	$7.95	$7.50	$7.25	$6.75	$6.25
336-CC-687-86	.290	.210	$7.95	$7.50	$7.25	$6.75	$6.25
336-CC-687-87	.290	.240	$7.95	$7.50	$7.25	$6.75	$6.25
336-CC-687-88	.475	.375	$7.95	$7.50	$7.25	$6.75	$6.25
336-CC-1.000 TAB							
FLANGE SIZE 1.000 SQUARE							
336-CC-1.000-80	.300	.090	$12.50	$11.25	$10.50	$10.20	$9.95
336-CC-1.000-81	.230	.110	$12.50	$11.25	$10.50	$10.20	$9.95
336-CC-1.000-82	.245	.110	$12.50	$11.25	$10.50	$10.20	$9.95
336-CC-1.000-83	.300	.145	$12.50	$11.25	$10.50	$10.20	$9.95
336-CC-1.000-84	.375	.175	$12.50	$11.25	$10.50	$10.20	$9.95
336-CC-1.000-85	.260	.200	$12.50	$11.25	$10.50	$10.20	$9.95
336-CC-1.000-86	.290	.210	$12.50	$11.25	$10.50	$10.20	$9.95
336-CC-1.000-87	.290	.240	$12.50	$11.25	$10.50	$10.20	$9.95
336-CC-1.000-88	.475	.375	$12.50	$11.25	$10.50	$10.20	$9.95

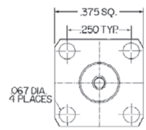
Prices listed effective as of 1 July 2008 and subject to change at any time.

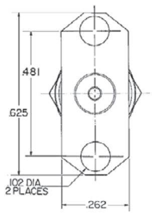
SMA Flange Mount Jack • Plug • Extended Terminal • Captive Contact

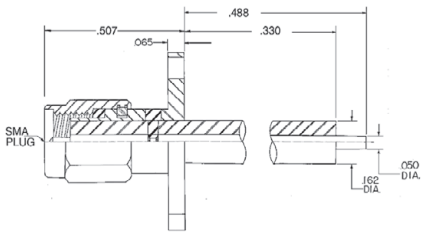
For non-captive contact or brass body with a hard nickel finish body type. consult factory for pricing.

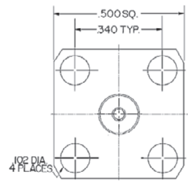


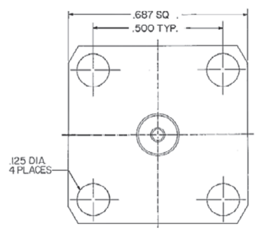






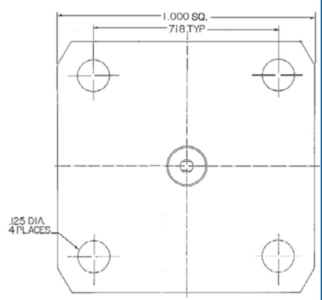






SMA JACK 4 HOLE PANEL MOUNT EXTENDED STRAIGHT TERMINAL

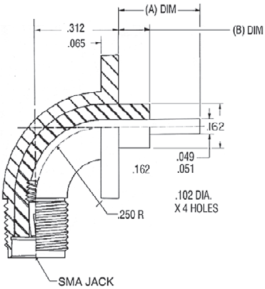
336-CC-(TABULATED)						
PART NO	FLANGE	1-9	10-24	25-49	50-99	100+
336-CC-2	2-HOLE	$8.00	$7.75	$7.50	$7.00	$6.75
336-CC-2-SF	2-HOLE	$7.50	$7.25	$7.00	$6.50	$6.25
336-CC-375	.375 SQ	$7.75	$7.50	$7.25	$6.75	$5.75
336-CC-375-SF	.375 SQ	$7.25	$7.00	$6.75	$6.25	$5.25
336-CC	.500 SQ	$7.75	$7.50	$7.25	$6.75	$5.75
336-CC-SF	.500 SQ	$7.25	$7.00	$6.75	$6.25	$5.25
336-CC-687	.687 SQ	$8.45	$8.00	$7.75	$7.25	$6.75
336-CC-687-SF	.687 SQ	$7.95	$7.50	$7.25	$6.75	$6.25
336-CC-1.000	1.000 SQ	$13.00	$11.75	$11.00	$10.70	$9.95
336-CC-1.000-SF	1.000 SQ	$12.50	$11.25	$10.50	$10.20	$9.45

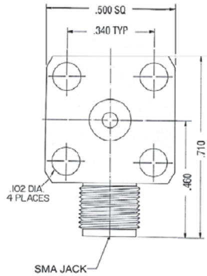


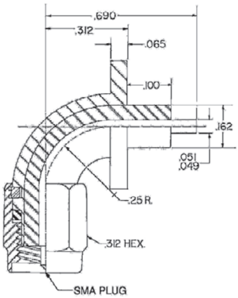
SMA PLUG 4 HOLE PANEL MOUNT EXTENDED STRAIGHT TERMINAL

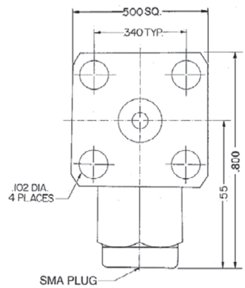
347-CC-(TABULATED)						
PART NO	FLANGE	1-9	10-24	25-49	50-99	100+
347-CC-2	2-HOLE	$10.75	$10.30	$9.75	$9.25	$8.50
347-CC-2-SF	2-HOLE	$10.25	$9.80	$9.25	$8.75	$8.25
347-CC-375	.375 SQ	$10.25	$9.77	$9.35	$8.75	$8.15
347-CC-375-SF	.375 SQ	$9.75	$9.27	$8.85	$8.25	$7.65
347-CC	.500 SQ	$10.25	$9.77	$9.35	$8.75	$8.15
347-CC-SF	.500 SQ	$9.75	$9.27	$8.85	$8.25	$7.65
347-CC-687	.687 SQ	$18.00	$17.25	$16.00	$15.25	$14.75
347-CC-687-SF	.687 SQ	$17.50	$16.75	$15.50	$14.75	$14.25
347-CC-1.000	1.000 SQ	$22.25	$21.25	$20.75	$20.60	$20.45
347-CC-1.000-SF	1.000 SQ	$21.75	$20.75	$20.25	$20.10	$19.95

SMA Flange Mount • Radius Right Angles • Extended Terminal









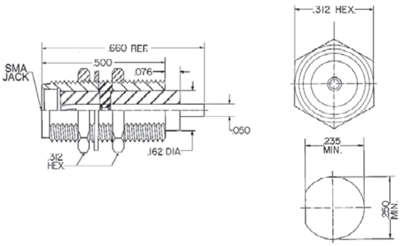
375-CC-(TABULATED) RADIUS RIGHT ANGLE JACK SMA 4 HOLE PANEL MOUNT CAPTIVE CONTACT EXTENDED STRAIGHT TERMINAL

PART NO.	A DIM.	B DIM.	1 - 9	10 - 24	25 - 49	50 - 99	100 +
375-CC-1	.310	.000	$35.50	$33.70	$32.04	$30.45	$27.50
375-CC-2	.074	.000	$35.50	$33.70	$32.04	$30.45	$27.50
375-CC-3	.100	.000	$35.50	$33.70	$32.04	$30.45	$27.50
375-CC-4	.050	.000	$35.50	$33.70	$32.04	$30.45	$27.50
375-CC-5	.250	.000	$35.50	$33.70	$32.04	$30.45	$27.50
375-CC-6	.400	.000	$35.50	$33.70	$32.04	$30.45	$27.50
375-CC-7	.460	.000	$35.50	$33.70	$32.04	$30.45	$27.50
376-CC	.300	.100	$35.50	$33.70	$32.04	$30.45	$27.50
379-CC	.705	.590	$45.00	$41.50	$37.25	$34.50	$31.40

372-1 4 HOLE RADIUS RIGHT ANGLE PLUG PANEL MOUNT EXTENDED STRAIGHT TERMINAL

PART NO.	1 - 9	10 - 24	25 - 49	50 - 99	100 +
372-1	$41.17	$39.06	$37.11	$35.26	$31.73

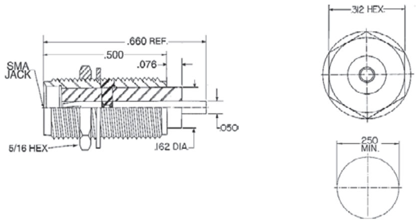
SMA Jack • Bulkhead Mount • Extended Terminal • Captive Contact



PANEL CUTOUT

BULKHEAD FEED THROUGH JACK D
HOLE MOUNT CAPTIVE CONTACT

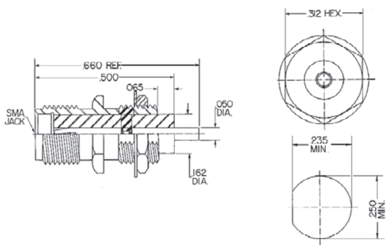
PART NO	1-9	10-24	25-49	50-99	100+
369-CC	$8.50	$8.25	$8.00	$7.75	$7.25
369-CC-SF	$8.00	$7.75	$7.50	$7.25	$6.75



PANEL CUTOUT

BULKHEAD .250 HOLE MOUNT FEED
THROUGH JACK CAPTIVE CONTACT

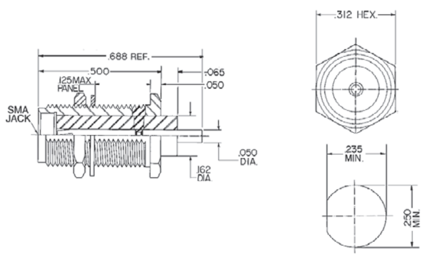
PART NO	1-9	10-24	25-49	50-99	100+
365-CC	$8.00	$7.75	$7.50	$7.25	$6.75
365-CC-SF	$7.50	$7.25	$7.00	$6.75	$6.25



PANEL CUTOUT

BULKHEAD JACK D HOLE MOUNT
CAPTIVE CONTACT

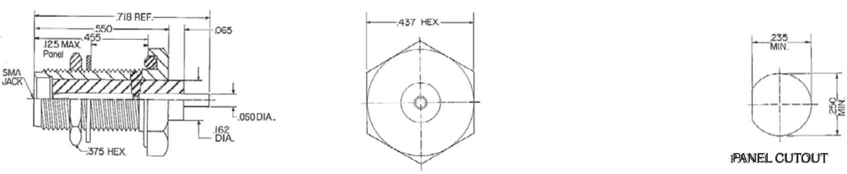
PART NO	1-9	10-24	25-49	50-99	100+
363-CCST	$8.35	$7.95	$7.75	$7.30	$6.80
363-CCST-SF	$7.85	$7.45	$7.25	$6.80	$6.30



PANEL CUTOUT

BULKHEAD FEED THROUGH JACK D
HOLE MOUNT CAPTIVE CONTACT

PART NO	1-9	10-24	25-49	50-99	100+
362-CCST	$7.25	$7.00	$6.75	$6.50	$6.25
362-CCST-SF	$6.75	$6.50	$6.25	$6.00	$5.75

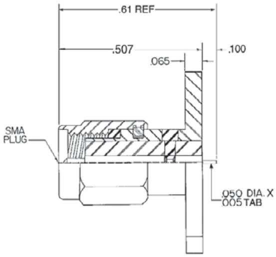


PANEL CUTOUT

BULKHEAD FEED THROUGH JACK D HOLE MOUNT "O" RING CAPTIVE CONTACT

PART NO	1-9	10-24	25-49	50-99	100+
361-CCST	$10.25	$10.00	$9.75	$9.50	$9.25
361-CCST-SF	$9.75	$9.50	$9.25	$9.00	$8.75

SMA • Flange Mount • Tab Terminal • Captive Contact



SMA PLUG TAB

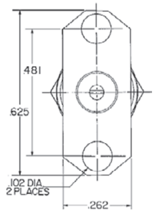


FIG A

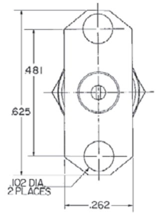


FIG B

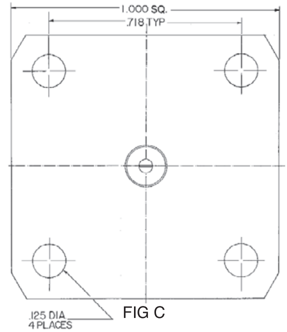
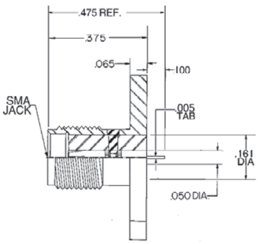


FIG C



SMA JACK TAB

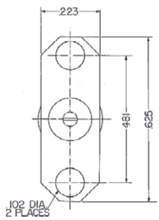


FIG D

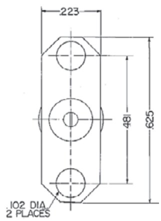


FIG E

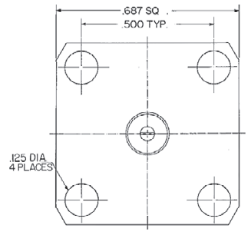


FIG F

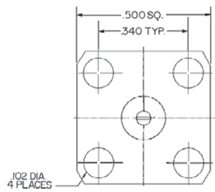


FIG G

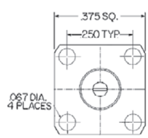


FIG H

349-TABULATED SMA 2 & 4 HOLE PANEL MOUNT TAB TERMINAL

349-CC (TABULATED) SMA PLUG							
PART NO	FLANGE	FIG	1-9	10-24	25-49	50-99	100+
349-2-CC-H	2 HOLE	FIG A	$9.75	$9.27	$8.85	$8.25	$7.55
349-2-CC-V	2 HOLE	FIG B	$9.75	$9.27	$8.85	$8.25	$7.55
349-CC-375	.375 SQ	FIG H	$9.50	$9.05	$8.50	$7.95	$7.35
349-CC	.500 SQ	FIG G	$9.50	$9.05	$8.50	$7.95	$7.35
349-CC-T	.687 SQ	FIG F	$17.50	$16.75	$15.50	$14.75	$14.25
349-CC-N	1.000 SQ	FIG C	$21.75	$20.75	$20.25	$20.10	$19.95

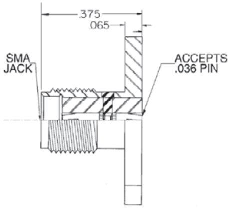
340-TABULATED SMA 2 & 4 HOLE PANEL MOUNT TAB TERMINAL

320-CC-T, 325-CC-T AND 340-CC (TABULATED) SMA JACK							
PART NO.	FLANGE	FIG	1-9	10-24	25-49	50-99	100+
340-2-CC-H	2 HOLE	FIG D	$6.75	$6.50	$6.25	$5.75	$4.75
340-2-CC-V	2 HOLE	FIG E	$6.75	$6.50	$6.25	$5.75	$4.75
340-CC-375	.375 SQ	FIG H	$6.45	$5.81	$5.23	$4.71	$4.24
340-CC	.500 SQ	FIG G	$6.45	$5.81	$5.23	$4.71	$4.24
320-CC-T	.687 SQ	FIG F	$7.45	$6.75	$6.25	$5.75	$5.25
325-CC-T	1.000 SQ	FIG C	$11.75	$10.75	$10.25	$10.10	$9.95

For non-captive contact, passivated stainless finish or brass body with a hard nickel finish body type. consult factory for pricing.

Prices listed effective as of 1 July 2008 and subject to change at any time.

SMA • Flange Mount • Socket Terminal • Captive Contact



310-CC SMA JACK SOCKET TERMINAL

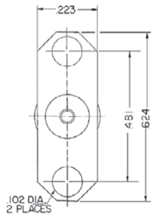


FIG A

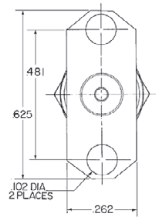
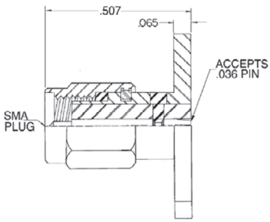


FIG B



312-CC SMA PLUG SOCKET TERMINAL

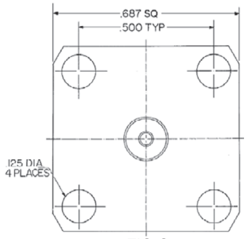


FIG C

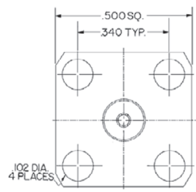


FIG D

310 TABULATED JACK
312 TABULATED PLUG
For non-captive contact, passivated stainless finish or brass body with a hard nickel finish body type. consult factory for pricing.

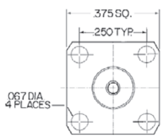


FIG E

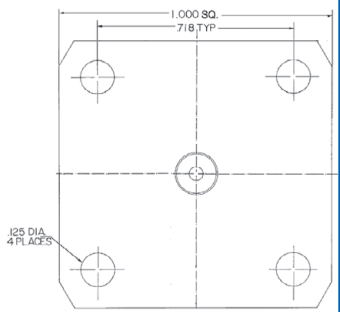
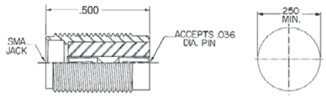


FIG F

310-CC TABULATED SMA JACK SCOKET TERMINAL							
PART NO.	FLANGE SIZE	FIGURE	1-9	10-24	25-49	50-99	100+
310-CC-375	.375 SQ.	FIG-E	$7.25	$7.00	$6.75	$6.25	$5.75
310-CC-2	2 HOLE	FIG-A	$7.50	$7.25	$7.00	$6.50	$6.00
310-CC	.500 SQ.	FIG-D	$7.25	$7.00	$6.75	$6.25	$5.75
310-CC-T	.687 SQ.	FIG-C	$7.95	$7.50	$7.25	$7.00	$6.75
310-CC-N	1.000 SQ.	FIG-F	$12.50	$11.25	$10.50	$10.20	$9.95
312-CC TABULATED SMA PLUG SCOKET TERMINAL							
PART NO.	FLANGE SIZE	FIGURE	1-9	10-24	25-49	50-99	100+
312-CC-375	.375 SQ.	FIG-E	$10.00	$9.50	$9.15	$8.50	$7.85
312-CC-2	2 HOLE	FIG-B	$10.25	$9.75	$9.40	$8.75	$8.10
312-CC	.500 SQ.	FIG-D	$10.00	$9.50	$9.15	$8.50	$7.85
312-CC-T	.687 SQ.	FIG-C	$17.50	$16.75	$15.30	$14.75	$14.25
312-CC-N	1.000 SQ.	FIG-F	$21.75	$20.75	$20.25	$20.10	$19.95

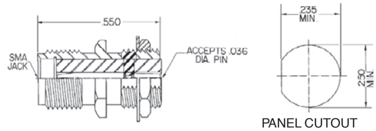
SMA • Bulkhead Mount • Socket Terminal • Captive Contact



PANEL CUTOUT

BULKHEAD FEED THROUGH JACK .250 HOLE MOUNT
CAPTIVE CONTACT DOUBLE SOCKET

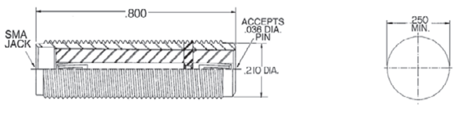
PART NO	1-9	10-24	25-49	50-99	100+
382-05-02	$16.00	$15.45	$14.70	$14.30	$13.40
382-05-02-SF	$15.50	$14.95	$14.20	$13.80	$12.90



PANEL CUTOUT

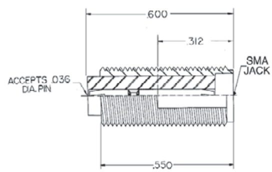
BULKHEAD FEED THROUGH JACK CAPTIVE CONTACT .250
MOUNTING HOLE DOUBLE SOCKET

PART NO	1-9	10-24	25-49	50-99	100+
363-DS	$18.50	$18.25	$16.75	$15.75	$15.00
363-DS-SF	$18.00	$17.75	$16.25	$15.25	$14.50



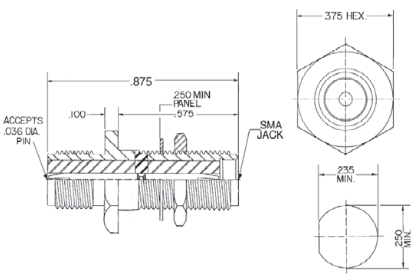
PANEL CUTOUT

382-02-CC BULKHEAD FEED THROUGH JACK CAPTIVE
CONTACT .250 MOUNTING HOLE DOUBLE SOCKET



382-03-CC BULKHEAD FEED THROUGH JACK CAPTIVE
CONTACT .250 MOUNTING HOLE WITH .217 DIM.
ACROSS BOTH FLATS DOUBLE SOCKET

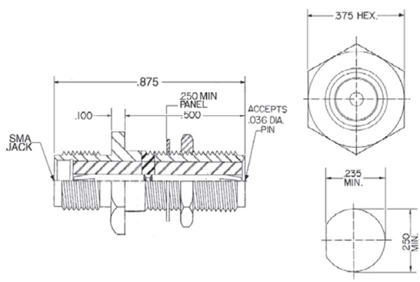
PART NO	1-9	10-24	25-49	50-99	100+
382-02-CC	$18.00	$16.75	$16.00	$15.30	$14.25
382-02-CC-SF	$17.50	$16.25	$15.50	$14.80	$13.75
382-03-CC	$18.00	$16.75	$16.00	$15.30	$14.25
382-03-CC-SF	$17.50	$16.25	$15.50	$14.80	$13.75



PANEL CUTOUT

BULKHEAD D HOLE MOUNT
SMA JACK TO SOCKET ADAPTER
CAPTIVE CONTACT

PART NO	1-9	10-24	25-49	50-99	100+
364-DS-CC	$18.50	$18.25	$16.75	$15.75	$15.00
364-DS-CC-SF	$18.00	$17.75	$16.25	$15.25	$14.50



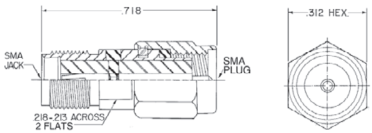
PANEL CUTOUT

BULKHEAD D HOLE MOUNT
SMA JACK TO SOCKET ADAPTER
CAPTIVE CONTACT

PART NO	1-9	10-24	25-49	50-99	100+
364-1-DS-CC	$18.50	$18.25	$16.75	$15.75	$15.00
364-1-DS-CC-SF	$18.00	$17.75	$16.25	$15.25	$14.50

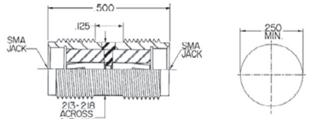
SMA In Series Adapters

* Operating Frequency DC-26.0 GHz



SMA JACK TO SMA PLUG
CAPTIVE CONTACT

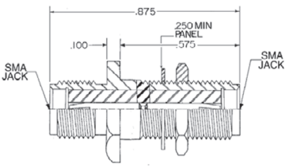
PART NO	1-9	10-24	25-49	50-99	100+
357-CC	$13.25	$13.00	$12.25	$11.75	$10.75
*** 357-CC-26**	$15.25	$15.00	$14.25	$13.75	$12.75
357-CC-SF	$12.75	$12.50	$11.75	$11.25	$10.25
*** 357-CC-SF-26**	$14.75	$14.50	$13.75	$13.25	$12.25

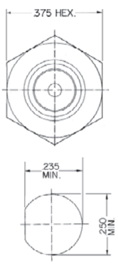


PANEL CUTOUT

SMA JACK TO SMA JACK ADAPTER
CAPTIVE CONTACT

PART NO	1-9	10-24	25-49	50-99	100+
355-CC	$13.25	$13.00	$12.25	$11.75	$10.75
*** 355-CC-26**	$15.25	$15.00	$14.75	$14.25	$13.75
355-CC-SF	$12.75	$12.50	$11.75	$11.25	$10.25
*** 355-CC-SF-26**	$14.75	$14.50	$13.75	$13.25	$12.25

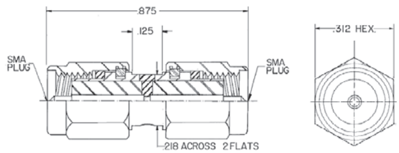




BULKHEAD D HOLE MOUNT
SMA JACK TO SMA JACK ADAPTER
CAPTIVE CONTACT

PANEL CUTOUT

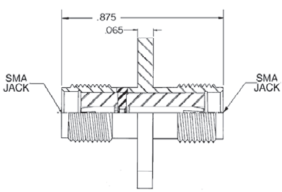
PART NO	1-9	10-24	25-49	50-99	100+
364-CC	$15.00	$14.45	$13.70	$13.30	$12.40
*** 364-CC-26**	$17.00	$16.45	$15.70	$15.30	$14.40
364-CC-SF	$14.50	$13.95	$13.20	$12.80	$11.90
*** 364-CC-SF-26**	$16.50	$15.95	$15.20	$14.80	$13.90

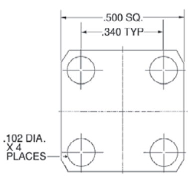


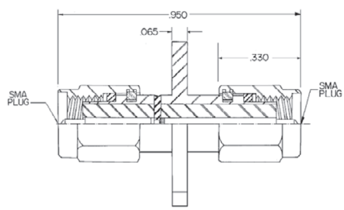
SMA PLUG TO SMA PLUG
ADAPTER CAPTIVE CONTACT

PART NO	1-9	10-24	25-49	50-99	100+
356-CC	$13.25	$13.00	$12.25	$11.75	$10.75
*** 356-CC-26**	$15.25	$15.00	$14.25	$13.75	$12.75
356-CC-SF	$12.75	$12.50	$11.75	$11.25	$10.25
*** 356-CC-SF-26**	$14.75	$14.50	$13.75	$13.25	$12.25

Operating Frequency DC-18.0 GHz







355-CCFL
SMA FEMALE TO SMA FEMALE
CAPTIVE CONTACT .500 4 HOLE FLANGE

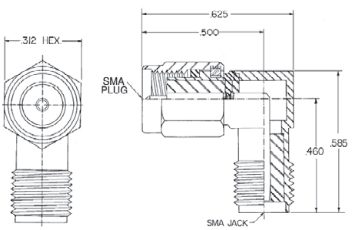
356-CCFL
SMA MALE TO SMA MALE
CAPTIVE CONTACT .500 4 HOLE FLANGE

PART NO	1-9	10-24	25-49	50-99	100+
355-CCFL	$18.00	$16.75	$16.00	$15.30	$14.00
355-CCFL-SF	$17.50	$16.25	$15.50	$14.80	$13.50
356-CCFL	$29.40	$28.15	$27.00	$26.25	$25.40
356-CCFL-SF	$28.90	$27.65	$26.50	$25.75	$24.90

United Microwave Products Inc.
Direct Sales, Tech Support and Current Order Status
 22129 S.Vermont Ave. Torrance CA. 90502 Phone (310) 320-1244 Fax (310) 320-9729 Email umpinc@pacbell.net

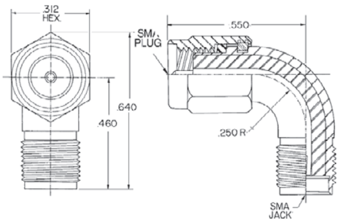
Prices listed effective as of 1 July 2008 and subject to change at any time.

