Vol. 50 • No. 3

March 2007

Microwave Journal

Test, Measurement and CAD

Convergence of Analog and Digital Simulation

Today's Digital RF World

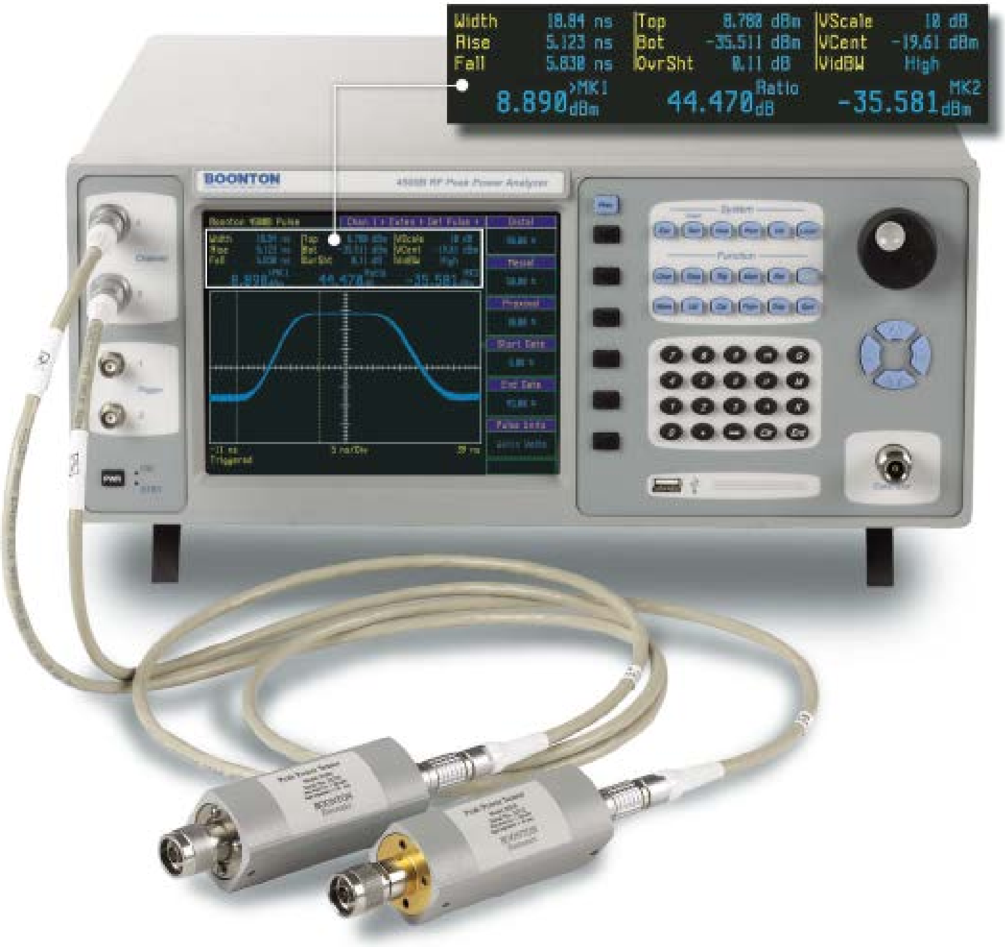
LXI Standard: Past, Present and Future

horizon house

Founded in 1958

www.mwjournal.com

We've Taken Performance To A New Peak.



BOONTON 4500B PEAK POWER ANALYZER AND FAST PEAK SENSORS

Introducing the 56006 and 58318 peak power sensors optimized for use on the 4500B peak power analyzer. The 56006 peak power sensor features a unique combination of industry leading video bandwidth and unsurpassed dynamic range that make it ideal for measuring communication signals in 3G and future 4G wireless applications. The 58318 peak power sensor offers a combination of broad RF frequency range and fast risetime measurement capability for the most demanding military and commercial pulsed RF radar applications.

56006

- **RF Frequency range to 6 GHz**
- **<7 nsec risetime (typical video bandwidth up to 65 MHz)**
- **70 dB dynamic range (pulse mode) or 80 dB dynamic range (modulated mode)**

58318

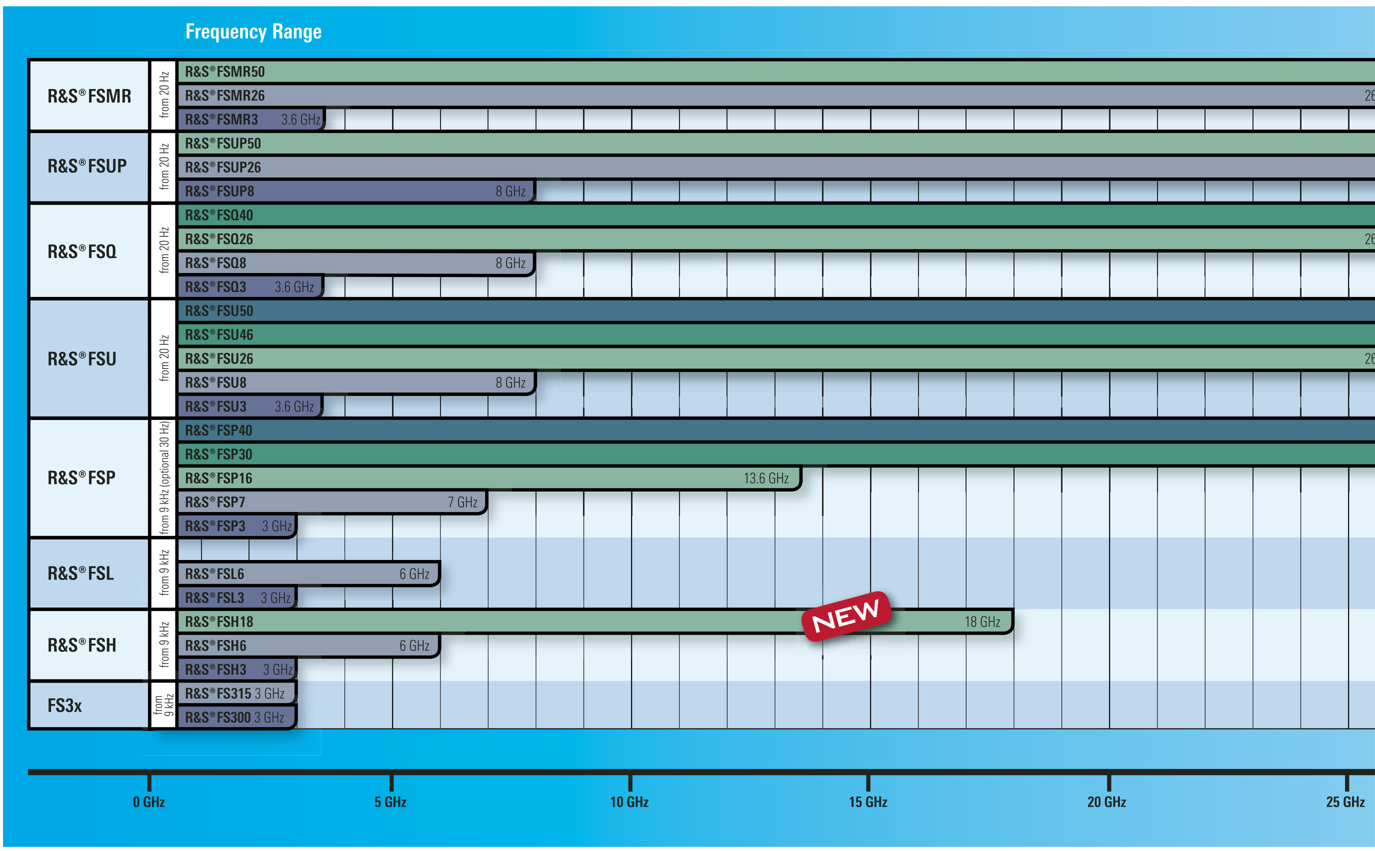
- **RF frequency range to 18 GHz**
- **<10 nsec risetime (8 nsec typical)**
- **44 dB dynamic range (pulse mode) or 54 dB dynamic range (modulated mode)**

BOONTON
A WIRELESS TELECOM GROUP COMPANY

boonton@boonton.com • +1 (973) 386-9696 • Fax +1 (973) 386-9191 • www.boonton.com

Visit http://mwj.hotims.com/11714-26 or use RS# 26 at www.mwjournal.com/info

The Rohde & Schwarz Wo



R&S®FS300 Cost-efficient 3 GHz spectrum analyzer for applications in service, production and education

R&S®FSH Versatile handheld spectrum analyzer up to 18 GHz for mobile applications in the field and in service

R&S®FSL Compact lightweight analyzer for applications in development, service and installation with 20 MHz I/Q demodulation bandwidth

R&S®FSP Medium-class spectrum analyzer up to 40 GHz for most lab applications, service and measurements in production

R&S®FSU High-end spectrum analyzer up to 50 GHz for applications in R&D and production with high demands on dynamic range

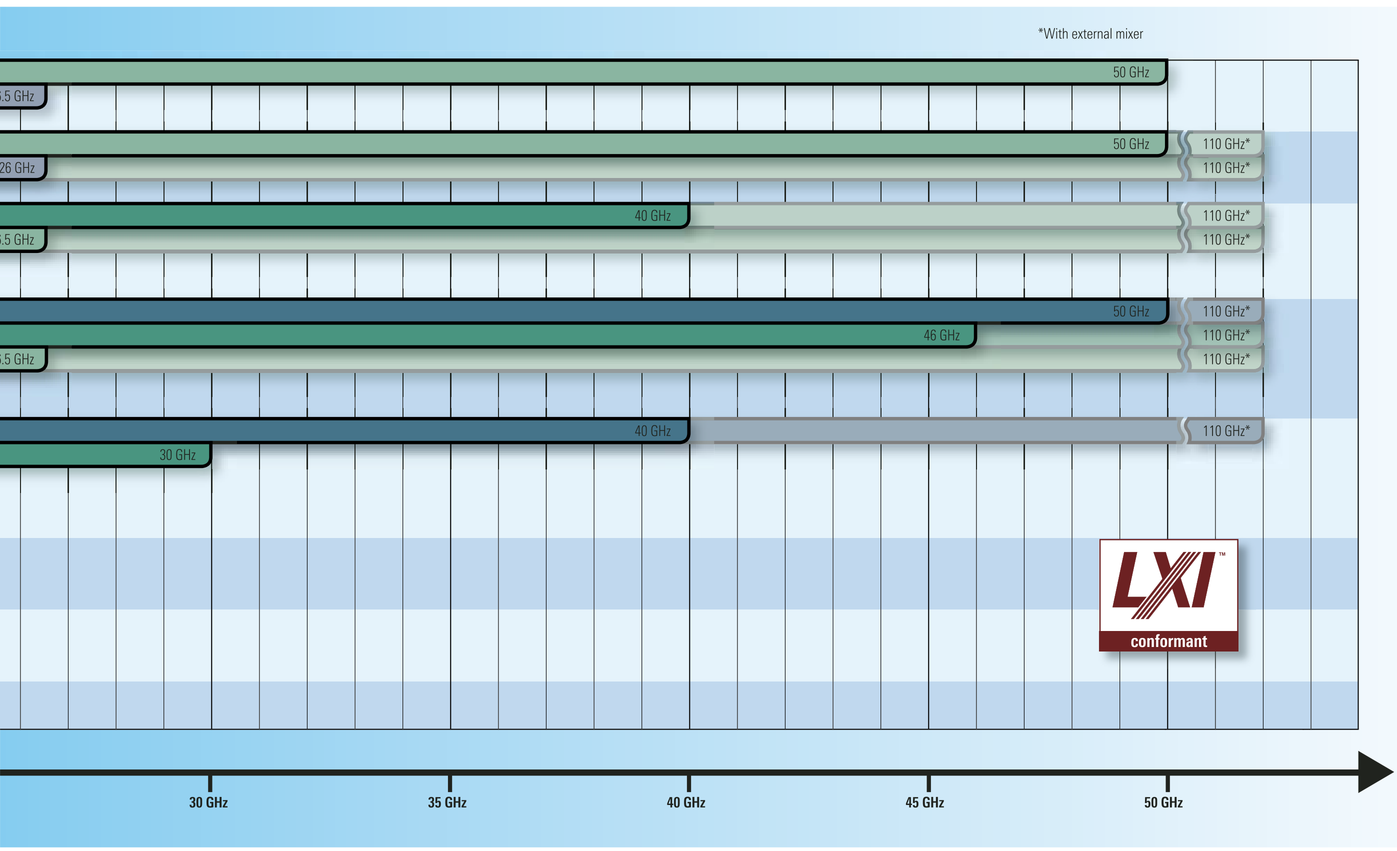
R&S®FMU Baseband analyzer with balanced and unbalanced analog inputs (I/Q)

R&S®FSQ Signal analyzer with integrated spectrum analyzer up to 40 GHz (similar to the R&S®FSU) and up to 120 MHz I/Q demodulation bandwidth

R&S®FSMR Measuring receiver for signal generator and attenuator calibration with high linearity

R&S®FSUP Phase-noise test set and signal source analyzer with integrated high-end spectrum analyzer

orld of Spectrum Analysis



R&S® FSU/FSQ/FSUP/FSMR/FMU

R&S® FSP

R&S® FSL

R&S® FSH

R&S® FS3xx

Want to know more? Just give us a call, send us an e-mail or fax us this page.

Europe:

Phone: +49 1805 12 42 42
E-Mail: customersupport@rohde-schwarz.com
Fax: +49 89 4129 63778

Asia:

Phone: +65 65130 488
E-Mail: customersupport.asia@rohde-schwarz.com
Fax: +65 68 46 18 72

North America:

Phone: +1 410-910-7988

E-Mail: customersupport@rsa.rohde-schwarz.com

Fax: +1 410 910 78 01

Please send me more information about the following products:

____

____

____

Please contact me

Name ________________________________

Company ________________________________

Phone number ________________________________

E-Mail ________________________________

ROHDE&SCHWARZ

www.rohde-schwarz.com

VCOs

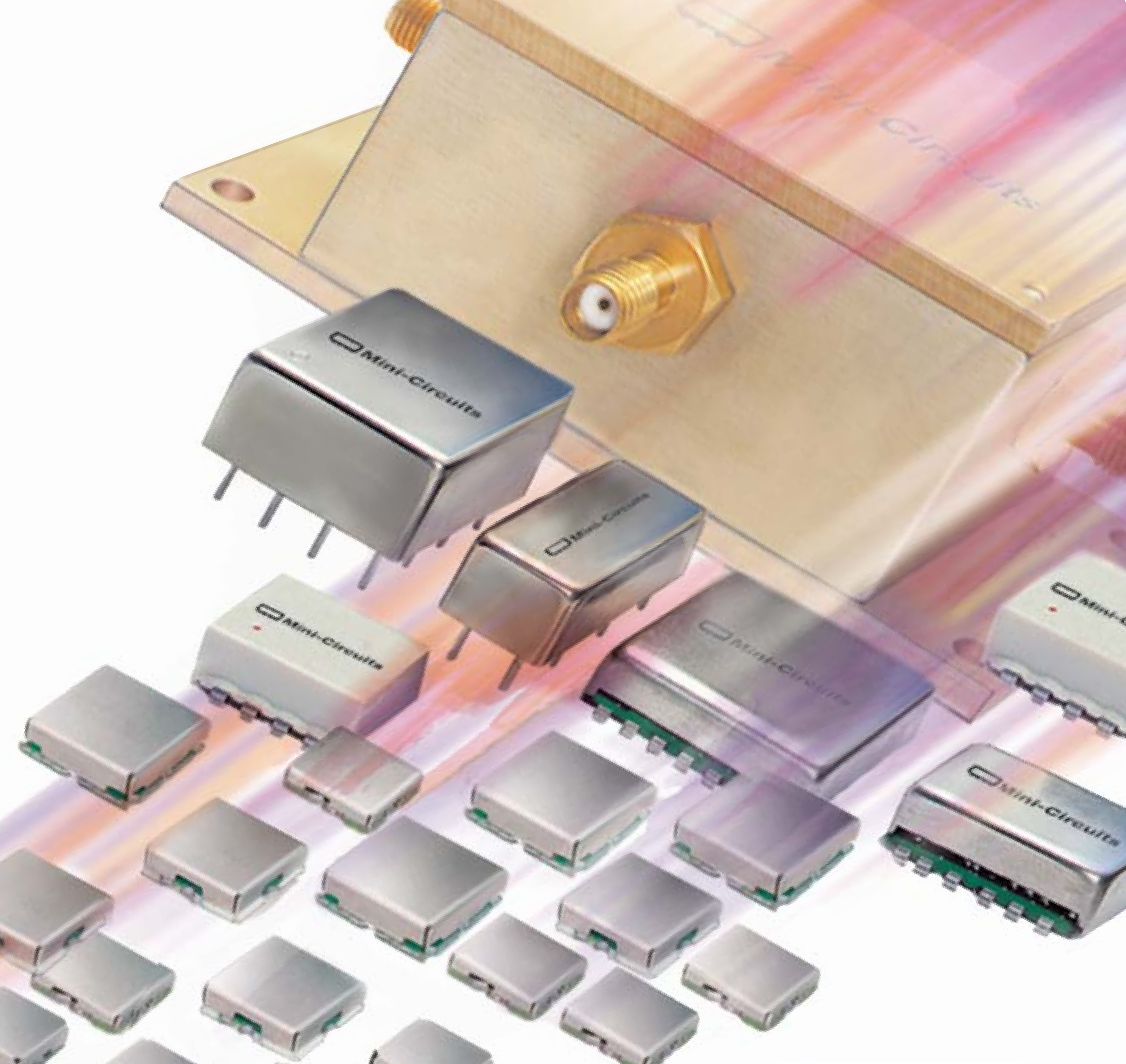
10 to 4400 MHz from $11.95 ea. (qty. 5)

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.
With YONI2, you just enter your specs…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!


Mini-Circuits
Mini-Circuits
Mini-Circuits
Mini-Circuits
Mini-Circuits

Do Your Connectors Cause Damage?

Using Maury connector gages to verify critical interface dimensions BEFORE damage occurs helps ensure accuracy in your measurements.

THE PROBLEM:

- Protruding contacts damage mating connectors
- Recessed contacts cause poor electrical performance and create uncertainty in your measurements

THE SOLUTION:

- Always use Maury connector gages to verify pin depth and position before mating

The A048A 1.85mm/2.4mm Digital Connector Gage Kit Includes Female & Male Gages, Master Standards, Torque Wrench & Open End Wrench

Maury Digital Gage Features:

- Large, bold, easy-to-read US standard and/or metric digital displays
- No needle position to misread
- No scales to misinterpret
- Downloadable for external data display
- Reduce your inspection time and increase your throughput

Maury Microwave, the company that invented connector gages, offers Digital Gages in 1.85mm, 2.4mm, 2.92mm, 3.5mm & Type N. Over 30 gage configurations are available. MAURY has complete cal standards for your VNA/PNA.

CELEBRATING FIFTY YEARS OF SERVICE TO OUR CUSTOMERS

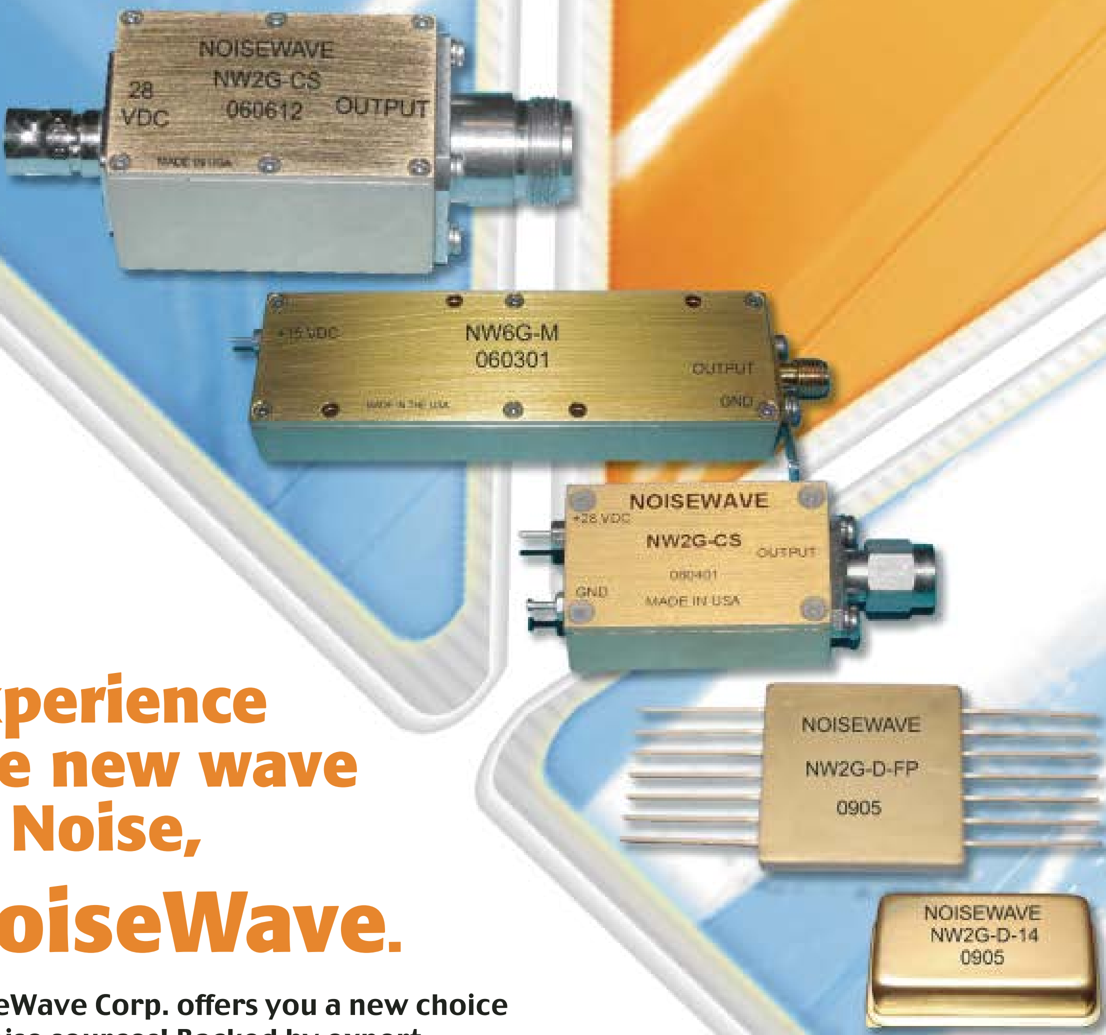
MAURY MICROWAVE
CORPORATION

Celebrating our 50th Year of Commitment to Precision Manufacturing of Cal Kits and Accessories!

Find It Fast With Our Interactive Adapter Finderat: http://www.maurymw.com/adapterfinder/index.php

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

More Noise



Experience the new wave in Noise,

NoiseWave.

NoiseWave Corp. offers you a new choice in Noise sources! Backed by expert designers in Noise, NoiseWave provides reliable Noise Components, Noise Diodes and Noise Generators for telecommunications.

Our goal is to give you the most reliable, the most advanced and the most cost effective Noise products, while providing unmatched, superior service.

Contact us to order a standard product, always available from stock, or let us design a custom noise source guaranteed with a quick delivery.

Choose NoiseWave, the new wave in Noise!

For more information
Contact Ed Garcia at:

NOISEWAVE
The new wave in NOISE

NoiseWave Corp.
Phone (973) 386–1119
Fax (973) 386–1131
egarcia@noisewave.com
www.noisewave.com

Visit http://mwj.hotims.com/11714-101 or use RS# 101 at www.mwjournal.com/info

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 30x faster and 10x 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 the biggest in the world with more than 5,000 Aeroflex 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/warranty

AEROFLEX
A passion for performance.

Visit http://mwj.hotims.com/11714-3 or use RS# 3 at www.mwjournal.com/info

Microwave Journal

MARCH 2007 VOL. 50 • NO. 3

FEATURES

50 Years of Publishing Excellence

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

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.

Horizon House also publishes *Telecommunications*®

Posted under Canadian international publications mail agreement #0738654


So you've used the same design tools for years. Or has it been the other way around?
AWR
Why struggle to create great designs with vintage tools? A recent EDA survey indicated that you-know-who finished near the bottom of leading EDA vendors in customer satisfaction. Life is short. There's a better design path that's been empirically proven: Microwave Office.™ Thousands of users have already discovered that superior layout technology, great technical support and faster simulations lead to shorter design cycles and first pass success. Stop beating your head against the monitor. Download a 30-day trial today and break the habit.
Microwave Office
appwave.com
© 2006 Applied Wave Research, Inc. All rights reserved.
Visit http://mwj.hotims.com/11714-19 or use RS# 19 at www.mwjournal.com/info

Microwave Journal

FEATURES

APPLICATION NOTE

PRODUCT FEATURES

DEPARTMENTS

Cover design by Igor Valdman

THIS MONTH ON THE WEB

Visit www.mwjournal.com for the latest industry news and exclusive on-line articles

3GSM World Congress 2007
February 12–15, 2007
Barcelona, Spain

A wrap-up of select news, information and product announcements at this year's 3GSM World Congress, including a detailed look at the new products on display.

Improving a Classic: The 200 MHz to 2 GHz Dual-ridged Horn Antenna

By Vicente Rodriguez
Senior Principal Antenna Design Engineer
ETS-Lindgren

Use of a commercially available Computational Electromagnetics (CEM) package to analyze the 200 MHz to 2 GHz version of a dual-ridged horn antenna.

Ultra Low Cost Handsets

The global market for sub-$20 ultra low cost handsets will be over 330 million units in 2011. A new study from ABI Research finds that over 50% of these handsets will be shipped in the emerging markets of Asia Pacific and the remainder in the markets of Africa, the Middle East, Latin America and Eastern Europe.

ABIresearch®

Tensolite RF/Microwave Connectors & Assemblies

Tensolite's RF Connectors and Assemblies are found in components requiring the utmost in reliability. Complete test results for all of Tensolite's over 3,000 products are available consistently insuring accurate, predictable performance under the most difficult circumstances. Our quality control, manufacturing flexibility and engineering produce RF connectors and assemblies known for their reliability and performance.

UP TO 65GHz

Our engineering staff is always eager to work with you to meet and exceed your needs.

Tensolite
A Carlisle Company

(866) 282-4708 phone • (562) 494-0955 fax • www.tensolite.com • Go to www.Tensolite.com for more

Visit http://mwj.hotims.com/11714-143 or use RS# 143 at www.mwjournal.com/info

IMS 2007: TECHNICAL PROGRAM

IMS 2007 is the largest international conference devoted to the research, development and application of RF and microwave theory and techniques. The Technical Program Committee (TPC) consists of 232 dedicated reviewers who received a near-record 1039 submissions from 33 countries and regions. After much hard work, the TPC selected 381 papers for oral presentation and 142 for the Interactive Forum. This year, we arranged the Interactive Forum into four two-hour sessions. This will give the presenters and attendees more flexibility to acquire technical information. We have created five Focused Sessions and three Special Sessions. The Focused Sessions provide information on the latest technical advances in the following areas: (1) millimeter-wave imaging; (2) microwave in societal security; (3) microwave systems in deep space missions; (4) microwave-photonic signal processing; and (5) advances in GaN technology. Two Special Sessions are on microwave activities in the Pacific Rim countries and the submillimeter-wave activities of Mauna Kea. The other Special Session is dedicated to the memory of the late Dr. Leo Young, who is well known among the microwave community, particularly in the area of passive components and filters.

There will be five Panel Sessions during lunchtime on Signal Integrity, GaN, MEMS, Terahertz and GaAs. In addition, there is an Information Session on research funding by the National Science Foundation. We will enhance the operation of the Student Paper Competition. The selected finalists will present extremely high level research results carried out as graduate students. These papers are not only presented in the regular sessions but will also compete during the Student Paper Competition session in an interactive format.

In the recent history of the IMS, the Workshops have become more and more popular. This year is no exception. We have organized a total of 47 Workshops distributed on Sunday (20), Monday (14) and Friday (13). Topics cover almost all imaginable subjects related to RF and microwaves, and range from advanced to tutorial in nature. For the first time in the recent history of the IMS, we have implemented a Short Course program. We plan to provide eight Short Courses on Sunday, Monday and Friday. Short Courses differ from Tutorial Workshops. The course is typically taught by one to two instructors and the attendees can obtain IEEE certified CEU (Continuing Education Unit). We have organized Workshops and Short Courses with strong electromagnetic flavor on Friday so that these events may be conveniently attended by the participants of the IEEE Antennas and Propagation Symposium to be held on the subsequent week, also in Honolulu.

On behalf of the TPC, I am confident that all attendees will have a very rewarding experience by participating in the technical activities of IMS 2007. ■

TATSUO ITOH
Technical Program Chair, IMS 2007

Ask Harlan

How it works: Harlan has selected one question from his "Ask Harlan" column to be featured in the magazine. Please visit www.mwjournal.com/askharlan to provide an answer to this month's featured question (see below). Harlan will be monitoring the responses and will ultimately choose the best answer to the question. Although all of the responses to the featured question will be posted on our web site, we plan to publish the winning answer in the May issue. All responses must be submitted by **April 6, 2007**, to be eligible for the participation of the March question.

The winning response will win a free book from Artech House, along with an "I Asked Harlan!" t-shirt. In addition, everyone who submits a legitimate response will be sent an "I Asked Harlan!" t-shirt.

January Question and Winning Response

The January question was submitted by John McFarland from SNC:

Dear Harlan,

Can you explain why the polarization sense of a circularly polarized plane wave changes when it bounces off a reflecting surface? For instance, Right Hand Circular Polarization (RHCP) turns into Left Hand Circular Polarization (LHCP) when undergoing a single bounce off a reflector. The sense of the polarization is defined by the sense (CW/CCW) of rotation of the composite wave (vector sum of the H and V waves) as viewed in the direction of its propagation. When the incident wave undergoes two bounces—say off a dihedral corner reflector—it changes back to the originally incident sense, e.g., RHCP undergoing two bounces will propagate back to the transmitter as RHCP. I know this is what happens from experience, but I have never been able to explain why.

The winning response to the January question is from Phong Vu of Powerwave Technologies Inc.:

Circularly polarized EM waves can be decomposed into two perpendicular EM plane waves of the same propagating direction, the same frequency, equal amplitude and a 90° difference in phase. The sense of a circular EM polarization is reversed when the two component plane waves exchange their relative phases. That is when the plane wave component that lags the other by 90° becomes the one that leads by 90°. For continuity of variations of electric and magnetic field magnitudes at the boundary, a plane wave has the sum of the phases of its incident and reflected waves equal zero at the reflection boundary. The zero phase sum reflection causes the 90° leading incident plane wave component of a circularly polarized wave to produce the 90° lagging component of the reflected circularly polarized wave. Hence, the polarization sense reverses as a circularly polarized wave bounces off a reflection surface.

Harlan's response:

A circularly polarized wave consists of two equal e-vectors at 90 degrees to each other. When they reflect off a conducting surface they experience a 180 degree phase reversal so the leading vector becomes the lagging vector and a RHCP becomes a LHCP. A double reflecton will restore the original relationship.

This Month's Question of the Month

(answer on-line at www.mwjournal.com/askharlan)

Madhusudhan from VT University, Belgaum, India has submitted this month's question:

Dear Harlan,

I would like to introduce myself as a PhD student in microwave and MEMS doing research in India. I have just started my research in modeling of MEMS devices and I have encountered a problem. I am very much confused by different things like field solvers and SPICE models. Could you provide any clarity between the two and also suggest field solvers or a low cost field solver that I can work with for my degree?

If your response is selected as the winner,
you'll receive a free book of your choice from Artech House.
Visit the Artech House on-line bookstore at www.artechhouse.com
for details on hundreds of professional-level books in microwave engineering and related areas
(maximum prize retail value $150).

STAFF

Publisher: Carl Sheffres
Associate Publisher: Edward Johnson
Editor: Harlan Howe, Jr.
Managing Editor: Keith W. Moore
Technical Editor: Frank M. Bashore
Associate Technical Editor: Dan Massé
Staff Editor: Jennifer DiMarco
Editorial Assistant: Barbara Walsh
Consulting Editor: Howard I. Ellowitz
Consulting Editor: Peter Staecker
Consulting Editor: Dan Swanson
Web Editor: Stephen Heiser
Traffic Manager: Edward Kiessling
Traffic Administrator: Ken Hernandez
Director of Production & Distribution: Robert Bass
Multimedia Designer: Eli Conner
DTP Coordinator: Janet A. MacDonald

EUROPE

Deputy Publisher: Michel Zoghob
European Editor: Richard Mumford
Office Manager: Eugenie Hardy

CORPORATE STAFF

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

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

2007 IEEE Radio Frequency Integrated Circuits Symposium Honolulu, Hawaii June 3-5, 2007

IEEE

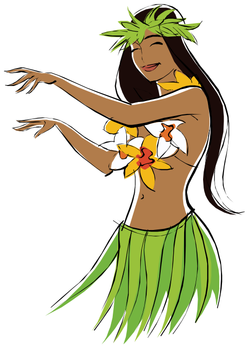
Aloha,

When you think of the word Hawaii, what first comes to mind? Sunshine, beautiful beaches, snorkeling, and a great place to visit are immediate thoughts many of us would have. In addition to all of this, add one more thought: three days of some of the most remarkable RFIC technology to be found anywhere in the world. Mark your calendar and make reservations for the **2007 IEEE RFIC Symposium** (www.RFIC2007.org) to be held in Honolulu, Hawaii from June 3rd through June 5th.

Once again, this year's RFIC Symposium continues its tradition as the premier conference showcasing the latest advancements and innovations occurring in RF integrated circuits, wireless sub-systems, broadband communications, and circuit technology for emerging wireless applications. The symposium continues to provide a forum for some of the most innovative advancements from both industry and academia.

Hawaii: Sun, beaches, and ....

remarkable RFIC technology !



The vitality of the RFIC community appears stronger than ever, as an all-time record number of manuscripts were submitted to this year's conference. The Technical Program Committee has worked diligently to provide a superior venue for this vast array of RFIC technology. The symposium will feature 15 workshops and tutorials on Sunday, June 3rd. In addition, 30 oral sessions, an Interactive Forum, and two panel sessions will be given on Monday and Tuesday, covering nearly all facets of RFIC technology.

A Plenary Session will be held on Sunday evening, with keynote addresses given by two renowned industry leaders. The first speaker, Charles Persico, Senior Vice President of Engineering at Qualcomm Inc. will present a talk entitled "Wireless Convergence – Your Phone is Not Just a Phone Anymore." The second speaker, Dwight C. Streit, Ph.D., Vice President, Electronics Technology, Northrop Grumman Space Technology, will discuss "Technology Directions for Future RF Applications." The three best student paper awards will also be presented in the Plenary Session. The highly anticipated RFIC Reception will follow immediately after the Plenary Session, providing a relaxing time for all to mingle with old friends and catch up on the latest news.

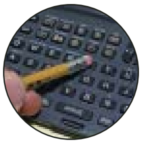
On behalf of the RFIC Technical Program Committee, we look forward to seeing you at the 2007 RFIC Symposium. Mahalo.

Luciano Boglione
RFIC General Chair

Tina Quach & Jenshan Lin
RFIC Technical Program Chairs

MTT-S®

Sponsored by the IEEE MTT-S, EDS, and SSCS
http://www.rfic2007.org



CALL FOR PAPERS

Antenna Measurement Techniques Association (AMTA)
by May 7, 2007
Asia-Pacific Microwave Conference (APMC)
by June 15, 2007

MARCH

MILITARY TECHNOLOGIES CONFERENCE
March 27–28, 2007 • Boston, MA
www.miltechconference.com

CTIA WIRELESS 2007
March 27–29, 2007 • Orlando, FL
www.ctiawireless.com

RF & HYPER EUROPE 2007
March 27–29, 2007 • Paris, France
www.rfhyper.com

INTERNATIONAL WIRELESS COMMUNICATIONS EXPO (IWCE 2007)
March 28–30, 2007 • Las Vegas, NV
www.iwceexpo.com

APRIL

ARMMS RF AND MICROWAVE SOCIETY CONFERENCE
April 16–17, 2007 • Steventon, Oxfordshire, UK
www.armms.org

IEEE RADAR CONFERENCE 2007
April 17–20, 2007 • Waltham, MA
www.radar2007.org

JUNE

IEEE MTT-S INTERNATIONAL MICROWAVE SYMPOSIUM AND EXHIBITION
June 3–8, 2007 • Honolulu, HI
www.ims2007.org

IEEE RADIO FREQUENCY INTEGRATED CIRCUITS SYMPOSIUM (RFIC 2007)
June 3–8, 2007 • Honolulu, HI
www.rfic2007.org

69TH ARFTG CONFERENCE
June 7–8, 2007 • Honolulu, HI
www.arftg.org

IEEE INTERNATIONAL SYMPOSIUM ON ANTENNAS AND PROPAGATION (AP-S)
June 10–15, 2007 • Honolulu, HI
http://hcac.hawaii.edu/conferences/aps2007/

WCA 2007
June 11–14, 2007 • Washington, DC
www.wcai.com/events.htm

4TH INTERNATIONAL WORKSHOP ON ADVANCED GROUND PENETRATING RADAR (IWAGPR 2007)
June 27–29, 2007 • Naples, Italy
www.irea.cnr.it/IWAGPR2007

JULY

IEEE EMC SYMPOSIUM
July 8–13, 2007 • Honolulu, HI
www.emc2007.org

SEPTEMBER

IEEE INTERNATIONAL CONFERENCE ON ULTRA-WIDEBAND (ICUWB 2007)
September 24–26, 2007 • Singapore
www.icuwb2007.org

OCTOBER

EUROPEAN MICROWAVE WEEK (EUMW 2007)
October 8–12, 2007 • Munich, Germany
www.eumweek.com

MILITARY COMMUNICATIONS CONFERENCE (MILCOM 2007)
October 29–31, 2007 • Orlando, FL
www.milcom.org

NOVEMBER

ANTENNA MEASUREMENT TECHNIQUES ASSOCIATION (AMTA 2007)
November 4–9, 2007 • St. Louis, MO
www.amta2007.com

Visit http://mwj.hotims.com/11714-44

Workshops & Courses

Ansoft Designer Training

■ **Topics:** This one-day course uses examples and exercises to provide a comprehensive understanding of Designer. The course is intended for beginners and intermediate users and assumes no prior knowledge of Designer. Covers using the Ansoft Designer Desktop features, creating and manipulating Circuit/System/Planar EM models, and working with different data types. Includes basic sections on field visualization and high level and low level data manipulation.
■ **Site:** Irvine, CA
■ **Date:** April 12, 2007
■ **Contact:** For more information, visit www.ansoft.com.

Reverberation Chamber Theory and Experiment Short Course

■ **Topics:** This course is designed for engineers who will be involved in radiated emission or immunity testing of commercial or military systems using reverberation chambers. The theory portion will cover the statistical nature of reverberation chamber testing, characterization of the EM test conditions, and the tradeoff between uncertainty in test results and test time. The experiments include typical measurement techniques, chamber calibration, immunity, emission and pulse testing in reverberation chambers.
■ **Site:** Stillwater, OK
■ **Dates:** April 30–May 4, 2007
■ **Contact:** For more information, visit http://rc-course.okstate.edu.

Making Accurate Low Level Electrical Measurements

■ **Topics:** This course provides users with a detailed understanding of how to make accurate low level electrical measurements. Users will learn what constitutes a low level measurement, the limitations of these measurements, sources of measurement error and techniques to eliminate these errors. Additional topics include selecting the proper product for a desired measurement and understanding the basics of how to communicate with an instrument from a PC.
■ **Site:** Cleveland, OH
■ **Dates:** June 19–20, 2007
■ **Contact:** For more information, visit www.keithley.com.

Practical Antenna Design

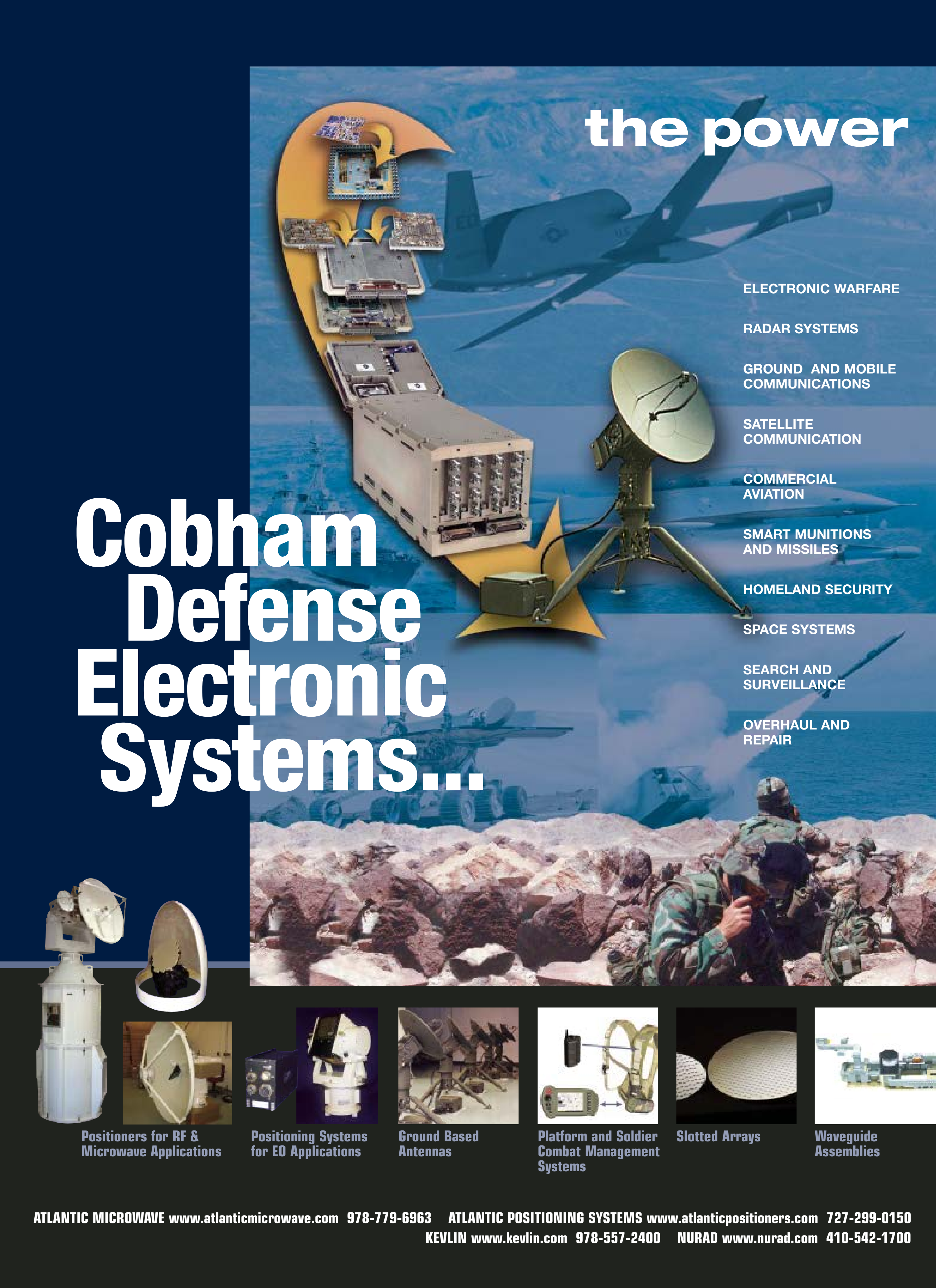
■ **Topics:** The course covers the important and timely issues involving modern antenna design and theory. Developed specifically for engineers and designers who work with radar and radio communications, this workshop will give participants the understanding of antenna theory and techniques, the skills to analyze, design and measure various antennas, and the knowledge of antenna measurements. For more information, visit www.conted.ox.ac.uk.
■ **Site:** Summertown, Oxford, UK
■ **Dates:** June 20–21, 2007
■ **Contact:** University of Oxford Continuing Education, +44 (0) 1865 286958 or e-mail: anthony.santiago@conted.ox.ac.uk.

The Entrepreneurial Engineer

■ **Topics:** This short course is an efficient and memorable 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.

PCB Design Techniques for EMC and Signal Integrity

■ **Topics:** This course will assist practicing engineers who are responsible for PCB designs and system-level products. Disciplines include PCB layout, logic design, regulatory compliance and EMC. For more information, visit http://epdwww.engr.wisc.edu.
■ **Site:** For location information, please visit url.
■ **Dates:** For date information, please visit url.
■ **Contact:** University of Wisconsin, Department of Engineering Professional Development, 432 North Lake Street, Madison, WI 53706 (800) 462-0876.



the power
ELECTRONIC WARFARE
RADAR SYSTEMS
GROUND AND MOBILE COMMUNICATIONS
SATELLITE COMMUNICATION
COMMERCIAL AVIATION
SMART MUNITIONS AND MISSILES
HOMELAND SECURITY
SPACE SYSTEMS
SEARCH AND SURVEILLANCE
OVERHAUL AND REPAIR
Cobham Defense Electronic Systems...
Positioners for RF & Microwave Applications
Positioning Systems for EO Applications
Ground Based Antennas
Platform and Soldier Combat Management Systems
Slotted Arrays
Waveguide Assemblies
ATLANTIC MICROWAVE www.atlanticmicrowave.com 978-779-6963
ATLANTIC POSITIONING SYSTEMS www.atlanticpositioners.com 727-299-0150
KEVLIN www.kevlin.com 978-557-2400
NURAD www.nurad.com 410-542-1700

COVER FEATURE
INVITED PAPER

RF, ANALOG AND DIGITAL SYSTEMS CONVERGE FOR NEXT GENERATION ELECTRONICS

The market demand for increased functionality, higher reliability and performance within ever shrinking form factors has placed new demands on designers of high performance designs. The convergence of RF, analog and digital systems within the same design and package now requires engineers to consider coupling effects that were heretofore negligible. This article will highlight the new challenges today's designers encounter and present new solutions using case studies from collaborations with the world's leading technology companies.

One trend that has become absolute is the convergence of RF, analog and digital systems in the same design and package. An example of such a device is the SCH-B570 phone introduced by Samsung Electronics. The Samsung phone has an 8 GB hard drive capable of recording 16 movies, picture-in-picture functionality, a 2 Mp camera, GPS functionality and an MP3 player capable of storing 1600 files.

To achieve the goal of high performance in small size at low power consumption, system-on-chip (SoC), system-in-package (SiP) and package-on-package (PoP) designs have become prevalent design configurations. These platforms combine RF, analog and digital components to enable efficient integration of computing, multimedia and communications functions. Cost/performance targets drive the integration of ICs, SoCs and SiPs onto low cost printed circuit boards. Process migration to 65 nm and below, multiple stacking packages, high performance CPUs and multi-band antenna topologies are at the heart of mobile products and technology strategies worldwide.

The challenges posed by RF/analog/digital integration require the integration of electronic design automation (EDA) software as well. In years past, it was sufficient to use one EDA vendor's tool to perform harmonic balance circuit simulation on an oscillator, power amplifier or mixer, another vendor's time domain circuit simulation tool to compute the transient response of a data converter or PLL, and still a third vendor's electromagnetic simulation tool to compute the effect of interactions in

ZOLTAN J. CENDES
Ansoft Corp.
Pittsburgh, PA

the interconnects. With tightly integrated systems, chip/package/board co-design is required. The days when RF, analog and digital designs were performed in isolation are nearing an end.

NEW CHALLENGES IN HIGH PERFORMANCE, INTEGRATED DESIGN

The first challenge faced in high performance design is that of simulating in both the time and frequency domains and integrating RF metrics (such as gain, phase noise and insertion loss) with analog metrics (such as eye diagrams and skew rates). For consistency and accuracy, it is important to use the same simulator to perform both frequency domain harmonic balance analysis and time domain Spice simulation. The circuit models deployed should not vary across the frequency domain and time domain, ensuring results across analysis domains are the same. Ansoft's circuit simulator Nexxim® provides designers with the ability to accurately simulate in both domains and successfully integrates the disparate harmonic balance and Spice simulation technologies.

Consider the design of a voltage-controlled oscillator for an ultra-wideband radio. It is important to perform a harmonic balance simulation of this circuit to determine its oscillation frequencies and to compute the phase noise. In addition, it is important to determine the transient response of the circuit at start-up. If two different simulators are used to perform these two types of analysis, a discrepancy between the results may occur. However, Nexxim uses a single set of models and fundamental numerical constructs in both types of analysis. As shown in ***Figure 1***, the result obtained from the harmonic balance simulation is the same as that obtained using a long (long enough to achieve steady state) transient simulation.

The second challenge faced in next generation design is substrate coupling due to the higher levels of device integration. Substrate coupling effects and other parasitics are often described in the frequency domain while the operating frequencies within a radio circuit are defined by the carrier frequency, the local oscillator and all tones (harmonics and intermodulation) generated by circuit nonlinearities. For high frequency designs, simulation in the frequency domain is more efficient and faster than in the time domain. This efficiency and speed provide a distinct advantage for harmonic balance over other techniques in the analysis of broadband radio blocks.

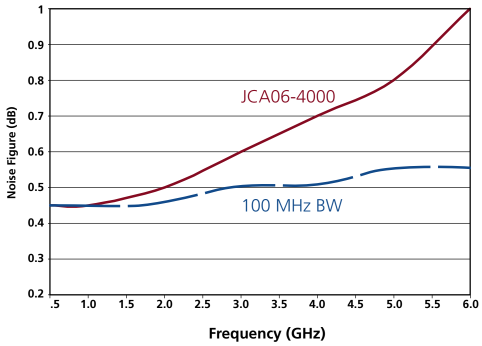
In the past two decades, harmonic balance algorithms have worked well for RF board and MMIC applications containing device counts ranging up to a few hundred transistors. However, next generation RFICs incorporate thousands of active device and tens of thousands of post-layout parasitics and operate with many independent and harmonically related tones. Traditional harmonic balance solvers are incapable of handling the large number of devices and circuit harmonics. Nexxim incorporates pro-

JCA Amplifiers™ Low Noise

You can see clearly now—the noise is gone

Endwave's latest JCA Amplifiers are the answer when you need to improve sensitivity, increase dynamic range, and lower reception thresholds. By combining standard JCA amplifier stages with an innovative circuit approach, we're able to optimize performance and cost, leaving you seeing clear.

Endwave. Plug us in.



- ***Narrowband noise figure < 0.5 dB***
- ***Broadband noise figure < 1.0 dB***
- ***Ka-Band noise figure of < 3.0 dB***
- ***Unconditionally stable***
- ***2 to 4 weeks delivery***
- ***ISO9001 and AS9100 certified***

Model	Frequency GHz	Gain dB Min	Noise Figure dB Max	Gain Flatness +/- dB Max	P1dB dBm Min	VSWR In/Out Max	DC Current +15v, mA
LNAs							
JCA01-3041	0.50 to 0.60	40	**0.5**	1.00	15	2.0:1	250
JCA01-3042	0.60 to 0.70	40	**0.5**	1.00	15	2.0:1	250
JCA01-3043	0.70 to 0.80	40	**0.5**	1.00	15	2.0:1	250
JCA01-3044	0.80 to 0.90	40	**0.5**	1.00	15	2.0:1	250
JCA01-2034	0.80 to 0.90	30	**0.5**	1.00	10	2.0:1	200
JCA01-2035	0.90 to 1.00	30	**0.5**	1.00	10	2.0:1	200
JCA01-3045	0.90 to 1.00	40	**0.5**	1.00	15	2.0:1	250
JCA01-2001	0.50 to 1.00	30	**0.9**	2.00	10	2.0:1	200
JCA12-2000	1.00 to 2.00	30	**0.9**	1.50	10	2.0:1	200
JCA12-3000	1.00 to 2.00	40	**0.9**	1.50	15	2.0:1	250
JCA12-4000	1.00 to 2.00	50	**0.9**	1.50	15	2.0:1	300
JCA14-3001	1.00 to 4.00	40	**0.9**	2.00	15	2.5:1	250
JCA14-2001	1.00 to 4.00	30	**0.9**	2.00	10	2.5:1	200
JCA14-4001	1.00 to 4.00	50	**0.9**	2.00	15	2.5:1	300
JCA24-2000	2.00 to 4.00	30	**0.9**	1.50	10	2.0:1	200
JCA24-3000	2.00 to 4.00	40	**0.9**	1.50	15	2.0:1	250
JCA24-4000	2.00 to 4.00	50	**0.9**	1.50	15	2.0:1	300
JCA06-4000	0.50 to 6.00	30	**1.2**	2.00	10	2.5:1	300
JCA26-2001	2.00 to 6.00	30	**1.2**	2.00	10	2.0:1	200
JCA26-3001	2.00 to 6.00	40	**1.2**	2.00	15	2.0:1	250
JCA26-4001	2.00 to 6.00	50	**1.2**	2.00	15	2.0:1	300
New High Frequency Models							
JCA2640-4000	26.0 to 40.0	37	**3.0**	3.50	10	2.5:1	275
JCA2640-3000	26.0 to 40.0	27	**3.0**	3.00	10	2.5:1	200

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

Search our complete line of amplifiers online!
www.endwave.com

endwave®
Defense Systems

www.endwave.com

prietary preconditioning schemes and iterative solution techniques that reduce the computational complexity and memory requirements for harmonic balance analysis, enabling the analysis of even larger circuits.

To examine the capabilities of this new iterative solver for large circuits, the RFIC differential IQ mixer, shown in ***Figure 2***, was simulated with post-layout parasitics included in the simulation. The total component count was 95,127 of which approximately 1500 were MOSFETs and 90,000 elements were extracted RC parasitic elements. The mixer was driven by two independent RF signals which included two harmonics each and the local oscillator tone including one harmonic. This problem size proved too large for conventional harmonic balance simulation, which fails to converge. Nexxim's algorithmic innovations allowed the same problem to be solved in just 42 minutes.

FULL-WAVE ACCURATE PCB SIMULATIONS

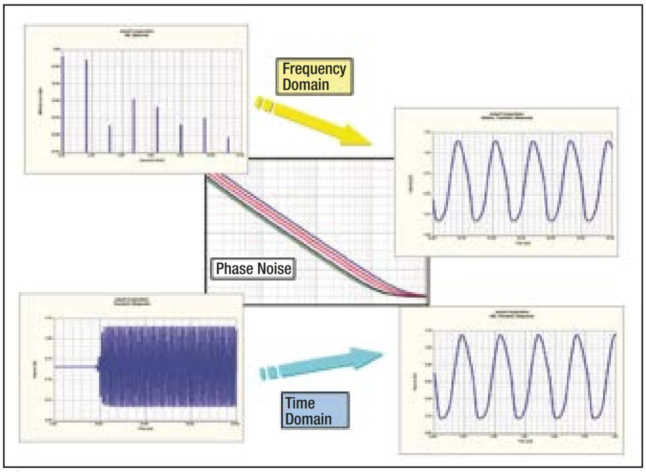
Next generation electronics often contain PCBs and packages of immense complexity. To determine the electromagnetic interactions of these structures, a new technology was developed that exploits their predominantly planar composition. The software tool is called SIwave and it provides fast package and PCB analysis for large complex structures by taking advantage of the orthogonality of planar modes and transmission line modes. These orthogonal modes allow the software to significantly reduce the problem size from what it would be if the same structure were analyzed using a full 3D solver. SIwave solves a wave equation based upon the finite element method between the planes, providing a full-wave solution that is accurate until non-TEM parallel plate modes begin to propagate (that occurs when the plane-to-plane spacing approaches half a wavelength; about 300 GHz for FR4 with 10-mil spacing).

SIwave extracts parasitic parameters (S, Y and Z), displays 3D electromagnetic fields and generates broadband SPICE and/or S-parameter models from layout data that is directly imported from industry standard PCB and package layout tools. The resulting data allows engineers to characterize resonances, reflections and coupling between traces and power/ground planes for boards such as the 30 by 40 cm, 26 layer PCB with 6500 nets shown in ***Figure 3***. This particular board resulted in a problem size of 1.75 million unknowns yet was solved in less than 20 minutes. The simulation closely matches measured results from 1 MHz to 10 GHz.

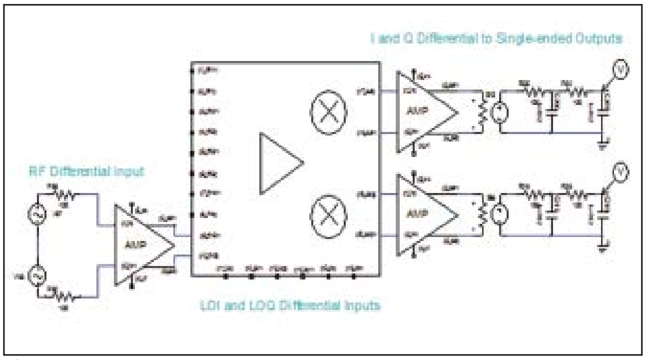
FREQUENCY-BASED MODELS IN THE TIME DOMAIN

In addition to handling larger problems, today's circuit simulation requires the flexibility to handle models from multiple vendors at varying levels of abstraction. This involves the ability to natively parse a variety of descriptive languages (SPICE, Verilog, VHDL, IBIS, Touchstone…), the ability to integrate and simulate cir-

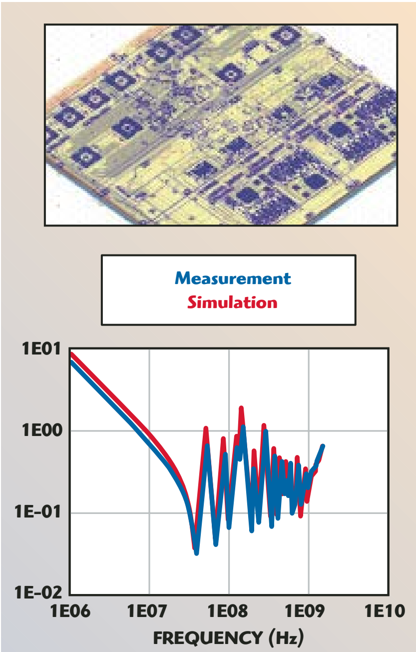
cuits and sub-circuits described at the transistor level up to behavioral level as well as the ability to include the parasitics associated with passive interconnects and components operating at high frequencies. These parasitics are typically represented as static S-parameters from electromagnetic (EM) simulation or from measurement or as dynamic S-parameters via parametric EM/circuit co-simulation. One growing concern with S-parameters is that they are frequency domain models that must often be used in transient time domain simulations. The simple solution would seem to be to apply an inverse FFT, impulse response or convolution technique to the S-parameters to make them suitable for transient analysis. However, these approaches often raise problems with causality, non-passivity, lengthy simulation run times and in some cases wrong results or a failed simulation altogether.



▲ *Fig. 1 Consistency of oscillator results across time and frequency domains.*



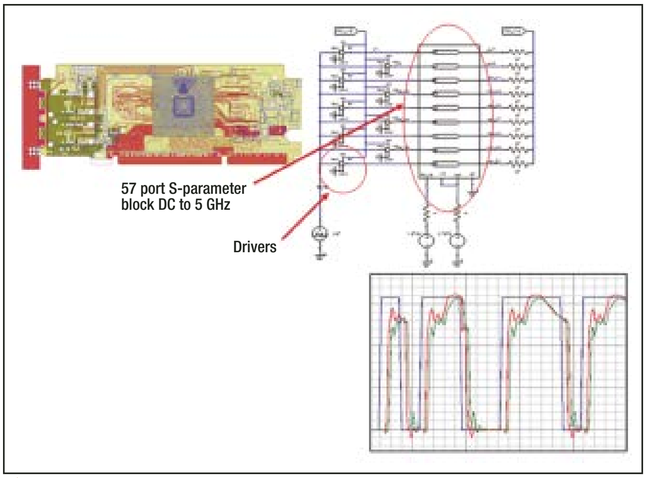
▲ *Fig. 2 Differential IQ mixer simulated with the post-layout parasitics included, approximately 95,000 components in total.*



▲ *Fig. 3 PCB (30x40 cm board, 26 layers, 6500 nets) solved with SIwave in less than 20 minutes.*

Nexxim utilizes a state space approach based on a pole-residue fit to the frequency domain data. By applying this formulation to only stable poles, causality is preserved. The model-order reduction also includes a passivity enforcement algorithm that may be set by the designer. This proprietary pole-residue fitting algorithm leads to extremely efficient transient simulations by reducing the problem to a simple first-order differential equation enabling fast and accurate simulation results. The advantage of the state space approach is evident in the investigation of simultaneous switching noise on the high speed PCB shown in ***Figure 4***. The board, modeled as a 57 port S-parameter block from DC to 5 GHz, was terminated with 18 IBIS drivers and 50 Ω loads. The transient simulation from t = 0 to t = 50 ns took just over


SUCOTEST CABLE ASSEMBLIES
Precision at a constant high level
Test + Measurement with SUCOTEST™
Highest electrical performance – unique handling
SUCOTEST™ 18A armored test assemblies offer excellent electrical performances (low insertion loss combined with unique stability and excellent return loss) for heavy-duty, outdoor, and harsh environment measurements.
■ Phase and loss stability during flexure
■ Crush, torque, and kink-resistant
■ Waterproof IP68
■ Flexible and with newly designed N and 7/16 nut
■ Outstanding durability
■ Multicoax high density connectors for data transmission tests
HUBER+SUHNER offers furthermore: test leads, phase matched adapters, precision adapters, Quick-mate adapters, precision and power terminations and attenuators, low Intermodulation test components.
SUCOTEST™
be precise
HUBER+SUHNER
HUBER+SUHNER AG
CH-9100 Herisau, Switzerland
Phone +41 (0)71 353 41 11
Fax +41 (0)71 353 45 90
www.hubersuhner.com
Visit http://mwj.hotims.com/11714-62 or use RS# 62 at www.mwjournal.com/info
Excellence in Connectivity Solutions



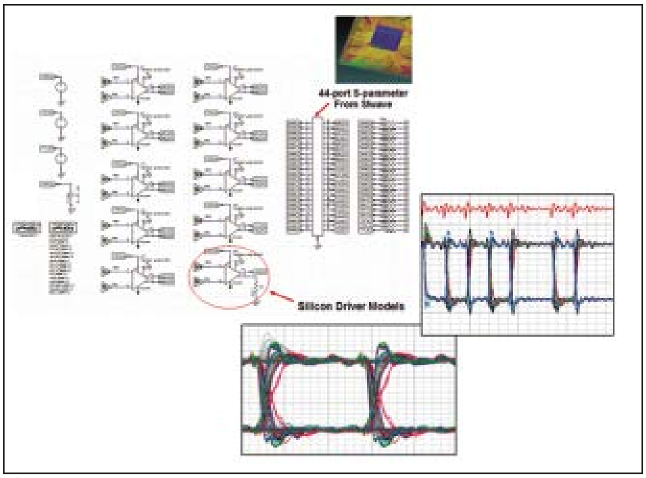
▲ *Fig. 4 A complex PCB modeled as a 57 port S-parameter block from DC to 5 GHz using SIwave; the transient response of the PCB excited by 18 IBIS drivers and 50 Ω loads simulated by Nexxim.*

five minutes to complete. Automatic caching of the pole-residue fitting data re-applies the results of the fitting operation for an unchanged passive network to further speed subsequent time domain analyses.

Today's technology leaders often demand greater simulation accuracy than what IBIS models provide. However, the complexity and size of such a problem using silicon or transistor-level drivers is beyond the limits of traditional circuit simulation methods. Nexxim was designed to satisfy this unique requirement. In ***Figure 5***, the complete design is solved with transistor level accuracy and frequency dependant layout effects. The design includes an extracted, 44 port S-parameter package model, and the complete circuit with 148,000 MOSFETs, 1.7 million capacitors and 500,000 resistors. Designers may now fully verify much larger designs with full-wave and transistor level accuracy to minimize surprises after tape-out. Further system simulation accuracy may be achieved when silicon or transistor-level drivers are incorporated instead of IBIS behavioral models. In the past, the complexity and size of such a problem was beyond the limits of existing circuit simulation. Today, Nexxim has the capacity to address the complete driver/receiver/channel chain as is demonstrated in the example. This level of design verification will be critical to eliminating repeated board, package and/or IC design cycles.

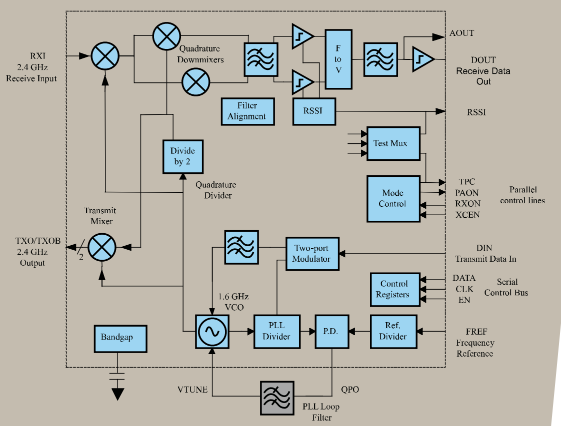
CHIP/PACKAGE/BOARD CO-DESIGN

To illustrate the next generation of integrated design environment, consider the example of an advanced DDR2 test bench. This system consists of a driver circuit and package, a main printed circuit board, an interface board, several connectors, a coaxial cable and the test board itself. The system operates using a double data rate (DDR) channel in which logic triggers under both the rise and fall of each signal. The DDR standard calls for operational clock rates from 133 to 200 MHz, DDR2 from 266 to 400 MHz and DDR3 from 533 to 800 MHz. To maintain data integrity as clock speeds increase, full channel analysis is required from the main board through the connectors to the test board and back again.

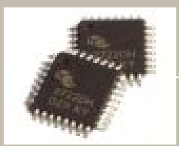


▲ *Fig. 5 Transient analysis and resulting eye diagrams for a system containing a 44 port full-wave channel model and silicon driver models consisting of 148,000 MOSFETs, 1.7 million capacitors and 500,000 resistors.*

The high level schematic of the



- Easy to use
- No production tuning/calibration
- 1.5Mbps – the highest data rate in its class
- Can be used with Sirenza LNA and/or PA products for improved performance
- Ideal for wireless audio or video applications
- Interfaces to many different basebands
- Transverter also available to upband existing 2.4GHz products to 5.8GHz



SIRENZA MICRODEVICES

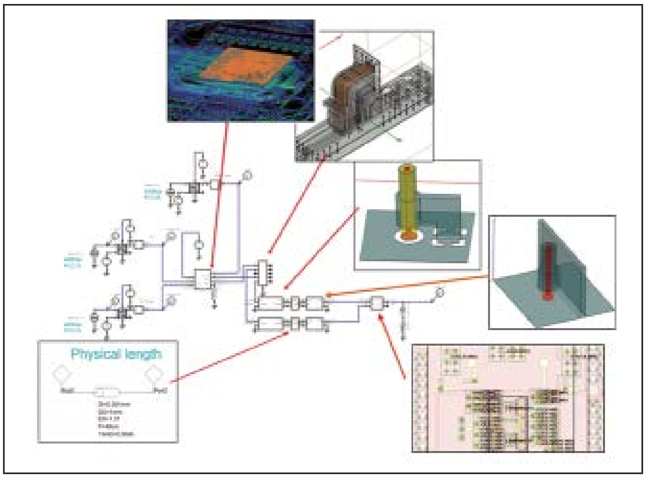
Sirenza's new Transceivers feature best-in-class 1.5 Mbps data rate—ideal for streaming wireless audio and video applications.

These fully integrated, 2FSK ISM-band transceivers include complete receiver, transmitter and synthesizer on a single chip. They are designed for simple ease-of-use with a minimum of external components and no tuning/alignment. To help customers get started quickly, Sirenza also offers a starter kit that demonstrates a working wireless link using a low-cost microcontroller and simple packet protocol.

Visit us at either www.sirenza.com or www.microlinear.com for more information about our new ISM transceiver and networking solutions.

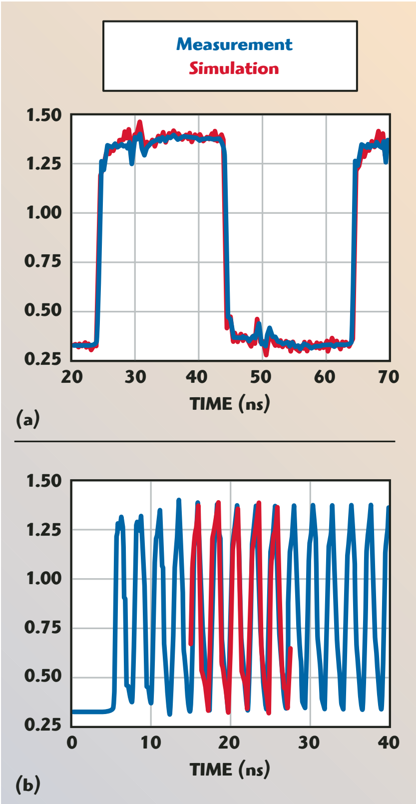
RoHS and WEEE compliant parts are also available.

Visit http://mwj.hotims.com/11714-127 or use RS# 127 at www.mwjournal.com/info



▲ *Fig. 6 DDR2 test system consisting of a driver circuit and package, a main printed circuit board, an interface board, several connectors, a coaxial cable and the test board.*

memory test system is shown in ***Figure 6***. In this schematic, the various elements represent the main components of the system. The main board and the test board are simulated in SIwave to compute the input impedance of the boards as a function of frequency. The frequency dependent S-parameter block is then used in Nexxim circuit simulation. The connector and interface board is simulated in the 3D electromagnetic field simulator HFSS.™ The parasitics of the interface board to coaxial cable connection as well as the coax to test board are computed by using the 3D parameter extraction tool Q3D Extractor.® The coaxial cable itself is modeled using analytical models in Ansoft Designer.® Finally, a test probe model from the data sheet is included to ensure a one-to-one correspondence between the measurement parameters and the simulation parameters.



▲ *Fig. 7 Simulated versus measured results of the DDR2 test system for (a) 50 Mbps and (b) 830 Mbps.*

Simulated versus measured results for both 50 and 830 Mbps are presented in ***Figure 7***. Excellent agreement is observed. The full-channel simulation methodology is then employed to perform a number of design studies. A pseudo-random bit steam is introduced on the aggressor line and an eye diagram of the response is computed, as shown in ***Figure 8***. By examining the eye diagram crossovers, the maximum skew rate of the channel is determined.

SIMULATING ELECTRONICS IN THE NEXT GENERATION WORLD

The ability to integrate EM-based S-parameter models, behavioral and transistor-level circuit models as well as digital models and effectively incorporate them into an existing design flow is illustrated by the design methodology adopted at Intel. To maintain their leading position in the PC market, Intel has adopted a Design for Manufacturing (DFM) approach in which Design of Experiments (DOE) is used together with scripts, circuit and electromagnetic simulation tools to simulate and optimize over a wide range of computer operating conditions. Previously, this approach incorporated simple models of electromagnetic effects and worked well in the design of earlier, slower speed computers. However, it proved inadequate at accurately predicting system behavior as slow parallel buses were being replaced by high

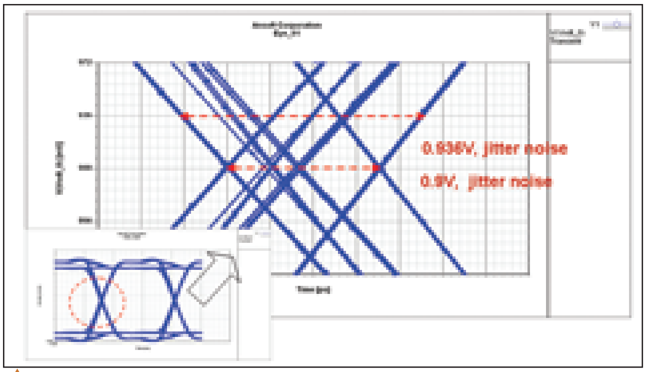


Fig. 8 DDR2 channel jitter noise analysis based on transient simulation of full-wave extracted channel model.

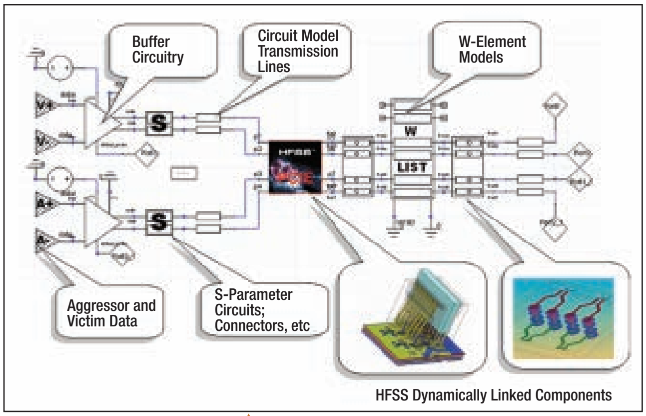


Fig. 9 EM-based Design for Manufacturing simulation environment supporting high speed serial designs.

speed serial buses including PCI Express and ATA. The block diagram of the new simulation requirements is presented in ***Figure 9***. In this figure, W-elements are used to characterize transmission lines, S-parameter models are adopted to characterize three-dimensional interconnects and planar electromagnetics solutions are used to characterize transitions.

A key feature of this methodology is the ability to perform rapid analysis and optimization on multiple levels of model accuracy. Initial design is performed at a high level using only behavioral and circuit level components. As the design is refined, circuit level models may be replaced by more detailed electromagnetic models using the unique Solver-on-Demand™ technology. With this method, a one button click is all that is required to switch from a circuit level simulation to an electromagnetic level simulation. If the selected component has been previously solved using an EM solver, the model is cached and the pre-computed values are used; otherwise, the electromagnetic simulator is called and the precise electromagnetic solution computed. Since all parameters in geometry, materials and frequencies

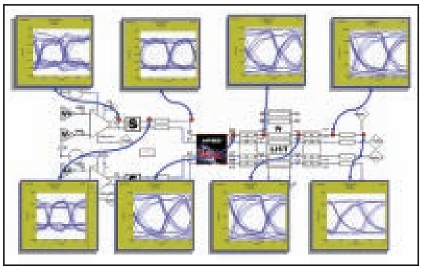


Fig. 10 Examining the eye closure at various points in the high speed channel.


JUNE 5, 2007
IT'S JUDGMENT DAY FOR TOAST.
www.nomoretoast.com

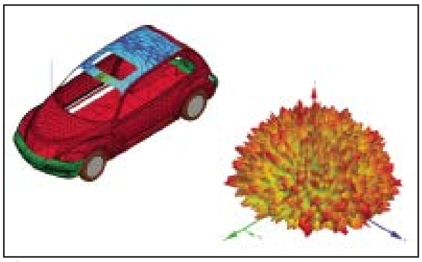
are common between the electromagnetic, circuit and system level simulators, it is easy to perform what-if analyses to optimize performance and ensure successful designs.

In addition, Intel requested a "bypass" capability in the design management system that allows any component to be short circuited in the design. This allows designers to study the effect of each component individually as well as together on degrading signal propagation through the channel. ***Figure 10*** shows the eye diagram evaluated at a number of locations along the channel. By selectively by-passing each of these components, the amount of closure caused by each component can be evaluated and any signal degradation beyond specifications can be flagged. In the example shown, the connector had the largest effect on closing the eye.

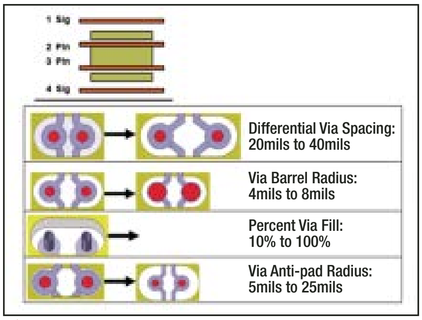
ELECTROMAGNETICS IN THE ENVIRONMENT

Along with understanding the interactions that occur between the chip, package and board levels, engineering teams often need to investigate the wider environment within which their devices operate. The proliferation of wireless devices has resulted in a setting where numerous devices are working in close proximity leading to potential signal interference. Mobile phones, GPS and RFID are just a few of the application areas where antennas are placed in close proximity to electronic circuitry; the actual and precise location of the antenna affects the system performance. As a result, antenna designers are increasingly performing simulations to characterize the interactions between the antenna and the electronics.

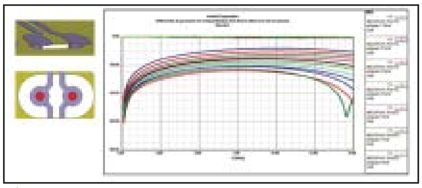
Figure 11 shows the electromagnetic fields that result from a GPS an-



▲ *Fig. 11 The electromagnetic field and radiation far field pattern resulting from a GPS antenna placed on the roof of a Chrysler PT Cruiser.*



▲ *Fig. 12 Model of a differential via structure for a high frequency multi-layer printed circuit board in HFSS.*



▲ *Fig. 13 Parametric simulation with the Distributed Solve Option accelerates the simulation run time of this return loss and insertion loss versus oval anti-pad radius study.*

DIGITAL ATTENUATORS

0.5 to 31.5 dB in 0.5 and 1 dB Steps

From $2.69 ea. Qty. (1,000)

24 Models To Choose From IN STOCK

- *Choose single +3V or dual +3V, -3V supply voltage @ 100 µA*
- *Select 5 or 6 Bit, serial or parallel interface*
- *Up to 31.5 dB, either 0.5 or 1 dB steps*
- *High attenuation accuracy, 50 or 75 ohm*
- *Very high IP3 +52 dBm, 0.2 dB compression @ +24 dBm above 1 MHz*
- *CMOS programmable start-up and always immune to latch-up*

ZX76 Series

All our surface mount models are available in coaxial versions with SMA connectors

DAT SELECTION GUIDE

Specifications Typical at: T_{AMB} = 25°C

Model Series	Interface	Z (Ω)	Freq. MHz	Atten. dB	Steps dB	Bits	Price $ea. (Qty.10)
DAT-15R5-P ▲	Parallel	50	DC-4000	15.5	0.5	5	3.55
DAT-15R5-S ▲	Serial	50	DC-4000	15.5	0.5	5	3.55
DAT-15575-P ▲	Parallel	75	DC-2000	15.5	0.5	5	3.55
DAT-15575-S ▲	Serial	75	DC-2000	15.5	0.5	5	3.55
DAT-31-P ▲	Parallel	50	DC-2400	31.0	1.0	5	3.55
DAT-31-S ▲	Serial	50	DC-2400	31.0	1.0	5	3.55
DAT-3175-P ▲	Parallel	75	DC-2000	31.0	1.0	5	3.55
DAT-3175-S ▲	Serial	75	DC-2000	31.0	1.0	5	3.55
DAT-31R5-P ▲	Parallel	50	DC-2400	31.5	0.5	6	3.80
DAT-31R5-S ▲	Serial	50	DC-2400	31.5	0.5	6	3.80
DAT-31575-P ▲	Parallel	75	DC-2000	31.5	0.5	6	3.80
DAT-31575-S ▲	Serial	75	DC-2000	31.5	0.5	6	3.80

▲To specify Supply Voltage:
Add the letter (P) to model number for positive +3 volts.
Add the letter (N) to model number for Dual ±3 volts.
Example: DAT-15R5-PP or DAT-15R5-PN

Top View Exposed Metal Bottom
Small 4x4mm Package.

DAT test fixture available.

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

404 Rev E

Visit http://mwj.hotims.com/11714-83 or use RS# 83 at www.mwjournal.com/info

tenna placed on the roof of a Chrysler PT Cruiser. To model these fields, the air space around the car was over 2500 cubic wavelengths. From these fields the radiation pattern of the antenna and car can be determined. Since the car body involves many large conducting surfaces, the resulting images produce a "sea urchin" radiation pattern.

Leveraging Today's Compute Power

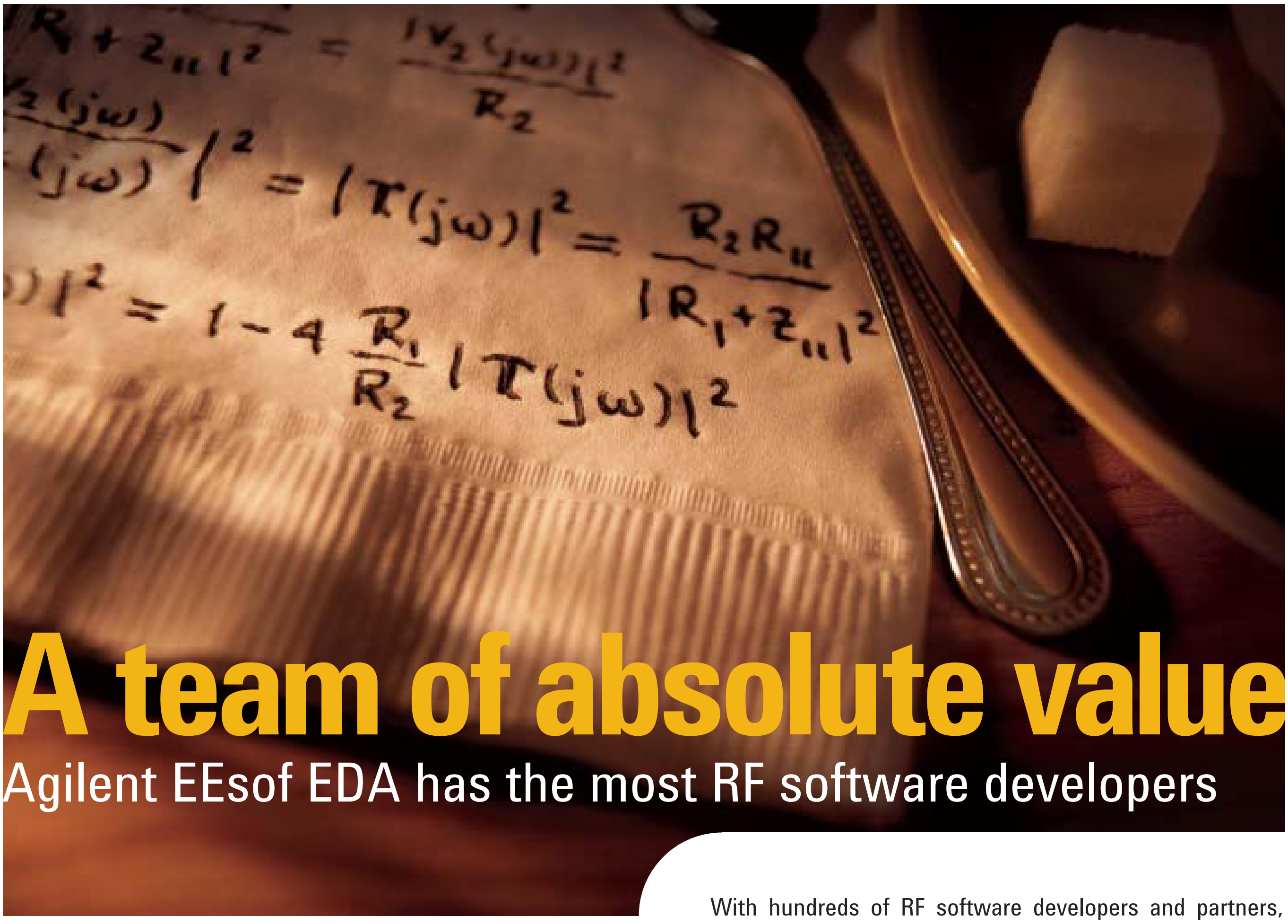
New compute architectures pack more processors into less space with large memory allowing massive simulations. While Intel and AMD are delivering multi-core processors with 64-bit architectures, system vendors like HP, Sun and others are working with multinationals to install ever more powerful compute farms. Early on, Ansoft recognized this trend and developed 64-bit solvers, multithreaded architectures and new options like DSO (Distributed Solve Option). These new technologies allow designers to more rapidly explore device or system performance over a range of dimensions, orientations, material parameters and frequency. Sensitivity analysis, design of experiments, genetic algorithm optimizers, manufacturing tolerances and material variances are being combined to provide engineers with design insights that have never before been possible.

The power of these new methods can be seen using a simple example to study vias in a PCB. ***Figure 12*** illustrates a differential via structure with geometric parameters including spacing, barrel radius, percent fill and anti-pad radius. The goal is to minimize the return loss by adjusting these parameters. ***Figure 13*** shows a plot of the return loss and insertion loss performance as a function of anti-pad radius and the dramatic effect on return loss especially at the higher frequencies. Twenty-five CPUs, all managed from a single engineer's desktop, were used for the simulations. The distributed network took only seven minutes to complete the simulations vs. 110 minutes using a single computer. In addition, data management software caches these solutions and makes them available to the circuit designer, so that upstream and/or downstream design changes can be made in concert with a variety of layout options for the vias.

Conclusion

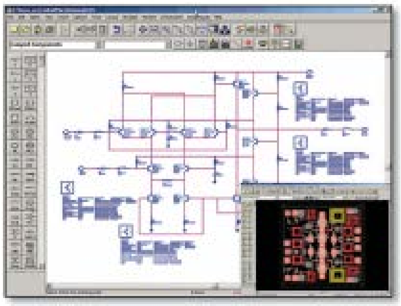
Next generation electronics involves the convergence of RF, analog and digital devices into tightly coupled high performance systems. Design of these systems requires the integration of RF, analog and digital circuits with careful consideration of the new physics that occur with more closely spaced high performance designs. New solutions have been developed to combine 3D EM physics together with new algorithms for time and frequency domain circuit simulation. Special attention to integrate these new solutions into the existing design flows has been made and case studies that highlight the ability to include frequency dependant layout effects and simulate the larger, more complex circuits that result have been shown. In addition, new algorithms have been developed to leverage the power of new compute systems, providing designers with unprecedented insight prior to building prototypes. ■

Zoltan Cendes *is founder and chairman of Ansoft Corp., Pittsburgh, PA. He also serves as Ansoft's chief technology officer and is responsible for managing the company's research and development. He has made significant contributions in the area of finite element modeling of electromagnetic devices. In particular, he solved the problem of spurious modes that prior to his work had made the application of finite element methods in electrical engineering impractical. He, along with his coworkers, developed new types of finite elements called edge elements that eliminate the problem of spurious modes. He also introduced the Delaunay mesh generation algorithm and adaptive mesh refinement procedures to finite element analysis and the transfinite element method and model order reduction procedures to high frequency electromagnetics. In 1980, he was appointed associate professor of electrical engineering at McGill University, Montreal, Canada. In 1982, he joined the faculty of electrical and computer engineering at Carnegie Mellon University, Pittsburgh, PA, where he was a professor until 1996. Cendes received his MS and doctoral degrees in electrical engineering from McGill University. Dr. Cendes is a Fellow of the IEEE, has served on the Editorial Board of IEEE Spectrum, on the International Steering Committee of the COMPUMAG Conference and as an IEEE Antennas and Propagation Society (IEEE AP-S) Distinguished Lecturer. He is a member of the International Workshop on Finite Elements in Microwave Engineering Steering Committee.*



A team of absolute value

Agilent EEsof EDA has the most RF software developers



Eagleware-Elanix is now part of Agilent EEsof EDA.

With hundreds of RF software developers and partners, Agilent works the high frequency EDA equation like no other company.

Our 25-year experience in high-frequency design began with Agilent RF engineers creating design software for their own use. The result has been the absolutely broadest selection of capabilities to meet both technical and budget needs of high-frequency designers. And as our team grows you can expect upgrades and new technologies proportional to our size – all focused on helping you tackle the latest design challenges and communication standards.

Now the Agilent EEsof EDA team has grown larger with the addition of Eagleware-Elanix and its own team of experts. Combine this with technical support that consistently ranks the best in the high-frequency EDA industry – and you can be confident that you're with the right team.

Let the world's largest team of RF EDA experts help you find the right solution for your needs and budget. Visit www.agilent.com/find/eesof-innovations for details

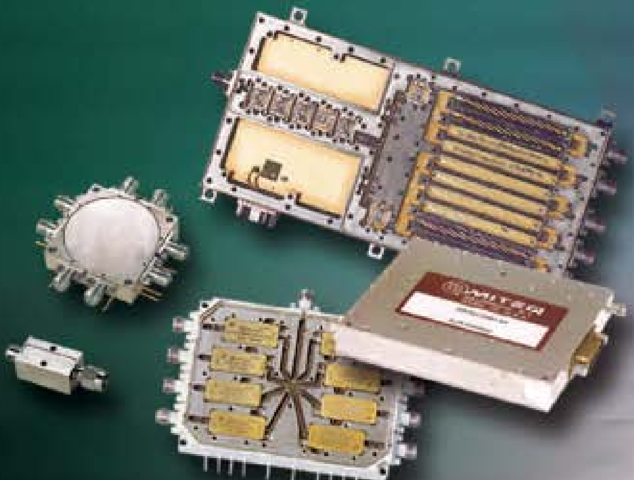
www.agilent.com/find/eesof-innovations

Agilent Technologies

Microwave Components

MIXERS TO 60 GHz

- Single-, double-, and triple-balanced
- Image rejection and I/Q
- Single-sideband, BPSK and QPSK modulators
- High dynamic range
- Active and passive frequency multipliers



CONTROL PRODUCTS

- PIN diode and high power switches
- Switch matrices
- Analog and digital PIN attenuators, phase shifters
- Limiters
- Delay lines

INTEGRATED SUBASSEMBLIES TO 60 GHz

- Integrated up/downconverters
- Monopulse receiver front ends
- Missile receiver front ends
- Switched amplifier/filter assemblies

IF AND VIDEO SIGNAL PROCESSING

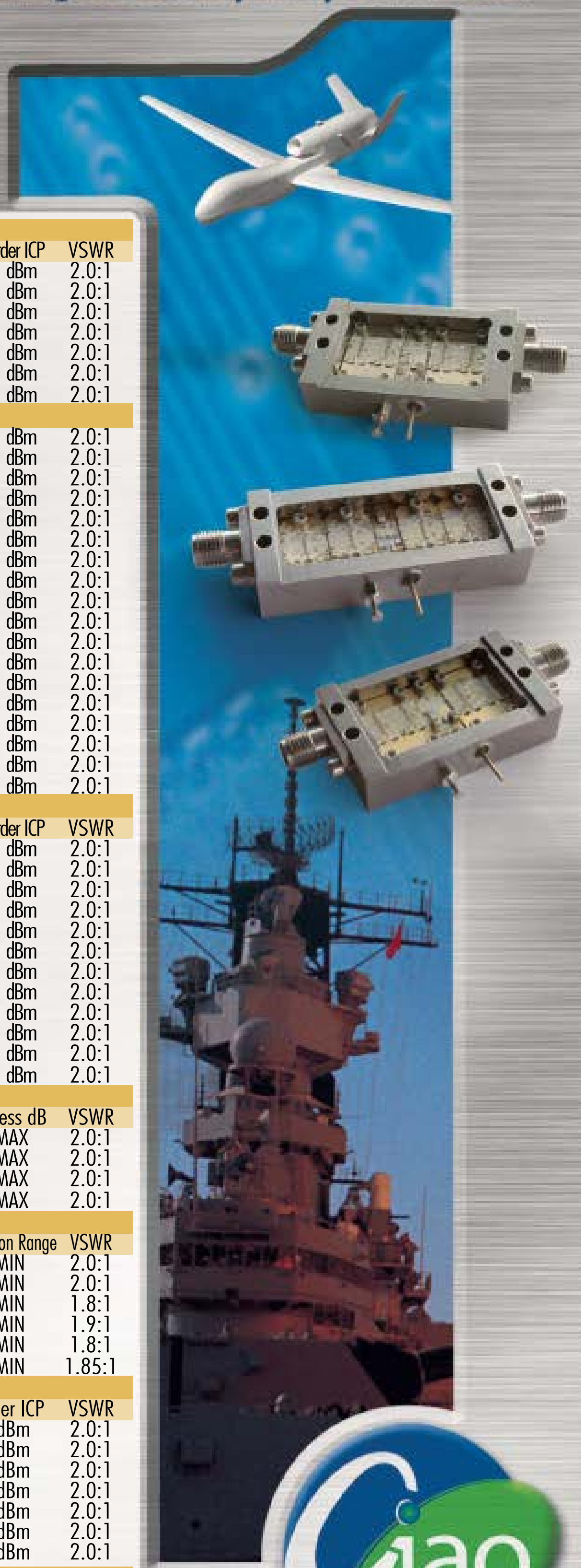
- Logarithmic amplifiers
- Constant phase-limiting amplifiers
- AGC/VGC amplifiers
- Digital DLVAs
- Digital logarithmic amplifiers and frequency discriminators

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

Harris Completes Advanced EHF Navy Multi-band Terminal Testing

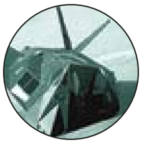
Harris Corp. has successfully completed the Advanced EHF Multi-band Terminal Prototype Testing (PT1) on its tri-band ship antenna and associated RF components five months ahead of schedule. Early completion of the PT1 testing ensures that compliant hardware will be available for system-level testing of the Navy Multi-band Terminal scheduled for March 2007. The testing is part of the US Navy competition for the engineering, manufacture and development phase of the contract, which is expected to be awarded in June 2007 and could exceed $1 B in value by 2015 for the winning company. Harris won a contract in 2003 to develop four prototypes of the next generation AEHF Navy Multi-band terminal for the Space and Naval Warfare Systems Command, which awarded the contract on behalf of its organizational partner, the Navy's Program Executive Office for C41. The first phase of the program is a 43-month effort to design and develop Q-band SATCOM submarine and shipboard terminals in support of the Navy's FORCEnet concept. The new terminals will provide the Navy with a modernized, highly reliable system that provides more than four times the data capacity of today's Milstar terminals. Additional phases will add high performance Ka- and X-band capabilities to the common terminal. The resulting system will replace current single- and dual-band terminals, yielding significant life cycle cost reductions and improved reliability. This approach offers the Navy better access to SATCOM assets, increased bandwidth and protection from jamming and interception of transmissions.

Lockheed Martin Upgrades Missile Warning System

Lockheed Martin announced the successful delivery of a new missile warning system to address tactical and strategic missile threats against the United States and Canada. US Strategic Command, US Northern Command and North American Aerospace Defense commanders will rely on this upgraded technology to quickly and accurately identify threats and coordinate response across forces. These Combatant Commander's Integrated Command and Control System (CCIC2S) Spiral 2 upgrades were developed as part of the Integrated Space Command and Control (ISC2) contract to integrate approximately 40 systems inside the Cheyenne Mountain Command Center into a common, interoperable command and control infrastructure. The delivery enhances the CCIC2S Spiral 1 air mission system deployed in 2004, improves the enterprise system operations capability and deploys the second release of the communication system. "This delivery is a significant step forward in our nation's missile warning capability," said John Mengucci, vice president and general manager of the Mission and Combat Support Solutions Group for Lockheed Martin's Integrated Systems and Solutions business area. "The advanced technology implemented in this CCIC2S Spiral 2 enterprise system accurately and quickly depicts tactical and strategic missile threats posed by modern day weapon systems, providing commanders new capabilities to identify threats and coordinate responses across forces." Industry standard commercial-off-the-shelf technology in the new missile warning system will enable future integration with existing missile defense systems. The system also includes an updated missile processing display for theater users that includes support for the Joint Staff's emergency action procedures. With this release, the current Cold-War era system can be decommissioned, as operations are migrated to the new, flexible, open standard infrastructure that takes advantage of commercial products and technologies. When completely deployed, CCIC2S will be a "virtual command center," where operators can effortlessly reach across the full spectrum of the nation's space and strategic assets. War fighters at all echelons will have a common operational picture of the global battlefield derived from shared, real-time data that is available anytime and to any location in the world for specified users. This translates into faster response to enemy actions and improved strategic and tactical coordination among forces.

Raytheon Successfully Demonstrates Satellite Communications Alternative

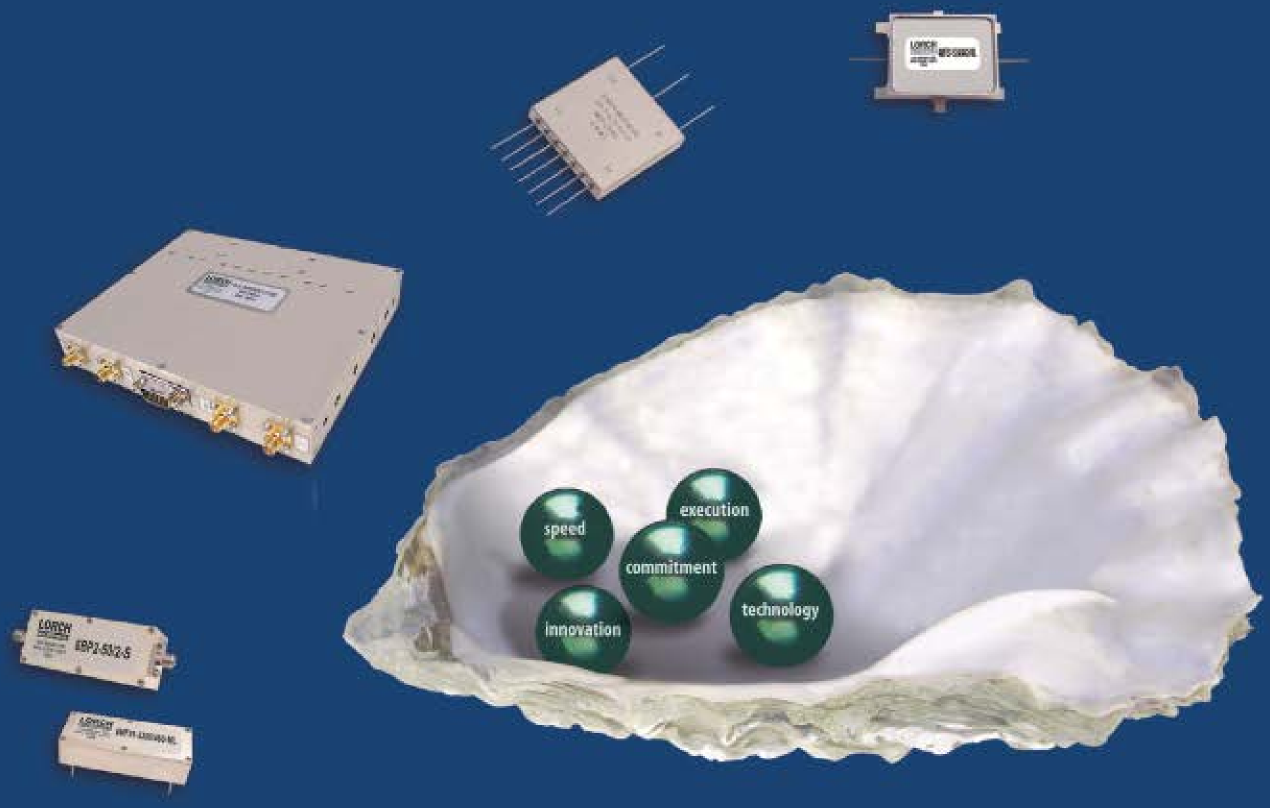
During an exercise with the I Marine Expeditionary Force at Camp Pendleton, CA, Raytheon successfully demonstrated that a traditional, transportable satellite communications terminal could be field configured to communicate without acquiring a satellite connection. This capability, known as Troposcatter, or TROPO, transmits radio waves over the curvature of the Earth without using satellites. The US military currently employs these systems for tactical and strategic communications throughout the world. "This demonstration showed that it is possible to provide a viable alternative to traditional satellite communications with a light-weight, low power and rapidly deployable solution," said Jerry Powlen, vice president, Network Centric Systems' Integrated Communications Systems. "Enemy threats to satellite communications are real. We are offering a high performance, cost-effective solution to counter these threats." Colonel Kirk Bruno, information technology officer for the I Marine Expeditionary Force, said: "The ease of deployment and setup and the improved data rates with the TROPO systems drastically reduce the support needed to carry out a mission. Increased data throughput without relying on already stressed satellites is critical and unlike satellite communications, TROPO systems provide cost-free access."



Raytheon established the TROPO communications link between its Dual-mode, All-band Re-locatable Tactical Terminal, or DART-T, and a modified Joint Network Node satellite transportable terminal. The demonstration showed that the widely fielded JNN terminal could be adapted to include a high bandwidth troposcatter mode, which not only minimizes the current limitation of existing satellite bandwidth, but also provides continuous and reliable communications in areas of the world that do not have access to SATCOM.

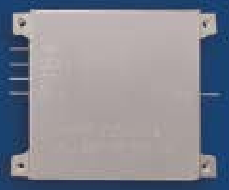
Northrop Grumman Develops a New GPS Range Tracking System

A newly certified Global Positioning System (GPS) range tracking system, developed for the Minuteman III Intercontinental Ballistic Missile (ICBM) by Northrop Grumman Corp., was successfully flown at Vandenberg Air Force Base for the first time, as one of the two independent tracking systems required for range safety. The GPS Metric Tracking System (GMTS) was developed, tested and provided by Northrop Grumman's Mission Systems sector as part of its role as the US Air Forces' ICBM prime integrating contractor. "This new system will greatly improve capabilities for range users through more precise tracking, fewer range delays caused by radar downtime and significantly reduced launch support costs," said John Clay, vice president and general manager of the Northrop Grumman ICBM Prime Contract. The GMTS replaces the C-band transponders previously used to track the Minuteman III test launches from Vandenberg Air Force Base. As directed by the Air Force Space Command, the C-band tracking system is to be deactivated in FY 2007 for cost saving and modernization. The C-band tracking radars use the on-board C-band transponder signal to lock onto the missile and track missile position and velocity. The GMTS now utilizes the GPS satellite constellation to ensure accurate tracking worldwide. The Minuteman III incorporates GPS translators on the missile to receive information from the satellites and relay translated time and identification data to ground facilities. This data is used to more accurately calculate the position and velocity of the missile, which is required for range safety tracking during missile flight. Northrop Grumman is the Air Force's ICBM prime integration contractor charged with modernizing and maintaining alert readiness of the US ICBM weapon system through 2020. The company manages a team consisting of three principal teammates—Boeing, Lockheed Martin and ATK—and more than 20 subcontractors. ■



a pearl is nature's gift
knowledge and experience are ours

For more than 30 years Lorch Microwave has been a leading supplier of RF and Microwave components, delivering innovative solutions for even the most demanding applications. From high performance micro miniature filters to ceramics, cavity and integrated assemblies, the Lorch Microwave name is found on military and commercial products worldwide. Let us put our knowledge and experience to work for you.



LORCH MICROWAVE

Salisbury, MD 21802
410.860.5100
800.780.2169
www.lorch.com

smiths

European Consortium Forges NFC Development

A pan-European consortium of companies, universities and user groups has been created to develop an open architecture for the development, deployment and use of Near Field Communication (NFC) enabled applications in mobile handsets. Co-funded by the European Commission and the Information Society Technologies (IST) programme, the *Store Logistics and Payment with NFC* (StoLPaN) project aims to define open commercial and technical frameworks for NFC enabled services on mobile devices.

In order to accurately address the interoperability issues currently affecting the technology, various usage cases are to be defined within the StoLPaN framework and tested throughout Europe. These usage cases will contribute to the identification of a common set of business rules, which will define the roles and responsibilities of every player in the NFC ecosystem. The results will then be submitted for approval to the relevant industry bodies for standardization of payments, mobile, transit and ticketing.

Based on these findings, the consortium will look into the specifications for technical requirements and the security aspects of NFC enabled applications. They will also explore the connection to existing contactless platforms, easing the burden on individual providers. At the same time the project team will demonstrate how the business rules and technical requirements can be implemented in existing contactless infrastructures. Also, a NFC host application will be developed to support a range of services.

The StoLPaN project team expects to issue its first version of the business rules and technical requirements by the summer of 2007. These will be accompanied by the first version of the host application, with the StoLPaN project scheduled for completion by 2009.

Intelligent Move as Wavecom Joins ERTICO

Wavecom has joined the ERTICO alliance—a partnership of companies whose goal is to reinforce a future European transport system that is safer, more efficient, more sustainable and more secure. Through Intelligent Transport Systems (ITS) and Services technology, combined with the appropriate investment in infrastructure, the partnership's efforts are aimed at reducing the number of accidents and congestion, while making transport networks more secure and minimizing their impact on the environment.

Membership in ERTICO is a natural extension to the contribution Wavecom is already making to the European Commission's eSafety Forum. The EC's major initiative, eCall is implementing an action plan to promote pan-European in-vehicle emergency call initiatives by using combined information and communications technologies of which Wavecom is a leading supplier.

Pierre Piver, Wavecom vice president, automotive, commented, "ERTICO represents the best in cooperation among a wide variety of players in the transport industry who are working together to improve all aspects of the industry in Europe. To date, the results coming from ERTICO demonstrate true world leadership and we are looking to bring our experience and our solutions in order to help improve transport systems not only in Europe but around the world."

aRfic Integrates R&D with NTU

In order to advance research and development in Radio Frequency Integrated Circuit (RFIC) technology, Advanced RFIC (aRfic) Pte Ltd. is investing $9 M in a new collaboration with Nanyang Technological University (NTU), Singapore. RFIC is a highly specialised segment of the semiconductor industry. It involves engineering design and development for which the work is patented. It is a segment that Singapore is increasingly pursuing to move the local industry up the value chain and is seen as the next step in the local industry's growth.

As part of the aRfic investment, a new laboratory dedicated to the research of RFIC technology will be set up at the NTU's School of Electrical and Electronic Engineering. It will contain state-of-the-art equipment, including a world class 300 mm probe system that will facilitate the modeling, measurement and characterization of nano-RF devices as well as integrated circuits. The investment will also create 30 postgraduate scholarships worth $2000 per month for 24 months, with the selected students working on four key projects over two years.

Henry Liu, chairman, aRfic, commented, "This joint collaboration aims to further research on deep submicron nanometre devices as well as develop design software that helps predict device performance; strengthening the company's R&D capabilities. We are confident that this nine million dollar collaboration will harvest greater expertise in this high technological area and more as aRfic and NTU scale greater heights together."

NXP and ASE Join Forces in China

NXP Semiconductors and Advanced Semiconductor Engineering have signed a Memorandum of Understanding (MoU) to form a joint venture in Suzhou, China focused on semiconductor testing and packaging. It is planned that NXP will hold a 40 percent share while

ASE will hold the remaining 60 percent. Terms of the agreement are subject to final negotiations between the two companies and the receipt of necessary approvals from regulatory authorities.

The joint venture will serve the international and domestic Chinese markets, focusing on testing and packaging of a wide range of semiconductors in areas such as mobile communications, consumer electronics and automotive products. Since the new company will be located at NXP's existing manufacturing site in Suzhou, the parties expect that the joint venture will be able to quickly and efficiently serve customers and support the required fast time-to-market requirements necessary to compete in the high tech arena.

The joint venture is expected to begin operations in Q2 2007. NXP will contribute its existing testing and packaging operation in Suzhou as its initial investment into the joint venture. This joint venture does not affect the other testing and packaging sites for NXP in Asia and Europe.

Ajit Manocha, chief manufacturing officer, NXP Semiconductors, stated, "We are pleased to be able to strengthen our relationship with ASE through the formation of this joint venture and appreciate the willingness of governments to help in this regard. The joint venture combines the expertise of both companies to provide high quality, competitive products to address the needs of electronics manufacturers around the world."

EADS Commits to Singapore Aerospace Programme

European aerospace leader EADS is ramping up its Research and Technology (R&T) activities with Singaporean partners by signing a Memorandum of Understanding (MoU) with the country's Agency for Science, Technology and Research (A*STAR) agency in its National Aerospace Programme. This MoU envisages a tier 1 membership for EADS in the programme, along with other international aerospace companies.

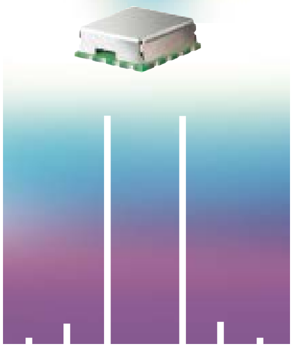
The Aerospace Programme is aiming at the R&T in precompetitive technologies with an option for members to set up specific projects with A*STAR at preferential rates. It targets five main directions of research, namely communication and electronics, inspection, modeling and security, materials and coatings, and manufacturing and automation. The programme has been launched in order to engage the international aerospace industry with the R&T community in Singapore and to drive innovation in the local aerospace industry and in related sectors.

As a tier 1 member, EADS will contribute S$200,000 annually to the research programme and membership entitles the company to royalty-free access to all results of the research activities carried out in the framework of the programme. It also gives voting rights to EADS in the decision making process aimed at defining the R&T projects that will be launched. ■

VERY HIGH IP3...to +36 dBm

MIXERS

2 to 2500 MHz



- *Very Wide Band, 2-2500 MHz*
- *Very High Isolation, up to 52 dB*
- *Very High 1 dB Compression, up to +23 dBm*
- *Very Low Conversion Loss, from 6.3 dB*

It's an industry first...only from Mini-Circuits!

Mini-Circuits shielded RoHS LAVI frequency mixers deliver the breakthrough combination of very high IP3 up to +36 dBm, ultra-wideband operation, and outstanding electrical performance.

From $13[95] *ea. Qty. (100)* **IN STOCK**

By combining our advanced ceramic, core & wire, and semi-conductor technologies, we've created these evolutionary broadband mixers that are specially designed to help improve overall dynamic range so you can realize lower distortion and combat interference in today's crowded spectrum. They're the very best, very low in cost, and immediately available off-the-shelf from the world leader in mixer technology, ***Mini-Circuits!***

TYPICAL SPECIFICATIONS

Model No.	Frequency (MHz) RF	LO	IF	LO Pwr. (dBm)	IP3 (dBm)	1dB Comp. (dBm)	Conv.Loss (dB)	Isolation (dB) L-R	L-I	Price $ ea. Qty.(1-9)
LAVI-9VH+	820-870	990-1040	120-220	+19	+36	+23	7.2	46	46	15.95
LAVI-10VH+	300-1000	525-1175	60-875	+21	+33	+20	6.3	50	45	22.95
LAVI-17VH+	470-1730	600-1800	70-1000	+21	+32	+20	6.8	52	50	22.95
LAVI-22VH+	425-2200	525-2400	100-700	+21	+31	+20	7.7	50	45	24.95
LAVI-2VH+	2-1100	2-1100	2-1000	+23	+34	+23	7.5	48	47	24.95
LAVI-25VH+	400-2500	650-2800	70-1500	+23	+32	+20	7.5	50	45	24.95

U.S. Patent Number 6,807,407

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

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

Patent Pending

RF/IF MICROWAVE COMPONENTS

412 RevC

Cellular Carriers Need to Develop WiMAX Strategy Now

The impact of WiMAX on the cellular industry is not currently known, but carriers need to put together their strategies concerning WiMAX now, reports In-Stat. For existing cellular carriers, WiMAX may potentially become a big competitor, a great ally or a minor factor, the high tech market research firm says. Nevertheless, it is clear that a strategy for WiMAX is the biggest decision cellular carriers have had to make since planning for 3G deployment. "WiMAX faces many challenges, including multiple incompatibility standards, different frequency allocations in each country and expensive consumer devices," says Allen Nogee, In-Stat analyst. "But fixed-line WiMAX is here and mobile WiMAX will be arriving in the next few years." *Recent research by In-Stat found the following:*

- Mobile VoWiMAX is not likely to be used much before 2009.
- There are many "profiles" in different regions of the world, meaning that WiMAX devices will likely operate differently in different regions, unless device manufacturers are willing to accept extra expenses to make a universal WiMAX device that supports all profiles.
- When WiMAX competes with cellular, cellular operators will be forced to decrease their prices for wireless data services over cellular. Even if WiMAX fails after that point, it is unlikely that cellular carriers will ever again be able to charge the amount they currently do for wireless data services.

The research, "WiMAX and Cellular: Threat or Opportunity – Cellular Strategies," covers the impact of WiMAX on the cellular industry. It includes a detailed analysis of WiMAX drivers and challenges and the potential responses by cellular carriers. It also contains a forecast of Voice over WiMAX subscribers through 2011.

2.4 GHz Products Ready to Win Share in Wireless Mouse and Keyboard Markets

The wireless human interface device (HID) market, which includes wireless mice, keyboards and remote controls, has historically been dominated by products operating in the 27 MHz band. But 2008 looks set to be a crossover year in which shipments of 2.4 GHz-based products outstrip those running at 27 MHz, thanks to wholesale product changes by major OEMs. ABI Research expects that by 2011, 2.4 GHz products will account for triple the number of 27 MHz products shipped. Some wireless HID products may employ other communication methods such as Bluetooth, but according to research director Stuart Carlaw, "Bluetooth still does not have price points low enough to allow it to penetrate much outside of its present territory: products aimed at smartphones and mice for use with Bluetooth-enabled laptops. The narrowing cost differential between 2.4 GHz and 27 MHz ICs and the improved range of 2.4 GHz mean that 2.4 GHz products are well positioned to take advantage of the growing need to support media center PCs with rich navigational solutions such as Vista's Side Show." A new ABI Research Brief, "Wireless PAN Technologies in PC and Mobile HID," forecasts the total market for wireless HID to grow from just over 100 million units in 2005 to over 168 million units in 2012, at a CAGR of 8 percent. A respectable share of that growth may be claimed by companies such as Nordic Semiconductor and TI, which stand to profit from the shift to 2.4 GHz products. According to Carlaw, a wild card in the development and growth in this market is Wibree, the new low power wireless local area network technology. "While Wibree is interesting and may have significant potential," he says, "it is still very new and the jury remains out on the question of whether it can make significant inroads in the wireless HID market." "Wireless PAN Technologies in PC and Mobile HID" profiles market trends affecting the uptake of wireless HID in both mobile and computing environments. It addresses issues including the market mix of 27 MHz and 2.4 GHz products, the impact of standardized products such as Bluetooth and Wibree, and rich navigation scenarios stemming from Media Center and Vista uptakes. It forms part of two ABI Research Services: Short Range Wireless and Home Networking.

Ultrawideband Coming to Market in 2007

As reported by In-Stat, this year the Consumer Electronic Show (CES) saw Ultrawideband (UWB), a high data rate, short-range wireless technology, getting very close to market. While the first UWB-enabled products were shipped in the fourth quarter of 2006 in Japan, wide commercial availability of UWB products should be available worldwide in 2007. At CES, there were several companies demonstrating UWB-based solutions in their booths and suites, and UWB chip companies were well represented, including WiQuest, Staccato, Intel, WiLinx, Alereon, Wisair, NEC, NXP, Focus Enhancements and Artimi. The first manifestation of UWB chip solutions will be in wireless USB solutions in the first half of 2007. The specifications that govern certified Wireless USB (WUSB) products are overseen by both the Wi-Media Alliance and the USB Implementer's Forum.

The first WUSB products will be dongle and wireless hub solutions for PCs and PC peripherals, such as printers, multifunction devices and external hard disc drives. By late 2007, embedded WUSB solutions should begin to be shipped in PCs. In total, In-Stat expects 10.4 million WUSB-enabled devices to be shipped in 2007. The future of UWB extends beyond WUSB. For example, there were companies at CES that were demonstrating UWB as a medium for high definition video transmission, including wireless transmission. These companies include Pulse-LINK, Tzero Technologies, WiQuest and Radiospire. Looking at the number of UWB companies at CES, in addition to the quality of their demos, the future of UWB looks extremely bright.

WiMAX and Metro Wi-Fi Are More Energy-efficient Than Cellular

Energy costs represent the third most significant operating expense (OPEX) item for cellular carriers today and fluctuating energy costs are a significant area of concern for business planners. The introduction of mobile broadband to the equation means that the energy required per subscriber arising from increasing the data uptake will push per-subscriber energy OPEX for cellular solutions past acceptable barriers—unless carriers move from a traditional cellular only approach to one that integrates WiMAX and Metro Wi-Fi. Stuart Carlaw, director of wireless research at ABI Research, says that "From a pure coverage perspective WiMAX is twice as energy-cost-effective and Metro Wi-Fi is 50 times more energy-cost-effective than WCDMA. When data traffic is factored into the equation, WiMAX can accommodate 11 times today's average data consumption and still be more energy-cost-efficient compared to WCDMA or HSDPA." A recent ABI Research study found that the total energy consumption arising from mobile service delivery is forecast to grow from 48.2 billion kilowatt hours (KWh) in 2005 to 124.4 billion KWh in 2011. The Asia Pacific region will account for the majority of this growth. The report, "Energy Efficiency Analysis for Mobile Broadband Solutions," provides a theoretical and real world analysis of the relative costs of deploying WCDMA, HSDPA, CDMA2000 1xRTT, EV-DO, WiMAX and Municipal Wi-Fi. It offers strategic recommendations to the industry as to the best way of combating rising power consumption costs. It forms part of two ABI Research Services: Mobile Devices and Mobile Broadband, which also include other Research Reports, Research Briefs, Market Data, Online Databases, ABI Insights and analyst inquiry support. ■

INDUSTRY NEWS

■ **Ohmite Manufacturing Co.** announced that it has acquired both the Ultronix Precision Wirewound Resistor and Angstrohm Rheostat Businesses of **Vishay Intertechnology Inc.** Ultronix is a Pennsylvania-based manufacturer of precision wirewound resistors. Angstrohm, based in Hagerstown, MD, is a manufacturer of wirewound rheostats.

■ **Elcom Technologies Inc.** announced a strategic partnership with **Frequency Electronics Inc.** (FEI). FEI has acquired an approximate 20 percent interest in Elcom Technologies, which includes preferred stock, a convertible note and 10-year warrant to purchase additional stock in exchange for an undisclosed amount of cash and shares of FEI common stock.

■ **Antenova Ltd.** has acquired the RF design engineering team from a US-based developer of advanced RF power amplifiers for mobile handsets. The team will be housed in a new Design and Support Center in the Chicago area in the first quarter of 2007 and will complement the company's North American sales organization already established in California and Texas. The initiative is a major advance in the company's aggressive expansion from delivering embedded antennas to providing integrated radio antenna modules for the mobile device markets.

■ **Agilent Technologies Inc.** announced it has completed the acquisition of certain assets of **PXIT Inc.**, a privately held company that provides signal integrity testing systems for broadband optical transceiver manufacturers. Financial details were not disclosed. All of PXIT's Massachusetts-based employees have joined Agilent.

■ **Freescale Semiconductor** and **IBM** announced that Freescale will join the IBM technology alliance for joint semiconductor research and development. The agreement includes Complementary Metal Oxide Semiconductor (CMOS) and Silicon-on-Insulator (SOI) technologies as well as advanced semiconductor research and design enablement transitioning at the 45-nanometer generation. Freescale is the first technology development partner in the IBM technology alliance to participate in both low power and high performance technology research and development. This agreement brings together Freescale's leadership in key embedded markets with IBM's success in developing world-class technology and industry-leading systems expertise.

■ **Andrew Corp.** announced it has become the first company to manufacture both radio frequency cable products and antennas in India with the opening of its newly-built production facility in Goa. Andrew's new Indian facility will serve the various equipment manufacturers and network operators in this rapidly growing market with technically superior, high quality products, which previously were available only through importing. For the first time, customers can benefit from the local supply of Indian-produced RF products, backed by in-country technical assistance and customer support. The new facility also hosts a staffed service and repair depot for Andrew RF repeater products.

■ **TenXc Wireless Inc.**, an innovator in intelligent radio frequency solutions for enhanced wireless networks, and **Coherent Designs Pvt.** announced the establishment of a joint development center in Islamabad, Pakistan. The new development center expands TenXc's existing research and development capabilities and will play an integral role in the development of evolving fourth generation (4G) access systems such as mobile WiMAX and 3GPP LTE with combined MIMO/AAS technology.

■ **Val Jackson + Associates Inc.**, an established applications engineering-oriented sales and marketing company, has relocated within the Pacific Northwest area of the United States. The company has relocated from Scotts Valley, CA to Port Angeles, WA. Founded in 1994, Val Jackson + Associates represents leading manufacturers within the high technology, RF/microwave defense electronics and commercial wireless communications markets. For more information, contact: Val Jackson + Associates Inc., 818 N. Barr Road, Port Angeles, WA 98362 (360) 452-7308, fax: (360) 452-7306, e-mail: vjackson@cruzio.com or visit: www.valjacksonassoc.com.

■ **Manncorp**, a provider of SMT assembly equipment, announced plans to expand its West Coast location to meet increasing demands for machines including pick and place, lead-free wave solder and reflow ovens. The address and phone number remain the same: 4901 Morena Boulevard, Suite #314, San Diego, CA 92117 (858) 490-6266.

■ **Alereon Inc.**, an ultra-wideband (UWB) technology leader for mobile WiMedia and Wireless USB solutions, announced its support for the USB Implementers Forum's (USB-IF) plan to add support for ultra-wideband (UWB) frequencies above 6 GHz in the Wireless USB specification in 2007. The extended specifications will expand the current options for manufacturers in specific geographic regions and better utilize the total available spectrum allocated for UWB.

■ **Aeroflex** has announced it has added the ability to undertake live receiver testing and transmitter testing, including HSDPA on its highly successful 6413A UMTS base station test system. The capability is ideal for the ongoing maintenance of UMTS base stations to ensure they perform to specification. It enables testing to be undertaken without any disruption to live traffic caused by taking the base station out of service.

■ The ZigBee® Alliance, a global ecosystem of companies creating wireless solutions for use in residential, commercial and industrial applications, announced that **Eaton Corp.** is now a Promoter level member and the newest member of the ZigBee Alliance Board of Directors. Eaton has been a Participant level member of the ZigBee Alliance since the Alliance's inception in 2002. As a key early member of the Alliance, Eaton provided valuable input into the development of the ZigBee standard.

■ **Vishay Intertechnology Inc.** announced that its Asian subsidiary, Vishay Intertechnology Asia Pte Ltd., recently received a certificate of accomplishment from Agilent Technologies in recognition of its excellent support to the latter between November 2005 and December 2006. Vishay had successfully supported and fulfilled Agilent's quick orders for electronic components, which in turn, had enabled Agilent to enhance its quarterly sales forecasts.

CONTRACTS

■ Comtech Telecommunications Corp. announced that its Melville, New York-based subsidiary, **Comtech PST Corp.**, received a $4.8 M contract from a major domestic OEM to supply high power amplifiers. These amplifiers are key components in a complex Identification Friend or Foe (IFF) system used to interrogate aircraft to determine their friend or foe status. This order supplements a significant installed base of Comtech IFF high power amplifiers previously delivered to this customer.

■ **Micronetics Inc.** announced that its subsidiary **Stealth Microwave Inc.** has been awarded a $2.5 M order from **IP-Wireless** for high power amplifiers on the Universal Mobile Telecommunications System (UMTS) platform. IP-Wireless is planning to incorporate these high performance amplifiers as part of a comprehensive wireless network to be installed in New York City. This wireless network is expected to enhance the existing mobile wireless communications network with secure high speed data and video capabilities, and deploy several new, advanced wireless applications to support first responders and other public safety personnel.

■ **Applied Radar Inc.**, a small business based in North Kingstown, RI, is the recipient of a $1.4 M congressional earmark to develop a Wideband Digital Airborne Electronic Sensing Array for the US Air Force. Supported by Senator Jack Reed (D-RI), the set-aside will be used to develop an advanced prototype of a novel digital radar receiver initiated under a Department of Defense (DoD) Phase II Small Business Innovative Research (SBIR) contract with the Air Force Research Laboratory (AFRL) at Hanscom Air Force Base, MA.

■ **RF Monolithics Inc.** announced that its subsidiary **Cirronet Inc.** received an initial production order as part of a wireless sensor network contract with an industrial original equipment manufacturer (OEM). The production order combined with its associated development contract represents approximately $500K cumulatively from this OEM customer, a Fortune 500 company. The order, consisting of wireless sensor nodes, routers and base stations, will permit deployment of several thousand sensor nodes in an industrial application. The overall market opportunity for this industrial application includes a million or more of existing potential sensor points.

■ **Unity Wireless Corp.** announced that it has successfully concluded the first phase 18-month trial of the company's patented synchronized multi-source transmission technology with China's second largest wireless carrier. Unity's unique

technology overcomes multi-path fading and economically increases existing network capacity and coverage.

FINANCIAL NEWS

■ **Merrimac Industries Inc.** reports sales of $6.8 M for the third quarter ended September 30, 2006, compared to $7.9 M for the same period in 2005. Net loss for the quarter was $599,000 ($0.19/per share), compared to a net income of $228,000 ($0.07/per share) for the third quarter of last year.

■ **Auriga Measurement Systems LLC** announced that it has accepted additional funding from **White Oak Partners Inc.** in order to develop and launch its next generation of products for RF and microwave modeling, characterization and test industry customers. After achieving worldwide acceptance in its first two years, Auriga is now refining its product suite to offer enhanced products that incorporate key features to protect its customers' capital equipment investment while maximizing its test capabilities. For more information, visit www.auriga-ms.com.

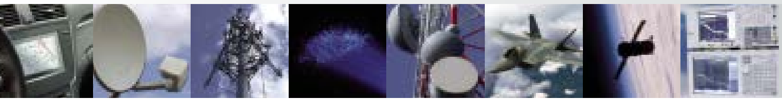
■ **Inphi® Corp.** announced it has won the FSA award for "Outstanding Financial Performance by a Private Fabless Company." FSA, the voice of the global fabless business model, made the announcement at its 12th annual FSA Awards Dinner in Santa Clara, CA. This award recognizes private companies that doubled either revenue or net income with no negative quarters over eight consecutive quarters ending June 2006.

NEW MARKET ENTRIES

■ **RFMD**'s newest RF switches—the RF1200 and RF1450—utilize RFMD's industry-leading GaAs manufacturing capability and leverage the switch technology developed for use in the company's transmit modules. These high performance switches enable front-end applications in multiple market segments, including multimode GSM/WCDMA cellular handsets, antenna tuners, IEEE 802.11a/b/g WLAN and cellular infrastructure. RFMD expects to grow revenue in the RF switch market as it introduces new products and enhances its growing leadership position in cellular RF.

■ **Comarco Inc.**, a supplier of wireless test systems for field applications, announced that its Wireless Test Systems division is expanding its range of test, optimization and Quality of Service (QoS) measurement products. In November, Comarco announced that it had formed an alliance with Ascom to develop and market advanced QoS test and measurement solutions for 3G and 4G wireless standards. The company further intends to accelerate the introduction of several products that will help wireless carriers optimize the performance of new cellular networks. Comarco is also increasing its sales and marketing resources in Asia and Latin America to better serve its customers in these growing markets and to the position the company for the deployment phase of 3G systems in China, Mexico and elsewhere in Latin America.

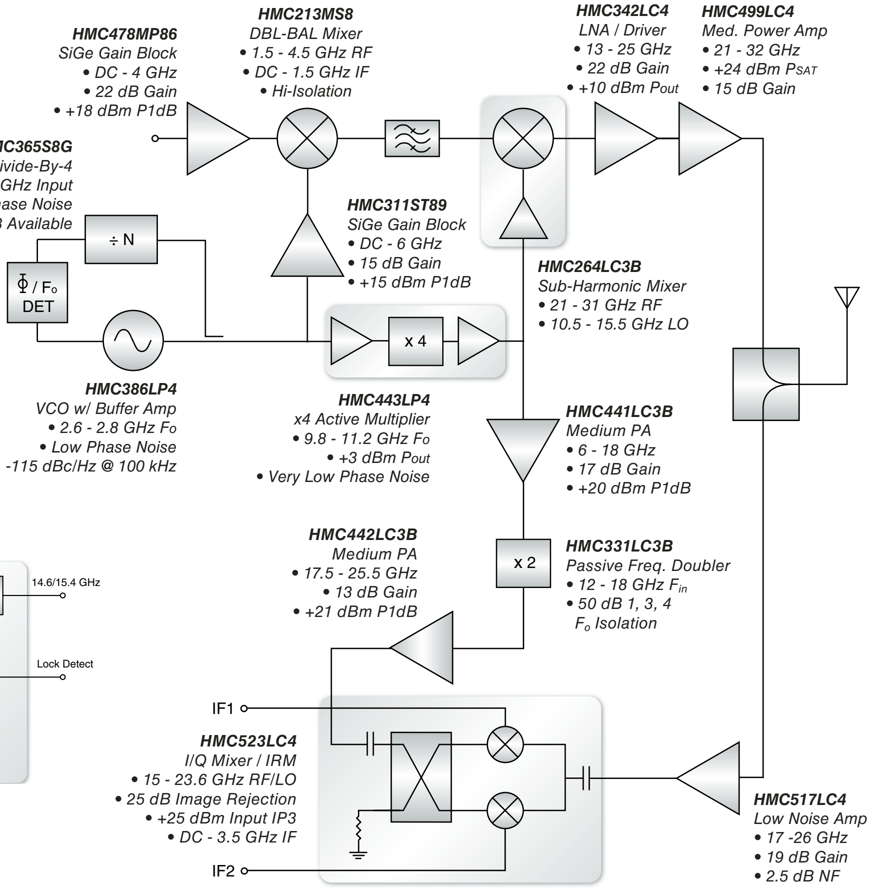
MMICs for M



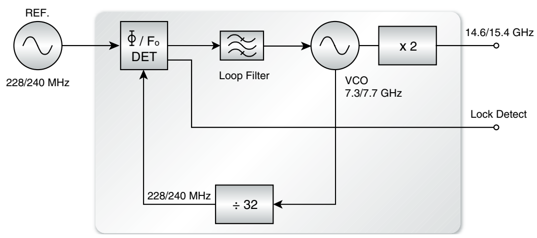
Point-to-Point & VSAT MMIC Die & S

The Microwave Designer's Component Source

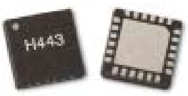
Hittite Microwave Corporation offers the Industry's most complete standard and custom product line of MMIC die and SMT components for Microwave Radio applications; including solutions for Transmit, Receive, LO Generation & LO Distribution Subsystems.



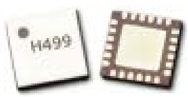
15 GHz Integrated PLO



HMC535LP5
Phase Locked Oscillator
• 14.7 - 15.4 GHz
• 12 dBm Output Power
• Low Phase Noise
-110 dBc/Hz @ 100 kHz



All SMT products are available in RoHS compliant packages.



Hittite
MICROWAVE CORPORATION

RoHS ✓ EARTH FRIENDLY

TÜV SÜD ISO/TS 16949 ISO 9001

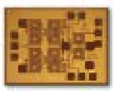
ICROWAVE RADIO

Analog & Mixed-Signal ICs, Modules & Subsystems

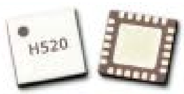
MT SOLUTIONS COVERING 7 TO 38 GHz!

A SELECTION OF HITTITE TRANSCEIVER COMPONENTS FOR STANDARD MICROWAVE RADIO BANDS

Function	7 / 8 GHz	11 GHz	13 GHz	15 GHz	18 GHz	23 GHz	26 GHz	28 GHz	32 / 38 GHz
Low Noise Amplifier	HMC564 HMC564LC4 HMC565 HMC565LC5	HMC516LC5 HMC564 HMC564LC4 HMC565 HMC565LC5	HMC516LC5 HMC565 HMC565LC5	HMC516LC5 HMC565 HMC565LC5	HMC517LC4 HMC565 HMC565LC5	HMC341LC3B HMC517LC4	HMC341LC3B HMC517LC4	HMC341LC3B HMC518	HMC263 HMC566
Driver Amplifier	HMC441LP3 HMC451LC3 HMC516LC5	HMC441LP3 HMC451LC3 HMC516LC5	HMC441LC3B HMC451LC3 HMC490LP5	HMC441LC3B HMC451LC3 HMC490LP5	HMC383LC4 HMC442LC3B HMC498LC4	HMC383LC4 HMC442LC3B HMC498LC4	HMC383LC4 HMC283LM1 HMC499LC4	HMC383LC4 HMC283LM1 HMC499LC4	HMC283LM1 HMC300LM1 HMC383LC4
Power Amplifier	HMC486LP5 HMC590LP5 HMC591LP5	HMC487LP5 HMC592	HMC489LP5 HMC592	HMC489LP5	HMC498LC4	HMC498LC4	HMC499LC4	HMC499LC4	HMC283LM1
Attenuator: Analog	HMC346LP3	HMC346LP3	HMC346LP3	HMC346LC3B	HMC346LC3B				
Divide-by-2	HMC361S8G	HMC364S8G	HMC492LP3	HMC492LP3	HMC492LP3				
Divide-by-4	HMC362S8G	HMC365S8G	HMC493LP3	HMC493LP3	HMC447LC3	HMC447LC3	HMC447LC3		
Divide-by-8	HMC363S8G	HMC363S8G	HMC494LP3	HMC494LP3					
Multiplier: Active X2	HMC368LP4 HMC575LP4 HMC561LP3	HMC368LP4 HMC573LC3B HMC561LP3	HMC368LP4 HMC573LC3B HMC561LP3	HMC368LP4 HMC573LC3B HMC561LP3	HMC448LC3B HMC576 HMC576LC3B	HMC448LC3B HMC576 HMC576LC3B	HMC448LC3B HMC578 HMC578LC3B	HMC449LC3B HMC577LC4B HMC578LC3B	HMC449LC3B HMC578LC3B HMC579
Multiplier: Active X4		HMC443LP4	HMC370LP4	HMC370LP4					
Multiplier: Passive X2	HMC189MS8	HMC189MS8	HMC204MS8G	HMC204MS8G	HMC204MS8G	HMC205	HMC205	HMC331	HMC331
I/Q Receiver	HMC567LC5	HMC568LC5	HMC569LC5	HMC570 HMC570LC5	HMC571 HMC571LC5	HMC572 HMC572LC5	HMC572 HMC572LC5		
I/Q Mixer / IRM	HMC520LC4 HMC525LC4	HMC521LC4 HMC527LC4	HMC521LC4 HMC527LC4	HMC522LC4 HMC528LC4	HMC523 HMC523LC4	HMC523 HMC523LC4 HMC524	HMC524 HMC524LC3B	HMC524 HMC524LC3B	HMC404 HMC524 HMC555 HMC556
Mixer: Fundamental	HMC129LC4 HMC144LC4 HMC219MS8 HMC220MS8 HMC553 HMC553LC3B	HMC144LC4 HMC411MS8G HMC412MS8G HMC553 HMC553LC3B	HMC144LC4 HMC411MS8G HMC412MS8G HMC553 HMC553LC3B	HMC144LC4 HMC260LC3B HMC412MS8G HMC554 HMC554LC3B	HMC144LC4 HMC260LC3B HMC292LC3B HMC554 HMC554LC3B	HMC260LC3B HMC292LC3B	HMC292LC3B HMC329LC3B HMC560 HMC560LM3	HMC292LC3B HMC329LC3B HMC560 HMC560LM3	HMC294 HMC329LM3 HMC560 HMC560LM3
Mixer: Sub-Harmonic				HMC258LM3	HMC258LM3 HMC337	HMC264LC3B HMC338LC3B	HMC264LC3B HMC338LC3B	HMC265LM3 HMC338LC3B	HMC338 HMC339
Switch	HMC547LP3	HMC547LP3	HMC547LP3	HHMC547LP3	HMC547LP3				
VCO & PLO: **Requires X2 or X4	HMC505LP4 HMC506LP4 HMC532LP4 HMC586LC4B HMC587LC4B	HMC513LP4 HMC515LP5 HMC534LP4 HMC588LC4B	HMC513LP4 HMC529LP4 HMC584LP5	HMC529LP4 HMC531LP5 HMC535LP5	HMC429LP4	HMC431LP4	HMC515LP5	HMC531LP5	HMC505LP4 HMC506LP4



See the full product listing on www.hittite.com MICROWAVE section.



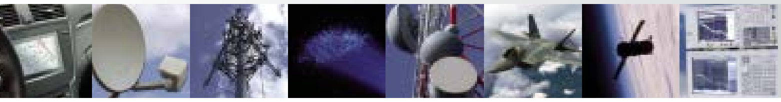
Hittite Microwave Corporation

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	asia@hittite.com
HMC Co., Ltd. Shanghai	Ph +86-21 6237-6717	china@hittite.com

Order On-Line www.hittite.com

Visit http://mwj.hotims.com/11714-59 or use RS# 59 at www.mwjournal.com/info

CONNECTORIZED MI



TEST & MEASUREMENT ♦ MILITARY

AMPLIFIERS - Low Noise, Drivers, PAs & >10 Watt PA Modules

	Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	Part Number
NEW!	29 - 36	Low Noise	20	22	2.9	11	+3V @ 80mA	C-10 Module	HMC-C027
	2 - 20	Wideband LNA	15	24	2.2	14	+12V @ 65mA	C-1 Module	HMC-C001
	2 - 20	Wideband LNA	14	26	2	18	+12V @ 60mA	C-2 Module	HMC-C002
	2 - 20	Wideband LNA	14	27	2	16	+8V @ 75mA	C-2B Module	HMC-C022
	7 - 17	Wideband LNA	22	25	2.5	14	+8V @ 93mA	C-1 Module	HMC-C016
	17 - 27	Wideband LNA	18	25	3	14	+8V @ 96mA	C-1B Module	HMC-C017
	0.01 - 20	Wideband Driver	16	33	3	23	+12V @ 195mA	C-3 Module	HMC-C004
	0.01 - 20	Wideband Driver	15	30	3	23	+12V @ 225mA	C-3B Module	HMC-C024
NEW!	2 - 35	Wideband Driver	11	26	4	16	+11V @ 92mA	C-10 Module	HMC-C038
NEW!	0.01 - 15	Wideband PA, 1/2 Watt	12	36	4	28	+11V @ 360mA	C-10B Module	HMC-C036
NEW!	0.01 - 15	Wideband PA, 1/2 Watt	12	36	4	28	+11V @ 360mA	C-12 Module	HMC-C037
	2 - 20	Wideband PA	15	34	4	26	+12V @ 310mA	C-2 Module	HMC-C003
	2 - 20	Wideband PA	14	30	4	24	+12V @ 310mA	C-2B Module	HMC-C023
	2 - 20	Wideband PA	28	30	3	25	+12V @ 400mA	C-3B Module	HMC-C026
NEW!	17 - 24	Wideband PA	22	33	3.5	24	+8V @ 250mA	C-10 Module	HMC-C020
NEW!	21 - 31	Wideband PA	15	32	5	24	+8V @ 215mA	C-10 Module	HMC-C021
	0.4 - 1.0	10 Watt PA	40	54	12	40	+12V @ 6.5A	C-7 Module	HMC-C012
	0.8 - 2.0	10 Watt PA	43	56	12	40	+12V @ 6.5A	C-7 Module	HMC-C013
	1.8 - 2.2	15 Watt PA	42	53	6	42	+14V @ 6.5A	C-7 Module	HMC-C008

ATTENUATORS - Digital

	Frequency (GHz)	Function	Loss (dB)	Atten. Range (dB)	Input IP3 (dBm)	Control Input (Vdc)	Package	Part Number
NEW!	DC - 13	6-Bit Digital, Serial Control	3.6	0.5 to 31.5	32	Serial TTL/CMOS	C-6 Module	HMC-C018
	DC - 13	6-Bit Digital	3.2	0.5 to 31.5	38	0 / +5V	C-6 Module	HMC-C025

FREQUENCY DIVIDERS (Prescalers)

	Input Freq. (GHz)	Function	Input Power (dBm)	Output Power (dBm)	100kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	Part Number
	0.5 - 18	Divide-by-2	-15 to +10	-4	-150	+5V @ 75mA	C-1 Module	HMC-C005
	0.5 - 18	Divide-by-4	-15 to +10	-4	-150	+5V @ 93mA	C-1 Module	HMC-C006
NEW!	0.5 - 8	Divide-by-5	-15 to +10	-1	-155	+5V @ 80mA	C-1 Module	HMC-C039
	0.5 - 18	Divide-by-8	-15 to +10	-4	-150	+5V @ 98mA	C-1 Module	HMC-C007
NEW!	0.5 - 17	Divide-by-10	-15 to +10	-1	-155	+5V @ 152mA	C-1 Module	HMC-C040

FREQUENCY MULTIPLIERS - Active

	Input Freq. (MHz)	Function	Output Freq. (GHz)	Input Power (dBm)	Output Power (dBm)	100kHz SSB Phase Noise (dBc/Hz)	Package	Part Number
NEW!	3000 - 5000	Active x2	6 - 10	3	17	-140	C-10 Module	HMC-C031
NEW!	9000 - 14500	Active x2	18 - 29	3	16	-132	C-10 Module	HMC-C032
NEW!	12000 - 16500	Active x2	24 - 33	3	17	-132	C-10 Module	HMC-C033
NEW!	16000 - 23000	Active x2	32 - 46	3	13	-130	C-10 Module	HMC-C034

Hittite MICROWAVE CORPORATION

RoHS ✓ EARTH FRIENDLY

ISO/TS 16949 TÜV SÜD ISO 9001

CROWAVE MODULES

Analog & Mixed-Signal ICs, Modules & Subsystems

& SPACE ♦ COMMUNICATIONS

I/Q MIXERS

	RF/LO Freq. (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Image Rejection (dB)	Input IP3 (dBm)	Package	Part Number
	4 - 8.5	I/Q Mixer	DC - 3.5	-7.5	37	23	C-4 Module	HMC-C009

MIXERS

	RF Freq. (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	LO/RF Isol. (dB)	Input IP3 (dBm)	Package	Part Number
NEW!	23 - 37	+13 LO, DBL-BAL	DC - 13	-9	35	19	C-11 Module	HMC-C035
	16 - 32	+13 LO, DBL-BAL	DC - 8	-8	28	19	C-11 Module	HMC-C014
	24 - 38	+13 LO, DBL-BAL	DC - 8	-8.5	35	20	C-11 Module	HMC-C015

PHASE SHIFTERS - Analog

	Frequency (GHz)	Function	Insertion Loss (dB)	Phase Range (deg)	2nd harmonic Pin = 10 dBm (dBc)	Control Voltage Range (Vdc)	Package	Part Number
	6 - 15	Analog	7	750° @ 6 GHz 450° @ 15 GHz	40	0V to +5V	C-1 Module	HMC-C010

SWITCHES

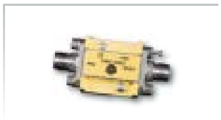
	Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package	Part Number
NEW!	DC - 20	SPST, Hi Isolation	3	100	23	0 / +5V	C-9 Module	HMC-C019
	DC - 20	SPDT, Hi Isolation	2.0	40	23	0 / -5V	C-5 Module	HMC-C011

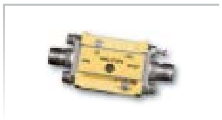
VOLTAGE CONTROLLED OSCILLATORS

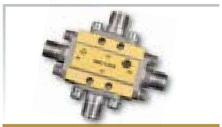
	Output Freq. (GHz)	Function	Output Power (dBm)	10kHz SSB Phase Noise (dBc/Hz)	100kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	Part Number
NEW!	4 - 8	Wideband VCO	20	-75	-95	+12V @ 185mA	C-1 Module	HMC-C028
NEW!	5 - 10	Wideband VCO	20	-64	-93	+12V @ 195mA	C-1 Module	HMC-C029
NEW!	8 - 12.5	Wideband VCO	21	-59	-83	+12V @ 195mA	C-1 Module	HMC-C030

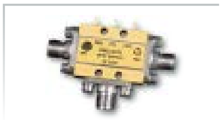
In Stock Module Products! Contact Us With Your Custom Requirements!

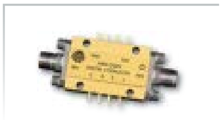

C-1 / C-1B
35.31 x 17.78 x 7.38 mm


C-2 / C-2B
38.1 x 17.78 x 7.38 mm

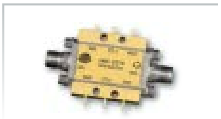

C-3 / C-3B
40.89 x 17.78 x 7.38 mm

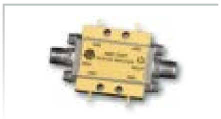

C-4
41.66 x 36.32 x 8.50 mm

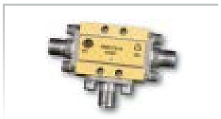

C-5
41.66 x 29.84 x 8.50 mm

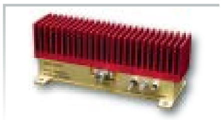

C-6
45.34 x 17.27 x 8.50 mm


C-7
192.3 x 106.7 x 35.0 mm


C-9
41.66 x 27.59 x 8.50 mm


C-10 / C-10B
41.66 x 27.59 x 8.50 mm


C-11
41.66 x 29.84 x 8.50 mm


C-12
107.6 x 43.0 x 43.0 mm

Order On-Line
www.hittite.com

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	asia@hittite.com
HMC Co., Ltd. Shanghai	Ph +86-21 6237-6717	china@hittite.com

PERSONNEL

■ Superconductor Technologies Inc. (STI), a provider of high performance infrastructure products for wireless voice and data applications, announced the appointment of **David Vellequette** to its board of directors. With the addition of Vellequette, STI's board has seven members. Vellequette currently serves as chief financial officer of JDSU, a position he has held since June of 2005.

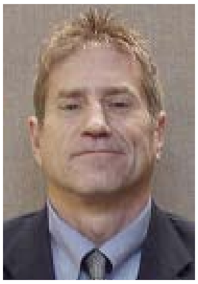
■ Tower Semiconductor Ltd., a pure-play independent specialty foundry, announced that its board of directors has nominated **Dov Moran** to serve as the company's new chairman of the board. Moran is co-founder of msystems Ltd., a leader in flash memory development, which was recently acquired by SanDisk Corp. Moran was president, CEO and chairman of the board of directors of msystems from 1989 until September 2006.