SMA In Series Adapters



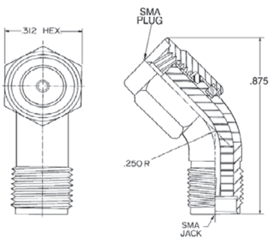
RIGHT ANGLE SMA PLUG TO SMA JACK ADAPTER CAPTIVE CONTACT

PART NO	1-9	10-24	25-49	50-99	100+
357-RA	$19.75	$18.50	$18.00	$17.50	$16.00
357-RA-SF	$18.75	$17.50	$17.00	$16.50	$15.00



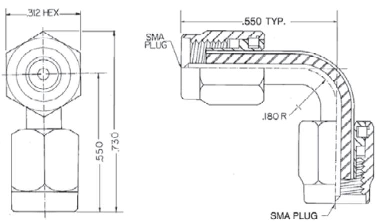
RADIUS RIGHT ANGLE SMA PLUG TO SMA JACK ADAPTER

PART NO	1-9	10-24	25-49	50-99	100+
370	$29.25	$27.50	$26.00	$24.25	$23.50
370-26	$38.50	$35.25	$32.50	$30.00	$28.25
370-SF	$28.25	$26.50	$25.00	$23.25	$22.50
370-SF-26	$37.50	$34.25	$31.50	$29.00	$27.25



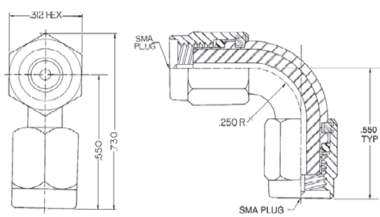
45° ANGLE SMA PLUG TO SMA JACK ADAPTER

PART NO	1-9	10-24	25-49	50-99	100+
370-45	$43.75	$40.50	$38.25	$35.50	$30.50
370-45-SF	$42.75	$39.50	$37.25	$34.50	$29.50



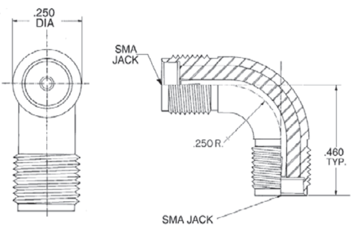
RADIUS RIGHT ANGLE
SMA PLUG TO SMA PLUG ADAPTER 141 SEMI-RIGID TYPE

PART NO	1-9	10-24	25-49	50-99	100+
AA-141-550	$28.50	$26.75	$25.25	$23.50	$22.75



RADIUS RIGHT ANGLE SMA PLUG TO SMA PLUG ADAPTER

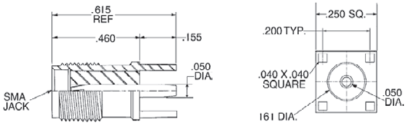
PART NO	1-9	10-24	25-49	50-99	100+
370-M	$32.75	$30.50	$29.25	$27.50	$26.25
370-M-SF	$31.75	$29.50	$28.25	$26.50	$25.25



RADIUS RIGHT ANGLE SMA JACK TO SMA JACK ADAPTER

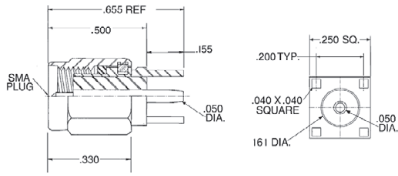
PART NO	1-9	10-24	25-49	50-99	100+
370-F	32.75	$30.50	$29.25	$27.50	$26.25
370-F-SF	$31.75	$29.50	$28.25	$26.50	$25.25

SMA PC Mount Receptacles



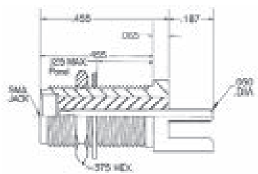
SMA FEMALE PC MOUNT

PART NO	1-9	10-24	25-49	50-99	100+
328PC	$8.75	$8.50	$8.00	$7.50	$7.25

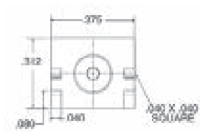


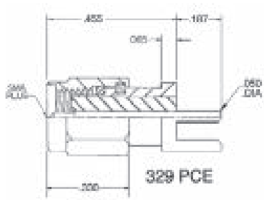
SMA MALE PC MOUNT

PART NO	1-9	10-24	25-49	50-99	100+
329PC	$10.75	$10.50	$10.00	$9.75	$9.50



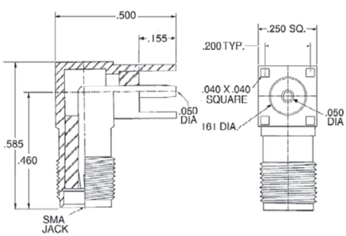
SMA FEMALE LAUNCHER MOUNT





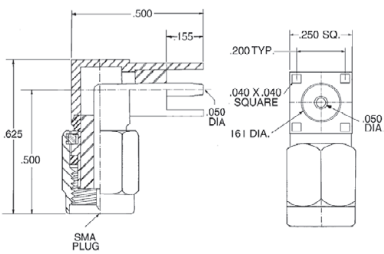
SMA MALE LAUNCHER MOUNT

PART NO	1-9	10-24	25-49	50-99	100+
328PCE	$9.75	$9.50	$9.00	$8.50	$8.25
329PCE	$11.75	$11.50	$11.00	$10.75	$10.50



SMA FEMALE RIGHT ANGLE PC MOUNT

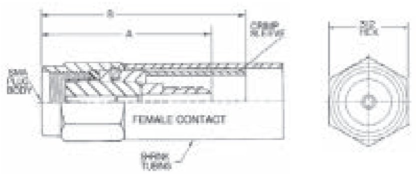
PART NO	1-9	10-24	25-49	50-99	100+
315PC	$10.75	$10.50	$10.00	$9.50	$8.75



SMA MALE RIGHT ANGLE PC MOUNT

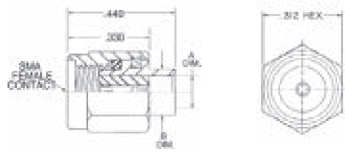
PART NO	1-9	10-24	25-49	50-99	100+
315PCM	$12.75	$12.50	$12.25	$12.00	$11.75

Reverse Polarity SMA Connectors Per FCC Part 15.203 Requirement



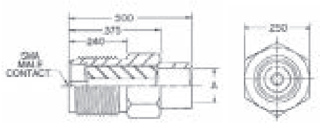
POLARIZED 352 SMA
MALE BODY SMA FEMALE CONTACT FLEXIBLE CABLE

PART NO.	CABLE	A DIM.	B DIM.	1 - 9	10 - 24	25 - 49	50 - 99	100 +
352-1 PZ	RG-55/U,142, 223	.690	.945	$8.49	$7.99	$7.49	$6.99	$6.49
352-2 PZ	RG-58/U,141, 303, 400	.690	.945	$8.49	$7.99	$7.49	$6.99	$6.49
352-3 PZ	RG-174/U, 179, 187, 188, 316	.655	.815	$8.49	$7.99	$7.49	$6.99	$6.49



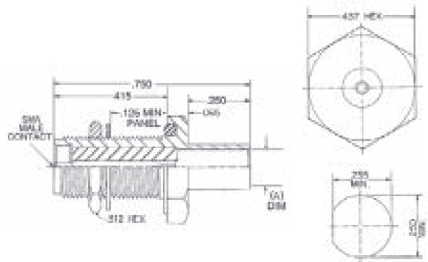
300 & 301 POLARIZED SMA
MALE BODY SMA FEMALE CONTACT SEMI RIGID

PART NO	A DIM	B DIM	CABLE	1-9	10-24	25-49	50-99	100+
300-7 PZ	.143	.187	141	$5.75	$5.50	$5.25	$5.00	$4.75
301-1 PZ	.087	.120	085	$5.75	$5.50	$5.25	$5.00	$4.75
301-3 PZ	.049	.120	047	$19.25	$18.50	$17.75	$17.25	$16.75



302 POLARIZED SMA
FEMALE BODY MALE CONTACT SEMI RIGID

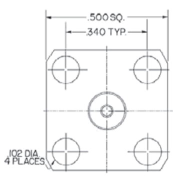
PART NO	A DIM	CABLE	1-9	10-24	25-49	50-99	100+
302 PZ	.143	.141 SR	$8.50	$8.25	$8.00	$7.75	$7.50
302-1 PZ	.0875	.085 SR	$8.50	$8.25	$8.00	$7.75	$7.50
302-3 PZ	.049-.052	.047 SR	$19.25	$18.50	$17.75	$17.25	$16.75



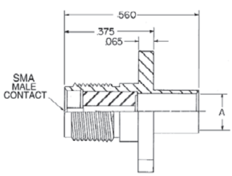
PANEL CUTOUT

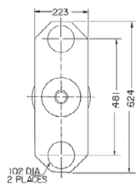
304 POLARIZED SMA
FEMALE BODY SMA MALE CONTACT SEMI RIGID

PART NO	A DIM	CABLE	1-9	10-24	25-49	50-99	100+
304 PZ	.143	.141 SR	$9.25	$9.00	$8.75	$8.50	$8.25
304-1 PZ	.0875	.085 SR	$9.25	$9.00	$8.75	$8.50	$8.25
304-3 PZ	.049-.052	.047 SR	$25.50	$24.50	$24.25	$24.00	$23.25



303 POLARIZED SMA 4 HOLE
FEMALE BODY SMA MALE CONTACT SEMI RIGID

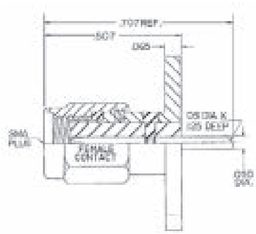


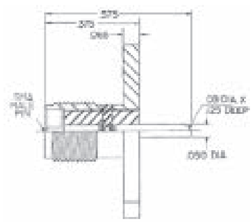


307 POLARIZED SMA 2 HOLE
FEMALE BODY SMA MALE CONTACT SEMI RIGID

PART NO	A DIM	CABLE	1-9	10-24	25-49	50-99	100+
303 PZ	.143	.141	$10.25	$10.00	$9.75	$9.50	$9.25
303-1 PZ	.0875	.085	$10.25	$10.00	$9.75	$9.50	$9.25
303-2 PZ	.048	.047	$11.25	$11.00	$10.75	$10.50	$10.25
307 PZ	.143	.141	$10.75	$10.50	$10.25	$10.00	$9.75
307-1 PZ	.0875	.085	$10.75	$10.50	$10.25	$10.00	$9.75
307-3 PZ	.048	.047	$13.75	$13.50	$13.25	$13.00	$12.75

Reverse Polarity SMA Connectors Per FCC Part 15.203 Requirement





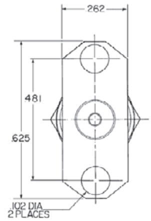


FIG-C

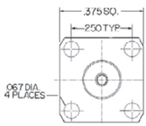


FIG-D

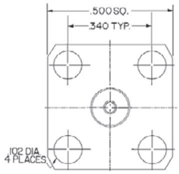


FIG-E

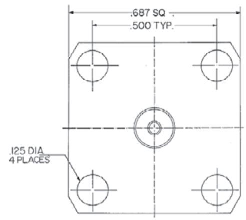


FIG-F

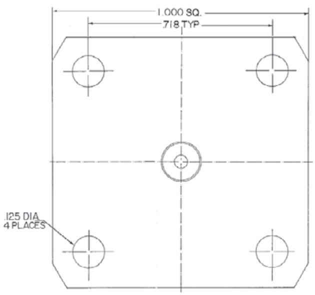
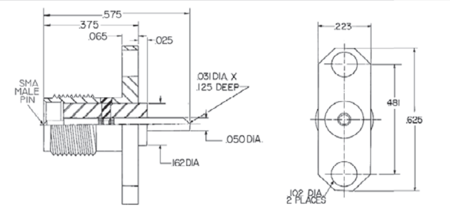


FIG-G



341-CC-PZ 2 HOLE FLANGE MOUNT JACK SOLDER POT TERMINAL MALE CAPTIVE CONTACT

FIG-H

TABULATED, VARIOUS FLANGE MOUNT JACK SOLDER POT TERMINAL CAPTIVE CONTACT

345CC FIG A (SMA PLUG)							
PART NO.	FLANGE SIZE	FIGURE	1-9	10-24	25-49	50-99	100+
345-CC-375-PZ	.375 SQ	FIG D	$10.50	$10.05	$9.50	$8.95	$8.35
345-CC-2H-PZ	2 HOLE	FIG C	$11.25	$10.80	$10.25	$9.75	$9.25
345-CC-PZ	.500 SQ	FIG E	$10.50	$10.05	$9.50	$8.95	$8.35
345-SCC-PZ	.687 SQ	FIG F	$18.50	$17.75	$16.50	$15.75	$15.25
345-2CC-PZ	1.000 SQ	FIG G	$22.75	$21.75	$21.25	$21.10	$20.95
337CC FIG B (SMA JACK)							
PART NO.	FLANGE SIZE	FIGURE	1-9	10-24	25-49	50-99	100+
337CC-375-PZ	.375 SQ	FIG D	$6.45	$5.81	$5.23	$4.71	$4.24
341-CC-PZ	2 HOLE	FIG H	$6.95	$6.30	$5.85	$5.30	$4.75
337CC-PZ	.500 SQ	FIG E	$6.45	$5.81	$5.23	$4.71	$4.24
320CC-S-PZ	.687 SQ	FIG F	$7.45	$6.75	$6.25	$5.75	$5.25
325CC-S-PZ	1.000 SQ	FIG G	$11.75	$10.75	$10.25	$10.10	$9.95

For non-captive contact, delete the "CC" designator.
Add the suffix SF for passivated stainless finish.
Suffix BR for brass body with a Hard Nickel Finish.

BR (brass body) unavailable for
ALL SMA MALE (PLUG) CONNECTORS!

ALL PRICES STATED ARE FOR GOLD FINISH PLEASE CONSULT FACTORY FOR BRASS OR STAINLESS FINISH BODY STYLE

TNC Connectors

The TNC series connector was originally designed offering threaded coupling nut mating in lieu of the popular BNC bayonet-type coupling. TNC connectors offer superior electrical performance, higher frequency range the ability to withstand severe shock and vibration requirements.

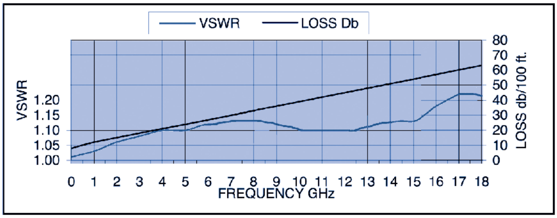
Using cutting edge microwave technology, United Microwave Products has improved the original TNC connector designs by maintaining minimal disturbance or change in characteristic impedance, reducing tolerance extremes, and using materials such as stainless steel to provide the utmost in mechanical integrity.

United Microwave TNC connectors are composed of nickel plated brass. However, our TNC connectors are available in passivated stainless steel if desired. Also, they are designed to be free of higher order mode resonance.

All precision TNC connectors will intermate with the MIL-C-39012 interface, conform to Air Force MIL-C-104, ASNAE-68-38A and Navy MIL-T-81490 specifications.

Figure 2.1

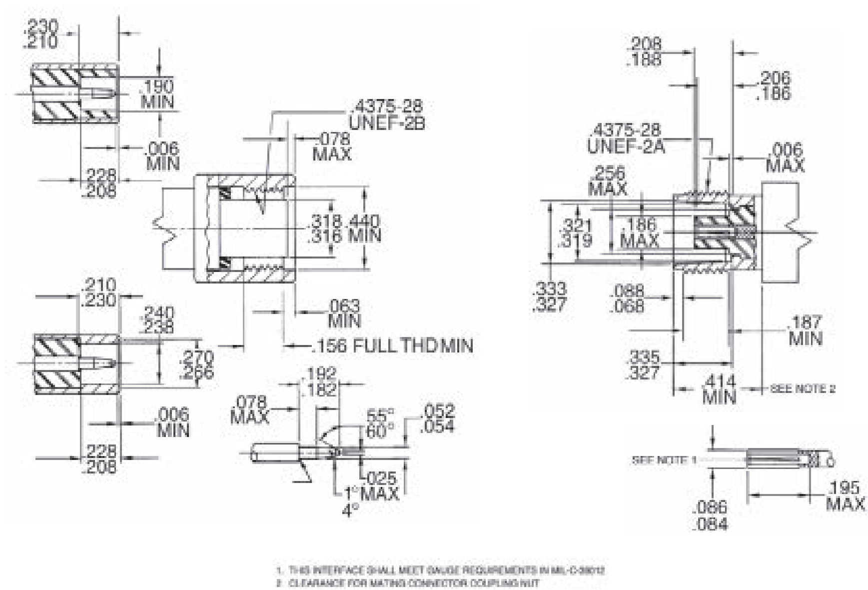
Figure 2.2



GG-165-01.00.0 TNC MALE to TNC MALE ONE FOOT MICROFLEX 165 CABLE

Figure 2.3

TNC Interface Dimensions Per MIL-C-39012



TNC Specifications Per MIL-C-39012

REQUIREMENT	MIL-C-39012 PARA	SPECIFICATIONS
MATERIAL	3.3	Steel corrosion resistant per QQ-S-763, class 303, Beryllium Copper per QQ-C-530 condition HT Silicone Rubber per ZZ-R-765, class II B, Grade 65-75 TFE Fluorocarbon per L-P-403 Soft copper per QQ-B-825
FINISH	3.31	Center contacts: 0.00005 min. gold per MIL-G-45204 type II Grade C over 0.0001 min. copper per MIL-C-14550. Other Metal parts: Sufficient to meet corrosion requirements PARA 3.14 of MIL-C-39012.
DESIGN	3.4	Mating dimensions are in accordance with Figure 2.3
INSULATION RESISTANCE	3.11	10,000 MEGOHMS minimum per MIL-STD-202, Method 302.
DIELECTRIC WITHSTANDING VOLTAGE AND RF HIGH POTENTIAL	3.18	MIL-STD 202, Method 301. CABLES / VRMS @ 60CPS / VRMS @5MHz RG-58, 142, 223, 303, .141.S, R, / 1,500 / 1,000 RG-122, 174, 179, 316 & .085 SR. / 750 / 500
CONTACT RESISTANCE (Millivolt Drop)	317	Maximum millivolt drop Initial / After Center Contact 1.5 / 2.1 Outer Contact 2.0 / Not applicable Braid to Body 0.5 / Not applicable
VOLTAGE STANDING WAVE RATIO (VSWR)	3.14	Straight Plugs and Jacks CABLES / VSWR RG- 122, 174, 179 & 316 / 1.15+0.02 (F) GHz RG-58, 142, 223 & 303 / 1.15+0.01 (F) GHz 085 DIA. S.R. (RG-405) / 1.15+0.01 (F) GHz .141 DIA. S.R. (RG-402) / 1 .05+0.005 (F) GHz Right Angle Plugs and Jacks CABLES / VSWR RG- 122, 174, 179 & 316 / 1.15+0.03 (F) GHz RG-58, 142, 223 & 303 / 1.15+0.02 (F) GHz 085 DIA. S.R. (RG-405) / 1.15+0.015 (F) GHz .141 DIA. S.R. (RG-402) / 1 .05+0.01 (F) GHz
INSERTION LOSS	3.29	Straight plugs and jacks, dB Max. = .05 x√GHz Freq. Right Angle plugs, dB Max. = .15x√GHz Freq.
FORCE TO ENGAGE AND DISENGAGE	3.51	Longitudinal force is not applicable. torque 2 in-lbs. maximum.
COUPLING NUT PROOF TORQUE	3.27	30 inch-pounds minimum.

TNC Specifications Per MIL-C-39012

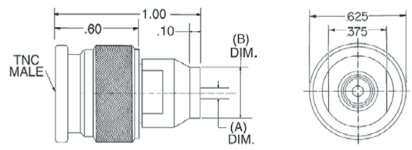
REQUIREMENT	MIL C 39012 PARA	SPECIFICATIONS
CONNECTOR DURABILITY	3.16	Insertion and withdrawal **500** cycles minimum. Maximum rate of 12 Cycles Per Minute. Connector shall show no evidence of mechanical failure and shall meet the mating characteristics requirements of MIL-C-39012,PARA 3.26
CABLE RETENTION FORCE	3.26	See Table I

TABLE 1 -Cable retention force.