■ Credence Systems Corp. announced the appointment of **Lavi Lev** as president and chief executive officer. Lev succeeds Dave Ranhoff who has stepped down. Lev has more than twenty years of experience in the design tool and semiconductor industries at companies including National Semiconductor, Intel, Sun Microsystems, Silicon Graphics, MIPS Technologies and Cadence. He most recently served as the executive vice president and general manager of the products and solution business at Cadence Design Systems Inc., where he had responsibility for Cadence's worldwide product portfolio.


▲ Walt Dollman

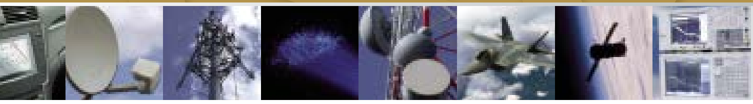
■ Remtec announced that **Walt Dollman** has joined the company's management team as vice president of sales and marketing. Dollman has nearly 30 years of previous experience in senior sales, marketing and management positions in the ceramics and electronics industry. Serving as a senior manager, Dollman's most recent position was with CeramTec North America Corp.

■ Tundra Semiconductor Corp. announced that **Robert Fischer** has been promoted to the position of vice president of sales. In this new role, he will lead Tundra's global sales effort across all markets. Fischer will be responsible for defining and implementing strategic and tactical sales plans to accelerate growth and increase the company's market share while exceeding customers' expectations. Fischer previously held the position of North American sales director at Tundra, having joined the company in July 2006.


▲ Glenn A. Johnson

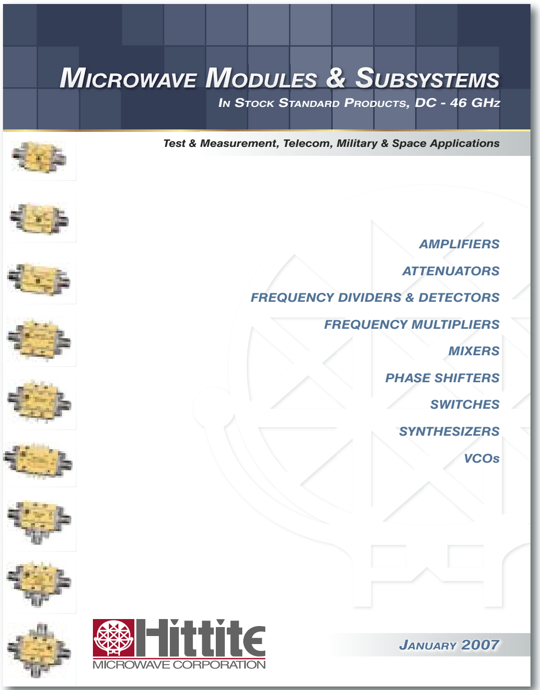
■ M2 Global Technology Ltd. announced that **Glenn A. Johnson** has joined the company as director of operations. Johnson is a senior management professional with over 20 years of diverse experience in industrial engineering, manufacturing operations, plant management, and marketing and sales.

2007 MODULE CATALOG



Analog & Mixed-Signal ICs, Modules & Subsystems

INTRODUCING OUR NEW MODULE CATALOG FOR 2007!



Request Your Catalog Now!

Hittite Microwave Corporation is proud to announce the release of our first Microwave Modules & Subsystems Catalog, featuring full specifications on 42 microwave components and synthesizers ideal for Test & Measurement, Telecom, Military and Space applications.

- ***Test & Measurement Accessory Components***
- ***Military & Space Upscreening***
- ***Ruggedized Construction***
- ***Integrated CMOS Control & DC Power Regulation***
- ***Over-Voltage and Reverse Polarity Protection***
- ***RoHS-5 Compliant***

2007 Designer's Guide 2 Volume Catalog Set Released!

Hittite offers a broad product portfolio of over 482 standard products including those featured in the Microwave Modules & Subsystems catalog. Our web site features full specifications for all of our IC, SMT and Module Amplifiers, Attenuators, Data Converters, Frequency Dividers/Detectors, Frequency Multipliers, Mixers, Modulators/Demodulators, Phase Shifters, Power Detectors, Switches, Synthesizers and VCOs/PLOs.

These components are well-suited to a wide variety of Automotive, Broadband, Cellular, Microwave/Millimeterwave, Test & Measurement, Fiber Optic, Military and Space market applications.

To request your 2007 Microwave Modules & Subsystems catalog and our new 2007 Designer's Guide catalog set, please visit www.hittite.com and select the "Submit Inquiry" button. Quantities are limited - order today!

High Performance Analog & Mixed-Signal ICs, Modules & Subsystems

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	asia@hittite.com
HMC Co., Ltd. Shanghai	Ph +86-21 6237-6717	china@hittite.com

Order On-Line
www.hittite.com

ISO/TS 16949 TÜV SÜD ISO 9001

He is proficient at restructuring companies and developing and imple-menting business, manufacturing, and marketing strategies that achieve rapid turnarounds and dramatic improvements in productivity and profits.

▲ *Carsten Barth*

■ Elcoteq SE has appointed **Carsten Barth** as director, corporate strategy and global marketing. He brings marketing experience in the automotive, plastics and financial services industries to direct the company's focus on total customer orientation from design through a product's lifecycle. Prior to joining Elcoteq, Barth spent eight years in marketing leadership positions with General Electric in Germany as well as technology companies in the Netherlands, Austria and Switzerland.

■ Nextreme Thermal Solutions has recently named **Phil Deane** as senior technology fellow. Deane, formerly the director of packaging for the Advanced Optoelectronic Components Group at JDS Uniphase, joins Nextreme to address thermal management and thermoelectric packaging issues. Deane will define product and packaging strategies for insertion of Nextreme thermoelectric coolers into customer's products.

REP APPOINTMENTS

■ **Richardson Electronics** announced a North American distribution partnership with **Avago Technologies**, San Jose, CA, to distribute its complete line of RFIC, transistor, Schottky and PIN diode, and millimeter-wave (mmW) products. Avago's extensive line of RF semiconductors provides solutions for numerous markets including cellular base station, WLAN, WiMAX, GPS, ISM, RFID and mmW including radio links, VSAT and military.

■ **Digi-Key Corp.** and **Cree Inc.** announced the signing of a global distribution agreement for Cree's silicon carbide-based power devices. Digi-Key is currently stocking Cree's Schottky diodes with voltage ratings ranging from 300 to 1200 V and current ratings from 1A to 20A. These products are featured in both Digi-Key's print and on-line catalogs and are available for purchase directly from Digi-Key. This new distribution agreement will enable Digi-Key to fulfill both the design and production quantity needs of its diverse customer base.

■ Triton Electron Technology Division (ETD) of **Triton Services Inc.** has made several new rep appointments. **CDB Enterprises Inc.** will be responsible for the territory of metropolitan New York and northern New Jersey. **Matrix Sales Inc.** will handle the territory of Maine, New Hampshire, Vermont, Rhode Island, Massachusetts and eastern Connecticut. **Northern Technical Sales Inc.** will cover the territory of northern New York state and **Anglia Microwaves Ltd.** will be responsible for the territory of the UK.

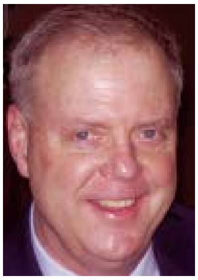
THE LXI STANDARD: PAST, PRESENT AND FUTURE

The idea for an LXI standard was first formulated in 2004. Since then, what progress has been made? What is the role of the LXI Consortium? How does LXI fit with competing standards? Are LXI-compliant products being widely produced and adopted? And what does the future hold? This Special Report attempts to offer some answers.

Test and measurement (T&M) is one of the most dynamic sectors of our industry as rapidly developing technologies require complementary, parallel T&M development to support and augment their implementation. Technological advances are moving apace, particularly in the communications sector as manufacturers of handsets, wireless systems, etc. develop products to satisfy the seemingly insatiable demand for the latest innovations. Test and measurement manufacturers have a significant role to play in developing the associated standards, test procedures and protocols for prototyping right through to full production of the end product.

To provide insight into just what this role entails this Special Report focuses on the development of the LXI standard and resultant initiatives and products. First, key figures from the LXI Consortium provide background information, starting from the identification of the need for a new standard, then chart its development and proffer future goals and objectives. Second, to give a 'coal-face' perspective, representatives from individual companies involved in the development of the standard and compliant products answer questions on their involvement in the development of the LXI standard, its adoption, the availability of compliant products, international reach and future developments.

DEVELOPMENT OF THE LXI STANDARD



Bob Helsel, ***president of Bode Enterprises and executive director of the LXI Consortium, and*** **Fred Bode,** ***retired president of Bode Enterprises***

The LXI standard is the result of several change vectors prevalent at the beginning of this millennium. The Ethernet had become more ubiquitous and a number of test and measurement companies began experimenting with this interface. No one, though, had solidified this into a vision or a set of products that challenged the current dominant interconnect for instruments—GPIB—although it was clear that a successor for GPIB was desired for many applications.

Many interfaces had been proposed and introduced on instruments. Firewire, or IEEE-1394, and USB were leading contenders at

RICHARD MUMFORD
Microwave Journal ***European Editor***


WE'RE MORE THAN
HIGH POWER!
BM27258-30
20-2500MHz
30 Watt Power Amplifier Module
Size: 6.4" x 2.5" x 1.5"
BM27258-50
20-2500MHz
50 Watt Power Amplifier Module
Size: 6.4" x 6.7" x 1.4"
PROVEN
MULTI-OCTAVE
CAPABILITY
BM88258-20
800-2500MHz
20 Watt Power Amplifier Module
Size: 6.4" x 2.5" x 1.0"
BM2719-80
20-1000MHz
80 Watt Power Amplifier Module
Size: 6.4" x 2.5" x 1.5"
WHEN LITTLE THINGS LIKE SIZE,
WEIGHT, POWER, AND COST MATTER...
COMTECH PST
ISO 9001:2000 Certified
Comtech PST Corp. 105 Baylis Road Melville, NY 11747
Tel: (631)777-8900 Fax: (631)777-8877 E-mail: info@comtechpst.com www.comtechpst.com

one time, and a few products were introduced with these interfaces. However, it was generally recognized that Ethernet was the obvious choice, but there was no agent for change.

That was until 2004 when Agilent Technologies and VXI Technology banded together and proposed forming an open consortium for standardizing Local Area Network (LAN)-based instrumentation systems. After publicly announcing the initiative at AUTOTESTCON 2004 in September of that year the first meeting was held in Salt Lake City, UT, in November 2004. Over 50 people encompassing vendors, systems integrators and end users attended the open meeting where a very rough draft of the initial specification was circulated, scrutinised and discussed. Some excellent work had been done in formulating the outlines of the specification and defining particular parameters, but it was clear that there was still a lot of work to be done to complete the specification.

However, from this first meeting, a few things were very clear. First, there was tremendous interest and enthusiasm in this new proposed technology from the test and measurement industry. Second, many companies in attendance had thought about connecting their instruments to computers via a LAN interface and many had done some preliminary investigations into how to develop such an interface. Third, there was virtually unanimous agreement that an industry standard for LAN interfacing of instrumentation was needed and viable.

From this positive standpoint, what followed was an extremely rapid formation and development of the LXI standard from draft to first release, very strong growth in the membership of the LXI Consortium and the rapid introduction of new products that were conformant to the standard. To put the pace and extent of these developments into perspective consider the initial accomplishments.

Within the first two months the LXI Consortium had been joined by five additional Sponsor members, bringing the number of Directors to seven. They had elected officers, hired a management firm (Bode Enterprises), set up a Technical Committee, formed six Technical Subcommittees to work on various aspects of the specification, hired a firm to develop the *LXIstandard.org* web site and began holding weekly technical subcommittee meetings.

Within 18 months of the concept being first introduced the membership had grown to over 40. The first release of the LXI standard was at AUTOTESTCON 2005, less than nine months after the first meeting of the LXI Technical Committees in January of 2005. At AUTOTESTCON 2006 over 150 products had been introduced by a large array of instrument vendor member companies, which had been invented, tested for compliance and offered for sale.

This momentum has continued and to explain some of the intricacies of the LXI standard's progress, its place within the larger LAN/instrumentation picture and future development, consider some pertinent questions.

First, "Isn't LAN already a standard?" Of course, LAN is a well-established standard, and the Consortium follows it completely. This is especially important since the design and protocol (TCP/IP) is very widespread and universally recognized. In addition, LAN data transfer speed is flexible and has been designed in such a way as to grow with technology. While initial LXI implementations are required to work with 10 MHz systems, most implementations are being designed to work with 100 MHz systems, which are currently being deployed. 1 GHz systems are available now, and the LAN and LXI standards will be able to seamlessly adopt the new faster implementations as they develop.

The answer to the question, "What else needs to be added for instrumentation systems?" is quite a bit, actually. Particularly significant are the 'extensions for instrumentation' that LXI has standardized. The first to look at is *Discovery*, which is when a new printer (or other standard peripheral, such as a scanner or hard drive) is connected to a PC, it notifies the user of the new device, identifies the type and suggests the right driver. The user may still have to locate the correct driver, download and install it, but MS Windows makes this fairly straightforward. However, there are millions of these similar devices and Microsoft is very interested in making this interconnect easy for its millions of consumers. The test and measurement industry is much smaller and has hundreds of instrument categories, in each of which the number of installations is probably only in the thousands. This makes each instrument category three or four orders of magnitude less important to Microsoft (or any other OS developer).

No matter how much we would like connecting a new instrument to a PC to be as easy as hooking up a new printer, Microsoft is not going to do this for us. Therefore, we need agreement on some software that will help in this process. The industry already has such a standard, called VXI-11, which was developed by the VXIbus Consortium, but works for other interconnects too. It is a little cumbersome but it is well proven and currently available. The computer industry is working on additional standards in this area, and the LXI Consortium plans to follow this development and may adopt a more elegant way of discovery in the future, but for now, it has adopted the VXI-11 method and made it a requirement for LXI-compliant devices.

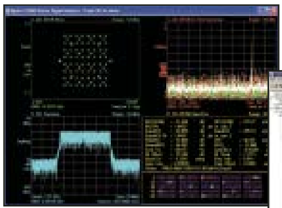
With regards to the *Web Interface* extension, the natural way for any computer controlled device to be controlled when it is initially connected is through a computer screen interface, in this instance, a web interface. There are thousands of ways to design a web interface, but upon studying the problem, the LXI design engineers all agreed on a specific set of functions.

For instance, the LXI Web Welcome Page requires the following information: Instrument Model, Manufacturer, Serial Number, Short Description, LXI Class (A, B or C), LXI specification version (initially Rev. 1.0), Host Name, MAC address, TCP/IP address, Firmware of software revision and IEEE-1588 current time (optional for Class C devices). LAN Configuration Web Pages and SYNC Configuration Web Pages have similar lists of required information. Standardization of this information goes a long way to ensuring that the system integrator will have the information needed to quickly implement a system and this will help ensure rapid implementation of LXI systems.

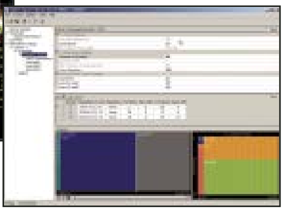
For *Software Control of the Instruments – IVI Drivers* the industry has been working for many years to standardize software solutions to help test engineers control their instru-

You take WiMAX forward

Agilent clears the way



89601A 802.16 WiMAX modulation analysis software



Signal Studio for 802.16 WiMAX

New Agilent MXA and MXG for 802.16 WiMAX

u.s. 1-800-829-4444

canada 1-877-894-4414

www.agilent.com/find/wimaxad

Move forward to what's possible in WiMAX. Agilent cleared the way for fixed and mobile WiMAX and WiBro with the industry's first design tools. Tools like our Advanced Design System, the ESG signal generator with Signal Studio software, and VSA modulation analysis software have made WiMAX possible. Now, our latest products, like the Agilent MXG signal generators and MXA signal analyzers, can help you anticipate potential roadblocks and get you through them fast and efficiently. Stay ahead, find the edge, move it forward.

To see how Agilent's WiMAX test solutions let you bring your products to market faster, go to www.agilent.com/find/wimaxad. It's WiMAX testing at the edge of possibility.

Agilent Technologies

ments. This started with the Standard Commands for Programmable Instruments (SCPI), which was first introduced in 1990. That effort gave way to VXIplug&play drivers, introduced in 1995, which used SCPI commands as their default command set. As the demand for an even more robust standard became evident and the requirement for interchangeable instruments and drivers rose in importance, the Interchangeable Instruments Foundation (IVI) was formed by the same manufacturers who had worked on SCPI and VXIplug&play standards. Both of these former organizations were absorbed by the IVI Foundation and the resulting IVI Driver standards are well recognized as 'the' software driver standards supplied by the leading test instrument vendors. LXI requires that an IVI compliant driver be supplied with every LXI instrument.

With regards to *Hardware Triggering* any LXI device can supply trigger signals or receive triggers in a wide variety of ways. Most current programmable GPIB instruments can receive or provide triggers via external BNC connectors, or via software over GPIB. This is also perfectly acceptable for any LXI device, if it provides acceptable trigger precision. However, triggering precision has undergone considerable advances since GPIB was invented some 35 years ago.

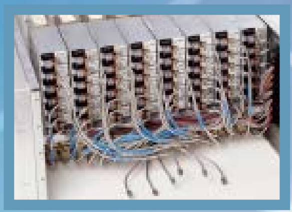
Therefore, both VXI and PXI, with their controlled impedance backplanes and known distance between modules, have been able to offer the industry much tighter triggering. Considerable effort has been invested in working with commercial manufacturers of connectors, cabling and internal circuits to develop unique hardware trigger systems that could match or exceed anything available, without the constraints of a fixed backplane and this is available on Class A LXI instruments.

Finally, there is *Software Triggering, Time Stamping and IEEE-1588 Capability – The Precision Time Protocol*. Perhaps the most exciting and interesting new capability introduced to the industry by LXI is the adoption of the IEEE-1588 Precision Time Protocol. This new standard has already been adopted by other industries, but is just now being introduced into the test industry. Briefly described, it allows all instruments on the same network to automatically look for the most accurate clock available to them on their internet subnet, synchronize to it and then provide either time of daytime stamps or synchronization signals to all instruments with exceptional accuracy. It also provides peer-to-peer communications between instruments (relieving traffic congestion and loading of the control computer). We are still learning about this capability as new implementations appear and, as time goes by, this may be the most important aspect of LXI.

Another pertinent question is: "By adding additional requirements, do you break LAN compatibility?" The answer is a resounding no. All LAN requirements are intact, and we expect to be able to follow the developments of the LAN development with complete transparency.

Test, Simulation, RF Distribution Subsystems...
Smart Solutions at Work!

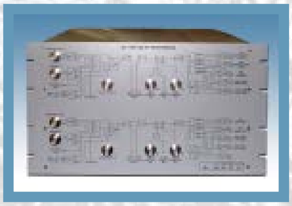
AEROFLEX WEINSCHEL



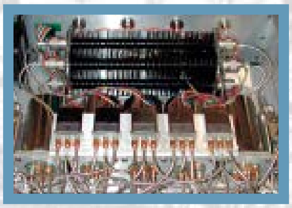
Attenuation Matrices & Multi-Channel Subsystems

RF Distribution Networks

Switch Matrices



RF/Microwave Frequency Translators



Cellular & Wireless Subsystems with Low IM Performance

Mobile Unit (Radio & WLAN) Fading Simulators

Cable Modem Redundant Switches & Test Systems

Aeroflex / Weinschel offers smart solutions to challenging test, simulation and RF distribution requirements by offering subsystem products that are either off-the-shelf or designed to customer specifications. Our subsystems feature:

- Standard communication interfaces (IEEE-488, RS-232, Ethernet) with proprietary SmartStep® Technology;
- Flexible, high-density mechanical layout & packaging;
- 50 & 75 Ω configurations.

Our subsystems are employed in telecommunications, radar and CNI, satellite and ground communication systems, base station and mobile unit software conformance verification, signal analysis, cable modem and VoIP testing, production test systems and precision microwave related test instruments.

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

www.aeroflex.com

AEROFLEX
A passion for performance.

Also frequently asked is, "Do I have to wait for enough LXI instruments to make a complete system, or can I mix VXI, PXI or GPIB instruments in the same system with LXI instruments?" Again, the answer is easy. LXI instruments are expected to be used in test systems with legacy instrumentation that already exists. This includes GPIB instruments, clusters of LXI and/or PXI instruments, and perhaps other interfaces. It is extremely important that LXI instruments integrate easily with other interface technologies, and the LXI Consortium is working on specifying bridges and enhancing our own specifications to make this transition easy and transparent. While testing is still ongoing, we have not yet found a combination that could not be accomplished, usually in a very straightforward manner.

Perhaps the most important question though remains, "Is LXI a viable replacement for GPIB, and if so, will it be successful?" There is no doubt that the jury is still out, but some pretty strong indicators are already visible. First, there is the impressive list of enhancements to LAN listed above. Then there are the advantages that LAN brings to instrument connectivity when compared to GPIB even without any of the LXI enhancements. These include low cost cabling and no requirement for a GPIB interface card, no distance restriction, whereas GPIB is limited to 20 m, no restriction on the number of instruments, while GPIB is limited to 14 instruments per interface, and the LAN speed is faster for large data transfers and will get faster still as internet technology progresses.

Also, the cost to implement basic LXI requirements (Class C) for instrument manufacturers is low, as LAN technology is mass produced and very inexpensive. This may eventually drive down the cost of instruments, although for some time vendors are expected to provide LAN interfaces in addition to GPIB and other current interfaces.

What cannot be ignored is the overwhelming acceptance of the concept by the test and measurement vendor community, as evidenced by the growth of the LXI Consortium membership, the intense activity for specification development and immediate product introductions.

That said, it is also true that the T&M user community is very conservative and adopts new technology slowly. Most test engineers subscribe to the old adage, "If it ain't broke, don't fix it," as do we. The intriguing point of the argument then, is that GPIB is not broken. It works just fine. Sure, it may be a little slow for some applications, but it works for most. It may be a little more expensive, and the thick cable is a pain, but users are used to it, and it is not that burdensome.

SUMMARY

After tracing the developments and presenting the evidence what can we conclude? Undoubtedly, users will vote with their money, but the momentum behind LXI is fairly overwhelming. Some unforeseen glitches could still be encountered, but we are beginning to get some significant experience with implementation, both


CAP Wireless has exceptional thinkers. Tap into this knowledge well and see how effectively we implement innovative ideas.
Human intelligence combined with sophisticated computer modeling and cutting-edge design results in industry leading performance, and provides our customer with the technical edge. Advanced implementation techniques leveraging industry standard process coupled with extensive technical expertise enables CAP Wireless to meet your technical requirements, at your demand rate. CAP Wireless delivers.
Creative Amplification Products
Visit http://mwj.hotims.com/11714-27 or use RS# 27 at www.mwjournal.com/info
CAP Wireless
www.capwireless.co
805.499.1818

in developing compatible instruments and by initial systems integrators developing systems.

So is GPIB dead? Not by a long shot. GPIB instruments will be around for a very long time… probably another 35 years or so. However, as more LXI instruments are introduced, and as more systems are implemented using LXI, we believe the inherent advantages of LAN and the enhancements offered by the LXI extensions will become increasingly apparent. As more IEEE-1588 implementations appear, these will foster new applications not possible by GPIB instruments, which will open still more applications.

And if more powerful tools for systems integration through the use of the internet are provided, then LXI will, over time, become the de facto instrument standard that GPIB has been for the last 35 years. Of course, this will not happen overnight. It may take five or possibly 10 years, but it will happen and hopefully the preceding explanations have proffered the reasons why.

A COMMERCIAL VIEWPOINT

That is the history, background, development and prospects for the LXI standard, but what are the practicalities of promoting, developing and selling LXI compliant products. To get another perspective, this time from the manufacturer's point of view, *Microwave Journal* asked representatives from leading T&M manufacturers, who are also key players in the LXI Consortium, questions designed to give a commercial insight into the development of the LXI standard.

COMPANY SURVEYS

Aeroflex Inc.

David Poole, *technical fellow, Aeroflex; chairman, Hybrid Systems, Physical Specifications and Resource Management Working Groups, LXI Consortium*

MWJ: *Briefly explain Aeroflex's role to date in the development of the LXI standard.*

DP: Aeroflex has been very active in supporting the development of the LXI standard. We are a Participating Member of the Consortium and, as such, work very closely with the other members, while also advising the Board of Directors on various matters. At the initial meeting of the Consortium we volunteered to chair two working groups—the Programmatic Interface WG (which we led for 18 months) and the Physical Specifications WG, which defines the mechanical, thermal and electrical standards for LXI devices. Since then we have also chaired two of the new working groups that were formed to solve specific applications: Hybrid Systems was tasked with establishing interfaces to non-LXI instruments; and Resource Management with developing specifications for the control of LXI devices assembled into an integrated system in a multi-threaded environment for use by more than

one client. We also continue to participate and advise at various levels in the LXI Consortium, including on the other working groups and the Technical Committee.

MWJ: *What do you see as the next key stage of development of the LXI standard?*

DP: The IEEE-1588 version 2.0 standard (due out near the end of 2007) will bring improvements in terms of reduced uncertainty in system wide timing with possible applications to any large scale test system. It will have the capability to synchronize all test and data tag times of LXI Class A and B devices to around 10 nanoseconds (from the 50 nanoseconds of V 1.0) using only the LXI Ethernet bus. The Consortium is also pursuing the development of conformance tests that will allow manufacturers to certify their own instruments, which will definitely help the manufacturing base. However, it seems clear that LXI will have to go through the adoption phase by both commercial and military users before any more major developments can occur. The Consortium will be actively focusing on this aspect over the next year.

MWJ: *As they are developed are LXI products being readily accepted and adopted?*

DP: LXI is still in its infancy and it is difficult to gauge the impact on the overall market. There were over 170 LXI products registered with the Consortium at the end of 2006, and it is clear that these manufacturers believe it has a bright future. The LXI specification is also starting to emerge in some procurements. Overall, it seems a natural step for instrument customers to use the ubiquitous LAN bus to connect various devices into a system. Consequently, we assume that LXI devices will generally be accepted by some segments of the test market.

MWJ: *Generally, do potential customers need to be educated as to the benefits of LXI products and if so how can this be best achieved?*

DP: There is no easy answer to this question since the knowledge of LXI and the inherent advantages vary widely across the customer base. There is still a strong market and a well-established customer base for PXI and VXI products. Consequently, LXI will have to compete with these other standards and start establishing a footprint of its own. Doubtlessly there are real advantages to all these standards and form factors in different applications. At this point in time all indications point toward coexistence of the various standards as well as possible integration of VXI, PXI and LXI-based devices and system components.

MWJ: *The vast majority of the member companies of the LXI Consortium are North American. Is this a true reflection of the global commitment to LXI?*

DP: At present there are many North American members. However, there are also T&M OEMs such as Agilent, Rhode & Schwarz and Aeroflex that are very active with an established global presence. Now that the initial specifications have been defined the Consortium is also focusing on Europe and Asia since there is a significant interest in LXI in these geographical areas.

Agilent Technologies Inc.

Bob Rennard, ***program manager, Agilent; LXI Consortium president***

MWJ: *Briefly explain Agilent's role to date in the development of the LXI standard.*

BR: Agilent, along with VXI Technology, founded the LXI Consortium in 2004 following some conversations where we realized we were pursuing very similar paths. We also noted others were pursuing LAN-based instruments as well and we reasoned it made more sense to collaborate as an industry standard than to develop independent implementations. Our goal was simply to recommend a common LAN implementation to ensure instruments behave in a consistent manner, simplifying life for system designers and integrators. LXI is really a bunch of test and measurement companies who recognize that LAN is an ideal interface for test systems and agree on a common implementation.

Recognizing the power and potential of Ethernet as an instrument interface, VXIT and Agilent approached other companies in the industry to solicit interest and participation. The response was overwhelming. Most vendors were already developing products with LAN ports on them and we all realized a common implementation would improve multi-vendor interoperability and simplify integration tasks. The two founder companies developed the initial draft document describing LXI and presented it to potential members at the first meeting in Salt Lake City. During that meeting, we proposed a governance structure and set up technical working groups to develop the specification.

Addressing your question directly, Agilent contributed many engineers to help create and test the specification and we license our IEEE-1588 IP to member companies. We also contributed leadership, chairing the Consortium since its inception. Further, Agilent contributes leadership and engineering to IVI, IEEE-1588, DoD SIWG and DoD ATML, organizations that draw upon or contribute technology to LXI.

MWJ: *What do you see as the next key stage of development of the LXI standard?*

BR: As a new standard, LXI's top priority and challenge is to build awareness and preference to spur LXI system demand. We want to show LXI is real, there are real products available and users are building real systems with it. In its first year, over 300 LXI products were launched by test vendors across all product classes. There were 171 by the end of 2006, which ballooned to 313 in January 2007, just 13 months after the first one was certified.

In addition to terrific acceptance by the vendor community, we have seen some very impressive system performance improvements by some leading system integrators. Our biggest challenge now is to spread the word and show how it is done through tutorials, application examples and LXI User Groups.

IEEE Radio & Wireless Symposium

22 - 24 January, 2008, Orlando, FL, USA

incorporating WAMICON

IEEE MTT-S IEEE COMMUNICATIONS SOCIETY

Electronic Submission Deadline: 13 July 2007 www.radiowireless.org

Call For Papers

General Chair
Aly E Fathy, *University of Tennessee*
fathy@ece.utk.edu

General Co-Chair
Richard Abrahams,
Harris GCSD RF/Microwave Engineering
rabrah01@harris.com

Technical Program Chair
Afshin Daryoush, *Drexel University*
daryoush@ece.drexel.edu

Technical Program Co-Chairs
Peter Hill, *Cranfield University* (Europe)
Abbas Jamalipour, *University of Sydney* (Asia/Pacific)

Publications Chair
Jeremy Muldavin, *MIT Lincoln Laboratory*

Electronic Submission Co-Chairs
Jeremy Muldavin, *MIT Lincoln Laboratory*
George Heiter, *Heiter Microwave Consulting*

Workshop/Short Course Chair
Gamal Hegazi, *Rockwell Collins*

Plenary/Focused/Special Session Co-Chairs
Arye Rosen, *Drexel University*
Mohammad Madihian,
NEC Laboratories America

Poster Sessions Co-Chairs
Jenshan Lin, *University of Florida*
Clemens Ruppel, *EPCOS AG*

Panel/Rump Session Chair
Charlie Jackson, *IEEE*

Student Paper Award Chair
Arye Rosen, *Drexel University*

Publicity Co-Chairs
Takao Inoue, The *Univ. of Texas at Austin*
Luciano Boglione, *Custom One Design*

Local Arrangements Co-Chairs
Bob Helsby, *Ansoft*
Eric Schwartz, *Agilent*
Sergio Palma Pacheco, *FreeScale*

Registration Co-Chairs
Nitin Jain, *Anokiwave*

WAMICON Liaison
Larry Dunleavy, *University of South Florida*

Exhibition Chair
Larry Dunleavy, *University of South Florida*

Symposium Planning & Management
Jennifer More, *Fly Events LLC*

Webmaster
Takao Inoue, *Univ. of Texas at Austin*

RWS Executive Committee Chair
Mohammad Madihian,
NEC Laboratories America

The 2008 IEEE Radio and Wireless Symposium (RWS 2008) incorporating IEEE Wireless and Microwave Technology Conference (WAMICON) will be held in Orlando, FL, on 22 - 24 January 2008 as part of the Radio Wireless Week technical event. In addition to oral presentations and posters, RWS 2008 includes workshops, panels, and an exhibition. Others collocating in the event are the Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems (SiRF) and the IEEE Topical Workshop on Power Amplifiers for Wireless Communications (PA Symposium).

RWS 2008 sessions will highlight applications including (but not limited to):

- 3G/4G Wireless Communication including Emergency/Location Services
- Satellite Network and Wireless LAN Systems
- Software Defined Radio/Cognitive Radio and other Emerging Technologies
- 802.16/LMDS Broadband Fixed Wireless and Last-Mile Access Techniques
- Wireless Mesh and Broadband Local/Personal Area Networks
- Wireless Sensors and Ad Hoc Networks towards Anytime Anywhere Internetworking
- Ultrawideband (UWB) Technologies
- High-Power and Efficient RF Transmitters
- Low-Power/Low Noise RF/Analog IC and System-On-Chip Solutions
- Propagation, Channel Characterization and Fading Countermeasures
- Heterogeneous Mobile Networks and Mobile Network Convergence
- Wireless Security and RFID Technologies
- Seamless Mobility and All-IP Mobile Networks
- Multicasting and Broadcasting

Sessions will cover systems and enabling technologies in the areas of:

- Wireless System Architecture, Integration, and Convergence Issues
- Digital/Analog Adaptive/Collaborative Signal Processing
- System Level Design, Modeling, and Simulation
- MIMO/Space-Time Processing, Relaying Technology, and Smart Antennas
- Signal Generation/Power Amplification, Linearization, and Active Components
- Front-end Passive and Active Sub-systems
- Cross-Layer Design
- Radio on Fiber and optical techniques for UWB communications
- Electrically Small Antennas and handset Packaging

Workshop Proposals

Proposals for workshop topics are solicited, and must be received by 28 June 2007. Details on the process and requirements can be found at www.radiowireless.org.

Paper Submission Instructions

Authors must submit a summary (not more than 4 pages including figures) electronically using the www.radiowireless.org web page by **13 July 2007**; this is a firm date and will be strictly enforced! Authors can indicate their preference for oral or poster presentation format but the Technical Program Committee reserves the right regarding final presentation format decision. Please note that the only accepted file format is pdf.

Submissions will be evaluated for originality, significance of the work, technical content, and interest to a wide audience. Authors will be notified by 1 September 2007. Final manuscripts of accepted papers (4 pages in length) must be received by **4 November 2007** to be included in the published Proceedings.

The top priorities for the LXI Consortium in 2007 include simplifying the LXI infrastructure and ease of adoption for integrators, developing and demonstrating basic and advanced features, and updating the LXI specification and developing marketing programmes to build awareness and preference for LXI as the successor to GPIB.

MWJ: *As they are developed are LXI products being readily accepted and adopted?*

BR: Absolutely. We are seeing a large number of requests for LXI instruments and many leading systems integrators clearly see the benefits of networked test systems. The beauty of LXI is it is just an interface standard. There is a simple migration path from GPIB and other interfaces—integrators can simply swap a GPIB cable for a LAN cable. Yet LXI also gives integrators new tools they can use when they want to adopt them. They get to use the same products with the same performance they are accustomed to. We are seeing LXI products available in both bench top and card implementations, allowing integrators to leverage software and specifications from development through deployment.

LXI, at its basic implementation, simply brings an additional IO to allow networked systems, significantly reducing costs and improving performance over legacy GPIB. At its best, it offers advanced new capabilities like peer-to-peer, downloadable scripts and precision timing capabilities that make high performance synthetic instruments realizable. The DoD Synthetic Instruments Working Group (SIWG) has enthusiastically endorsed LXI and chose it as the basis for military synthetic instrument implementations.

MWJ: *Generally, do potential customers need to be educated as to the benefits of LXI products and if so how can this be best achieved?*

BR: Yes and no. At its basic level, LXI is just another interface and many integrators use the LAN port much as they would the familiar GPIB port. LXI was developed to provide a very easy transition from GPIB to LXI. Integrators can use as much or as little capability as they want without penalty. Think of it as allowing integrators to use the same familiar GPIB capabilities with a new toolbox available when they want and need it.

That said, many systems designers are still unfamiliar with creating networks, particularly without the assistance of IT professionals. In most implementations, LXI will be used in a dedicated subnet, completely isolated from IT, enterprise traffic and bad guys who may lurk on the other side of the firewall. In practice, it is no more complex or vulnerable than familiar GPIB, but it is still new to many systems designers. For that reason, we are putting time and resources into tutorials, best practice guides and infrastructure recommendations to help designers accelerate the learning curve.

MWJ: *The vast majority of the member companies of the LXI Consortium are North American. Is this a true reflection of the global commitment to LXI?*

BR: We view LXI as a global standard and three of the eight LXI board members are international (Rohde & Schwarz, Pickering and EADS). Further, the Aeroflex Board member is European, so the board is essentially half international. We get strong technical participation from the European board members and companies such as B&K in Denmark. However, we are conscious of becoming US centric and we are actively reaching out to the international community. We had a meeting and Plug-fest in Germany last spring and we participated twice in Electronica/Productronica in Germany. We will do that again this year. We have several system integrators and OEM/self integrators throughout Europe actively working on LXI systems for automotive, aerospace and wireless applications.

In Asia, we participated in several Chinese system integrator meetings towards the end of last year. We are engaged with the China Test & Control, Metrology and Instrument Technology Institute, a government supported organization that represents 132 companies in China. Agilent represented the LXI Consortium by presenting at the 2006 Test & Control Bus Technology and LXI Technology Conference in Zhang Jia Jie as well as the 15th China Test & Measurement and Fault Diagnosis Technology Conference in Xi'an, China. We will have our June LXI General Meeting in China and, in addition to these organizations, we have several member companies from Japan, Taiwan and China.

Keithley Instruments

Chuck Cimino, ***marketing director, Keithley Instruments; member of the LXI Board of Directors***

MWJ: *Briefly explain Keithley Instruments' role to date in the development of the LXI standard.*

CC: Keithley was the first joining member of the consortium (after founders Agilent and VXI Tech) at the strategic (BoD) level in late 2004. Our technology lab manager was asked to chair the technical working groups that developed the various elements of the standard and continues to do so. Numerous Keithley business and technical people have and do actively participate in the on-going advancement of the standard now in its second version 1.1. We contribute to weekly teleconferences with the LXI BoD, marketing and technical committees, as well as quarterly combined general and Plug-fest conformance testing meetings.

MWJ: *What do you see as the next key stage of development of the LXI standard?*

CC: Moving forward into the development and release of version 1.2 during 2007 there is a roadmap to address the evolution of technologies such as IEEE-1588 v2, newer methods of instrument discovery and the continuous knowledge gained from the vendor and applications communities. Keithley will continue to support the continued adoption and evolution of this important standard as new products continue to emerge.

MWJ: *As they are developed are LXI products being readily accepted and adopted?*

CC: Keithley now has two LXI enabled RF products that are being embraced by our customers in large part due to the advantages of their LXI capabilities. In some cases the remote web browser interface provides useful capabilities and in others the basic Ethernet interface provides lower cost and data transfer advantages. Interoperability with other LXI instruments has also been an advantage of embracing the standard.

MWJ: *Generally, do potential customers need to be educated as to the benefits of LXI products and if so how can this be best achieved?*

CC: Globally detailed LXI awareness remains fairly low despite high levels of PR spending by the Consortium and key members such as Agilent over the past year or so and since the release of v1.0 towards the end of 2005. Keithley has developed a number of presentations on the various aspects and advantages of LXI applied to our targeted applications, and has made them available through various sources. There is still a lot to be done to drive awareness and preference for LXI in the Asia region, for example, and the Consortium and member companies are acting accordingly.

MWJ: *The vast majority of the member companies of the LXI Consortium are North American. Is this a true reflection of the global commitment to LXI?*

CC: Expanding on the comment above about Asia, the Consortium is fully aware of, and concerned about, the urgent need for more international participation. We are actively working on broadening the membership through various PR activities in China, for example. We are also looking to increase liaison leverage through existing and potential international members to increase the international content and preference for LXI.

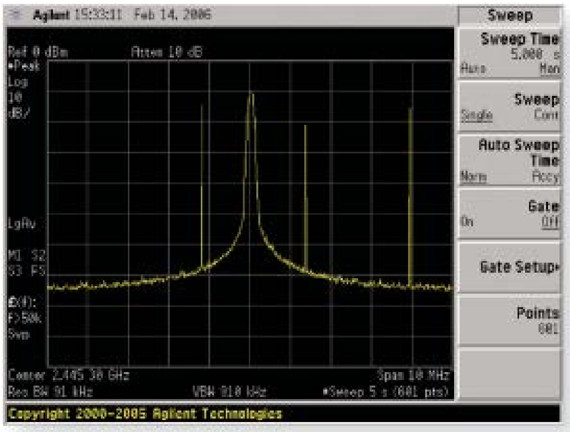
Rohde & Schwarz

Jochen Wolle, ***head of R&D software spectrum and network analyzers; member of LXI BoD, LXI Conformance WG chair***

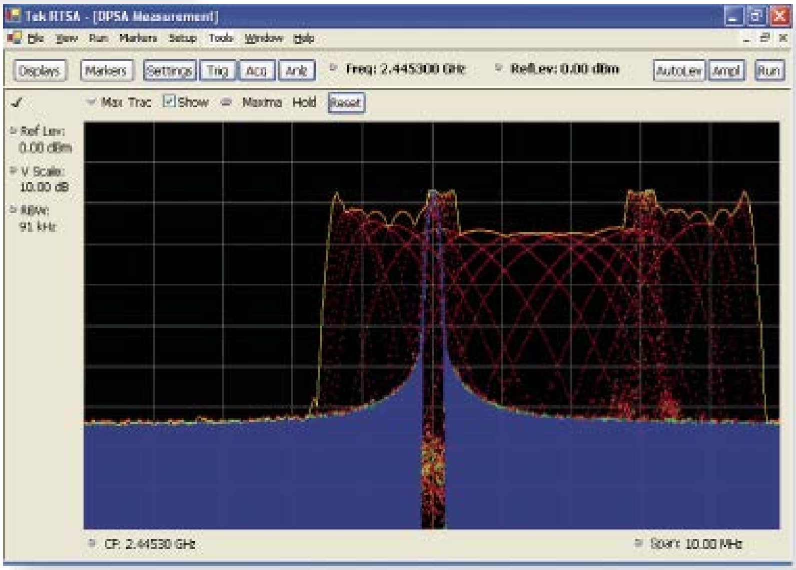
MWJ: *Briefly explain Rohde & Schwarz' role to date in the development of the LXI standard.*

JW: Rohde & Schwarz strongly supports the LXI Consortium and the move to open standards for modular instrument platforms. LAN is a ubiquitous interface in today's test and measurement world and LXI's LAN-based architecture provides the basis for flexible, modular instruments for the aerospace, defence and communications markets. Rohde & Schwarz joined the Consortium as a strategic member at an early stage in November 2004 and hosted the first LXI Plug-fest outside North America in Munich, Germany, in April 2006. The event had 69 registered attendees representing more than 25 different organizations, encompassing manufacturers, system integrators, customers, universities and the press.

We are contributing to the standard development by chairing the Conformance Working Group and leading the effort to define the conformance process as well as participating in the joint development of the Multi Vendor Systems Demo, which was shown at AUTOTESTCON 2006 and Electronica 2006. Also, Rohde & Schwarz has certified the FSL, FSP, FSU and FSQ spectrum analyzer families as well as the SMU, SMJ and SMATE signal generators as LXI compliant, making a total of more than 20 instruments.



Agilent 5 seconds



Tektronix 5 seconds

The two screens represent an Agilent E4440A PSA and a Tektronix RSA6114A running DPX™, each detecting an identical signal that changes frequency every 1.28 seconds.

It's time to get real.

Tektronix RSA6100A Series Real-Time Spectrum Analyzers. Nothing else comes close. Troubleshooting transient glitches? Use the best tool. One with greater capture bandwidth (110 MHz) than Agilent, uniquely combined with 73 dB spurious free dynamic range (SFDR) for complete analysis. And nearly 1000 times more spectrum measurements per second than existing products (48,000 spectrum measurements/sec vs. Agilent's 50). And an intuitive color display that shows a live view of your signal changing over time. You'll see RF signal characteristics that are practically invisible with any other instrument.

See for yourself.
www.tektronix.com/getreal

Tektronix®
Enabling Innovation

Visit http://mwj.hotims.com/11714-142 or use RS# 142 at www.mwjournal.com/info

MWJ: *What do you see as the next key stage of development of the LXI standard?*

JW: The LXI Consortium is currently working on the LXI Standard Release v1.2. The working groups are actively developing the specifications for resource management and for an enhanced discovery protocol based on XML schema. The upcoming new release v2.0 of the IEEE-1588 precision time protocol will also be adopted by the LXI standard and the LXI Consortium is also working on a self-certification process supported by tools for LXI Class C devices.

MWJ: *As they are developed are LXI products being readily accepted and adopted?*

JW: We are seeing a growing interest in the LXI standard from our customers. Nevertheless, customers are still in the investigation phase regarding the benefits and integration of LXI-based test systems. We expect to see more LXI instruments being used in hybrid systems, combining existing GPIB/VXI/PXI-based instruments, together with LXI devices in the near future. As more and more compliant LXI instruments become available, this adoption process will quicken.

MWJ: *Generally, do potential customers need to be educated as to the benefits of LXI products and if so how can this be best achieved?*

JW: There is still a great need to educate potential customers concerning the benefits of the LXI technology. Therefore, the LXI Marketing Committee coordinates the promotional activities with articles, application notes, web blogs, seminars and trade show participation. Rohde & Schwarz is actively involved in all of these efforts and serves as a focal point for the promotion of the LXI standard in Europe.

MWJ: *The vast majority of the member companies of the LXI Consortium are North American. Is this a true reflection of the global commitment to LXI?*

JW: The primary initiators of the LXI standardization were companies in North America. Nevertheless, there has been a growing interest for LXI in Europe and Asia, too. As an example, the June 2007 Plug-fest that will be held in Beijing, China, demonstrates the global commitment being undertaken outside of North America, in order to help promote the awareness of LXI.

CONCLUSION

The development of the LXI standard has come a long way in a relatively short period of time. Instigated by the emergence of LAN and driven by the LXI Consortium and its partners, the standard has gained considerable momentum. They have a commercial interest in making it a success and are striving towards that goal. That said, there is still some work to be done. Technologically, compatibility and interoperability issues need to be addressed, especially if the standard is to be widely accepted by a traditionally conservative T&M user community. Efforts to publicise and extend its global reach are key too. The LXI standard has progressed rapidly and has now reached a critical stage of its development. It will be interesting to see how that development advances over the next few years. ■

"I Hate Rules."

Donald "Shep" Shepherd
President
AR

"It'll never work. You can't do that. You're breaking the rules."

That's what I heard over 35 years ago when we started AR. And I'm still hearing it today. I never liked rules. To me, rules limit possibilities.

With the market changing by the millisecond, we've got to be open to all possibilities. And we've got to break some rules. Or at least rethink them.

That's why AR is making products that don't just help you now, but products that will help you get to where you want to go. It's why our engineers are peeking into the future and developing technology that will get you there… ahead of your competition… and ready to meet the demands of tomorrow.

Okay. I guess there is one rule that governs everything we do at AR: "Give the customer everything they need; and more than they expect." Anyone who breaks that rule will have to answer to me.

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

rf/microwave instrumentation • modular rf • receiver systems • ar europe

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

In Europe, call ar emv United Kingdom 441-908-282766 • ar emv France 33 -1-47-91-75-30 • emv Germany 89-614-1710 • emv Netherlands 31-172-423-000

Visit http://mwj.hotims.com/11714-20 or use RS# 20 at www.mwjournal.com/info

It's a Wrap: 2007 Radio & Wireless Symposium and Exhibition

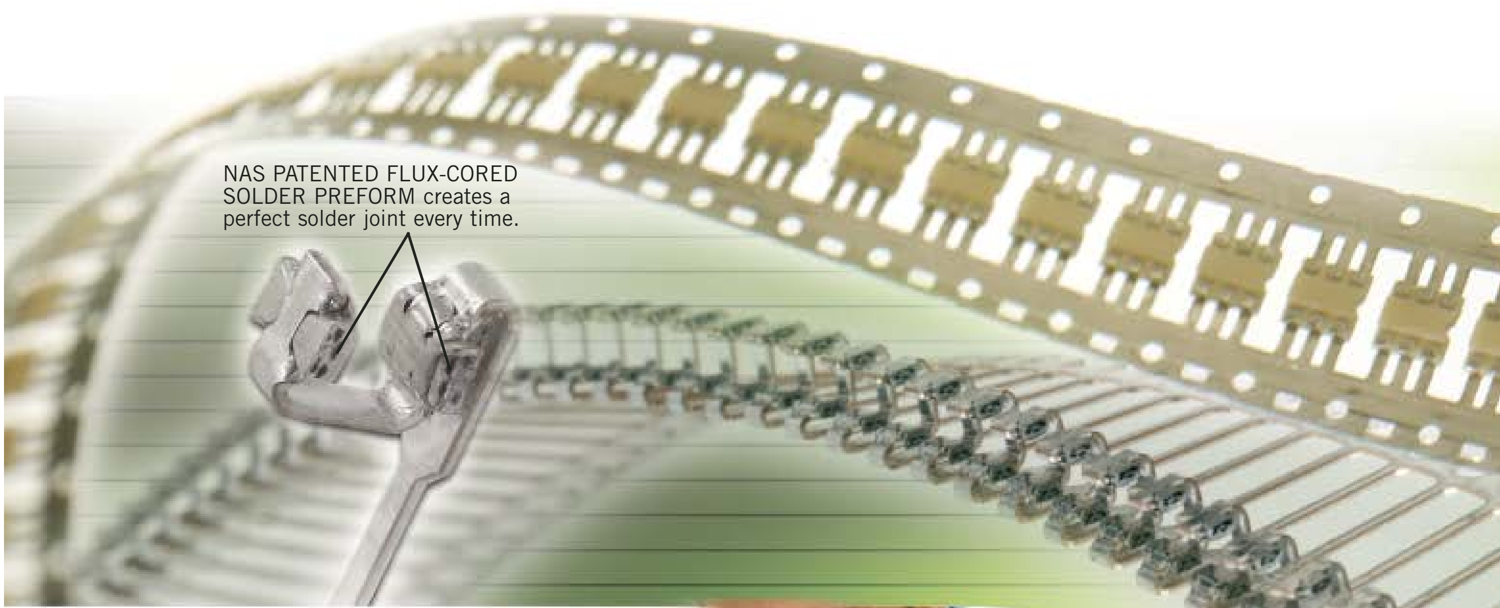
Keith Moore and Frank Bashore
Microwave Journal *staff*

The second IEEE Radio & Wireless Week was held January 7–12, 2007, in Long Beach, CA, and was comprised of the IEEE Radio and Wireless Symposium (RWS), the IEEE Topical Symposium on Power Amplifiers for Wireless Communications (PAS), the Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems (SiRF) and an accompanying Industry Exhibition. Although the local residents were complaining about the relatively cold weather, most of the 1200+ participants were enjoying the mild winter temperatures. The newly combined symposium attracted over 500 delegates from around the world and was an interesting and rewarding event for the attendees. The combined technical programs featured 214 technical presentations, six workshops and one short course, along with three poster sessions comprised of 51 individual presentations.

The Industry Exhibition this year was made up of over 60 exhibiting companies in 88 booths and attracted a modest attendance. One bright spot was the daily Wireless Walk Raffle. Frederick Raab walked away with the $1500 prize on the final day, while the many daily $500 prize winners included Nitin Jain, Kyung Heons Koo, Cory Root and Dong-yun Jung on Tuesday; Ke Wu, Song Lin, Oystein Jensen and Sherwin Wang on Wednesday; and Jack Pekarik, Dimitri Lederer, Ji Hoon Kim and Debabani Choudhury on Thursday. Congratulations to all the winners.

Exhibition Highlights

As with any Industry Exhibition, many of the exhibiting companies were showing off their newest products. A collection of some of the more notable products on display follows. Due to space limitations, we are unable to include every company.


NAS PATENTED FLUX-CORED
SOLDER PREFORM creates a
perfect solder joint every time.

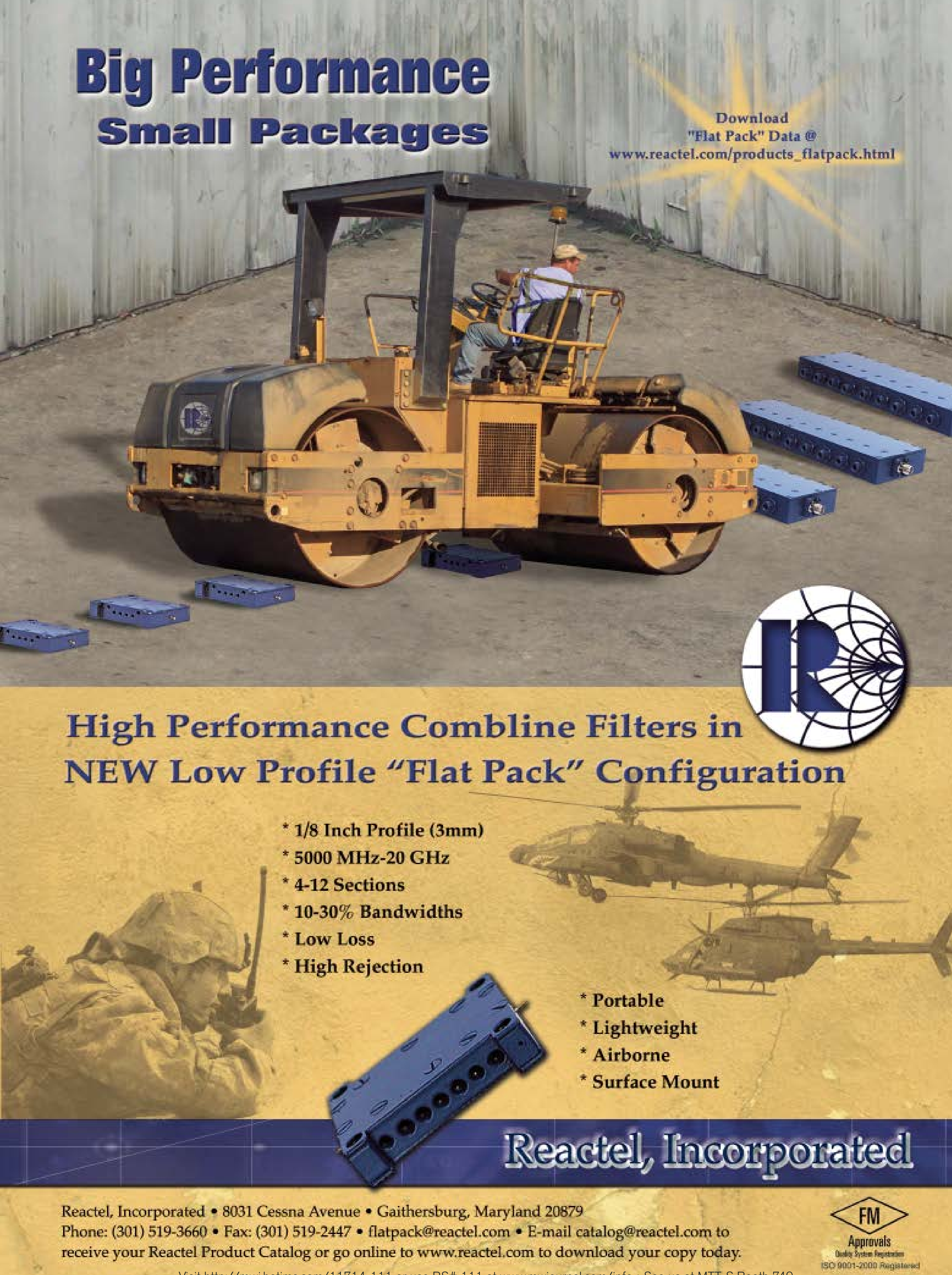
Agilent Technologies featured new test solutions for the fast growing 3GPP LTE, MIMO, fixed and mobile WiMAX, and WiMedia markets based on the popular Agilent ADS and recently introduced signal generators, analyzers and power meters. These innovative and leading products provide engineers with the test resources they need to efficiently and effectively deliver the next generation of high speed/high capacity wireless devices and networks.

Also featured in booth 637 was the new Time Division-Synchronous Code Division Multiple Access (TD-SCDMA) measurement capability for its PSA series high performance spectrum analyzers, a test and measurement solution for analysis of HSDPA/8PSK signals over TD-SCDMA.

Agilent showcased a series of first-to-market, broadband microwave test accessories specifically optimized for communications and aerospace/defense applications. Also on display was the 1xEV-DO Release A Enhancement to its 8960 Wireless Communications Test Set running 1xEV-DO networks. The 1xEV-DO Release A system is an upgrade to existing 1xEV-DO networks.

AR Worldwide RF/Microwave Instrumentation showcased two amplifier series that cover the WiMAX frequency range. Very linear amplification is available from 800 MHz to 4.2 GHz (1 to 700 W) and another series that covers 4 to 8 GHz (1 to 60 W). The company also introduced a custom amplifier module for the emerging wireless access market. The CMS1070 is a 3.4 to 3.7 GHz solid-state power amplifier module for the wireless broadband network. This 20 W, 43 dBm output linear power amplifier has a scaleable gain of 20 to 50 dB and is designed to meet the WiMAX 802.16d specifications. It can be modified to meet various types of OFDM or NPR requirements. The module comprises a printed wiring assembly housed in a machined aluminum enclosure. The amplifier is protected from thermal overload, over power, over voltage or wrong voltage polarity as well as having an internal isolator.

Computer Simulation Technology (CST) featured its CST STUDIO SUITE 2006B, including the industry-standard 3-D EM Time Domain tool, CST MICROWAVE STUDIO. In this latest release, improved and extended solver technology has been at the


Big Performance
Small Packages
Download
"Flat Pack" Data @
www.reactel.com/products_flatpack.html
High Performance Combline Filters in
NEW Low Profile "Flat Pack" Configuration
* 1/8 Inch Profile (3mm)
* 5000 MHz-20 GHz
* 4-12 Sections
* 10-30% Bandwidths
* Low Loss
* High Rejection
* Portable
* Lightweight
* Airborne
* Surface Mount
Reactel, Incorporated
Reactel, Incorporated • 8031 Cessna Avenue • Gaithersburg, Maryland 20879
Phone: (301) 519-3660 • Fax: (301) 519-2447 • flatpack@reactel.com • E-mail catalog@reactel.com to
receive your Reactel Product Catalog or go online to www.reactel.com to download your copy today.
FM
Approvals
ISO 9001-2000 Registered

ports, and the performance of mesher and solver has been increased. CST MWS 2006B's range of solvers has been enriched by the addition of an Integral Equation solver based on the Multilevel Fast Multipole Method (MLFMM).

To provide an alternative for many test scenarios in which only a high quality CW source is required, **dBm** introduced the SSG synthesized CW signal generator. The SSG is small and light and can be held in one hand, yet has enough mass to stay planted on the workbench with heavy coax cables attached to it. Giving up little or nothing in terms of performance, the SSG provides excellent phase noise, and switching speed that is much faster than YIG-based signal generators. The SSG can function within an automated test system since it can be remotely controlled via IEEE-488.2, RS-232 and 10/100BaseT Ethernet.

Focus Microwaves has developed a multi-purpose tuner (MPT) for WLAN, WiMAX and 3G/4G applications. The model iMPT-1818-TC uses three independent wideband probes allowing independent control of the amplitude and phase of the reflection factor at all three harmonic frequencies. The main application of the MPT is harmonic load pull, although it can also be used as a single-probe tuner as well as a high VSWR prematching tuner. The ultra-stable (fundamental only) mode of operation is a necessity for on-wafer vibration-free testing and is accomplished by moving the probes only vertically. MPT option "TC" (twin carriage) allows wideband operation up to one Decade. The iMPT-1818-TC covers the frequency range from 3 to 18 GHz.

Freescale Semiconductor unveiled four general-purpose broadband RF amplifiers that deliver high gain and linearity over bandwidths from DC up to 6 GHz. The amplifiers are well suited for applications ranging from WiMAX base stations to meter readers, set-top boxes, RFID readers and any application requiring a cost-effective, small-signal gain source. In addition, the company introduced its first 3.3 V UHF television radio frequency (RF) modulators based on CMOS technology. The modulators offer customers cost-effective, low power solutions designed to help shorten design-to-market cycles. They also reduce system requirements for television-related applications in-

cluding DVD/DVDR players, modules and video games, as well as analog, digital and internet protocol set-top-boxes for satellite, terrestrial or cable television. Freescale also showcased a development platform utilizing Power Architecture™ technology for the creation of WiMAX baseband applications. Incorporating high performance PowerQUICC™ communication technology, StarCore™ digital signal processors and a field programmable gate array (FPGA), the WiMAX baseband platform works together with Media Access Control (MAC) and Physical Layer (PHY) software to provide the performance and programmable processing required for production of WiMAX base station products. According to In-Stat, the number of fixed WiMAX subscribers worldwide is projected to reach 16 million by 2010, and the number of mobile WiMAX subscribers is expected to range from 15 to 25 million. Designed to support both fixed and mobile stations, the WiMAX platform provides the essential hardware functionality required for a first generation WiMAX IEEE 802.16-2005 mobile base band platform in a single Advanced Mezzanine Card (AMC) form factor.

JFW Industries introduced a new 20 to 2500 MHz high power switch. Model 50S-1505 delivers high power (25 W average; 200 W peak) and is designed for rugged military environments.

Keithley demonstrated its 2910 vector source and 2910 vector analyzer that allows engineers to create new signal formats and analyze them using general lab tools such as Matlab. The 2910 creates an RF signal by converting the time record to an IF, with 16 bits of resolution and up converting the signal to an RF frequency. Conversely, the newly created signal was captured by the 2810, down converted and digitized with 14 bits of resolution, and stored as an IQ time record in the analyzers memory. In less than a second the record was exported from the instrument and displayed as a constellation on the PC using Matlab.

M/A-COM introduced several new items including two new HBT MMIC amplifiers. The MAAM-007865-0P1R00 and the MAAM-007866-0P1R00 exhibit exceptional broadband frequency performance using only a single application circuit to cover frequency bands from 50 to 2000 MHz and 50 to 3300 MHz, respectively.

M/A-COM announced the MAAP-007649-000100, a 2 W power amplifier for the 800 to 1000 MHz frequency band. The MAAP-007649-000100 design displays optimum performance for RFID reader applications, with greater than 1 W dense reader mode (DRM) spectral mask linearity and a flat gain response.

M/A-COM also featured a new low cost RoHS compliant 2.4 GHz linear power amplifier for 802.11b/g Multiple-Input Multiple-Output

(MIMO) WLAN applications that require high gain, high efficiency and small size. The MAAP-008015 amplifier provides 20 dBm of linear output power with EVM < 3.0 percent, maximizing system performance while maintaining low DC power consumption.

MicroMetrics featured high power PIN diodes. The structures consist of a P+ layer of carrier concentration > 1020, an intrinsic layer > 3000 ohm-cm and a substrate > 0.001 ohm-cm. The intrinsic layer is varied depending upon the voltage, lifetime, switching speed and series resistance. The > 3000 ohm-cm intrinsic layer produces a larger mesa diameter for a given capacitance value enhancing the power handling capability of these devices. This creates a diode structure that is ideal when power handling is a primary concern. The ceramic passivation enables the user to put the diode chip directly onto a substrate, or the devices can be packaged in various configurations offered by the company.

Nitronex showcased a high voltage platform to support next generation wireless infrastructure applications. Leveraging the company's existing qualified NRF1 (GaN on Silicon) technology, the new platform takes advantage of thermal enhancements in wafer processing, transistor design and packaging to support 48 V operation under all waveforms and extreme flange temperatures. The initial products planned will be designed for WiMAX and 3G/3G LTE waveforms operating in frequency bands from 1.8 to 2.2 GHz and 2.3 to 2.7 GHz. Lineups with output power ranging from 5 to 200 W will be supported.

precisionWave Corp. introduced its next low cost, high performance RF vector signal generator. The new p1511A generates digitally modulated and CW signals in the 800 to 1000 MHz and 1700 to 2200 MHz cellular bands for developers of cellular technology-based products. The instrument's I/Q generator produces high accuracy signals for any digital modulation scheme used in these bands. As examples, EDGE avg. RMS EVM is typically less than 0.8 percent, and GSM phase error is below 1°. With a wide –100 to +20 dBm power output range, harmonic suppression is better than –40 dBc at +13 dBm, and spurious is below –80 dBc. The source's 1 GHz CW phase noise is less than –100 dBc/Hz at 20 kHz offset, and at 2.2 GHz is better than

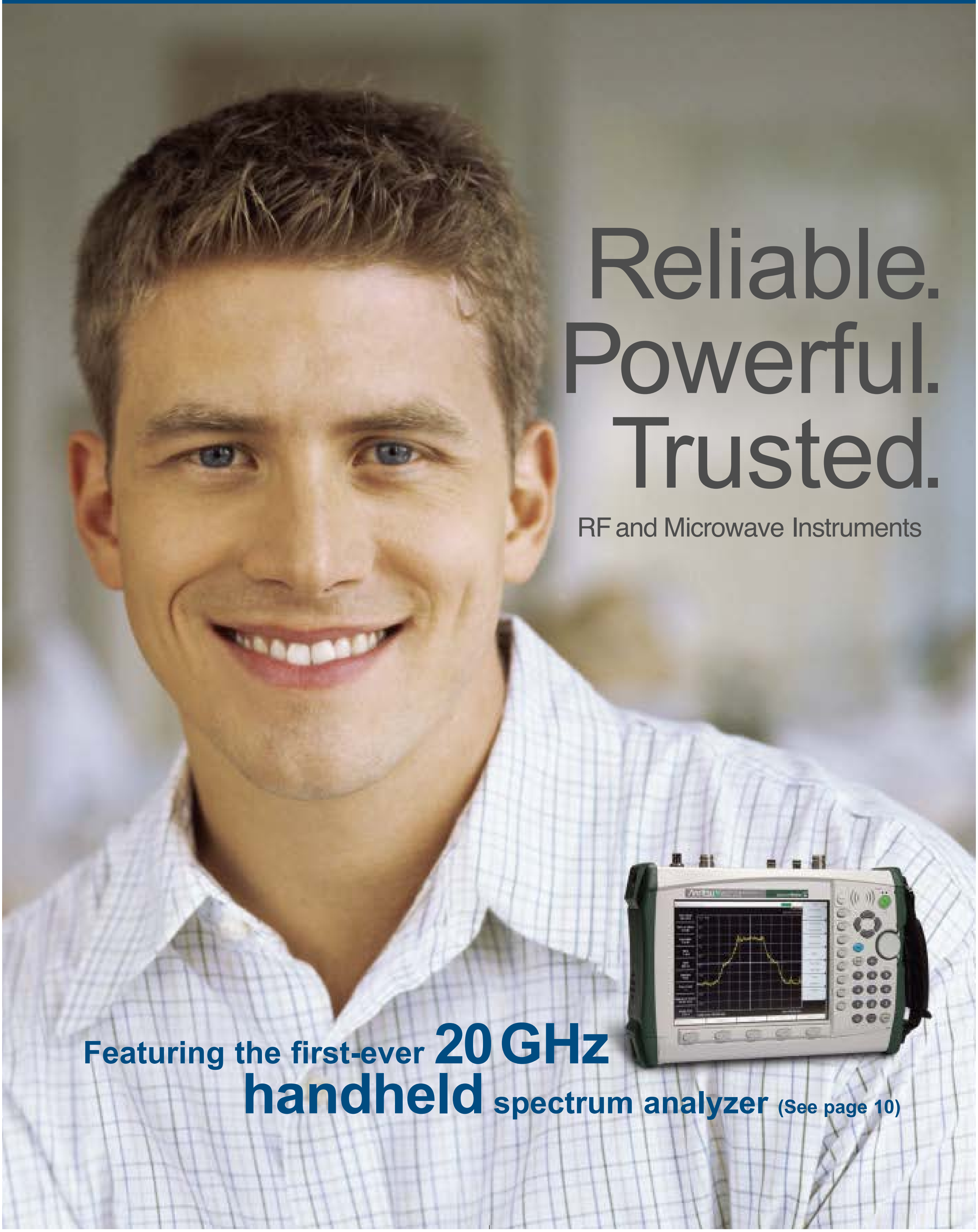
–92 dBc/Hz at 20 kHz offset. Like all precisionWave instruments, the source is CE certified, and is fully warranted for one year.

RF Micro Devices Inc. (RFMD) had a couple of announcements, the first of which was that its RF3159 linear EDGE power amplifier (PA) is supporting Samsung's SGH-D900 "Black Carbon" mobile phone, the thinnest slider phone in the world. A member of Samsung's Ultra Edition line of handsets, the SGH-D900 is a GSM/GPRS/EDGE quadband handset featuring an MP3 player with a micro SD-card expansion slot, 3.13 megapixel camera, support for a Bluetooth® stereo headset, TV-output and a vivid 2.1" 262K color screen for a full multimedia experience. Samsung's use of the RF3159 further extends RFMD's industry leadership in EDGE PAs and supports the company's continued growth in the EDGE market. The RF3159 is a high linearity quadband GSM/GPRS/EDGE PA designed to support EDGE transceivers utilizing a linear transmit architecture, including transceivers by Silicon Laboratories, Infineon Technologies and NXP Semiconductors. The RF3159 PA module is fully matched for easy implementation and is housed in a small 6 × 6 mm package, which is industry-leading for the linear EDGE PA market. The product's gain and linearity lineups enable handset manufacturers to optimize the transmit chain to meet various requirements of linearity, efficiency and output power. The module is designed to be the final amplification stage in a dual-mode GSM/GPRS/EDGE mobile transmit lineup operating in the 824 to 915 MHz and 1710 to 1910 MHz bands.

The company also introduced its newest RF switches – the RF1200 and RF1450. The RF1200 is a single-pole double-throw (SPDT) high power switch that meets all linearity requirements for WCDMA and features low insertion loss, low control voltage and very good harmonic characteristics. It is fabricated with 0.5 µm GaAs PHEMT process and is packaged in a very compact 2×2 mm, 6-pin, leadless QFN package. The RF1450 is a single-pole four-throw (SP4T) high power switch specifically designed to provide superior linearity performance for multimode WCDMA applications. The RF1450 includes integrated decoding logic, allowing just two control lines needed for switch control. It is packaged in a compact 3 × 3 × 0.6 mm, 16-pin, leadless QFN package.

Rogers had on display a replacement product for PTFE woven glass circuit material that provides superior mechanical and thermal properties, uses the RO4000® resin system for ease of fabrication and is a cost competitive option for base station antenna applications.

Rohde & Schwarz has expanded its flagship ZVA series vector network analyzers with R&S Option ZVA-K7, which enables pulse profile measurements to be made on semiconductor components and antenna/radar systems. Absolute levels,


Reliable.
Powerful.
Trusted.
RF and Microwave Instruments
Featuring the first-ever 20 GHz
handheld spectrum analyzer (See page 10)

Spectrum Analyzers

Model	Frequency	RBW	Noise Level	Key Features
MS2661C	9 kHz to 3 GHz	30 Hz	–130 dBm	■ Frequency counter ■ C/N ■ Adjacent channel power ■ Occupied-frequency bandwidth ■ Burst average power ■ Noise power ■ PASS/FAIL limit lines
MS2663C	9 kHz to 8.1 GHz	30 Hz	–130 dBm	
MS2665C	9 kHz to 21.2 GHz	30 Hz	–130 dBm	■ Compact, lightweight (13 kg standard) ■ High C/N and superior distortion characteristics ■ Easy-to-use operation ■ Options support wide range of applications ■ MS2665C supports easy set up auto measurements ■ MS2667/68C supports millimeter applications
MS2667C	9 kHz to 30 GHz	10 Hz	–135 dBm	
MS2668C	9 kHz to 40 GHz	10 Hz	–135 dBm	
MS2681A	9 kHz to 3 GHz	1 Hz to 20 MHz	Down to –148.3 dBm (option and frequency dependent)	■ Fast data transmission speed (GPIB transmission speed:120 kbytes/second) ■ Optional measurement software for high-speed modulation analysis (1.5 seconds with WCDMA, 0.5 seconds with IEEE 802.11a) ■ Optional narrow resolution bandwidth from 1 Hz
MS2683A	9 kHz to 7.8 GHz	1 Hz to 20 MHz	Down to –146.5 dBm (option and frequency dependent)	
MS2687B	9 kHz to 30 GHz	1 Hz to 20 MHz	Down to –146.5 dBm (option and frequency dependent)	■ Optional measurement software for high-speed modulation analysis (0.5 seconds with IEEE 802.11a) ■ Optional power meter that measures up to 32 GHz ■ Fast data transmission speed (GPIB transmission speed:120 kbytes/second)
MS2717A Economy	100 kHz to 7.1 GHz	10 Hz to 3 MHz	–153 dBm typical to 1 GHz	■ Typical dynamic range of 100 dB ■ Typical phase noise of –110 dBc/Hz at 10 kHz offsets up to 6 GHz ■ WCDMA/HSDPA RF measurements ■ Demodulate WCDMA signals and display code domain power, error vector magnitude, codogram and modulation summary
MS2781B Signature™ High-Performance Signal Analyzer	100 Hz to 8 GHz	0.1 Hz to 8 MHz	–167 dBm	■ Excellent measurement performance ■ Fully functional and upgradable built-in PC with a Windows® XP GUI™ ■ Compatibility with simulation tools, such as MATLAB® and Simulink®
MS8608A Digital Mobile Radio Transmitter Tester	9 kHz to 7.8 GHz	1 Hz to 20 MHz	Down to –146.5 dBm (option and frequency dependent)	■ Excellent performance for evaluating WCDMA modulation signals ■ Supports GSM/EDGE, HSDPA, WLAN/802.11, CDMA, 1xEVDO, and Pi/4DQPSK (PHS, PDC, IS–136) measurements ■ Resolution bandwidth of up to 20 MHz via built-in spectrum analyzer ■ Power can be measured with an accuracy of ±0.4 dB using the power sensor
MS8609A Digital Mobile Radio Transmitter Tester	9 kHz to 13.2 GHz			

▶ Take a closer look at Anritsu Spectrum Analyzers at www.anritsu.us/family

Take advantage of a **large selection of options** to handle a wider range of applications at a reasonable cost.

MS2717A with stand

Spectrum Analyzers

Superior performance. Advanced capabilities. Affordable pricing. The Anritsu family of spectrum analyzers delivers high frequency/level accuracies and a broad set of smart, intuitive features—including models with built-in one-button measurements.

MS2661C

MS2668C

Vector Network Analyzers

Vector Network Analyzer	Frequency	Key Features	Target Applications
37000D Series Lightning Family Microwave and Millimeter Wave VNA	40 MHz to 110 GHz (expandable to 500 GHz)	■ Flexible test port configuration ■ Multiple upgrade paths ■ High stability and reliability ■ Powerful VNA utilities software ■ Multiple port solutions ■ AutoCal automated calibration	■ Microwave and millimeter wave component test ■ On-wafer ■ Waveguide S-parameter ■ Multi-port device and balanced differential ■ R&D and production environments
37200D Series Lightning for Passive Device Testing	40 MHz to 67 GHz	■ Accurate, fast measurements of passive devices ■ High power and wide dynamic range ■ Multiple source control and frequency offset for frequency conversion devices ■ Calibration utility for mixer measurements	■ E/O (modulators) and O/E (photodiodes, receivers) component measurement capability ■ Automatic de-embedded mixer ■ Embed/De-embed application ■ Materials measurements of dielectric properties
37300D Series Lightning for Active Device Testing	40 MHz to 67 GHz	■ Internal bias tees ■ Extended power range (source step attenuator and test port attenuator) ■ Gain compression application	■ Amplifier ■ Device characterization ■ On-wafer
ME7808C Lightning Broadband and MMWave VNA	40 MHz to 110 GHz Coax Up to 500 GHz in waveguide bands	■ Continuous broadband frequency coverage from 40 MHz to 110 GHz in W1 (1 mm) coaxial output ■ Supports on-wafer device characterization, broadband coaxial and waveguide measurements	■ Broadband characterization ■ Parameter extraction ■ Device modeling ■ Millimeter wave
MS462XA Series Scorpion RF Transmission/ Reflection Analyzer	10 MHz to 9 GHz	■ Fast, accurate and repeatable 1-path, 2-port S-parameter measurements	■ Passive 2-port handset components, such as filters
MS462XB Series Scorpion RF VNMS	10 MHz to 9 GHz	■ Industry's best 2- and 3-port test for active devices delivers superior accuracy	■ Handset components such as duplexers, amplifiers, and mixers
MS462XC Series Scorpion RF Direct Receiver	10 MHz to 9 GHz	■ Direct access to receivers for flexibility and versatility	■ Antennas, mixers, power amplifiers and other multi-port devices
MS462XD Series Scorpion RF 4-port VNMS Configuration	10 MHz to 9 GHz	■ Converts S-parameters into real-time differential and common-mode analysis ■ Most popular configuration for functionality, performance and value	■ Most wireless components and emerging balanced devices
MS4630B RF VNA	10 Hz to 300 MHz	■ Accurate magnitude and phase measurements ■ Filter and resonator analysis functions ■ High-speed device evaluation	■ Passive filters, resonators for both R&D and manufacturing ■ Optimized for IF measurements

▶ Take a closer look at Anritsu Vector Network Analyzers at www.anritsu.us/family

37397D

ME7808C

The **versatility to completely characterize** wireless components and systems.

Vector Network Analyzers

Anritsu VNAs encompass a wide range of high-performance, component test tools designed to address the growing needs of defense, satellite, radar, broad-band communication and optoelectronic component markets. Choose the Lightning family for troubleshooting any active or passive device measurements—from characterization and designing to manufacturing and verification. And for RF frequency applications, the Scorpion® series provides excellent transmission/reflection, balanced/differential and S-parameter measurement solutions.

37397D Lightning VNA with 65 GHz Multiport Test Set

Power Meters | Signal Analyzers

ML2496A

Power Meters (RF Microwave)

Anritsu power meters provide accurate measurements for the full range of communications, wireless and aerospace applications.

Power Meter	Frequency	VBW	Dynamic Range (dBm)	Channels
ML2437A Power Meter	100 kHz to 65 GHz Sensor dependent	100 kHz	–70 to +20 dBm Sensor dependent	1
ML2438A Power Meter		100 kHz		2
ML2487A Wideband Peak Power Meter		20 MHz		1
ML2488A Wideband Peak Power Meter		20 MHz		2
ML2495A Wideband Peak Power Meter		65 MHz		1
ML2496A Wideband Peak Power Meter		65 MHz		2
ML2530A Calibration Receiver	100 kHz to 3 GHz	100 kHz	Range dependent	1

The preferred choice of service providers, network operators and contractors worldwide.

Signal Analyzers

Technicians looking for exceptional engineering insight for advanced RF and communications products need to look no further. Anritsu Signal Analyzers offer cost-effective solutions with integrated fixed and mobile WiMax measurements, industry-best DANL and dynamic range and comprehensive WCDMA/HSDPA measurements.

MS2781B

Signal Analyzer	Frequency	RBW	Noise Level	Key Features
MS2781B Signature™	100 Hz to 8 GHz	0.1 Hz to 8 MHz	–167 dBm	■ Excellent measurement performance ■ Fully functional and upgradable built-in PC with a Windows® XP GUI ■ Compatibility with simulation tools, such as MATLAB® and Simulink®

▶ Take a closer look at Power Meters and Signal Analyzers at www.anritsu.us/family

Synthesized Signal Generators

Anritsu provides the best
synthesized signal generator solutions.

MG3696B

Synthesized Signal Generators

Whether you test in the microwave, fixed or mobile satellite communications or defense industries, Anritsu provides the best synthesized signal generator solutions. With high-signal purity, low noise and excellent frequency stability, our signal generators are a fundamental measuring instrument for your lab or manufacturing site. Choose instruments with a full range of modulation capabilities for signal simulations from simple to the most complex, including Amplitude (AM), Frequency (FM), Phase (ϕ) and Pulse (PM). Plus, you'll find a series of configurable and upgradable broadband high-performance signal generators that meet your exact specifications.

Signal Generator	Frequency Range	Key Features	Key Applications
MG3633A Synthesized Signal Generator	10 kHz to 2700 MHz	■ High-performance ■ Analog modulation ■ Super low phase noise	■ Mobile communication
MG3641A Synthesized Signal Generator	125 kHz to 1040 MHz	■ 0.01 Hz resolution ■ –100 dBc non-harmonic spurious	■ Radio receiver interference testing ■ On-site maintenance ■ R&D
MG3642A Synthesized Signal Generator	125 kHz to 2080 MHz	■ 0.01 Hz resolution ■ –100 dBc non-harmonic spurious	■ Radio receiver interference testing ■ On-site maintenance ■ R&D
MG3681A Digital Modulation Signal Generator	250 kHz to 3000 MHz	■ Broadband vector modulation ■ Excellent ACPR ■ Analog modulation	■ 3GPP applications ■ All major mobile and communication applications ■ HSDPA
MG3690B Series RF/Microwave Signal Generator	0.1 Hz to 67 GHz/325 GHz and greater	■ High-performance ■ High-output power ■ Ultra-low phase noise ■ Analog/Pulse modulation	■ Microwave communications ■ Aerospace/defense ■ Applications signal simulation ■ ATE systems
MG3700A Vector Signal Generator	250 kHz to 3 GHz (6 GHz option)	■ 160 MHz arbitrary waveform generator yields high-level accuracy and large capacity baseband memory	■ Digital modulation of signals for all major wireless communication systems
MG442A Synthesized Level Generator	10 Hz to 20/30 MHz	■ High-precision ■ Balanced and unbalanced	■ Telecommunications
MG724E1/G1 Signal Generator	6.3 to 7.8 GHz 12 to 13 GHz	■ Compact high-performance	■ Line repeater ■ Maintenance

Handheld Solutions

Don't let their size fool you. These rugged, lightweight and easy-to-use instruments deliver powerful, field-tested, lab-approved reliability and accuracy to the palm of your hand—and to wherever there's microwave or communication systems issues.

S332D

Delivering benchtop performance in a handheld instrument.

Handheld Cable and Antenna Analyzer: Site Master

As powerful as it is easy to use, more field technicians choose Site Master than any other handheld analyzer. And for applications as VHF, broadcasting, paging, cellular, GPS, PCS/GSM, 3G, ISM, WLAN and WLL, Site Master delivers accurate, repeatable measurements.

Site Master	Frequency	Measurements	
S113C Cable and Antenna Analyzer	2 MHz to 1600 MHz	■ Return loss ■ Cable loss	■ SWR ■ Distance-to-fault
S114C Cable and Antenna Analyzer	2 MHz to 1600 MHz		
S331D Cable and Antenna Analyzer	25 MHz to 4000 MHz		
S251C Cable and Antenna Analyzer	625 MHz to 2500 MHz	■ Gain/Insertion ■ Cable loss ■ RF Source	■ Return loss/SWR ■ Distance-to-fault
S332D Cable and Antenna Analyzer	25 MHz to 4000 MHz	■ Channel power ■ Field strength	■ Occupied bandwidth ■ Adjacent channel power ratio
S810D Broadband Microwave Transmission Line and Antenna Analyzer	2 MHz to 10.5 GHz	■ Return loss ■ 1-port cable loss	■ Distance-to-fault ■ 2-port cable loss ■ Coax and waveguide VSWR
S820D Broadband Microwave Transmission Line and Antenna Analyzer	2 MHz to 20 GHz		

▶ Take hold of handheld Anritsu solutions. See more at www.anritsu.us/family

MT8222A

MT8212B

Quickly and easily perform all measurements for wireless network deployment, installation and maintenance.

Handheld Base Station Analyzers: BTS Master and Cell Master

BTS Master™ is like having multiple tools in one compact instrument. You get the functionality of a transmitter analyzer (WCDMA/HSDPA, GSM/GPRS/EDGE, WiMax), plus all the features of the field-proven Spectrum Master.

Cell Master eliminates the need to carry, manage and learn multiple test sets. It includes a transmitter analyzer (GSM, CDMA, cdmaOne, CDMA2000 1xRTT, and CDMA2000 1xEV-DO), a transmission analyzer for 2-port devices, interference analyzer, channel scanner, GPS receiver, CW signal generator (tests LNAs, repeaters or base station receiver sensitivity) and T1/E1 analyzer.

Base Station Analyzer	Frequency	Measurements	
BTS Master MT8222A	■ 10 MHz to 4 GHz (Built-in cable and antenna analyzer) ■ 100kHz to 7.1 GHz (Built-in spectrum analyzer) ■ 10 MHz to 7.1 GHz (Built-in power meter)	■ Spectrum analysis ■ Interference analysis ■ Cable loss ■ Fixed WiMax (802.16–2004) ■ WCDMA/HSDPA code domain power	■ Channel scanner ■ Return loss ■ GSM/EDGE channel power ■ Distance-to-fault ■ GPS receiver
Cell Master MT8212B	■ 25 MHz to 4 GHz (Built-in cable and antenna analyzer) ■ 100 kHz to 3 GHz (Built-in spectrum analyzer) ■ 4.5 MHz to 3.0 GHz (Built-in power meter)	■ Return loss ■ Distance-to-fault ■ Interference analyzer ■ Transmitter measurements (cdmaOne, CDMA2000 1xRTT, CDMA2000 1xEV-DO, GSM)	■ Cable loss ■ Channel scanner ■ GPS receiver ■ T1/E1 analyzer ■ Transmission analyzer for 2-port devices

Handheld Solutions

MS2026A

Handheld Vector Network Analyzers: VNA Master

Need unparalleled performance and essential RF capabilities at modest prices? Enter the VNA Master series—simply the most advanced ultra-portable handheld VNAs on the market.

VNA Master	VNA Frequency	SPA Frequency	Measurements
MS2024A	2 MHz to 4 GHz	—	■ Return loss ■ Cable loss ■ VSWR ■ 1-port phase ■ 2-port phase ■ Smith chart ■ 2-port gain ■ Distance-to-fault
MS2026A	2 MHz to 6 GHz	—	
MS2034A	2 MHz to 4 GHz	100 kHz to 4 GHz	MS2024A measurements plus: ■ High-performance spectrum analysis ■ Channel scanner ■ Interference analysis
MS2036A	2 MHz to 6 GHz	100 kHz to 7.1 GHz	

MS2721B

Handheld Spectrum Analyzers: Spectrum Master

As the de facto industry standard, the Spectrum Master™ series provides ultimate measurement flexibility in a lightweight, rugged package for field environments and mobile applications. With frequencies ranging from 9 kHz to 20 GHz, the Spectrum Master is ideal for such applications as identifying sources of interference, measuring field strength of cellular, satellite and military land mobile signals, field analysis of 802.11a/b/g wireless LAN signals and measurement of RF output from circuits, devices and instruments.

Spectrum Master	Frequency	RBW	Noise Level (dBm)
MS2711B	100 kHz to 3 GHz	10 kHz to 1 MHz	–115 dBm
MS2711D	100 kHz to 3 GHz	100 Hz to 1 MHz	–135 dBm
MS2721A	100 kHz to 7.1 GHz	10 Hz to 3 MHz	–153 dBm typical to 1 GHz
MS2721B **NEW!**	9 kHz to 7.1 GHz	1 Hz to 3 MHz	–163 dBm typical to 1 GHz in 1 Hz RBW
MS2723B **NEW!**	9 kHz to 13 GHz	1 Hz to 3 MHz	–156 dBm to 1 GHz, 1 Hz RBW –139 dBm to 3 GHz, 1 Hz RBW
MS2724B **NEW!**	9 kHz to 20 GHz	1 Hz to 3 MHz	–156 dBm to 1 GHz, 1 Hz RBW –136 dBm to 18 GHz, 1 Hz RBW

Specialized Products

Frequency Counters

Anritsu's frequency counters provide the most comprehensive frequency measurements in the industry.

Frequency Counter	Frequency	Key Features	Key Applications
MF2400 Microwave Frequency Counter	10 Hz to 20/27/40 GHz	■ Wideband measurement ■ High-accuracy burst measurement ■ Analog display function ■ Template function ■ High-speed transient measurement ■ Gating function	■ Mobile radio communications devices and circuits ■ Carrier frequency and pulse width of burst signal

Instrumentation Grade Attenuators

Highly accurate, versatile and economical, Anritsu Instrumentation Grade Attenuators also provide GPIB standard and feature automatic measuring system components.

Grade Attenuators	Frequency	Key Features	Key Applications
MN63A/65A/72A/64B Programmable Attenuator	DC to 18 GHz	■ Wide frequency range ■ High accuracy ■ Long operating life ■ High-speed switching	■ R&D ■ Inspection ■ Production

Precision Components, Precision Measurements

Technicians rely on Anritsu for industry-leading design and production of precision microwave components.

- Precision coaxial connector systems to 65 GHz
- High-directivity SWR auto testers and bridges
- Precision terminations and air lines
- Precision step attenuators
- Precision bias tees
- Precision coaxial and waveguide to coax adapters
- RF detectors
- Precision fixed attenuators
- Precision power dividers and splitters
- Broadband microwave limiters








▶ To get your free Anristu connector user guide poster, go to www.anritsu.us/connectorguide

ANRITSU Corporation
5-1-1 Onna, Atsugi-shi, Kanagawa, 243-8555 Japan
Phone: +81-46-223-1111
Fax: +81-46-296-1264

- U.S.A.
ANRITSU Company
1155 East Collins Boulevard, Suite 100,
Richardson, Texas 75081
Toll Free: 1-800-ANRITSU (267-4878)
Phone: +1-972-644-1777
Fax: +1-972-671-1877

- Canada
ANRITSU Electronics Ltd.
700 Silver Seven Road, Suite 120, Kanata,
Ontario K2V 1C3, Canada
Phone: +1-613-591-2003
Fax: +1-613-591-1006

- Brazil
ANRITSU Electrônica Ltda.
Praca Amadeu Amaral, 27-1 andar
01327-010 - Paraiso, São Paulo, Brazil
Phone: +55-11-3283-2511
Fax: +55-11-3886940

- U.K.
ANRITSU EMEA Ltd.
200 Capability Green, Luton,
Bedfordshire LU1 3LU, U.K.
Phone: +44-1582-433280
Fax: +44-1582-731303

- France
ANRITSU S.A.
9, Avenue du Québec Z.A. de Courtaboeuf
91951 Les Ulis Cedex, France
Phone: +33-1-60-92-15-50
Fax: +33-1-64-46-10-65

- Germany
ANRITSU GmbH
Nemetschek Haus, Konrad-Zuse-Platz 1
81829 München, Germany
Phone: +49 (0) 89 442308-0
Fax: +49 (0) 89 442308-55

- Italy
ANRITSU S.p.A.
Via Elio Vittorini, 129, 00144 Roma, Italy
Phone: +39-06-509-9711
Fax: +39-06-502-2425

- Sweden
ANRITSU AB
Borgafjordsgatan 13, 164 40 Kista, Sweden
Phone: +46-8-534-707-00
Fax: +46-8-534-707-30

- Finland
ANRITSU AB
Teknobulevardi 3-5, FI-01530 Vantaa, Finland
Phone: +358-20-741-8100
Fax: +358-20-741-8111

- Denmark
ANRITSU A/S
Kirkebjerg Allé 90 DK-2605 Brondby, Denmark
Phone: +45-72112200
Fax: +45-72112210

- Spain
Anritsu EMEA Ltd.
Oficina de Representación en España
Edificio Veganova
Avda de la Vega, nº 1 (edf 8, pl1, of 8)
28108 ALCOBENDAS - Madrid, Spain
Phone: +34-914905761
Fax: +34-914905762

- United Arab Emirates
ANRITSU EMEA Ltd.
Dubai Liaison Office
P O Box 500413 - Dubai Internet City
Al Thuraya Building, Tower 1, Suit 701, 7th Floor
Dubai, United Arab Emirates
Phone: +971-4-3670352
Fax: +971-4-3688460

- Singapore
ANRITSU Pte. Ltd.
10, Hoe Chiang Road #07-01/02, Keppel Towers,
Singapore 089315
Phone: +65-6282-2400
Fax: +65-6282-2533

- P. R. China (Hong Kong)
ANRITSU Company Ltd.
Units 4 & 5, 28th Floor, Greenfield Tower,
Concordia Plaza, No. 1 Science Museum Road,
Tsim Sha Tsui East, Kowloon, Hong Kong, P.R. China
Phone: +852-2301-4980
Fax: +852-2301-3545

- P. R. China (Beijing)
ANRITSU Company Ltd.
Beijing Representative Office
Room 1515, Beijing Fortune Building,
No. 5 , Dong-San-Huan Bei Road,
Chao-Yang District, Beijing 100004, P.R. China
Phone: +86-10-6590-9230
Fax: +82-10-6590-9235

- Korea
ANRITSU Corporation, Ltd.
8F Hyunjuk Bldg. 832-41, Yeoksam-Dong,
Kangnam-ku, Seoul, 135-080, Korea
Phone: +82-2-553-6603
Fax: +82-2-553-6604

- Australia
ANRITSU Pty Ltd.
Unit 21/270 Ferntree Gully Road, Notting Hill
Victoria, 3168, Australia
Phone: +61-3-9558-8177
Fax: +61-3-9558-8255

- Taiwan
ANRITSU Company Inc.
7F, No. 316, Sec. 1, Neihu Road.,
Taipei 114, Taiwan
Phone: +886-2-8751-1816
Fax: +886-2-8751-1817

- India
ANRITSU Pte. Ltd.
India Liaison Office
Unit No.S-3, Second Floor,
Esteem Red Cross Bhavan,
No.26, Race Course Road,
Bangalore 560 001 India
Phone: +91-80-32944707
Fax: +91-80-22356648

Catalog No. 11410-00415, Rev. A
Printed in United States 2007-02

complex S parameters and other data can be displayed in real time with resolution of 12.5 ns. The option also allows the analysis of periodic and single pulses. The pulsed RF signal is generated by an external signal source such as the R&S SMR signal generator or it can be generated by modulating the signal generator in the R&S ZVA with an external pulse modulator. The concept employed by Rohde & Schwarz is based on directly recording the signal with a sampling rate of 80 MHz, which makes dynamic range and system error correction independent of duty cycle. Option R&S ZVA-K7 allows pulses with a minimum width of 50 ns and rise times of up to 33 ns to be measured. Measurement bandwidth can be up to 30 MHz, and because of the instrument's large memory, the user can continuously record pulse profiles of up to 3 ms.

Sonnet introduced Version 11 of its software program. Featuring an easy-to-administer cluster computing capability and significantly enhanced interfaces to Agilent, AWR and Cadence, the new port calibration program is designed to enhance high frequency design methodology in the field of radio frequency integrated circuit design.

SUSS MicroTec Test Systems featured AccuraCV,™ part of the SussCal® Professional calibration and measurement software suite. It addresses the challenges resulting from shrinking device sizes by making accurate impedance measurements of physically small elements. Having the capability to make such measurements is becoming increasingly important–for instance, the International Technology Roadmap for Semiconductors (ITRS) reports that in 2012 the thickness of gate oxides, characterized using impedance measurements, is predicted to be about half as thick as it is today. AccuraCV is an intuitive tool for optimizing the frequency of impedance measurements that will provide the most accurate results. In addition, it can be used to optimize device design by reducing the costs incurred during process control.

Tektronix highlighted its new RSA6100A series real-time spectrum analyzers. Featuring the revolutionary DPX™ spectrum display, these spectrum analyzers offer an intuitive live color view of signal transients changing over time in the frequency domain, giving immediate confidence in the stability of a design, or instantly displaying a fault when it occurs. This live display of transients is impossible with other signal analyzers. Once a problem is discovered with DPX, the RSA6100A series can be set to trigger on the event, capture a continuous time record of changing RF events and perform time-correlated analysis in all domains. The functionality of a wideband vector signal analyzer, a spectrum analyzer and the unique trigger-capture-analyze capability of a real-time spectrum analyzer exists all in a single pack-

age. The patented DPX spectrum processing engine brings live analysis of transient events to spectrum analyzers. Performing > 48,000 frequency transforms per second, transients as brief as 24 µs in length are displayed in the frequency domain. This is a 1000-fold improvement over swept analysis techniques. Events can be color coded by rate of occurrence onto a bit-mapped display, providing unparalleled insight into transient signal behavior.

Zeland Software Inc. announced the release of IE3D V12. IE3D V12 features a FastEM Design Kit for real-time full-wave EM synthesis; multi-fold speed improvement and multi-CPU support for improved efficiency; equation-based schematic-layout editor with Boolean operations for easy and flexible geometry editing; and lumped equivalent circuit automatic extraction and optimization for convenient circuit designs.

Looking Ahead

Next year the 2008 Radio & Wireless Week will be held January 20–25 in Orlando, FL, and will include the IEEE Wireless and Microwave Technology Conference (WAMICON) along with PAS and SiRF. Orlando is always a great host city for these types of events with many local attractions and a warm, pleasant climate for a winter getaway. Next year's general chair, Aly Fathy, and co-chair, Richard Abrahams, and their staff are already working hard to put together a rewarding and informative technical symposium, and the staff of *Microwave Journal* is hard at work making the Industry Exhibition a fruitful endeavor for all those companies that wish to highlight their wares. We look forward to seeing you in sunny Florida. ■

2008 IEEE Radio and Wireless Symposium

January 20–25, 2008

Orlando, FL

www.radiowirelessweek.org

From $21.95 IN STOCK ea. Qty. (1-9)

DC-13 GHz Low & High Pass

FILTERS

Mini-Circuits VLF Low Pass and VHF High Pass SMA Filters, featuring excellent stopband rejection and passband matching, flat passband response, and sharp roll-off, are unparalleled solutions for RF filtering over a wide range of bandwidths from DC to 13 GHz. Our unique patented Unibody package measures less than 1½" in length and is designed to minimize interconnect losses and improve reliability. Combine that with the temperature stability, performance repeatability, and low cost from our LTCC ceramic technology, and the result is a very rugged, high performance, competitively priced series. These filters are ideal for test set-ups as well as transmitter/receiver filtering in both tactical and commercial applications.

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

For RoHS compliant requirements,
ADD + SUFFIX TO BASE MODEL No. *Example: VLF-80+*

Low Pass *VLF Models $21.95 ea. (1-9)*

Model	Passband (MHz)	fco, Nom. Loss 3 dB (MHz) Typ.	Stopband Loss >20 dB (MHz) Min.
VLF-80	DC-80	145	200
VLF-95	DC-95	165	220
VLF-105	DC-105	180	250
VLF-120	DC-120	195	280
VLF-160+	DC-160	230	330
VLF-180+	DC-180	270	370
VLF-190+	DC-190	280	400
VLF-225	DC-225	350	460
VLF-320	DC-320	460	560
VLF-400	DC-400	560	660
VLF-490	DC-490	650	800
VLF-530	DC-530	700	820
VLF-575	DC-575	770	900
VLF-630	DC-630	830	1000
VLF-800	DC-800	1075	1275
VLF-1000	DC-1000	1300	1550
VLF-1200	DC-1200	1530	1865
VLF-1400	DC-1400	1700	2015
VLF-1450	DC-1450	1825	2025
VLF-1500	DC-1500	1825	2100

Model	Passband (MHz)	fco, Nom. Loss 3 dB (MHz) Typ.	Stopband Loss >20 dB (MHz) Min.
VLF-1525	DC-1525	1750	2040
VLF-1575	DC-1575	1875	2175
VLF-1700	DC-1700	2050	2375
VLF-1800	DC-1800	2125	2425
VLF-2250	DC-2250	2575	2900
VLF-2500	DC-2500	3075	3675
VLF-2600	DC-2600	3125	3750
VLF-2750	DC-2750	3150	4000
VLF-2850	DC-2800	3300	4000
VLF-3000	DC-3000	3600	4550
VLF-3800+	DC-3900	4850	6000
VLF-4400+	DC-4400	5290	6700
VLF-5000	DC-5000	5580	6850
VLF-5500+	DC-5500	6200	7200
VLF-5850+	DC-5850	6540	7600
VLF-6000	DC-6000	6800	8500
VLF-6400+	DC-6400	7200	8300
VLF-6700	DC-6700	7600	9300
VLF-7200+	DC-7200	8150	9500

U.S. Patent Numbers 6,790,049 & 6,943,646

High Pass *VHF Models $24.95 ea. (1-9)*

Model	Passband (MHz)	fco, Nom. Loss 3 dB (MHz) Typ.	Stopband Loss >20 dB (MHz) Min.
VHF-650	710-2490	650	480
VHF-740	780-2800	740	550
VHF-880	950-3200	880	640
VHF-1200	1220-4600	1180	940
VHF-1300	1400-5000	1300	930
VHF-1320	1400-5000	1320	1060
VHF-1500	1600-5500	1550	1250
VHF-1600	1650-5000	1600	1290
VHF-1760	1900-5500	1760	1230
VHF-1810	1900-4750	1810	1480
VHF-1910	2000-5200	1910	1400
VHF-2000	2260-6250	2000	1530
VHF-2100	2200-6000	2100	1530

Model	Passband (MHz)	fco, Nom. Loss 3 dB (MHz) Typ.	Stopband Loss >20 dB (MHz) Min.
VHF-2275	2450-7000	2275	1770
VHF-2700	2650-6500	2500	1800
VHF-2700A+	2900-8700	2700	2150
VHF-3100+	3400-9900	3100	2450
VHF-3500+	3900-9800	3500	2800
VHF-3800	4250-10000	3800	3200
VHF-4400+	5000-10100	4400	3500
VHF-4600+	5000-11000	4600	3800
VHF-5050+	5500-10000	5050	4200
VHF-5500	6000-11500	5500	4500
VHF-7150+	7900-11000	7150	6150
VHF-8400	9000-13000	8400	6000

U.S. Patent Number 6,790,049

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 394 Rev Q

REDEFINING DYNAMIC RANGE FOR TODAY'S DIGITAL RF WORLD

Dynamic range and bandwidth have traditionally been banner specifications for spectrum analyzers and other receivers designed to measure RF signals. Dynamic range is a measure of a receiver's ability to receive small signals while in the presence of large ones. Analysis bandwidth describes the range of frequencies that can be processed simultaneously. Dynamic range and bandwidth have traditionally been applied to steady-state signals and are fundamental figures-of-merit for analyzing RF signals. The advent of digital radio, with packet transmissions and other approaches that maximize spectrum usage, has created a need to consider how dynamic range and bandwidth apply to signals that have short durations and unknown timing. This article extends the concepts of dynamic range and bandwidth as they apply to discovering and capturing single RF events. Once captured, the events and their effects can be fully analyzed using digital signal processing (DSP).

RF signals are undergoing dramatic changes as a result of the digital RF revolution. The RF spectrum is becoming increasingly crowded as wireless devices multiply. Data is replacing analog signals as the primary payload and there is a race to design efficient modulation and coding schemes capable of sending an ever-increasing number of bits over the same valuable bandwidth. While traditional transmissions were continuous and tended to occupy a single frequency channel, the new digital transmissions tend to be packet-based and often employ frequency hopping or have dynamic channel assignments. These changes in the RF signal environment have driven requirements in the test equipment used by those who design, build, install or service RF systems. This article explores how dynamic range and bandwidth, key specifications for equipment designed to test and measure RF signals, need to be re-examined.

SIGNALS WITH SHORT DURATION AND RANDOM TIMING

Consider the two cases illustrated in ***Figure 1***. In each case, there is a short burst of interference lasting a few milliseconds. The analog signal in the upper part of the figure has duration of several minutes. A single short-duration interfering signal may cause a

MARCUS DASILVA
Tektronix Inc.
Beaverton, OR

p r o v i d i n g   o p t i m a l   s e m i c o n d u c t o r   s o l u t i o n s   w o r l d w i d e

Providing up to 10W power amplifier modules for satellite handsets for transmit and receive solutions

Supplying driver, 1W and 2W packaged power amplifiers for satellite ODUs

Our industry-leading semiconductors are redefining global coverage by meeting the high power and low noise requirements of Ku-band and Ka-band satellite communications systems and satellite handsets. Visit www.mimixbroadband.com to learn more about these devices:

Device	Description	Frequency (GHz)	Gain (dB)	Output P1dB (dBm)
CMM1118-QT	Driver Amplifier	11.0-20.0	20.0	+14.0
CMM1434-SM	Power Amplifier	13.5-14.5	31.0	+34.5 (Psat)
CMQ1432-QH	Power Amplifier	13.5-15.5	32.0	+32.0 (Psat)
XR1002-BD	Receiver	18.0-34.0	2.0-14.0	NF = 3.0 dB
XL1000-BD	Low Noise Amplifier	20.0-40.0	20.0	NF = 2.0 dB
XP1026-BD	Power Amplifier	27.0-32.0	22.0	+33.0 (Psat)
XP1027-BD	Power Amplifier	27.0-33.0	21.0	+36.0 (Psat)
XU1007-BD	Transmitter	27.0-36.0	9.0	+13.0

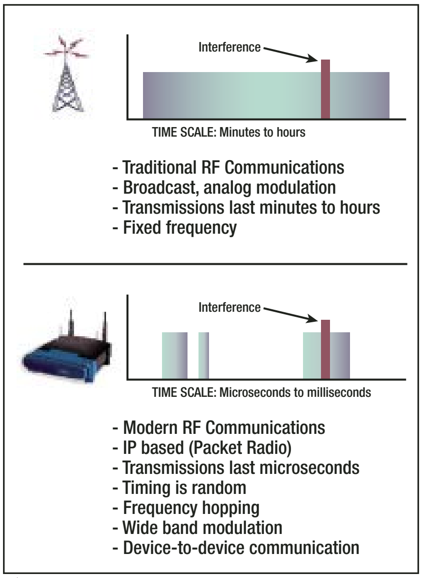
Mimix BROADBAND™

Visit http://mwj.hotims.com/11714-80 or use RS# 80 at www.mwjournal.com/info

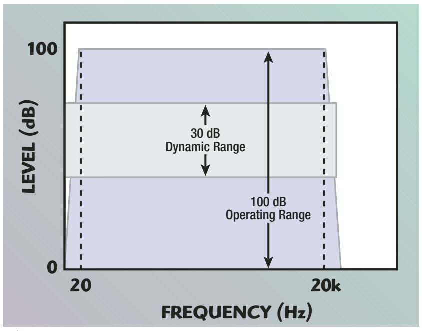
Mimix Broadband, Inc., 10795 Rockley Rd., Houston, TX 77099 U.S. 281.988.4600 mimixbroadband.com pop or glitch in the reception, without changing the nature of the signal being received. The digital RF signal in the lower half of the figure transmits data packets. Each packet is sent in the form of an RF burst lasting a few milliseconds. The same interfering burst that caused barely a glitch in an analog radio signal causes the irretrievable loss of a number of transmitted symbols. The entire packet is lost if the number of lost symbols exceeds the ability of error correction algorithms to recover them. The need to detect, measure and analyze short-duration signals is changing the test equipment requirements. It is no longer enough to have sufficient bandwidth to demodulate a signal and enough dynamic range to separate weak signals from much stronger ones. It is necessary to detect, capture and analyze signals with increasingly short duration and random timing that occur in the presence of other, often much larger signals, each of which is also changing with time.

DYNAMIC RANGE AND BANDWIDTH FOR STEADY-STATE SIGNALS

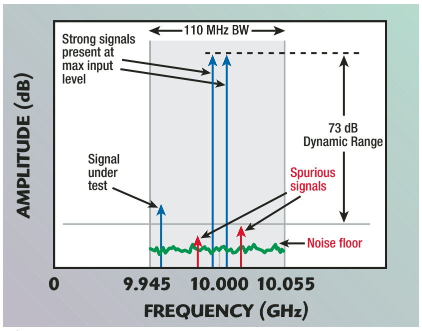
Dynamic range is the ability of receiving systems to detect small signals in the presence of larger ones. In the human ear, for example, the difference between a weak sound pressure at the threshold of hearing and a strong sound pressure at the threshold of pain is approximately 100 dB. The ear's ability to distinguish between two sounds that are present simultaneously is approximately 30 dB, reflecting the reality that a human is unable to hear a pin drop during a rock concert. Human hearing has an operating range of 100 dB and a dynamic range of 30 dB, as shown in **Figure 2**. The frequency range of an RF analyzer defines the minimum and maximum frequencies that can be processed by a particular system. Its analysis bandwidth defines the portion of the spectrum that can be simultaneously analyzed. RF receivers, including spectrum analyzers (SA) and vector signal analyzers (VSA) operate on an analysis bandwidth that is a bandpass function surrounding a center frequency. The analysis bandwidth of SAs and VSAs is typically much narrower than their frequency range. Spectrum and vector signal analyzers are available in many performance levels. Frequency ranges run from DC to more than 300 GHz with a variety of specified bandwidth and dynamic ranges. A dynamic range of 80 dB at 28 MHz bandwidth and 73 dB at a bandwidth of 110 MHz define the state-of-the-art at the time of this publication. **Figure 3** illustrates the dynamic range and analysis bandwidth of a VSA. Signals within the 110 MHz analysis bandwidth can be examined



▲ *Fig. 1 The effects of a short burst of interference.*



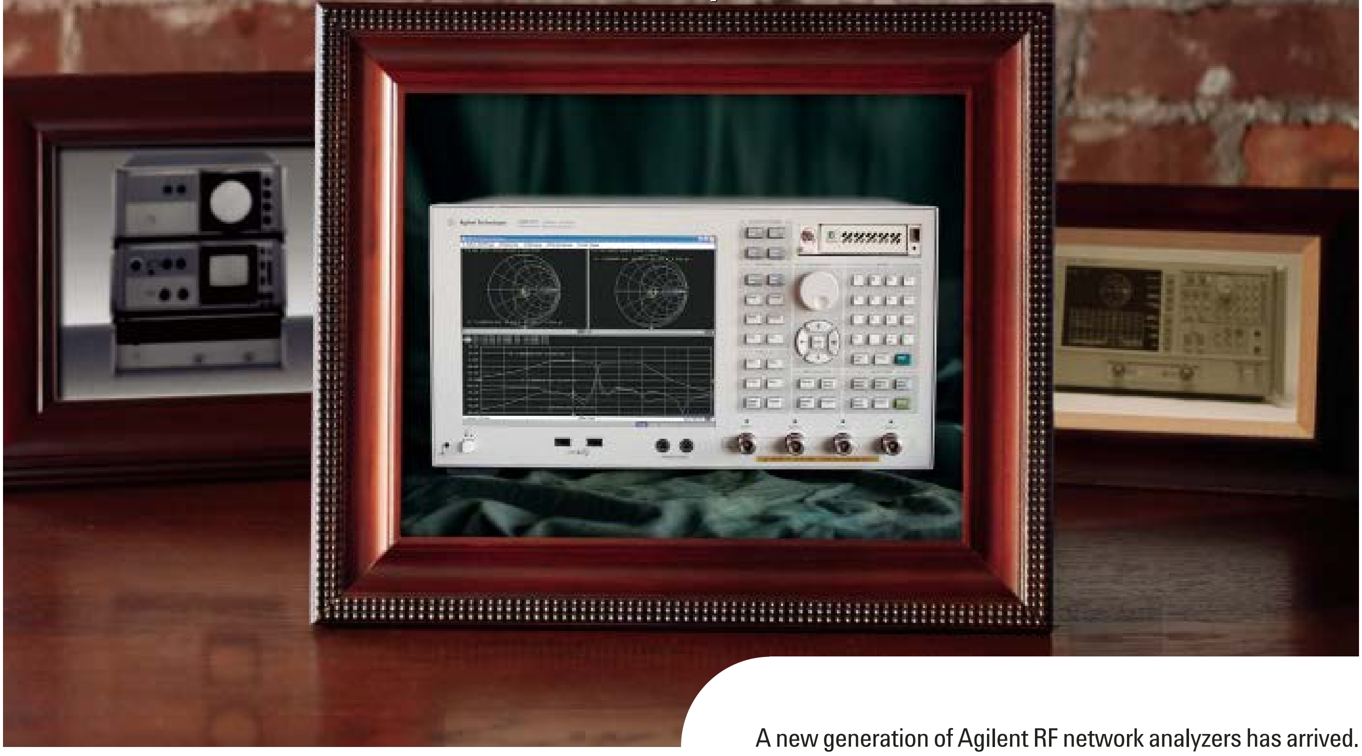
▲ *Fig. 2 Human hearing dynamic range and bandwidth.*



▲ *Fig. 3 Steady-state dynamic range and bandwidth in a vector signal analyzer.*

It has great genes

The ENA carries on the family tradition



Agilent E5071C ENA
9 kHz to 8.5 GHz frequency range
> 123 dB dynamic range
Trace noise < 0.004 dB rms at 70 kHz IF bandwidth
39 ms measurement speed (1601 points, full 2-port calibration)
2- or 4-port measurements

A new generation of Agilent RF network analyzers has arrived. And its Agilent 8753 ancestors would be proud. The ENA Series builds on the family's 40-year legacy of excellence to deliver new standards in speed, accuracy, and versatility for RF network analysis.

With the ENA Series, you'll get excellent performance across its entire frequency range. No other network analyzer can match its dynamic range, trace noise, or measurement speed. And no one else has a frequency range that reaches from 8.5 GHz down to 9 kHz.

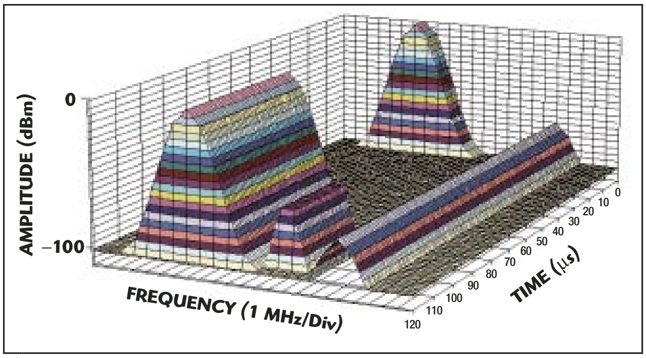
It's the kind of performance you'd expect from the 8753 family. Only now, it goes even further to help you do more—and do it better. It helps to have great genes on your side.

Put the ENA Series to work for you. For application notes and more information, visit www.agilent.com/find/genes.

u.s. 1-800-829-4444
canada 1-877-894-4414
www.agilent.com/find/genes

Agilent Technologies

Visit http://mwj.hotims.com/11714-9 or use RS# 9 at www.mwjournal.com/info



▲ *Fig. 4 Three signals shown as a function of frequency and time.*

simultaneously. Multiple signals present within the analysis bandwidth can be unambiguously resolved as long as their relative levels are within 73 dB, the specified dynamic range. The analyzer, in this example, has enough over-range capability to accommodate the peak addition of the two large signals. All signals present are assumed to be of steady state. The steady-state dynamic range and bandwidth are the principal attributes that define the performance of an analyzer used to measure signals from traditional communications systems. These attributes, however, are not enough to define performance when measuring digital RF signals, where transmissions are sent in asynchronous bursts and interfering signals with exceedingly short durations can cause data packet errors. Therefore, it is necessary to consider an analyzer's ability to detect RF bursts and transients in the presence of larger signals that are themselves changing over time.

DIGITAL RF SIGNALS

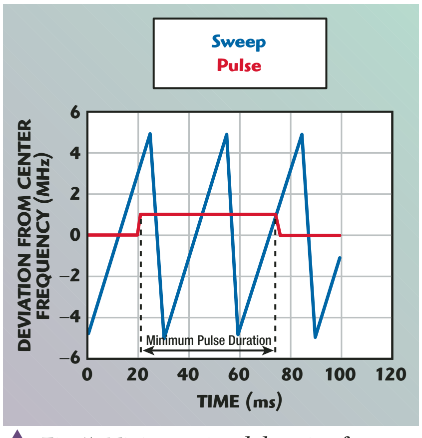
Consider the spectrum versus time plot shown in ***Figure 4***. The time record shows two regularly occurring digitally modulated RF bursts occupying the lower half of the displayed frequency span. Each burst lasts 50 µs (one shown partially). The plot also shows a continuous signal in a neighboring channel and a single interfering burst of RF lasting 25 µs. Both the burst and the continuous signal are more than 45 dB lower than the stronger modulated signal. The interferer occurs so infrequently that it can be considered a single event. These hypothetical digital RF signals will now be applied to several classes of equipment in an attempt to discover the lone interfering burst of RF and to analyze its contents.

TRANSIENT DISCOVERY

Often, the toughest problem in troubleshooting digital RF signals is discovering the transients that degrade data transmissions. The short duration of digital RF signals, their unpredictable timing and the wide range of levels that can occur simultaneously make transient interference problems difficult, time consuming and frustrating. Once a transient signal is discovered, it must be analyzed. Triggering on the transient occurrence allows a time record of the waveform containing the signal of interest to be captured and subsequently analyzed using the powerful digital signal processing tools available in most modern analyzers.

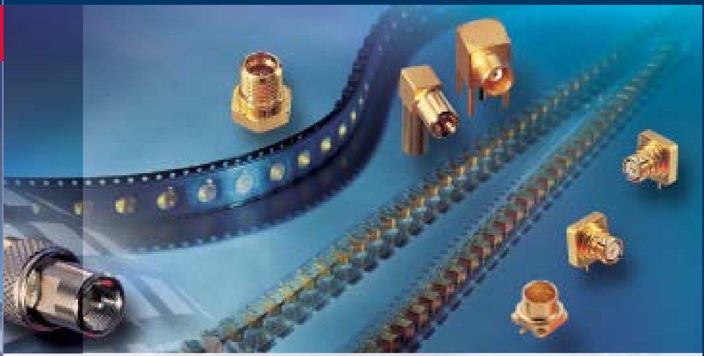
TRANSIENT DISCOVERY WITH SWEPT SPECTRUM ANALYZERS

Consider, for example, a swept spectrum analyzer, as shown in ***Figure 5*** with a 75 dB dynamic range, 25 ms sweep speed, a retrace time of 5 ms and a frequency span of 40 MHz about an arbitrary center frequency. Even though the MAX Hold function can catch and display a single occurrence, a transient signal must be present for the entire sweep for its spectrum to be displayed accurately. The random timing of the burst relative to the sweep means that the minimum burst duration for 100 percent probability of discovery is twice the sweep



▲ *Fig. 5 Minimum signal duration for an asynchronous sweep.*

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.

Exploring new directions

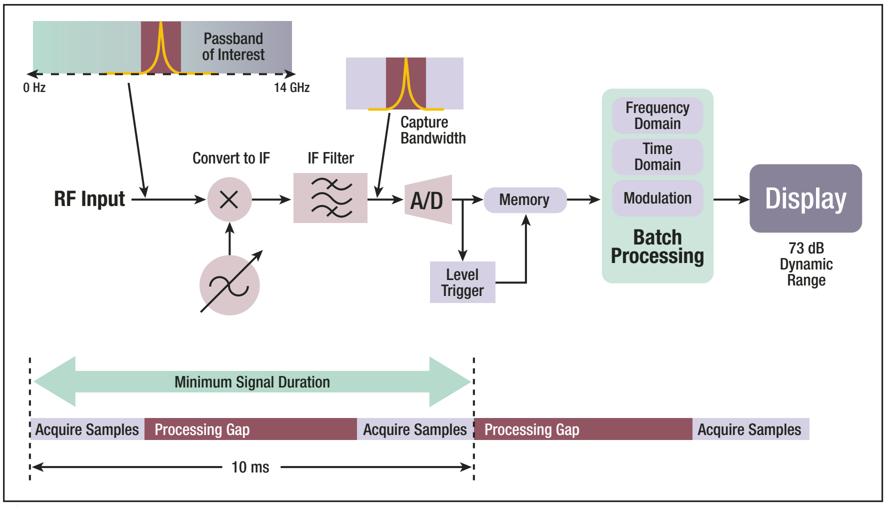
Ask us for more information:

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: +49-8684-18-0 · Fax: +49-8684-18-499
info@rosenberger.de · www.rosenberger.de



▲ *Fig. 6 Vector signal analyzer block diagram.*

time plus the retrace. The minimum signal duration to guarantee that the correct spectrum is displayed in the example is 55 ms for a burst of RF with random timing. The swept spectrum analyzer can be said to have a single event dynamic range of 75 dB with minimum duration of 55 ms for 100 percent probability of detection. The swept spectrum analyzer can easily show the continuous signal shown previously. The 50 µs pulses have a repetition rate that is frequent relative to the sweep speed, causing their pulse spectrum to be displayed on the swept spectrum analyzer screen. However, the single 25 µs burst is much too short to be displayed with any certainty.

TRANSIENT DISCOVERY IN VECTOR SIGNAL ANALYZERS

Figure 6 shows a simplified block diagram of a vector signal analyzer. The input signal is down-converted and a passband of interest is digitized. The digitized samples are placed in memory. The contents of the sample memory are then analyzed. Digital signal processing (DSP) software makes many kinds of analysis possible, including spectrum, modulation, timing and signal statistics. This flexibility comes at the price of processing delay. The DSP algorithms, typically running on a programmable processor, cannot keep up with the incoming signal causing gaps in the analysis record. It should be noted that several models offer swept spectrum analysis and vector signal analysis in that same package. This article will treat them separately for simplicity.

Consider the VSA shown, with a 40 MHz analysis bandwidth, a 100 MHz sample rate and 75 dB dynamic range. Even if a fast Fourier transform (FFT) only requires a 20 µs time record, the computations take several milliseconds. The minimum duration for computing the spectrum of an RF burst with random timing is twice the acquisition length plus the computation gap. The VSA in this example requires a minimum transient duration of 10 ms for 100 percent probability of discovery of a single transient. The VSA in this example can catch the regularly occurring modulated signal and correctly show its spectrum. It will also correctly show the spectrum of the continuous signal. The probability that it will catch the single transient, however, is very small.

TRANSIENT DISCOVERY IN REAL-TIME SPECTRUM ANALYZERS

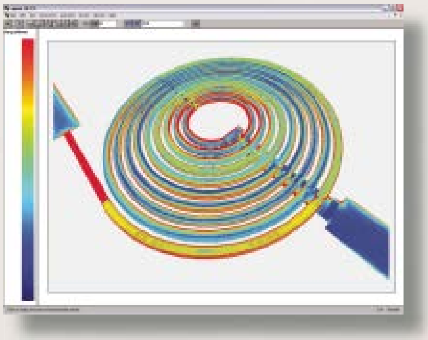
Consider the real-time spectrum analyzer (RTSA) architecture illustrated in ***Figure 7***. Like the VSA, the RTSA digitizes a wide bandwidth IF signal. The RTSA, however, places a real-time processor after the ADC. The real-time processor is capable of performing digital Fourier transforms (DFT) at a rate that keeps up with incoming signals, reducing or eliminating the processing gap and even allowing for overlapped DFTs. This ability to analyze signals without having to post-process the contents of the sample memory gives the RTSA the unprecedented ability to discover rare short-duration RF events. The ability to continuously perform Fourier

We Realize That Mistakes Happen....
We Just Don't Want **You** to Make Them...

Accurate High Frequency Electromagnetic Simulation

For over 20 years, high frequency designers around the world have put their trust in SONNET®. With unmatched *accuracy*, Sonnet's superior EM analysis engine accounts for hidden parasitics, cross-coupling, material losses and provides models for structures where models don't exist. Sonnet can handle your 20-plus layer stack-ups and ultra thin dielectrics with ease... And analyze it accurately!

We know there is no room for error in doing your job... That's why you turn to Sonnet.



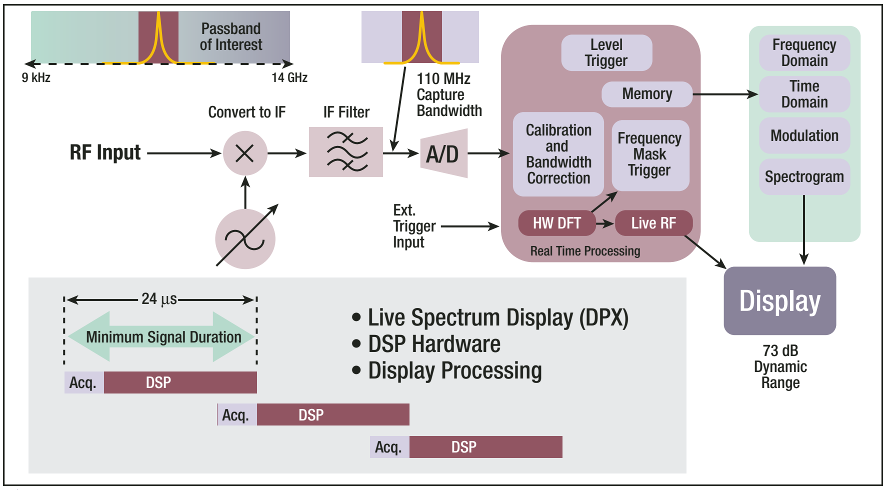
SONNET®'s advanced Conformal Mesh with true Thick Metal modeling allows accurate and efficient modeling of complex thick metal RFIC and MMIC structures.

Sonnet Means ACCURACY.
Trust In Sonnet.

SONNET®

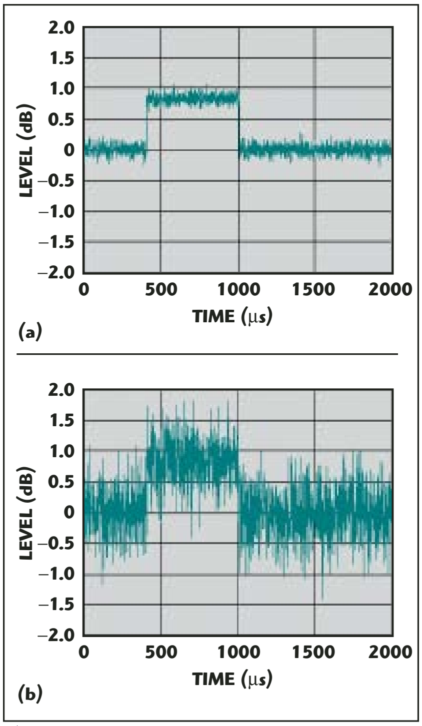
www.sonnetsoftware.com
Phone: 315.453.3096
Download free SONNET® Lite™ at: www.sonnetsoftware.com/lite

Visit http://mwj.hotims.com/11714-130 or use RS# 130 at www.mwjournal.com/info



▲ *Fig. 7 Real-time spectrum analyzer block diagram.*

analysis with minimum processing gaps allows the real-time spectrum analyzer to provide a live display of the input spectrum. Variable persistence, also called digital phosphor or DPX processing, enables users to visualize the changes in the spectrum of the input signal while providing an indication of how often spectral events occur. Setting the persistence to infinite allows the discovery of single events. The real-time spectrum analyzer shown has a 110 MHz real-time analysis bandwidth, a specified 73 dB



▲ *Fig. 8 Power versus time display of a continuous signal at 0 dB with a pulsed signal at -20 dB; (a) unmodulated signal and (b) increasing modulation adds to trigger uncertainty.*

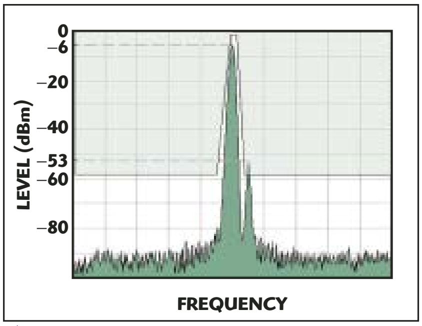
dynamic range and a minimum signal duration of 24 µs for a 100 percent probability of discovery using its DPX mode. The real-time spectrum analyzer is thus able to display all three of the signals present in the original example and to indicate the presence of the single transient event, correctly displaying its spectral components.

TRIGGERING

Triggering systems are used to facilitate signal analysis by allowing the user to selectively capture only the time segment of a signal that contains an event of interest, the trigger event. Modern triggering systems are capable of storing a time record of events that leads to the trigger as well as what happens after it. Once the waveform of a signal is captured into analysis memory, the full power of DSP can be used to analyze any and all of its relevant parameters.

LEVEL TRIGGERS IN OSCILLOSCOPES

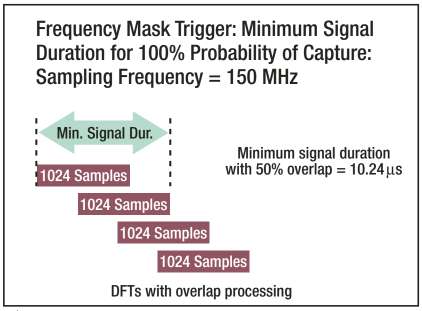
Oscilloscopes have very complex and fast triggering systems that cover the oscilloscope's bandwidth and vertical range. The dynamic range over which the oscilloscope can trigger on short-duration signals is limited by the ability of its triggering system to detect changes in a waveform produced by the occurrence of a low level transient on top of an existing waveform. The peak voltage displayed on an oscilloscope will vary by 10 percent or approximately 1 dB when a burst containing another sinusoid of 20 dB lower level is added to a constant sinusoidal signal. Noise, modulation and other signal variations further limit the effective dynamic range of a level trigger. Although the trigger range of the typical oscilloscope covers its entire vertical resolution, the ability of the oscilloscope to trigger on a weak signal in the presence of larger ones varies from approximately 20 dB for noiseless unmodulated signals to 0 dB for signals with complex modulation or poor SNR. The oscilloscope can easily trigger on the large RF bursts. Its low steady-state dynamic range places the oscilloscope noise and distortion floor at about the same level as the other two signals, making the capture and analysis of the other two signals unlikely and inaccurate at best.



▲ *Fig. 9 A small intermittent interferer in the presence of a large signal.*

LEVEL TRIGGERS IN SPECTRUM ANALYZERS AND VECTOR SIGNAL ANALYZERS

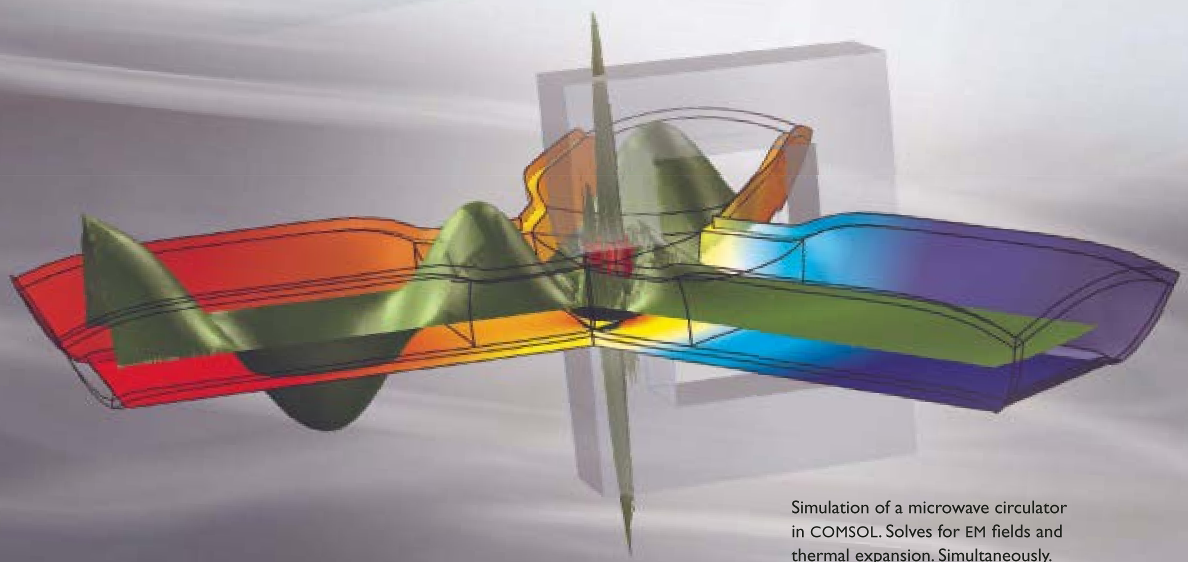
Figure 8 illustrates a power versus time display available on many spectrum analyzers and vector signal analyzers. Like oscilloscopes, modern SAs and VSAs have the ability to trigger on the composite level of the signals present in their IF. While the operating range of the level trigger can be quite large, the ability to trigger on a weak signal in the presence of stronger ones is much more limited. Like an oscilloscope, a 20 dB trigger dynamic range is a reasonable esti-



▲ *Fig. 10 Frequency mask trigger minimum signal duration for 100 percent probability of capture.*

COMSOL MULTIPHYSICS™

RF simulation goes multiphysics



Simulation of a microwave circulator in COMSOL. Solves for EM fields and thermal expansion. Simultaneously.

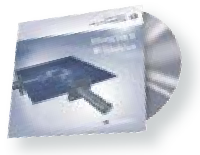
COMSOL sets the stage for innovation using multiphysics simulations. Custom interfaces offer one collaborative workspace across scientific and engineering specializations. A complete solution for today's technological challenges!

TOP FEATURES IN COMSOL

- Specialized RF Module
- Predefined physics and custom physics in the GUI
- Unlimited multiphysics capabilities

Get the free CD today

Introduction to RF Simulation
www.comsol.com/intro/rf



www.comsol.com

COMSOL

TABLE I

TYPICAL STEADY-STATE TRANSIENT PERFORMANCE FOR DIFFERENT SIGNAL ANALYZERS

	Digital Storage Oscilloscope	*Swept Spectrum Analyzer*	*Vector Signal Analyzer*	*Real-time Spectrum Analyzer*
Analysis bandwidth	15 GHz	swept	10 to 120 MHz	15 to 110 MHz
Steady-state dynamic range/BW	45 dB/15 GHz	50 to 80 dB swept	70 to 80 dB	65 to 75 dB
Single event dynamic range for transient discovery	< 20 dB	50 to 80 dB	50 to 80 dB	65 to 75 DPX
Minimum signal duration for 100% probability of discovery	< 100 ps	> 5 ms	> 5 ms	24 µs
Single event dynamic range for triggering	< 20 dB level trigger	< 20 dB level trigger	< 20 dB level trigger	60 to 75 dB frequency mask trigger
Minimum signal duration for 100% probability of capture	100 ps level trigger	1/RBW triggered sweep	< 10 ns level trigger	10 µs frequency mask trigger

mate for triggering on the composite level of two unmodulated carriers. The dynamic range degrades significantly for signals with noise or complex modulation. The VSA shown previously (see Figure 6) can easily trigger on the larger pulsed signal and analyze its contents. Its dynamic range allows it to show the continuous signal as well. The spectrum of the single interfering burst, however, will only be shown correctly if it happens to coincide with the capture interval of the analyzer. Therefore, the probability of capture is very low.

FREQUENCY MASK TRIGGER IN REAL-TIME SPECTRUM ANALYZERS

Advances in digital signal processing and computational hardware have enabled real-time spectrum analysis. A real-time spectrum analyzer computes Fourier transforms at a rate that keeps pace with the incoming signal. This enables the direct observation of how frequency components of a signal change over time. It also enables triggering in the frequency domain and dramatic improvements in the ability to trigger on small signals occurring in the presence of larger ones. The digital Fourier transform used in frequency mask triggering separates the various components of the incoming waveform with a high dynamic range. Consider the case of a small intermittent interferer in the vicinity of a much larger signal, as shown in ***Figure 9***. The interferer lasts 25 µs and, at 47 dB below the larger signal, is too small to be captured by power or level triggers. A real-time spectrum analyzer continuously computes Fourier transforms of the input signal, separating the signal into its spectral components. Independent trigger levels can be applied to each spectral component. The result is a frequency domain mask. A trigger is generated whenever any of the spectral components cross the mask. In this example, the mask excludes the larger signal. A trigger and subsequent signal capture is initiated on each and every occurrence of the smaller interferer. Once the trigger conditions are detected, then the real-time spectrum analyzer can capture a time record of the signal into memory. DSP software is then used to analyze the captured signals.

TIME LIMITATIONS IN FREQUENCY MASK TRIGGER

Digital Fourier Transforms (FFT, Chirp-Z) are computed over finite time records. A transient event must encompass the complete time record used to

Adapters, Attenuators, Blind Mate Connectors, Cable Assemblies, Connectors, Delay Lines, Duplexers Equalizers, Fine Grain Equalizers, Gain Amplitude Equalizers, Line Stretchers, Machines, Phase Adjusters, Push - On Connectors & Adapters, Quick Connections, Terminations (Coax-), Tools, Waveguide to Coax - Adapters & Transmissions, and..................

WG/Coax Adapters

Rectangular WG & Double Ridge WG, End Launched & Top Launched
Aluminum, Copper, Brass, All Standard Flanges available
WR 650 to WR 22, Frequency: 1.12 GHz to 50.0 GHz
Most Coax Connectors Series at NO Surcharge.

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: specelek@compuserve.com

Visit http://mwj.hotims.com/11714-132 or use RS# 132 at www.mwjournal.com/info

WG-CoaxE

compute a transform in order for its frequency components to be accurately computed. This places the requirement of minimum signal duration for 100 percent capture using frequency mask trigger. ***Figure 10*** illustrates the minimum signal duration for 1024 sample DFTs. The minimum signal duration is three halves the DFT length for the case of 50 percent overlap, decreasing to a minimum of a single FFT length if more overlap is used. The key parameter is the minimum event duration that can accurately generate a trigger, which, along with analysis bandwidth and dynamic range, determine the analyzers ability to catch elusive transient events. The real-time spectrum analyzer shown previously uses overlap processing to perform a digital Fourier transform every 10.24 µs. It then compares its results with a user-defined mask, generating a trigger. A single transient event with frequency content that crosses the mask and lasts longer than 10.24 µs has a 100 percent probability of generating a trigger. Once triggered, the selected time segment is captured into memory. The full capability of the analyzer's digital signal processor can then be applied to the stored time record.

COMPARISONS

Table 1 shows the expected bandwidth, the steady-state dynamic ranges, the single event dynamic ranges for discovery and triggering along with the minimum signal duration for 100 percent probability of detection. Oscilloscopes are the instruments of choice when extreme bandwidth and high timing accuracy are needed. Oscilloscopes offer the best bandwidth and are capable of detecting signals of extremely short duration. Although modern oscilloscopes have the ability to perform Fourier transforms on the incoming signals, their dynamic range is limited to approximately 45 dB. Swept spectrum analyzers offer the highest dynamic range in narrow spans and are the instrument of choice for measuring RF signals that do not change quickly over time. Swept spectrum analyzers are capable of steady-state dynamic ranges in excess of 80 dB. The swept analyzer's ability to discover unknown transient signals is limited because a sweep cannot see all frequencies in a span simultaneously, requiring a signal to remain present for an entire sweep for a spectrum to be displayed accurately. Vector signal analyzers are capable of steady-state dynamic ranges in the order of 80 dB and of analysis bandwidths of over 100 MHz. The VSAs available at the time of this publication are limited in their ability to discover short transients by their reliance on post-processing of stored data for performing Fourier transforms or other analysis. The minimum time for 100 percent probability of discovery is of the order of 5 to 10 ms. Level triggers can detect events of the order of 10 ms, but only with very limited dynamic range. The real-time DSP engine at the heart of a real-time spectrum analyzer makes it possible to perform digital Fourier transforms with minimal or no gaps. This allows for the discovery of single RF events as short as 24 ms and for triggering on events as short as 10 µs with high single event dynamic range.

CONCLUSION

Modern RF communications systems are increasingly utilizing digital modulation transmitted in RF bursts lasting mere microseconds. Analysis and testing of these systems requires the ability to discover and capture RF events with increasingly short durations that happen in the presence of many other signals. Traditional definitions of bandwidth and dynamic range that require signals to be present for long periods of time may no longer be enough. One must look beyond the steady state and examine the ability of instrumentation to catch single RF events with high dynamic range and bandwidth, and ever decreasing durations.

Marcus daSilva *received his BS and MS degrees in electrical engineering from the University of Missouri-Rolla. He has held various engineering, management and marketing positions at Hewlett-Packard and Agilent over a 23-year period, and made contributions in frequency synthesis, test methodologies, device modeling, microwave component design and metrology. He was vice president of engineering and chief technical officer at Vivato, where he assembled and managed the team that developed the industry's first WiFi switch. He is currently principal engineer and manager of strategy and advanced technology, RF products, at Tektronix Inc.*

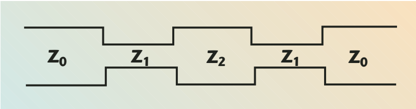
ANALYSIS AND DESIGN OF A ONE-TWELFTH WAVELENGTH THREE-SECTION DIRECTIONAL COUPLER

This article describes the design and development of a three-section 10 dB backward wave directional coupler at Ku-band. The approach demonstrates a two-third reduction in the line length of each section, compared to the traditional approach. The simulated and measured results of both traditional as well as the proposed circuits are compared. Bandwidth enhancement and size reduction, along with maintained symmetry, are the main advantages of this topology. Furthermore, the achieved dimensions can be easily fabricated using standard etching techniques. Close agreement between the measured results and those simulated validates the adopted approach.

Presently, the trend in satellite communication is focusing on high frequencies with wider user bandwidths. Directional couplers are an integral part of onboard as well as ground applications, either for combining or splitting power. Planar directional couplers, using coupled microstrip lines, are commonly used for different coupling values.[1] Couplers can be either three- or four-port networks. Four-port couplers are preferred, due to their inherent advantage of better matching, isolation and reliability. Backward wave couplers are classified as four-port networks.

The major advantage of using backward wave directional couplers is that the input signal port and the coupled output signal port are on the same side and their implementation in a system configuration becomes easier. The major constraints, in the realization of planar directional couplers, are size and bandwidth requirements. A traditional technique for achieving broadband is to increase the number of coupled sections, each a quarter-wavelength long. The coupling coefficients for each section are calculated using standard equations.[2] In this article, a proposed three-section directional coupler is investigated and compared with a standard coupler. The

K. SINGH, V. VINAYAKAROHIT,
R. RAMASUBRAMANIAN AND S. PAL
ISRO Satellite Centre
Bangalore, India



▲ *Fig. 1 Equivalent transmission line model for a three-section filter.*

proposed coupler is designed using one-twelfth wavelength-long coupled sections, along with modified coupling coefficients. The design and development of a 10 dB coupler at Ku-band, in the frequency range 13 to 18 GHz, is described. A standard three-section design was also carried out and compared with the proposed approach. This novel approach gives a size reduction of at least 66 percent, along with improved performance characteristics. Symmetry is maintained for ease of implementation. The one-twelfth wavelength coupled sections are analytically inexact, but practically exact for engineering applications, as shown here.

ANALYSIS AND DERIVATION

The traditional design approach for a directional coupler uses binomial, Chebyshev or Klopfenstein tapering,[2] along with impedance transformations for the different sections. A broad bandwidth can be achieved by using an increased number of sections along with the Chebyshev transformation. A three-section coupled-line structure, each a quarter-wavelength long and with different coupling coefficients, is the most widely used. The solution for the standard design, using Fourier analysis for the Chebyshev transformation, gives rise to the following coupling coefficients for a 10 dB coupler.[4]

$$c_1 = 0.0395 => C_1 = -28 \text{ dB}$$
(outer section)

$$c_2 = 0.3950 => C_2 = -8.07 \text{ dB}$$
(center section)

where

$L = \lambda/4$ for each section

This shows that the coupling at the outer section is loose compared to that at the middle section. ***Figure 1*** shows the proposed design of a three-section directional coupler and its equivalent single line model. This model is applicable for multiple sections with the condition that $Z_{0e}Z_{0o} = Z_0^2$ is maintained throughout the section.

The input impedance at A is given by

$$Z_A = Z_1 \left\{ \frac{(Z_B + jZ_1 \tan\beta x_1)}{(Z_1 + jZ_B \tan\beta x_1)} \right\} \quad (1)$$

at point B, it can be written as

$$Z_B = Z_2 \left\{ \frac{(Z_C + jZ_2 \tan\beta x_2)}{(Z_2 + jZ_C \tan\beta x_2)} \right\} \quad (2)$$

and at point C

$$Z_C = Z_1 \left\{ \frac{(Z_0 + jZ_1 \tan\beta x_3)}{(Z_1 + jZ_0 \tan\beta x_3)} \right\} \quad (3)$$

These equations give rise to transcendental equations, which, with some assumptions, can be solved for Z_1, Z_2, Z_3, x_1, x_2, x_3 using nonlinear software.

Solution

This solution will be in the form

$$Z_1 = K^{1/4} \times 50$$

$$Z_2 = K^{2/4} \times 50$$

$$x_1 = x_2 = 0.083\ \lambda_0$$

where

K = variable and taken to be 2^7

The nonlinear solution for Equations 1 to 3 gives rise to $Z_1 = 70\ \Omega$, $Z_2 = 59\ \Omega$ for $x = 0.083\ \lambda_0$. The proposed design uses the three-section coupled line structure, with one-twelfth wavelength line, using the single line model, and the impedances obtained by solving the transcendental equations.