Cable dielectric Outer diameter	Non crimp Single braid		Crimp Single braid	
	Center contact		Center contact	
Inches (max)	Captive Pounds (max)	Non Captive Pounds (max)	Captive Pounds (max)	Non Captive Pounds (max)
,066	25	20	25	20
,110	35	30	35	30
,122	45	40	45	40

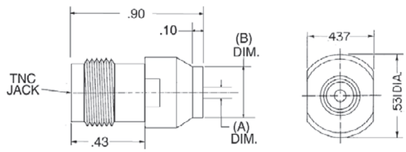
REQUIREMENT	MIL C 39012 PARA	SPECIFICATIONS
MATING CHARACTERISTICS	3.7	Contacts with spring members Center contact (female) **Oversize test pin** - .055 minimum diameter **Test pin finish** - 16 **Insertion depth** - .1250 **Number of insertions** - 1 **Insertion force test: Steel test pin Diameter** - .0540 minimum **Insertion depth** - .1250 **Test pin finish** - 16 **Insertion force** - 2 lbs. maximum **Withdrawal force test: Steel test pin Diameter** - .052 maximum **Insertion depth** - .1250 **Withdrawal force** - 2 Ounce minimum **Test pin finish** - 16
VIBRATION	3.18	MIL-STD-202, method 204, test condition B. No discontinuities.
SHOCK	3.19	MIL-STD-202, method 213, test condition I. No discontinuities.
THERMAL SHOCK	3.20	Refer to applicable military slash sheet or consult factory.
CORROSION SALT SPRAY	3.13	MIL-STD-202, method 101, test condition **B,** the salt solution shall be 5 percent.
MOISTURE RESISTANCE	3.23	MIL-STD-202, method 106. Insulation 200 MEGOHMS min. within 5 minutes after removal from humidity.
CABLE RETENTION	3.24	Refer to applicable military slash sheet or consult factory.
CORONA LEVEL	3.22	Refer to applicable military slash sheet or consult factory.

TNC Connectors to Semi Rigid Cables



TNC STRAIGHT CABLE PLUG DIRECT SOLDER

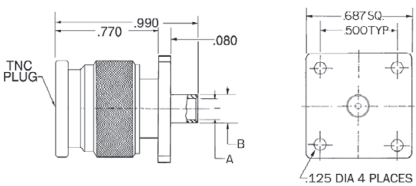
PART NO.	CABLE	(A) DIM	(B) DIM	1-9	10-24	25-49	50-99	100+
516-087	RG-405	.089	.12	$17.50	$16.00	$15.25	$14.50	$13.75
516-141	RG-402	.145	.18	$17.50	$16.00	$15.25	$14.50	$13.75



TNC STRAIGHT CABLE JACK DIRECT SOLDER

PART NO.	CABLE	(A) DIM	(B) DIM	1-9	10-24	25-49	50-99	100+
517-087	RG-405	.089	.12	$18.50	$17.00	$16.25	$15.50	$14.75
517-141	RG-402	.145	.18	$18.50	$17.00	$16.25	$15.50	$14.75

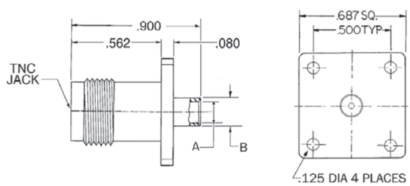
FLANGE MOUNT ALSO AVABLE WITH #3-56
THREADS CONTACT FACTORY FOR DETAILS



TNC 4 HOLE CABLE JACK DIRECT SOLDER

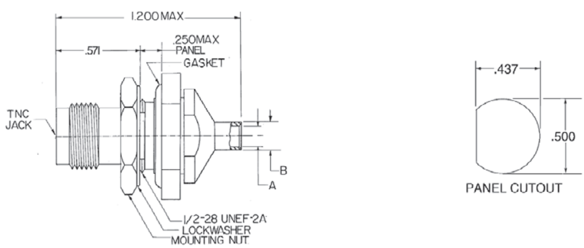
PART NO.	CABLE	(A) DIM	(B) DIM	1-9	10-24	25-49	50-99	100+
530M-087	RG-405	.089	.12	$34.00	$32.00	$31.00	$29.00	$26.00
530M-141	RG-402	.145	.18	$34.00	$32.00	$31.00	$29.00	$26.00

FLANGE MOUNT ALSO AVABLE WITH #3-56
THREADS CONTACT FACTORY FOR DETAILS



TNC 4 HOLE FLANGE STRAIGHT CABLE JACK DIRECT SOLDER

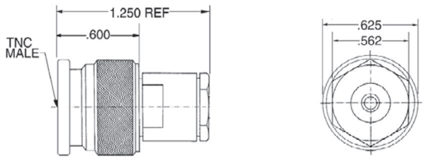
PART NO.	CABLE	(A) DIM	(B) DIM	1-9	10-24	25-49	50-99	100+
530-1	RG-405	.089	.12	$24.75	$22.50	$21.25	$19.00	$17.50
530-2	RG-402	.145	.18	$24.75	$22.50	$21.25	$19.00	$17.50



TNC BULKHEAD FEED THROUGH CABLE JACK DIRECT SOLDER

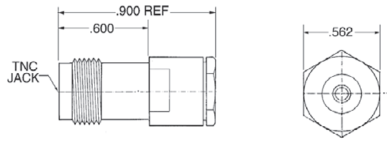
PART NO.	CABLE	(A) DIM	(B) DIM	1-9	10-24	25-49	50-99	100+
531-1	RG-405	.089	.12	$19.50	$18.00	$17.00	$15.50	$14.00
531-2	RG-402	.145	.18	$19.50	$18.00	$17.00	$15.50	$14.00
531-1SF (STAINLESS BODY)	RG-405	.089	.12	$39.00	$37.50	$36.00	$34.00	$31.50
531-2SF (STAINLESS BODY)	RG-402	.145	.18	$39.00	$37.50	$36.00	$34.00	$31.50

TNC Connectors Solder Crimp Clamp



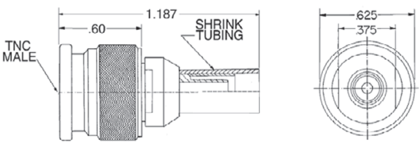
TNC STRAIGHT CABLE PLUG CLAMP

PART NO.	CABLE	1-9	10-24	25-49	50-99	100+
528-1 CLP	RG-188, 316	$12.50	$12.25	$11.50	$11.00	$10.50
528-2 CLP	RG-55, 58, 141, 142, 223, 303	$12.50	$12.25	$11.50	$11.00	$10.50



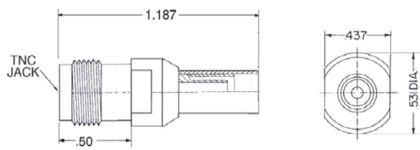
TNC STRAIGHT CABLE JACK CLAMP

PART NO.	CABLE	1-9	10-24	25-49	50-99	100+
529-1 CLP	RG-188, 316	$21.50	$20.25	$19.50	$18.75	$18.00
529-2 CLP	RG-55, 58, 141, 142, 223, 303	$21.50	$20.25	$19.50	$18.75	$18.00



TNC STRAIGHT CABLE PLUG SOLDER\CRIMP

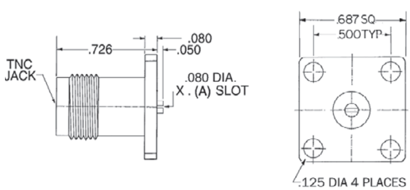
PART NO.	CABLE	1-9	10-24	25-49	50-99	100+
528-1	RG-188, 316	$14.50	$14.25	$13.50	$13.00	$12.50
528-2	RG-55, 58, 141, 142, 223, 303	$14.50	$14.25	$13.50	$13.00	$12.50



TNC STRAIGHT CABLE JACK SOLDER\CRIMP

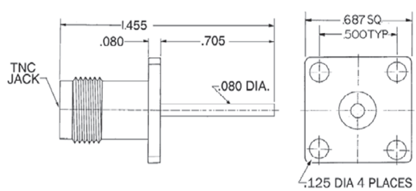
PART NO.	CABLE	1-9	10-24	25-49	50-99	100+
529-1	RG-188, 316	$21.50	$20.25	$19.50	$18.75	$18.00
529-3	RG-55, 58, 142, 223, 303, 400	$21.50	$20.25	$19.50	$18.75	$18.00

TNC Panel Mount Receptacles



TNC JACK FLANGE MOUNT RECEPTACLE SLOT

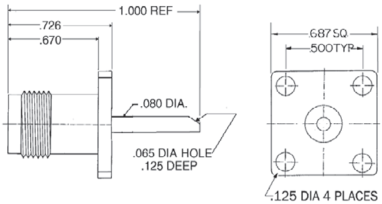
PART NO.	SLOT WITH	1-9	10-24	25-49	50-99	100+
562-1	.012	$12.45	$11.75	$10.50	$9.75	$9.10
562-2	.018	$12.45	$11.75	$10.50	$9.75	$9.10
562-3	.028	$12.45	$11.75	$10.50	$9.75	$9.10



TNC JACK FLANGE MOUNT RECEPTACLE

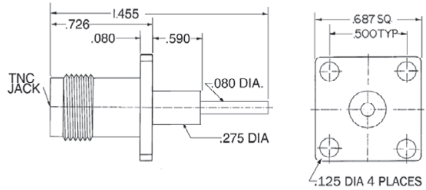
PART NO.	1-9	10-24	25-49	50-99	100+
527S	$12.45	$11.75	$10.50	$9.75	$9.10

TNC Panel Mount Receptacles



TNC JACK FLANGE MOUNT RECEPTACLE SOLDER POT

PART NO.	1-9	10-24	25-49	50-99	100+
532	$12.45	$11.75	$10.50	$9.75	$9.10

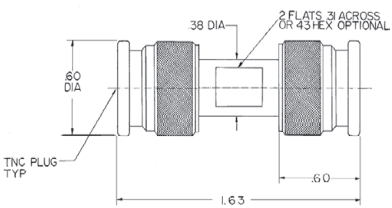


TNC JACK FLANGE MOUNT
RECEPTACLE EXTENDED INSULATOR & TERMINAL

PART NO.	1-9	10-24	25-49	50-99	100+
513	$12.45	$11.75	$10.50	$9.75	$9.10

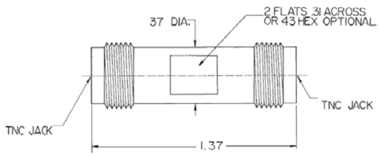
TNC In Series Adapters

These Precision Adapters are Furnished With Stainless Steel Bodies Operating Range DC-18GHz



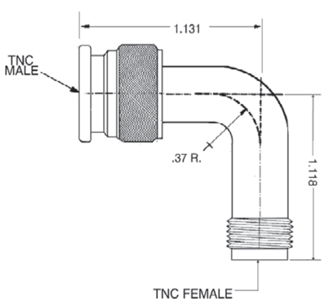
TNC PLUG TO TNC PLUG

PART NO.	1-9	10-24	25-49	50-99	100+
1830	$36.50	$34.50	$33.00	$31.00	$28.00



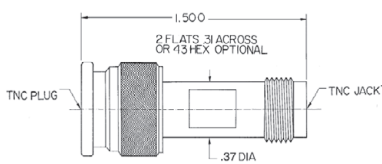
TNC JACK TO TNC JACK

PART NO.	1-9	10-24	25-49	50-99	100+
1810	$36.50	$34.50	$33.00	$31.00	$28.00



TNC PLUG TO TNC JACK RADIUS RIGHT ANGLE

PART NO.	1-9	10-24	25-49	50-99	100+
6421	$115.45	$106.00	$98.00	$92.00	$85.00



TNC JACK TO TNC PLUG CONNECTOR SAVER

PART NO.	1-9	10-24	25-49	50-99	100+
1820	$36.50	$34.50	$33.00	$31.00	$28.00

Type "N" Connectors

The type N series coaxial connectors were originally designed as medium-size low voltage constant impedance 50 OHM connectors. Type N connectors found immediate popularity for microwave applications because of the 7 mm size air-filled mating interface. United Microwave Products has developed a complete line of precision type N series connectors. Constructed of stainless steel, Teflon dielectrics, and gold plated beryllium copper center contacts, these precision N connectors will mate nondestructively to the standard MIL-C-39012 interface.

Additionally, United Microwave Products has extended the upper operating frequency to 18.0 GHz as compared to 11.0 GHz offered in MIL-C-39012. These precision type N connectors are offered for both semi-rigid and flexible cables, panel mount receptacles, in-series adapters, and strip-line transmission applications. Panel mount N connectors are available in both nickel plated brass & passivated stainless steel.

Figure 3.1

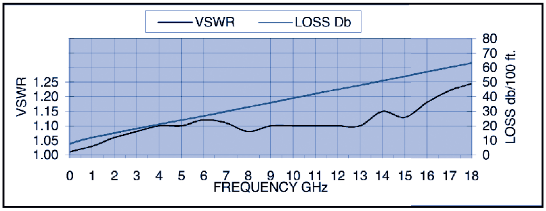
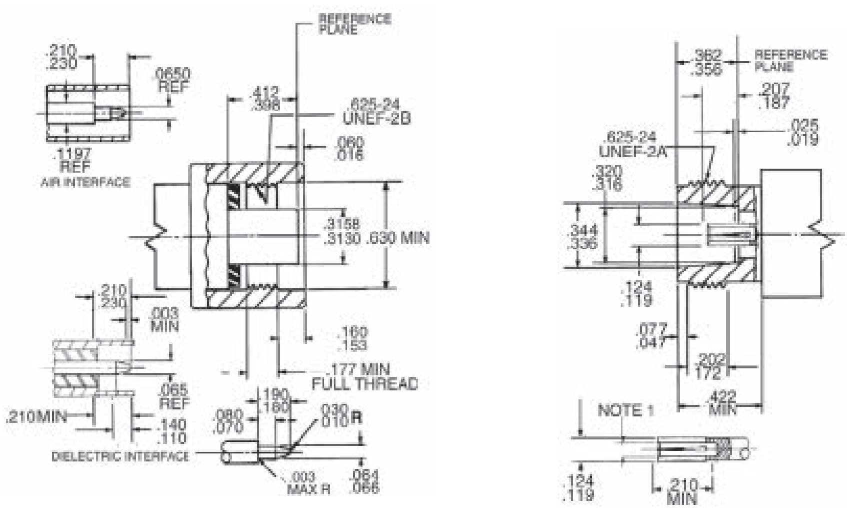


Figure 3.2 OO-165 -01.00.0 "N" MALE to "N" MALE ONE FOOT MICROFLEX 165 CABLE

Figure 3.3

Type "N" Interface Dimensions



NOTES:

1. ID TO MEET VSWR AND CONTACT RESISTANCE WHEN MATED WITH .0630/.0660 DIA PIN
2. WHEN FULLY ENGAGED, THE TWO REFERENCE PLANES MUST COINCIDE WITH METAL TO METAL CONTACT.

N Specifications Per MIL-C-39012

REQUIREMENT	MIL-C-39012 PARA	SPECIFICATIONS
MATERIAL	3.3	Steel corrosion resistant per QQ-S-763, class 303, Beryllium Copper per QQ-C-530 condition HT Silicone Rubber per ZZ-R-765, class II B, Grade 65-75 TFE Fluorocarbon per L-P-403 Soft copper per QQ-B-825
FINISH	3.31	Center contacts: 0.00005 min. gold per MIL-G-45204 type II Grade C over 0.0001 min. copper per MIL-C-14550. Other Metal parts: Sufficient to meet corrosion requirements PARA 3.14 of MIL-C-39012.
DESIGN	3.4	Mating dimensions are in accordance with page 33 Figure 3.3 of this catalog
INSULATION RESISTANCE	3.11	10,000 MEGOHMS minimum per MIL-STD-202, Method 302.
DIELECTRIC WITHSTANDING VOLTAGE AND RF HIGH POTENTIAL	3.18	MIL-STD 202, Method 301.

CABLES	VRMS @ 60CPS	VRMS @5MHz
RG-214, 225 & 393	2500	1500
RG-58, 142, 223, 303 & .141 S.R.	1,500	1000
RG-122, 174, 179, 316 & .085.S.R.	750	500

REQUIREMENT	MIL-C-39012 PARA	SPECIFICATIONS
CONTACT RESISTANCE (Millivolt Drop)	3.17	Maximum millivolt drop

Initial	After
Center Contact 1.5	2.5
Outer Contact 2.0	Not applicable
Braid to Body 0.5	Not applicable

REQUIREMENT	MIL-C-39012 PARA	SPECIFICATIONS
VOLTAGE STANDING WAVE RATIO (VSWR)	3.14	Straight Plugs and Jacks

CABLES	VSWR	
RG-214, 225 & 393	1.20+.025	(F) GHz
RG- 122, 174, 179 & 316	1.15+0.02	(F) GHz
RG-58, 142, 223 & 303	1.15+0.01	(F) GHz
085 DIA. S.R. (RG-405)	1.15+0.01	(F) GHz
.141 DIA. S.R. (RG-402)	1 .05+0.005	(F) GHz
Right Angle Plugs and Jacks		
RG- 214, 225 & 393	1.20+0.03	(F) GHz
RG- 122, 174, 179 & 316	1.15+0.03	(F) GHz
RG-58, 142, 223 & 303	1.15+0.02	(F) GHz
085 DIA. S.R. (RG-405)	1.15+0.015	(F) GHz
.141 DIA. S.R. (RG-402)	1 .05+0.01	(F) GHz

REQUIREMENT	MIL-C-39012 PARA	SPECIFICATIONS
INSERTION LOSS	3.29	Straight plugs and jacks, dB Max. = .05 x√GHz Freq. Right Angle plugs, dB Max. = .15x√GHz Freq.
FORCE TO ENGAGE AND DISENGAGE	3.51	Longitudinal force is not applicable. torque 2 in-lbs. maximum.
COUPLING NUT PROOF TORQUE	3.6	30 inch-pounds minimum.

N Specifications Per MIL-C-39012

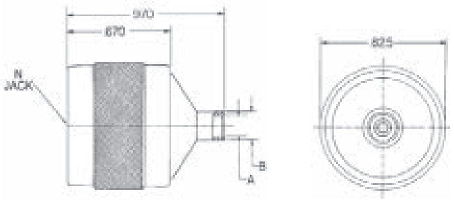
REQUIREMENT	MIL C 39012 PARA	SPECIFICATIONS
CONNECTOR DURABILITY	3.16	Insertion and withdrawal **500** cycles minimum. Maximum rate of 12 Cycles Per Minute. Connector shall show no evidence of mechanical failure and shall meet the mating characteristics requirements of MIL-C-39012,PARA 3.26
CABLE RETENTION FORCE	3.26	See Table I

TABLE 1 -Cable retention force.

Cable dielectric Outer diameter	Non crimp Single braid		Crimp Single braid	
	Center contact		Center contact	
Inches (max)	Captive Pounds (max)	Non Captive Pounds (max)	Captive Pounds (max)	Non Captive Pounds (max)
.036	13	10	13	10
.066	25	20	25	20
.110	35	30	35	30
.122		40	45	40

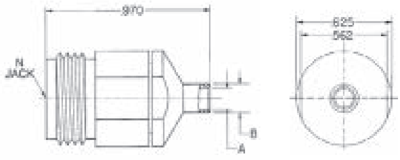
MATING CHARACTERISTICS	**3.7**	Contacts with spring members Center contact (female) Oversize test pin - **.0670 inch** minimum diameter Test pin finish - **16** Insertion depth - **.1250 inch** Number of insertions - **3** Insertion force test: Steel test pin Diameter - **.065** minimum diameter Insertion depth - **.1250 inch** Test pin finish - **16** Insertion force - **3 pounds** maximum Withdrawal **force test: Steel test** pin Diameter - **.064** maximum diameter Insertion depth - **.1250** Withdrawal force - **1 Ounce** minimum Test pin finish - **16**
VIBRATION	**3.18**	MIL-STD-202, method 204, test condition B. No discontinuities.
SHOCK	**3.19**	MIL-STD-202, method 213, test condition I. No discontinuities.
THERMAL SHOCK	**3.20**	Refer to applicable military slash sheet or consult factory.
CORROSION SALT SPRAY	**3.13**	MIL-STD-202, method 101, test condition **B,** the salt solution shall be 5 percent.
MOISTURE RESISTANCE	**3.23**	MIL-STD-202, method 106. Insulation 200 MEGOHMS min. within 5 minutes after removal from humidity.
CABLE RETENTION	**3.24**	Refer to applicable military slash sheet or consult factory.
CORONA LEVEL	**3.22**	Refer to applicable military slash sheet or consult factory.

"N" Connectors to Semi Rigid Cables



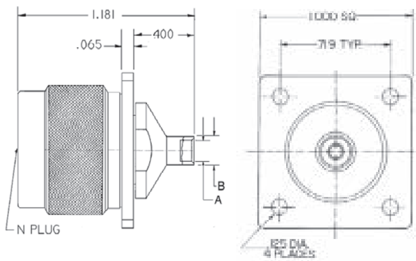
N PLUG STRAIGHT CABLE DIRECT SOLDER

PART NO.	CABLE	(A) DIM	(B) DIM	1-9	10-24	25-49	50-99	100+
1523-1	RG-402	.145	.18	$12.50	$11.75	$10.75	$9.75	$9.50
1523-1SF	RG-402	.145	.18	$15.50	$14.75	$13.75	$12.75	$12.50
1523-2	RG-405	.089	.12	$12.50	$11.75	$10.75	$9.75	$9.50
1523-2SF	RG-405	.089	.12	$15.50	$14.75	$13.75	$12.75	$12.50



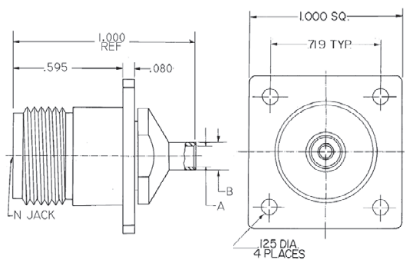
N JACK STRAIGHT CABLE DIRECT SOLDER

PART NO.	CABLE	(A) DIM	(B) DIM	1-9	10-24	25-49	50-99	100+
1519-1	RG-402	.145	.18	$17.50	$16.75	$16.25	$15.75	$14.50
1519-2	RG-405	.089	.12	$17.50	$16.75	$16.25	$15.75	$14.50



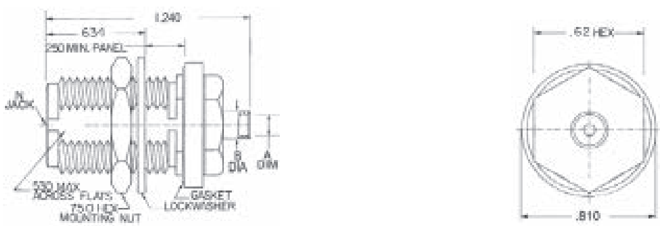
N 4 HOLE FLANGE STRAIGHT CABLE PLUG DIRECT SOLDER

PART NO.	CABLE	(A) DIM	(B) DIM	1-9	10-24	25-49	50-99	100+
1523-1FLG	RG-402	.145	.18	$42.50	$41.75	$40.50	$37.25	$34.75
1523-2FLG	RG-405	.089	.12	$42.50	$41.75	$40.50	$37.25	$34.75



N 4 HOLE FLANGE STRAIGHT CABLE JACK DIRECT SOLDER

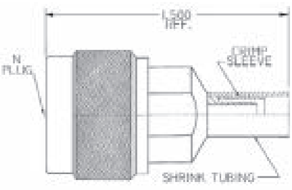
PART NO.	CABLE	(A) DIM	(B) DIM	1-9	10-24	25-49	50-99	100+
1524-1	RG-402	.145	.18	$37.50	$36.75	$35.50	$32.25	$29.75
1524-2	RG-405	.089	.12	$37.50	$36.75	$35.50	$32.25	$29.75

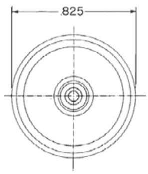


N BULKHEAD FEED THROUGH JACK SEMI-RIGID FLEXIBLE CABLE RG-TYPE

PART NO.	CABLE	(A) DIM	(B) DIM	1-9	10-24	25-49	50-99	100+
1526-1	RG-402	.145	.18	$19.50	$18.75	$17.75	$16.50	$15.50
1526-2	RG-405	.089	.12	$19.50	$18.75	$17.75	$16.50	$15.50
1526-3	RG-401	.255	.30	$19.50	$18.75	$17.75	$16.50	$15.50
1526-HEL	1/4 HELIAX	.255	.30	$23.50	$22.75	$21.75	$20.50	$19.50
1526-LL	1/4 LOW LOSS	.255	.30	$23.50	$22.75	$21.75	$20.50	$19.50

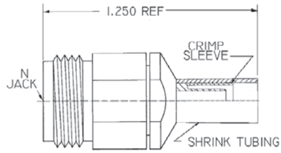
"N" Connectors to Flexible Cables

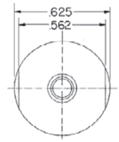




N PLUG SOLDER/CRIMP RG TYPE FLEXIBLE CABLE

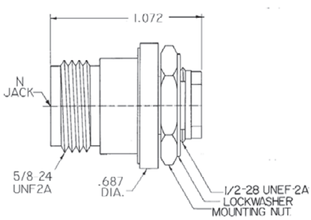
PART NO.	CABLE	1-9	10-24	25-49	50-99	100+
1523-1FLX	RG-155, 142, 223	$17.50	$16.75	$15.55	$14.75	$14.25
1523-2FLX	RG- 58, 141, 303	$17.50	$16.75	$15.55	$14.75	$14.25
1523-3FLX	RG-304	$17.50	$16.75	$15.55	$14.75	$14.25

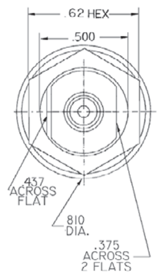




N JACK SOLDER/CRIMP RG TYPE FLEXIBLE CABLE

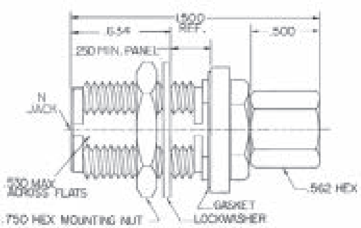
PART NO.	CABLE	1-9	10-24	25-49	50-99	100+
1519-1FLX	RG-155, 142, 223	$18.75	$17.50	$16.75	$15.50	$14.75
1519-2FLX	RG- 58, 141, 303	$18.75	$17.50	$16.75	$15.50	$14.75
1519-3FLX	RG-304	$18.75	$17.50	$16.75	$15.50	$14.75

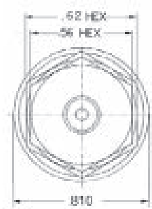




N JACK BULKHEAD FEEDTHROUGH SOLDER/CRIMP RG TYPE FLEXIBLE CABLE

PART NO.	CABLE	1-9	10-24	25-49	50-99	100+
1519-1CLP	RG-155, 142, 223	$48.75	$44.50	$41.25	$39.70	$37.50
1519-2CLP	RG- 58, 141, 303	$48.75	$44.50	$41.25	$39.70	$37.50
1519-3CLP	RG-304	$48.75	$44.50	$41.25	$39.70	$37.50

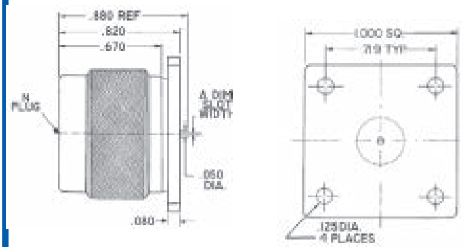




N JACK BULKHEAD FEED THROUGH SOLDER/CRIMP RG TYPE FLEXIBLE CABLE

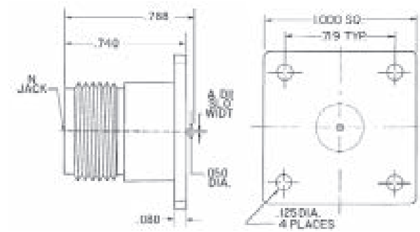
PART NO.	CABLE	1-9	10-24	25-49	50-99	100+
1526-1FLX	RG-155, 142, 223	$29.50	$29.25	$28.75	$27.50	$27.25
1526-2FLX	RG- 58, 141, 303	$29.50	$29.25	$28.75	$27.50	$27.25
1526-3FLX	RG-304	$29.50	$29.25	$28.75	$27.50	$27.25

"N" Panel Mount Receptacles



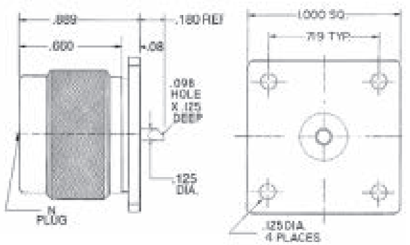
SLOT CAPTIVE CONTACT PLUG TERMINAL FLANGE MOUNT

PART NO.	SLOT WITH	1-9	10-24	25-49	50-99	100+
1549-1	.012	$19.75	$18.95	$17.50	$16.50	$15.50
1549-2	.018	$19.75	$18.95	$17.50	$16.50	$15.50
1549-3	.028	$19.75	$18.95	$17.50	$16.50	$15.50



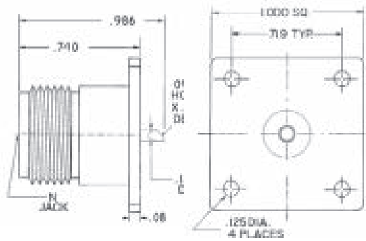
SLOT CAPTIVE CONTACT JACK TERMINAL FLANGE MOUNT

PART NO.	SLOT WITH	1-9	10-24	25-49	50-99	100+
1552-1	.012	$14.75	$13.50	$12.75	$11.75	$10.25
1552-2	.018	$14.75	$13.50	$12.75	$11.75	$10.25
1552-3	.028	$14.75	$13.50	$12.75	$11.75	$10.25



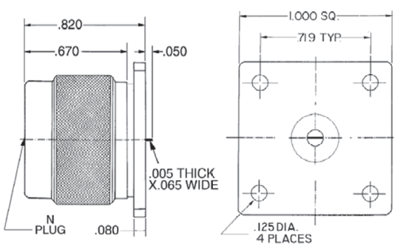
SOLDER POT
FLANGE MOUNT PLUG
CAPTIVE CONTACT

PART NO.	1-9	10-24	25-49	50-99	100+
1543	$19.75	$18.95	$17.50	$16.50	$15.50



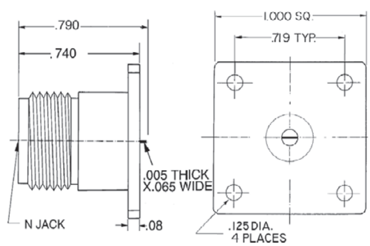
SOLDER POT
FLANGE MOUNT JACK
CAPTIVE CONTACT

PART NO.	1-9	10-24	25-49	50-99	100+
1544	$14.75	$13.50	$12.75	$11.75	$10.25



STRIPLINE
FLANGE MOUNT PLUG
CAPTIVE CONTACT

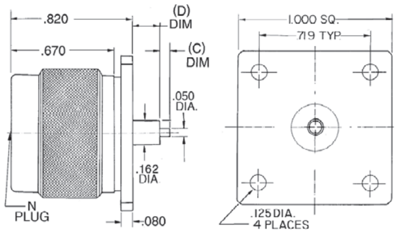
PART NO.	1-9	10-24	25-49	50-99	100+
1539	$19.75	$18.95	$17.50	$16.50	$15.50



STRIPLINE
FLANGE MOUNT JACK
CAPTIVE CONTACT

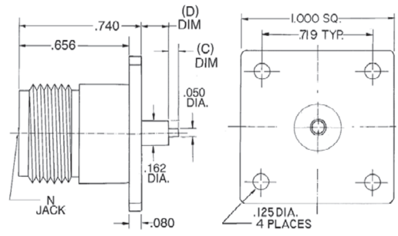
PART NO.	1-9	10-24	25-49	50-99	100+
1538	$14.75	$13.50	$12.75	$11.75	$10.25

"N" Panel Mount Receptacles



EXTENDED TERMINAL FLANGE MOUNT PLUG CAPTIVE CONTACT

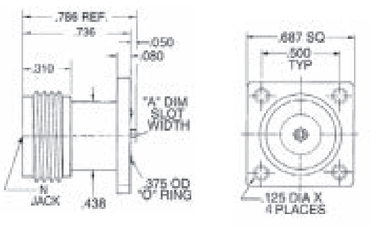
PART NO.	(C) DIM	(D) DIM	1-9	10-24	25-49	50-99	100+
1545-550	.160	.550	$19.75	$18.95	$17.50	$16.50	$15.50
1545-375	.050	.375	$19.75	$18.95	$17.50	$16.50	$15.50
1545-260	.200	.260	$19.75	$18.95	$17.50	$16.50	$15.50
1545-380	.050	.380	$19.75	$18.95	$17.50	$16.50	$15.50
1545-320	.055	.320	$19.75	$18.95	$17.50	$16.50	$15.50



EXTENDED TERMINAL FLANGE MOUNT JACK CAPTIVE CONTACT

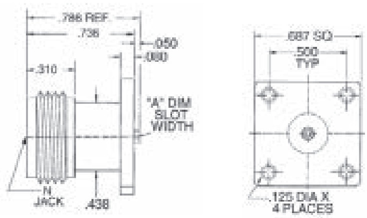
PART NO.	(C) DIM	(D) DIM	1-9	10-24	25-49	50-99	100+
1540-550	.160	.550	$14.75	$13.50	$12.75	$11.75	$10.25
1540-375	.050	.375	$14.75	$13.50	$12.75	$11.75	$10.25
1540-260	.200	.260	$14.75	$13.50	$12.75	$11.75	$10.25
1540-380	.050	.380	$14.75	$13.50	$12.75	$11.75	$10.25
1540-320	.055	.320	$14.75	$13.50	$12.75	$11.75	$10.25

"N" Panel Mount Receptacles TNC Flange



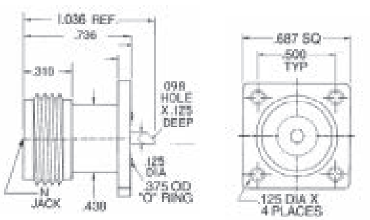
SLOT TERMINAL TNC FLANGE JACK O-RING CAPTIVE CONTACT

PART NO.	SLOT WITH	1-9	10-24	25-49	50-99	100+
1552-1 687 O	.012	$16.75	$16.10	$15.50	$14.50	$13.75
1552-2 687 O	.015	$16.75	$16.10	$15.50	$14.50	$13.75
1552-3 687 O	.018	$16.75	$16.10	$15.50	$14.50	$13.75



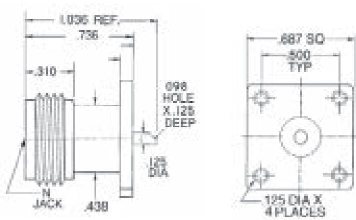
SLOT TERMINAL TNC FLANGE JACK CAPTIVE CONTACT

PART NO.	SLOT WITH	1-9	10-24	25-49	50-99	100+
1552-1 687	.012	$11.75	$11.10	$10.50	$9.85	$9.25
1552-2 687	.015	$11.75	$11.10	$10.50	$9.85	$9.25
1552-3 687	.018	$11.75	$11.10	$10.50	$9.85	$9.25



SOLDER POT JACK TNC FLANGE MOUNT O RING CAPTIVE CONTACT

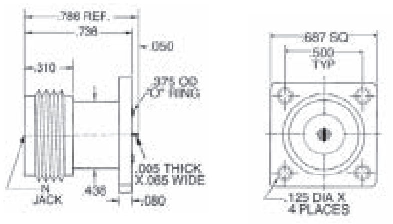
PART NO.	1-9	10-24	25-49	50-99	100+
1544-687 O	$16.75	$16.10	$15.50	$14.50	$13.75



SOLDER POT TNC FLANGE MOUNT JACK CAPTIVE CONTACT

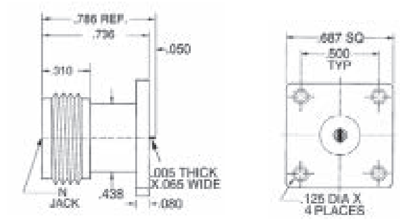
PART NO.	1-9	10-24	25-49	50-99	100+
1544-687	$11.75	$11.10	$10.50	$9.85	$9.25

"N" Panel Mount Receptacles TNC Flange



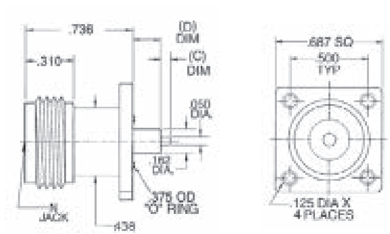
STRIPLINE TNC O RING FLANGE MOUNT JACK CAPTIVE CONTACT

PART NO.	1-9	10-24	25-49	50-99	100+
1538-687 O	$16.75	$16.10	$15.50	$14.50	$13.25



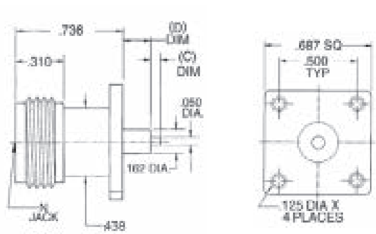
STRIPLINE TNC FLANGE MOUNT JACK CAPTIVE CONTACT

PART NO.	1-9	10-24	25-49	50-99	100+
1538-687	$11.75	$11.10	$10.50	$9.85	$9.25



EXTENDED TNC TERMINAL O RING FLANGE
JACK CAPTIVE CONTACT

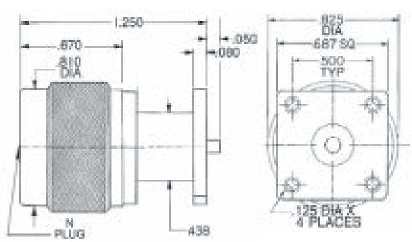
PART NO.	C DIM	D DIM	1-9	10-24	25-49	50-99	100+
1540-550 687 O	.160	.550	$16.75	$16.10	$15.50	$14.50	$13.75
1540-687 O	.050	.375	$16.75	$16.10	$15.50	$14.50	$13.75
1540-260 687 O	.200	.260	$16.75	$16.10	$15.50	$14.50	$13.75
1540-380 687 O	.050	.380	$16.75	$16.10	$15.50	$14.50	$13.75
1540-320 687 O	.055	.320	$16.75	$16.10	$15.50	$14.50	$13.75



EXTENDED TERMINAL TNC FLANGE JACK CAPTIVE CONTACT

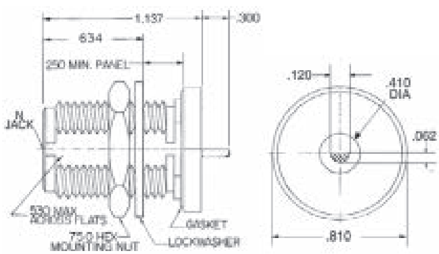
PART NO.	C DIM	D DIM	1-9	10-24	25-49	50-99	100+
1540-550-687	.160	.550	$11.75	$11.10	$10.50	$9.85	$9.25
1540-687	.050	.375	$11.75	$11.10	$10.50	$9.85	$9.25
1540-260-687	.200	.260	$11.75	$11.10	$10.50	$9.85	$9.25
1540-380-687	.050	.380	$11.75	$11.10	$10.50	$9.85	$9.25
1540-320-687	.055	.320	$11.75	$11.10	$10.50	$9.85	$9.25

"N" Male Panel Mount & Female Bulkhead Feed Through Connectors



EXTENDED TERMINAL TNC FLANGE MOUNT
PLUG CAPTIVE CONTACT CAPTIVE CONTACT

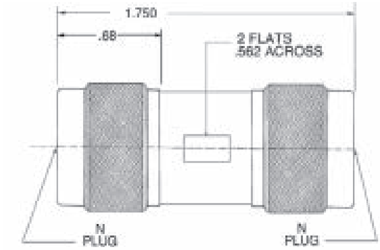
PART NO.	1-9	10-24	25-49	50-99	100+
1545-687	$21.50	$19.50	$17.75	$16.75	$15.75



N JACK BULKHEAD FEED THROUGH EXTENDED TERMINAL
D STYLE CAPTIVE CONTACT

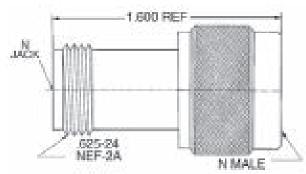
PART NO.	1-9	10-24	25-49	50-99	100+
1561	$14.50	$13.75	$12.75	$12.25	$10.75

"N" In Series Adapters



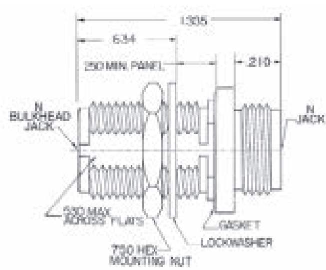
N PLUG TO N PLUG IN SERIES ADAPTER

PART NO.	1-9	10-24	25-49	50-99	100+
1551	$59.50	$56.25	$52.50	$47.50	$42.50



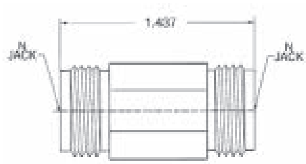
STRAIGHT ADAPTER PLUG N JACK TO N PLUG

PART NO.	1-9	10-24	25-49	50-99	100+
1579	$59.50	$56.25	$52.50	$47.75	$42.50



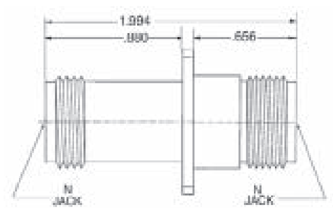
BULKHEAD FEED THROUGH MOUNT ADAPTER N JACK TO N JACK

PART NO.	1-9	10-24	25-49	50-99	100+
1550-BLK	$99.50	$96.75	$92.75	$87.50	$84.50



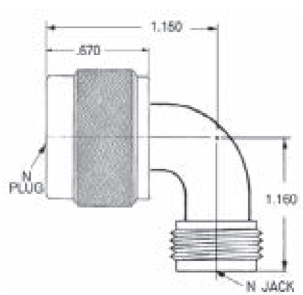
N JACK TO N JACK IN SERIES ADAPTER

PART NO.	1-9	10-24	25-49	50-99	100+
1550	$59.50	$56.25	$52.50	$47.75	$42.50



N JACK TO N JACK ONE INCH FLANGE .I25 DIA HOLES
4 PLACES FLANGE MOUNT IN SERIES ADAPTER

PART NO.	1-9	10-24	25-49	50-99	100+
1505	$76.00	$73.50	$66.25	$61.50	$55.00



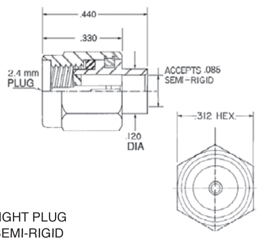
N JACK TO N PLUG RADIUS RIGHT ANGLE IN SERIES ADAPTER

PART NO.	1-9	10-24	25-49	50-99	100+
1521	$142.00	$135.00	$127.00	$119.00	$112.00

High Performance Connectors

United Microwave Products High Performance SMP and Precision Semi-Rigid Connectors are constructed of metallic parts with a Gold Plated finish. All connectors listed on this page have Gold Plated BeCu center conductors and PTFE Dielectric as Per MIL-P-19468. The SMP connectors have been Qualified to US Navy DWG. 6783472 with A, B, &C testing including RF Leakage and Corona at Altitude.

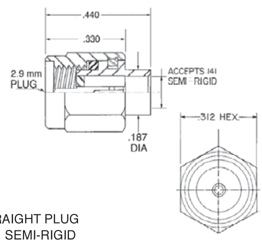
2.4mm Connectors



STRAIGHT PLUG
.085 SEMI-RIGID
WITH CONTACT

PART NO.	1-9	10-24	25-49	50-99	100+
301-1-2.4	$22.75	$21.50	$18.50	$17.25	$16.95

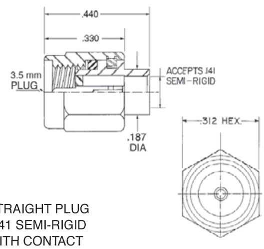
2.9mm Connectors



STRAIGHT PLUG
.141 SEMI-RIGID
WITH CONTACT

PART NO.	1-9	10-24	25-49	50-99	100+
300-7-2.9	$18.50	$17.25	$16.75	$15.50	$14.25

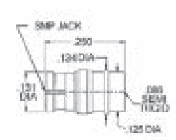
3.5mm Connectors



STRAIGHT PLUG
.141 SEMI-RIGID
WITH CONTACT

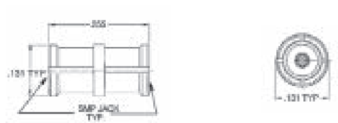
PART NO.	1-9	10-24	25-49	50-99	100+
300-7-3.5	$49.50	$47.75	$42.50	$39.00	$37.50

SMP Type Connectors



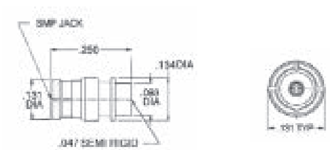
SMP .086 SEMI-RIGID CABLE STRAIGHT

PART NO.	1-9	10-24	25-49	50-99	100+
202-085	$13.75	$12.50	$11.25	$10.75	$9.50



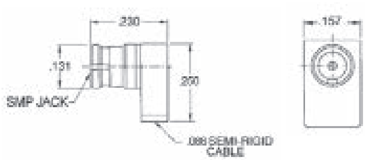
SMP JACK BULLET

PART NO.	1-9	10-24	25-49	50-99	100+
202-BT	$16.50	$15.50	$14.75	$13.75	$12.50



SMP .047 SEMI-RIGID CABLE STRAIGHT ATTACHMENT

PART NO.	1-9	10-24	25-49	50-99	100+
202-047	$13.75	$12.50	$11.25	$10.75	$9.50

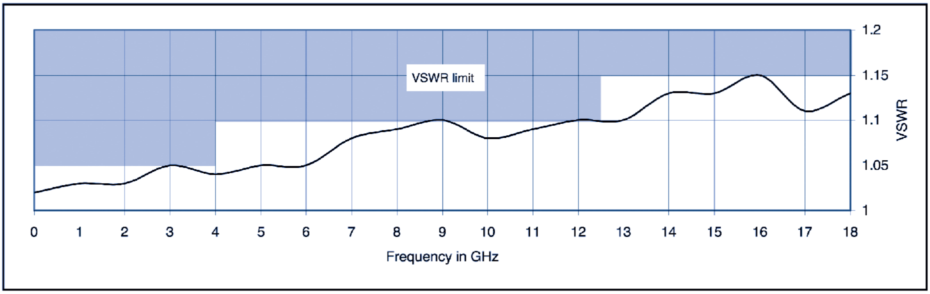


SMP FEMALE .086 SEMI-RIGID RIGHT ANGLE ATTACHMENT

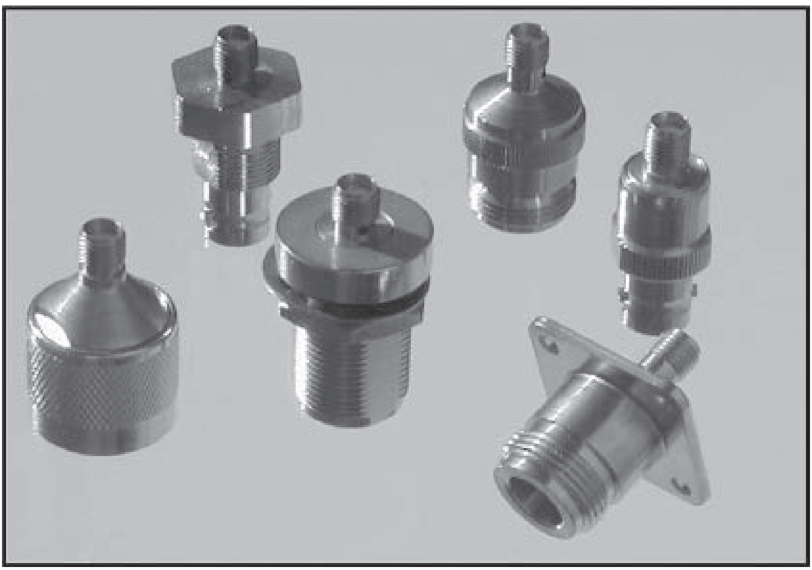
PART NO.	1-9	10-24	25-49	50-99	100+
201-086	$18.75	$17.50	$16.75	$15.75	$14.50

Between Series Coaxial Adapters

United Microwave Products between series coaxial adapters provide a convenient method for inner-connecting two different series or size coaxial connectors. Ideal for both measurement and systems use, these precision adapters offer a low VSWR over a broad frequency spectrum. In particular, the 7MM between series adapters are precision laboratory instruments used for testing microwave coaxial transmission lines. All standard units are constructed of stainless steel with a passivated finish, Teflon dielectrics, and gold plated beryllium copper center contacts. Panel mount adapters are available that permit small sized connectors for internal use while external connectors can be made with larger more rugged connectors

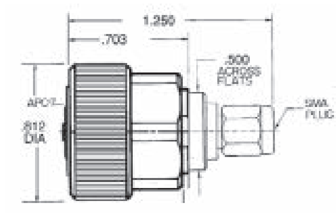


DATA FROM UMP PART # 1370



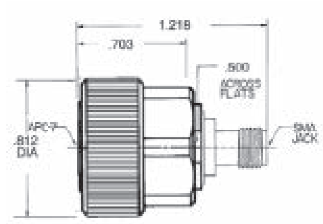
Prices listed effective as of 1 July 2008 and subject to change at any time.