Broadbanding Approach

The following data has been collected via simulation to validate the approach for the given topology. ***Table 1*** shows the analysis results for sections of different line lengths to validate the approach. The table shows that, by using three $\lambda/4$ sections with the center frequency at 14.5 GHz, the second peak appears at 24.5 GHz, the next at 34 GHz and so on. However, by using three $\lambda/12$ sections with the center frequency again at 14.5 GHz, the second peak appears at 42.5 GHz, the next at 69.5 GHz and so on. For the same amplitude in both cases, it is obvious that three $\lambda/12$ sections will provide more bandwidth than three

Get up to **$5000** off when buying a CNT-90XL Microwave Counter/Analyzer

Please visit **www.pendulum-instruments.com/tradein.php**

ULTRAHIGH RANGE, SPEED & RESOLUTION

- 27, 40, 46 or 60 GHz frequency range

- 250k meas. / sec. of frequency or power

VERSATILITY

- Frequency or power, CW or burst to 60 GHz

- All Timer / Counter functions to 300 MHz

FAST ANALYSIS

- Modulation domain analysis to 60 GHz

- View FM or AM on graphical display

- Frequency or power stability, settling or drift

AFFORDABLE

- The world's best Timer / Counter included!

pendulum

Incorporating XL Microwave

Pendulum Instruments

- Experts in Time & Frequency Calibration, Measurement and Analysis

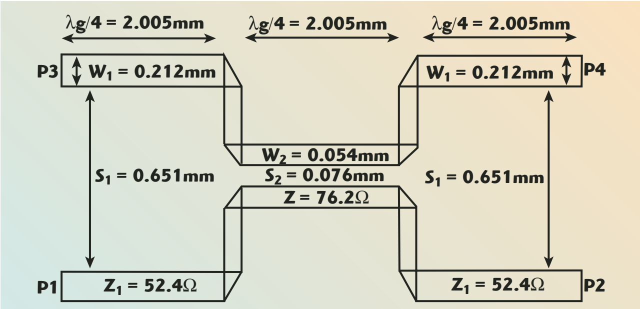
Phone: +1 510-428-9488 (US), +46 8 598 510 55 (Int.)

www.pendulum-instruments.com

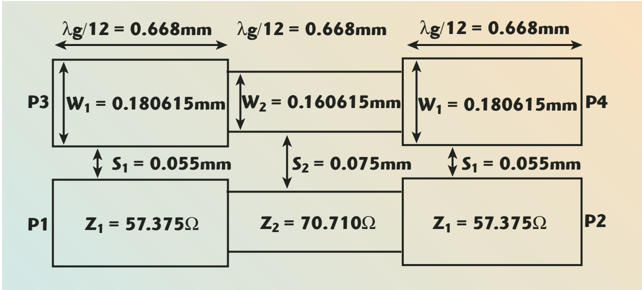
Visit http://mwj.hotims.com/11714-104 or use RS# 104 at www.mwjournal.com/info

TABLE I
COMPARISON OF PEAKS FOR DIFFERENT LENGTH OF SECTION

Length (l)	First Peak (GHz)	Second Peak (GHz)	Third Peak (GHz)	Fourth Peak (GHz)	Fifth Peak (GHz)
λ/4	f_c = 14.5	42.5	67.5	–	–
3λ/4	5.0	f_c = 14.5	24.5	34.0	–
5λ/4	2.5	8.0	f_c = 14.5	20.5	30.5
3*λ/12	f_c = 14.5	42.5	69.5	–	–
5*λ/20	f_c = 14.5	41.5	69.0	–	–



▲ *Fig. 2 Standard design of a three-section coupler at Ku-band.*



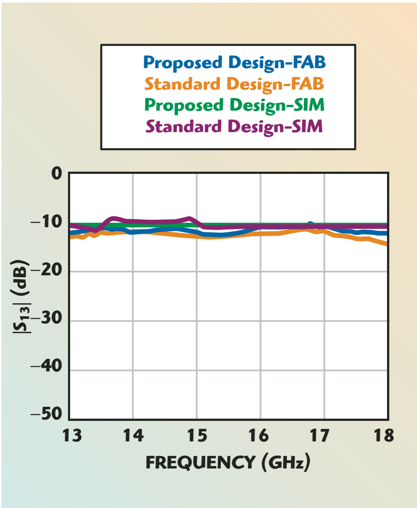
▲ *Fig. 3 Proposed structure showing design dimensions.*

λ/4 sections, thereby providing broadband characteristics. The slight change in the frequencies of the second and third peak, when using five λ/20 sections, is due to the slight change in wavelength, because of impedance mismatch between the sections. The approach is to use odd number of multiple (N) sections each of length λ/4N, so that the total length is always Nλ/4N = λ/4, and hence the fundamental peak alone is dealt with, solving the amplitude criticality problem.

DESIGN METHODOLOGY

The number of sections is chosen to be three for both the standard as well as the proposed design. The length of each section of the standard coupler is made to be $\lambda_0/4$ and the couplings obtained being –8.07 dB (for the center section) and –28 dB (for the outer section). The coupling of the outer sections is loose, while that of the center section is tight, resulting in a –10 dB-coupled output over a broad frequency range. The circuit was fabricated on a 10-mil thick alumina substrate (ε_r = 9.8). The line dimensions corresponding to the coupling are shown in ***Figure 2***.

The proposed three-section coupler has been designed using three λ/12 coupled sections, the coupling coefficients being 0.131 and 0.176 (using Fourier analysis), which corresponds to couplings of –8.5 dB (outer sections) and –10 dB (center section). Here, too, the coupling coefficient of the outer section is different from that of the middle section. The difference between the standard and proposed designs is in the tightness of

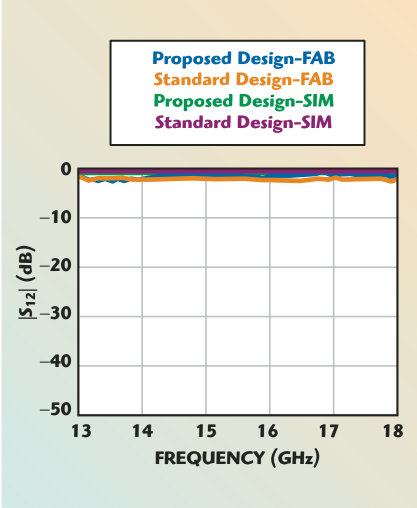


▲ *Fig. 4 Comparison between simulated and measured coupling of the standard and proposed couplers.*

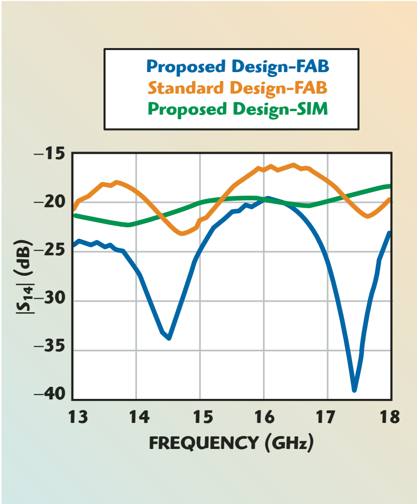
coupling. The proposed design has tight coupling in the outer sections while incorporating loose coupling in the middle section, which is contrary to the standard design. The corresponding dimensions, along with the spacings, are shown in ***Figure 3***.

Simulation

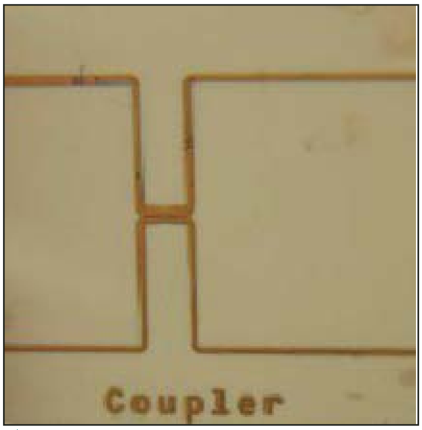
Simulation was carried out using Linmic software,[8] which is basically an electromagnetic analysis tool. The software tool generates the look-up tables at the desired frequencies, taking into account the discontinuities as well as line losses and parasitics and these are used in the simulation. These results are further verified using electromagnetic simulation with Momentum from ADS. The corresponding widths and lengths are found using standard formulae.[4,5] The symmetry of the middle section is maintained by adjusting the line dimensions. The impedance at the outer section is maintained at 57.37 Ω instead of 53 Ω, after optimization.



▲ *Fig. 5 Comparison between simulated and measured insertion loss of the standard and proposed couplers.*



▲ *Fig. 6 Comparison between simulated and measured isolation of the proposed and standard couplers.*



▲ *Fig. 7 Photograph of the proposed structure.*

Visit http://mwj.hotims.com/11714-45 or use RS# 45 at www.mwjournal.com/info

EXPERIMENTAL RESULTS

The fabricated circuit has been tested using a network analyzer (8510C from Agilent). ***Figure 4*** shows the measured and simulated coupling, comparing the standard design with the proposed design in the 13 to 18 GHz frequency range. ***Figure 5*** shows the comparison of the insertion loss, which is better than 2 dB for the proposed design over the wideband range. The connector losses as well as the conductor and radiation losses are included in the measurement. ***Figure 6*** shows the isolation between ports, which is better than 25 dB. A return loss better than 18 dB is achieved over the entire frequency band. These measurements were carried out with a standard jig of dimensions 30.2 × 12 mm. For the circuit to fit within the jig dimensions, the 50 Ω line lengths have been extended by 10 mm at each port, resulting in increased line losses.[6] The circuit size is approximately 2.1 × 0.88 mm. ***Figure 7*** is a photograph of the proposed coupler circuit.

CONCLUSION

The proposed coupler shows a close agreement between the simulated and measured results. The repeatability of the structure was verified. This approach is different from the traditional approach where the middle section is tightly coupled and the outer loosely coupled. An added advantage is a considerable size reduction without compromising the other characteristics. This design approach can be easily extended to higher frequencies for both MIC and MMIC configurations. Because of the present fabrication limitations in MIC, due to etching difficulties to achieve the spacing and tight coupling specifications, only a three-section coupler could be designed and fabricated. However, in the future, as the fabrication limitations are eased, couplers using five or even seven sections for tight coupling can be designed and developed using this novel approach. ■

References

1. G. Matthaei, L. Young and E.M.T. Jones, *Microwave Filters, Impedance-matching Networks and Coupling Structures*, Artech House Inc., Norwood, MA, 1980.
2. D.M. Pozar, *Microwave Engineering*, Second Edition, John Wiley & Sons Inc., New York, NY, 2004.
3. G.D. Vendelin, A. Pavio and U.L. Ulrich, *Microwave Circuit Design Using Linear and Nonlinear Techniques*, John Wiley & Sons Inc., Somerset, NJ, 2004.
4. T.C. Edwards, *Foundations for Microstrip Circuit Design*, John Wiley & Sons Inc., Somerset, NJ, 1981.
5. E.H. Fooks and R.A. Zakarevicius, *Microwave Engineering Using Microstrip Circuits*, Prentice Hall PTR, Upper Saddle River, NJ, 1990.
6. V. Vinayakarohit, K. Singh and R. Ramasubramanian, "Analysis of Coupling Deviation in Broadband Backward Wave Directional Coupler at Higher Frequencies," accepted for oral presentation at INCMARS, India, 2006.
7. Y.L Chow and K.L Wan, "A Transformer of One-third Wavelength in Two Sections– For a Frequency and its First Harmonic," *IEEE Microwave and Wireless Components Letters*, Vol. 12, No. 1, January 2002, pp. 22–23.
8. *Linmic+/N 6.3 User Manual*, AC Microwave, Aachen, Germany.

ADAPTATION OF A GMIC PROCESS TO MICROWAVE OFFICE USING A PROCESS DEVELOPMENT KIT FROM APPLIED WAVE RESEARCH

The glass microwave integrated circuit (GMIC) process, provided by M/A-COM, Tyco Electronics UK Ltd., has been adapted to Microwave Office (MWO) with the Process Development Kit (PDK) from Applied Wave Research (AWR). GMIC elements have been written in C++ and dynamically linked together with suitable simulation models in MWO. Elements such as spiral inductors, thin-film capacitors, Lange couplers and thin-film resistors have been included in the component library. Custom models have been created with the Model Wizard tool from AWR. Model Wizard is used to generate C++ code of models that can be compiled as a .dll file. The adapted component library to MWO has been used in the design of a balanced X-band low noise amplifier. The amplifier is described briefly in this article. If a custom process is adapted to MWO, the development time when designing microwave circuits in the specific process will be reduced. Another important advantage with the PDK is that design errors will almost be eliminated.

Applied Wave Research (AWR) offers customization tools for particular processes to the Microwave Office (MWO) design environment. The tools needed to adapt a custom process to MWO are a text editor, Model Wizard, the Source Development Kit (SDK) and a MS Visual C++ compiler. The MWO plug-in Model Wizard is used to create the source code for custom models. Models can also be included in the Process Development Kit (PDK) as sets of S-parameter files. It is also possible to use existing MWO models. The AWR SDK is needed by the C++ compiler to turn the source code for the models and layout cells into .dll files. A layout cell is implemented by built-in functions in the SDK. Various functions for different geometric shapes exist in the SDK. It is also possible to implement design rules in the source code. Layout cells and models are dynamically linked together by an .xml file in the PDK. The PDK also contains a modified MWO shortcut, an initialization (.ini) file and a layer process definition (.lpf) file. If an MWO-228 license is available, a design rule check (DRC) file can be included in the PDK.

RIKARD ELIASSON, ANDERS SUNDBERG AND ANDERS WALL
SAAB Bofors Dynamics AB
Linköping, Sweden

Schedule at a Glance

Webinars		Dates	Earlybird Deadline & Price		Reg. Price
059-3869	RF Fundamentals	Jun 25-29	Jun 18	$449.00	$499.00
059-3765	RF Fundamentals	Sep 10-14	Aug 31	$449.00	$499.00
187-3766	How to Speak RF (and Wireless)	Oct 15-19	Oct 5	$449.00	$499.00
Burlington, MA		**Dates**	**Earlybird Deadline & Price**		**Reg. Price**
001-3716	Applied RF Techniques I	May 14-18	Apr 9	$1,995.00	$2,195.00
027-3720	DSP Made Simple for Engineers	May 16-18	Apr 9	$1,195.00	$1,295.00
052-3719	Frequency Synthesis and Phase-Locked Loop Design	May 14-16	Apr 9	$1,195.00	$1,295.00
016-3713	Modern Digital Modulation Techniques	May 14-18	Apr 9	$1,995.00	$2,195.00
166-3715	Production Testing of RF and SOC Devices for Wireless	May 14-18	Apr 9	$1,995.00	$2,195.00
186-3721	RF Fundamentals, Modeling and De-Embedding Techniques	May 14-16	Apr 9	$1,195.00	$1,295.00
031-3717	RF Transceiver Architecture, Design and Evaluation	May 14-18	Apr 9	$1,995.00	$2,195.00
151-3718	Security for 802.11 Wireless LAN	May 16-18	Apr 9	$1,195.00	$1,295.00
San Jose/Sunnyvale, CA		**Dates**	**Earlybird Deadline & Price**		**Reg. Price**
135-3773	RF Measurements:Principles & Demonstration	Aug 6-10	Jul 2	$2,195.00	$2,395.00
086-3775	Advanced Wireless and Microwave Techniques	Aug 13-17	Jul 9	$1,995.00	$2,195.00
001-3774	Applied RF Techniques I	Aug 13-17	Jul 9	$1,995.00	$2,195.00
104-3778	Bluetooth: Operation and Use	Aug 15-17	Jul 9	$1,295.00	$1,395.00
027-3782	DSP Made Simple for Engineers	Aug 15-17	Jul 9	$1,295.00	$1,395.00
193-3781	EMC and Signal Integrity Design Strategies	Aug 13-15	Jul 9	$1,295.00	$1,395.00
195-3780	Mobile Broadband Wireless Access	Aug 15-17	Jul 9	$1,295.00	$1,395.00
016-3783	Modern Digital Modulation Techniques	Aug 13-17	Jul 9	$1,995.00	$2,195.00
180-3779	Radio System Design - Theory and Practice	Aug 13-15	Jul 9	$1,295.00	$1,395.00
004-3777	RF and Wireless Made Simple	Aug 13-15	Jul 9	$1,295.00	$1,395.00
194-3805	Silicon BiCMOS for High Speed and Mixed Signal Design	Aug 14-14	Jul 9	$495.00	$550.00
108-3776	Ultra Linear High Efficiency Power Amplifier Design	Aug 13-17	Jul 9	$1,995.00	$2,195.00
Dallas, TX		**Dates**	**Earlybird Deadline & Price**		**Reg. Price**
037-3788	Antennas & Propagation for Wireless Communications	Nov 12-14	Oct 8	$1,295.00	$1,395.00
001-3785	Applied RF Techniques I	Nov 12-16	Oct 8	$1,995.00	$2,195.00
027-3784	DSP Made Simple for Engineers	Nov 12-14	Oct 8	$1,295.00	$1,395.00
052-3787	Frequency Synthesis and Phase-Locked Loop Design	Nov 14-16	Oct 8	$1,295.00	$1,395.00
181-3793	Monolithic Microwave Integrated Circuit (MMIC) Design	Nov 14-16	Oct 8	$1,295.00	$1,395.00
004-3791	RF and Wireless Made Simple	Nov 14-16	Oct 8	$1,295.00	$1,395.00
084-3790	RF CMOS Design	Nov 12-13	Oct 8	$795.00	$895.00
031-3786	RF Transceiver Architecture, Design and Evaluation	Nov 12-16	Oct 8	$1,995.00	$2,195.00
183-3792	Semiconductor Device Physics for RF Design	Nov 12-14	Oct 8	$1,295.00	$1,395.00
085-3794	Short Range Wireless Networks	Nov 13-16	Oct 8	$1,595.00	$1,695.00
176-3795	WiMAX Broadband Wireless Access	Nov 14-16	Oct 8	$1,295.00	$1,395.00
San Jose, CA		**Dates**	**Earlybird Deadline & Price**		**Reg. Price**
003-3801	Applied RF Techniques II	Dec 3-7	Oct 29	$1,995.00	$2,195.00
184-3797	Broadband Wireless Communications:3G/4G, WLAN etc.	Dec 3-7	Oct 29	$1,995.00	$2,195.00
182-3802	EMI/EMC Fundamentals with Emphasis on Shielding	Dec 3-4	Oct 29	$795.00	$895.00
166-3789	Production Testing of RF and SOC Devices for Wireless	Dec 3-7	Oct 29	$1,995.00	$2,195.00
004-3799	RF and Wireless Made Simple	Dec 5-7	Oct 29	$1,295.00	$1,395.00
174-3800	Satellite Communications	Dec 3-4	Oct 29	$795.00	$895.00
151-3803	Security for 802.11 Wireless LAN	Dec 5-7	Oct 29	$1,295.00	$1,395.00
112-3796	Wireless Circuits, Systems and Test Fundamentals	Dec 3-7	Oct 29	$1,995.00	$2,195.00
191-3798	Wireless Technologies for Broadband Access	Dec 6-7	Oct 29	$795.00	$895.00
135-3804	RF Measurements:Principles & Demonstration	Dec 10-14	Nov 5	$2,195.00	$2,395.00

"The instructor was very professional and knowledgable. Great material and lots of information. Looking forward to taking more RF courses from Besser Associates. This was the best RF course I have ever taken!!" Jehu Pineda, Qualcomm

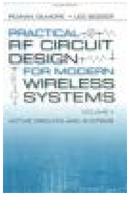
"Excellent technical material and top-notch instructor." Kausalya Palavesam, Texas Instruments

"I really liked the fact that the instructor did a great job of making complex math calculations understandable." Glenn Howell

Besser Associates.com
The Worldwide Leader in RF & Wireless Training

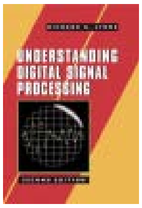
Courses Coming to Boston this May:

Applied RF Techniques I - FREE Book!



Switching from traditional definitions based on voltages and currents, to power-flow concepts and scattering parameters, the course has smooth transition into the wireless domain. We review S-parameter measurements and applications for both single-ended (unbalanced) and balanced circuits and have a brief introduction to RF systems and their components. Impedance matching is vitally important in RF systems and we use both graphical (Smith Chart) and analytical techniques throughout the course. We also examine discrete and monolithic component models in their physical forms, discussing parasitic effects and losses, revealing reasons why circuit elements behave in surprising manners at RF.

DSP Made Simple for Engineers - FREE Book!



This three-day course is the beginner's best opportunity to efficiently learn DSP. Intuitive, nonmathematical explanations and well-chosen examples develop the student's fundamental understanding of DSP theory. The practical aspects of signal processing techniques are stressed over discrete system theory. Participants will leave with a collection of tricks-of-the-trade used by DSP professionals to make their processing algorithms more efficient.

RF Transceiver Architecture, Design and Evaluation

This five-day course provides participants with the engineering tools to architect, design, and test wireless systems. Critical system requirements and specifications will be presented for many advanced wireless standards such as EDGE, GSM, CDMA, CDMA2000, Wideband CDMA, 802.11, 802.16, RF Tags, Bluetooth, etc. Techniques to generate and receive analog and digital signal inputs including: BPSK, DBPSK, QPSK, OQPSK, GSM, p/4 DPSK, QAM, 3p/8-shifted 8PSK, GFSK, OFDMA—as well as their properties will be presented. The various transmit and receiver configurations will be shown and compared so that the appropriate one can be selected for a particular application. Transmitter and receiver nonlinearities will be described with their negative effect on system performance including techniques to meet system specifications. Design techniques for signal generation and reception using digital signal processing and phased locked loops will be shown. Software defined radio technologies will be explored for reconfigurable multi-mode/multi-band applications. Finally, transceiver test and troubleshooting procedures will be described.

RF Fundamentals, Modeling and De-Embedding Techniques

This 3-day course provides technical professionals with the fundamental concepts and engineering tools needed to understand RF fundamentals and test fixture de-embedding techniques. The latest software simulation tools are used to demonstrate these concepts and techniques.

Frequency Synthesis and Phase-Locked Loop Design

This three-day course provides both the theoretical and practical knowledge necessary to design frequency synthesis circuits and systems using phase-locked loops and related technologies.

Modern Digital Modulation Techniques

Modern digital modulation techniques and multiple access techniques have an impact on our everyday life. Techniques such as adaptive modulation and coding methods, OFDM, DMT, CDMA, GMSK, QAM and others, are used in all areas of wireless, cellular, wireline, and satellite communication systems. These modulations are used in Second and Third Generation IMT-2000 Cellular Systems (including GSM, GPRS, IS-95 and WCDMA), and broadband wireless systems (e.g., Hiperlan2 and IEEE802.11) . Modulation and multiple access techniques, as well as new ideas such as MIMO, BLAST and space-time coding, are used at the physical interface of all major transmission systems for data communication. It is thus important to have a thorough understanding of these techniques both for system designers and suppliers of systems, as well as integrators and operators, who make use of the systems.

Production Testing of RF and SOC Devices for Wireless Communications - FREE Book!

A merger of RF and mixed-signal test is upon us with the increasing number of integrated wireless devices being developed with System-On-a-Chip (SOC) technology. Test engineering is becoming an engineering class unto itself. It no longer suffices to be an RF test engineer, or mixed signal engineer or digital engineer. A new breed of engineer, the SOC test engineer, is becoming a necessity. This highly sought after skill set is what is demanded by wireless chip manufactures (Bluetooth, WLAN, 2G, 2.5G, 3G, UWB). This course is the first of its kind to help train the already talented test engineers with the necessary SOC skill sets required for the next generation devices.

Security for 802.11 Wireless LAN

This three-day course addresses IEEE 802.11 wireless local area network security in detail. Aspects of disclosure, data integrity, and denial-of-service threats are presented. Indoor RF propagation physics are used to calculate the extent of eavesdropping and jamming threats to the physical layer. The 802.11 medium access control methods are studied and the numerous threats to this layer are discussed. Next, wired equivalent privacy (WEP) is presented and its weaknesses examined in areas of disclosure, data integrity, and authentication. The IEEE 802.11i-based solutions are discussed, beginning with interim solutions such as temporal key integrity protocol (TKIP), and moving on to stronger solutions based upon the advanced encryption standard (AES). The synergism between Wi-Fi protected access (WPA) and 802.11i is demonstrated. Finally, upper layer authentication and key management as provided by IEEE 802.1X are discussed.

What you learned in school yesterday may not be sufficient in today's world. University education provides only the foundation of what is realistically needed to perform well in the industry. Furthermore, studies reveal that within each 3-5 year period, one-half of an engineer's technical knowledge becomes obsolete.

As a recognized international leader, Besser Associates is dedicated to providing RF and wireless professionals with the training and skills they need to excel at their jobs. Our instructors are top-notch design engineers, well-versed in both technology and the art of teaching. We can customize our courses to meet your specific needs.

Register Online Now—It's Easy!

Besser Associates' On-site Courses can be conducted at any US or International location and any course can be customized to fit the specific needs of your group. Special incentives are available now, please call for details.

BESSER ASSOCIATES™
The Worldwide Leader in RF and Wireless Training

201 San Antonio Circle
Suite 225
Mountain View, CA 94040
Phone: (650) 949-3300
Fax: (650) 949-4400
E-mail: info@besserassociates.com
Web: www.besserassociates.com

BesserNet™
"Training and tools to help you perform your job better"

Visit www.bessernet.com for industry news, applets and our new glossary of RF terms.

Registration Fees

Course fees cover instruction, course material, and refreshments. Lunches, travel, and lodging expenses are not included. Confirmed (paid) registrants receive exact time, hotel and location information. **Please do not make travel plans until you have received confirmation of registration from Besser Associates.**

TABLE I THE GMIC COMPONENT LIBRARY		
Folder	**Component**	**Description**
Components	TFR MRINDSBR MICAP TFCM TFCM PEDESTAL	thin-film resistor spiral inductor interdigital capacitor thin-film capacitor thin-film capacitor placed on pedestal
Lines	MLIN MTEE MCROSS MTAPER MTRACE MLEF MXOVER	microstrip line microstrip tee junction microstrip cross junction microstrip tapered line microstrip meander line microstrip open line microstrip cross-over
Other	AIRBRIDGE PEDESTAL ABPOST EPA018A FOOTPRINT PROBE POINT LANGE COUPLER	airbridge interconnection plated via-hole to ground plane airbridge support pillar footprint for the transistor Excelics EPA018A probe point Lange coupler
Substrates	MSUB MSUB2	microstrip substrate definition two-layer microstrip substrate definition needed for MXOVER

The .ini file specifies additional information, such as file paths to model and layout libraries, that needs to be added to the program on startup. File paths to the .lpf and .xml files are included in the .ini file. The modified MWO shortcut contains the path to the .ini file.[1]

THE COMPONENT LIBRARY

The GMIC process has been adapted to MWO with the PDK. The GMIC process is a circuit technology, which has been under development at M/A-COM since 1985. GMIC provides a broad range of hybrid applications as well as efficient integration. GMIC is a robust fabrication technology capable of meeting the needs for high performance, complex microwave circuits in space, defense and other high reliability applications. M/A-COM offers different techniques of manufacturing GMIC applications. The adapted GMIC library to MWO uses the full glass process since it provides the highest performance and highest design flexibility.[2]

The GMIC substrate consists of a glass wafer laminated to a silicon wafer. The glass layer serves as the microstrip transmission medium and the silicon layer provides mechanical support and creates an integral carrier. Since glass has poor thermal conductivity, the silicon layer provides good heat transfer through the substrate. The composite microwave structure allows the use of standard silicon chemical processing, photolithographic and thin-film deposition techniques. By this method, it is possible to produce two layers of metallization, resistors, capacitors, inductors, conductors, air bridges and plated via-holes.[2]

The elements in ***Table 1*** have been included in the GMIC component library. Dynamic layouts for all of the elements in the table have been constructed with the SDK. Model Wizard has been used to create models for pedestals, airbridge support pillars and probe points. The constructed models were aggregated from MWO schematics. For instance, the pedestal was modeled as a small resistor terminated to ground. The resistance values were found by simulating the pedestal in the High Frequency Structure Simulator (HFSS) from Ansoft. For other elements, the layouts have been linked together with existing MWO models.

A signal analyzer clocked at 5 ms

Buckle up for speed.

Agilent MXA Midrange Signal Analyzer

Marker Peak Search	< 5 ms
W-CDMA ACLR (0.2 dB, standard deviation)	≤ 14 ms
Measurement Mode Switching	< 75 ms
Analysis Bandwidth	25 MHz
Absolute Amplitude Accuracy	0.3 dB
W-CDMA ACLR Dynamic Range	73 dB

Shift gears to what's possible. The new Agilent MXA has broken all speed limits with measurement times **30-300% faster** than other analyzers. Pressure to keep ahead requires driving down test time. The MXA signal analyzer helps you keep the lead with exceptional speed and performance. Stay ahead, find the edge, move it forward.

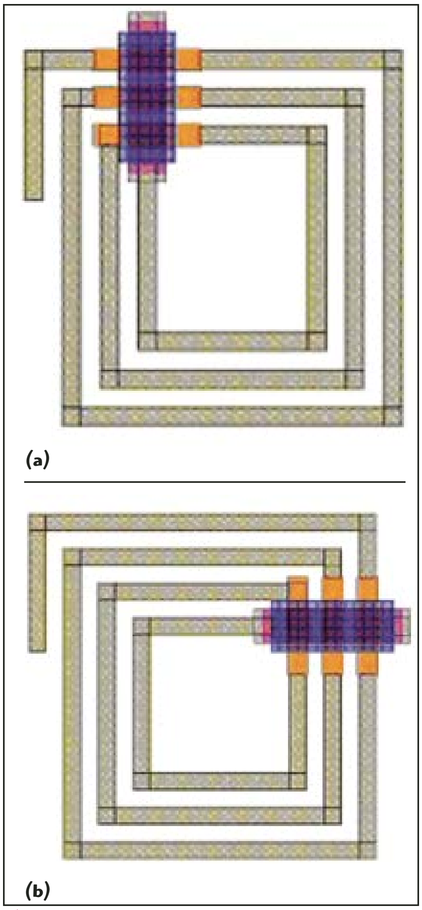
Agilent Open

LXI

To see how the new MXA lets you perform at speeds never before possible, go to www.agilent.com/find/possible1. It's signal and spectrum analysis at the edge of possibility.

u.s. 1-800-829-4444, ext. 5461
canada 1-877-894-4414, ext. 5461
www.agilent.com/find/possible1

Agilent Technologies

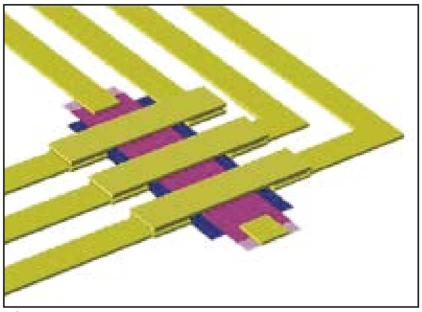


▲ *Fig. 1 Possible bridge locations in spiral inductors; (a) 13 segments and (b) 14 segments.*

The model for the Lange coupler has been modified by Model Wizard. The existing MWO model MLANGE has no parameters that specify the widths of the four feeding lines. In the modified model, the parameters for the four ports have been added to the existing model by Model Wizard. Values of the port widths do not affect the performance of the MWO model. The model for the Lange coupler is only used to generate layouts. To obtain as accurate a model as possible, the Lange coupler needs to be exported to an EM simulator.

Spiral Inductors

GMIC spiral inductors are implemented on the substrate as loops in one of the metallization layers. The inner turn is brought to the outside by a conductor crossing. A conductor crossing is constructed as a thin conductor with a dielectric layer above overlapped by an airbridge. The main motive for the dielectric layer is to prevent a short-circuit if the airbridge is crushed.[3] The existing MWO model of a microstrip spiral inductor (MRINDSBR) has a parameter that defines the number of linear segments. A layout that takes consideration of this parameter has been constructed with the SDK. The layout is valid between 5 and 27 linear segments. Of course, other parameters that define the geometry such as conductor width, outer dimensions and line spacing have also been taken into consideration. The layout has been linked together with the existing MWO model by the .xml library. ***Figure 1*** show the layouts of the spiral inductor for different numbers of linear segments. It can be seen that the location of the bridge varies if the number of linear segments is changed. The MWO model is only used to generate the layouts. Since a spiral inductor is dependant upon electric coupling, the structure needs to be simulated in an EM simulator.



▲ *Fig. 2 3D close-up view of the conductor crossing in a spiral inductor.*

When an arbitrary structure is exported from MWO to an EM simulator, it is possible to preset the 3D properties in the .lpf file. ***Figure 2*** shows a 3D close-up view of the conductor crossing in a spiral inductor. The correct thicknesses of the layers that define the inductor have been specified in the .lpf file.

Thin-film Capacitors

A thin-film capacitor consists of two parallel metal plates separated by a dielectric layer. The bottom plate of the capacitor consists of a thin metal layer followed by a dielectric layer. The top plate of the capacitor consists of one of the metallization layers. An airbridge is used to interconnect the capacitor top-plate with the adjacent conductor.[3] Thin-film capacitors are modeled by the existing MWO model TFCM. ***Figure 3*** shows the created layouts of the thin-film capacitor. If the capacitor width ex-

Halogen-Free	RoHS	Lead-Free
RO4003™ R/flex® 3000 LCP Series TMM® Series	RT/duroid® 5000 Series RT/duroid® 6000 Series R/flex® 3000 LCP Series RO3000® Series RO4000® Series TMM® Series ULTRALAM® 2000	RT/duroid® 5000 Series RT/duroid® 6000 Series R/flex® 3000 LCP Series RO3000® Series RO4000® Series TMM® Series ULTRALAM® 2000

Decomposition Temperature:

	Unit	RO4003C™	RO4350B™	RO3003™	High Tg Epoxy Blends
Td - TGA	°C	425°C	390°C	500°C	300 - 350°C

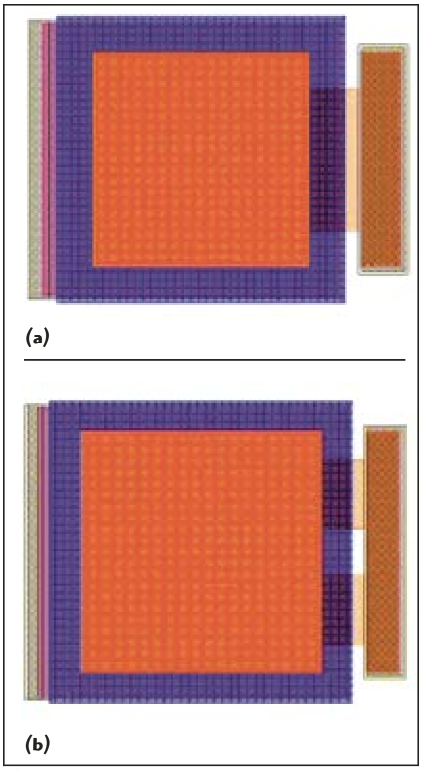
Learn more at **www.rogersgreenworld.com**

ROGERS CORPORATION

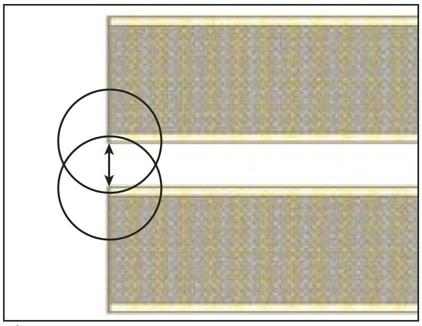
Advanced Circuit Materials

The world runs better with Rogers.

USA - AZ, tel. +1 480-961-1382 • EUROPE - BELGIUM, tel. +32 9 235 3611 • CHINA - SHANGHAI, tel. +86-21-63916088



▲ *Fig. 3 Airbridge configuration in thin-film capacitors; (a) w<maximum allowed airbridge width and (b) w>maximum allowed airbridge width.*



▲ *Fig. 4 Polygon-based design rule violation between adjacent microstrip lines.*

ceeds the maximum allowed airbridge width, the airbridge configuration will be changed. Since airbridges are fabricated by a wet etch process, the airbridges cannot be as wide as possible. When a large airbridge is required, one or more slots must be included in the bridge to increase the span. Geometric properties, such as airbridge configuration and offsets of the layers that define the capacitor, are automatically fixed with the SDK.

To evaluate the Microwave Office model of a thin-film capacitor, the layout has been exported to HFSS from Ansoft. The HFSS simulation tool utilizes the finite element method (FEM) to solve Maxwell's equations in the 3D structure. The results from HFSS showed that the accuracy of the MWO model is excellent in the frequency range from 5 to 15 GHz.

Design Rule Checking

If a MWO 228 license is available, design rule checking is possible to implement in the PDK. Design rules can be included as cell-based or polygon-based checking. Both types of design rule checking have been implemented in the GMIC component library.

The cell-based checks are implemented by overriding a checking function in the parameterized layout cell implementation. Design errors appear as dialog boxes when the check is performed. Rules, implemented as cell-based design rules, check only individual layouts. No interaction between adjacent elements is checked with this feature.[4]

Polygon-based design rules are implemented by built-in functions in MWO using a simple text editor. Rule checks for separation between layers, minimum area, overlap, minimum width, etc., exist in the set of functions. Polygon-based design rules work on arbitrary layout geometries in MWO. With this type of design rule check, it is possible to locate errors in dynamic layouts as well as in static GDSII layouts.[4] ***Figure 4*** shows a polygon-based design rule violation between two adjacent microstrip transmission lines. The spacing between the two lines is too small. As shown in the figure, a polygon-based design rule violation is visualized clearly in the MWO interface. Other types of polygon-based design errors, such as minimum area and overlap violations, are visualized in the same way. For more comprehensive knowledge about design rule checking, see Reference 4.

DESIGN EXAMPLE

The created GMIC component library was used in a master's thesis called "Design of a Balanced X-band Low Noise Amplifier using a GMIC Process."[5] Some of the specified amplifier requirements are listed below:

- Frequency range: 8 to 12 GHz (X-band)
- $S_{11} < -15$ dB
- $S_{21} > 8$ dB
- $S_{12} < -20$ dB

Our Unbounded Horns Deliver Uncommon Performance.

- Multiband, UHF thru Ku
- Flat Gain in Upper 2/3 of Range
- Linear and Circular Polarization

3164-06 3164-07 3164-05

Stable Pattern Behavior and Good Directivity in a Compact Design

The distinctive open-sided, "open boundary" design of our new quadridge horns makes these antennas unique in appearance and performance. Side structures on traditional antennas have been shown to split the main beam. Our open-sided design provides a more stable antenna pattern and better beam directivity.

Need to make linear or circular polarization measurements quickly? These antennas are equipped with dual ports so both orthogonal field elements can be measured simultaneously–without a mechanical positioner.* And for even more efficiency, the multi-octave operating frequency means you don't have to stop for band breaks.

More information is available at: ets-lindgren.com/3164.

Enabling Your Success

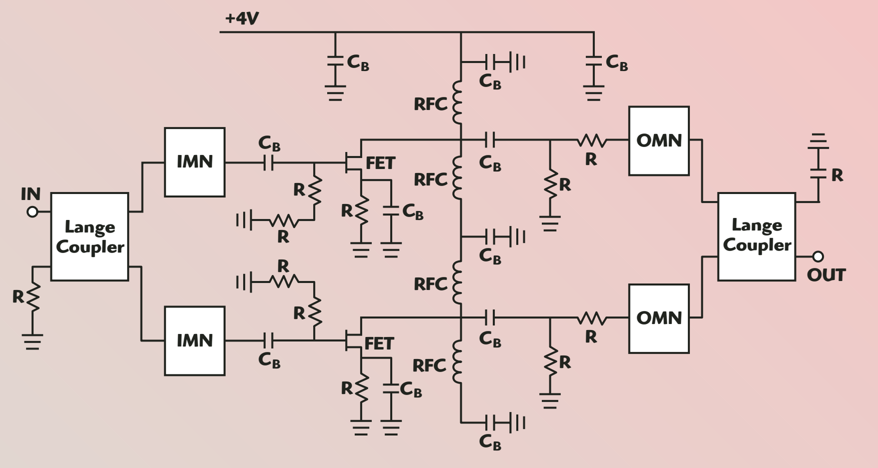
ETS·LINDGREN™

An ESCO Technologies Company

www.ets-lindgren.com

Corporate offices: USA +512.531.6400 and Finland +358.2.8383300
Company locations in the US, UK, Finland, France, Singapore, Japan, China and Taiwan
Representatives and Distributors worldwide

**Requires a hybrid: not supplied.*



▲ *Fig. 5 Schematic of the balanced X-band low noise amplifier.*

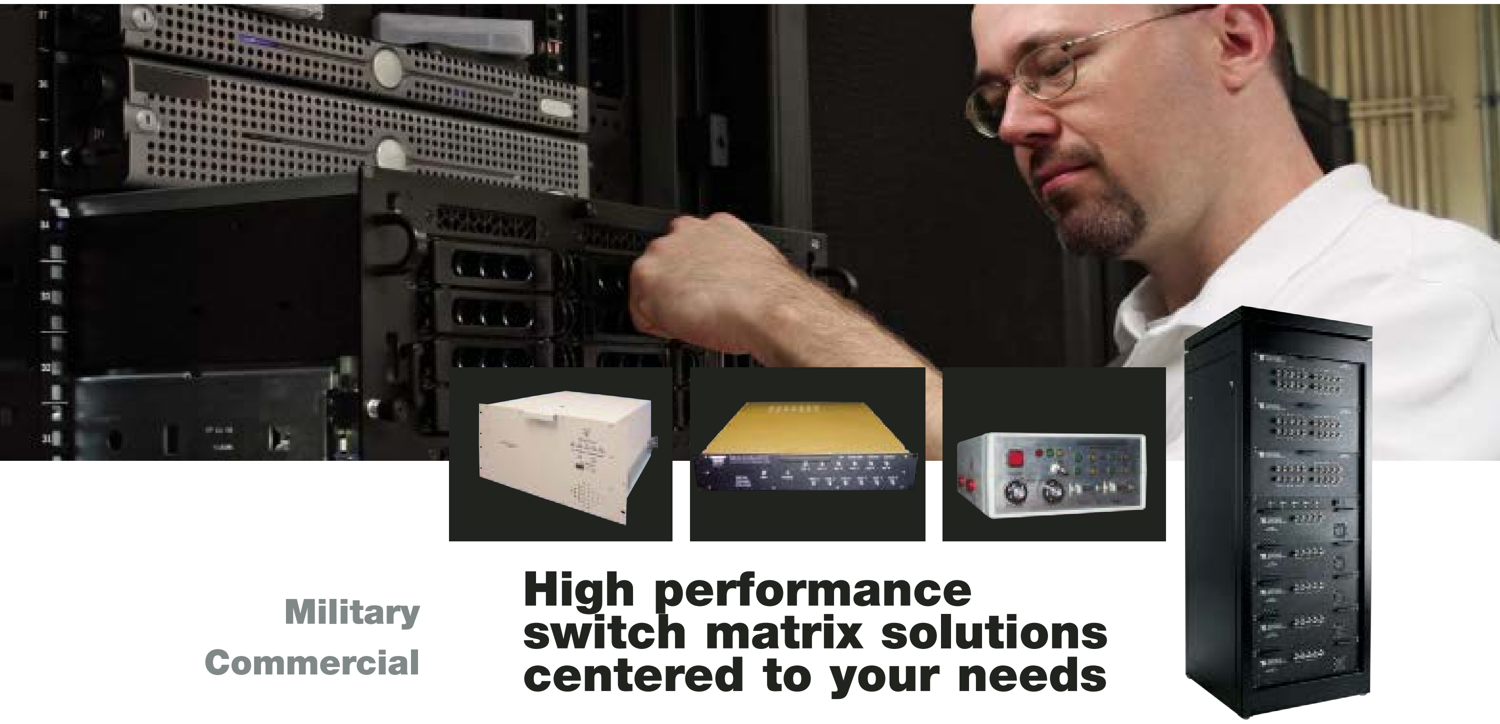
- S_{22} < –15 dB
- NF < 3 dB
- P1dB > 5 dBm
- Gain variation within frequency range: ±1 dB
- Current consumption: < 50 mA
- Supply voltage: +4 V
- The two amplifier branches should be biased from the same DC supply.

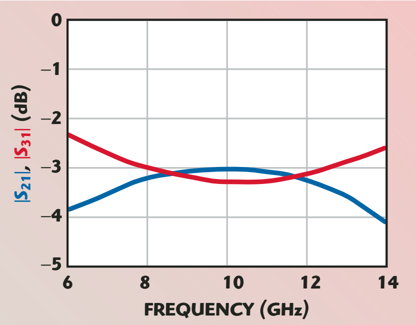
Figure 5 shows the circuit schematic of the amplifier. The selected transistor for the amplifier was the Excelics EPA018A high efficiency heterojunction power FET. The EPA018A has a noise figure of 0.75 dB and an associated gain of 12.5 dB at 12 GHz. S-parameter files measured under specific bias conditions were supplied by the manufacturer. The large-signal model was represented as a Curtice-Ettenburg model in MWO. The large-signal model parameters were provided by the manufacturer.[6]

According to the design specification, the two amplifier branches should be biased from the same DC supply. This problem was circumvented with a DC network, which consists of radio frequency chokes (RFC) and blocking capacitors. The constructed network divides the current contributed by the supply equally between both amplifier branches. The resistors connected to the transistor sources limit the currents through the transistors and give the required bias settings on the gates. Both transistors have been biased with +4 V and 25 mA. An amplifier with this bias settings results in a compromise between class A and class AB operation. The requirements for unconditional stability were satisfied by placing shunt resistors at the inputs and outputs. Series resistors have also been placed at the outputs. According to basic amplifier theory, resistors are preferably placed on the transistor output since the noise caused by a resistor at the input results in amplified noise. No combination without a shunt resistor at the input was found to satisfy the unconditional stability requirements. The resistors at the inputs are also required for the DC bias settings. To compensate the gain variations, input and output matching networks (IMN and OMN) have been included in the design. The main disadvantage with this technique is the poor impedance match. Since the gain is decreased at some frequencies, more power is reflected. A good impedance match is achieved if two identical amplifier stages are placed between two 3 dB 90° hybrids. The incident power wave on the input is equally divided in magnitude but with a phase shift of 90° between the input ports of the two amplifier branches. The output 3 dB 90° hybrid combines the output signals from the two amplifiers by introducing an additional 90° phase shift, thus bringing them in phase again. Lange couplers were used in the design, since they are the smallest microstrip realization of a 3 dB 90° hybrid and can be fabricated with the GMIC process. Signals reflected from the input and output ports of the two amplifier branches are summed together and dissipated in the 50 Ω terminations of the Lange couplers.[7]

Lange Coupler

A Lange coupler has been constructed with the adapted component library of MWO. The Lange coupler consists of microstrip segments interconnected by cross-unders, that is,



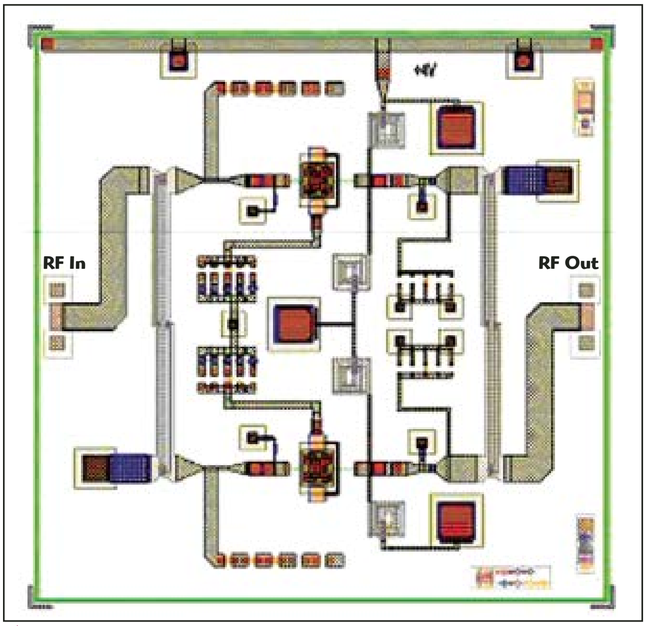


▲ *Fig. 6 Transmissions through the Lange coupler.*

the same type of interconnections as in the spiral inductors. The MWO model was only used to generate layouts of the Lange coupler. The feeding lines were designed with a characteristic impedance of 50 Ω. Optimal dimensions were found by simulating the structure in HFSS. With optimal dimensions, the transmission S-parameters S_{21} and S_{31} shown in ***Figure 6*** were obtained. The results show that the transmission parameters S_{21} and S_{31} are both –3 dB, that is, the magnitude of the incident power on port 1 is equally divided between ports 2 and 3. Another important feature of the Lange coupler is the phase difference of 90° between ports 2 and 3. Since the length of the Lange coupler is λ/4 at 10 GHz, phase differences of 90° at 8 GHz and approximately 92° at 12 GHz were achieved. The 2° difference between the frequencies 8 and 12 GHz can be neglected.

The Balanced Amplifier

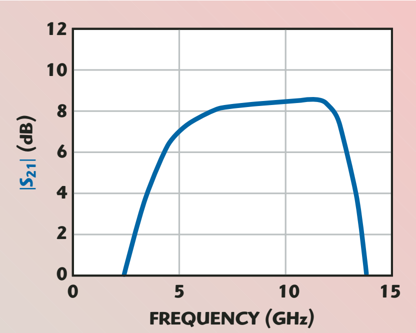
Figure 7 shows the layout of the complete balanced X-band low noise amplifier. The outer dimensions of the amplifier are 9 by 9 mm. All the layout work has been accomplished with the adapted GMIC component library to MWO. Optimal dimensions of the input and output matching networks were found by using the optimization utility in MWO. The input-matching network suppresses high frequencies and the output-matching network suppresses low frequencies. High gain at low frequencies can start undesired oscillations in the amplifier; the output-matching network improves the stability. Tuning options have been included in the resistor networks and in the input and output matching networks. For instance, the source resistance value can be changed if the airbridge interconnection in the middle network branch is moved. To facilitate manual bonding, airbridge support pillars have been added on both sides of the conductor gaps in the resistor networks. The tuning options in the matching networks were implemented in the same way. The 50 Ω resistors terminating the Lange couplers were designed with the same width as the feeding lines. A 50 Ω resistor with smaller dimensions than the implemented resistor required an impedance transformer to minimize the discontinuity introduced at the interface of the Lange coupler. The additional length added by the impedance transformer reduced the performance of the balanced amplifier, since the phases of the reflected signals were changed in the 50 Ω terminations. The motive for the RFC (the spiral inductor) and the blocking capacitor placed on the lower amplifier branch is to ensure that the output ports of the two branches are seeing equal impedances. According to the balanced amplifier performance, the amplifier has



▲ *Fig. 7 Layout of the balanced X-band low noise amplifier.*

TABLE II
SIMULATED RESULTS

Parameter	Simulated Result
Frequency range (GHz)	8 to 12
S_{11} (dB)	< –22
S_{21} (dB)	> 8.4
S_{12} (dB)	< –24
S_{22} (dB)	< –28
NF (dB)	< 2.3
P1dB (dBm)	> 12.7
Gain variation within frequency range (dB)	±0.3
Current consumption (mA)	50
Supply voltage (V)	+4



▲ *Fig. 8 Gain of the balanced amplifier.*

been designed to be as symmetrical as possible.

Simulations

Table 2 contains some of the simulated results of the balanced amplifier. As shown, all of the amplifier requirements have been satisfied. According to the design specification, the 1 dB compression point P1dB should be greater than 5 dBm. The amplifier delivers linear output powers up to approximately 13 dBm. One of the reasons for this feature is the balanced amplifier configuration. A balanced amplifier delivers twice the output power of a single amplifier branch.

The poor impedance matches in the single branch amplifiers were heavily reduced by introducing the Lange couplers in the design. As shown in the table, S_{11} and S_{22} have magnitudes less than –22 and –28 dB, respectively.

As shown in ***Figure 8***, the gain requirements have been satisfied. The flat and broadband frequency response was achieved by the frequency compensated matching networks placed on the inputs and outputs of the amplifier branches.

CONCLUSION

With a basic knowledge in C++ programming, it is possible to adapt a custom process to MWO with the PDK. Instead of designing microwave circuits with manually implemented static layouts, the PDK is a convenient way to make dynamic layouts. If a custom process is adapted to MWO, the development time when designing microwave circuits in the specific process will be reduced. Another important advantage with the PDK is that design errors will almost be eliminated. When the design work of the balanced low noise amplifier was finished, the layout was submitted to the manufacturer M/A-COM. The layout was reviewed for manufacturability only. Since no design errors were found, the adaptation of the GMIC process to MWO was considered successful. ■

ACKNOWLEDGMENTS

The authors gratefully acknowledge Mats Eriksson at MTT AB for providing the Microwave Office 228 license and the PDK tools. Rikard Eliasson would also like to express appreciation to his colleagues within the Microwave and Proximity Fuze Technology Development Group at SAAB Bofors Dynamics AB in Linköping, Sweden, for their supervision and support.

References

1. Applied Wave Research, "AWR PDK Training.zip," Various PDK Presentation Materials from MTT AB, May 2005.
2. A. Buckle and A. Paffard, "GMIC-Glass Microwave Integrated Circuit, a Wafer Level Technology for Improved Performance of Microwave Components and Subsystems," M/A-COM Ltd., ESA WPP-063, May 1993.
3. L. Christie, "GMIC Process Overview," Tyco Electronics UK Ltd., M/A-COM Division, 2003-10-31 (restricted property of M/A-COM).
4. Applied Wave Research, *Microwave Office User Guide*, V5.5, July 2002.
5. R. Eliasson, "Design of a Balanced X-band Low Noise Amplifier Using a GMIC Process," MSc Thesis, LITH-ITN-ED-EX-06/007-SE, February 2006.
6. Excelics Semiconductors Inc., "Data Sheet for the Transistor EPA018A," www.excelics.com/p018a.pdf, accessed 21st September 2005.
7. G. Gonzalez, *Microwave Transistor Amplifiers-Analysis and Design*, Second Edition, Prentice Hall, Upper Saddle River, NJ, 1997.

A NEW GENERATION OF NETWORK ANALYZERS

Given the increasing pressure on engineers to speed the R&D process, maximize manufacturing throughput and reduce cost, the need for flexible, highly integrated test and measurement solutions has now been thrust firmly into the spotlight. For engineers developing and manufacturing RF and microwave frequency components, particularly amplifiers, mixers and converters, for the aerospace and defense, satellite, broadband wireless access and wireless communications industries, that need has become all the more acute. Utilizing a new generation of network analyzer that not only delivers the highest performance and accuracy, but that can also be configured for various measurement scenarios, now offers these engineers a viable way to address the challenges they face.

DEFINING THE NEXT GENERATION

While conventional network analyzers can effectively be used to measure active devices like amplifiers, mixers and converters, they fail to provide the accuracy, ease-of-use and speed that today's R&D and manufacturing engineers crave. Such functionality is extremely important in the wireless communications industry where time-to-market can often make the difference between a company's ultimate success or failure. Consider, for example, that in manufacturing any delay in throughput or decrease in yield can have a tremendous impact on a company's bottom line in terms of both time and cost. Consider also, that use of a conventional network analyzer to perform a range of measurements on a number of different components can be a slow and tedious process, complicated by the need to continually re-arrange the test equipment setup. Today's engineers now demand a faster, more efficient alternative.

What is required is a new type of integrated network analyzer—capable of measuring active as well as passive devices—and that offers functionality equivalent to having multiple tools in one box. It must be able to make lots of measurements quickly and with great accuracy. Additionally, it must be defined by the following characteristics:

- High available power to provide the larger signals needed; for example, to drive an amplifier into its compression region.
- Low source harmonics to test amplifiers for harmonic distortion or intermodulation distor-

AGILENT TECHNOLOGIES INC.
Santa Rosa, CA

Millimeter Wave Vector Analysis

Modules from 50 GHz and above

.325 to .500 THz available now*

OML VNA products extend

☑ *Agilent PNA and 8510 systems*

☑ *Anritsu Lightning and Panorama systems*

Plug & Play feature

- ☑ **Two T/R modules—"S" parameters measurement**
- ☑ **One T/R and one T module—1 path 2 port ("S11" and "S21") measurement**
- ☑ **One T/R or S and one T module—antenna and materials characterization**
- ☑ **One T/R or S and one T2 module—antenna polarization testing**
- ☑ **All OML VNA modules can be upgraded to a higher configuration**
- ☑ **OML offers a complete line of waveguide VNA calibration kits**

*.500 to .750 THz under development

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

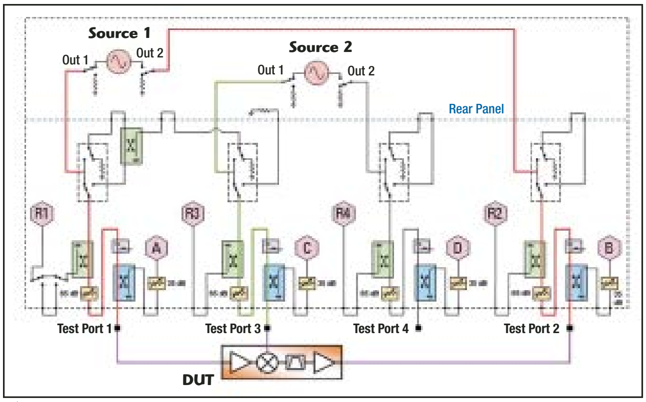


Fig. 1 The second internal source is used here as a fast fixed or swept LO signal for conversion loss or conversion gain measurements of frequency converters and mixers.

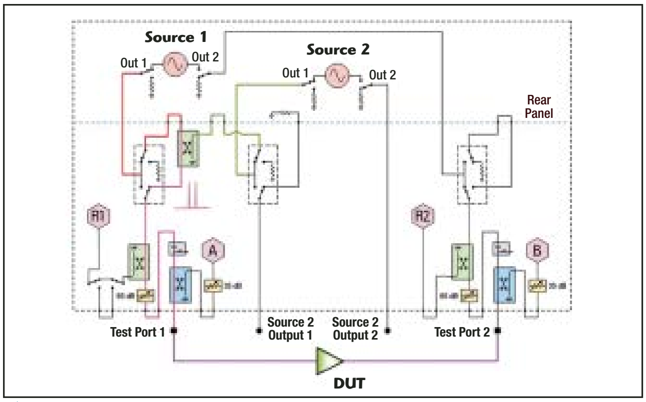


Fig. 2 In this configuration, the PNA-X analyzer's two sources are combined internally and routed out of test port 1 for intermodulation distortion measurements.

tion (IMD) performance. Additionally, the combination of high output power and low harmonics results in simplified setup since it reduces the need for external amplifiers and filters.

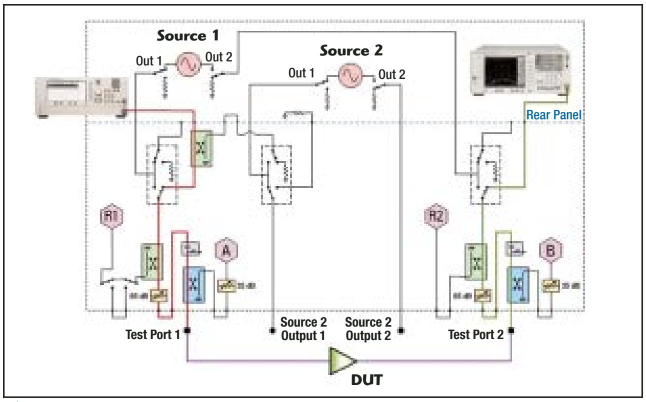
- High stability level to reduce the number of calibrations, thereby saving time and increasing measurement confidence.
- Excellent gain compression to improve measurement accuracy, especially at high power levels where, if the network analyzer is not well specified, it may inadvertently contribute error to the measurement of amplifier compression.
- Integrated pulse hardware to simplify the setup for making pulsed S-parameter measurements. With integrated pulse modulators and pulse generators, the need for anything external to the network analyzer to make this measurement is eliminated.
- A second RF signal generator for measuring amplifiers, mixers and frequency converters. A second signal source provides a convenient and fast local oscillator (LO) signal for exceptionally quick fixed-IF tests of converters and mixers, and it can be used as one of the RF signals in an amplifier IMD measurement.
- An internal source-combining network to eliminate the need to find and hook up an external combiner with the right frequency range, thereby making it easier for engineers to perform IMD measurements on amplifiers and converters and saving valuable time. With the internal combiner, S-parameter and IMD tests on components can be performed without having to change the test setup.
- A configurable signal routing architecture to provide the engineer with the flexibility to make a range of measurements with multiple pieces of test equipment via a single connection to the DUT. It is no longer necessary therefore to modify the test equipment setup to make additional measurements beyond those that can be done with the network analyzer. For example, an external signal generator with digital modulation capability and a vector signal analyzer can be switched to the inputs and outputs of an amplifier to make additional measurements such as adjacent-channel power ratio (ACPR), error-vector magnitude (EVM), or complementary cumulative distribution function (CCDF). The flexible architecture also makes it easy to add external signal-conditioning hardware such as filters and booster amplifiers.

A NEW PREMIER-PERFORMANCE NETWORK ANALYZER

The N5242A PNA-X is a new premier-performance network analyzer from Agilent Technologies for testing components from 10 MHz to 26.5 GHz. It not only delivers all of the previously detailed functionality, but also features an unsurpassed combination of speed and accuracy. Because it is configurable, it provides engineers with flexibility never before possible. The result is higher levels of test integration, the ability to work with higher frequencies, and reduced setup time, measurement complexity, time to make measurements, and test costs.

The new PNA-X boasts all of the same core functionality of the existing PNA series, such as advanced connectivity via LAN, USB and GPIB; an easy to use Windows®-based open architecture; an embedded help system; a frequency converter measurement application (FCA); automatic port extensions; and an optional ECal feature for precision, single connection electronic calibration. It also offers a host of new features, which include:

- Improved source performance that provides higher output power and low harmonics to simplify setup by reducing the need for external amplifiers and filters. A receiver compression spec of 0.1 dB at +12 dBm improves accuracy at high power levels, while high stability reduces the number of calibrations, thereby saving time and increasing measurement confidence.
- An internal second source for convenient setup and fast, fixed-IF converter tests, and for amplifier tests such as intermodulation distortion. Using the integrated second source is typically about thirty times faster than using an external source, providing exceptional test throughput. The PNA-X is the only two-port network analyzer available with an internal second source. With a four-port analyzer, the second source can be used to make match-corrected conversion gain measurements as well as match measurements of all three DUT ports (see ***Figure 1***).
- The PNA-X is the most configurable network analyzer with the highest number of RF access points, built-in combiner and internal pulse modulators, and generators for flexible, single connection measurements. It is the only network analyzer with internal pulse modulators and generators for fast, simplified pulse measurements. The internal source-combining network eliminates the need to find and hook up external combin-



▲ *Fig. 3 An example of a digitally modulated source and a vector signal analyzer switched in to measure ACPR, EVM and CCDF.*

ers, thereby simplifying measurement setup (see ***Figure 2***).

The PNA-X also provides internal switches for connecting the DUT to external instruments, such as a digitally modulated signal generator and a signal analyzer (see ***Figure 3***). The internal switches allow quick and efficient measurement transitions between S-parameters, IMD and many other measurements. They also enable alternate measurement paths, re-routing of signal paths and the addition of amplifiers, filters and attenuators to optimize system setup. The internal pulse modulators and generators enable a simple and fast setup and increase measurement speed by eliminating GPIB control of external pulse generators.

- The improved user interface features a large, touch-screen controlled front-panel display and an improved front-panel-keypad layout. The large display makes it easy to read multiple measurements at the same time, while the touch screen enables easy operation without a mouse. Additionally, eight soft keys plus a user definable key and a new hard key layout further simplifies the network analyzer's operation.

Using Agilent's new PNA-X network analyzer, today's engineers now have the flexibility and performance they demand. R&D engineers are better able to solve design challenges faster and with less iteration, while manufacturing engineers can realize increased throughput and yield, as well as reduced test costs. ***Table 1*** lists some of the PNA-X network analyzer's key performance characteristics.

TABLE I

N5242A PNA-X PERFORMANCE CHARACTERISTICS

Frequency range	10 MHz to 26.5 GHz
Dynamic range	> 130 dB at 24 GHz
Trace noise (@ 1 kHz IF BW)	< 0.0006 dB at 22.5 GHz
Output power	> +16 dBm at 24 GHz
Source harmonics	< –60 dBc at 24 GHz
0.1 dB receiver compression	> +12 dBm at 20 GHz
Power sweep range (ALC)	> 40 dB at 24 GHz

CONCLUSION

Agilent's new PNA-X premier-performance network analyzer is an integrated solution that reduces setup time and the time to make a variety of measurements, while also delivering an exceptionally high level of accuracy compared to existing network analyzers currently on the market. Its ease-of-use and flexibility now enables engineers to measure a broad range of high performance, leading-edge components, including amplifiers, mixers and converters, via a single connection. Such features make Agilent's new PNA-X network analyzer the ideal choice for addressing the challenges facing today's R&D and manufacturing managers and engineers developing and manufacturing RF and microwave frequency components for the A/D, satellite, broadband wireless access and wireless communications industries. Additional information may be obtained at www.agilent.com/find/pna-x.

Windows® is a US registered trademark of Microsoft Corp.

Agilent Technologies Inc., Santa Rosa, CA (800) 829-4444, www.agilent.com.

RS No. 305

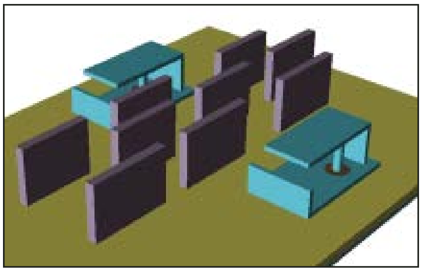
A SOFTWARE PACKAGE FOR ELECTROMAGNETIC DESIGN OPTIMIZATION

Computer simulation is essential for the rapid design of efficient RF and microwave components. Not only can 'what if?' questions be posed and answered—sometimes in seconds—but once a viable design concept has been identified it can be optimized to achieve cost and performance targets.

To facilitate this, parametric modeling has been introduced as a standard feature in the latest release of Vector Fields' Concerto electromagnetic design package, Series 6. This feature is further supported by enhanced optimization tools specifically aimed at the type of objective functions required for RF and microwave systems.

In this article, two applications are discussed to highlight the way in which the new software can speed virtual prototyping: antenna diversity and coaxial connector design. The Finite Difference Time Domain method is used for these examples, but Series 6 also includes the options of Finite Element and Method of Moment analysis methods that operate from the same model, providing designers with choices of solver to speed certain simulations, such as cavity modeling or antenna installed performance.

Fig. 1 Geometry of a pair of PIFA antennas with baffles in place.



OPTIMIZING ANTENNA DIVERSITY

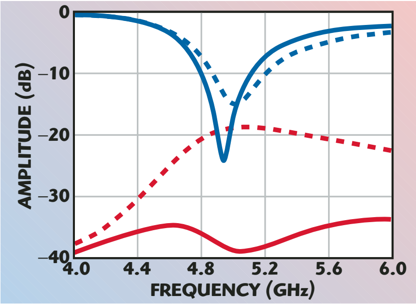
Minimizing coupling between elements of an antenna array intended to provide spatial or polarization diversity provides a topical demonstration of the new tools. Increasingly in wireless applications, multiple antennas are being used to improve performance. However, this depends on the antennas performing independently, and simply moving the antennas apart to improve isolation is not an option in most cases.

In the example design consisting of a pair of planar inverted-F antennas (PIFA) sited in close proximity (see ***Figure 1***), the individual antenna dimensions have been optimized for 5 GHz operation. This structure was selected to achieve a small size without using a high dielectric constant material, to make it less sensitive to material and temperature variations.

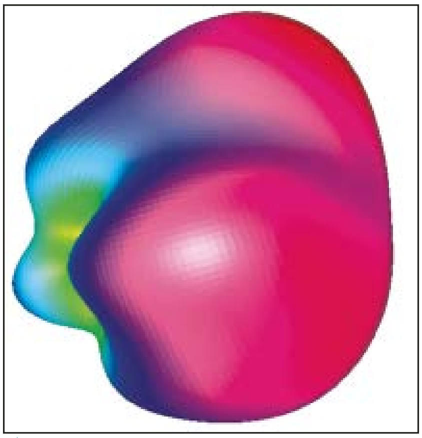
The initial design of the PIFA antennas was created using Concerto's built-in modeler. Most elements are simple shapes, and can be easily drawn with the aid of a new sketching facility

VECTOR FIELDS LTD.
Oxford, UK

YOUR SINGLE SOURCE...
RF Microwave Connectors & Cable Assemblies
TNC
BMA
BMAM
SMP
SMPM
SMPSM
Cable Assemblies
2.92mm
2.4mm
SMA
SSMA
MCX
MMCX
Type "N"
USA
As a leader with over 20 years experience in interconnect solutions we offer the broadest range of RF & microwave DC-60GHz connectors and cable assemblies in the industry. For a comprehensive view of our products and specifications, and to order our new 350 page product catalog, please visit our updated website at www.dynawave.com or contact your local representative.
NEW
CATALOG & WEBSITE!
RF Microwave Connectors and Cable Assemblies
dynawave
dynawave INCORPORATED
Dynawave Incorporated ISO 9001. Certificate No. A4851
UL REGISTERED FIRM
135 Ward Hill Ave., P.O. Box 8224, Haverhill, MA 01835 U.S.A.
Tel 978.469.0555 Fax 978.521.4589 sales@dynawave.com
Visit http://mwj.hotims.com/11714-40 or use RS# 40 at www.mwjournal.com/info



▲ *Fig. 2 Return loss (blue) and inter-element coupling (red) for a pair of PIFA antennas with (solid) and without (dotted) periodic baffles.*



▲ *Fig. 3 Final 3D radiation pattern for a PIFA antenna.*

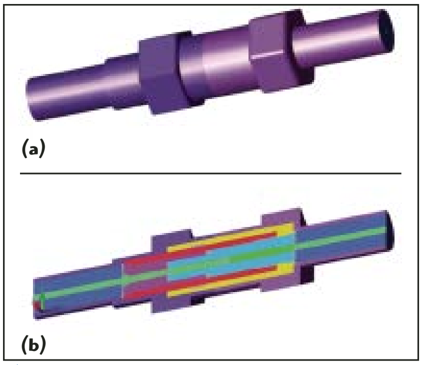
that allows primitives to be created using only a mouse, for speed.

In this case the PIFA antenna had been built previously and stored as a library item. The antenna component was imported and copied to make the pair, before a baffle structure was created using the modeler to minimize antenna coupling.

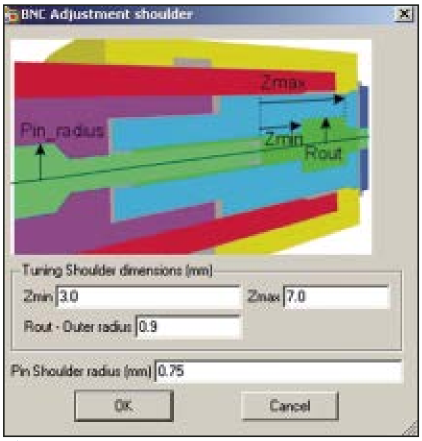
After the initial design had been created, for flexibility of optimization, key dimensions were then redefined as parameters rather than fixed values. This was achieved by simply going back through the recorded list of actions, selecting the relevant drawing operation and changing any value(s) to Model Dimension(s). Once this change was made, the subsequent actions were then automatically re-run to create the new completed model.

An initial solution was run using the new Adaptive Meshing option. The mesh was refined until the user's specified accuracy was achieved. The mesh can also be refined manually by adding extra constraints on cell size anywhere within the model.

A periodic structure of metal baffles was then inserted to minimize the coupling between the antennas. This acts as a filter suppressing the propagation of energy between the PIFA elements. The separation and length of the metal baffles were then set as parameters, which were varied to tune the filter.



▲ *Fig. 4 Geometry of a coaxial connector; (a) 3D view and (b) cut-away view.*



▲ *Fig. 5 Dialog screen to set parameter values when reading connector macro file.*

In this example the Objective Function was defined to be the minimization of S_{21}. The parameters were given initial values as well as a range of values that each could take (that is, constraints based on maximum possible limits, and to ensure they did not overlap).

The Optimizer Tool was able to automatically find the 'best' solution, reducing the coupling by 20 dB, while maintaining good radiation pattern characteristics. The return loss and inter-element coupling are shown in ***Figure 2***, both with and without the baffles in place. The radiation pattern of the design is shown in ***Figure 3***.

Figure 2 also shows that by adding the periodic structure, the antenna has become slightly detuned. Depending on the design criteria, it may be necessary to include a subsequent optimization to retune the antenna to achieve the required performance.

COAXIAL DEVICE DESIGN

Simulation and optimization of coaxial connectors provides another good example of the features of Series 6. A new entry-level version of the software called Concerto AS (axisymmetric) for coaxial device design can be used to simulate complex structures in just a few seconds. Combining this module with Concerto's optimization tools makes it possible to achieve RF performance targets in minutes.

Concerto AS has a 2D Finite Difference Time Domain solver specifically aimed at coaxial device analysis. The functionality of the tool is tailored around this objective, resulting in an inexpensive product for automating the design of devices such as coaxial connectors, as the following example illustrates.

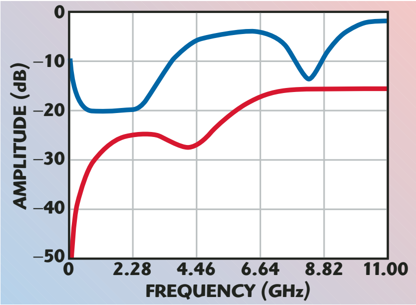
Concerto AS includes full parametric modeling facilities plus optimization options. For flexibility, models are initially constructed using the same 3D geometric modeler as the full version of the software. This provides a simple upgrade path should a user wish to analyze the effects of non-axisymmetric manufacturing tolerances, for example, or would like to optimize full 3D devices.

As an example, a coaxial connector (shown in ***Figure 4***) has been created using a macro. By running the macro within the modeler, the various parameters are prompted (see ***Figure 5***), after which the model is created. This allows manual design studies to be performed quickly and easily.