Between Series Coaxial Adapters



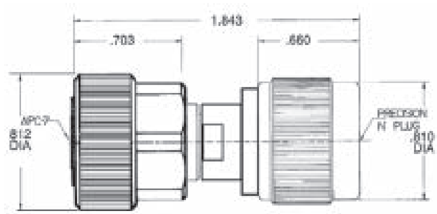
7mm TO SMA PLUG

PART NO.	1-9	10-24	25-49	50-99	100+
9001	$135.00	$130.00	$125.00	$120.00	$115.00



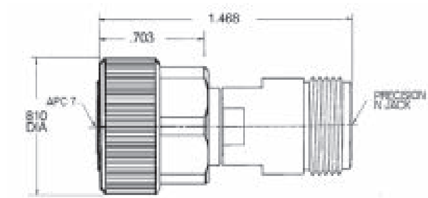
7mm TO SMA JACK

PART NO.	1-9	10-24	25-49	50-99	100+
9002	$135.00	$130.00	$125.00	$120.00	$115.00



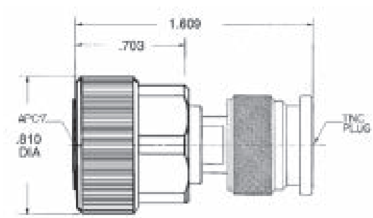
7mm TO N PLUG

PART NO.	1-9	10-24	25-49	50-99	100+
9004	$150.00	$140.00	$135.00	$125.00	$110.00



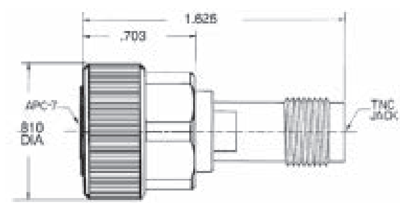
7mm TO N JACK

PART NO.	1-9	10-24	25-49	50-99	100+
9003	$150.00	$140.00	$135.00	$125.00	$110.00



7mm TO TNC PLUG

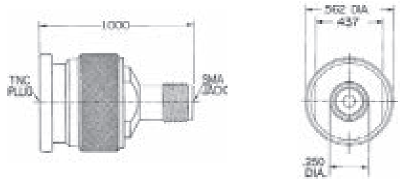
PART NO.	1-9	10-24	25-49	50-99	100+
9006	$150.00	$140.00	$135.00	$125.00	$110.00



7mm TO TNC JACK

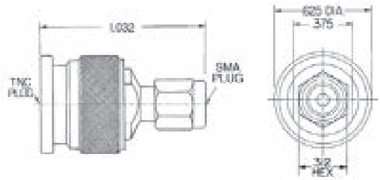
PART NO.	1-9	10-24	25-49	50-99	100+
9005	$150.00	$140.00	$135.00	$125.00	$110.00

Between Series Coaxial Adapters



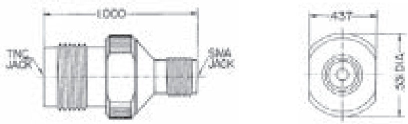
TNC PLUG TO SMA JACK

PART NO.	1-9	10-24	25-49	50-99	100+
7005	$24.65	$22.50	$20.25	$19.50	$18.75



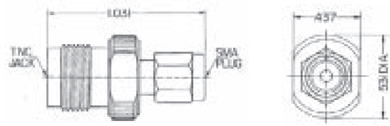
TNC PLUG TO SMA PLUG

PART NO.	1-9	10-24	25-49	50-99	100+
7006	$24.65	$22.50	$20.25	$19.50	$18.75



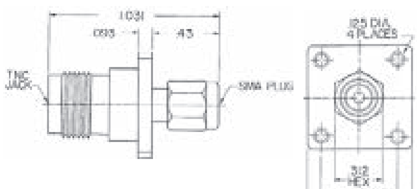
TNC JACK TO SMA JACK

PART NO.	1-9	10-24	25-49	50-99	100+
7002	$24.65	$22.50	$20.25	$19.50	$18.75



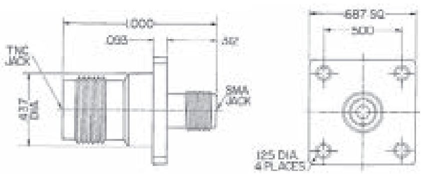
TNC JACK TO SMA PLUG

PART NO.	1-9	10-24	25-49	50-99	100+
7003	$24.65	$22.50	$20.25	$19.50	$18.75



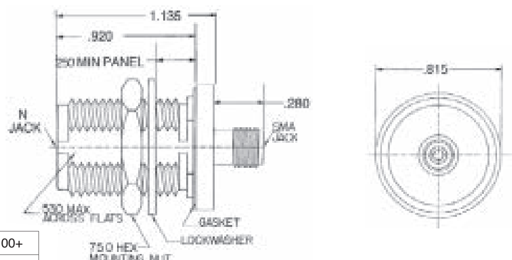
TNC JACK TO SMA PLUG PANEL MOUNT **FLANGE MOUNT ALSO AVABLE WITH #3-56 THREADS CONTACT FACTORY FOR DETAILS**

PART NO.	1-9	10-24	25-49	50-99	100+
7004	$32.00	$29.50	$27.75	$26.75	$24.75



TNC JACK TO SMA JACK PANEL MOUNT **FLANGE MOUNT ALSO AVABLE WITH #3-56 THREADS CONTACT FACTORY FOR DETAILS**

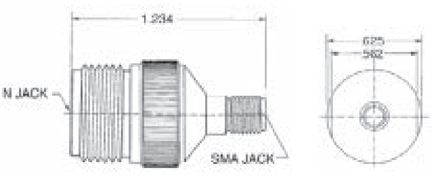
PART NO.	1-9	10-24	25-49	50-99	100+
7001	$32.00	$29.50	$27.75	$26.75	$24.75



N JACK FEED THROUGH BULKHEAD TO SMA JACK PANEL MOUNT

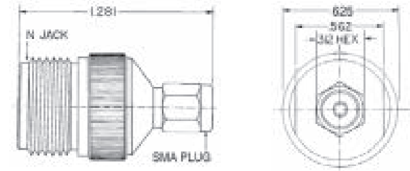
PART NO.	1-9	10-24	25-49	50-99	100+
1559BLK	$29.50	$27.75	$26.75	$24.75	$23.75

Between Series Coaxial Adapters



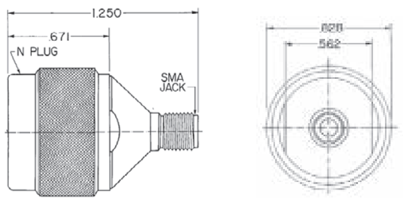
N JACK TO SMA JACK

PART NO.	1-9	10-24	25-49	50-99	100+
1350	$29.75	$28.20	$26.75	$25.80	$24.50



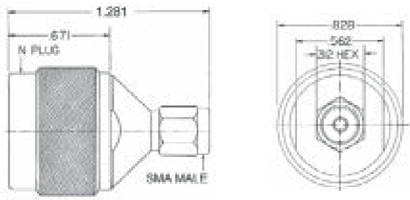
N JACK TO SMA PLUG

PART NO.	1-9	10-24	25-49	50-99	100+
1390	$29.75	$28.20	$26.75	$25.80	$24.50



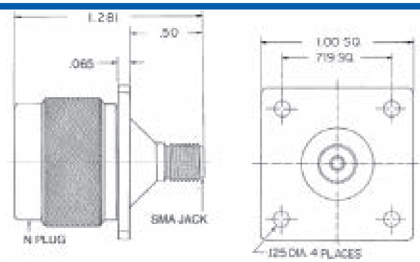
N PLUG TO SMA JACK

PART NO.	1-9	10-24	25-49	50-99	100+
1370	$29.75	$28.20	$26.75	$25.80	$24.50



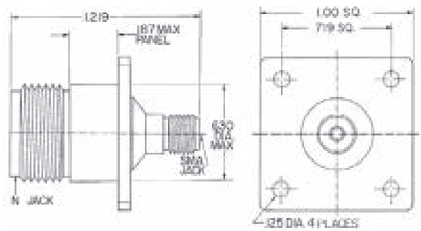
N PLUG TO SMA PLUG

PART NO.	1-9	10-24	25-49	50-99	100+
1400	$29.75	$28.20	$26.75	$25.80	$24.50



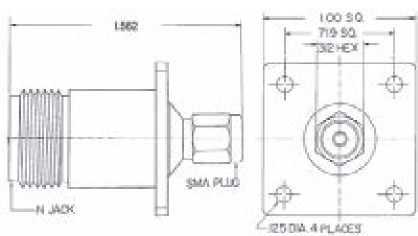
N PLUG TO SMA JACK PANEL MOUNT

PART NO.	1-9	10-24	25-49	50-99	100+
1375	$36.75	$34.75	$33.25	$31.50	$29.50



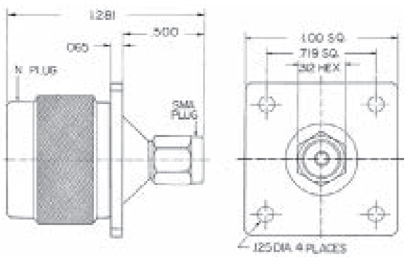
N JACK TO SMA JACK PANEL MOUNT

PART NO.	1-9	10-24	25-49	50-99	100+
1355	$36.75	$34.75	$33.25	$31.50	$29.50



N JACK TO SMA PLUG PANEL MOUNT

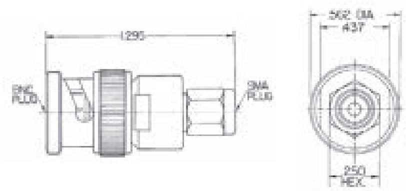
PART NO.	1-9	10-24	25-49	50-99	100+
1395	$36.75	$34.75	$33.25	$31.50	$29.50



N PLUG TO SMA PLUG PANEL MOUNT

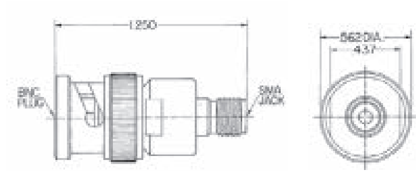
PART NO.	1-9	10-24	25-49	50-99	100+
1405	$36.75	$34.75	$33.25	$31.50	$29.50

Between Series Coaxial Adapters



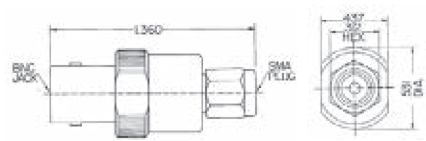
BNC PLUG TO SMA PLUG

PART NO.	1-9	10-24	25-49	50-99	100+
1520	$22.50	$21.25	$19.75	$18.50	$17.75



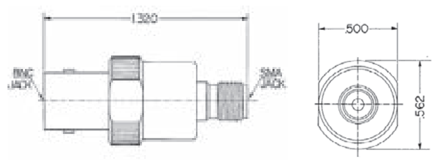
BNC PLUG TO SMA JACK

PART NO.	1-9	10-24	25-49	50-99	100+
1470	$22.50	$21.25	$19.75	$18.50	$17.75



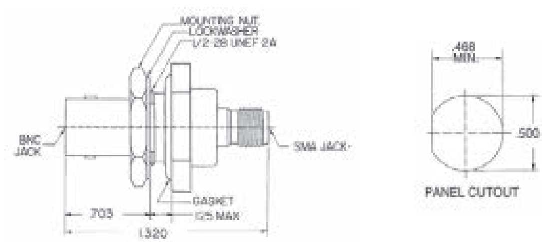
BNC JACK TO SMA PLUG

PART NO.	1-9	10-24	25-49	50-99	100+
1480	$22.50	$21.25	$19.75	$18.50	$17.75



BNC JACK TO SMA JACK

PART NO.	1-9	10-24	25-49	50-99	100+
1450	$22.50	$21.25	$19.75	$18.50	$17.75



BNC JACK TO SMA JACK
BULKHEAD MOUNT WITH GASKET

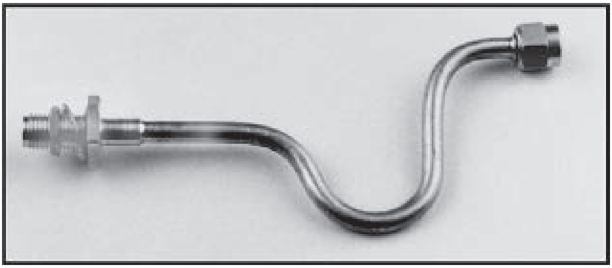
PART NO.	1-9	10-24	25-49	50-99	100+
7104	$29.75	$28.20	$26.75	$25.80	$24.50

Custom Cable Assemblies

United Microwave Products offers a complete custom cable assembly facility to service your needs. High reliable cable assemblies, rigidly controlled to customer specifications are assembled by experienced personnel trained in the latest microwave assembly techniques. Precision bending and trimming, custom tool design, and total quality control assures that each assembly delivered to our customer meets our 100% Guaranteed performance, availability, plus reasonable cost makes United Microwave Products
your number one choice for all cable assembly requirements. Contact us for complete technical and price information regarding your specific requirements.

AA-095-01.00.0

AA-098-01.00.0



CA-141-00.06.0 (3 CUSTOM BENDS SEMI-RIGID)

AA-155-01.00.0

UNITED MICROWAVE semi-rigid cable assemblies can also be custom formed and soldered to your intricate specifications (multiple bends, off tangent angles, three view drawings). All assemblies are fully tested and inspected per your requirements. Full tractability, material certs and source inspection are available upon request

Custom Cable Assemblies

The Connector Selection Chart lists our most popular cables readily available. By following the directions under the assembly number explanation, it is possible to assign part numbers for an infinite variety of assemblies.
For instance, a 2' long 085 Tin plate semi-rigid cable with a SMA straight plug on one end and a SMA straight plug on the other would be part number AA-085Sn-02.00.0. Another example is a 10' long RG 142 cable with an SMA straight plug on one end and an SMA 90° plug on the other would be part number AB -142-10.00.0

Types of semi-rigid cable readily available:
.047, .085, .141, and .250
Outer jacket available in bare copper(Cu),
tin plated(Sn), silver plated(Ag), and spline.
Air filled and Helix cable are available on special order.

CONNECTOR SELECTION CHART

A - SMA Straight Plug
B - SMA 90° Plug
C - SMA Bulkhead Jack
D - SMA Straight Jack
E - SMA 2 Hole Captive Contact Jack
G - TNC Straight Plug
H - TNC Bulkhead Jack
I - TNC 90° Plug
J - BNC Straight Jack
K - BNC Straight Plug
L - BNC 90° Plug
M- BNC Bulkhead Jack
N - BNC Straight Plug
O - N Straight Plug
P - N 90° Plug
R - N Straight Jack
S - N Bulkhead Jack
V - 7MM Straight Connector

SEMI-RIGID JACKET SELECTION

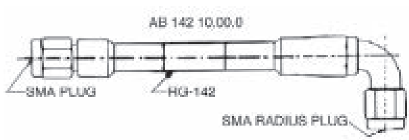
Ag - Silver
Cu - Bare Copper
Sn -Tin

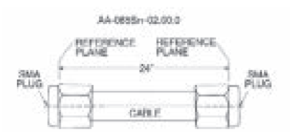
CONNECTORS AVAILABLE IN
PASSIVATED STAINLESS STEEL FOR DURABILITY
OR BRASS SHELL FOR ECONOMY
GOLD, SILVER, NICKEL, FINISH
UPON REQUEST

Types of RG cable readily available:
RG 55, 58, 142, 174, 178, 188,
223, 303, 315, 400

Types of Microflex cable readily available:
MICROFLEX 150, (FOIL OUTER CONDUCTOR)
MICROFLEX 155 & 095 (FOIL + BRAID OUTER CONDUCTOR)
MICROPORE 190 (AIR INDUCED DIELECTRIC)
MICROFLEX 165. (3 FOIL OUTER CONDUCTOR)

NOTE V.S.W.R. AND INSERTION LOSS LIMITS AS PER CHOSEN CONNECTORS. CONTACT UNITED MICROWAVE FOR CUSTOMER SERVICE & TECHNICAL SUPPORT

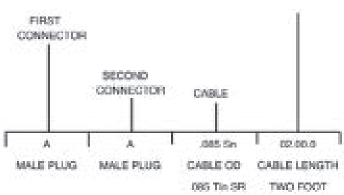


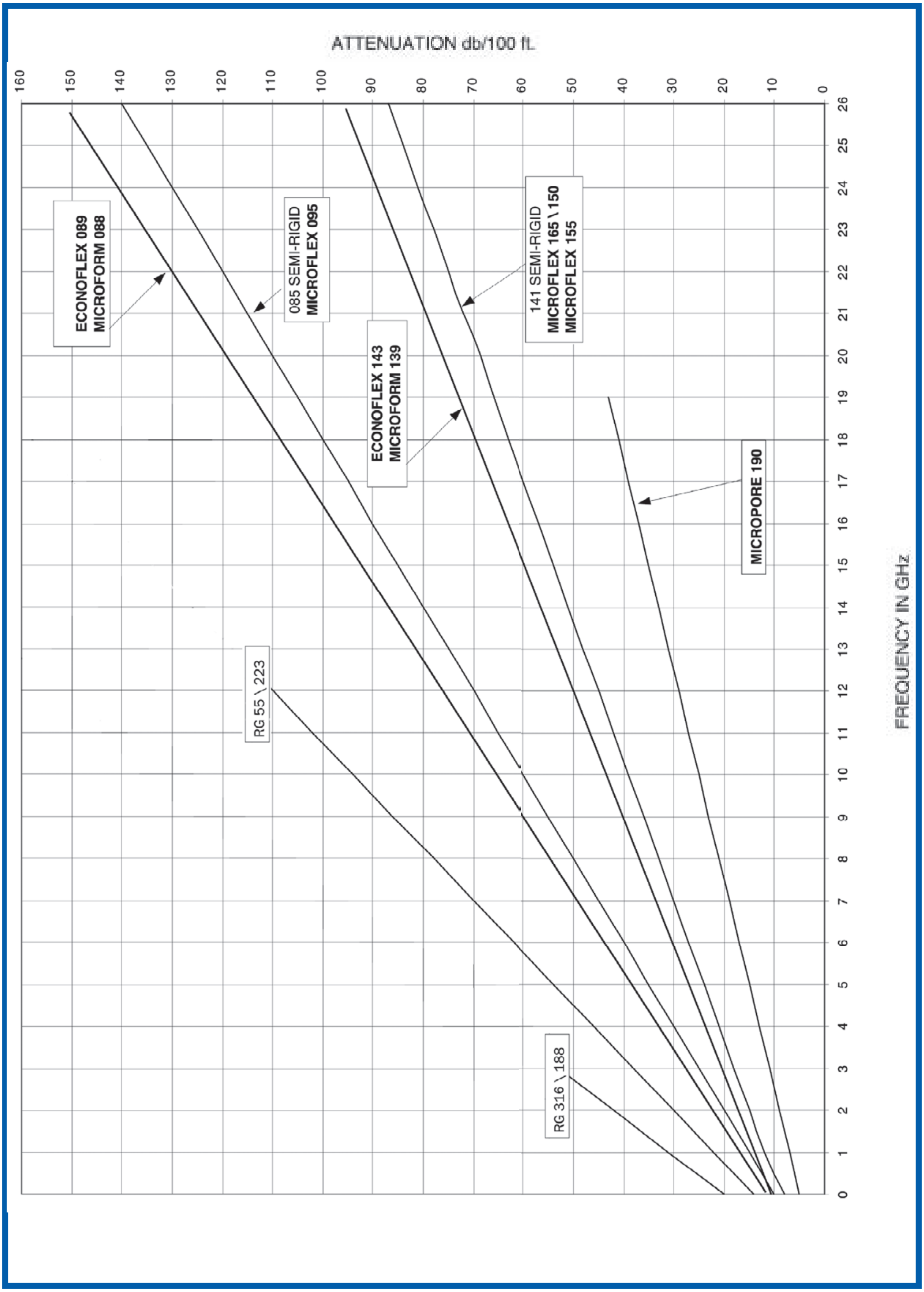


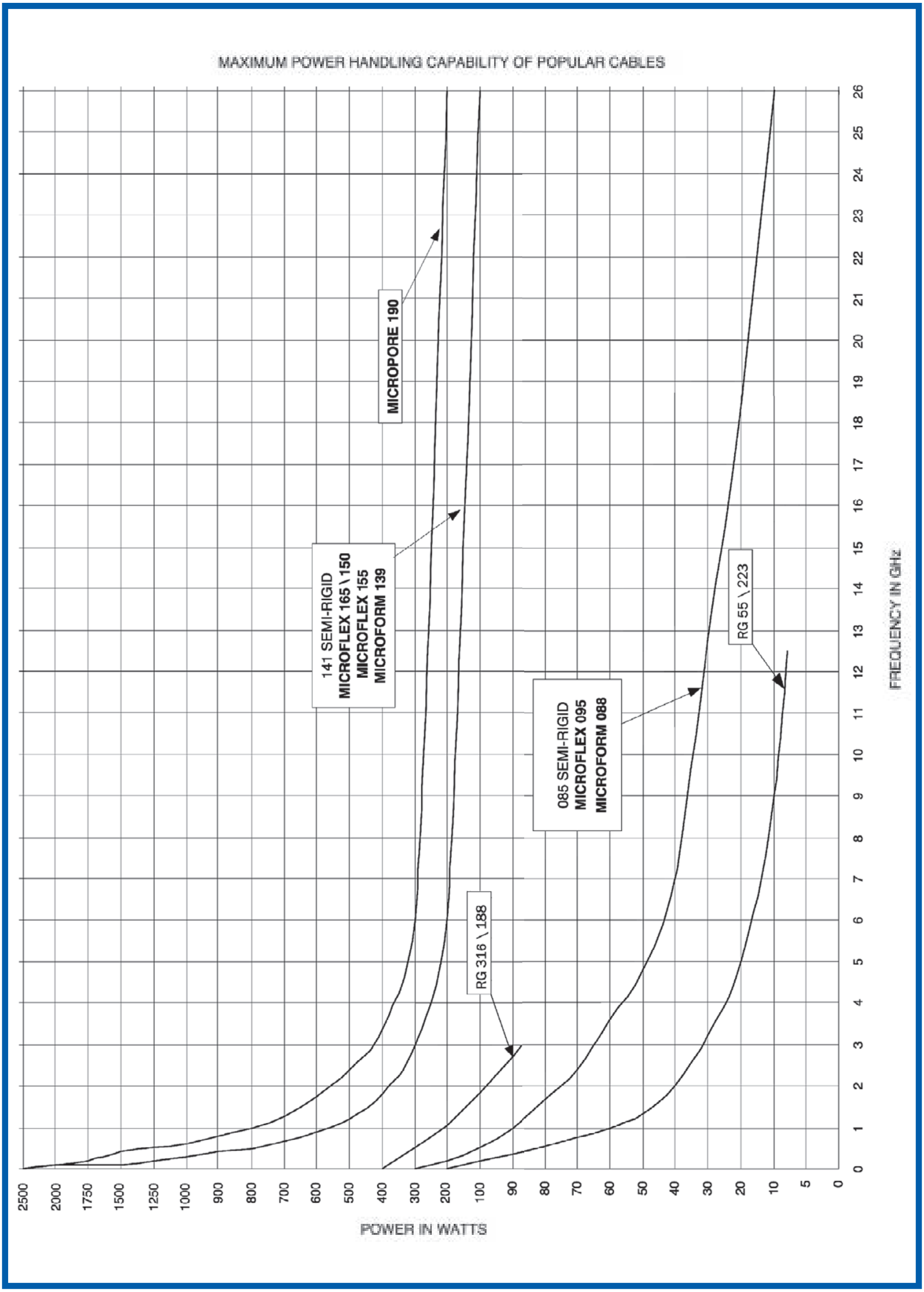
LENGTH	TOLERANCE
3" to 3'	- .25 INCH +0.5 INCH
3' to 6'	- .25 INCH +0.75 INCH
6' to 10'	- 1.50 INCH +2.50 INCH
10' to 20'	- 2.00 INCH +3.00 INCH

ASSEMBLY LENGTH

FIRST two digits represent feet while the next two digits inches, and the last digit a tenth of an inch. Lengths are measured to the reference plane of straight connectors and to the center line of right angle connectors shown in the assembly drawing




ATTENUATION db/100 ft.
FREQUENCY IN GHz
ECONOFLEX 089
MICROFORM 088
085 SEMI-RIGID
MICROFLEX 095
ECONOFLEX 143
MICROFORM 139
141 SEMI-RIGID
MICROFLEX 165 \ 150
MICROFLEX 155
MICROPORE 190
RG 55 \ 223
RG 316 \ 188

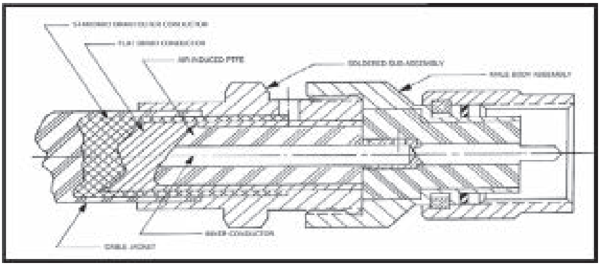

MAXIMUM POWER HANDLING CAPABILITY OF POPULAR CABLES
MICROPORE 190
141 SEMI-RIGID
MICROFLEX 165 \ 150
MICROFLEX 155
MICROFORM 139
RG 316 \ 188
085 SEMI-RIGID
MICROFLEX 095
MICROFORM 088
RG 55 \ 223
FREQUENCY IN GHz
POWER IN WATTS

AFFORDABLE LOW LOSS TEST CABLES

MICROPORE 190

Operating Frequency DC-18.0 GHz

MICROPORE 19O is a new inexpensive high performance super low loss cable. For applications requIrIng flexibility and the lowest possible loss at an economical price MICROPORE I90 Is the cable of choice. The cable is nonmagnetIc, has a double barrier outer conductor for improved shielding and features an air induced dielectric for low loss at hIgh frequency.