Creation of the macro is straightforward, and is usually achieved by first building the model using the 3D modeler facilities, and saving the list of commands into a file. This can immediately be used as a macro file, and all the commands can be replayed by loading the file into the modeler. The macro file can be further edited by the user to add commands or controls, if the application is likely to occur routinely.

The parameters are defined as described earlier, but this time are used within the macro file as a way to prompt the user for values each time the macro is run. In this way, it takes little or no expertise to run a whole series of solutions just by giving the appropriate values.

Again, the user can employ the Optimization Tool to automate the



▲ *Fig. 6 S_{11} for coaxial connector before (blue) and after (red) optimization.*

process of finding the best solution within a given range of parameter values. After having created the initial model, the simulator is launched and the Optimizer Tool selected, thus taking advantage of the new facility offered by Series 6 to set design goals for several parameters simultaneously. The Objective Function is defined (in this case minimizing S_{11} over the 0.1 to 11 GHz frequency range), and the four variables are all allowed to change, each with a different range of allowed values. The initial and final plots of S_{11} are shown in ***Figure 6***.

The 2D simulation approach used means that each solution is extremely fast, taking typically four seconds for each optimization step in this particular example. This means that optimizing a number of variables is perfectly feasible (compared with the time that might be required for a 3D simulation). A wide variable space can also be searched to get an optimal solution. After this is found, a few final optimization steps with the inclusion of small 3D features can then be performed to obtain the best solution—even for 3D structures.

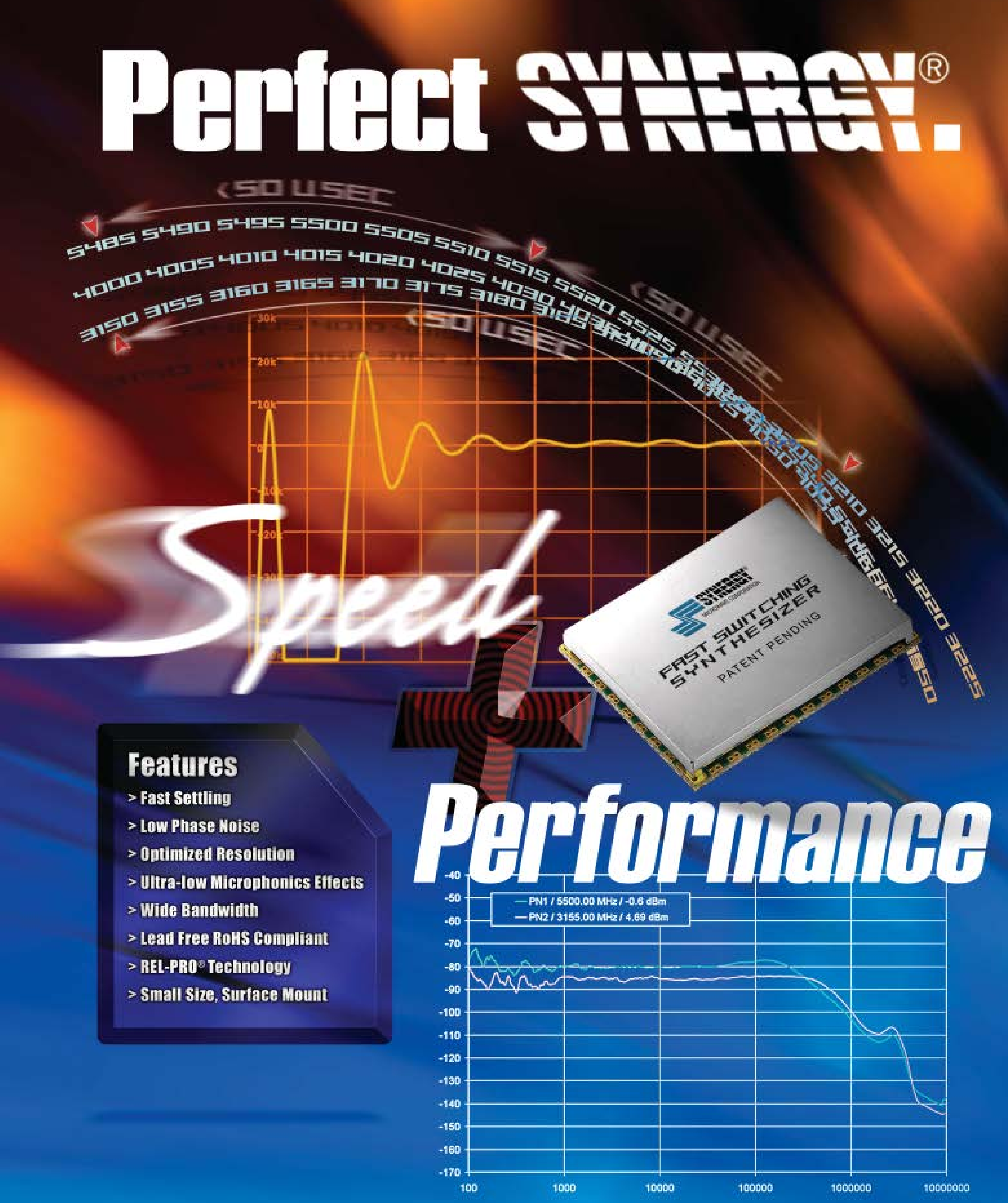
CONCLUSION

With Concerto Series 6, new features make the creation and optimization of real structures both practical and fast. A new sketching facility, context sensitive menus, and the ability to store and re-load library items (including those created in other CAD systems) all help to speed the model creation process, and makes it particularly easy for designers who routinely create variations of similar products, such as antennas. For full 3D structures, parameterization combined with automatic, multi-goal optimization, allow users to reduce costly design iteration cycles, and achieve the optimal solution much faster. In addition, for large analyses, sophisticated Pause, Freeze and Resume functions provide users with control over their PC.

Also, a new choice of solvers—all working from the same model—provides the best tool for each application. This choice extends to a new 2D version of the FDTD solver aimed at axisymmetric devices such as coaxial connectors, providing an upgradeable entry point to advanced electromagnetic virtual prototyping that can create and optimize designs in a matter of minutes.

Vector Fields Ltd.,
Oxford, UK +44 (0)1865 370151,
e-mail: info@vectorfields.co.uk;
Vector Fields Inc.,
Aurora, IL (630) 851-1734,
e-mail: info@vectorfields.com,
www.vectorfields.com.
Vector Fields is a Cobham group company.

RS No. 300


Perfect SYNERGY®
Speed
+
Performance
Features
> Fast Settling
> Low Phase Noise
> Optimized Resolution
> Ultra-low Microphonics Effects
> Wide Bandwidth
> Lead Free RoHS Compliant
> REL-PRO® Technology
> Small Size, Surface Mount
FAST SWITCHING SYNTHESIZER
PATENT PENDING
<50 uSEC
PN1 / 5500.00 MHz / -0.6 dBm
PN2 / 3155.00 MHz / 4.69 dBm

CELLULAR-BAND RF VECTOR SIGNAL GENERATOR LAUNCHES NEW PRICE AND PERFORMANCE STANDARDS

For some time now, test and measurement (T&M) industry leaders have produced exceptional RF vector signal generators (VSG) with wide frequency coverage, superb specifications and a rich feature set. These fine instruments can truly be used for just about any conceivable application… as long as you have the budget.

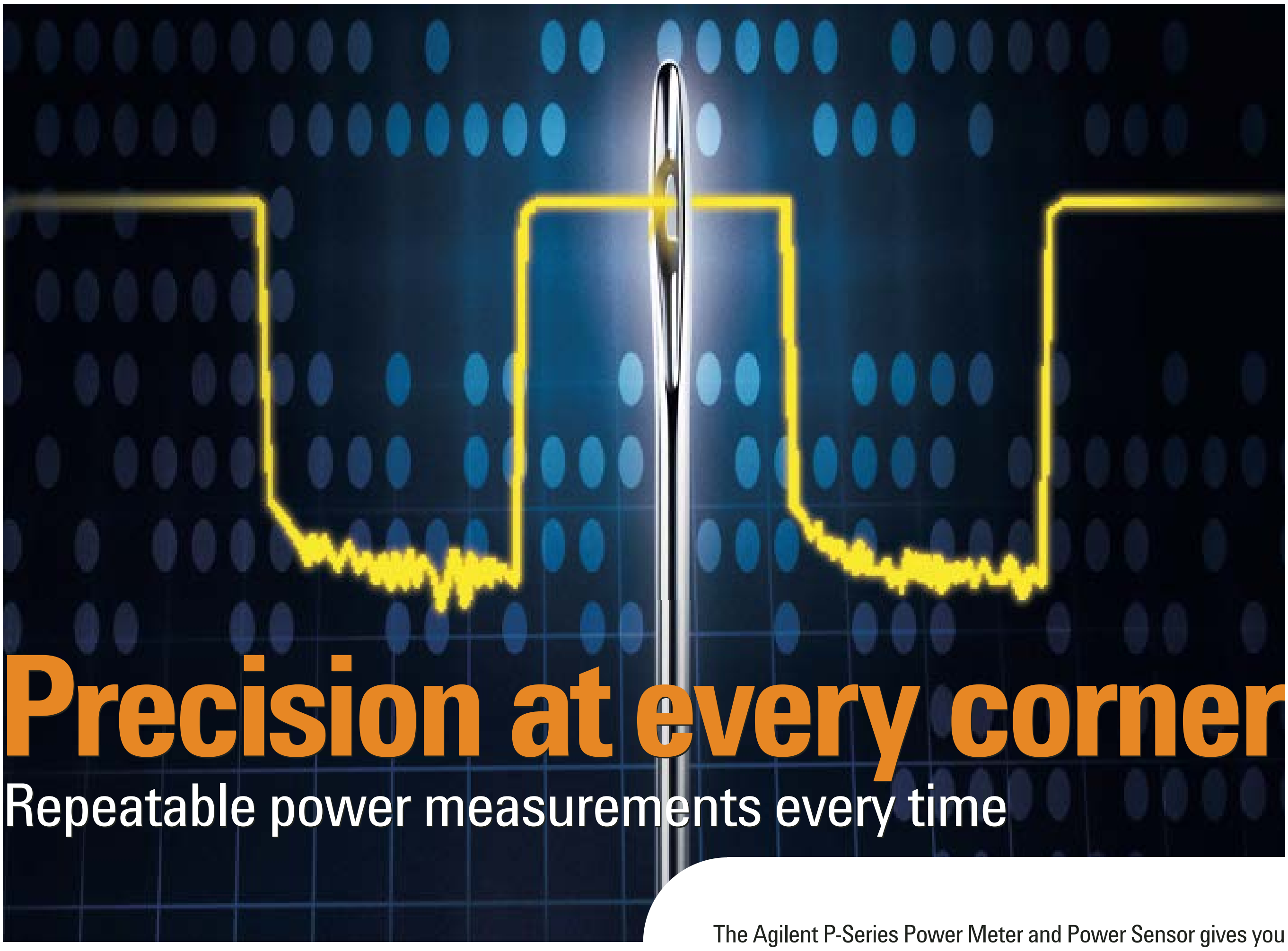
In the exploding cellular and wireless markets, the full power and flexibility of the traditional VSG is often underutilized. The exclusive use of digital modulation renders AM, FM, ΦM, pulse and simultaneous modulation modes largely superfluous. In addition, the majority of the VSG frequency range goes unused, as engineers tend to generate signals only within their device's FCC-assigned frequency bands. Many customers are being forced into buying much more instrument than necessary, just to get the specific features and performance they really need. precisionWave® Corp. is changing all that with the launch of its high performance, low cost line of RF vector signal generators.

Priced at $11,500 US, precisionWave's internally modulated model p1511A creates EDGE signals with an average rms EVM typically below 0.8 percent. This performance is achieved in part by low phase noise, typically less than –100 dBc/Hz at 20 kHz offset for a 1 GHz signal.

While ***Figure 1*** reveals that the p1511A's phase noise performance is not quite as good as the performance of a $42,000 VSG, both signals are well within the allowable spectral mask for an EDGE signal. Without compromising signal quality, the cost savings are significant.

Throughout the instrument's 800 to 1000 MHz and 1700 to 2200 MHz frequency range, available output power is –100 to +20 dBm, with less than –80 dBc spurious. Harmonics are less than –50 dBc in the low band and below –40 dBc in the high band.

PRECISIONWAVE CORP.
Colorado Springs, CO



The Agilent P-Series Power Meter and Power Sensor gives you exactly what you need in making power measurements; a steady hand and a sharp eye.

The fast sampling rate of 100 MSa/s and a 30 MHz video bandwidth ensures that no anomaly goes undetected. As you connect to each DUT, the P-Series internal zero and automatic calibration features not only reduce set-up time, but also the wear and tear on connectors. Set it up once and it's done. And at 55 dB, the peak power dynamic range gives you the accuracy and reliability you need.

The P-Series is a measurement tool you can count on to thread your way through today's electronics. Look into all their full capabilities at www.agilent.com/find/powermeter.

Agilent P-Series Power Meter and Power Sensor

- *100 MSa/s continuous sampling rate*
- *30 MHz wide video bandwidth*
- *Internal zero and automatic calibration features*
- *55 dB widest peak power dynamic range*

Now with WiMAX & HSDPA Presets

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

www.agilent.com/find/powermeter

**Take advantage of a 20% credit against the EPM/EPM-P Series or P-Series Power Meter when you trade in any 435B, 436A, 437B, or 438A unit. Available until 31 December 2006.*

Agilent Technologies

Visit http://mwj.hotims.com/11714-11 or use RS# 11 at www.mwjournal.com/info

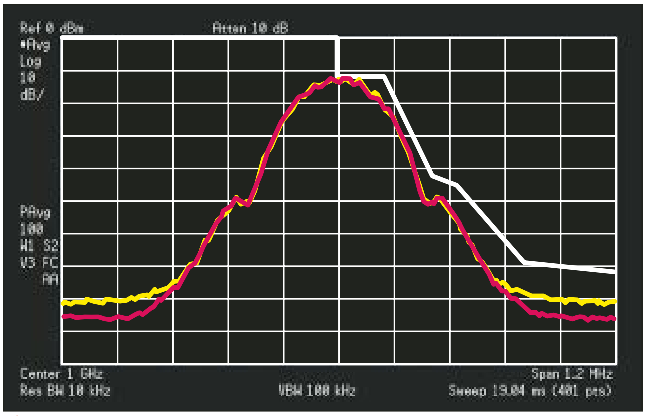


Fig. 1 The p1511A's EDGE signal (yellow) and a competing higher priced instrument's signal (magenta).

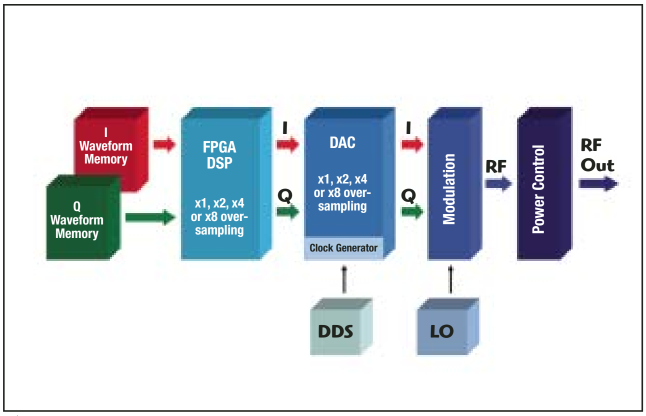


Fig. 2 The p1511A's internal digital modulation system is simple yet powerful.

Well-suited for bench-top and ATE applications, the instrument has frequency switching speeds better than 15 ms to within 100 Hz of the requested frequency. Output power switching is a very fast 2.5 ms.

The instrument's internal I/Q generator is accessible in an open-system manner, and can be loaded with simple three-column ASCII files created from a variety of commercial applications, as well as from user-written software. A growing set of common waveforms can be downloaded for only $250 each from precisionWave's web site.

In addition, precisionWave can generate custom waveforms quickly and inexpensively, especially considering the steep learning curve to create waveforms from scratch. Letting precisionWave develop specific waveforms is far more economical to using one of the many all-capable, but often difficult-to-understand waveform development applications.

The p1511A's internal I/Q generator produces any digitally modulated signal within the cellular bands. The 1 MSample memory depth for I and Q can be over-sampled from 1x to 64x greatly increasing the effective memory depth. The variable sampling rate can be made to match the symbol rate of any modulation standard. ***Figure 2*** shows the instrument's internal digital modulation system.

The p1511A's active matrix TFT LCD display is crisp and bright, with wide horizontal and vertical viewing angles. Instrument control is easy and intuitive through a touch-panel or optionally connected keyboard and mouse.

A unique (patent-pending) spectrum analyzer display reflects VSG settings and waveform content, assuring selection of the desired waveform without tying up an expensive spectrum analyzer.

An internal web server provides efficient browser access to the instrument, with remote desktop access to the instrument also available. TCP/IP over LAN remotely links the instrument to precisionWave-supplied, third-party or user-developed client software.

INDUSTRY STANDARDS

Strict use of industry standard technologies and components was vital in achieving the instrument's "low cost" market attribute. Candidates for p1511A architectural elements were drawn not only from "T&M industry standards," but from the much broader set of "PC industry standards."

Use of standards also improves user-friendliness, particularly when instruments are not in day-to-day use. The instant-familiarity of ***Figure 3*** was drawn from popular industry standard software examples, meaning that the front panel was not only inexpensive to develop and debug, but also easy to use. The design is ultimately flexible as well; users can run precisionWave's front panel to control their instrument remotely with the same front panel as on the instrument itself. They can even replace its front panel with their own design if they choose.

Industry standard hardware and software components and technologies leveraged massive industry momentum into the instrument, and its follow-on roadmap. Plummeting prices, accelerating performance, new and innovative features, and protection from obsolescence benefited the instrument design and customers alike. PC boards and RF modules also took on standard form-factor and standard USB or PCI connectivity (see ***Figure 4***).

The industry standard Microsoft Windows operating system was chosen for its familiarity to users, its rapidly advancing feature set and the opportunity it provides for user customization of look-and-feel. It further enables a cadre of VSG-related applications to be installed on the VSG it-

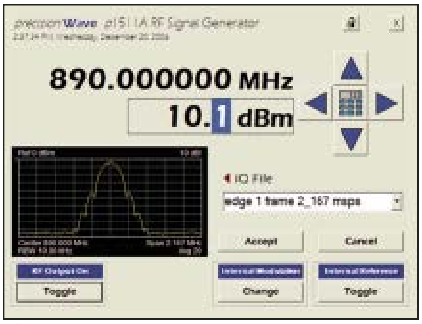


Fig. 3 The p1511A is simple to control and operate.

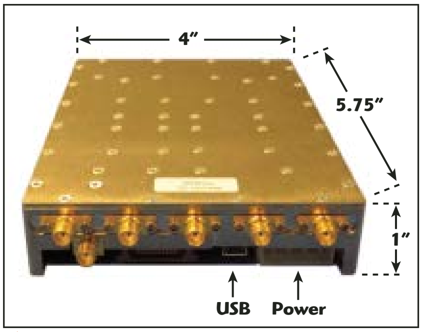


Fig. 4 Dimensioned exactly as a 3.5" PC hard drive, RF modules have excellent shielding and can be mounted wherever a hard drive can be placed.

self. Standard interconnection between computing networks and precisionWave instrumentation allow familiar printing, backup, file transfer, device and software use, remote control and remote access features now in customer daily use patterns.

Modular software designs, and those that leverage industry standards such as TCP/IP, object-oriented design, client/server models, hardware abstraction layers, internal web servers and the like, are advantageous in reducing R&D costs, improving quality and decreasing time-to-market.

Modular hardware designs are similarly beneficial, and enable precisionWave's "building block" strategy for quickly and economically constructing new or variant instruments. They also contribute to instrument serviceability, upgradeability and extensibility, and play a significant role in cost containment, through re-use, component volume purchasing, and inventory optimization and management.

CONCLUSION

For many markets and customers, most RF vector signal generators simply have too many features and too much performance. They are far more expensive than they need to be. Customers do not need each of their instruments to have the exceptional performance and feature sets offered by many manufacturers today, and they are tired of paying for the oversupply.

With its recently launched RF vector signal generator line and future RF instrumentation roadmap, precisionWave Corp. is on a refreshing new trajectory—rethinking test and measurement, bringing the right performance, the right features and the right price to customers who just do not need it all.

precisionWave Corp., Colorado Springs, CO (866) 386-6798, www.precisionwave.com.

RS No. 301

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) Nominal	Accuracy*
$29.95	$44.95	$54.95		
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.

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

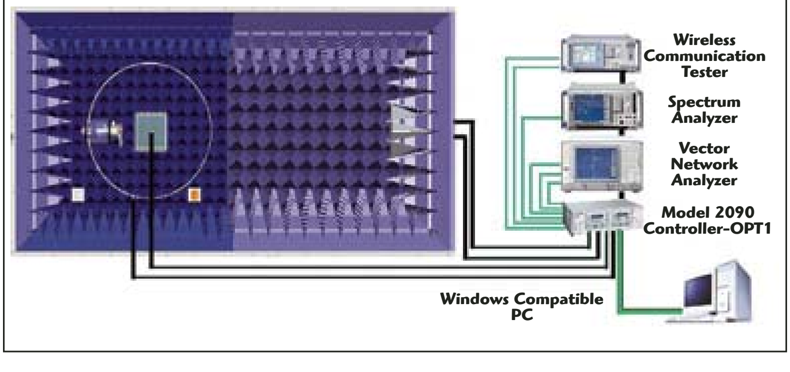
A SELF-CONTAINED, PORTABLE ANTENNA MEASUREMENT SYSTEM

ETS-Lindgren pioneered the over-the-air (OTA) performance testing market, designing and building the first CTIA Authorized Test Lab (CATL) for mobile station over-the-air antenna performance testing. Since then, the company has designed and built test chambers that have performed tests at some of the largest and best-known manufacturers of mobile wireless products. ETS-Lindgren's efficient and accurate test systems have contributed to the successful determination of transmit and receive characteristics under controlled conditions. This, in turn, has supported device makers in their quest to bring their products to market quickly and reliably.

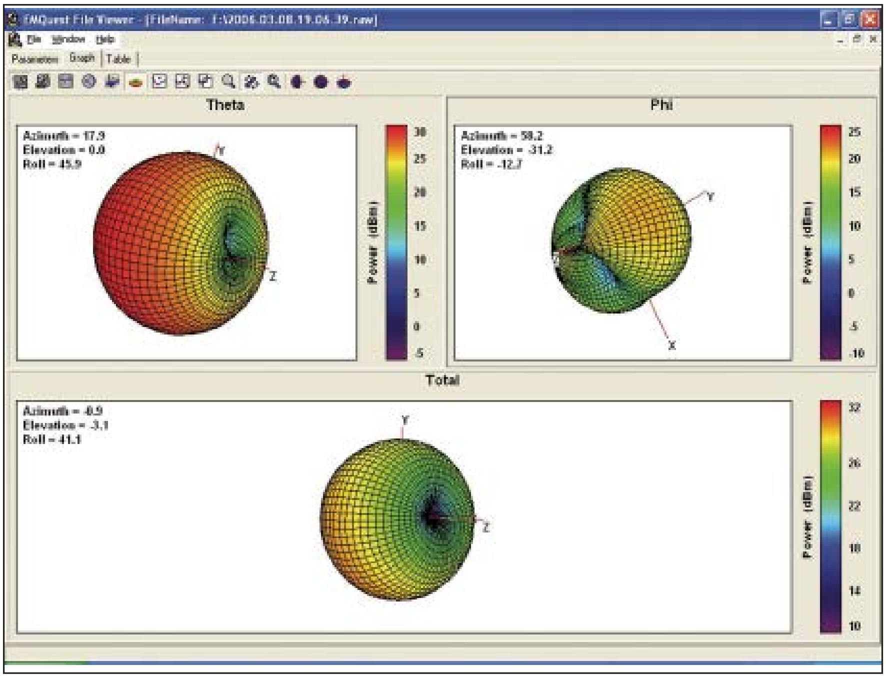
For a wireless technology to be successful in the marketplace, it must provide the end user with an acceptable and reliable level of performance. The physical functionality of the wireless device is key to the device's ability to "talk" to a network and vice versa. If the devices at either end of the link cannot "hear" each other, then communication breaks down. The now famous quantitative test "can you hear me now?" is an inefficient way to determine OTA performance of wireless devices. Network operators and designers, wireless device makers and antenna makers need more effective tools to qualify devices earlier in design sequence.

To address the needs of the pre-compliance wireless device OTA performance test market, ETS-Lindgren recently introduced the new AMS-8050 Antenna Measurement System. The AMS-8050 is a practical solution when building space is a limitation as it is a self-contained test lab for making efficient, over-the-air performance measurements of small wireless devices and mobile handsets. This lab is built on a movable chassis so the entire system may be transported between different test stations. The ability to transport the system and store all components within the cart makes it an ideal solution for multiple research and development groups. ***Figure 1*** shows the AMS-8050 system's configuration.

Fig. 1 The AMS-8050 wireless performance system (top cut view).



ETS-LINDGREN L.P.
Cedar Park, TX



▲ *Fig. 2 Example of a 3D spherical antenna pattern from EMQuest EMQ-100 software.*

Early experience by engineers using the AMS-8050 shows that when research and development or product development schedules are highly compressed, it is highly beneficial to have a dedicated, cost-effective, portable testing platform to more quickly assess the impact of design decisions and speed their design concept through the stage gates. Using a pre-compliance wireless performance test and measurement system in the design center yields higher confidence in initial designs to meet the accelerating schedule demands of the marketplace. Today's fast-paced wireless markets require device makers to know about their product's performance much earlier in the design process. Correcting designs on the fly has resulted in higher success rates at the time that full certification is required near the end of a design cycle (for example, higher first pass rates).

The AMS-8050 is small in size but big on operational throughput. It lets the user make fully automated 2D (polar) and 3D (spherical) antenna pattern measurements following measurement protocols that are consistent with the type used for compliance testing, yet in a compact, portable range. These pre-compliance data are analyzed and the measurement quantities such as total radiated power (TRP), effective isotropic radiated power (EIRP), total isotropic sensitivity (TIS), effective isotropic sensitivity (EIS), near-horizon partial radiated power (NHPRP) and near-horizon partial isotropic sensitivity (NHPIS) are generated by ETS-Lindgren's EMQuest™ EMQ-100 software. This premiere data acquisition and analysis software is the most widely used in CATL labs worldwide.

Wireless device manufacturers and network operators are interested in the total radiated power since this over-the-air test result is the only way to qualify the entire signal path of the wireless device. TRP data (shown graphically in ***Figure 2***) provide key measures to wireless carriers that demonstrate that a wireless device meets its required performance criteria. In a manufacturing quality program TRP can be used to detect and reject manufacturing defects as well as to test mobile equipment for proper operation in repair centers. Similarly, the AMS-8050 can collect the data needed to calculate total isotropic sensitivity. TIS is an indicator of the lowest signal strength when a device is in receive mode (the ability of the device to "listen" to the network, for example). The use of TRP and TIS are needed to plan the layout of a network for efficient and cost-effective geographical coverage.

Since the AMS-8050 is a pre-compliance measurement tool principally used in R&D and design labs, it is important to know how well the system performs when compared to a full-size CTIA Authorized Test Lab chamber. The key reported benefit of the AMS-8050 is to provide the engineer with the confidence his or her design will fare well in compliance tests. In a comparison study of total isotropic sensitivity and total radiated power measurements taken in a full-size compliance test environment and the AMS-8050 compact antenna lab, the results show a very high degree of agreement between the two systems. The comparison data supports the choice of the AMS-8050 for pre-compliance over-the-air performance testing of mobile handsets and small portable wireless devices. The data validates its importance as a key tool for:

- Design Validation
- Performance Measurement
- Pre-certification Testing
- Production Testing

CONCLUSION

A new portable self-contained antenna measurement system has been presented. Current owners of the AMS-8050 have found the measurement system ideal for wireless device pre-compliance performance testing, and have reported achieving faster time to market for their wireless handsets, reductions in product development cycle time, and savings in time and resources. They also enjoy the benefit of making it convenient for engineers to test performance without occupying a full compliance lab. As projects and priorities change, the AMS-8050 is a re-locatable measurement system without the encumbrance of a parent building installation. Additional information on the system and its advantages may be obtained by visiting www.ets-lindgren.com/8050.

ETS-Lindgren L.P.,
Cedar Park, TX (512) 531-6400.

RS No. 306

A NEW GENERATION OF MICROWAVE COUNTERS

Traditionally frequency counters have fallen into two main categories—general-purpose counters/timers and microwave counters. The former typically measure frequency from parts of a hertz to 200 to 300 MHz and can display frequency, time interval and period. Some general-purpose counters also provide ratio, phase comparison and low frequency burst measurement capabilities. Microwave counters typically measure frequency from 10 Hz to the end of their specified upper frequency, which can be anywhere from 3 to over 100 GHz. Some microwave counters can also measure power, either internally at the coax connector, or through a separate input, using external power sensors. Traditional counter designs use one or more versions of direct, reciprocal (with or without interpolation), or heterodyne mixer counting methods. These methods all have a defined start and stop period, plus some dead time between measurements, during which calculation and interpolation is done. Then the measurement is read out, registers are cleared, and the instrument is prepared and reset for the next measurement.

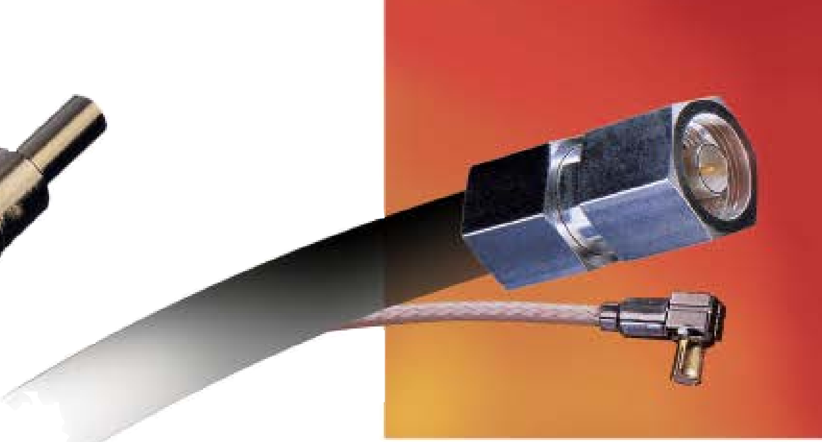
Such procedures are now a thing of the past with the new CNT-90XL microwave counter, which is a fundamental design departure from both general-purpose and microwave counters. It incorporates a unique counter/timer/analyzer with a sophisticated microwave counter/power meter. This new generation of instrument is a 'zero dead-time' microwave counter that uses a graphic display to show numeric and statistical data of measurement results. The instrument can display measurement data in a statistical format, including a graphic display of trend line and histogram distributions, and a numeric format of mean, min/max, peak-to-peak, Allan Deviation and standard deviation of the frequency or power of a microwave signal.

THE DESIGN

The CNT-90XL uses a unique time stamping method of measurement that allows for continuous event counting (no dead time between counts). With time stamping, the input events and the clock cycles are continuously counted, without being reset or interrupted. At regular intervals, pacing intervals, the momentary contents of the event count register and the time

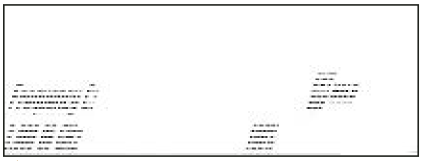
PENDULUM INSTRUMENTS AB
Bromma, Sweden


Custom.
Commercial.
Microminiature.



▲ *Fig. 1 Small amount of AM on carrier shown on the CNT-90XL counter's front panel display.*

▲ *Fig. 2 Numerical statistics of the AM signal shown in Figure 1.*



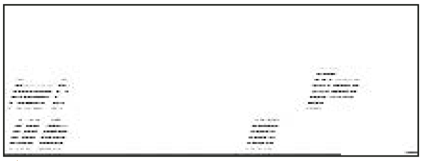
▲ *Fig. 3 1 kHz FM with a 12 ppm modulation depth.*

count register are transferred to memory. The read-out of the register contents is always synchronized to the input trigger, so it is the event trigger that is time stamped. Each stored time stamp is also interpolated 'on the fly' for improved resolution. The contents in the memory are thereafter post-processed.

Because the instrument can make and store hundreds of thousands of measurements per second without dead time, it can use a linear regression least squares line-fitting method to further improve measurement accuracy. The main advantage of linear regression is to reduce the influence of noise from the measurement process as well as superimposed random noise on the test signal, thus increasing frequency resolution.

The microwave input of the CNT-90XL uses a broadband hybrid superheterodyne sampling mixer with power measurement capability. Supporting circuitry (LO, synthesizer, etc.) delivers signal data to the counter for memory storage and display of both frequency and power. Once the microwave signal is acquired, which takes approximately 25 ms, measurements are made without dead time. Up to 250,000 measurements per second can be made and processed without dead time in the count chain, providing for advanced statistical analysis. The benefits of this kind of measurement process, which can be

▲ *Fig. 4 Pulse modulated frequency.*



▲ *Fig. 5 Generator power steps with signal off-time.*

applied to frequency as well as power, are numerous. Data on frequency and power stability over very short times can be analyzed, providing an insight into circuit function that is not available with other counters.

MEASUREMENT CHALLENGES

The instrument's design, fast measurement speed, and high resolution provide measurement and analysis of signals that could not be achieved previously. For example, short-term clock frequency variations over a given period of time (1 sec., 10 sec., 100 sec., etc.) are often expressed using Allan Variance, an estimate of the clock stability over a given period of time, from one averaging period to the next. Statistical Allan Deviation requires that there be no dead time between measured samples, with a minimum of 100 samples used for the calculation. Because of its fast zero dead-time measurement capability, the CNT-90XL can display Allan Deviation simultaneously with mean, min/max, peak-to-peak and standard deviation. Both frequency and power stability can be measured and displayed.

An example of a very small amount of AM on a carrier is shown in ***Figures 1*** (graphically) and ***2*** (numerically) on the instrument's front panel display. Other examples of the ability of the CNT-90XL to capture and display challenging measurements are shown in ***Figures 3*** and ***4***, while ***Figure 5*** shows the power steps from a generator (–30 to –5 dBm, in 5 dB steps), with a measurable off-time between power steps.

Real-world signals do not have constant stable frequencies or power, with modulated, frequency hopping, swept frequency or power, and burst signals being examples. Also, the concept of a mean frequency may be useless for these types of signals. The average frequency over 80-channels of WLAN using FHSS, or the average of several burst cycles containing chirp radar, is not meaningful.

Instead, the challenge is to closely follow and represent the actual frequency over time inside the burst, or alternatively, to see the statistical distribution of the WLAN channels. These types of signals require a very fast high resolution measurement and the new CNT-90XL meets these requirements.

Applications for this new counter include microwave link carrier calibration, satellite communication equipment testing, YIG and VCO testing, RF and microwave instrumentation calibration, and microwave frequency and power stability testing.

The CNT-90XL counter family includes four models that measure frequency from 0.001 Hz to 27, 40, 46 and 60 GHz (model dependant). The instruments feature 14 digits of numeric display, are capable of CW and burst measurement of frequency and power, and include both USB and GPIB connection as standard. Resolution is 12 digits/s (frequency), 0.01 dBm (power), 100 ps (time) and 0.001° (phase). Frequency measurement ranges from 0.001 Hz to the top of the instrument's range. Period measurements are available on A & B inputs (single or average) range from 3.3 ns to 1000 s, and 4 ns down to 17 ps (average) on the microwave input (model dependant). Ratio measurements between any two of the three inputs are included and power (dBm) on the microwave input is also provided.

CONCLUSION

The challenges of a fast-growing microwave product world and the applications provided by these new technologies are challenging test instrument manufacturers to keep pace with new test solutions to meet this changing environment. The CNT-90XL has answered the challenge.

Pendulum Instruments AB, Bromma, Sweden +46 8 598 51057; Pendulum Instruments Inc., Oakland, CA (510) 428-9488, www.pendulum-instruments.com.

RS No. 303

RF/Microwave Components

Aeroflex/Weinschel is teaming with Argosy Component Sales to offer the industry's largest selection of off-the-shelf RF and microwave components available. As Aeroflex/Weinschel's new stocking distributor, Argosy stocks a large selection of its coaxial attenuators, terminations, manual step and programmable attenuators, adapters, connectors, and other components for same day/next day delivery to anywhere in the US and Canada.

Aeroflex/Weinschel Inc.,
5305 Spectrum Drive,
Frederick, MD 21703

www.argosysales.com

New Product Slideshow

AR Worldwide RF/Microwave Instrumentation's home page now features a new product slideshow that features the latest AR products. Currently being featured is the family of 4 to 8 GHz solid-state amplifiers, the company's line of laser powered probes, the CI conducted immunity generators, the TGAR automotive transient generator system and its increase in power available in TWT amplifiers.

AR Worldwide RF/Microwave Instrumentation,
160 School House Road,
Souderton, PA 18964

www.ar-worldwide.com

Terminations, Resistors and Attenuators

This web site features the company's expanded product search and individual data sheets for its full line of power and precision thick film terminations, resistors and attenuators on alumina, BeO, BeO Free™ and aluminum nitride. The company also has an LTCC multilayer foundry, design and production facility for products to 40 GHz. High power ceramic packages and precision electroplating are also available.

Barry Industries Inc.,
60 Walton Street,
Attleboro, MA 02703

www.barryind.com

Engineering Tools Aid in Packaging Design

On the Thunderline-Z web site you will find an advanced search engine of the company's entire database of previously designed feedthrus. Search over 2000 models of RF/50 Ω, DC and capacitor/filter feedthrus to find the model that most closely resembles your application. In addition, you will find an impedance reference calculator. Use this tool to calculate the opposing dimension of glass-to-pin, or pin-to-glass that will achieve optimal impedance in your RF or microwave package.

Thunderline-Z,
11 Hazel Drive, Hampstead, NH 03841

www.thunderlinez.com

Components and Subsystems

Endwave's innovative components and subsystems enable the transmission, reception and processing of RF, microwave and millimeter-wave signals in next generation wireless communications networks, defense and homeland security systems. Featured on the company's web site are a variety of single and multi-function solutions including: JCA amplifiers, oscillators, multipliers, up/downconverters, synthesizers, transceivers, switch arrays and custom multi-function assemblies.

Endwave Corp.,
130 Baytech Drive,
San Jose, CA 95134

www.endwave.com

ICs, Modules and Subsystems

This comprehensive, versatile web site has recently added new product pull-down menus and RoHS-compliant component pages. The web site details full specifications for over 430 products, application notes, quality assurance and product support tools including Product Cross Reference, Parametric Search, PLL Phase Noise and Mixer Spur Chart Calculators, and expanded e-commerce. The company's new product selection guide, newsletter and CD can also be requested from the site.

Hittite Microwave Corp.,
20 Alpha Road,
Chelmsford, MA 01824

www.hittite.com

● Resistive Products

Providing design engineers with easily accessible specification product information, TT electronics IRC has enhanced its web site to include a comprehensive resource for customers of its entire line of resistive products. The IRC site also prominently features RoHS information from a link on the home page. Landing pages have been developed with direct links from the home page, which consolidate data sheets and pertinent information for specific product groups.

TT electronics,
IRC Advanced Film Division,
4222 S. Staples Street,
Corpus Christi, TX 78411

www.irctt.com

● RF/Microwave Filters and Subsystems

The Lorch site features an updated look in displaying the company's RF and microwave filters, subsystems and RF products. The site provides complete product line information, as well as filters now available from stock for immediate delivery. Also featured is the Filter Select+Plus selection software for bandpass filters. Additionally, the site includes RoHS-compliant offerings and features the latest company news and catalog downloads.

Lorch Microwave,
1725 N. Salisbury Blvd.,
Salisbury, MD 21802

www.lorch.com

● Passive Microwave Components

This web site provides links to the company's four business units. A globally recognized provider of passive microwave components, M2 Global also provides contract manufacturing services and lean manufacturing seminars. New to M2 Global is Trilogy Defense Services, a partnership with two other SBA businesses, providing a convenient source of diverse manufacturing capabilities for defense contractors.

M2 Global Technology Ltd.,
5714 Epsilon,
San Antonio, TX 78249

www.m2global.com

● Component Search Tool

Yoni2 is a component search tool on the company's web site that searches millions of actual measured data points from thousands of models in the company's database. The search function allows a user to enter parametric specifications and then outputs results, which allows engineers to quickly match a component to an application. Yoni2 currently supports searches across amplifiers, directional couplers, frequency mixers, power splitters/combiners, RF transformers, voltage-controlled oscillators and filters.

Mini-Circuits,
PO Box 350166,
Brooklyn, NY 11235

www.minicircuits.com

● Financial Insight

The RF to Light Index is a unique resource to the *Microwave Journal* web site that has been recently revamped. This resource provides extensive economic data covering 100 public companies operating in markets that include space and defense, communications services, network systems, RF semiconductors, RF components and F/O components. It includes 12 spreadsheets with charts that are updated weekly, providing financial insight into the microwave industry for investors and corporate managers.

Microwave Journal,
685 Canton Street,
Norwood, MA 02062

www.mwjournal.com

● Green World

The "Green Leader" web site contains information on the company's environmentally friendly specialty materials and related subjects. The company's environmentally friendly product lines include: high frequency laminates; flexible circuit materials; BISCO® silicones; PORON® urethanes; and DUREL® EL lamps and drivers. Letters of Compliance and flowchart examples to determine if equipment is within the scope of directives are also provided.

Rogers Corp.,
One Technology Drive, PO Box 188,
Rogers, CT 06263

www.rogersgreen-world.com

Check us out at www.planarelec.com/03

PLANAR electronics technology

Last Chance to Take Advantage of...
...these Incredible Savings!

RF / Microwave Amplifiers on SALE for only $495 each

New amplifiers listed at www.planarelec.com/03 are now on sale for only $495 each

All narrow band to Ultra-Broadband amplifiers covering the frequency range of 30 MHz to 20 GHz with 30 dB of gain or less are now offered for a low fixed price of $495 each when 10 or more pieces are ordered.

New listings offering hundreds of new models.

All LCA Series (Low-Cost - From Stock) models that are priced over $495 are included in this sale when 10 or more pieces are ordered.

Planar Electronics Technology & Planar Filter Company - (A division of Planar Electronics Technology, Inc.)
Phone: 1.877.PLANAR1 • 301.662.5019 • FAX: 301.662.1731
5715 Industry Lane, Unit 11, Frederick, MD 21704 USA
Email: PET-SALES@planarelec.com • Web: www.planarelec.com/03

FREE on-line order tracking system updated daily.

Terms and Conditions: This sale applies only to amplifiers that are ordered between January 1, 2007 and March 31, 2007. The sale is only for amplifiers listed on the present PET web site. The sales price is for any listed amplifier that has 30 dB of gain or less and has a maximum operating frequency of 20 GHz. The ten piece minimum order requirement must be met. Up to three different models totaling ten pieces may be ordered and will still be considered to meet the minimum order requirement. The specifications shown are typical. If a specific guaranteed specification is required please specify this requirement at the time of ordering and additional charges may apply. PET reserves the right to change the contents of its web site and/or model availability at anytime without notice. Specifications are subject to change without notice.

Visit http://mwj.hotims.com/11714-106 or use RS# 106 at www.mwjournal.com/info

RF/Microwave Components and Systems

Spectrum Microwave is a wholly-owned subsidiary of Spectrum Control Inc. and produces a wide range of RF and microwave components and systems. The company's diverse product line includes RF and microwave filters, switchable filter banks, integrated microwave assemblies, amplifiers, mixers and oscillators.

Spectrum Microwave Inc.,
2144 Franklin Drive N.E.,
Palm Bay, FL 32905

www.specwave.com

Infrastructure Products

This web site reflects the company's recently announced re-branding efforts as "STI." The extensive web site redesign features the company's high performance infrastructure products for wireless voice and data applications. The new look debuts the company's "STI" logo and refreshed sales focused content in an easy-to-navigate design.

Superconductor Technologies Inc. (STI),
460 Ward Drive,
Santa Barbara, CA 93111

www.suptech.com

3D Electromagnetic Field Simulation Software

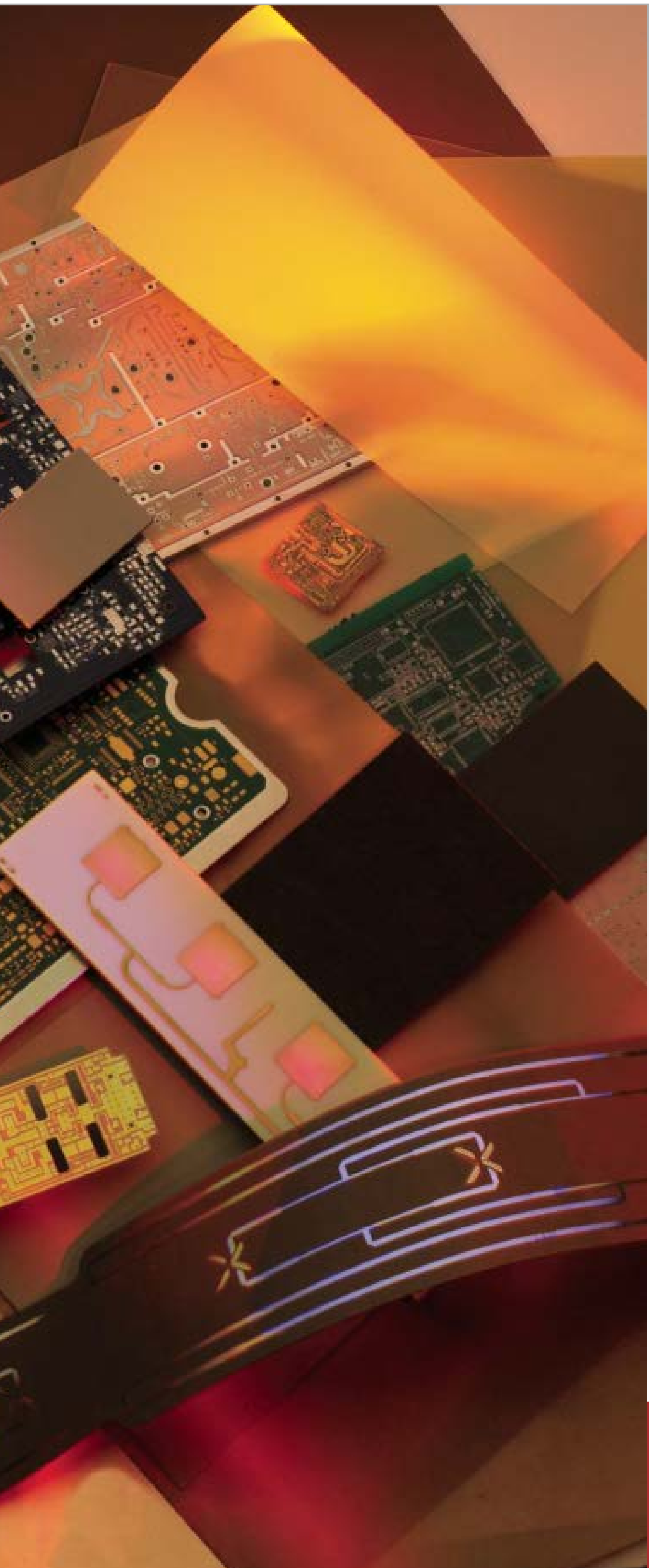
This recently updated web site features the company's 3D electromagnetic (EM) field simulation software for high frequency applications. New additions to the site include: Web-based videos demonstrating the state-of-the-art 3D EM simulator CST MICROWAVE STUDIO® 2006, applications articles, user forum, technical support area and downloads.

CST of America® Inc.,
10 Laurel Avenue, Suite 300,
Wellesley Hills, MA 02481

www.cst.com

CLTE-XT Microwave Laminate

The Next Generation of CLTE with Lowest Loss in its Class



Woven Glass Reinforced PTFE / Micro Dispersed Ceramic with Fantastic Temperature/Phase Stability

- CLTE-XT has "Best-in-Class" Insertion Loss and Loss Tangent
- Low CTExyz and Very Low TCεr for applications that require Electrical Phase Stability, DK Stability, and Mechanical Stability over a -55 to 150°C Operating Temperature
- Maintains the competitive advantages of CLTE *(dimensional stability, low absorption of moisture and processing chemicals, ease of processability)*
- Lower Insertion Loss through focus on Both Dielectric *(Lower Loss Tangent)* and Conductive Loss *(Copper-Laminate Interface)*
- Excellent Dimensional Stability Performance - Key for multilayer boards on thin laminates such as 0.005" and 0.010" or for consistent embedded resistance values with Ohmega-Ply® or TCR® foils.
- Applications include Space and Military Electronics that require a higher degree of performance consistency across temperature, such as Phase Sensitive Arrays and Manifolds for Radar, RF/Microwave Communications, Aircraft Collision Avoidance Systems, JTRS

DK	DF (10GHz)
2.94	0.0012

ARLON

TECHNOLOGY ENABLING INNOVATION

www.arlon-med.com

(800) 635-9333 or (302) 834-2100

Microwave
Honolulu, Hawai'i
Reserve a room at conference rates now at www.IMS2007.org
IMS2007
MICROWAVES ACROSS THE PACIFIC
International Microwave Symposium
RFIC Symposium · ARFTG Symposium
IEEE
MTT-S
www.IMS2007.org
www.gohawaii.com
Photo by Laszlo Ilyes

Week 2007

3–8 June 2007

The premier microwave and wireless conference featuring technical sessions and workshops for commercial and military applications

- Field Analysis and Guided Waves
- Frequency Domain Techniques
- Time Domain Techniques
- CAD Algorithms and Techniques
- Linear Device Modeling
- Nonlinear Device Modeling
- Nonlinear Circuit Analysis and System Simulation
- Transmission Line Elements
- Passive Circuit Elements
- Planar Passive Filters and Multiplexers
- Non-Planar Passive Filters and Multiplexers
- Active and Integrated Filters
- Ferroelectric, Ferrite and Acoustic Wave Components
- MEMS Components and Technologies
- Semiconductor Devices and Monolithic IC Technologies
- Signal Generation
- Frequency Conversion and Control
- HF/VHF/UHF Technologies and Applications
- Power Amplifier Devices and Integrated Circuits
- High Power Amplifiers
- Low Noise Components and Receivers
- Millimeter-wave and Terahertz Components and Technologies
- Microwave Photonics
- Digital Circuits and Systems at GHz Speeds
- Packaging, Interconnects, MCMs and Hybrid Manufacturing
- Instrumentation and Measurement Techniques
- Biological Effects and Medical Applications
- Smart Antennas, Spatial Power Combining and Phased Arrays
- Radars and Broadband Communication Systems
- Wireless and Cellular Communication Systems
- Sensors and Sensor Systems

- Full guest program for the family

www.IMS2007.org

For further information, please contact Kristen Dednah at:
kdednah@mwjournal.com
or 781-769-9750

Spectrum Analyzer Trio

Three new models have been added to the MS272xB series of handheld spectrum analyzers. The MS2724B offers continuous frequency coverage from 9 kHz to 20 GHz while the MS2721B and MS2723B cover frequencies up to 7.1 and 13 GHz, respectively. The MS2724B exhibits low phase noise of typically –104 dBc/Hz at 10 kHz offset at 2 GHz, and 1 Hz to 3 MHz RBW, making it well suited for spectrum monitoring, security and intelligence needs, RF/microwave measurements, or cellular signal measurements. Both the MS2721B and MS2723B have similar high performance. All three utilize the Spectrum Master design, which combines high durability with lightweight, have a standard built-in AM/FM/SSB demodulator and built-in preamplifier, and are the first in the family to feature a quasi-peak detector and CISPR bandwidths for EMC precompliance testing.

Anritsu EMEA Ltd.,
Luton, UK 01582 433242,
www.anritsu.com.

RS No. 216

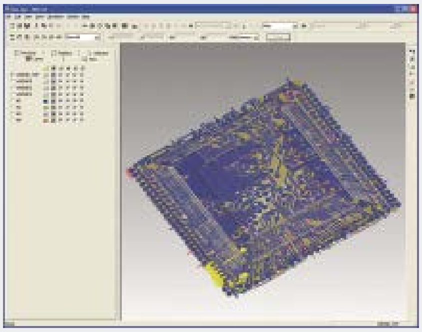
Microwave/RF IC Design Suite

The new version 6.4 of the LINMIC Microwave and RF IC Design Suite has been released. LINMIC is a physics-based suite of integrated tools for the efficient EM-based design and layout of passive and active, single-layer and multi-layer, linear and nonlinear RF and microwave circuits. Version LINMIC 6.4 is more powerful for the design of circuits containing surface-mount RLC components (SMD-RLC). Advanced new models taking multiple resonances and up to two connections per pad into account, and a respective parameter extractor (SMDMOD) have been implemented for SMD-RLC components.

AC Microwave GmbH,
Aachen, Germany +49 241-8793022,
www.linmic.com.

RS No. 246

High Performance EDA Software



The Turbo Package Analyzer™ (TPA) v5 introduces new automation, design flow and simulation capability needed for the extraction of the electrical characteristics of complex high performance ball-grid array (BGA) style packaging, including wirebond (WBBGA), flip-chip (FCBGA), chip-scale packages (CSP) and System in Packages (SiP). TPA v5 increases the capacity of the solver to address larger-sized packaging problems and introduces greater automation for generating and/or modifying 3D package layouts. TPA v5 introduces a new user interface that includes new 2D editing and 3D viewing capabilities, unlimited undo/redo capability, powerful new editing and automation features, such as geometry validation checking and support for VB scripting.

Ansoft Corp.,
Pittsburgh, PA (412) 261-3200,
www.ansoft.com.

RS No. 217

9 kHz to 1.2 GHz Signal Generator

This lightweight 2U, 3.5" high signal generator offers a bandwidth of 9 kHz to 1.2 GHz and an

RF output range from –140 to +13 dBm. The model SG1200 provides low carrier frequency with excellent resolution and low harmonics. The SG1200 is ideally suited for RF immunity testing for both conducted and radiated immunity systems covering the requirements for MIL-STD-461D/E, DO-160D/E, IEC 61000-4-3, IEC 61000-4-6 and many other EMC test standards.

AR Worldwide RF/Microwave Instrumentation,
Souderton, PA (215) 723-8181,
www.ar-worldwide.com.

RS No. 218

WiMAX R&D Test Set

The RSA-IQWIMAX demodulation and analysis software is part of a comprehensive test set to find and solve WiMAX design problems. RSA-IQWIMAX software is a new application specific test tool for characterizing and troubleshooting WiMAX device designs utilizing a Tektronix RSA3408A real-time spectrum analyzer and is the result of a partnership between Tektronix and LitePoint. With RSA-IQWIMAX and the RSA3408A, engineering teams will be able to more quickly detect, diagnose and resolve design issues improving time to market for WiMAX end-user products, including consumer electronics, computers and handheld devices.

Tektronix Inc.,
Beaverton, OR (800) 833-9200,
www.tektronix.com.

RS No. 224

Wideband Driver Amplifier

The model HMC-C038 is a GaAs MMIC distributed driver amplifier packaged in a miniature,

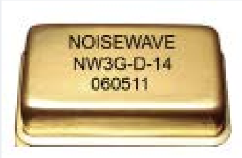
hermetic module with replaceable 2.92 mm connectors. Operating between 2 and 35 GHz, the HMC-C038 provides 12 dB of gain, +29 dBm output IP3 and up to +18 dBm of output power at 1 dB gain compression. Gain flatness is excellent from 2 to 16 GHz at ±0.5 dB making the HMC-C038 ideal for test and measurement applications. The HMC-C038 also exhibits a mid-band noise figure of 4 dB and is specified for operation over the full –55° to +85°C temperature range.

Hittite Microwave Corp.,
Chelmsford, MA (978) 250-3343,
www.hittite.com.

RS No. 219

Amplified Noise Source

The model NW3G-D-14 is a dual-in-line packaged amplified noise source that provides a



high level output DIP noise module covering 3 GHz. Extending to virtually all wireless frequency bands, this noise source provides the user with broadband high levels of noise for PCB mounting. Offering broadband frequency coverage from 10 MHz to 3 GHz, the NW3G-D-14 features –10 dBm output power with noise flatness of ±2.5 dB or better. Standard operation is from +15 VDC with a 100 mA maximum current draw. The NW3G-D-14 is housed in an industry standard 14 pin DIP package. Utilizing small internal parts count, the NW3G-D-14 is economically priced and delivery is typically from stock.

Noisewave Corp.,
East Hanover, NJ (973) 386-1119,
www.noisewave.com.

RS No. 220

Grandmaster Clock

The XLi IEEE 1588 Grandmaster Clock with GPS reference is designed for IEEE 1588 protocol test and measurement applications. IEEE 1588 protocol enables accurate synchronization over Ethernet LANs and offers users the ability to synchronize clocks to better than one hundred nanoseconds accuracy with only a network connection. The XLi IEEE 1588 Grandmaster provides the precise time and is also equipped to physically measure how well that time is transferred through the network with precision down to five nanoseconds resolution.

Symmetricom Inc.,
San Jose, CA (800) 544-0233, www.symmttm.com.

RS No. 223

Wireless Vector Signal Generator

The model *p*1411A is a high performance RF vector signal generator that serves the 800 and 1700 MHz cellular bands and produces high accuracy EDGE, GSM, IS-95, NADC, PHS, WCDMA and CW signals. The source includes an exclusive spectrum analyzer display along with an internal IQ waveform generator, and is available in bench-top or ATE configurations. User-created IQ waveforms can generate other signal types, specify data content or create worst-case signal scenarios for development and test of RFIC, subassemblies or completed wireless products. Price: $9990.00. Delivery: eight-week delivery ARO.

precisionWave Corp.,
Colorado Springs, CO (719) 325-0504, www.precisionwave.com.

RS No. 221

Switch Matrix

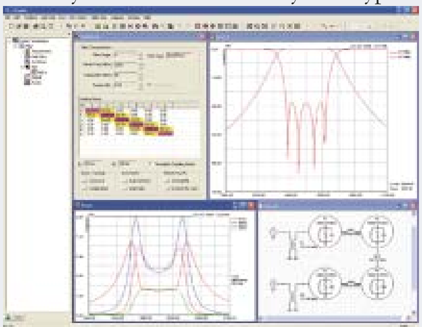
This DC to 6 GHz multi-functional WiMAX custom matrix is compact and designed with instrumentation to the DUT ports that are synthesized to a custom RF configuration. With a total of two DUT ports, six instrument ports and six auxiliary ports, this RF head-end switch matrix contains combiners, switches, programmable attenuators and required components for RF modulation. The industry standard 19-inch rack mounted switch matrix occupies 2 U of space. The six auxiliary ports aid in the calibration of six corresponding instrument ports and is controlled using a GPIB/IEEE-488.2 interface.

Renaissance Electronics Corp.,
Harvard, MA (978) 772-7774, www.rec-usa.com.

RS No. 222

Filter Synthesis and Design Software

FilSynth is a precision microwave filter design software that features direct synthesis of all commonly used types of passive filters with essentially no limitations. Transmission zeros can be placed freely within the stopband. For a bandpass filter, N+2 type coupling matrix is generated so that maximum transmission zeros can be realized by using source/load coupling. Together with synthesis function, optimization, analysis and power handling functions make FilSynth a powerful filter design software.



FilResearch Inc.,
Fairfax, VA, www.filresearch.com.

RS No. 247

COMPONENTS

Broadband SP5T Switch

The model SWN-1170-5DR is a reflective broadband single-pole five-throw switch with integral TTL driver. This switch operates in a frequency range from 1 to 18 GHz with low insertion loss of 3.25 dB maximum, an isolation of 60 dB minimum and a VSWR of 2.0 maximum. The switching speed is only 100 ns maximum while the RF power handling is +20 dBm operating and 1 W survival. Size: 1.25" × 1.25" × 0.70".

American Microwave Corp., Frederick, MD (301) 662-4700, www.americanmicrowavecorp.com.

RS No. 225

50 Ω Fixed Attenuators

The model 354-129-XXX is a 50 Ω fixed attenuator series. These 1 W units are available in standard BNC male/BNC female configurations (other gender, connector types and impedances are available). Model 354-129-XXX is rated DC to 2500 MHz, 1 to 40 dB in 1 dB value increments and 1.40 maximum VSWR. Attenuation accuracy is ±0.5 dB maximum for 1 to 10 dB values, ±0.75 dB maximum for 11 to 20 dB values and ±1 dB maximum for 21 to 40 dB values. Delivery: from stock to one week ARO (up to 1000 pieces).

BroadWave Technologies Inc., Franklin, IN (317) 346-6101, www.broadwavetech.com.

RS No. 226

90° Hybrid Coupler

The model IPP-2033 is a high power, 3 dB, 90° hybrid coupler that operates in a frequency range from 900 to 2500 MHz. This model combines two signals of up to 150 W CW of total output power. The 3 dB hybrid is produced in a miniature drop-in style package size of 1.3" × 0.25" × 0.2" with solder tab connections. Insertion loss is less than 0.3 dB, phase balance is less than ±5°, VSWR is less than 1.30, amplitude balance is less than ±0.90 dB, and there is greater than 18 dB of isolation. Delivery: stock to four weeks.

Innovative Power Products Inc., Holbrook, NY (631) 563-0088, www.innovativepp.com.

RS No. 252

Interference Notch Filter

The model WSN-00256 is a 941 MHz pager interference notch filter that mitigates signal interference caused by co-location of paging and cellular systems in buildings and businesses of all types. This custom notch filter is highly selective with 45 dB minimum rejection from 940 to 943 MHz and is temperature stabilized from 0° to 50°C. The 941 MHz notch filter maximizes performance trade-offs between sharp-shape factors and band-edge insertion losses. Size: 15" × 8" × 5".

K&L Microwave Inc., Salisbury, MD (410) 749-2424, www.klmicrowave.com.

RS No. 227

RF Distribution Assembly

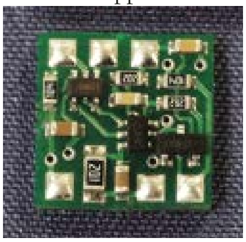
The model RFD-00001 is an RF distribution assembly used in military airborne signal processing applications. This assembly operates in a frequency range from 2 to 700 MHz, offers an insertion loss of 3.5 dB, and is phase and amplitude tracked from 2 to 700 MHz.

Lorch Microwave, Salisbury, MD (410) 860-5100, www.lorch.com.

RS No. 228

PIN Diode Switch Drivers

These PIN diode switch drivers are designed for use in applications where GaAs or high speed Si PIN diodes are utilized. External negative supply voltages may be as high as –18 V. Inputs are compatible with standard logic families. The switch drivers contain internal spiking and decoupling capacitors. MSD7800 switch drivers are assembled on FR-4 circuit boards. All components are conformal coated and meet RoHS lead-free requirements. Packaged switch drivers are available upon request.



MDT Corp., Westford, MA (978) 692-7800, www.mdtcorp.com.

RS No. 229

Coaxial Load Terminations

This family of 1, 2, 5, 10, 35, 50 and 100 W 7/16 DIN-Male coaxial loads are designed for next generation equipment deployments. These loads offer rugged construction and excellent performance (VSWR 1.10) across all wireless bands from DC to 6 GHz, which makes them ideal for base station and RF/microwave lab applications. These products are made in the US and are available from stock.

MECA Electronics, Denville, NJ (973) 625-0661, www.e-meca.com.

RS No. 230

SPDT Absorptive Switches

Models HSWA2-30DR+ are SPDT absorptive switches with an internal CMOS control driver that delivers performance by providing high isolation, low insertion loss and high input IP3 over the entire DC to 3000 MHz band. Operating from a single positive 3 V supply voltage, these RoHS-compliant switches are totally immune to latch-up so they always work. Incorporate the company's unique design-simultaneous switch-off of RF1 and RF2, and provide super low DC power consumption, essential for today's portable battery operated wireless devices. These switches are great solutions for base station infrastructure, CATV, DBS, MMDS, Wireless WLAN and band switching. In stock. Price: from $1.29 (1000).

Mini-Circuits, Brooklyn, NY (718) 934-4500, www.minicircuits.com.

RS No. 231

Ku-band Communication Upconverter

The 9900 series communication upconverter operates in a frequency range from 13.75 to 14.8 GHz and provides L-band monitor output, which is ideal for ENG/SNG and video broadcasting applications. It enables the operator to monitor the uplink signal using an L-band receiver or spectrum analyzer. A strong feature set of monitor and control functions supports powerful local and remote control. Features include: control of frequency, attenuation and 64 memory locations for each converter where various setups can be stored and recalled.

MITEQ Inc., Hauppauge, NY (631) 436-7400, www.miteq.com.

RS No. 232

2007 IEEE MTT-S International Microwave Symposium and Exhibition

FREE

Exhibition Only Registration
Compliments of
Microwave Journal

Bring This Card to the Registration Area at the Hawaii Convention Center to Register and Receive Your Badge

---

2007 IEEE MTT-S IMS

PREPAID EXHIBITION REGISTRATION

Compliments of: Microwave Journal

Host ID: 2050255

You are cordially invited to attend the 2007 IEEE MTT-S IMS Exhibition,
Hawaii Convention Center, Honolulu, HI, June 5–7, 2007
Enter the information requested below to receive a Complimentary admission badge to the show.

NAME ____________________ Last ____________________ First

AFFILIATION ____________________ Company, Etc. __________ Mail Stop

ADDRESS ____________________ Street

____________________ City ____ State __________ Zip Code

____________________ Country

TEL. NO. ____________________ FAX NO. ____________________

E-MAIL ____________________

☐ Yes, I would like to receive information by e-mail from IEEE/MTT-S
☐ Yes, I would like to receive information by e-mail from microwave/wireless industry companies

2007 IEEE MTT-S International Microwave Symposium and Exhibition

FREE

Exhibition Only Registration
Compliments of
Microwave Journal

Bring This Card to the Registration Area at the Hawaii Convention Center to Register and Receive Your Badge

---

2007 IEEE MTT-S IMS

PREPAID EXHIBITION REGISTRATION

Compliments of: Microwave Journal

Host ID: 2050255

You are cordially invited to attend the 2007 IEEE MTT-S IMS Exhibition,
Hawaii Convention Center, Honolulu, HI, June 5–7, 2007
Enter the information requested below to receive a Complimentary admission badge to the show.

NAME ____________________ ____________________
Last First

AFFILIATION ____________________ ____________________
Company, Etc. Mail Stop

ADDRESS ____________________
Street

____________________ ______ ____________
City State Zip Code

____
Country

TEL. NO. ____________________ FAX NO. ____________________

E-MAIL ____________________

☐ Yes, I would like to receive information by e-mail from IEEE/MTT-S

☐ Yes, I would like to receive information by e-mail from microwave/wireless industry companies

Broadband Relays

The RF311 family is ultraminiature, high repeatability broadband TO-5 relays. The RF311 and the sensitive RF331 are single-pole, dual-throw (SPDT) relays that deliver improved repeatability and performance over a broader bandwidth, DC to 8 GHz. These relays are available in coil voltages of 5, 12 and 26.5 VDC. The RF311 is designed for use in attenuator and other RF circuits. Features include high resistance to electrostatic discharge (ESD), a metal enclosure for EMI shielding, ground pin option to improve case grounding and high isolation between control and signal paths. The relay is RoHS compliant. Price: $32.22 each (500). Lead time for delivery is 14 weeks.

Teledyne Relays,
Hawthorne, CA (800) 284-7007,
www.teledynerelays.com.

RS No. 254

Triplexer/Diplexer Assembly

This triplexer/diplexer assembly is designed to meet a variety of applications including military, commercial and space. Typical features include: UHF/VHF frequency band up to 3000 MHz, low insertion loss of < 1 dB, VSWR of 1.3, and 50 Ω port VSWR 1.20 for both frequency ranges. Custom designs and package options are available (SMT, GPO, GPPO, SMA interfaces).

Networks International Corp.,
Overland Park, KS (913) 685-3400,
www.nickc.com.

RS No. 233

Threshold Detector

The model TD-30T-SHS-218-30DBAMP options DAC, DS, is an ultra-high speed, high sensitivity threshold detector designed for broadband applications in the 2 to 18 GHz frequency range. This model offers an eight-bit digital control to adjust the threshold level and has TTL output. The power supply is ±12 V. Size: 2.5" × 2" × 0.5".

Planar Monolithics Industries Inc.,
Frederick, MD (301) 631-1579,
www.planarmonolithicsindustries.com.

RS No. 234

High Power Directional Couplers

The P/N C40-105-481/4N is a 40 dB dual directional coupler that operates in a frequency range from 100 to 500 MHz. This coupler offers a coupling flatness of ±0.75 dB across the band and VSWR of 1.15. Insertion loss and directivity are respectively 0.2 dB and 20 dB and maximum input power is 500 W. Type N female connectors are utilized on the input and output ports and SMA female connectors on the coupled ports. Size: 3" × 2" × 1.5".

Pulsar Microwave Corp.,
Clifton, NJ (973) 779-6262,
www.pulsarmicrowave.com.

RS No. 253

High Power Compact Diplexer

The part number 2DP-925/1575-S11 is an L-band diplexer. This unit offers passbands of 905 to 925 and 1450 to 1700 while maintaining loss of less than 0.3 dB. This unit can withstand power of 60 W CW, has channel-to-channel isolation of at least 30 dB and maintains a VSWR of 1.5 or better.

Reactel Inc.,
Gaithersburg, MD (301) 519-3660,
www.reactel.com.

RS No. 235

Two-way Power Dividers/Combiners

These custom high power two-way dividers/combiners are in-phase "Wilkinson" type designs with excellent electrical performance within the band of ±12 percent of any center frequency between 750 to 2400 MHz. These devices can be used as dividers or combiners with 50 W CW per channel for failsafe applications, where typically one output is, for example, the loss of one element in an antenna array. As a divider, it can handle up to 200 W assuming a load VSWR of 1.2 or better.

RLC Electronics Inc.,
Mount Kisco, NY (914) 241-1334,
www.rlcelectronics.com.

RS No. 236

TNC and N Connectors

These 18 GHz TNC and N jacks are now available with the same 1/2-inch square mounting footprint as SMA. The connectors are field-serviceable for 0.015", 0.018", 0.020" and 0.036" diameter accessories. These jacks present a typical VSWR of 1.10 to 18 GHz and precision stainless steel housings. The connectors offer high power with 165°C maximum operating temperature and meet RoHS, DFARS requirements.

Southwest Microwave Inc.,
Tempe, AZ (480) 783-0201,
www.southwestmicrowave.com.

RS No. 237

Tower Top Filter

The model CFB5-899 filter features a design that provides high "Q" and stable temperature performance. This filter provides an excellent building block for compact diplexers and multiplexers with a passband of 896 to 902 MHz. The unit is a solution for tower top amplifier applications that require a compact mechanical and rugged environmental package. Isolation is specified at 90 dB at f_c ±37 MHz and the insertion loss is 1 dB. Size: 1.90" × 3.063" × 5.25" with SMA female connectors.

Trilithic Inc.,
Indianapolis, IN (317) 895-3600,
www.trilithic.com.

RS No. 238

SMA Plug Termination

The model 2003-6112-01 is a compact, lightweight, 50 Ω, SMA plug coaxial termination.

Product highlights include excellent VSWR to 18 GHz and compact size measures 0.312" diameter × 0.34" long. This product is constructed with a gold plated passivated stainless steel body and passivated stainless steel coupling nut. This product is ideal for test and measurement applications as well as system use requiring long-term performance and low cost. Price: starting under $10 (Qty 1–9).

XMA Corp.,
Manchester, NH (603) 222-2256,
www.xmacorp.com.

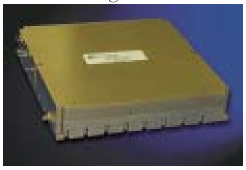
RS No. 239

CLASSIFIED

AMPLIFIERS

GaN Broadband Power Amplifier

The model SSPA 0.8-2.5-200 is a high power, broadband, gallium nitride (GaN) RF amplifier



that operates in a frequency range from 0.8 to 2.5 GHz. This PA is ideal for broadband military platforms as well as commercial applications because it is robust and offers high power over a multi-octave bandwidth. This amplifier operates with a base plate temperature of 85°C with no degradation in the MTBF for the GaN devices inside. It is packaged in a modular housing that is approximately 8" × 8" × 1.5".

Aethercomm Inc.,
San Marcos, CA (760) 598-4340,
www.aethercomm.com.

RS No. 240

High Power Amplifiers

The model AMP0.1G2.5-20-35P is a broadband maximally flat high power amplifier that

operates in a frequency range from 100 MHz to 2.5 GHz. This amplifier family features 23 dB gain with gain flatness better than ±1.5 dB. The amplifier outputs at least 2 W of power. Current draw is 600 mA from +24 V. Connectors are SMA (f) and delivery is typically from stock. Other models are available that feature additional gain, different input voltages and frequency ranges.

Amplical Corp.,
Verona, NJ (201) 919-2088,
www.amplical.com.