ELECTRICAL PROPERTIES

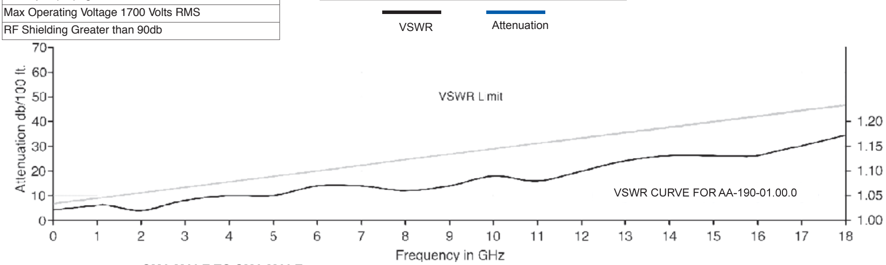
Impedance 50 ± 2 OHMs
Cut off Frequency 33.0 GHz
Nominal Capacitance 25 pf/f
velocity of propagation 82.5%
Max Operating Voltage 1700 Volts RMS
RF Shielding Greater than 90db

MATERIALS

Inner Conductor SIL PLT Solid Cu .051 Dia.
Outer Conductor Stripbraid Composite .184 Dia.
Dielectric Air Expanded PTFE .152 Dia.
Jacket FEP Teflon .195 Dia.

MECHANICAL PROPERTIES

Bend Radius Minimum 1.0 Inch
Temp Range -55ºF/+400ºF
Weight .6 oz/ft



SMA MALE TO SMA MALE

PART NO.	CONNECTORS	LENGTH	1-9	10-24	25-49
AA-190-02.00.0	SMA PLUG to SMA PLUG	2.00 Ft.	$78.50	$75.25	$72.15
AA-190-03.00.0		3.00 Ft.	$83.25	$79.75	$77.25
AA-190-04.00.0		4.00 Ft.	$88.50	$85.25	$82.50
AA-190-05.00.0		5.00 Ft.	$93.75	$89.75	$87.75
AA-190-06.00.0		6.00 Ft.	$98.50	$95.25	$93.25
AA-190-10.00.0		10.00 Ft.	$122.50	$119.25	$116.50

SMA MALE TO SMA MALE RIGHT ANGLE

PART NO.	CONNECTORS	LENGTH	1-9	10-24	25-49
AB-190-02.00.0	SMA PLUG to SMA PLUG RIGHT ANGLE	2.00 Ft.	$109.50	$107.25	$104.75
AB-190-03.00.0		3.00 Ft.	$115.50	$113.25	$110.75
AB-190-04.00.0		4.00 Ft.	$121.50	$119.25	$116.75
AB-190-05.00.0		5.00 Ft.	$127.50	$125.75	$122.75
AB-190-06.00.0		6.00 Ft.	$133.50	$131.25	$128.75
AB-190-010.00.0		10.00 Ft.	$157.50	$155.25	$153.75

SMA MALE TO TYPE N MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
AO-190-02.00.0	SMA PLUG to TYPE "N" PLUG	2.00	$101.50	$98.25	$95.75
AO-190-03.00.0		3.00	$107.50	$105.25	$102.75
AO-190-04.00.0		4.00	$113.50	$110.25	$107.75
AO-190-05.00.0		5.00	$119.50	$116.25	$113.75
AO-190-06.00.0		6.00	$125.50	$122.25	$119.75
AO-190-10.00.0		10.00	$149.50	$146.25	$143.75

TYPE N MALE TO TYPE N MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
OO-190-02.00.0	TYPE "N" PLUG to TYPE "N" PLUG	2.00	$120.50	$118.00	$115.25
OO-190-03.00.0		3.00	$126.50	$124.00	$121.25
OO-190-04.00.0		4.00	$132.50	$130.00	$127.25
OO-190-05.00.0		5.00	$138.50	$136.00	$133.25
OO-190-06.00.0		6.00	$144.50	$142.00	$139.25
OO-190-10.00.0		10.00	$168.50	$166.00	$163.25

TYPE N MALE TO TYPE N MALE RIGHT ANGLE

PART NO.	CONNECTORS	LENGTH	1-9	10-24	25-49
OP-190-02.00.0	TYPE "N" PLUG to TYPE "N" PLUG RIGHT ANGLE	2.00 Ft.	$150.50	$148.00	$145.25
OP-190-03.00.0		3.00 Ft.	$156.50	$154.00	$151.25
OP-190-04.00.0		4.00 Ft.	$162.50	$160.00	$157.25
OP-190-05.00.0		5.00 Ft.	$168.50	$166.00	$163.25
OP-190-06.00.0		6.00 Ft.	$174.50	$172.00	$169.25
OP-190-10.00.0		10.00 Ft.	$198.50	$196.00	$193.25

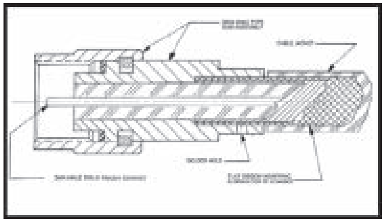
For Connectors or Lengths not listed contact Factory.

AFFORDABLE TEST CABLES

MICROFLEX 155

Operating Frequency DC-18.0 GHz

MICROFLEX 155 is a new inexpensive standard duty test cable. For applications requIrIng flexibility at an economical price MICROFLEX I55 Is the cable of choice. The cable is has a double barrier outer conductor for improved shielding at hIgh frequency.



ELECTRICAL PROPERTIES

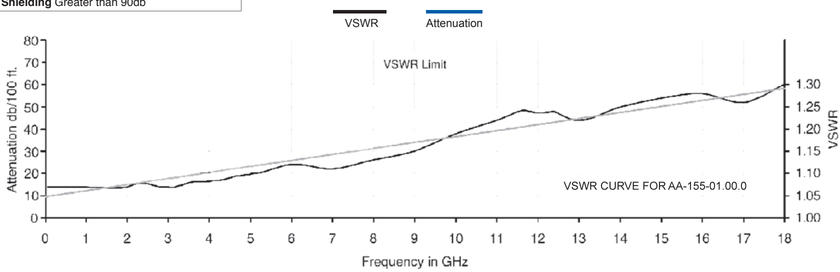
Impedance 50 ± 2 OHMs
Cut off Frequency 33.0 GHz
Nominal Capacitance 29.4 pf/f
Velocity of propagation 69.5%
Max Operating Voltage 1200 Volts RMS
RF Shielding Greater than 90db

MATERIALS

Inner Conductor SIL PLT Cu Clad Steel .036 Dia.
Outer Conductor Cu Ribbon & Braid .135 Dia.
Dielectric Solid PTFE .116 Dia.
Jacket FEP Teflon .155 Dia.

MECHANICAL PROPERTIES

Bend Radius Minimum 1.0 Inch
Temp Range -55ºF/+400ºF
Weight .47 oz/ft



SMA MALE TO SMA MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
AA-155-02.00.0	SMA PLUG to SMA PLUG	2.0	$66.50	$65.25	$64.15
AA-155-03.00.0		3.0	$69.25	$68.75	$67.25
AA-155-04.00.0		4.0	$72.50	$71.25	$70.50
AA-155-05.00.0		5.0	$75.75	$74.75	$73.75
AA-155-06.00.0		6.0	$78.50	$77.25	$76.25
AA-155-10.00.0		10.0	$89.50	$88.25	$87.50

SMA MALE TO SMA MALE RIGHT ANGLE

PART NO.	CONNECTORS	LENGTH	1-9	10-24	25-49
AB-155-02.00.0	SMA PLUG to SMA PLUG RIGHT ANGLE	2.0 Ft.	$91.50	$90.50	$89.50
AB-155-03.00.0		3.0 Ft.	$94.50	$93.50	$92.50
AB-155-04.00.0		4.0 Ft.	$97.50	$96.50	$95.50
AB-155-05.00.0		5.0 Ft.	$100.50	$99.50	$98.50
AB-155-06.00.0		6.0 Ft.	$103.50	$102.50	$101.50
AB-155-10.00.0		10.0 Ft.	$115.50	$114.50	$113.50

SMA MALE TO TYPE N MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
AO-155-02.00.0	SMA PLUG to TYPE "N" PLUG	2.0	$82.50	$81.50	$80.50
AO-155-03.00.0		3.0	$85.50	$84.50	$83.50
AO-155-04.00.0		4.0	$88.50	$87.50	$86.50
AO-155-05.00.0		5.0	$91.50	$90.50	$89.50
AO-155-06.00.0		6.0	$94.50	$93.50	$92.50
AO-155-10.00.0		10.0	$106.50	$105.50	$104.50

TYPE N MALE TO TYPE N MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
OO-155-02.00.0	TYPE"N" PLUG to TYPE "N" PLUG	2.0	$93.50	$92.50	$91.50
OO-155-03.00.0		3.0	$96.50	$95.50	$94.50
OO-155-04.00.0		4.0	$99.50	$98.50	$97.50
OO-155-05.00.0		5.0	$102.50	$101.50	$100.50
OO-155-06.00.0		6.0	$105.50	$104.50	$103.50
OO-155-10.00.0		10.0	$117.50	$116.50	$115.50

TYPE N MALE TO TYPE N MALE RIGHT ANGLE

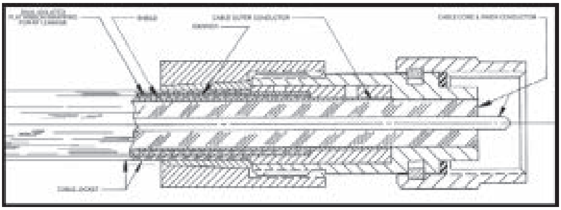
PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
OP-155-02.00.0	TYPE"N" PLUG to TYPE "N" RIGHT ANGLE PLUG	2.0	$114.50	$113.50	$112.50
OP-155-03.00.0		3.0	$117.50	$116.50	$115.50
OP-155-04.00.0		4.0	$120.50	$119.50	$118.50
OP-155-05.00.0		5.0	$123.50	$122.50	$121.50
OP-155-06.00.0		6.0	$126.50	$125.50	$124.50
OP-155-10.00.0		10.0	$138.50	$137.50	$136.50

For Connectors or Lengths not listed contact Factory.

MICROFLEX 165

Operating Frequency DC-26.0 GHz

MICROFLEX 165 is designed for high isolation and stability under demanding conditions. It features a totally **NONMAGNETIC** construction with a fused laminated PTFE core. The shielding characteristics are unsurpassed in a flexible cable. MICROFLEX 165 has a finished diameter of .165 inch. The SMA connectors are passivated stainless steel and feature a thick wall design for durability and repeated mating cycles. The inner conductor and core become an integral part of the SMA connector for better VSWR and electrical characteristics. MICROFLEX 165 cable assemblies are designed to provide maximum durability, shielding and electrical performance under extremes of handling, vibration and environmental exposure



ELECTRICAL PROPERTIES

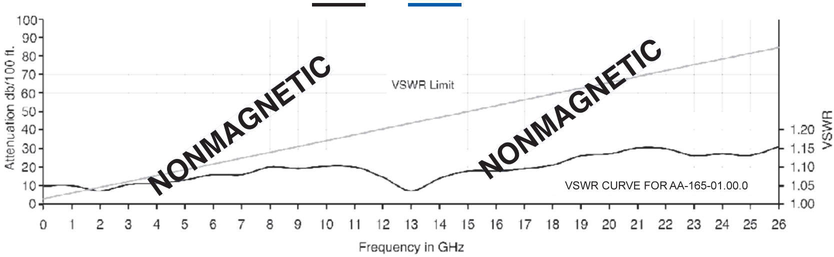
Impedance	50 ± 1 OHM
velocity of propagation	69.5%
Cut off Frequency	35.0 GHz
Max Operating Voltage	1900 Volts RMS
Nominal Capacitance	29.4 pf/f
RF Shielding	Greater than 90db

MATERIALS

Inner Conductor	SIL PLT. Be Cu .036 Dia.
Dielectric	PTFE .116 Dia.
Outer Conductor	Dual Isolated SIL PLT Copper Ribbon . 140 Dia.
Jacket	FEP Teflon .165 Dia.

MECHANICAL PROPERTIES

Bend Radius	Minimum 1.0 Inch
Weight	.6 oz/ft
Temp Range	-55ºF/+400ºF



SMA MALE TO SMA MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
AA-165-00.06.0	SMA PLUG to SMA PLUG	0.6	$74.50	$72.00	$69.50
AA-165-01.00.0		1.0	$74.50	$72.00	$69.50
AA-165-01.06.0		1.5	$77.50	$75.00	$72.50
AA-165-02.00.0		2.0	$80.50	$78.00	$75.50
AA-165-02.06.0		2.5	$83.50	$81.00	$78.50
AA-165-03.00.0		3.0	$86.50	$84.00	$81.50
AA-165-04.00.0		4.0	$92.50	$90.00	$87.50
AA-165-05.00.0		5.0	$98.50	$96.00	$93.50
AA-165-06.00.0		6.0.	$104.50	$102.00	$99.50
AA-165-10.00.0		10.0	$128.50	$126.00	$105.50

SMA MALE TO SMA MALE RIGHT ANGLE

PART NO.	CONNECTORS	LENGTH	1-9	10-24	25-49
AB-165-00.06.0	SMA PLUG to SMA PLUG RIGHT ANGLE	0.5 Ft.	$114.50	$112.00	$109.50
AB-165-01.00.0		1.0 Ft.	$114.50	$112.00	$109.50
AB-165-01.06.0		1.5 Ft.	$117.50	$115.00	$112.50
AB-165-02.00.0		2.0 Ft.	$120.50	$118.00	$115.50
AB-165-02.06.0		2.5 Ft.	$123.50	$121.00	$118.50
AB-165-03.00.0		3.0 Ft.	$126.50	$124.00	$121.50
AB-165-04.00.0		4.0 Ft.	$132.50	$130.00	$127.50
AB-165-05.00.0		5.0 Ft.	$138.50	$136.00	$133.50
AB-165-06.00.0		6.0 Ft.	$144.50	$142.00	$139.50
AB-165-10.00.0		10.0 Ft.	$168.50	$166.00	$163.50

SMA MALE TO SMA BULKHEAD FEMALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
AC-165-01.00.0	SMA PLUG to SMA BULKHEAD JACK	1.0	$94.50	$92.50	$89.50
AC-165-01.06.0		1.5	$97.50	$95.00	$92.50
AC-165-02.00.0		2.0	$100.50	$98.00	$95.50
AC-165-02.06.0		2.5	$103.50	$101.00	$98.50
AC-165-03.00.0		3.0	$106.50	$104.00	$101.50
AC-165-04.00.0		4.0	$112.50	$110.00	$107.50
AC-165-05.00.0		5.0	$118.50	$116.00	$113.50
AC-165-06.00.0		6.0.	$124.50	$122.00	$119.50

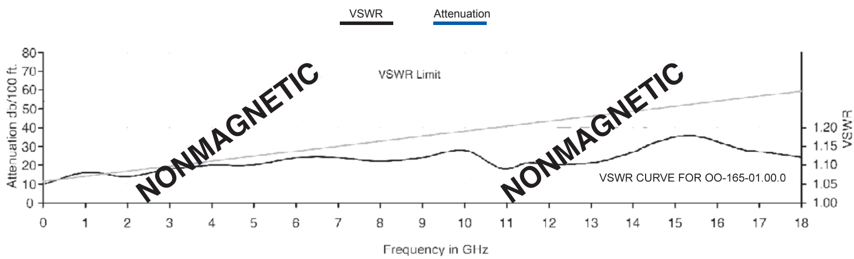
SMA MALE RIGHT ANGLE TO SMA MALE RIGHT ANGLE

PART NO.	CONNECTORS	LENGTH	1-9	10-24	25-49
BB-165-00.06.0	SMA PLUG RIGHT ANGLE to SMA PLUG RIGHT ANGLE	0.5 Ft.	$143.50	$141.00	$135.50
BB-165-01.00.0		1.0 Ft.	$143.50	$141.00	$138.50
BB-165-01.06.0		1.5 Ft.	$146.50	$144.00	$141.50
BB-165-02.00.0		2.0 Ft.	$149.50	$147.00	$144.50
BB-165-02.06.0		2.5 Ft.	$152.50	$150.00	$147.50
BB-165-03.00.0		3.0 Ft.	$155.50	$153.00	$150.50
BB-165-04.00.0		4.0 Ft.	$161.50	$159.00	$156.50
BB-165-05.00.0		5.0 Ft.	$167.50	$165.00	$162.50
BB-165-06.00.0		6.0 Ft.	$173.50	$171.00	$168.50

Prices listed effective as of 1 July 2008 and subject to change at any time.

MICROFLEX 165

Operating Frequency DC-18.0 GHz



SMA MALE TO TYPE N MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
AO-165-01.00.0	SMA PLUG to TYPE "N" PLUG	1.0	$95.50	$93.00	$90.50
AO-165-01.06.0		1.5	$98.50	$96.00	$93.50
AO-165-02.00.0		2.0	$101.50	$99.00	$96.50
AO-165-02.06.0		2.5	$104.50	$102.00	$99.50
AO-165-03.00.0		3.0	$107.50	$105.00	$102.50
AO-165-04.00.0		4.0	$113.50	$111.00	$108.50
AO-165-05.00.0		5.0	$119.50	$117.00	$114.50
AO-165-06.00.0		6.0	$125.50	$123.00	$120.50

TYPE N MALE TO TYPE N MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
OO-165-01.00.0	TYPE "N" PLUG to TYPE "N" PLUG	1.0	$105.50	$103.00	$100.50
OO-165-01.06.0		1.5	$108.50	$106.00	$103.50
OO-165-02.00.0		2.0	$111.50	$109.00	$106.50
OO-165-02.06.0		2.5	$114.50	$112.00	$109.50
OO-165-03.00.0		3.0	$117.50	$115.00	$112.50
OO-165-04.00.0		4.0	$123.50	$121.00	$118.50
OO-165-05.00.0		5.0	$129.50	$127.00	$124.50
OO-165-06.00.0		6.0	$135.50	$133.00	$130.50

SMA MALE TO TYPE N BULKHEAD FEMALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
AS-165-01.00.0	SMA PLUG to TYPE "N" BULKHEAD JACK	1.0	$105.50	$103.00	$100.50
AS-165-01.06.0		1.5	$108.50	$106.00	$103.50
AS-165-02.00.0		2.0	$111.50	$109.00	$106.50
AS-165-02.06.0		2.5	$114.50	$112.00	$109.50
AS-165-03.00.0		3.0	$117.50	$115.00	$112.50
AS-165-04.00.0		4.0	$123.50	$121.00	$118.50
AS-165-05.00.0		5.0	$129.50	$127.00	$124.50
AS-165-06.00.0		6.0.	$135.50	$133.00	$130.50

TNC MALE TO TNC MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
GG-165-01.00.0	TNC PLUG to TNC PLUG	1.0	$144.50	$142.00	$139.50
GG-165-01.06.0		1.5	$146.50	$144.00	$141.50
GG-165-02.00.0		2.0	$149.50	$147.00	$144.50
GG-165-02.06.0		2.5	$152.50	$150.00	$147.50
GG-165-03.00.0		3.0	$155.50	$153.00	$150.50
GG-165-04.00.0		4.0	$161.50	$159.00	$156.50
GG-165-05.00.0		5.0	$167.50	$165.00	$162.50
GG-165-06.00.0		6.0.	$173.50	$171.00	$168.50

SMA MALE TO TNC MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
AG-165-01.00.0	SMA PLUG to TNC PLUG	1.0	$117.50	$115.00	$112.50
AG-165-01.06.0		1.5	$120.50	$118.00	$115.50
AG-165-02.00.0		2.0	$123.50	$121.00	$118.50
AG-165-02.06.0		2.5	$126.50	$124.00	$121.50
AG-165-03.00.0		3.0	$132.50	$130.00	$127.50
AG-165-04.00.0		4.0	$138.50	$136.00	$133.50
AG-165-05.00.0		5.0	$144.50	$142.00	$139.50
AG-165-06.00.0		6.0.	$168.50	$166.00	$163.50

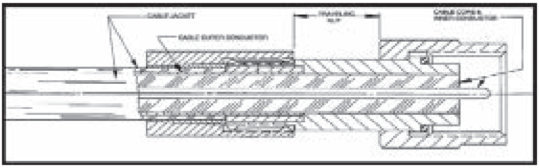
TYPE N MALE TO TYPE N BULKHEAD FEMALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
OS-165-01.00.0	TYPE "N" PLUG to TYPE "N" BULKHEAD JACK	1.0	$115.50	$113.00	$110.50
OS-165-01.06.0		1.5	$118.50	$116.00	$113.50
OS-165-02.00.0		2.0	$121.50	$119.00	$116.50
OS-165-02.06.0		2.5	$124.50	$122.00	$119.50
OS-165-03.00.0		3.0	$127.50	$125.00	$122.50
OS-165-04.00.0		4.0	$133.50	$131.00	$128.50
OS-165-05.00.0		5.0	$139.50	$137.00	$134.50
OS-165-06.00.0		6.0.	$145.50	$143.00	$140.50

MICROFLEX 150

Operating Frequency DC-26.0 GHz

MICROFLEX 150 is a flexible cable replacement for .141 semi-rigid delivering the same electrical performance. The standard stainless steel SMA connectors feature a thick wall construction for durability through repeated mating cycles. The coupling nut retracts for visual mating of the center conductors. The connector design is such that the core and center conductor become an integral part of the SMA connector. The use of MICROFLEX 150 eliminates complicated three plane drawing required with complex semi-rigid designs, often allowing one part number to replace several different cables. The flexibility of MICROFLEX 150 also eliminates cracked or broken solder joints caused by misalignment of semi-rigid cables during mating, while retaining the electrical performance of .141 semi-rigid.



ELECTRICAL PROPERTIES

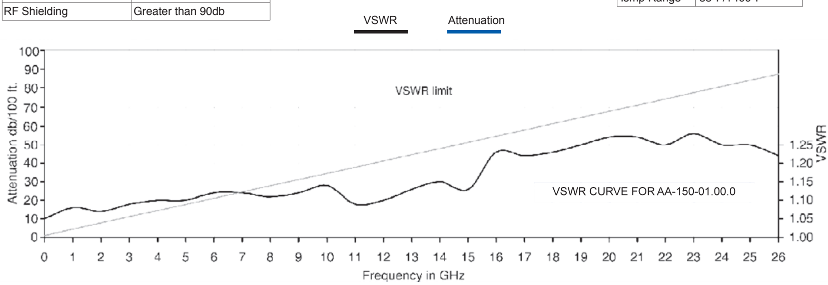
Impedance	50 ± 1 OHM
velocity of propagation	69.5%
Cut off Frequency	35.0 GHz
Max Operating Voltage	1900 Volts RMS
Nominal Capacitance	29.4 pf/f
RF Shielding	Greater than 90db

MATERIALS

Inner Conductor	SIL PLT. Cu Clad Steel.036 Dia.
Dielectric	PTFE .116 Dia.
Outer Conductor	SIL PLT Copper Ribbon .125 Dia.
Jacket	FEP Teflon .150 Dia.

MECHANICAL PROPERTIES

Bend Radius	Minimum 1.0 Inch
Weight	.4 oz/ft
Temp Range	-55°F/+400°F



SMA MALE TO SMA MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
AA-150-00.06.0	SMA PLUG to SMA PLUG	0.6	$37.50	$36.50	$35.50
AA-150-01.00.0		1.0	$39.50	$38.50	$37.50
AA-150-01.06.0		1.5	$41.50	$40.50	$39.50
AA-150-02.00.0		2.0	$43.50	$42.50	$41.50
AA-150-02.06.0		2.5	$45.50	$44.50	$43.50
AA-150-03.00.0		3.0	$47.50	$46.50	$45.50
AA-150-04.00.0		4.0	$51.50	$50.50	$49.50
AA-150-05.00.0		5.0	$55.50	$54.50	$53.50
AA-150-06.00.0		6.0.	$59.50	$58.50	$57.50
AA-150-10.00.0		10.0	$75.50	$74.50	$73.50

SMA MALE TO SMA MALE RIGHT ANGLE

PART NO.	CONNECTORS	LENGTH	1-9	10-24	25-49
AB-150-00.06.0	SMA PLUG to SMA PLUG RIGHT ANGLE	0.6 Ft.	$80.25	$79.25	$78.25
AB-150-01.00.0		1.0 Ft.	$82.25	$81.25	$80.25
AB-150-01.06.0		1.5 Ft.	$84.25	$83.25	$82.25
AB-150-02.00.0		2.0 Ft.	$86.25	$85.25	$84.25
AB-150-02.06.0		2.5 Ft.	$88.25	$87.25	$86.25
AB-150-03.00.0		3.0 Ft.	$90.25	$89.25	$88.25
AB-150-04.00.0		4.0 Ft.	$94.25	$93.25	$92.25
AB-150-05.00.0		5.0 Ft.	$98.25	$97.25	$96.25
AB-150-06.00.0		6.0 Ft.	$102.25	$101.25	$100.25
AB-150-10.00.0		10.0 Ft.	$118.25	$117.25	$116.25

SMA MALE TO SMA BULKHEAD FEMALE

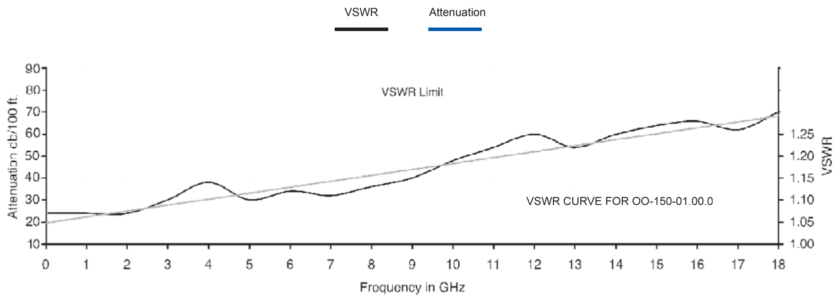
PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
AC-150-01.00.0	SMA PLUG to SMA BULKHEAD JACK	1.0	$54.00	$53.00	$52.00
AC-150-01.06.0		1.5	$57.00	$56.00	$55.00
AC-150-02.00.0		2.0	$60.00	$59.00	$58.00
AC-150-02.06.0		2.5	$63.00	$62.00	$61.00
AC-150-03.00.0		3.0	$64.50	$63.50	$62.50
AC-150-04.00.0		4.0	$69.00	$68.00	$67.00
AC-150-05.00.0		5.0	$74.25	$73.25	$72.25
AC-150-06.00.0		6.0.	$79.50	$78.50	$77.50

SMA MALE RIGHT ANGLE TO SMA MALE RIGHT ANGLE

PART NO.	CONNECTORS	LENGTH	1-9	10-24	25-49
BB-150-00.06.0	SMA PLUG RIGHT ANGLE to SMA PLUG RIGHT ANGLE	0.6 Ft.	$126.00	$125.00	$124.00
BB-150-01.00.0		1.0 Ft.	$126.00	$125.00	$124.00
BB-150-01.06.0		1.5 Ft.	$129.00	$128.00	$127.00
BB-150-02.00.0		2.0 Ft.	$132.00	$131.00	$130.00
BB-150-02.06.0		2.5 Ft.	$135.00	$134.00	$133.00
BB-150-03.00.0		3.0 Ft.	$138.00	$137.00	$136.00
BB-150-04.00.0		4.0 Ft.	$144.00	$143.00	$142.00
BB-150-05.00.0		5.0 Ft.	$150.00	$149.00	$148.00
BB-150-06.00.0		6.0 Ft.	$156.00	$155.00	$154.00

MICROFLEX 150

Operating Frequency DC-18.0 GHz



SMA MALE TO TYPE N MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
AO-150-01.00.0	SMA PLUG to TYPE "N" PLUG	1.0	$57.75	$56.75	$55.75
AO-150-01.06.0		1.5	$60.00	$59.00	$58.05
AO-150-02.00.0		2.0	$62.25	$61.25	$60.25
AO-150-02.06.0		2.5	$64.50	$63.50	$62.50
AO-150-03.00.0		3.0	$66.75	$65.75	$64.75
AO-150-04.00.0		4.0	$71.25	$70.25	$69.25
AO-150-05.00.0		5.0	$75.75	$74.75	$73.75
AO-150-06.00.0		6.0	$80.25	$79.25	$78.25
AO-150-10.00.0		10.0	$98.25	$97.25	$96.25

TYPE N MALE TO TYPE N MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
OO-150-01.00.0	TYPE "N" PLUG to TYPE "N" PLUG	1.0	$66.75	$65.75	$64.75
OO-150-01.06.0		1.5	$69.00	$68.00	$67.00
OO-150-02.00.0		2.0	$72.00	$71.00	$70.00
OO-150-02.06.0		2.5	$74.25	$73.25	$72.25
OO-150-03.00.0		3.0	$76.50	$75.50	$74.50
OO-150-04.00.0		4.0	$81.75	$80.75	$79.75
OO-150-05.00.0		5.0	$86.25	$85.25	$84.25
OO-150-06.00.0		6.0	$91.50	$90.50	$89.50
OO-150-10.00.0		10.0	$108.75	$107.75	$106.75

SMA MALE TO TYPE N BULKHEAD FEMALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
AS-150-01.00.0	SMA PLUG to TYPE "N" BULKHEAD JACK	1.0	$67.50	$66.50	$65.50
AS-150-01.06.0		1.5	$69.75	$68.75	$67.75
AS-150-02.00.0		2.0	$72.00	$71.00	$70.00
AS-150-02.06.0		2.5	$74.25	$73.25	$72.25
AS-150-03.00.0		3.0	$76.50	$75.50	$74.50
AS-150-04.00.0		4.0	$81.00	$80.00	$79.00
AS-150-05.00.0		5.0	$85.50	$84.50	$83.50
AS-150-06.00.0		6.0.	$90.00	$89.00	$88.00

TNC MALE TO TNC MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
GG-150-01.00.0	TNC PLUG to TNC PLUG	1.0	$81.00	$80.00	$79.00
GG-150-01.06.0		1.5	$84.00	$83.00	$82.00
GG-150-02.00.0		2.0	$87.00	$86.00	$85.00
GG-150-02.06.0		2.5	$89.25	$88.25	$87.25
GG-150-03.00.0		3.0	$91.50	$90.50	$89.50
GG-150-04.00.0		4.0	$96.00	$95.00	$94.00
GG-150-05.00.0		5.0	$101.25	$100.25	$99.25
GG-150-06.00.0		6.0.	$106.50	$105.50	$104.50

SMA MALE TO TNC MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
AG-150-01.00.0	SMA PLUG to TNC PLUG	1.0	$60.75	$59.75	$58.75
AG-150-01.06.0		1.5	$63.75	$62.75	$61.75
AG-150-02.00.0		2.0	$66.00	$65.00	$64.00
AG-150-02.06.0		2.5	$68.25	$67.25	$66.25
AG-150-03.00.0		3.0	$71.25	$70.25	$69.25
AG-150-04.00.0		4.0	$75.75	$74.75	$73.75
AG-150-05.00.0		5.0	$81.00	$80.00	$79.00
AG-150-06.00.0		6.0.	$85.50	$84.50	$83.50

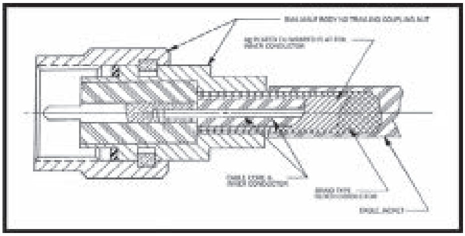
TYPE N MALE TO TYPE N BULKHEAD FEMALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
OS-150-01.00.0	TYPE "N" PLUG to TYPE "N" BULKHEAD JACK	1.0	$80.25	$79.25	$78.25
OS-150-01.06.0		1.5	$82.50	$81.50	$80.50
OS-150-02.00.0		2.0	$84.75	$83.75	$82.75
OS-150-02.06.0		2.5	$87.00	$86.00	$85.00
OS-150-03.00.0		3.0	$89.25	$88.25	$87.25
OS-150-04.00.0		4.0	$93.75	$92.75	$91.75
OS-150-05.00.0		5.0	$98.25	$97.25	$96.25
OS-150-06.00.0		6.0.	$102.75	$101.75	$100.75

MICROFLEX 095

Operating Frequency DC-18.0 GHz

MICROFLEX 095 is a miniature flexible cable with the approximate size and electrical characteristics of .085 semirigid at a price comparable to an RG-316 assembly and the flexibility of RG-188. The cable Is approximately half the size of RG-142 with 4 to 5 times the flexibility. MICROFLEX 095 has a finished diameter of .095 inch. The cable is designed to offer excellent shielding characteristics and good flexibility while maintaining the attenuation performance of .085 semi-rigid.



ELECTRICAL PROPERTIES

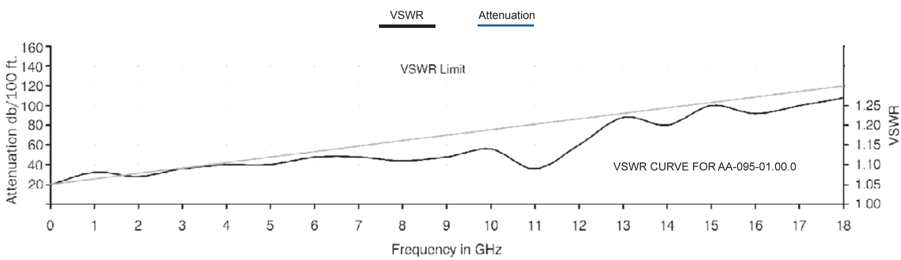
Impedance	50 ± 1 OHM
velocity of propagation	69.5%
Cut off Frequency	60.0 GHz
Max Operating Voltage	1200 Volts RMS
Nominal Capacitance	29.4 pf/f
RF Shielding	Greater than 90db

MATERIALS

Inner Conductor	SIL PLT. Cu Clad Steel.020 Dia.
Dielectric	PTFE .066 Dia.
Outer Conductor	SIL PLT Copper Ribbon .080 Dia.
Jacket	FEP Teflon .095 Dia.

MECHANICAL PROPERTIES

Bend Radius	Minimum 0.5 Inch
Weight	.175 oz/ft
Temp Range	-55°F/+400°F

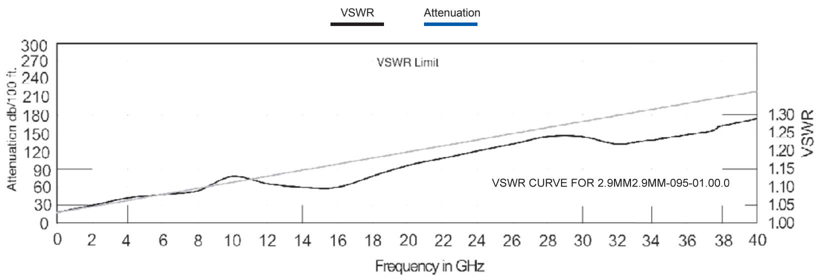


SMA MALE TO SMA MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
AA-095-00.06.0	SMA PLUG to SMA PLUG	0.6	$25.00	$24.00	$23.00
AA-095-01.00.0		1.0	$25.00	$24.00	$23.00
AA-095-01.06.0		1.5	$27.00	$26.00	$25.00
AA-095-02.00.0		2.0	$29.00	$28.00	$27.00
AA-095-02.06.0		2.5	$31.00	$30.00	$29.00
AA-095-03.00.0		3.0	$33.00	$32.00	$31.00
AA-095-04.00.0		4.0	$37.00	$36.00	$35.00
AA-095-05.00.0		5.0	$41.00	$40.00	$39.00
AA-095-06.00.0		6.0.	$45.00	$44.00	$43.00

MICROFLEX 095

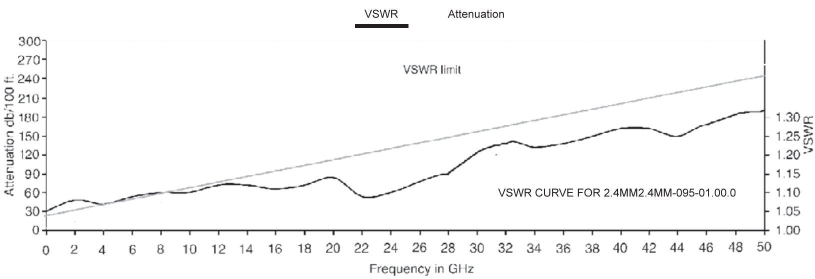
Operating Frequency DC-40.0 GHz



2.9MM MALE TO 2.9MM MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
2.9MM2.9MM-095-00.06.0	2.9MM PLUG to 2.9MM PLUG	0.6	$88.00	$87.00	$86.00
2.9MM2.9MM-095-01.00.0		1.0	$88.00	$87.00	$86.00
2.9MM2.9MM-095-01.06.0		1.5	$90.50	$89.50	$88.50
2.9MM2.9MM-095-02.00.0		2.0	$93.00	$92.00	$91.00
2.9MM2.9MM-095-02.06.0		2.5	$95.50	$94.50	$93.50
2.9MM2.9MM-095-03.00.0		3.0	$98.00	$97.00	$96.00
2.9MM2.9MM-095-04.00.0		4.0	$105.00	$104.00	$103.00
2.9MM2.9MM-095-05.00.0		5.0	$110.00	$109.00	$108.00
2.9MM2.9MM-095-06.00.0		6.0	$115.00	$114.00	$113.00

Operating Frequency DC-50.0 GHz



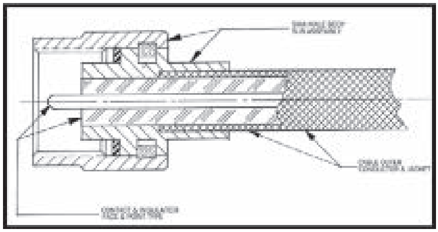
2.4MM MALE TO 2.4MM MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
2.4MM2.4MM-095-00.06.0	2.4MM PLUG to 2.4MM PLUG	0.6	$100.00	$99.00	$98.00
2.4MM2.4MM-095-01.00.0		1.0	$100.00	$99.00	$98.00
2.4MM2.4MM-095-01.06.0		1.5	$102.50	$101.50	$100.50
2.4MM2.4MM-095-02.00.0		2.0	$105.00	$104.00	$103.00
2.4MM2.4MM-095-02.06.0		2.5	$107.50	$106.00	$105.50
2.4MM2.4MM-095-03.00.0		3.0	$110.00	$109.00	$108.00
2.4MM2.4MM-095-04.00.0		4.0	$115.00	$114.00	$113.00
2.4MM2.4MM-095-05.00.0		5.0	$120.00	$119.00	$118.00
2.4MM2.4MM-095-06.00.0		6.0	$125.00	$124.00	$123.00

MICROFORM 139

Operating Frequency DC-26.0 GHz

MICROFORM 139 is a hand formable replacement for .141 semi-rigid cable. Easily formed by hand, it's shape is retained with no spring back. Available as pre-made assemblies with SMA connectors. MICROFORM 139 cables are economical replacements for semi-rigid. **Contact Factory for Connectors and Electrical Performance not listed.**



ELECTRICAL PROPERTIES

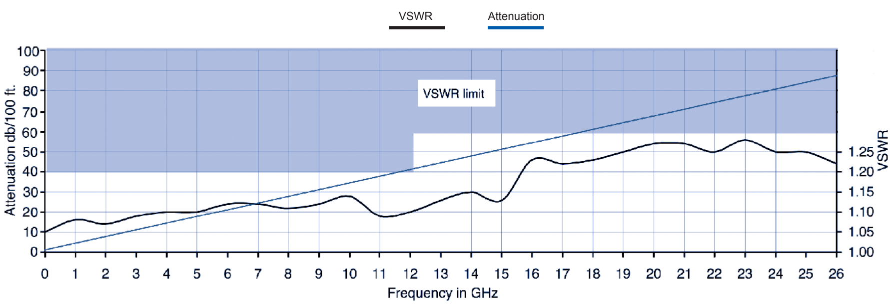
Impedance	50 ± 1 OHM
velocity of propagation	69.5%
Cut off Frequency	35.0 GHz
Max Operating Voltage	1900 Volts RMS
Nominal Capacitance	29.4 pf/f
RF Shielding	Greater than 90db

MATERIALS

Inner Conductor	SIL PLT. Cu Clad Steel.036 Dia.
Dielectric	PTFE .116 Dia.
Outer Conductor	Cu/Sn Composite Shield 100% Coverage .139 Dia. Nominal

MECHANICAL PROPERTIES

Bend Radius	Minimum 0.25 Inch
Weight	.3 oz/ft
Temp Range	-55ºF/+400ºF

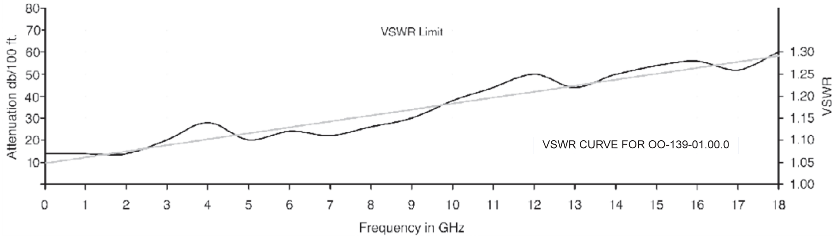


SMA MALE TO SMA MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-24	24-49	50-99
AA-139-00.06.0	SMA PLUG to SMA PLUG	0.6	$26.00	$25.00	$24.00
AA-139-01.00.0		1.0	$26.00	$25.00	$24.00
AA-139-01.06.0		1.5	$27.50	$26.50	$25.50
AA-139-02.00.0		2.0	$29.00	$28.00	$27.00
AA-139-02.06.0		2.5	$30.50	$29.50	$28.50
AA-139-03.00.0		3.0	$32.00	$31.00	$30.00
AA-139-04.00.0		4.0	$35.00	$34.00	$33.00
AA-139-05.00.0		5.0	$38.00	$37.00	$36.00
AA-139-06.00.0		6.0.	$41.00	$40.00	$39.00

MICROFORM 139

Operating Frequency DC-18.0 GHz



SMA MALE TO TYPE N MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-24	25-49	50-99
AO-139-00.06.0	SMA PLUG to TYPE "N" PLUG	0.5	$49.00	$48.00	$44.00
AO-139-01.00.0		1.0	$49.00	$48.00	$44.00
AO-139-01.06.0		1.5	$50.50	$49.50	$45.50
AO-139-02.00.0		2.0	$52.00	$51.00	$47.00
AO-139-02.06.0		2.5	$53.50	$52.50	$48.50
AO-139-03.00.0		3.0	$55.00	$54.00	$50.25
AO-139-04.00.0		4.0	$58.00	$57.00	$53.75
AO-139-05.00.0		5.0	$61.00	$60.00	$56.00
AO-139-06.00.0		6.0	$64.00	$63.00	$59.00

SMA MALE TO TYPE N BULKHEAD FEMALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-24	25-49	50-99
AS-139-00.06.0	SMA PLUG to TYPE "N" BULKHEAD JACK	0.5	$59.00	$58.00	$57.00
AS-139-01.00.0		1.0	$59.00	$58.00	$57.00
AS-139-01.06.0		1.5	$60.50	$59.50	$58.50
AS-139-02.00.0		2.0	$62.00	$61.00	$60.00
AS-139-02.06.0		2.5	$63.50	$62.50	$61.50
AS-139-03.00.0		3.0	$65.00	$64.00	$63.00
AS-139-04.00.0		4.0	$68.00	$67.00	$66.00
AS-139-05.00.0		5.0	$71.00	$70.00	$69.00
AS-139-06.00.0		6.0	$74.00	$73.00	$72.00

TYPE N MALE TO TYPE N MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-24	25-49	50-99
OO-139-00.06.0	TYPE "N" PLUG to TYPE "N" PLUG	0.5	$46.00	$45.00	$47.00
OO-139-01.00.0		1.0	$46.00	$45.00	$47.00
OO-139-01.06.0		1.5	$47.50	$46.50	$48.50
OO-139-02.00.0		2.0	$49.00	$48.00	$50.00
OO-139-02.06.0		2.5	$50.50	$49.50	$51.50
OO-139-03.00.0		3.0	$52.00	$51.00	$53.00
OO-139-04.00.0		4.0	$55.75	$54.75	$56.00
OO-139-05.00.0		5.0	$58.00	$57.00	$59.00
OO-139-06.00.0		6.0	$61.00	$60.00	$62.00

SMA MALE TO SMA BULKHEAD FEMALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-24	25-49	50-99
AC-139-00.06.0	SMA PLUG to SMA BULKHEAD JACK	0.5	$37.00	$36.00	$35.00
AC-139-01.00.0		1.0	$37.00	$36.00	$35.00
AC-139-01.06.0		1.5	$38.50	$37.50	$36.50
AC-139-02.00.0		2.0	$40.00	$39.00	$38.50
AC-139-02.06.0		2.5	$41.50	$40.50	$39.50
AC-139-03.00.0		3.0	$43.00	$42.00	$41.00
AC-139-04.00.0		4.0	$46.00	$45.00	$44.00
AC-139-05.00.0		5.0	$49.00	$48.00	$47.00
AC-139-06.00.0		6.0	$52.00	$51.00	$50.00

TYPE N MALE TO TYPE N BULKHEAD FEMALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-24	25-49	50-99
OS-139-00.06.0	TYPE "N" PLUG to TYPE "N" BULKHEAD JACK	0.5	$66.75	$65.75	$64.75
OS-139-01.00.0		1.0	$66.75	$65.75	$64.75
OS-139-01.06.0		1.5	$67.50	$66.50	$65.50
OS-139-02.00.0		2.0	$69.00	$68.00	$67.00
OS-139-02.06.0		2.5	$70.50	$69.50	$68.50
OS-139-03.00.0		3.0	$72.00	$71.00	$70.00
OS-139-04.00.0		4.0	$75.80	$74.80	$72.80
OS-139-05.00.0		5.0	$78.00	$77.00	$76.00
OS-139-06.00.0		6.0	$81.00	$80.00	$79.00