RS No. 241

Solid-state Power Amplifier

The model BM2719-80 is a Class AB linear amplifier that operates over the full 20 to 1000

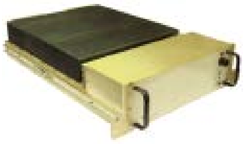
MHz frequency range with output power of 80 W. This amplifier is compact (6.4" × 3.4" × 1.06") and weighs only 1 pound. The model features a solid-state design and offers wideband operation. Model BM2719-80 is compact and lightweight and designed for the military environment.

Comtech PST,
Melville, NY (631) 777-8900,
www.comtechpst.com.

RS No. 242

High Power Amplifiers

These compact, LDMOS-based, linear high power amplifiers (HPA) are designed for



L- and S-band applications for digital radio and video broadcasting. The HPA is capable of operating with DVB-T, XM, Sirius, STiMi and T-DMB waveforms. The HPA output power is rated at 300 W at 30 dB shoulder for all of the above waveforms. It is capable of handling multiple channels of COFDM signals. These HPAs are designed to operate in both indoor and outdoor environments. The HPA system includes 220 V power supply, complete remote control, self-monitoring and protection, and high performance carbon fins heat sink.

Unique Broadband Systems Ltd.,
Ontario, Canada (905) 669-8533,
www.uniquesys.com.

RS No. 243

ANTENNA

Ground Data Terminal Antenna

This Ground Data Terminal (GDT) antenna is in a Ku-band configuration to support current

and future Tactical Common Data Link requirements. The new Ku-band GDT is a follow-on system to the company's S/C-band GDT used for the Shadow® 200 Tactical Unmanned Aircraft System (TUAS). The US Army has indicated that all future systems that provide command, control and telemetry reception should be delivered with a Ku-band Tactical Common Data Link (TCDL) capability. In operation, the Ground Data Terminal communicates directly with the TUAS, gathers data from onboard sensors over the area of interest, and transmits the data to the ground terminal for processing and dissemination. Featuring a four foot reflector, this GDT design offers high gain performance (+41 dBic, minimum) and is a low weight system (< 150 lbs.).

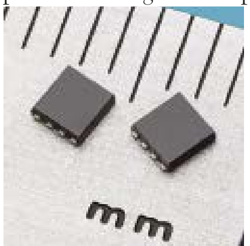
TECOM Industries Inc.,
Thousand Oaks, CA (805) 267-0100,
www.tecom-ind.com.

RS No. 244

INTEGRATED CIRCUIT

SiGe Prescaler

The model UPB1514TU SiGe divide-by-8 prescaler is designed for input frequencies of 8



to 16 GHz and delivers typical output power of –5 dBm at 1 to 2 GHz. Fabricated using NEC's 50 GHz UHS2 silicon bipolar process, the UPB1514TU is ideal for up and down conversion applications in Ku-band satellite and terrestrial communications. The UPB-1514TU prescaler delivers excellent performance and is designed to serve as a low cost alternative to GaAs devices. Size: 2.2 × 2.0 × 0.5 mm TU package. Price: from $2.71 in 10K quantities.

California Eastern Laboratories (NEC),
Santa Clara, CA, www.cel.com.

RS No. 245

SOURCES

Microwave Pulse Source

The MPS-5KW is a microwave pulse source designed to accept plug-in modules from 220 to 5000 MHz, producing over 5 kW peak power at some frequencies. Microwave component manufacturers will use this instrument to determine the peak power capability of their components. System designers will benefit by generating microwaves to test their designs for RF susceptibility.
H6 Systems Inc.,
Nashua, NH (603) 880-4190,
www.h6systems.com.

RS No. 255

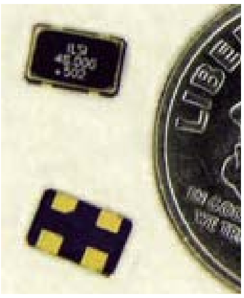
X-band Synthesizer

This high performance synthesizer operates over the X-band SATCOM range of 6.410 to 7.545 GHz and can be customized to meet step size requirements from 1 kHz down to 1 Hz. It features outstanding spectral purity and low phase noise of –77 dBc at 100 Hz offsets and –125 dBc at 1 MHz offsets. The X-band synthesizer is ideal for harsh-environment defense applications where a combination of low noise, wide bandwidth and very small step size are essential. The base model is based on Endwave's proprietary YIG oscillators. Applications include: field portable X-band SATCOM terminals, control links for unmanned aerial vehicles (UAV) and tri-band converters.
Endwave Defense Systems,
Sunnyvale, CA (408) 522-3180,
www.endwave.com.

RS No. 248

Spread Spectrum Oscillator

The ISM72 series of spread spectrum oscillators are available from 10 to 80 MHz. Its output level is HC-MOS, with 50 percent ±10 percent duty cycle, and rise/fall times of 7 ns maximum. Stabilities are as low as 25 ppm over a temperature range of 0° to 70°C. It features a tri-state function with enable/disable time of 100 ms maximum. Supply voltage is 3.3 VDC. Lead free (RoHS) ceramic package measures 3.2 × 5 × 1.1 mm. Price: $2.39 each (1K pcs.). Delivery: 8 to 10 weeks ARO.



ILSI America,
Reno, NV (775) 851-8880,
www.ilsiamerica.com.

RS No. 256

Frequency Synthesizer

The WaveCor 2.50 dual frequency synthesizer is the latest addition to the WaveCor line of high performance DDS-based frequency synthesizers and features two independent microwave synthesizers in a single rack-mount enclosure. Each high performance synthesizer operates over a frequency range from 300 MHz to 2.5 GHz. At 1.2 GHz, the WaveCor 2.50 dual provides phase noise levels of –140 dBc/Hz at a 10 kHz offset and typical spurious levels of –70 dBc. Switching speeds are less than 300 ns maximum when tuning to any operating frequency. The WaveCor 2.50 dual's high reliability and performance are available in a 5U rack-mount chassis.
ITT Microwave Systems – AES Division,
Lowell, MA (978) 441-0200,
www.ittmicrowave.com.

RS No. 249

AT-Cut Crystal

The NX8045GB series is a commercially available 4 MHz thickness shear vibration mode

(AT-cut) SMD crystal unit. The low frequency operation keeps the power consumption low (drive level 50 µW) and can be applied with existing IC designs. It is available in a frequency range from 4 to 40 MHz with a frequency tolerance of ±30 ppm at an ambient temperature of +25°C. The NX8045GB is ideal for automotive applications with an operating temperature range of –40° to +125°C while delivering superior environmental performance including high heat, vibration and impact resistance. Size: 8 × 4.5 × 1.8 mm package.
NDK (Nihon Dempa Kogyo Co. Ltd.),
Belvidere, IL (800) 635-9825,
www.ndk.com.

RS No. 257

S-band Voltage-controlled Oscillator

The model V614ME26-LF is a voltage-controlled oscillator that operates in a frequency range from 1900 to 2100 MHz. This product offers a low phase noise performance of –98 dBc/Hz at 10 kHz offset from the carrier. The typical tuning sensitivity of this product is 62 MHz/V and the harmonic suppression is –15 dBc while delivering an O/P power of 4 ± 2 dBm over the extended operating temperature range of –40° to 85°C. It covers 200 MHz within 8 VDC. Size: 0.50" × 0.50" × 0.22". Price: $18.95/VCO (5 pcs min). Delivery: stock to four weeks.

Z-Communications Inc.,
San Diego, CA (858) 621-2700,
www.zcomm.com.

RS No. 250

SUBSYSTEM

Two-channel Radiometer Front-end

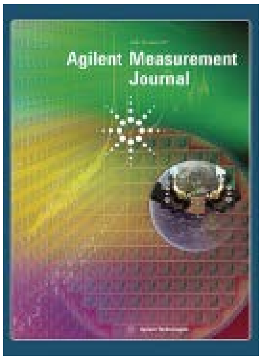
The model RR89-1 is a two-channel radiometer front-end that is configured with two orthogonal receive channels covering 88 to 90 GHz input. A single 89 GHz Gunn oscillator drives the LO for the mixers in both channels. Using a noise generator, approximately 120 K excess noise temperature is injected into the mixer at each channel through a 20 dB crossguide coupler. 20 dB of isolation is achieved between the coupler and mixer using an isolator. The IF output spans 40 to 1000 MHz with 50 dB of gain and a DSB noise figure of 6.5 dB typical, 7.5 dB maximum.

Spacek Labs Inc.,
Santa Barbara, CA (805) 564-4404,
www.spaceklabs.com.

RS No. 251

New Literature

Measurement Journal



The Measurement Journal provides today's engineers with the information they need to stay ahead of the competition and on top of the latest technologies, trends and Agilent measurement solutions. It covers a wide range of industries, including aerospace and defense, wireless communications and industrial, and features articles with significant contributions from Agilent engineers in the fields of electronics as well as life sciences and chemical analysis.

Agilent Technologies Inc.,
Santa Clara, CA (800) 829-4444,
www.agilent.com.

RS No. 200

Designer's Guide

The 12th edition Designer's Guide catalog for 2007 includes full specifications for 482 components, 91 new RFIC and MMIC product data sheets, quality/reliability, application and packaging/layout information. New for 2007 the two volume catalog format now includes: Volume 1: Amplifiers, Control Devices & Power Detectors and Volume 2: Data Converters, Frequency Generation, Mixers & Modulators. To request a 2007 catalog two volume set, visit www.hittite.com and select the "Submit Inquiry" button.

Hittite Microwave Corp.,
Chelmsford, MA (978) 250-3343,
www.hittite.com.

RS No. 205

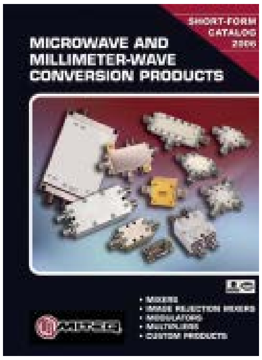
Parametric Test Handbook

The *Parallel Test Technology: The New Paradigm for Parametric Testing* is a semiconductor parametric test handbook. This 60-page handbook offers an overview of the emerging test technique known as parallel parametric testing, a strategy for wafer-level parametric testing that uses concurrent execution of multiple tests on multiple scribe line test structures.

Keithley Instruments Inc.,
Cleveland, OH (800) 688-9951,
www.keithley.com.

RS No. 201

Short Form Catalog



This recently released microwave and millimeter-wave conversion products short-form catalog features a sampling of the company's latest mixers, images, rejection mixers, modulators, multipliers and custom products. There are also sections discussing quality assurance, manufacturing flow diagrams, MITEQ's Space Heritage and options available to the customer.

MITEQ Inc.,
Hauppauge, NY (631) 436-7400,
www.miteq.com.

RS No. 202

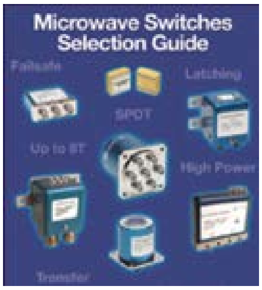
Product Brochure

This brochure has been updated to reflect the expansion of the extra-durable Storm Flex™ miniature cable line to include a larger, 0.160" diameter cable that is a high strength flexible replacement for RG-402 semi-rigid cable. Mechanical, electrical product specifications, competitive analysis graphs for VSWR, phase, insertion loss vs. flexure, applications, and complete ordering information are also included.

Storm Products–Microwave,
Woodridge, IL (630) 754-3300,
www.stormproducts.com/microwave.

RS No. 203

Selection Guide

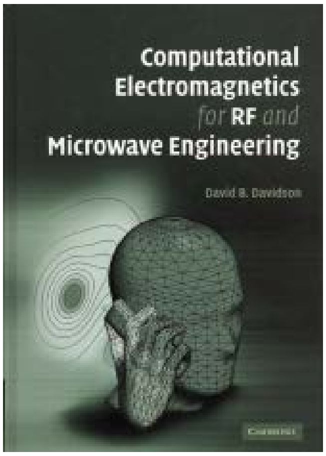


The switches selection guide features 20 families of coaxial switches and relays in a tabular format. The guide, designed to help engineers quickly choose a product, now features schematic drawings for all switches and relays. The 24-page digest provides detailed information about the switches and relays, which span the range from DC to 26.5 GHz and cover SPDT (single-pole, double-throw) up to SP8T and transfer switches.

Teledyne Relays,
Hawthorne, CA (800) 284-7007,
www.teledynerelays.com.

RS No. 204

Computational Electromagnetics for RF and Microwave Engineering

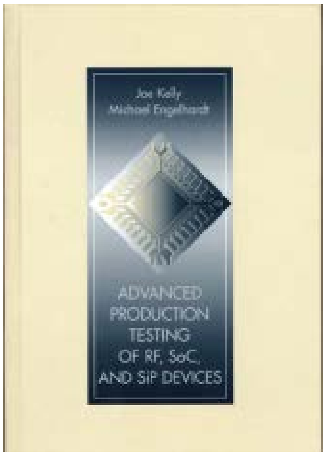


David B. Davidson
Cambridge University Press • 430 pages; $80, £47
ISBN: 0-521-83859-2

This book is designed to serve as an introduction to computational electromagnetics for RF applications. It comprises essentially three parts. The first part, Chapters 2 and 3, deals with the finite difference time domain (FDTD) method, in one and (primarily) two dimensions, respectively. Chapter 2 uses a simple transmission line problem to introduce many of the basic ideas of the FDTD method. Chapter 3 goes on to extend these ideas to two dimensions and considers a number of the issues raised when handling radiation and scattering in free space, in particular the use of absorbing boundary conditions. The second part, Chapters 4 to 8, deals with the method of moments (MoM). Here, the five chapters largely alternate theoretical developments with practical applications. Chapters 4 and 5 form a unit, first introducing MoM theory for thin-wire antennas and then applying it using both a commercial and a public domain code. Chapter 6, on modeling surfaces (and also volumes) using the MoM, is largely self-contained. The material in Chapter 6 on the hybrid MoM/PO, as well as on high performance computing and fast methods can be omitted without interrupting the flow of the book. Chapters 7 and 8 form a further unit on the theory and application of the Sommerfeld mixed potential integral equation approach to modeling stratified media (of which microstrip antennas are the most encountered application). The third and final part, Chapters 9 and 10, is devoted to the finite element method (FEM). Chapter 9 goes directly into two-dimensional vector element FEM theory; it is also used to illustrate the solution of an eigenvalue problem. The material in the last chapter, Chapter 10, is primarily to sensitize readers to more advanced formulations and applications (in this case, of the FEM).

To order this book, contact:
Cambridge University Press
100 Brook Hill Drive
West Nyack, NY 10994-2133
(845) 353-7500

Advanced Production Testing of RF, SoC and SiP Devices



Joe Kelly and Michael Engelhardt
Artech House • 321 pages; $99, £60
ISBN: 1-58053-709-X

This book is a follow-up to *Production Testing of RF and System-on-a-Chip Devices for Wireless Communications* (Artech House, 2004). Like the previous publication, it is intended for a wide variety of audiences, including SoC applications engineers, engineering managers, product engineers and students, although other disciplines can benefit as well. Chapter 1 is an overview of the concepts presented in the book. Its content is designed to enable a semi-technical reader to gain knowledge about the topics that are presented in depth further on. Chapters 2 to 5 present many different aspects of production measurements and also provide enough background to build the reader's knowledge base to a level of competence needed to implement these tests in a production environment as well as on bench top instruments to perform correlation, including RF receivers, digitizers, AWGs and digital subsystems. Chapter 6 describes the many aspects of the equipment that is used in both ATE test systems and rack and stack instrumentation. Chapter 7 discusses the topic of test costs and how recent changes in industrial models have impacted costs. Because a production measurement is only as good as the calibration of the test hardware, Chapter 8 describes how calibration is performed on each of the pieces of hardware that make up a test system. Additional emphasis on RF measurement calibration is also presented. Considered possibly the most important piece of the production testing setup, contactors are discussed in Chapter 9. Chapters 10 and 12 discuss handlers and prober interfaces to the test setup. An in-depth presentation of the requirements for developing and fabricating a load board to interconnect the DUT to the test system is found in Chapter 11.

To order this book, contact:
Artech House
685 Canton St.
Norwood, MA 02062
(781) 769-9750 ext. 4030; or
6 Gillingham St.
London SW1V 1HH, UK
+44 (0) 207-8750

ADVERTISING INDEX

RS No.	Advertiser	Page No.	Phone	Fax	Web Address
1	Advanced Switch Technology	189	613-384-3939	613-384-5026	http://mwj.hotims.com/11714-1
2	Advanced Technical Ceramics Company	118	423-755-5400	423-755-5438	http://mwj.hotims.com/11714-2
3	Aeroflex	9	516-694-6700	516-694-2562	http://mwj.hotims.com/11714-3
4	Aeroflex/Inmet, Inc.	116	734-426-5553	734-426-5557	http://mwj.hotims.com/11714-4
5	Aeroflex/Weinschel, Inc.	75	800-638-2048	301-846-9116	http://mwj.hotims.com/11714-5
6,7,8, 9,10,11	Agilent Technologies, Inc.	21,41,73, 109,133,157	800-829-4444	415-857-5518	http://mwj.hotims.com/11714-6
12	American Microwave Corporation	153	301-662-4700	301-662-4938	http://mwj.hotims.com/11714-12
13	American Technical Ceramics	79	631-622-4700	631-622-4748	http://mwj.hotims.com/11714-13
14	AML Communications Inc.	35	805-388-1345	805-484-2191	http://mwj.hotims.com/11714-14
15	AMTA 2007	98	425-868-2558		http://mwj.hotims.com/11714-15
16	Anhui E-car Technology, Co., Ltd.	134	0086-551-3816718	0086-551-3838799	http://mwj.hotims.com/11714-16
17	Ansoft Corporation	101	412-261-3200	412-471-9427	http://mwj.hotims.com/11714-17
18	Applied Computational Sciences	124			http://mwj.hotims.com/11714-18
19	Applied Wave Research, Inc.	11	310-726-3000		http://mwj.hotims.com/11714-19
20	AR Worldwide	87	215-723-8181	215-723-5688	http://mwj.hotims.com/11714-20
21	Arlon-Materials for Electronics Division	177	800-635-9333	302-834-2574	http://mwj.hotims.com/11714-21
22	Artech House	181	800-225-9977	781-769-6334	http://mwj.hotims.com/11714-22
23,24	Auriga Measurement Systems, LLC	15,37	978-441-1117	978-441-2666	http://mwj.hotims.com/11714-23
25	Bird Technologies Group	96	866-695-4569		http://mwj.hotims.com/11714-25
26	Boonton Electronics (a Wireless Telecom Group Company)	COV 2	973-386-9696	973-386-9191	http://mwj.hotims.com/11714-26
27	CAP Wireless Inc.	77	805-499-1818		http://mwj.hotims.com/11714-27
28	Cernex, Inc.	112	408-541-9226	408-541-9229	http://mwj.hotims.com/11714-28
29	Channel Microwave Corporation	20	805-482-7280	805-987-8794	http://mwj.hotims.com/11714-29
30	Charter Engineering	68	727-549-8999	727-549-8018	http://mwj.hotims.com/11714-30
31	Ciao Wireless, Inc.	44	805-389-3224	805-389-3629	http://mwj.hotims.com/11714-31
32	Cobham Defense Electronic Systems	22–23	978-557-2400	978-557-2800	http://mwj.hotims.com/11714-32
33	Coilcraft	14	800-322-2645	847-639-1469	http://mwj.hotims.com/11714-33
34	COMSOL, Inc.	115	781-273-3322	781-273-6603	http://mwj.hotims.com/11714-34
35	Comtech PST Corp.	71	631-777-8900	631-777-8877	http://mwj.hotims.com/11714-35
36	CPI Beverly Microwave Division	26	978-922-6000	978-922-2736	http://mwj.hotims.com/11714-36
37	Crane Aerospace & Electronics	58	480-961-6269		http://mwj.hotims.com/11714-37
38	CST of America, Inc.	29	781-416-2782	781-576-5702	http://mwj.hotims.com/11714-38
39	dBm, LLC	154	973-709-0020	973-709-1346	http://mwj.hotims.com/11714-39
40	Dynawave Incorporated	151	978-469-0555	978-521-4589	http://mwj.hotims.com/11714-40
41	Eastern Wireless TeleComm, Inc.	128	410-749-3800	410-749-4852	http://mwj.hotims.com/11714-41
42	Elcom Technologies	136	201-767-8030	201-767-6266	http://mwj.hotims.com/11714-42
43	Electro Magnetic Careers	176			http://mwj.hotims.com/11714-43
44	EMC Technology Inc.	19	772-286-9300	772-283-5286	http://mwj.hotims.com/11714-44
45	Emerson Network Power	127	800-247-8256		http://mwj.hotims.com/11714-45
46	Emhiser Micro-Tech	76	775-345-0461	775-345-1152	http://mwj.hotims.com/11714-46
47	Empower RF Systems, Inc.	103	310-412-8100	310-412-9232	http://mwj.hotims.com/11714-47
48	Endwave Defense Systems	27	408-522-3180	408-522-3181	http://mwj.hotims.com/11714-48
49	ES Microwave, LLC	189	301-519-9407	301-519-9418	http://mwj.hotims.com/11714-49
50	ET Industries	159	973-394-1719	973-394-1710	http://mwj.hotims.com/11714-50
51	ETS-Lindgren	137	512-531-6400		http://mwj.hotims.com/11714-51
52	EuMW 2007	99	+ 44 20 7596 8742	+ 44 20 7596 8749	http://mwj.hotims.com/11714-52
53	European Microwave Conference	142	44-20-7861-6391	44-20-7861-6251	http://mwj.hotims.com/11714-53
54	Feko	100	+27 21 880 1880		http://mwj.hotims.com/11714-54
55	Filtronic Compound Semiconductors, Ltd.	147	408-850-5740	831-621-8074	http://mwj.hotims.com/11714-55
44	Florida RF Labs Inc.	19	800-544-5594		http://mwj.hotims.com/11714-44
56	Herley-CTI	60	973-884-2580	973-887-6245	http://mwj.hotims.com/11714-56
57	Herotek, Inc.	40	408-941-8399	408-941-8388	http://mwj.hotims.com/11714-57
58,59,60,61	Hittite Microwave Corporation	61,62–63,64–65,67	978-250-3343	978-250-3373	http://mwj.hotims.com/11714-58
62	Huber + Suhner AG	31	+41 (0)71 353 41 11	+41 (0)71 353 45 90	http://mwj.hotims.com/11714-62
	IEEE MTT-S International Microwave Symposium – Hawaii	178–179	781-769-9750	781-769-5037	www.ims2007.org
	IEEE Radar Conference 2007	131			www.radar2007.org
	IEEE Radio and Wireless Symposium	82	781-769-9750	781-769-5037	www.radiowireless.org

Advertising Index

RS No.	Advertiser	Page No.	Phone	Fax	Web Address
63	Interplex NAS, Inc.	89	201-768-8388	201-768-8988	http://mwj.hotims.com/11714-63
64,65,66	J microTechnology	189	503-614-9509	503-531-9325	http://mwj.hotims.com/11714-64
67	K&L Microwave, Inc.	7	410-749-2424	443-260-2268	http://mwj.hotims.com/11714-67
68	KR Electronics, Inc.	189	732-636-1900	732-636-1982	http://mwj.hotims.com/11714-68
69	Krytar	74	877-734-5999	408-734-3017	http://mwj.hotims.com/11714-69
70	Lorch Microwave	47	800-780-2169	410-860-1949	http://mwj.hotims.com/11714-70
71	LPKF Laser & Electronics	64	800-345-LPKF	503-682-7151	http://mwj.hotims.com/11714-71
72	Maury Microwave Corporation	6	909-987-4715	909-987-1112	http://mwj.hotims.com/11714-72
73	MECA Electronics, Inc.	140	973-625-0661	973-625-9277	http://mwj.hotims.com/11714-73
74	MFG Ratech	94	775-827-2222		http://mwj.hotims.com/11714-74
75	MiCIAN GmbH	102	+49(421)16899351	+49(421)16899352	http://mwj.hotims.com/11714-75
76	Micon Precise Corp.	181	886-2-2917-7528	886-2-2912-1659	http://mwj.hotims.com/11714-76
77	Microsemi	36	408-986-8031	408-986-8120	http://mwj.hotims.com/11714-77
78	Microwave Filter Company, Inc.	190	800-448-1666	315-463-1467	http://mwj.hotims.com/11714-78
	Microwave Journal	*129,197	800-225-9977	781-769-5037	www.mwjournal.com
79	Milmega Limited	187	+44 (0) 1983 618004	+44 (0) 1983 811521	http://mwj.hotims.com/11714-79
80	Mimix Broadband, Inc.	107	281-988-4600	281-988-4615	http://mwj.hotims.com/11714-80
81,82,83, 84,85,86, 87,88,89, 90,91,92, 93,94,95	Mini-Circuits	4–5,18,39, 51,52,69, 93,104,105, 119,149,161, 171,183,195	718-934-4500	718-332-4661	http://mwj.hotims.com/11714-81
96,97	MITEQ Inc.	3,42–43	631-436-7400	631-436-7430	http://mwj.hotims.com/11714-96
98	Modelithics, Inc.	68	888-359-6359	813-558-1102	http://mwj.hotims.com/11714-98
99	Molex RF/Microwave Connector Division	169	317-834-5600	317-834-5611	http://mwj.hotims.com/11714-99
100	Narda Microwave-East, an L3 Communications Co.	48	631-231-1700	631-231-1711	http://mwj.hotims.com/11714-100
101	NoiseWave Corp.	8	973-386-1119	973-386-1131	http://mwj.hotims.com/11714-101
102	OML Inc.	145	408-779-2698	408-778-0491	http://mwj.hotims.com/11714-102
103	Pascall Electronics Limited	50	+44(0) 1983 817300	+44(0) 1983 564708	http://mwj.hotims.com/11714-103
104	Pendulum Instruments	123	+46 8 598 510 55		http://mwj.hotims.com/11714-104
105	Picosecond Pulse Labs Inc.	95	303-209-8100	303-447-2236	http://mwj.hotims.com/11714-105
106	Planar Electronics Technology, Inc.	175	301-662-5019	301-662-1731	http://mwj.hotims.com/11714-106
107	Prewell Corporation	138	82-31-420-8362	82-31-420-8369	http://mwj.hotims.com/11714-107
108	Programmed Test Sources, Inc.	COV 3	978-486-3400	978-486-4495	http://mwj.hotims.com/11714-108
109	Pulsar Microwave Corporation	46	800-752-3043	973-779-2727	http://mwj.hotims.com/11714-109
110	R.C. Hansen Inc.	189	800-225-5945		http://mwj.hotims.com/11714-110
111	Reactel, Incorporated	91	301-519-3660	301-519-2447	http://mwj.hotims.com/11714-111
112	Remcom	173	814-861-1299	814-353-1420	http://mwj.hotims.com/11714-112
113	REMEC Defense & Space	38	858-560-1301		http://mwj.hotims.com/11714-113
114	Renaissance Electronics Corporation	139	978-772-7774	978-772-7775	http://mwj.hotims.com/11714-114
115	RF Micro Devices	121	336-678-5570	336-931-7454	http://mwj.hotims.com/11714-115
116	RF TEC Mfg., Inc.	188	770-487-2187	770-486-9499	http://mwj.hotims.com/11714-116
117,118,119	RFHIC	30,32,34	82-31-250-5011	82-31-250-5088	http://mwj.hotims.com/11714-117
120	RLC Electronics, Inc.	25	914-241-1334	914-241-1753	http://mwj.hotims.com/11714-120
121	Rogers Corporation	135	480-961-1382	480-961-4533	http://mwj.hotims.com/11714-121
122	Rohde & Schwarz GmbH	59	+49-1805-124242	+49-89-412913777	http://mwj.hotims.com/11714-122
123	Rohde & Schwarz, Inc.	*129	888-837-8772	410-910-7801	http://mwj.hotims.com/11714-123
124	Rosenberger	111	+49-8684-18-0	+49-8684-18-499	http://mwj.hotims.com/11714-124
125	Roswin Inc.	110	+82-41-621-4450	+82-41-621-4451	http://mwj.hotims.com/11714-125
126	Sector Microwave Industries, Inc.	189	631-242-2300	631-242-8158	http://mwj.hotims.com/11714-126
127	Sirenza Microdevices	33	303-327-3030		http://mwj.hotims.com/11714-127
128	Sivers IMA AB	126	46 (0) 8 703 68 04	46-8-7519271	http://mwj.hotims.com/11714-128
129	Skyworks Solutions, Inc.	55	781-376-3000		http://mwj.hotims.com/11714-129
130	Sonnet Software, Inc.	113	315-453-3096	315-451-1694	http://mwj.hotims.com/11714-130
131	Spacek Labs Inc.	92	805-564-4404	805-966-3249	http://mwj.hotims.com/11714-131
132	Spectrum Elektrotechnik GmbH	117	+49-89-3548-040	+49-89-3548-0490	http://mwj.hotims.com/11714-132
133,134	Spectrum Microwave, Inc.	80–81,83	888-553-7531	302-727-3729	http://mwj.hotims.com/11714-133
135	Suss MicroTec AG	78	(+49) 35240/73-0		http://mwj.hotims.com/11714-135
136	Symmetricom	28	978-232-1497		http://mwj.hotims.com/11714-136

ADVERTISING INDEX

*REGIONAL DISTRIBUTION ONLY

Visit **Microwave Journal** *on the Web at* **www.mwjournal.com**

Visit mwjournal.com/info and enter RS# to request information from our advertisers

SALES REPRESENTATIVES

CARL SHEFFRES, PUBLISHER

ED JOHNSON, ASSOCIATE PUBLISHER

KEN HERNANDEZ, TRAFFIC ADMINISTRATOR

Eastern and Central Time Zones
Chuck Curley
Northeast Reg. Sales Mgr.
(New England, Upstate NY, Eastern Canada)
685 Canton Street
Norwood, MA 02062
Tel: (781) 769-9750
FAX: (781) 769-5037
ccurley@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

Brian Green
Inside Sales Manager
685 Canton Street
Norwood, MA 02062
Tel: (781) 769-9750
FAX: (781) 769-5037
bgreen@mwjournal.com

Eastern and Central Time Zones
Ed Johnson
Associate Publisher
PO Box 5962
Ocala, FL 34478-5962
Tel: (352) 620-2442
FAX: (352) 620-2443
ejohnson@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
Tel: +44 207 596 8742
rvaughan@horizonhouse.co.uk

Michel Zoghob
Deputy Publisher
Tel: +44 207 596 8741
mzoghob@horizonhouse.co.uk

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

Germany, Austria, and Switzerland (German-speaking)
Juergen Wissling
Wissling Marketing Services
Riedstrasse 5
72813 St. Johann-Wuertingen
Germany
Tel: +49 7122 828140
FAX: +49 7122 828145
jwissling@horizonhouse.com

Israel
Oreet Ben Yaacov
Oreet International Media
15 Kineret Street
51201 Bene-Berak, Israel
Tel: +972 3 570 6527
FAX: +972 3 570 6526
obenyaacov@horizonhouse.com

Korea
Young-Seoh Chinn
JES Media International
2nd Floor, ANA Bldg.
257-1, Myungil-Dong
Kangdong-Gu
Seoul, 134-070 Korea
Tel: +82 2 481-3411
FAX: +82 2 481-3414
yschinn@horizonhouse.com

Japan
Katsuhiro Ishii
Ace Media Service Inc.
12-6, 4-Chome,
Nishiiko, Adachi-Ku
Tokyo 121-0824, Japan
Tel: +81 3 5691 3335
FAX: +81 3 5691 3336
amskatsu@dream.com

China
Alexander Glos
i2i Media
16-602 China Central Place
89# Jian Guo Road
Chaoyang District, Beijing,
China - 100025
Tel: ++86-10-65331960/61
FAX: ++86-10-65331959
aglos@i2i-m.com.cn

Wide bandwidth,
HIGH POWER DEVICES
Unsurpassed quality + on-time delivery, is the Werlatone promise

QUADRATURES COMBINERS DIVIDERS HYBRIDS

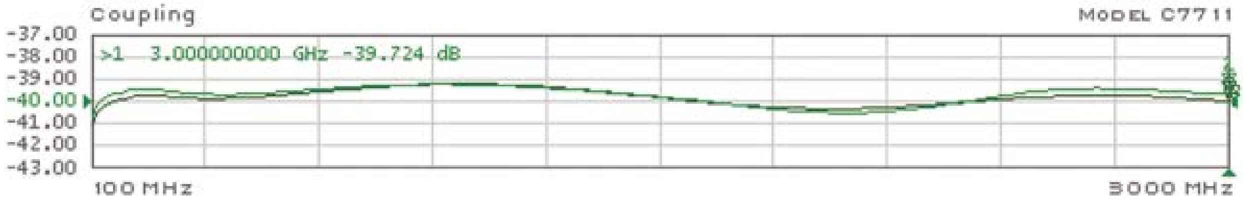
WERLATONE

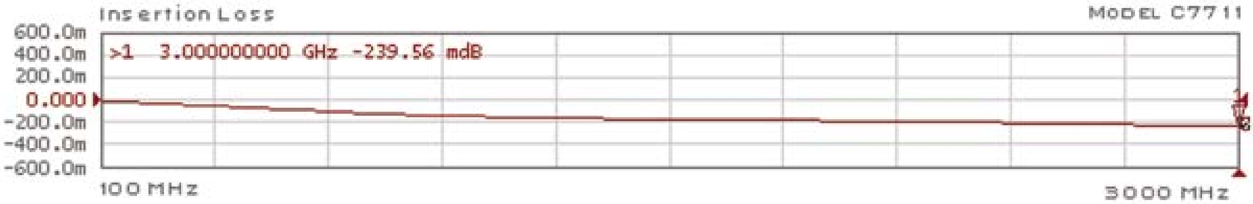
Breaking all the Rules

10:1+ Bandwidth Lowest Loss Directional 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

COUPLERS





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

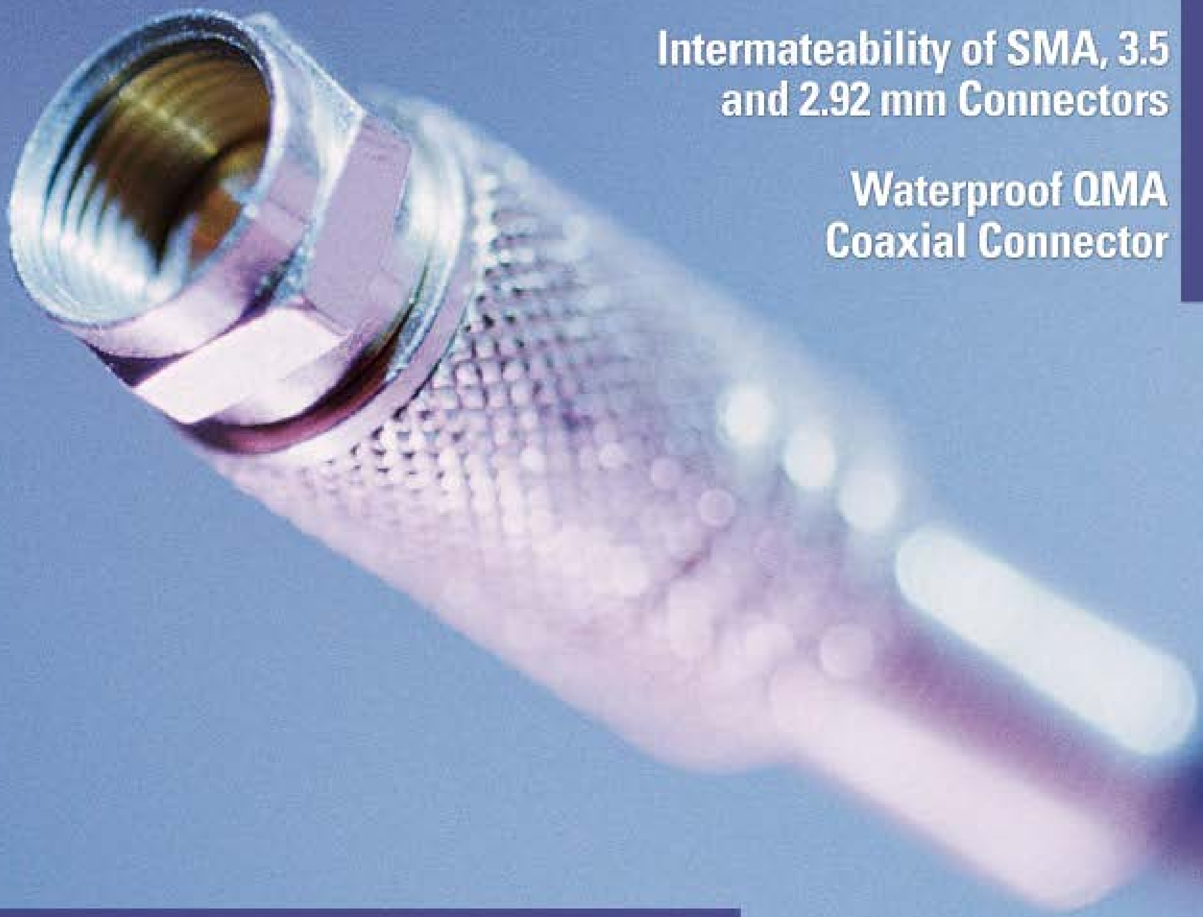
Cables & Connectors 2007

Connector, Cable and Cable Assembly Survey

Connector Pin Design

Intermateability of SMA, 3.5 and 2.92 mm Connectors

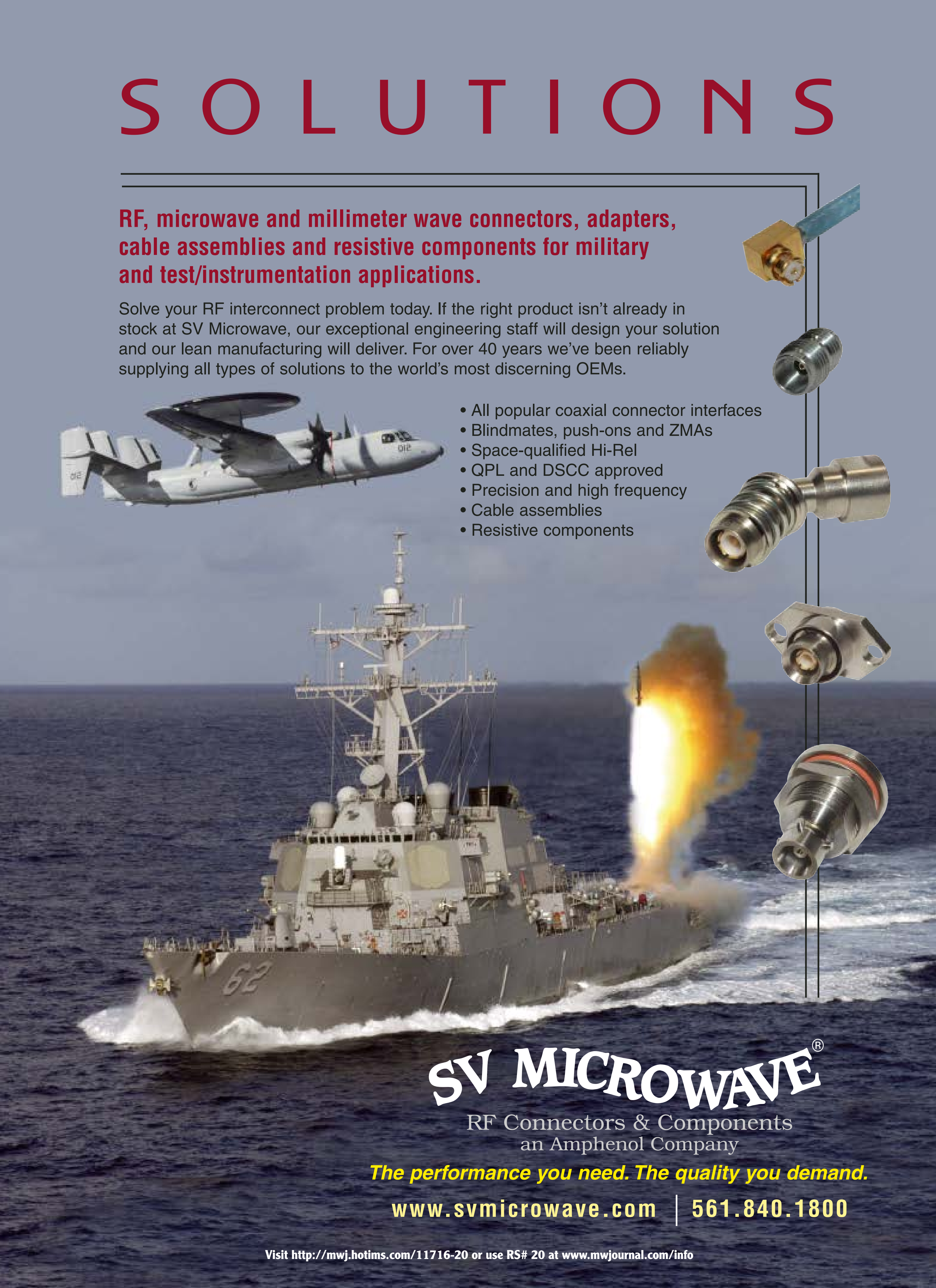
Waterproof QMA Coaxial Connector

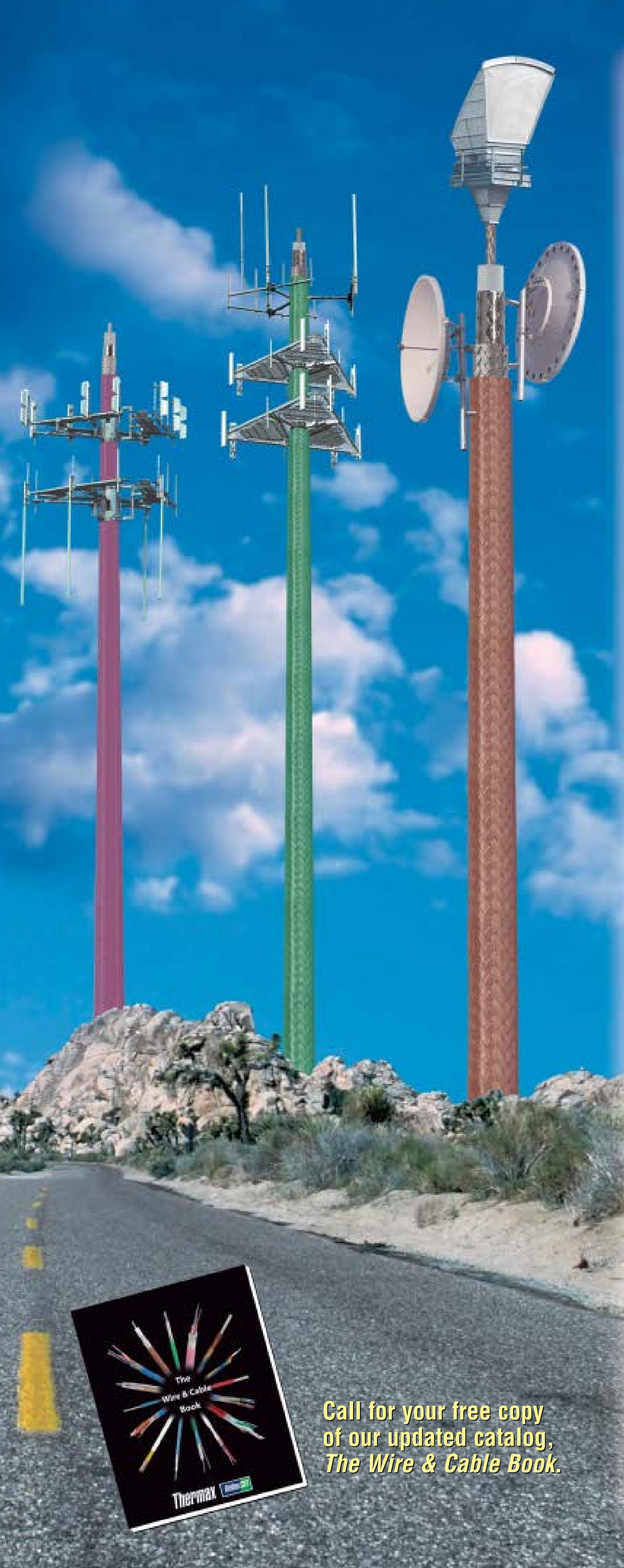


A Special Supplement to Microwave Journal

www.mwjournal.com

horizon house


SOLUTIONS
RF, microwave and millimeter wave connectors, adapters, cable assemblies and resistive components for military and test/instrumentation applications.
Solve your RF interconnect problem today. If the right product isn't already in stock at SV Microwave, our exceptional engineering staff will design your solution and our lean manufacturing will deliver. For over 40 years we've been reliably supplying all types of solutions to the world's most discerning OEMs.
• All popular coaxial connector interfaces
• Blindmates, push-ons and ZMAs
• Space-qualified Hi-Rel
• QPL and DSCC approved
• Precision and high frequency
• Cable assemblies
• Resistive components
SV MICROWAVE®
RF Connectors & Components
an Amphenol Company
The performance you need. The quality you demand.
www.svmicrowave.com | 561.840.1800
Visit http://mwj.hotims.com/11716-20 or use RS# 20 at www.mwjournal.com/info



The
Wire & Cable
Book
Thermax

Cables & Connectors Supplement Table of Contents

FEATURES

SPECIAL REPORT

TECHNICAL FEATURES

PRODUCT FEATURES

Staff

Publisher: Carl Sheffres
Associate Publisher: Edward Johnson
Editor: Harlan Howe, Jr.
Managing Editor: Keith W. Moore
Technical Editor: Frank M. Bashore
European Editor: Richard Mumford
Associate Technical Editor: Dan Massé
Staff Editor: Jennifer DiMarco
Editorial Assistant: Barbara Walsh
Consulting Editor: Howard I. Ellowitz
Consulting Editor: Peter Staecker
Consulting Editor: Dan Swanson
Web Editor: Stephen Heiser
Traffic Manager: Edward Kiessling
Traffic Administrator: Ken Hernandez
Director of Production & Distribution: Robert Bass
Multimedia Designer: Eli Conner
DTP Coordinator: Janet A. MacDonald

EUROPE

Deputy Publisher: Michel Zoghob
European Editor: Richard Mumford
Office Manager: Eugenie Hardy

CORPORATE STAFF

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

Supplement to the March 2007 issue of Microwave Journal

Horizon House also publishes *Telecommunications®*

Posted under Canadian international publications mail agreement #0738654

2007 CONNECTOR, CABLE AND CABLE ASSEMBLY SURVEY

This is the fifth survey of connectors, cables and cable assemblies sponsored by Microwave Journal. *We will continue to update it annually with continued industry support and participation.*

We are very pleased to offer this updated survey of companies providing connectors, cables and cable assemblies. Seventy-seven companies responded to our request for information this year, which is an increase from the 74 companies in last year's survey. In addition, 10 of last year's participants have updated their information as well, so this survey represents the most comprehensive listing ever offered of companies providing RF and microwave cable and connector products.

There is clearly a large overlap of similar products being produced by the 77 companies included in the survey, particularly the standard connectors. However, careful examination of the information shows that virtually all of the companies have at least one unique, proprietary or patented product that addresses some niche market and which forms the core of their business, as well as customized products to meet specific requirements. These special products and services seem to be the principal reason for the diversity of suppliers. In addition, some companies specialize in different markets such as Hi-Rel, military and base stations as opposed to low cost commercial and consumer. Thus, in reality, the overlap is not as great as it seems.

Every manufacturer has provided an address for its web site. Most of these sites contain either full catalog information or selected data sheets. We have also provided phone and e-mail points of contact for each company where available. In some cases, both foreign and domestic contacts have been provided.

I would like to thank the many people who responded to our request for information. Because of limited space, we were not able to use some detailed information that was sent in addition to the specific survey answers; however, we were able to use some of that information to expand on the brief answers to the questions. The data are presented in table format on the following pages. Readers are encouraged to use the web information and contact points to gain additional insight on the products, services and capabilities of a company of interest.

HARLAN HOWE, JR.
Editor, **Microwave Journal**

Company	Standard Connector Types	Special Connectors	Raw Cable Manufacturing
Aeroflex/Weinschel	Planar Crown® and Planar Blind-mate® systems, which are compatible with N, TNC, GPC-7, 3.5 mm, 2.92 mm and 2.4 mm series	Planar Crown® and Planar Blind-mate® allow connector interfaces to be changed for custom applications or for damage replacement	Do not manufacture cable
Aliner	MMCX, MCX, SSMB, SSMA, MC card, SMP, SMA, QMA, SMB, SMC, TNC, BNC, N	MMCX switch connector, MCII, SSMCX, board-to-board connectors, ACX board-to-board	Do not manufacture cable
Amphenol RF	MMCX, AMC, MCX, QN, SMP, SMB, SMC, SMA, 1.0/2.3, QMA, FAKRA, BNC, TNC, Mini BNC, Twin BNC, Triax, UHF, Mini UHF, N, F, 7/16	SMP, AFI, QMA, FAKRA, AMC	Yes, please visit www.amphenol.com
Anritsu	K series (2.92 mm), V series (1.85 mm), W1 Connector (1 mm)	Over 300 special or custom designed connectors	Do not manufacture cable
Applied Engineering Products, a Radiall company	SMA, SMB, SMC, SLB, SSMB, SSMC, SSLB, SSMA, MCX, 75 Ω MCX, MMCX, 75 Ω Snap-on, 75 Ω Screw-on, BNC, TNC, N, adapters between series and over 100 styles of MIL-PRF-39012 QPL connectors	Water-proof and weather-tight, special leg configurations for PCBs, special plating and finishes, custom contact configurations, special cable types, connectors with internal functions like switches, unique captivation, reverse polarity, special testing	Do not manufacture cable
Astrolab Inc.	N, SMA, SMP, SMPM, TNC, ATNC, 3.5 mm, 2.9 mm, 2.4 mm, 1.85 mm, BNC, 7 mm, 7/16, BMA, TK, SC, HN, M39029 coax contacts – in various forms such as straight, right angle, swept bend, bulkhead and flanged	SMA designs up to 27.5 GHz, SSMA designs up to 40 GHz, low IM space qualified TNC, multipaction resistant designs, Flouraloy dielectric, M39029 contacts up to 12 GHz, phase shifter/line stretchers up to 26.5 GHz, HF hermetically sealed	0.041 to 0.310 diameter from 70% VP to 82% VP, semi-rigid to highly flexible with capability up to 90 GHz
Atlantic Microwave	SMA, SMP, SSMP, 2.9 mm, 2.4 mm, 1.85 mm, N, TNC, BNC, MCX, MMCX, SMB, SMC	Special body lengths, special PCB connections, moisture ingress protection, special cable types	Semi-rigid, copper, aluminum, tin-plated, reformable, flexible, composite, commercial RG-types, bulk and assemblies, telecommunications, Satcom, cellular, base station, industrial
Aviel Electronics, Div. of RF Industries	See RF Industries listing	Special designs for non-standard types such as hermetically sealed, low PIM, polarized special interface for compliance with FCC 15.203, blind mate, hermetic right angle, 45°, custom make to order capability	Do not manufacture cable
Belden Inc.	Do not manufacture connectors	Do not manufacture connectors	Mil-Spec RG type coax for high frequency applications as well as 50 Ω antenna coax for wireless communications applications including base stations, wireless LANs and other in-building wireless applications
BTC Electronics Inc.	BMB, BNC, C, G874, GHV, HN, LC/LT, MCX, MHV, MMCX, MQD, N, QDS, QMA, SC, SMA, SMB, SMC, TNC, TPS, TRB, TW34, TWBNC, UHF, 1.0/2.3, 7/16	Special connector configurations to customer's drawing	Do not manufacture cable
Cable Experts Inc.	No standard connector products	No special connectors	Do not manufacture cable
CE Precision Assemblies Inc.	No standard connector products	Special designs for specific customer problems such as a 600 W version of the SMP connector. The company also builds radiation hardened connectors, high temperature and high power connectors as well as low IM and waveguide connectors	Semi-rigid and special cables
Coax Co. Ltd.	SMA, SSMA, N, TNC, BNC	SMA and SSMA for 0.013" (0.33 mm) diameter cable	Semi-rigid from 0.013" to 0.379" and impedances from 7 to 122 Ω. Combinations of materials such as: niobium, cupronickel, stainless steel, beryllium copper, etc. PTFE, PFA, PE dielectric cables, triaxial cables, aluminum jacketed cables
Compel Group	1.0/2.3 and 1.6/5.6 – 50 or 75 Ω, SMA, SMB, SMC, BMA, SMP, MMCX, MCX, N, 7/16, BT-43, DIN41612, PCMCIA, BNC, Metric 2.0 & 2.5, D-SUB, adapters, terminations and dust covers, singlemode and multimode optical connectors	Special designs are available using a wide variety of materials and processes	Do not manufacture cable but does re-sell under some circumstances
Connectronics	All connector series from MMCX through 7/16 sizes, between series adapters, trin-ax/triax, coax contacts (arianc type), 50 Ω and 75 Ω connectors	Custom connectors, machined components and value added brazing/assembly work	Do not manufacture cable
Corning Gilbert Inc.	GPO (DC to 26.5 GHz), GPPO (DC to 65 GHz), GMS (DC to 23 GHz)	Custom versions of the GPO, GPPO and GMS designs for backplane mounting, waveguide launches and group mating configurations	Do not manufacture cable
Delta Electronics Mfg. Corp.	N, 7/16, SMA, 27 GHz SMAs, SMK, SMP, MMCX/MCX TNC/BNC, 1.0/2.3, MHV, C, HN, QDS, G874, YPS, TRB, LC/LT, Mil-PRF-30912 & Mil-PRF-55339	QDS, slide-on, BMA, pressmounts, Mini QDS, G874	Do not manufacture cable
Deutsch Advanced Interconnect	DPP series of connectors in N and SMA configurations with push-pull coupling, 7/16, circular multi-pin, blind mate, environmental power connectors, fiber optic	Custom connectors for special environmental interfaces	Do not manufacture cable
Dynawave Inc.	SMA, SSMA, SMB, SMC, MCX, MMCX, BMA, BMA miniature, SMP, SMPM, SMPSM, SMT, 2.4 mm, 2.92 mm, 3.5 mm, 7 mm, N, TNC, SC, HN, BNC, 7/16	Custom designs for cables, field replaceable, PCB mount, edge mount, hermetic connectors and seals, tabbed contact, adapters	Semi-rigid and flexible as well as custom designs
Electronika International Inc.	BNC, TNC, FME, SMB, SMC, UHF, 3.5 mm, SMA, N, MMCX, MCX, LC, GR874	Special testing and matching	Do not manufacture cable
ESM Cable Corp.	Do not manufacture connectors	Do not manufacture connectors	Do not manufacture cable
EZ Form Cable Corp.	MCX, MMCX, BMA, SMA, SMB, SMC, N, TNC, BNC, SSMA, SSMB, 7/16, DSB	EZ Quick-Connect™ plug (SMA compatible), standard series to stripline and microstrip transitions, standard series for low loss and custom cables	Semi-rigid cable from 0.020 to 0.325 inch in copper or aluminum at impedances from 25 to 100 Ω. Custom cables from special materials, flexible cable such as EZConformable in diameters from 0.034 to 0.250 inch at 50 and 75 Ω, EZFlex 401, 402 and 405 flex
Flexco Microwave Inc.	LC, LT, GPO, BNC, EIA, HN, precision N, precision SMA, SC, SMC and TNC	Special connectors for use on cable assemblies such as GPPO, SSMA and ZMA types	Custom cable is manufactured for use in Flexco cable assemblies

Cable Assemblies	Unique Products	Web site and Contact Information
Do not manufacture cable assemblies	US and international patents on both Planar Crown® and Planar Blind-Mate® systems	www.aeroflex-weinschel.com Technical: Jimmy Dholoo, Sales: Thomas Steidel, sales@aeroflex-weinschel.com
General purpose and military for RG178, RG174, RG316, Filotex, LMR, Belden, flexible, semi-rigid	Specials and cable assemblies	www.aliner.com.tw Technical: Victor Chou, victor@aliner.com.tw
Flexible, semi-rigid, conformable, harnesses, phased matched, time delay	AFI Interface to compensate for axial and radial misalignment, which is available in both 50 and 75 Ω	www.amphenolrf.com Technical: Owen Barthelmes 203-796-2133, obarthelmes@amphenolrf.com Sales: Greg Straiton 203-796-2079, gstraiton@amphenolrf.com
Cable assemblies with APC, N, K, V and W1 connectors, mostly semi-rigid. Test cables both armored, semi-rigid and flexible	The new W1 connector, which can be used up to 250°C, VP series Blind Mate up to 65 GHz	www.us.anritsu.com 1-800-Anritsu
Flexible, conformable, semi-rigid, phase matched and delay lines	SLB/SA patented self aligning PCB to PCB system	www.aepconnectors.com, Technical: Joe Mastriano at jmastriano@aep.us, Sales: Dennis Flanders at dflanders@aepconnectors.com, General: sales@aepconnectors.com
Mini-bend flexible, convoluted semi-rigid for superconducting temperatures down to 4°K, high flexcables for gimbles and phase stable cables up to 60 GHz	Mini-bend cable assemblies, ever-flex cable and the Cobra-flex line	www.astrolab.com Mary Ceres 732-560-9570
Laboratory and test, general purpose, flexible, semi-rigid, phase stable, phase matched, high temperature	Ultra flexible high frequency, reformable, semi-rigid and flexible test cable are in stock	Joanna Bolton www.atlanticmicrowave.co.uk
Both standard and non-standard types, phase matched, semi-rigid, general purpose, commercial and military	Special fabrication for unique customer applications	www.avielelectronics.com Jack Kaufman 702-739-8155, avielconn@aol.com
Do not manufacture cable assemblies	Conformable™ coax for semi-flexible replacement of rigid-coax	www.belden.com Technical Support: 1-800-belden1
Do not manufacture cable assemblies	Special configurations and quick samples	www.btcelectronics.com Technical: Robert Barnett at rbarnett@btcelectronics.com, Sales: Audra Starling at astarling@btcelectronics.com, 800-526-2828
A large array of RF cable assemblies	CXP1318FX series, low loss RG8/U assemblies	www.cablexperts.com – Marc Abramson, Chuck Abramson
A wide range of custom cable assemblies including build-to-print and custom standard and low loss assemblies from DC to 65 GHz with limited capability to 110 GHz. Cable assemblies are available from commercial grade to space qualified, radiation hardened	All products are unique to the individual customer's requirements. Many are not available for export without government permission	www.cepainc.com, Technical: Henry Richards 480-940-0740 x222, hrichards@cepainc.com, Sales: Kathy Kennard x219, kkennard@cepainc.com
Semi-rigid, low temperature (cryogenics), superconducting, high temperature, medical, telecom, commercial, laboratory and test, electromagnetic probe	Small diameter cables using materials mentioned, polymide dielectric cable, semi-rigid probe cable using phosphor bronze or oxygen free copper. Soldering connector attachment on niobium and stainless steel is a unique technique	www.coax.co.jp/english/index.html Contacts: USA: Mike Cahill, Pete Alfano 978-456-9184 or 9186 info@responsemicrowave.com. Outside of USA: Satoshi Tanabe +81-15-572-3300, stanabe@coax.co.jp
Coaxial, multi-pin, fiber optic, semi-rigid, conformable, corrugated, flexible, multi-strand for commercial, military, laboratory and medical applications	Most comprehensive line of 1.0/2.3 connectors, adapters and cable assemblies. Patented plastic flange 7/16 (available in pms colors)	www.compel.it or www.responsemicrowave.com Contact: Peter Alfano 978-458-9186 or 9184 info@responsemicrowave.com
Do not make cable assemblies	One of the largest "private label" manufacturers specializing in custom-designed, obsolete and/or hard to find connectors. All products manufactured in the USA.	www.connectronicsinc.com Technical: John Barnes at johnb@connectronicsinc.com Sales: Michael Brewer at sales@connectronicsinc.com Phone: 812-526-8801; Fax: 812-526-9333
Laboratory and test, general purpose, semi-rigid, flexible	The GPO and GPPO push-on interconnects were created by Gilbert and are patented	www.corning.com/corninggilbert Technical and Customer Service (US and Canada): 800-651-8869 (International): (01)623-845-5613, push-info@corning.com
Do not make cable assemblies	Heli-grip, QDS, mini QDS, G874	www.deltarf.com Corinne Rose (Application Specialist), crose@deltarf.com and Terry Hannan, thannan@deltarf.com
Laboratory and test for push-pull N and SMA, assemblies to customer specs, test jumper cables with DPP on both ends	DPP series is unique as it does not require a special receptacle	www.deutschai.com Chief Engineer is Bryan Harrington, Customer Service Manager is Clyde Farren, Sales & Marketing is Ted Linder 909-791-2600, Fax: 909-791-2611
Instrumentation, laboratory and test, semi-rigid, formable, flexible, delay lines, phase stable, phase matched, low IM, high power, rigid	Internal R&D	www.dynawave.com Brian Nothum 978-469-0555, bnothum@dynawave.com
Laboratory and test, general purpose, flexible, semi-flexible, phase matched sets	Quick delivery on flexible specials	www.electronikainc.com Contact: Rick Modi at modi@electronikainc.com
Laboratory and test, general purpose, flexible, rigid, semi-rigid, phase stable, phase matched, high temperature	Specializing in RF and high frequency	www.esmcablecorp.com Greg Garno or David Doo at 209-892-3347
Custom cable assemblies using all of the EZ Form cables	EZ Quick-Connect™ is patented	www.ezform.com Technical: Tom Ricard at tricard@ezform.com Sales: Jeff Buccitti at jbuccitti@ezform.com
Cable assemblies using Flexco cable for commercial, test and military with emphasis on assemblies with very low phase and amplitude changes during flexure. See next column.	Flexco's cable assemblies are unique due to a combination of connectors and special cables with a wide range of jackets, braids and protective armoring. These are extremely rugged, while providing excellent phase and amplitude stability	www.flexcomw.com Bill Bright, Larry Cagno and Dan Beene at 908-850-5800 or dbeene@flexcomw.com

Company	Standard Connector Types	Special Connectors	Raw Cable Manufacturing
Florida RF Labs Inc.	Do not manufacture connectors	Do not manufacture connectors	Do not manufacture cable
Florida RS Technology	SMA, TNC and N with special strain relief	Special SMAs in plug, jack and bulkhead	Do not manufacture cable
Gigalane Co. Ltd.	2.4 mm, 2.92 mm, SMA, high performance SMA, SMB, MCX, MMCX, N, GPO	Customer specific designs are available	RG cable types, semi-rigid and special types
Harbour Industries	Do not manufacture connectors	Do not manufacture connectors	20 types of MIL-C-17 QPL approved RG cables, SB strip braid, CN communication network, LL low loss, SS spiral strip, SC sureform, HPF high performance foam, HIS high strength, TRX triaxial, LN low noise, plenum
Haverhill Cable and Manufacturing	Do not manufacture standard connectors	0.141 and 0.086" low loss male connectors available	semi-rigid, bare and tin plated copper, tin plated aluminum ultra-hand formable, low loss available in most sizes, flexible coax
HoSung Technics Co. Ltd.	MMCX, MCX, SMA, SMB, SMC, BNC, TNC, N, 7/16 DIN, adapters	Special products as requested	Do not manufacture cable
Huber + Suhner	1.0/2.3, 7/16, BMA, BNC, BNO, BNT, MCX, MHV, MMBX, MMCX, N, PC2.4, PC3.5, PC7, QLA, QMA, QN, SHV, SK, SMA, precision SMA, SMB, SMC, SMS, TNC, adapters	Custom MMBX, SUHNER QUICK-FIT, ARC series for automotive applications, quick lock connectors and adapters, phase trimmers	Standard RG types (58, 174, etc.), low loss RF cables, high temperature and flame-retardant, low noise for test applications, triaxial, twisted pair, multiple cables in the same jacket, radiation hardened
IMS Connector Systems GmbH	SMA, SMB, SMC, SMS, SSMB nano, SMP, SMM, MMCX, MCX, coaxial inserts DIN 41612, coaxial inserts sub-D, high power inserts, FME, BNC, TNC, N, 7/16, 1.6/5.6, SMBA (FAKRA Std.), antenna switches	QLS (quick lock, alternative to SMA connectors) SnapN (backwards compatible with N connectors), medical RF connectors	Do not manufacture cable
Ingun Pruefmittelbau	Spring-loaded test probes for test and measurement applications, contact solutions for MCX, BMA, MMCX, SMA, SMD, BMC, SMC, TNC, FAKFRA	Customized designs for all connectors are available on request	Do not manufacture cable, but do distribute it
Insulated Wire Inc.	SMA, TNC, N, SC, 1.85 mm, 2.4 mm, 2.9 mm, 3.5 mm, 7 mm	Custom designs including MIL 38999 multi-pin contacts, custom flange mounts, special interface connectors	Over 150 types ranging in size from 0.050 to 0.500" with impedances from 10 to 125 Ω. A wide variety of outer braids, shields and jacket materials. Multiple cables in common jackets and armored types as well as semi-rigid and reflex cables
Isotec	SMA, SSMA, SMB, SMZ, SSMB, SMC, SSMC, BNC, TNC, MCX, MMCX, N, 7/16 DIN, field replaceable SMA, reverse polarity and reverse thread, adapters	Slide-on, waterproof, special leg or board, cable types	Do not manufacture cable
Jyebao Co.	SMA, K, SMB, SSMB, SMP, FME, 7/16, SMC, MMCX, MCX, BNC, TNC, N, HN, C, SC, SHV, MHV, plus reverse polarity versions	Custom designs can be made	Semi-rigid and flexible, 0.034, 0.047, 0.085 and 0.141" with various platings
Kings Electronics	10 KV, 20 KV, 7-16, BNC, C, HN, K-loc, MHV, N, RCA, SC, SHV, SMA, SMZ, TNC, UHF, MDB , SDB, Twin BNC, TRB, TRT, Tri-Loc HDTV camera connectors, audio jacks and jackfields, audio patch plugs, video jacks and jackfields, video patch plugs and patch cord assemblies	Custom designs for customer requirements and unique applications	Do not manufacture cable
M/A-COM (Tyco)	SMP, 2.4 mm, SSMA, 2.92 mm, 3.5 mm, SMA, SMB, SMC, TR, TNC, BNC, GPO, GPPO, MCX, OSSP, OSP, MMCX, ETNC, N, 7 mm, SC, C, 7/16 IEC, HN, LC, LT, MLT, 7/8 EIA, 1 5/8 EIA (types N, TNC and 7/16 IEC available with low PIM), 3 1/8 EIA	MTNC – A multipactor free variant of TNC for high power space applications, size 8 and 12 contacts for low loss, low VSWR, high frequency performance for MIL-C-87104 and MIL-T-81490 in standard MIL-C-38999 housings, SL family of connectors	Hundreds of cable types from 0.05" to 1.40" with a variety of materials. Military airborne, space satellite, mobile mast, general lab, gimble, lightweight military, commercial aircraft, kapton and halogen free. Custom designs available.
Maury Microwave	1.85, 2.4, 2.92, 3.5, QT3.5, 7 mm, MPC8, N, TNC, BNC, HN, SC, C, LCP/OSP, 14 mm, 7-16, precision and high precision grades, 75 Ω N and BNC	Quick test 3.5 connectors in different sizes, turns and nut configurations, improved LCP/OSP for high repeatability	Do not manufacture cable
MegaPhase Inc.	Do not manufacture connectors	Special adapters for test applications	GrooveTube™ coaxial cable but do not sell raw cable
Meggitt Safety Systems	SMA, TNC, ETCN, N, 2.4, 2.92, 3.5, GPO, SMP, SC	Custom high frequency e.g. 50 GHz 2.9 mm, special military e.g. multiport, extreme environment e.g. non-magnetic, high temperature e.g. special alloy	Semi-rigid silicon dioxide dielectric cables
Micro-Coax Inc.	Manufacture connectors to support in-house cable assembly business only	Special connectors for multi-paction sensitive applications and low PIM requirements	Semi-rigid, aluminum jacketed, hand-formable-tin dipped, low loss and ultra-low loss flexible, miniature low loss, ultralight flexible
Micro-Mode Inc.	MSMA compatible to SMA 2.92, MBMB compatible to BMB, MMSP compatible to SMP, MSSP compatible to MSMP, MSSS,™ MM4S, TNC, SMA, SSMA, 2.92, 2.4, SMP, SMPM	Special applications with interface to SSMA, BMA, 2.4, SMC and TNC as well as customer interfaces	Do not manufacture cable
Microstock Inc. (Distributor)	SMA, SMB, SMC, MCX, MMCX, MMBX, 3.5 mm, 2.9 mm, 2.4 mm, 1.85 mm, BMA, QMA, SHV, MHV, N, 7/16, 1.0/2.3, 1.6/5.6, 4.1/9.5, TNC, BNC, UHF, plus between series adapters	Special SMAs for low loss 0.047" diam. semi-rigid cables such as UT-47-LL and UT-47-LL-TP, special SMA for 25 Ω 0.090 diam. cables such as UT-90-25 and UT-90-25-TP	Do not manufacture cable, but do distribute it
Microwave Distributors Co. (Midisco)	SMA, SMB, SMC, CMS, SSMA, SSMB, SSMC, MMCX, N, UHF, C, HN, 7/16 and others	Specials and custom products with reasonable minimum lot sizes	Semi-rigid (SNAKE and hand-formable) (Ultra-Flex) as well as distribution of cable from other manufacturers
Midwest Microwave, Emerson Network Power Connectivity Solutions	SMA, SSMA, SMM, BNC, TNC, TNC-A, N, BMA, QPL, 7 mm, 3.5 mm, SC, HN, SMB, SMC, 2.9 mm, BSAs and in-series adapters	Engineering and design support for specials with our sister division, Johnson Components	Do not manufacture cable
Mini-Circuits	Do not manufacture connectors	Do not manufacture connectors	Do not manufacture cable