MICROFORM 139

Operating Frequency DC-12.4 GHz

FURNISHED WITH CUBE TYPE RIGHT ANGLES

SMA MALE RIGHT ANGLE TO SMA MALE RIGHT ANGLE

PART NO.	CONNECTORS	LENGTH	1-24	25-49	50-99
BB-139-00.06.0	SMA PLUG RIGHT ANGLE to SMA PLUG RIGHT ANGLE	0.5 Ft.	$46.00	$45.00	$44.00
BB-139-01.00.0		1.0 Ft.	$46.00	$45.00	$44.00
BB-139-01.06.0		1.5 Ft.	$47.50	$46.50	$45.50
BB-139-02.00.0		2.0 Ft.	$49.00	$48.00	$47.00
BB-139-02.06.0		2.5 Ft.	$50.50	$49.50	$48.50
BB-139-03.00.0		3.0 Ft.	$52.00	$51.00	$50.00
BB-139-04.00.0		4.0 Ft.	$55.00	$54.00	$53.00
BB-139-05.00.0		5.0 Ft.	$58.00	$57.00	$56.00
BB-139-06.00.0		6.0 Ft.	$61.00	$60.00	$59.00

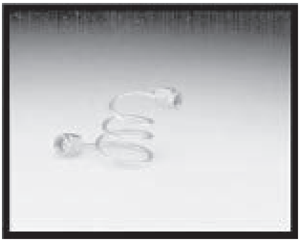
SMA MALE TO SMA MALE RIGHT ANGLE

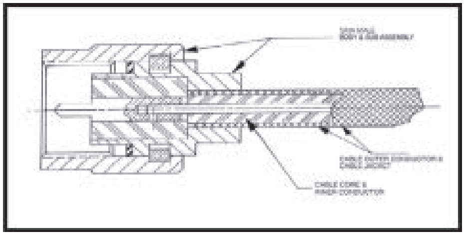
PART NO.	CONNECTORS	LENGTH	1-24	25-49	50-99
AB-139-00.06.0	SMA PLUG to SMA PLUG RIGHT ANGLE	0.5 Ft.	$36.00	$35.00	$34.00
AB-139-01.00.0		1.0 Ft.	$36.00	$35.00	$34.00
AB-139-01.06.0		1.5 Ft.	$37.50	$36.50	$35.50
AB-139-02.00.0		2.0 Ft.	$39.00	$38.00	$37.00
AB-139-02.06.0		2.5 Ft.	$40.50	$39.50	$38.50
AB-139-03.00.0		3.0 Ft.	$42.00	$41.00	$40.00
AB-139-04.00.0		4.0 Ft.	$45.00	$44.00	$43.00
AB-139-05.00.0		5.0 Ft.	$48.00	$47.00	$46.00
AB-139-06.00.0		6.0 Ft.	$51.00	$50.00	$49.00

MICROFORM 088

Operating Frequency DC-26.0 GHz

MICROFORM 088 is a hand formable replacement for .085 semi-rigid cable. Easily formed by hand, it's shape is retained with no spring back. Available as pre-made assemblies with SMA connectors. MICROFORM 088 cables are economical replacements for semi-rigid. **Contact Factory for Connectors and Electrical Performance not listed.**





ELECTRICAL PROPERTIES

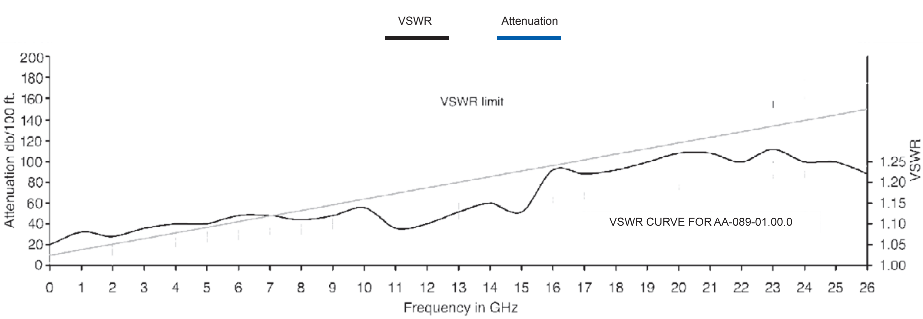
Impedance	50 ± 1 OHM
velocity of propagation	69.5%
Cut off Frequency	60.0 GHz
Max Operating Voltage	1200 Volts RMS
Nominal Capacitance	29.4 pf/f
RF Shielding	Greater than 90db

MATERIALS

Inner Conductor	SIL PLT. Cu Clad Steel.020 Dia.
Dielectric	PTFE .066 Dia.
Outer Conductor	Cu/Sn Composite Shield 100% Coverage . 088 Dia. Nominal

MECHANICAL PROPERTIES

Bend Radius	Minimum 0.5 Inch
Weight	.175 oz/ft
Temp Range	-55ºF/+400ºF

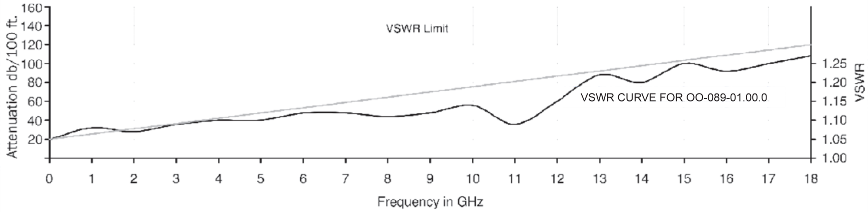


SMA MALE TO SMA MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-24	24-49	50-99
AA-088-00.06.0	SMA PLUG to SMA PLUG	0.6	$28.00	$27.00	$26.00
AA-088-01.00.0		1.0	$28.00	$27.00	$26.00
AA-088-01.06.0		1.5	$29.50	$28.50	$27.50
AA-088-02.00.0		2.0	$31.00	$30.00	$29.00
AA-088-02.06.0		2.5	$32.50	$31.50	$30.50
AA-088-03.00.0		3.0	$34.00	$33.00	$32.00
AA-088-04.00.0		4.0	$37.00	$36.00	$35.00
AA-088-05.00.0		5.0	$40.00	$39.00	$38.00
AA-088-06.00.0		6.0.	$43.00	$42.00	$41.00

MICROFORM 088

Operating Frequency DC-18.0 GHz



SMA MALE TO TYPE N MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-24	25-49	50-99
AO-088-00.06.0	**SMA PLUG to TYPE "N" PLUG**	0.5	$51.00	$50.00	$46.00
AO-088-01.00.0		1.0	$51.00	$50.00	$46.00
AO-088-01.06.0		1.5	$52.50	$51.50	$47.50
AO-088-02.00.0		2.0	$54.00	$53.00	$49.75
AO-088-02.06.0		2.5	$55.50	$54.50	$50.00
AO-088-03.00.0		3.0	$57.00	$56.00	$52.25
AO-088-04.00.0		4.0	$60.00	$59.00	$55.75
AO-088-05.00.0		5.0	$63.00	$62.00	$58.25
AO-088-06.00.0		6.0	$66.00	$65.00	$61.00

SMA MALE TO TYPE N BULKHEAD FEMALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-24	25-49	50-99
AS-088-00.06.0	**SMA PLUG to TYPE "N" BULKHEAD JACK**	0.5	$61.00	$60.00	$59.00
AS-088-01.00.0		1.0	$61.00	$60.00	$59.00
AS-088-01.06.0		1.5	$62.50	$61.50	$60.50
AS-088-02.00.0		2.0	$64.00	$63.00	$62.00
AS-088-02.06.0		2.5	$65.50	$64.50	$63.50
AS-088-03.00.0		3.0	$67.00	$66.00	$65.00
AS-088-04.00.0		4.0	$70.00	$69.00	$68.00
AS-088-05.00.0		5.0	$73.50	$72.50	$71.50
AS-088-06.00.0		6.0	$76.00	$75.00	$74.00

TYPE N MALE TO TYPE N MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-24	25-49	50-99
OO-088-00.06.0	**TYPE "N" PLUG to TYPE "N" PLUG**	0.5	$48.00	$47.00	$49.00
OO-088-01.00.0		1.0	$48.00	$47.00	$49.00
OO-088-01.06.0		1.5	$49.50	$48.50	$50.50
OO-088-02.00.0		2.0	$51.00	$50.00	$52.00
OO-088-02.06.0		2.5	$52.50	$51.50	$53.50
OO-088-03.00.0		3.0	$54.00	$53.00	$55.00
OO-088-04.00.0		4.0	$57.00	$56.25	$58.00
OO-088-05.00.0		5.0	$60.00	$59.00	$61.00
OO-088-06.00.0		6.0	$63.00	$62.00	$64.00

SMA MALE TO SMA BULKHEAD FEMALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-24	25-49	50-99
AC-088-00.06.0	**SMA PLUG to SMA BULKHEAD JACK**	0.5	$39.00	$38.00	$37.00
AC-088-01.00.0		1.0	$39.00	$38.00	$37.00
AC-088-01.06.0		1.5	$40.50	$39.50	$40.00
AC-088-02.00.0		2.0	$42.00	$41.00	$41.00
AC-088-02.06.0		2.5	$43.50	$42.50	$41.50
AC-088-03.00.0		3.0	$45.00	$44.00	$43.00
AC-088-04.00.0		4.0	$48.00	$47.00	$46.00
AC-088-05.00.0		5.0	$51.00	$50.00	$49.00
AC-088-06.00.0		6.0	$54.00	$53.00	$52.00

TYPE N MALE TO TYPE N BULKHEAD FEMALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-24	25-49	50-99
OS-088-00.06.0	**TYPE "N" PLUG to TYPE "N" BULKHEAD JACK**	0.5	$68.75	$67.75	$66.75
OS-088-01.00.0		1.0	$68.75	$67.75	$66.75
OS-088-01.06.0		1.5	$69.50	$68.50	$67.50
OS-088-02.00.0		2.0	$71.00	$70.00	$69.00
OS-088-02.06.0		2.5	$72.50	$71.50	$70.50
OS-088-03.00.0		3.0	$74.00	$73.00	$72.00
OS-088-04.00.0		4.0	$77.00	$76.00	$75.00
OS-088-05.00.0		5.0	$80.00	$79.00	$78.00
OS-088-06.00.0		6.0	$83.00	$82.00	$81.00

MICROFORM 088

Operating Frequency DC-12.4 GHz

FURNISHED WITH CUBE TYPE RIGHT ANGLES

SMA MALE RIGHT ANGLE TO SMA MALE RIGHT ANGLE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-24	25-49	50-99
BB-088-00.06.0	**SMA PLUG RIGHT ANGLE to SMA PLUG RIGHT ANGLE**	0.5	$48.00	$47.00	$46.00
BB-088-01.00.0		1.0	$48.00	$47.00	$46.00
BB-088-01.06.0		1.5	$49.50	$48.50	$47.50
BB-088-02.00.0		2.0	$51.00	$50.00	$49.00
BB-088-02.06.0		2.5	$52.50	$51.50	$50.50
BB-088-03.00.0		3.0	$54.00	$53.00	$52.00
BB-088-04.00.0		4.0	$57.00	$56.00	$55.00
BB-088-05.00.0		5.0	$60.00	$59.00	$58.00
BB-088-06.00.0		6.0.	$63.00	$62.00	$61.00

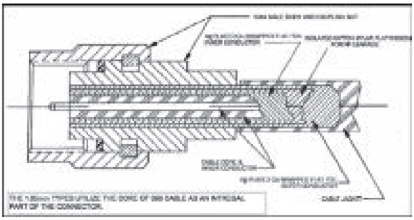
SMA MALE TO SMA MALE RIGHT ANGLE

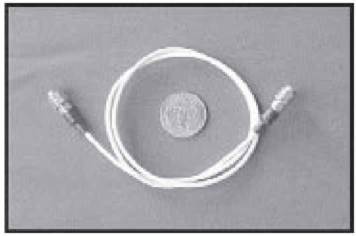
PART NO.	CONNECTORS	LENGTH (Ft.)	1-24	25-49	50-99
AB-088-00.06.0	**SMA PLUG to SMA PLUG RIGHT ANGLE**	0.5	$38.00	$37.00	$36.00
AB-088-01.00.0		1.0	$38.00	$37.00	$36.00
AB-088-01.06.0		1.5	$39.50	$38.50	$37.50
AB-088-02.00.0		2.0	$41.00	$40.00	$39.00
AB-088-02.06.0		2.5	$42.50	$41.50	$40.50
AB-088-03.00.0		3.0	$44.00	$43.00	$42.00
AB-088-04.00.0		4.0	$46.00	$46.00	$44.00
AB-088-05.00.0		5.0	$50.00	$49.00	$48.00
AB-088-06.00.0		6.0.	$53.00	$52.00	$51.00

MICROFLEX 098

Operating Frequency DC-65.0 GHz

MICROFLEX 098 Flexible Cable Assemblies. These Cable Assemblies are available with 1.85mm "V"® Male Connectors with performance to 65 GHz ("V" is Regesterd Trademark of the ANRITSU Company) Contact **UNITED MICROWAVE PRODUCTS INC**. Phone(310)-320-1244 Fax (310)-320-9729 Web http://www.unitedmicrowave.com Email umpinc@pacbell.net for other types of Precision Cables





ELECTRICAL PROPERTIES

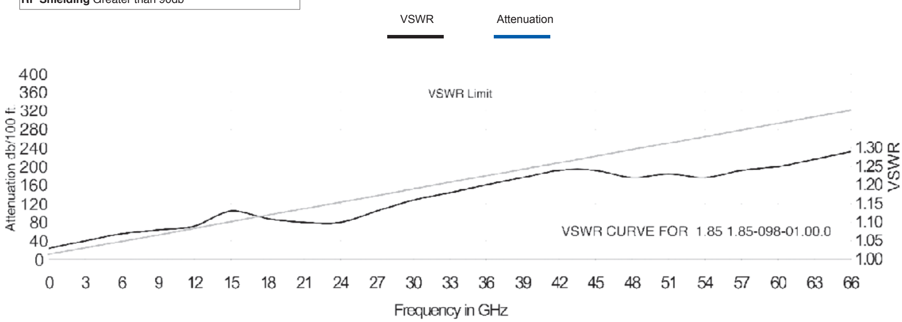
Impedance 50 ± 2 OHMs
Cut off Frequency 65.0 GHz
Nominal Capacitance 29.4 pf/f
Velocity of propagation 69.5%
Max Operating Voltage 1200 Volts RMS
RF Shielding Greater than 90db

MATERIALS

Inner Conductor SIL PLT Cu Clad Steel .0196 Dia.
Dielectric Solid PTFE .062 Dia.
Outer Conductor Dual SIL PLT Copper Ribbon Isolated By Mylar For RF Leakage .080 Dia.
Jacket FEP Teflon .098 Dia.

MECHANICAL PROPERTIES

Bend Radius Minimum 0.5 Inch
Temp Range -55ºF/+400ºF
Weight .175 oz/ft



1.85MM MALE TO 1.85MM MALE

PART NO.	CONNECTORS	LENGTH (Ft.)	1-9	10-24	25-49
1.85MM1.85MM-098-00.06.0	1.85mm M /1.85mm M	0.6	$112.00	$111.00	$110.00
1.85MM1.85MM-098-01.00.0	1.85mm M /1.85mm M	1.0	$112.00	$111.00	$110.00
1.85MM1.85MM-098-01.06.0	1.85mm M /1.85mm M	1.5	$114.50	$113.50	$112.50
1.85MM1.85MM-098-02.00.0	1.85mm M /1.85mm M	2.0	$117.00	$116.00	$113.00
1.85MM1.85MM-098-02.06.0	1.85mm M /1.85mm M	2.5	$119.50	$118.50	$117.50
1.85MM1.85MM-098-03.00.0	1.85mm M /1.85mm M	3.0	$122.00	$121.00	$120.00
1.85MM1.85MM-098-04.00.0	1.85mm M /1.85mm M	4.0	$127.00	$126.00	$125.00
1.85MM1.85MM-098-05.00.0	1.85mm M /1.85mm M	5.0	$132.00	$131.00	$130.00
1.85MM1.85MM-098-06.00.0	1.85mm M /1.85mm M	6.0	$137.00	$136.00	$135.00

COPY THIS FORM AND FAX, MAIL OR CONTACT FACTORY

EASY ORDER FORM

ORDER FORM MUST BE FILLED OUT COMPLETELY

DATE: ____________________ P.O. # ____________________

COMPANY: ____

STREET: ____

CITY: ______________________ STATE __________ ZIP __________

MINIMUM ORDER IS $ 100.00 U.S.

ALL SALES ARE FINAL!
CONTACT FACTORY FOR DETAILS

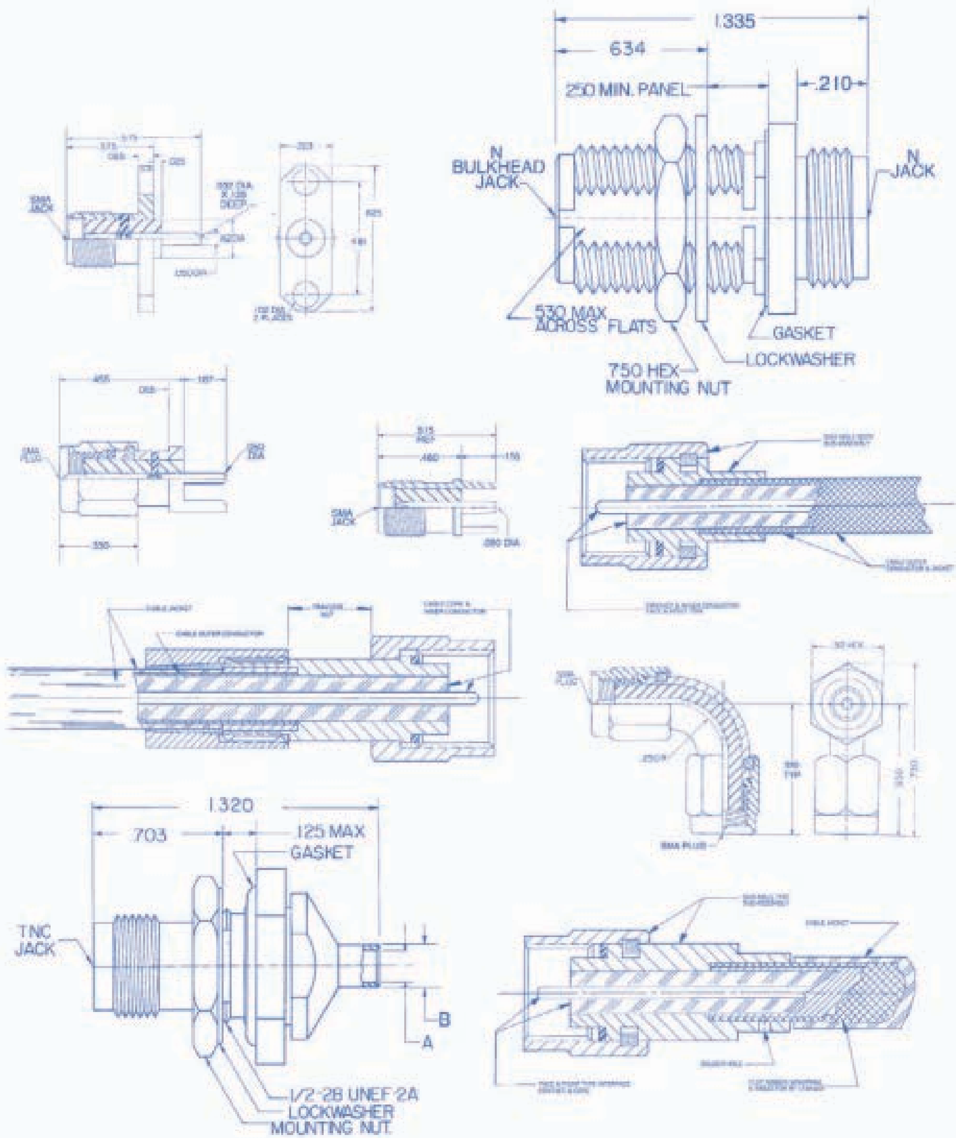
VISA ( ) MasterCard ( )	FOR RESALE, PLEASE ATTACH RESALE CERTIFICATE OR ENTER YOUR RESELLER'S PERMIT NUMBER IN THE SPACE BELOW AND SIGN THE ORDER SELLER'S PERMIT # ____________
CREDIT CARD ACCOUNT NUMBER	CARDHOLDER'S REGISTERED MAILIING ADDRESS IF DIFFERENT FROM ABOVE.
CARD SECURITY CODE (LAST 3 OR 4 DIGITS ON BACK OF CARD) / EXPIRATION DATE	NAME ____________ COMPANY ____________
CARDHOLDER'S NAME (PLEASE PRINT OR TYPE)	ADDRESS ____________ CITY ________ STATE ______ ZIP ______

ITEM NO.	QUANTITY	UNITED MICROWAVE PRODUCTS INC. PART NO.	UNIT PRICE	EXTENDED PRICE
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

YOUR UPS ACCOUNT NUMBER ____________ FRIGHT CHARGES WILL BE ADDED IF BLANK	SUB-TOTAL OF ORDER MINIMUM ORDER IS $100.00 U.S.	
( ) UPS GROUND ( ) UPS BLUE (2 day)	8.25% SALES TAX CA RESIDENTS ONLY	
( ) UPS RED (overnight) ( ) UPS ORANGE (3 day)	SHIPPING CHARGES	
	<u>TOTAL PRIOR TO SHIPPING CHARGES BEING ADDED</u>	

!!!! ALL SALES ARE FINAL !!!! RETURNS NOT ACCECPTED WITHOUT PRIOR APPROVAL AND PROPER RMA NUMBER FROM UNITED MICROWAVE	YOUR TELEPHONE NUMBER:
CARDHOLDER'S SIGNATURE (REQUIRED FOR ALL ORDERS)	YOUR FAX NUMBER:

MICROWAVE CABLES & CONNECTORS



http://www.unitedmicrowave.com

UNITED MICROWAVE PRODUCTS INC


Get in touch ...
Speed
Bandwidth
Easy operation
ROHDE&SCHWARZ

… with the next generation of signal analyzers – the R&S®FSV.

The new mid-range R&S®FSV signal analyzer is faster, easier to use, more accurate and has a broader analysis bandwidth than any other instrument in its price class.

Extreme speed

The R&S®FSV can perform up to 1000 sweeps/s, making it up to five times faster than any other signal analyzer on the market.

Wide analysis bandwidth

The 40 MHz analysis bandwidth of the R&S®FSV lets you enjoy the entire world of wideband technologies including WLAN 802.11n, WiMAX or LTE.

Ease of use

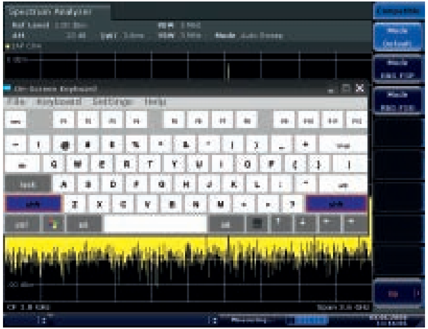
A touch screen makes operation easy and intuitive.

These and numerous other highlights make the R&S®FSV the first choice in development, production and service. And just like its technical assets, the price/performance ratio of the R&S®FSV can be expressed in one word: Outstanding.

More specifics? www.rohde-schwarz.com/ad/fsv

Touch screen for optimum convenience

The R&S®FSV's touch screen and innovative functions transform the manual operation of signal analyzers. The days of mouse and keyboard are over. Frequently recurring steps such as positioning markers can be completed in almost no time. Hotkeys, context-sensitive help and an undo/redo function add up to fast, smooth, and easy instrument operation.



Text can be entered via the convenient on-screen keyboard.

Multiple measurement functions can be active at the same time on the R&S®FSV. Like in a web browser, users can quickly switch between the displays by using tabs.

We wrote the book – and now you can get it too.

Rohde & Schwarz is the Driving Force in spectrum analysis. So it's logical that the next generation signal analyzer should come from us – the revolutionary R&S®FSV.
We have great expertise in the field. In fact, we literally wrote the book on spectrum analysis, and we'd like to send you a free copy.
Fundamentals of Spectrum Analysis is a 218-page, hardbound book that gives a solid grounding in the theory and practice of this key testing discipline. It belongs on every engineer's desk.

To get your free copy, just go to www.test-rsa.com/FSV/MJ0808.

Quantities are limited, so don't delay! Get your free copy of Fundamentals of Spectrum Analysis today.

(Offer good in United States only. Offer good only while supplies last)