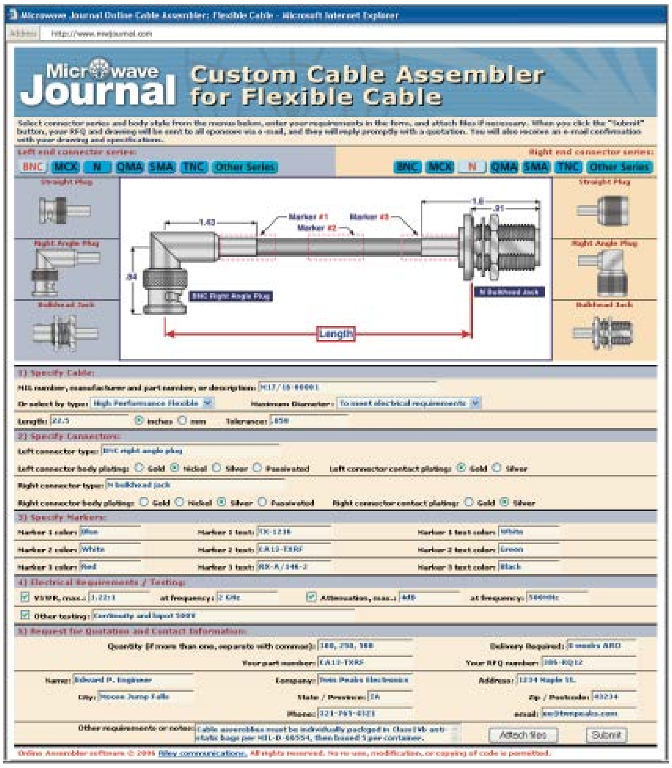
Cable Assemblies	Unique Products	Web site and Contact Information
Laboratory and test, general purpose, flexible, semi-rigid, hand formable, phase stable, phase matched, high temperature, space level and custom	Lab-Flex™ cables DC to 46 GHz with 2.4 mm, 2.9 mm, 3.5 mm SMA, precision type N & TNC as well as low cost assemblies for specific frequency ranges with 40% lower loss and shielding greater than 90 dB	www.rflabs.com Jim Walker 772-286-9300 or jwalker@rflabs.com
40 GHz test cables, low loss assemblies, semi-rigid configurations, Flex cables both standard and armored, sizes from 0.019 to 2 inches in diameter	Many of our assemblies are made on patented production equipment	www.flrst.com Technical: Tim Spacek & Al Ragl, Sales: Sandy Struthers, 772-221-8188
Low loss assemblies up to 40 GHz, semi-rigid and semi-flexible types, RG types	VEREND high performance and launch connector	www.gigalane.com Richard Song at sales@gigalane.com
Source of cable for many cable assembly houses	Many of the specialty cables incorporate proprietary materials and processes	www.harbourind.com John D. Palasciano at jpalasciano@harbourind.com
Semi-rigid and flexible cable assemblies, phase matched, custom bending available, special low loss assemblies available, custom designed delay lines	EZ Bend II, tin plated aluminum, ultra-light ultra formable semi-rigid	www.haverhillcable.com Sales: joshk@haverhillcable.com; susank@haverhillcable.com Technical: tomk@haverhillcable.com Phone: 978-372-6386; Fax: 978-374-5943
Flexible, semi-rigid and jumper cables	Quick delivery on specials within one week	www.hstcns.com – Anthony Ham at 82-32-683-8007 x216
Flexible RF, form stable, semi-rigid, hand formable, flexible MW	MMBX board-to-board, Sucoflex,™ LSFH (low smoke halogen free), enviroflex cables, low noise cables, triaxial, twisted pair (up to 100 Ω)	www.hubersuhner.com Local sales offices in 60 countries
Semi-rigid, semi-flexible, flexible, corrugated, coilcord, GPS cable, GSM cable, FAKRA cable	Press-fit and press-in as well as MIM manufacturing technology, miniature antenna switches and quick lock connectors	www.imscs.com Sales: Chris Hoy (UK) 0044/2392 75 00 11 sales@imscs.com
Do not manufacture cable assemblies, but do distribute them	Benefit from our unique solution, which builds up a perfect unit and covers the complete measurement section from the UUT through to the test system	www.ingun.com Local sales offices in over 35 countries
Low loss cable assemblies up to 65 GHz, general purpose and laboratory, medical and military applications	Proprietary dielectric of laminated, expanded or full density PTFE. Dielectric constant can be tailored anywhere from 1.3 to 2.0. Patented connector design for full captivation on large cables up to 18 GHz	www.iw-microwave.com Cable assemblies: 203-791-1999 or iwsales@iw.com Raw cable: 631-981-7424 or iw-microwave.com
Flexible, semi-rigid, semi-flex, corrugated UFL cable general purpose, commercial, phase matched, delay lines		www.isoconnector.com Edward Lee at 408-351-3450, isotec@unitel.com.kr
RG types, Japanese types, semi-rigid, handbendable, low loss, phase matched	Almost the only manufacturer of semi-rigid cable in Southeast Asia. Standard connectors are stocked and can be shipped within one week	www.jyebao.com.tw Jyebao Sales – pol-heyns@jyebao.com.tw
Video patch cord assemblies and custom cable assemblies for special applications such as high voltage test lab	Several patented designs including the industry leading Tri-Loc camera connectors	www.KingsElectronics.com Technical: 803-909-5086 or SUPPORT@KingsElectronics.com Sales: 803-909-5500 or KINGSINFO@KingsElecronics.com
Laboratory, general purpose, airborne EW, phase stable, phase and amplitude matched, small diameter, radiation resistant, cable sets with interchangeable ends and replaceable heads, high shock for launch vehicles, space qualified	All products designed and produced in-house	www.macom.com, Technical: Ray Schwartz at 978-442-5487 schwartz@tycoelectronics.com. Sales (Americas): 800-366-2266, (Europe, Middle East, Africa): 44 (1908) 574200, (Asia/Pacific): 81-44-844-8296
Semi-rigid assemblies in general purpose type N as well as precision 2.4 mm, 3.5 mm, SMA, 7 mm, and N in 0.25, 0.141 and 0.085" diameter cables. Test port adapters and between series adapters as well as test cable kits	Quick test connectors and assemblies	www.maurymw.com/mmc_catalog/mmccatalog.htm Technical: Brian Wolf at bwolf@maurymw.com Domestic Sales: Shawna Johnson at sjohnson@maurymw.com Int'l Sales: Anita Luther at aluther@maurymw.com
Flexible and semi-rigid assemblies for test and system cable applications from 2 to 65 GHz. There are five product lines for test and measurement and eight product lines for system and general purpose cables	GrooveTube™ is unique to MegaPhase	www.megaphase.com Technical: Bob Fisher at 570-424-8400, bfisher@megaphase.com Sales: Joe Carbonara at 570-424-8400, sales@megaphase.com
Semi-rigid silicon dioxide dielectric cables and assemblies – phase stable from near 0K to 2400 F, phase matched, high temperature, harsh environments and precision configured assemblies	Meggitt is the only company to produce space qualified SiO_2 cables and assemblies	www.stablecable.com Cyril Berg at 805-584-4100, cberg@safetysystem.com
Test, general purpose, flexible, semi-rigid, phase stable, phase matched, high temperature, low loss, ultralight, space qualified	Flexible Ultralight UTiFLEX cable assemblies using DuPont's ARACON™ metal clad fibers	www.micro-coax.com Sales: Bruce Ash at 610-495-4225 Technical: John Lewis at 610-495-4326
Flexible, semi-rigid and rigid phase matched assemblies	MSSS™ series, which is 20% smaller than MSMP and 40% smaller than SMP. Over 500,000 parts produced	www.micromode.com Technical: Mark Perry 619-449-3844 x25, mperry@micromode.com Sales: Brian Peckham 619-449-3844 x46, brian@micromode.com
Laboratory and test, general purpose, flexible RG, semi-rigid formed to specification, phase stable, low loss rigid assemblies	No unique products	www.microstock-inc.com Technical contact: Dr. Bob Schafer, Sales: Scott Frobese, micrstok@ix.netcom.com, 215-699-0355
Standard RG cables, LMR,™ semi-rigid, ultra-flex, and phase stable assemblies	Unique configurations and combinations supported by a large inventory	www.microwavedistributors/idisco.net Technical: John Summerville, Sales: Mark Laurenti, instock@microwavedistributors.com
Test and measurement, general purpose, mil/aero applications, low loss, std. RG-type patch cords, semi-rigid and semi-flex, phase matched, delay lines Flexform I & II, production test cable assemblies featuring Emerson Network Power Johnson Brand Quick-Disconnect SMA	Flexform I and Flexform II are proprietary cable designs plus low loss and ultra low loss cables	www.midwest-microwave.com; www.emersonnetworkpower.com Contact: Ruth Fawson, 813-920-0170, ruth.fawson@emersonnetworkpower.com
Laboratory and test, general purpose, flexible, phase stable, phase matched	Phase stability over more than 20,000 flexes	www.minicircuits.com, Contact: Mini-Circuits Applications 718-934-4500, sales@minicircuits.com

Company	Standard Connector Types	Special Connectors	Raw Cable Manufacturing
Molex Inc.	MMCX, MCX, SMB, SMA, SMA field replaceable, SMP, 2.92, BNC, TNC, F, FAKRA, N, 7/16, between series adapters	Catalog derivative for special requirements such as: solderless edge mount, 45 degree SMB plugs, MCX custom coaxial headers	Do not manufacture cable
New and Forever	Low cost standard RF connectors	No specials	Semi rigid in sizes from 0.047" through 0.250" in both copper and aluminum with various plating, center conductors and impedances. Hand-formable, tin soaked in sizes from 0.047" to 0.250". Custom semi-rigid
Palco Connector	BMA, MNC, HN, MCX, MMCZ, N, SMA, SMB, SMC, SMP, SSMA, SSMB, TNC, full range of size 8 and size 12 coax contacts	Specials for all of the standard series	Do not manufacture cable
Radiall	BNC, BMA, coaxipack 2, coaxi-kit, DIN 1.02/2.3, DIN 1.6/5.6, DTF, FME, FAKRA II, HN, mini UHF, microswitch, MC-CARD, MCX, MMCX, N, 7/16, PR, SMA, SSMA, SMB, SSMB, SMC, SMP, SMP commercial, SMB carlock, triax, twinax, TNC, UHF, USCar, adapters	QMA, QN, MMBX, MMS, MMT, MiniQuick, non-magnetic connectors, IMP, UMP, SNB lock	Low loss and ultra low loss raw cable
RF Industries Inc.	RF Connector Division offers: BNC, 7/16 DIN, FME, F, N, SMA, SMB, mini SMB, TNC, UHF and mini UHF	Aviel Division designs and manufactures custom RF connectors including standard and custom interfaces, hermetically sealed, blind mate, special PCB footprint, miniature mating and non-magnetic	Do not manufacture cable
RF TEC Mfg. Inc.	SMA, SMB, SMC, SSMA, SSMB, SSMC, TNC, MCX, MMCX, MCCARD, MS147, N, 7/16	Snap-on/Push-on Slide-on adapters for SMA, K adapters, Push-on N adapters, special thin center pin SMA panel mount plug and receptacle, reverse polarity SMA receptacle with special flange, 18 mm connectors, torque reinforced screwed center pin for N and BNC receptacles, 1" long body 75 Ω SMB receptacle, N bulkhead jack for 1.32 mm double shield coax	Do not manufacture cable
Rhophase Microwave Ltd.	No standard connector products	Custom connectors for special applications such as SMA 10 Ω for a laser application	Do not manufacture cable but are UK agents for Insulated Wire Inc., Harbour Industries Corp. and Haverhill Cable and Manufacturing Corp.
Rosenberger Hochfrequenztechnik GmbH & Co. and **Rosenberger of North America**	No standard connector products	SMCC for surface-mount, custom products on request	Do not manufacture cable
SGMC Microwave	1.85 mm, 2.4 mm, 2.9 mm, 3.5 mm, PGM, SSMA, SMA, SMB, SMC, SMM, TNC, N, 7 mm, ASSMA	Custom designs are available on request, including 1.0 mm (DC-110 GHz), 2.9 spark plug over 1-1/2" long, special straight and angle flange mounts, PCB mounts in many series	Do not manufacture cable
Sabritec Inc.	SCX, Micro-D, SMP, SMPM, high frequency D-sub size 8 coax contacts	Custom designs are available on request	Do not manufacture cable
San-tron Inc.	N, 7/16, SMA, BNC, TNC, C, HN, LC, MHV, SC, SHV, UHF, 1.0/2.3 3.5 mm, 2.92 mm, SMP and within and between series adapters	Extended insulators and contacts, custom flanges, custom cable sizes, custom designs based on standard interface designs	Do not manufacture cable
Semflex Inc.	MCX, SMA, BMA, 3.5 mm, 2.9 mm, 2.4 mm, 1.85 mm, BNC, TNC, ETNC, N, 7 mm, SC, HN, 7/16 DIN, 7/8 EIA, 1 3/8 EIA, 1 5/8 EIA	High power/high temperature, environmental sealed, custom interfaces, push-on, blind-mate, phase trimmers	High performance 50 Ω, low loss, high power, low density PTFE dielectrics, RG cable types, communications cable, custom cable
Sources East	SMA, SMB, SMC, SMK, SMP, SMZ, SSMA, SSMB, MCX, MMCX, BMA, BNC, TNC, N, 7-16 (L29), CCWX, DSB, DSD, ISMA, 2.92, SMB-75, SSMB-75, SMC-75, MCX-75, SMZ-75, SAA-75, TNC-75, BNC-75, reverse polarity SMA, MCX, TNC and BNC	Special connectors from modified standards with special pin length, shape or termination. Special housings and finishes	Do not manufacture cable
Southwest Microwave Inc.	SMA, enhanced high temperature SMA, N, TNC, SSMA, OPS/BMA, 2.92 mm, 2.4 mm, 1.85 mm, adapters between series, end-launch adapters, field replaceable accessories, new SSMA to 40 GHz and SSMA-to-2.4 mm adapters to 50 GHz	Custom designs are available on request. Waveguide launchers, mechanical switch connectors, special flanges, longer lengths, custom probes, 50% of shipments are non-catalog specials	Do not manufacture cable
Special Hermetic Products	Hermetic SMP (MIL-STD-348)	Modified SMPs for special interface mounting	Do not manufacture cable
Spectrum Elektrotechnik GmbH	1.4/4.4 mm, 1.8/5.6 mm, 2/5.5 mm, 1.85 mm (V), 2.4 mm, 2.92 mm (K), 3.5 mm, 7 mm, 7/16, BMA, BNC, C, HN, N, SC, SMA, SMP, SPPO (SSMP), TNC, TNX, SBX, SBY, SMP, SMPM, SQ-8, SSMA	SPM (Spectrum power miniature), push-ons for 7/16, N, TNC, SMA and SMA reverse sex, SBX (Spectrum blind-mate X), SBY (Spectrum sub sub miniature push-on) phase adjustable connectors. New mitred angle airline connectors and adapters (MA2-line) and swept edge airline connectors (MA2-line) to 63 GHz. New hermetically sealed connectors and adapters with venting holes for vacuum chamber test and space applications: N and TNC to 12.4 and 18 GHz and 2.9 mm to 40 GHz. High power adapters with venting holes	0.141" semi-rigid cable using a seamless convoluted stainless steel copper composite tubing known as "Handy Form Type 33"
Spinner GmbH	7/16 (low PIM), N (low PIM), 4.1-9.5 (low PIM), TNC, BNC, N, HN, 1.6-5.6 EIA, between series adapters	Custom 7/16 panel mount and EIA connectors with a coupling nut	Do not manufacture cable
SRC Cables Inc.	Do not manufacture connectors	Do not manufacture connectors	Do not make their own cable, custom designed cables are made for them
SRI Connector Inc.	1.85 mm, 2.4 mm, 2.9 mm, 3.5 mm 7 mm, N, SMA, TNC, ZMA and between series adapters	Superites SMA right angle connectors with high performance, proprietary custom designs	Do not manufacture cable
SSI Cable Corp.	Do not manufacture connectors	Stainless steel connectors made to their specifications and specials at customer request	0.093, 0.145, and 0.240" stainless steel cable in regular and low loss types as well as stainless steel jacket over copper outer conductor, PTFE or medium loss dielectric

Cable Assemblies	Unique Products	Web site and Contact Information
Laboratory, test and general purpose applications using flexible, semi-rigid and triax cable	Solderless Edge Mount is a patented Molex design. Supplied in panels up to 30 BNC receptacles	www.molex.com Technical: Don Gould, Dwaine Robison Sales: Roger Kauffman 317-834-5600, rf@molex.com
Low loss, general purpose, flexible, semi rigid and hand-formable	No unique products	www.newandforever-usa.com On-line sales and service
Laboratory, test and general purpose in flexible, semi-rigid, comformable configurations. Phase stable, phase matched and delay lines	The PkZ contact is a patented design	www.palcoconnector.com Contact: Gregg Pollack at gpollack@palcoconnector.com Phone: 603-431-1414
Flexible RG, flexible low loss ECO friendly (zero halogen and sulphur), semi-rigid, handformable, corrugated (spiral and ringed), SHF ultra low loss for general purpose lab and test, outdoor and air frame or lightweight purposes	QMA and QN (quick lock formula), IMP, UMP, MMT and MMS are patented by Radiall	www.radiall.com Technical: info@radiall.com
General purpose flexible braided assemblies including high flexibility, low loss, plenum rated, fire retardant, rigid and semi-rigid	RF adapter kits for engineers and technicians, including the Unidapt universal adapter kit series. The Unidapt concept allows for the assembly of virtually any adapter combination using multiple interfaces on site for test and measurement applications	www.rfindustries.com Contact: rf@rfindustries.com or 800-233-1728, 858-549-6340
Laboratory and test, general purpose, flexible, semi-rigid, rigid, phase stable, phase matched, high temperature, 1.85 mm, 1.00 mm, push-on/snap-on	Snap-on and push-on SMA, push-on N up to 14 GHz, long sleeve thumbnut SMA, connectors for 1.32 mm and 0.8 mm cables for Hirose U.FL connectors and cable assemblies	www.rftec.com Contact: Kiyoshi Endo 770-251-2235 or k4st@rftec.com
Laboratory and test to 50 GHz, medical, defense, general purpose, flexible, semi-rigid, phase stable, phase matched	No unique products	www.rhophase.co.uk Technical: Byron Putt & Nick Lewis, Sales: Jodie Di-Orio & Bob Davis
Flexible, semi-flexible, semi-rigid, corrugated, UTIFLEX cable assemblies, test cables	SMCC-surface-mount coaxial connector is patented coax to planar technology	www.rosenberger.de Europe: Harry Rausch (+49 8684-180) info@rosenberger.de US: Rosenberger of North America: www.rosenbergerna.com Contact: Jihan Mohammed 717-290-8000 x231 jmohammed@rosenbergerna.com
Do not manufacture cable assemblies	Internally swept right angle bends in 2.4, 2.92 and SMA series, ASSMA series, which is intermediate with SSMA connectors up to 50 GHz and uses an air-dielectric interface. New 1.0 mm series extends the capability to 110 GHz	www.sgmcmicrowave.com President/Technical: Larry Herring Sales: Jim Riter Phone: 321-409-0509; Fax: 321-409-0510; Mobile: 973-224-4510
RG-316 flexible coax, RG-178 flexible coax, RG-405 semi-rigid, RG-402 semi-rigid, RG-58 flexible coax, SR.047 semi-rigid	SCX-Air dielectric interface	www.sabritec.com/catalogs/catalogdownload.htm Contact: Mike Carlson mcarlson@sabritec.com
International provider of program specific cable assemblies	Reverse polarity types and unique 15 product line to meet FCC Part 15.203, customer focused factories for unique RF interconnect solutions	www.santron.com Technical: Fred Hull 978-356-1585, fred@santron.com, Sales: Chris Sanders, chris@santron.com
Test and measurement, phase or delay matched, semi-rigid and conformable, rigid air/dielectric electroform assemblies, custom splitters and power dividers, 1553 databus, custom harnesses and corrugated jumpers	High power KW series cable, lightweight RG+ series cable, rigid air dielectric electroform assemblies	www.semflex.com Technical: Robert Thiel Sales: Doug Hartje at doug.hartje@semflex.com
Flexible, semi-rigid, conformable, corrugated and other types	Wide variety with the ability to provide custom designs in small quantities	www.sourceseast.com Wayne Pittman at 408-374-1031, waynep@sourceseast.com
Semi-rigid and semi-flexible/conformable, field replaceable connectors, high-rel, high end for critical applications	All connectors are thermal tested, space qualified materials, high-rel, high temperature performance, lot control and material traceability, lead-free solder processing	www.southwestmicrowave.com Technical: Dusty Leavitt dusty@southwestmicrowave.com Bill Rosas, David Shaff 480-783-0201
Do not manufacture cable assemblies	Robust series for aluminum and kovar as well as other housing materials are covered by US patents or patents pending	www.shp-seals.com Technical: Jack Pollock jack@shp-seals.com Sales: Wendy Cheney wendy@shp-seals.com 603-654-2002, Fax: 603-654-2533
Flexible test and measurement, ruggedized, military, interconnect systems, power, commercial RG types, phase stable, hand formable, semi-rigid (0.034" to 0.50" diameter), radiation resistant, general purpose, new high power cable assemblies with vented connectors for vacuum test chamber and space applications	CNCA-700 cable cutting and stripping machine, push-on 7/16, N, SMA, TNC and SNX, SBY, SSPO and SPM are unique, new MA2-line and SA2-line angle air connectors, new hermetic glass beads	www.spectrum-et.com Peter Von Nordheim +49-89-3548-040 pvnordheim@compuserve.com
Corrugated cables for base stations and low IM test, braided general purpose, semi-rigid, phase stable, phase matched	Jumper cables for corrugated copper cables	www.spinner.de info@spinner.de
All types of cable assemblies	Proprietary coax types SRC-316, SRC-402SF & SRC-405SF	www.src-cables.com President: Dan Hirschnitz, dan@src-cables.com Sales Coordinator: Kathy Badger, kathy@src-cables.com
Do not make cable assemblies	Superite series	www.sriconnectorgage.com Mark Hiser 321-259-9688 hiser@sriconnectorgage.com
Semi-rigid (copper, stainless steel, aluminum), flexible, conformable, phase matched, delay lines, medium and low loss, wireless preps, wire harnesses, test, general purpose and cryogenic	Stainless steel cables are unique to SSI	www.ssicable.com Contacts: Bill Smith and Brek Sowers 360-426-5719, bsmith@ssicable.com

Company	Standard Connector Types	Special Connectors	Raw Cable Manufacturing
Storm Products Inc.	SMA, TNC, N, precision N, 3.5 mm, 2.4 mm, GPO, GPPO, GMS, 2.9 mm, 2.4 NMD	Custom designs for specific customer requirements	Semi-rigid, flexible, solid PTFE, low loss low density PTFE, microporous and expanded PTFE, ePTFE tape and foil wrapping, flat and round wire braiding, textile braiding, low and high temperature extrusion, semi-rigid die sizing
SV Microwave Inc.	SMA, SSMA, BMA, BMMA, BMZ, BZ, ZMA, MCX, MMCX, SMP, SMPM, TNC, precision TNC, N, precision N, SMB, SMC, 1.85 mm, 2.4 mm, SVK, 2.92 mm, 3.5 mm, 7 mm, C, SC, HN, 7-16, QDS, LC/LT, EIA, multi-contact assemblies	Custom designs including space qualified, high-rel and multi-contact	Do not manufacture cable
Synergy Microwave	Do not manufacture connectors	Do not manufacture connectors	Do not manufacture cable
Telegartner Inc.	BNC, TNC, UHF, mini-UHF, N, 7/16 DIN, 1.6/5.6 DIN, FME, SMA, SMB, SMC, SMS, SSMB, MCX, MMCX, ASMB	Custom designs as well as surge protectors (both gas and stub) for N and 7/16, low PIM types, special connectors for corrugated and non-standard cables	Do not manufacture cable
Tensolite Inc.	SMA, SSMA, SMP, SSMP, SSMT BMA, 2.92 mm, 1.85 mm, MCX, MMCX, SMK, 1.85 mm, N, TNC, QBC, HDRFI, 7 mm, TK	HF connectors to 65 GHz, integrated connector block interface assemblies, TK connectors, QBC, HDRFI, custom angle designs	Mil-C-17, LLF series cable; 70%, 77%, 82% Vp
Thermax/CDT	Do not manufacture connectors	Do not manufacture connectors	MIL-C-17 cables, MaxForm hand formable, MaxFlex cables, high temperature, low loss cables with air expanded PTFE, seamless wrap PTFE tape dielectric cables
Times Microwave Systems	N, TNC, BNC, SMA, UHF, mini-UHF, 1.0/2.3 DIN, 7/16 DIN, 7/8 EIA, 7 mm, 3.5 mm, reverse polarity	Reverse polarity, self-locking, phase trimmed, non-solder (EZ)	Commercial, aerospace and shipboard high reliability RF & microwave
Trompeter Electronics Inc.	BNC, TNC, N (all 50 or 75 Ω), SMZ, F, mini-BNC (75 Ω), WECO and mini-WECO, TPS, TRB, TRT, TRS, TTM, TRC, TRN, TWBNC	Patching and distribution panels, custom designs, hermetic, radiation resistant, space rated to NASA Spec SP-R-022	Do not manufacture cable
TRU Corp.	2.4 mm, 2.92 mm, 3.5 mm, 7 mm, 7/16 DIN, MCX, MMCX, SMA, SMB, SMC, SMP, BMA, BMMA, BNC, N, TNC, ATNC, C, SC, HN, LC, LT, EIA, TRIAX	Custom high power/high voltage interfaces, polarized, environmental sealed, low PIM, precision adapters, swept high power right angle adapters	High performance, high power/temperature, flexible 50 Ω, low loss, low density PTFE dielectrics, RG cable types, cintru™ communication cable, general purpose RF/microwave
Vitelec Co.	BNC (50 & 75 Ω), insulated BNC, twin BNC, TNC, SMA, SMB, SMC, MCX, MMCX, N, N (high frequency), twinax, UHF, mini-UHF, FME, F, euro, adapters	Modifications of standard product as well as custom designs	Do not manufacture cable
Winchester Electronics	SMA, SMB, SMC, MCX, BNC, TNC, QMA, N, Combo D housings, size 8 contacts	Quick Connect SMA™, Quick Connect N™, customs to specifications	Do not manufacture cable
W.L. Gore & Associates Inc.	7/16, N, TNC, TNCA, SMA, precision N, 7 mm, 3.5 mm, 2.92 mm, 2.4 mm, 1.85 mm, 1.0 mm, MCX, MMCX, BMA, BMMA, #8, #12, SMP, SMPM, adapters between series, blind mate adapters, PCB mount connectors	Special board mount footprints, custom cable connectors, replaceable interfaces	Broad capabilities including coaxial, RF/microwave, round, planar, ribbon, triaxial, and hybrid constructions, fiber optical, industrial, high flex

Cable Assemblies	Unique Products	Web site and Contact Information
Semi-rigid, flexible, general purpose, laboratory and test, military, communications, miniature low loss, phase stable, high-rel, thermal pre-conditioned	Phase Master® – exceptional phase stability with temperature, True Blue® – low loss with durability and value, Storm Flex™ – superior electrical performance, trouble free, durable, compact, Accu-Test® – calibration accuracy, repeatable phase measurement with flex	www.stormproducts.com/microwave Inside sales 888-347-8676
All types built to customer requirements	Custom blind-mate from DC-40 GHz multi blind-mate rack-and-panel types with reduced center-to-center dimensions, waterproof connectors (in both mated and unmated conditions)	www.svmicrowave.com Sales & Technical: 561-840-1800 sales@svmicrowave.com
General lab test high temperature DC-18 GHz flexible, semi-flexible and ultra-flex with SMA and Type N connectors	Specializes in RF/microwave and durable custom designs	www.synergymwave.com, Contact: Chi Man Shum 973-881-8800 x305, shum@synergymwave.com
Laboratory and test, general purpose, flexible, conformable, semi-rigid, low loss, high power corrugated, multi-core coax	SimFIX Plus™ connectors and low PIM telealloy plating	www.telegartner.com Technical: Allen Ehredt Sales: Jim Ziebka 630-616-7600, sales@telegartner.com
Laboratory and test (Workhorse, Workhorse Plus, Workhorse Low Loss), general purpose (Mil-C flexible, BNC assembly), flexible (Q-flex, Q-flex Plus, 40 GHz flexible, 50 GHz flexible), rigid (copper tube), semi-rigid (0.035 to 0.250" copper and aluminum tube) phase stable and phase matched (flexible and semi-rigid)	QBC series for blind mating with standard series, Netflight™ cables, UCCULITE™ cables, Q-Flex,® Semi-Flex® and Workhorse® cable assemblies, high density application cable assemblies such as HDSI® and HDSI-DP®	www.tensolite.com Contact: Mark Temple at mtemple@tensolite.com Phone: 866-282-4708 Fax: 562-494-0955
Do not manufacture cable assemblies	Thermax LTE expanded PTFE dielectric is proprietary as is seamless wrap PTFE dielectric and jackets	www.thermaxcdt.com Maria Neclerio 203-284-9610
Laboratory and test, general purpose, flexible, semi-rigid, phase stable, phase matched, high temperature	Miltech, blindmate, T-flex, stripflex, T-com, nu-trac, FlexRAD, testmate, phasetrack, LLSB, LSSB, and LMR cable and cable assemblies	www.timesmicrowave.com Technical: Joe Lanoue jlanoue@timesmicrowave.com Sales: Sue Reynolds sreynolds@timesmicrowave.com
1553 data buss and ground support, broadcast head-end patching, Telco central office, medical MRI test, laboratory and test	Separable BNC connectors for PC mount, miniature normal-through patch jacks with true 75 Ω for HDTV performance	www.trompeter.com, Technical: Mark Borton 818-865-6534, mark.borton@trompeter.com, Sales: Dale Reed 818-865-6538, dale.reed@trompeter.com or sales@trompeter.com
High power/high voltage phase and amplitude matched, shipboard and aerospace, flexible, semi-rigid, corrugated and rigid line assemblies, general purpose, cintru™ broadband communication, customized cable/connector attachments	Quick-disconnect line (QD16,™ QDL, QDM, QDS, QRM,™ SQS™), safety interlock interfaces, high temperature and frequency dielectric interfaces, solderless right angle cable attachments	www.trucorporation.com Brenda Wheeler, 978-532-0775
Semi-rigid, flexible (with or without data for telecoms, datacoms, wireless, test)	Gigaflex™ cable assemblies	www.vitelec.com.uk sales@vitelec.com.uk +44 (0) 1420 488661
General purpose, flexible, semi-rigid, phase matched, delay lines, wire harnesses	Quick Connect series for use with standard SMA and N jacks without compromising performance	www.winchesterelectronics.com Technical: Ron Ciecko 203-741-5484 Sales: Beth Beadle 203-741-5481
Flexible, laboratory and test, phase and amplitude stable, performance options through 110 GHz, ruggedized, general purpose, phase matched, high temperature, low loss, long length, high power, spaceflight, high density, airframe/vapor sealed	Performance to 110 GHz, precision test adapters, excellent phase and amplitude stability, low loss/long length assemblies, industry standard performance	www.gore.com/electronics 800-445-4673 or 302-292-5100 electronics.usa@wlgore.com



INTERMATEABILITY OF SMA, 3.5 MM AND 2.92 MM CONNECTORS

SMA, 3.5 mm and 2.92 mm connectors make reliable, RF components and instrumentation possible. These seemingly mundane devices are the result of evolutionary and revolutionary design, covering a 40-year period and involving several corporations. In their present state, they represent highly evolved, well-defined interface systems.

It is not widely understood that these connector types are mechanically intermateable; meaning, SMA, 3.5 mm and 2.92 mm connectors, of good quality and in good condition, will inter-mate across connector families without damage. But what are the electrical ramifications of inter-mating of these connector types? Can they be used interchangeably without an appreciable difference in performance, that is, will a significant impedance discontinuity occur when mixing types? Were they intended to be inter-mated in the first place? To properly answer these questions calls for a brief examination of the history and motivations behind these connectors.

THE SMA CONNECTOR

The SMA connector first appeared in the late '50s as the "BRM," manufactured by the Bendix Scintilla Division. In the '60s it was popularized as the "OSM," manufactured by Omni Spectra. In 1968 it received the "SMA" (Sub-miniature A) designation that we know today. The SMA connector uses a solid dielectric interface as opposed to an air dielectric. By definition, an air interface connector cannot have the designation "SMA." Performance is rated to 18 GHz, but higher frequency variants are available.

The SMA was designed as a miniaturized, economical connector for system application. It was never intended to be a precision connector for the laboratory. As it is only rated for 500 mate/de-mate operations, it was designed for use in semi-rigid cable assemblies and components not requiring frequent connect/disconnect.

THE 3.5 MM CONNECTOR

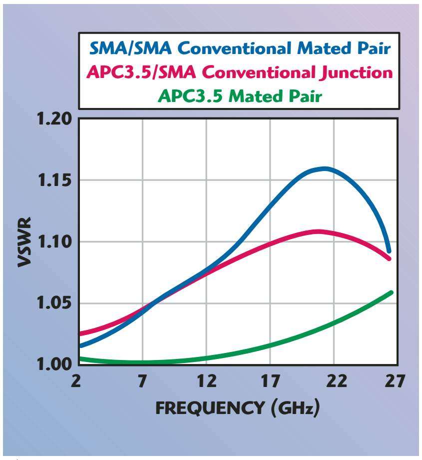
The 3.5 mm connector was the result of a joint venture in the early '70s between Hewlett Packard (now Aglient Technologies) and Amphenol. Hewlett Packard carried out the bulk of the development work and Amphenol manufactured the connector, dubbing it the "APC3.5" (Amphenol Precision Connector 3.5 mm). Hewlett Packard's design goals included the following:

PAUL PINO
W.L. Gore & Associates Inc.
Elkton, MD

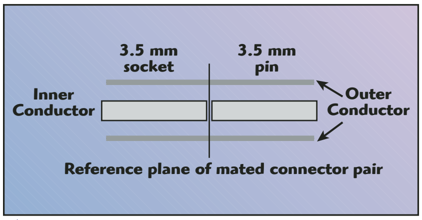
- a durable interface that would extend the upper frequency capability of their devices to 26.5 GHz
- an interface allowing for thousands of repeatable connections, and one that would mate with popular SMA dimensions

The 3.5 mm connector is rated to 26.5 GHz, with a theoretical upper operating frequency of 34 GHz. It is specified to possess a minimum of 3000 mate/de-mate cycles per the IEEE P287/D3 standard (provisional).

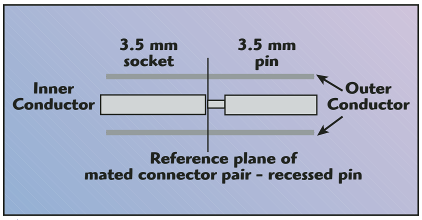
The 3.5 mm connector was designed to be a precision interface for calibrated measurements of SMA-equipped devices—it was created as a test connector for the SMA. As a result, an SMA-to-3.5 mm interface produces better results electrically than an SMA-to-SMA interface. The reason is due to an air gap that is formed between the solid dielectric interfaces of a mated pair of SMA connectors, creating an impedance discontinuity (see ***Figure 1***).



▲ *Fig.1 A comparison of 3.5 mm, SMA and 3.5 mm-to-SMA mated interfaces (courtesy of Maury Microwave Inc.).*



▲ *Fig. 2 Simplified cut-away diagram of a 3.5 mm mated pair.*



▲ *Fig. 3 Simplified cut-away diagram of a 3.5 mm connector pair displaying a gap at the reference plane.*

With this information, it can be seen that an SMA-to-3.5 mm mated interface, using good quality connectors, is an acceptable (and intended) practice where adverse electrical performance through 18 GHz should not be expected.

THE 2.92 MM CONNECTOR

The 2.92 mm geometry with an SMA mateable interface was developed to provide coaxial connector performance to 40 GHz. In the mid-'70s, Maury Microwave introduced the MPC3 connector using the aforementioned 2.92 mm geometry. Without an abundance of available instrumentation operating at 40 GHz, it found little usage. In the early 1980s, Weinschel Engineering utilized this geometry in an engineering design under a Department of Defense (DoD) contract.

Simultaneously, Wiltron Co. began a program to produce instrumentation operating to 40 GHz, and would therefore use the 2.92 mm connector. The connector and instrumentation were introduced in 1983 by Wiltron (now Anritsu Corp.); the term "K-connector" was trademarked by Wiltron, making reference to the connector's frequency band of operation, the K-band. Intermateability with the SMA was not an original design objective for the 2.92 mm connector. The ability of these two connector types to inter-mate grew out of convenience; the 2.92 mm was based upon proven SMA geometry.

BASIC ASSUMPTIONS ESTABLISHED

Now that the basic relationship between these three connector types has been explained, characterizing the electrical performance of these connector types when inter-mated can be addressed. It has been established that a 3.5 mm-to-SMA mated interface is an acceptable and intended practice, per the 3.5 mm connector design. All that remains is to demonstrate the electrical performance of a 3.5 mm-to-2.92 mm mated interface and a 2.92 mm-to-SMA interface.

A FEW WORDS REGARDING WEAR

The premise of intermateability is predicated upon connectors that are in serviceable condition. Misaligned center contacts or contact heights out-of-spec, worn outer conductors—especially in SMA designs—invite damage and a reduction in performance. Mating interfaces must be inspected and cleaned regularly. Pin height gauges are not reserved for metrology-grade applications; they are a good idea for anyone working with these connector types in frequent mate/de-mate scenarios.

ELECTRICAL PERFORMANCE AT THE CONNECTOR INTERFACE

Across the SMA, 3.5 mm and 2.92 mm connector types, a governing factor in electrical and mechanical performance is center contact height—a measure of protrusion or recession of the center contact with respect to the connector reference plane. Depending upon whether the connector is a LPC (Laboratory Precision Connector)-based or GPC (General Precision Connector)-based design, the center contact height has a prescribed allowable range; temperature and wear can impact variation within this range. Center contact height is a compromise between good mechanical performance, that is, non-destructive contact with its mating connector, and good electrical performance. But how does center contact height influence electrical performance?

A mated pair of 3.5 mm connectors is shown in ***Figure 2*** under ideal center contact height conditions. In other words, there is minimal gap or "zero gap" between the pin and socket center contact sections at the reference plane. Gap length is a direct result of contact height. This arrangement is considered ideal as it produces the smoothest impedance transition through the mated pair. However, it will not tolerate use over a range of temperatures; expansion at high temperatures may cause destructive mating to occur.

Figure 3 shows the same mated connector pair with the 3.5 mm pin in a recessed condition. In this exaggerated example, a gap is produced at the reference plane resulting in an inductive or high impedance section. The gap provides the necessary clear-

▲ *Fig. 4 The adapter/sliding load configuration (LPC grade 3.5 mm socket adapter indicated by red arrow).*

ance for over-temperature use, but also introduces an impedance discontinuity.

Although there are other areas of potential variation, connector center contact height variation plays a major role in defining interface electrical and mechanical performance. Good-quality 3.5 mm, 2.92 mm and SMA connectors—those whose interfaces are produced in accordance to the IEEE 287 (3.5 mm and 2.92 mm) and MIL-STD-348 (SMA) specifications—will have their critical dimensions constrained. These specifications/standards serve to support the practice of intermating these connector types. It is important to note that the IEEE 287 and MIL-STD-348 specifications address interface dimensions only; they do not touch upon design issues associated with a connector's "back end" or cable interface side. This issue is to be resolved by the manufacturer.

PERFORMANCE QUESTIONS ANSWERED

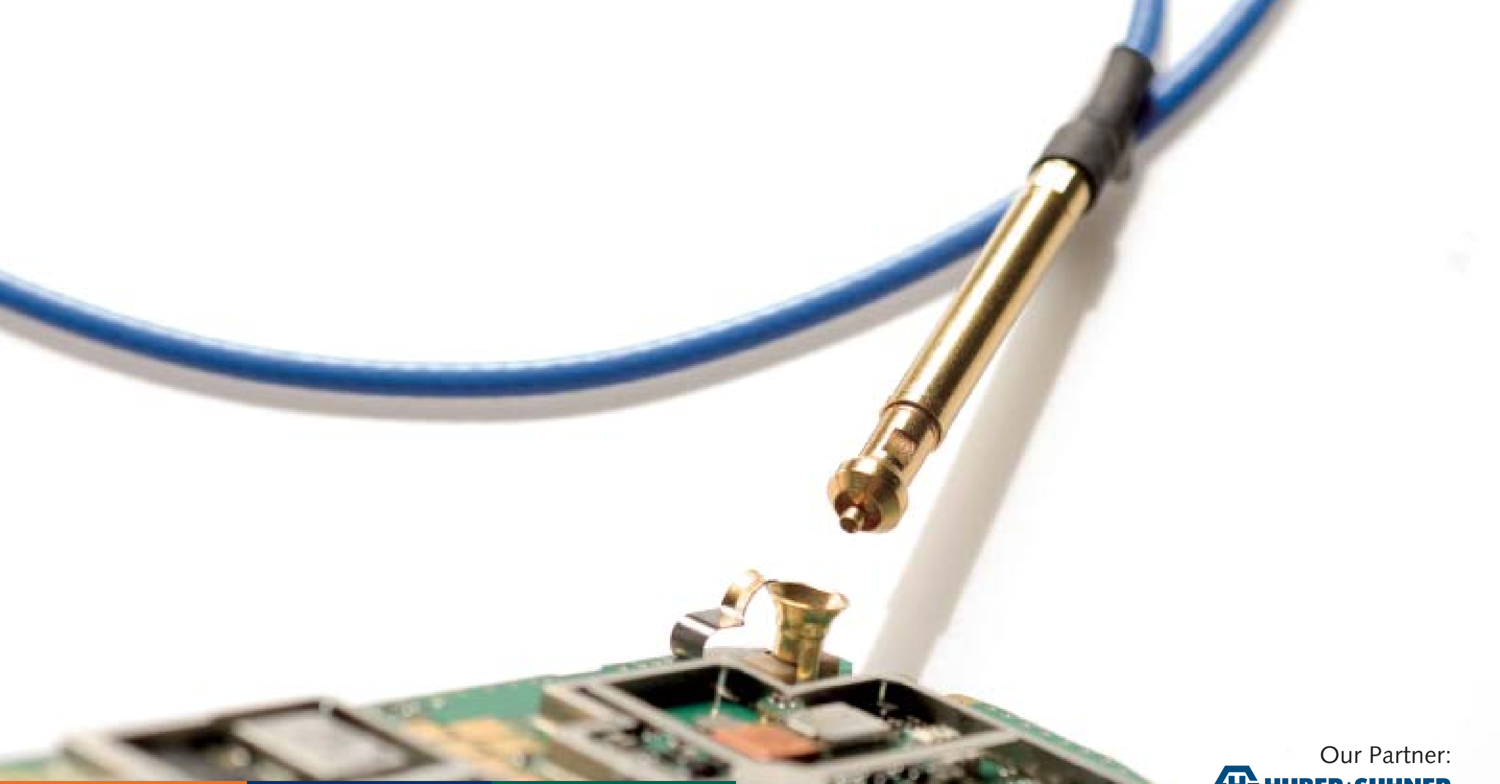
An experiment was devised to investigate the impact of center contact height (mated contact gap) variability on interface electrical performance within mixed mated pairs of connector types (3.5 mm-to-2.92 mm and 2.92 mm-to-SMA, for example).

To establish a reference, electrical performance vs. center contact height was examined using a mated pair of 3.5 mm connectors. Single-port VNA measurements through 26.5 GHz were made with LPC grade 3.5 mm connector adapters coupled to a 3.5 mm sliding load from an HP85052B 3.5 mm calibration kit. The adapter/sliding load arrangement is shown in ***Figure 4***.

A sliding load was selected for two reasons: (1) it contains a sufficiently long 50 Ω air line section that will facilitate gate placement for time domain gating operations used in the data analysis portion of the experiment; (2) the center contact height of the sliding load 3.5 mm interface is variable via an adjustment screw located at the rear of the sliding load. This allows for precise control of the gap between the 3.5 mm socket and 3.5 mm pin contacts when mated.

The experiment consists of the following steps:

- Using the mated pair of 3.5 mm connectors as an example, one end of the 3.5 mm LPC grade socket adapter was threaded into port 1 of the VNA
- Using a center contact height gauge, commonly called a pin height gauge, the sliding load interface-pin type was gauged and center contact height was adjusted to 0.0000 inches.
- The sliding load was then threaded onto the LPC 3.5 mm socket interface and tightened to the appropriate torque specification. The result is a 3.5 mm socket-to-pin mated interface



Our Partner: HUBER+SUHNER

Test Probes | Test Fixtures | Test Systems

Top RF Technology up to 6 GHz

Discover the unique solution set from INGUN for high-precision measurements up to 6 GHz – no matter whether for Wireless-LAN, Bluetooth or PDA´s.

INGUN is a global leader in the field of testing equipment. In cooperation with the Swiss RF specialist HUBER+SUHNER, we have developed a standardised and reliable complete solution, which can be used worldwide. The new solution set, consisting of the Radio Frequency Test Probe HFS-860 and the MCX Plug connection, covers the complete measurement section – from the UUT through to the Test System.

Our Solution Sets:

– **HFS-810 or HFS-840** with MCX Plug connector **SE-810 V** for applications up to 4 GHz

– **HFS-860** with MCX Plug connector **SE-860 V** for applications up to **6 GHz**

The future:

A complete standard solution for contacting applications up to 10 GHz.

You can find out more about INGUN and RF Technology under: www.ingun.com

RF&HYPER EUROPE 2007

27.–29. March 2007. CNIT Paris la Défense

You will find us on the following booths:

Agent: Cotelec booth A 12.

Partner: Huber+Suhner booth E25 / E23.

ingun

ingun Prüfmittelbau GmbH
Max-Stromeyer-Straße 162
78467 Konstanz
Germany
Tel. +49 7531 8105-0
Fax +49 7531 8105-65
info@ingun.com
www.ingun.com

Visit http://mwj.hotims.com/11716-8 or use RS# 8 at www.mwjournal.com/info

- An S-parameter measurement was made of the 3.5 mm mated interface; the resulting S_{11} data was recorded for subsequent examination of the mated interface's VSWR and impedance. The sliding load was removed from the 3.5 mm socket interface and contact height was lowered by 0.001 inches, as measured with the contact height gauge
- Repeat Steps 3 and 4 up to a contact height of –0.005 inches; the negative sign indicates a recessed condition, i.e., a position below the connector reference plane

The above steps were repeated using a 2.92 mm-to-3.5 mm mated interface and an SMA-to-2.92 mm mated interface. In these instances, a sliding load equipped with a 2.92 mm pin type interface was used in place of the 3.5 mm sliding load. ***Table 1*** provides contact and dielectric height data (if applicable) for each mating socket interface type used in the experiment.

PERFORMANCE QUESTIONS ANSWERED: SUMMARY OF FINDINGS

A rise in impedance occurs when terminating the mated interface pairs with a sliding load. This rise is due to a limitation inherent to the sliding load—the load's "cut-off frequency." The sliding load depicted in Figure 4 is recommended for use between 2.5 and 26.5 GHz. Below 1.8 GHz, the load displays an impedance of less than 50 Ω. At very low frequency, near DC, the sliding load is a short. This irregularity causes reflected impedance measurements to rise with time, and the VSWR to tend towards a value slightly above 1.00:1 as the frequency tends to zero (see ***Appendix A***). With this in mind, the impedance and VSWR data are accurate in that they faithfully portray the behavior of a mated pair interface under the noted load conditions.

VSWR: In all three mated interface combinations (3.5 mm-to-3.5 mm, 2.92 mm-to-3.5 mm and SMA-to-2.92 mm), the VSWR never exceeded 1.054:1 through 26.5 GHz, over the range of experimental center contact gaps. The 3.5 mm and 2.92 mm-to-3.5 mm mated interfaces produced very similar VSWR results over the range of gaps, having a nearly identical spread in maximum VSWR values: 1.005:1 to 1.050:1 through 26.5 GHz. The SMA-to-2.92 mm mated interface produced a much tighter, but overall higher spread of maximum values: 1.038:1 to 1.054:1 through 26.5 GHz.

Impedance: Impedance was examined via a time domain step response. As expected, the mated interface impedance closely mirrored VSWR on all mated pair combinations. Out of the mated pair combinations tested, the 3.5 mm mated interface produced the most ideal response, having a nearly flat transition occurring at a contact gap of 0.12 mils (0.00012"). A close second in terms of ideal response was the 2.92 mm-to-3.5 mm mated interface, producing a similarly flat transition at a contact gap of 2.65 mils (0.00265"). In third place was the SMA-to-2.92 mm mated pair, providing its best impedance transition performance at a 1.50 mil (0.0015") contact gap. Additional details on the data collection and analysis appear in Appendix A.

In ***Table 2***, the impedance values are corrected to 50 Ω to offset the previously mentioned rise in impedance. The table summarizes performance when the termination consists of a broadband 50 Ω load as opposed to a sliding load.

CONCLUSION

The experiment's purpose was to investigate the influence of center contact gap variations upon a mated pair's electrical performance; specifically, high frequency electrical performance. Gap variability was accomplished by varying the center contact height of one connector within the mated pair. By systematically changing the gap, real-life mated connector pair performance across mixed interface types was modeled. Although differences in performance were noted, no significant advantages or disadvantages in electrical performance were observed across the mixed interface mated pairs. In short, the inter-mixing of 3.5 mm, 2.92 mm and SMA interface types was not found to produce adverse performance and significantly different results when using connectors made by a reputable manufacturer.

TABLE I

CONTACT HEIGHT AND DIELECTRIC HEIGHT

Adapter Type	Manufacturer	Socket Contact Height*	Dielectric Height*
3.5 mm LPC grade socket-to-socket	Agilent Technologies	–0.00012"	N/A
2.92 mm GPC grade socket-to-socket	Agilent Technologies	–0.00065"	N/A
SMA pin-to-socket	Suhner	–0.0015"	–0.0025"

*negative sign indicates a recessed condition in relation to connector reference plane

TABLE II

IMPEDANCE VALUES

Mated Interface Combination	Impedance Through Interface Transition at Optimal Gap	Impedance Variation over Range of Gaps
3.5 mm	50.0 Ω	less than 0.1 Ω
2.92 mm-to-3.5 mm	50.0 Ω	approximately 0.1 Ω
SMA-to-2.92 mm	50.1 Ω	0.2 Ω

THE WORLD'S LARGEST SELECTION

POWER SPLITTERS/ COMBINERS

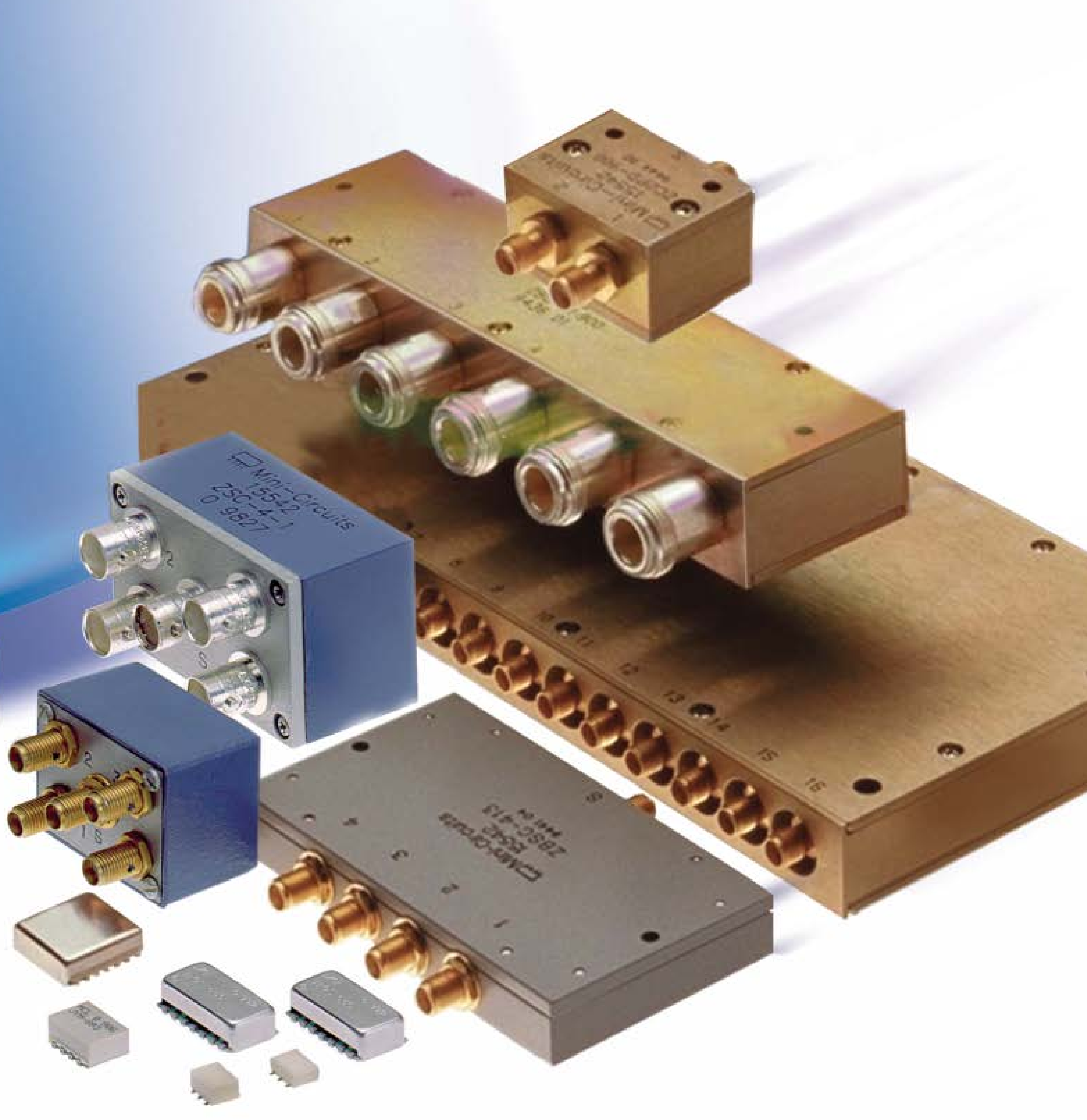
IN STOCK

RoHS COMPLIANT
RoHS models available, consult factory.

2 kHz to 12.6 GHz *from* 79¢

Need just the right surface mount, coaxial, thru mount, or flat pack power splitter or combiner for your project? Mini-Circuits is on the case offering you thousands of high performance, cost-effective models off-the-shelf and immediately available for your military and commercial applications. Choose from 2 and 3 way to 48 way; 0°, 90°, 180°; 50 & 75 ohms covering 2 kHz to 12.6 GHz and beyond, all characterized with detailed data and performance curves available to you in a flash 24/7 on "The YONI2 Search Engine" at the Mini-Circuits web site. Surface mount products include highly reliable LTCC designs giving you extremely small size, ultra-low profile, excellent stability over temperature, and high performance repeatability. Tough built coaxial models are available with SMA, BNC, TNC, and Type-N connectors and include broadband ZX10 units standing less than 3/4" in size. And when it comes to your custom needs…just let us know what you're looking for and our development team will go to work! Add our 1 year guarantee, knowledgeable applications support, and value pricing, and the decision is easy. Contact Mini-Circuits today!

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


Mini-Circuits
15542
ZSC-4-1
0 9827

The 3.5 mm and 2.92 mm-to-3.5 mm mated interfaces produced somewhat better results compared to the SMA-to-2.92 mm mated interface. However, these results are the product of tightly controlled contact heights; center contact heights on the order of -0.00012" are not the norm and are associated with costly, special purpose LPC connector types. The majority of applications employing 3.5 and 2.92 mm connectors utilize "test grade" versions of these connector types, that is, a grade of connector where center contact height is held at lower levels to accommodate frequent handling and use over temperature, thus wider mated center contact gaps will be encountered.

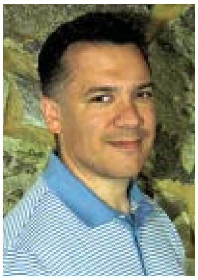
Test grade connectors can be made to comply with many of the IEEE 287 standards, but in specific areas, designers may choose to depart from these criteria for the sake of ease of manufacturing and/or cost concerns. In the end, the performance differences between these interface combinations are indeed very small even under controlled conditions. Under non-controlled conditions, such as those that prevail in all but the most demanding metrology applications, these differences become insignificant. ■

ACKNOWLEDGMENTS

The author extends his thanks to the following individuals without whose help this technical note would not have been possible: Harmon Banning, technologist, W.L. Gore & Associates Inc., Thomas Clupper, senior electrical engineer, W.L. Gore & Associates Inc., Jon Hvitfelt, RF connector designer, W.L. Gore & Associates Inc. and Marc Maury, president, Maury Microwave Corp.

References

1. Institute of Electrical and Electronic Engineers Inc., *IEEE P287/D3 – Provisional, Standard for Precision Coaxial Connectors (DC to 110 GHz)*, July 2005.
2. Maury Microwave Corp., Application Note 5A-011, *Improving SMA Tests with APC3.5 Hardware*, November 18, 1999.
3. Maury Microwave Corp., Application Note 5A-021, *Microwave Coaxial Connector Technology: A Continuing Evolution*, December 13, 2005.
4. Agilent Technologies Inc., Application Note, *General RF Connector Information*, December 2000.
5. Department of Defense, United States of America, *Interface Standard for Radio Frequency Connector Interfaces, MIL-STD-348A*, April 20, 1988.
6. Department of Defense, United States of America, *Performance Specification: General Specification for Connectors, Coaxial, Radio Frequency MIL-PRF-39012E*, April 27, 2005.



Paul Pino *received his BS degree in electrical engineering from the University of Delaware in 2000 after leaving a long career in the automotive industry. He joined W.L. Gore & Associates Inc. in 1999 and has worked with various groups including Gore's Signal Integrity Lab, the Planar Cable Team, the Fiber Optic Transceiver Team and for the past four years the ATE Microwave Group.*

APPENDIX A

DETAILED ANALYSIS OF EXPERIMENT

Test Equipment Information

- *Network Analyzer:* Hewlett Packard 8510, equipped with 8517 test set equipped with 2.4 mm pin port connections; operational frequency range: 0.045 to 50 GHz
- *Calibration Kits:* For 3.5 mm and 3.5-to-2.92 mm mated interfaces, Hewlett Packard, Model 85038 3.5 mm calibration kit. For the SMA-to-2.92 mm mated interface, Maury Microwave, Model 2.92 mm calibration kit. Contact height gauges from the Hewlett Packard kit were used to gauge 3.5 and 2.92 mm interfaces. For the SMA interfaces, gauges produced by Maury Microwave were used to check both dielectric and center contact height
- *Test Conditions:* Single-port, sliding load calibration; isolation omitted. Start frequency: 0.06625 GHz; stop frequency: 26.56625 GHz, 401 points. Averaging factor during calibration: 256 points; averaging factor during measurement: 125 points. No smoothing was used. A 2.4 (socket)-to-3.5 mm (pin) test port adapter from Agilent Technologies was used on port 1
- *Laboratory Conditions:* Controlled at 22°, 30 percent relative humidity. All test connections thoroughly inspected and cleaned with alcohol and allowed to dry before use. Test connections tighten to specification using appropriate torque wrench

Data Analysis

Single-port (S_{11}) measurements were made of each mixed mated interface pair. The subsequent S-parameter data was stored for retrieval and further examination using GORE's proprietary software package NEAT (Network Experimentation and Analysis Tools). NEAT emulates the front-end functionality of a VNA. S-parameter data can be viewed in both the time and frequency domains. Time domain gating can be applied as well. For each mixed mated interface pair, a cos2x gate was used in order to remove transmission path artifacts before and after the mated-pair interface. Gates were placed on "flat" 50 Ω sections of the time domain trace. Sufficient margin between the time domain gate and the feature under examination was used so as not to influence mated pair interface performance. Time domain gating was employed as a means to focus upon mixed mated interface performance and filter out all other transmission line effects.

TEST DATA: 3.5 MM-TO-3.5 MM MATED PAIR

Figure 5A displays the time domain gated impedance response of the 3.5 mm mated pair connection. The impedance is well controlled at a gap of 0.12 mils, then moves towards an inductive response at a gap of 5.12 mils. As the 3.5 mm pin contact is withdrawn from the 3.5 mm socket, the response is increasingly more inductive.

Figure 5B demonstrates the gated VSWR response of the 3.5 mm mated pair connection through 26.5 GHz. The best VSWR response, at 0.12 mils, agrees with the best impedance response indicated in Figure 5A.

TEST DATA: 2.92 MM-TO-3.5 MM MATED PAIR

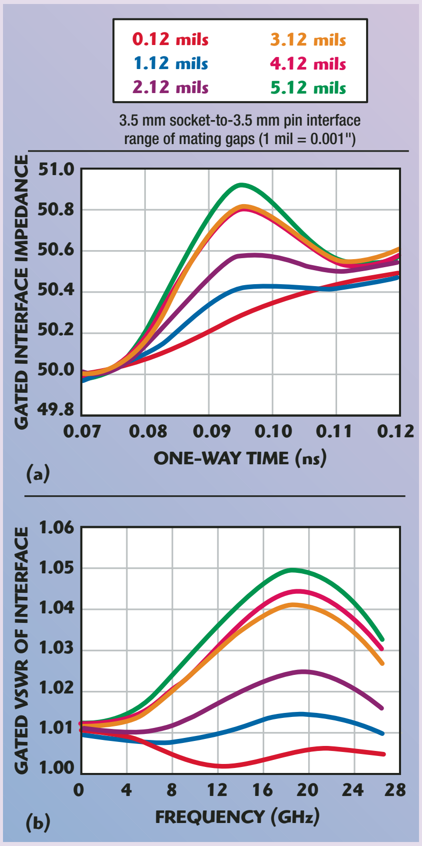
Figure 6A displays the time domain gated impedance response of the 2.92 mm-to-3.5 mm connection. The impedance starts off capacitive at nearly "zero gap," then moves towards an inductive response at a gap of 5.65 mils. The initial capacitance is due to the 3.5 mm's larger diameter center contact transitioning into the 2.92 mm smaller center contact.

Figure 6B illustrates gated VSWR performance over the range of various center contact gaps. Note that the best VSWR performance occurs at a center contact gap of 2.65 mils, which also produced the smallest impedance discontinuity as evidenced in Figure 6A.

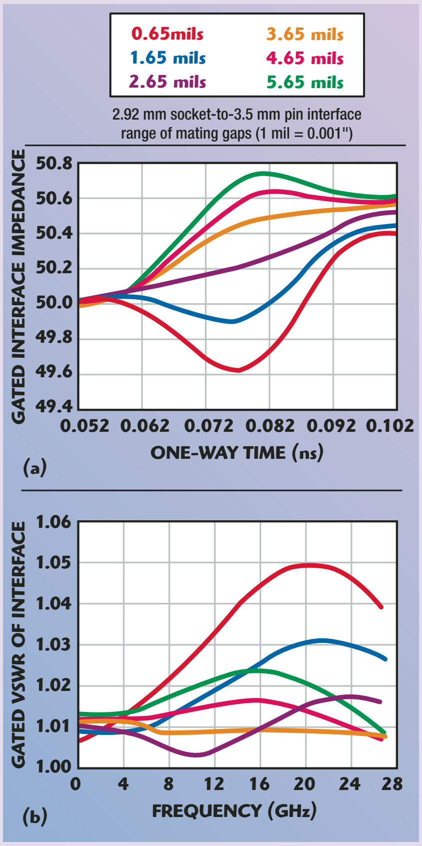
TEST DATA: SMA-TO-2.92 MM MATED PAIR

Figure 7A displays the time domain gated impedance response of the SMA-to-2.92 mm connection. The initial impedance is inductive, then increases inductively as gap widens. The reason for this inductive behavior is transitioning from full density PTFE within the SMA to the air dielectric of the 2.92 mm interface.

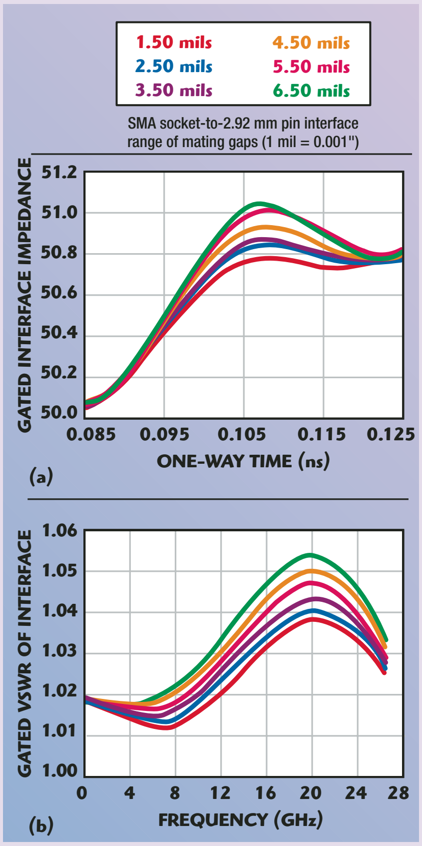
Figure 7B illustrates gated VSWR performance over the range of the SMA-to-2.92 mm contact gaps. Note the best VSWR performance occurs at a minimum center contact gap of 1.50 mils, which also produced the smallest impedance discontinuity as evidenced in Figure 7A. The VSWR and impedance data tell us this particular interface is primarily inductive. By reducing the center contact gap, the interface is being compensated, going more and more capacitive to offset the interface's inductive tendency.



▲ *Fig. 5 The time domain gated impedance response (a) and gated VSWR response (b) of the 3.5 mm mated pair.*



▲ *Fig. 6 The time domain gated impedance response (a) and gated VSWR response (b) of the 2.92 mm-to-3.5 mm connection.*



▲ *Fig. 7 The time domain gated impedance response (a) and gated VSWR response (b) of the SMA-to-2.92 mm connection.*

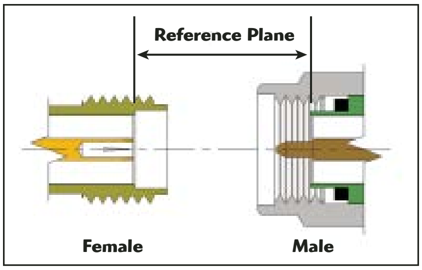
PIN HEIGHT

The importance and role of RF coaxial connector pin height and its impact on electrical and mechanical performance.

The job of an RF coaxial cable is to transmit a signal from one point to another with as little signal or power loss over its length and to keep its signal isolated from or to the outside world. A coaxial cable's structure consists of three major components: a center conductor, a dielectric and an outer conductor. These three components are put together in a way to maximize the cable's performance over its intended frequency range for the desired application. A jacketing or covering is added to the cable to protect and seal the RF structure from outside elements and give the cable additional environmental or mechanical advantages.

A coaxial connector is used to attach the end of a coaxial cable to enable it to be connected to another cable or RF device. It also has a center conductor, a dielectric and an outer conductor. The center conductor of the connector is typically referred to as the contact. The portion of the connector that is intended to mate with another connector is called the mating interface. These connector interfaces typically come polarized in male and female configurations (see ***Figure 1***). The RF coaxial connector's center conductor or contact is normally arranged into pin and socket configurations to facilitate positive electrical contact between the male and the female connector. The mating portion of the male contact that engages the mating female spring fingered socket is referred to in the industry as the mating pin. It is the height or length of this pin and the position of the contacts within the connector's interface that this article addresses.

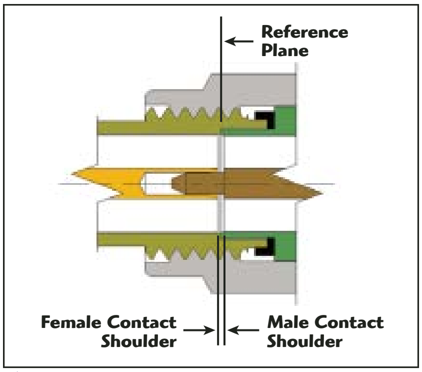
Fig. 1 Polarized male and female interfaces.



Pin heights are often taken for granted. We seldom think of its importance in traditional pin and socket configurations because they seldom fail in their application. RF connectors, particularly those used in microwave applications, require tightly toleranced interfaces to achieve the intended electrical and mechanical performance of the design. Most of a connector's interface dimensions are achieved through the tolerancing of the machined components that make up the interface. Setting and maintaining the pin height or the location of the pin requires that special attention be paid to correctly positioning it during the assembly of the connector components. Some connector designs require that the position of the center pin be set during attachment to the cable.

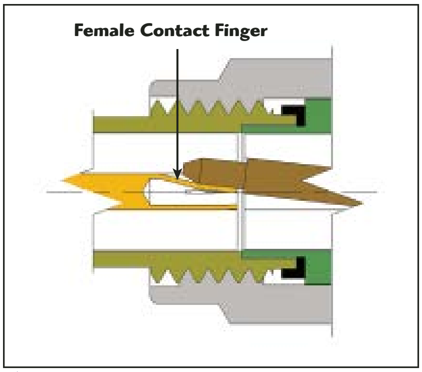
What is pin height? As mentioned earlier, most RF connector center contacts are designed to have a solid pin that inserts into a spring finger female contact or socket. In order to maintain the characteristic impedance and ensure electrical performance of the coaxial transmission line, most connector contacts incorporate a smaller diameter-mating pin

DAVID CRITELLI
Times Microwave Systems
Wallingford, CT

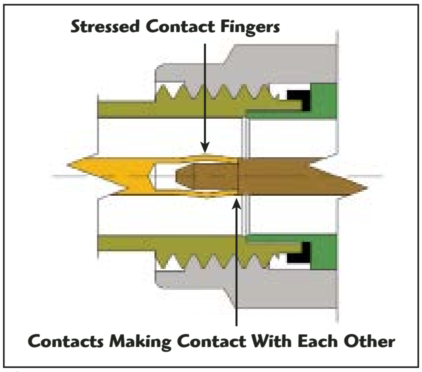


▲ *Fig. 2 Mated connectors making electrical contact at the connector reference planes.*

▲ *Fig. 3 Gauges used to measure connector interfaces.*



▲ *Fig. 4a Misaligned pin caught between insular and female contact fingers.*



▲ *Fig. 4b Contact between connector contacts could break female contact fingers.*

with a shoulder on one of the mating interfaces. This contact shoulder is located within the connector at a point where the mating connector seats against it and is optimized in a way to minimize electrical reflections created by discontinuities between the two connector interfaces. Likewise, the face of the mating female or socket contact (which is also referred to as the shoulder) must also be located within the connector at a position that optimizes performance. This point where the two connectors come together is called the connector reference plane (see ***Figure 2***).

The connector performs best when the shoulders of the male contacts are closest to the reference plane without going above it. The idea is to create the smallest gap possible between the two mating contact shoulders to minimize its impact on electrical performance. The size of the gap that can be tolerated is dependent on the intended operating frequency of the connector. Lower operating frequencies can tolerate larger gaps between the contacts without degrading electrical performance. However, coaxial connectors are designed to operate across broad frequency spectrums so the contact gap must be designed to perform with minimal electrical degradation at its highest operating frequency.

The pin height is measured from the connector's reference plane to the shoulder of the contact. High and low limits are characterized to ensure proper engagement length of the male pin with the mating connector's socket contact. The tip of the male pin also has a characterized taper to minimize mating forces on the female contact and to guarantee high mating cycles and long life.

Manufacturers control most of the pin's positioning and dimensioning through close tolerancing of the machined components associated with the connector's interface. However, close or tight tolerancing of the connector's interface components adds cost and seldom guarantees that the contact will be positioned to achieve optimal electrical and mechanical performance of the connector. Therefore, special attention needs to be given by the manufacturer to fine-tune the pin height and gap at the interface by resetting the contact's position during assembly to optimize performance. The responsibility of setting the contact into its optimal position may also be passed on to the end user if the connector is supplied with a loose contact to facilitate ease of cable termination.

More important than positioning the contact pin for optimal performance is positioning it to mate with any connector within its series (for example: SMA series, TNC series, N series, etc.), regardless of who manufactures the connector. For this reason, interface standards have been developed. There are a variety of industry, commercial and government standards in place that regulate interfaces dimensionally to guarantee intermateabilty between manufacturers' connectors. Government and/or industry standards govern most of the well-established connector interfaces on the market. However, newer products with uniquely designed interfaces may not yet be adopted by a standards group and have no governing standard. In these cases, the manufacturer that developed the unique interface is responsible for specifying and controlling the connector interface tolerances. Sometimes connector manufacturers will work together to develop a unique interface and together develop the interface standard for it. The QMA series interface was developed in this way.

Every connector series interface is unique with respect to other series interfaces. An SMA interface is uniquely different than a TNC interface, SMA and TNC interfaces are uniquely different to the N series interface, and so on. They all have different interface dimensions with respect to their size and the location of the contact's pin and shoulder position with respect to the connector's reference plane. Therefore, the gauging requirements for each interface are different. Most connector reference plans are located at some depth below the face of the connector (reference Figures 1 and 2). Special gauges are available for most well-established interfaces to make it easy to measure the location of the contact from the reference plane. Nonetheless, it is possible to measure the contact location with a standard dial indicator depth gauge (see ***Figure 3***). In the photograph the three smaller gauges are special interface gauges. The gauge mounted on the post is a standard dial indicator depth gauge. The importance of controlling pin height cannot be downplayed. The height of the pin cannot and should not be ignored. Problems result both mechanically and electrically if the pin is positioned too high (long) or too low (short) with respect to the interface as it is specified.

If the pin is too high or forward the pin could misalign during mating. The male pin could get caught between the insulator and the fingers of the female contact (see ***Figure 4a***). This typically results in a broken female contact. Also, if the contact's pin position is too high, the contact's shoulder could end up above the connector's reference plane (based on the fixed length of the pin-to-shoulder dimension subjected by most connector specifications). If the contact shoulder ends up above the connector reference plane there is the potential that it will make contact with the mating contact and break the female contact fingers (see ***Figure 4b***). These two conditions, the male pin getting wedged between the insulator and female contact, and the contact shoulders making contact with each other, have the potential to put enough force on the female contact finger to crack it. These cracks are internal to the connector and not visible to the end user. Cracks of this nature will ultimately lead to an intermittent signal, and an eventual catastrophic contact failure and kill signal integrity.

If the contact is positioned too low or short the contact could lose its contact with the mating female contact. This sometimes happens when blind mate connectors are positioned beyond their specified mounting tolerances. It can also happen in connectors that do not have captivated contacts. Non-captive contacts have the potential of being pulled back into the connector away from the mating connector by forces applied to it by the attached cable, thus shortening the mating pin height. Additionally, it leads to increased contact gaps between the mating contacts and contributes to higher than intended discontinuities in the connector interface and can degrade electrical performance from consequent high reflections. Power levels could be greatly reduced if the pin is positioned so far back that the mating contact fingers ride on the tapered section of the male pin (see ***Figure 5***). Significantly reduced power handling will result if the contact fingers ride on the taper section of the male pin.

End users attaching connectors to cable also need to be aware of the effects of incorrect pin heights. Contacts of connectors that are designed to attach to cable can be supplied loose by the manufacturer or captured within the connector.

Loose contacts are generally supplied to simplify the connector design and facilitate ease of assembly to the cable's center conductor while keeping the pricing in line with the user's expectations. This means some degree of accuracy is left up to the assembler to ensure proper location of the contact with respect to the connector's reference plane. Loose contacts can be either soldered or crimped onto the cable's center conductor. They can be set into position by either sitting the contact directly on the cable core, using a dielectric spacer or shim, or positioning the contact with a shim that is later removed after attachment of the contact is achieved. The idea is to provide the proper electrical spacing to optimize the cable-to-connector termination electrically and provide the proper positioning for the contact at the connector's interface (see ***Figure 6***).

Spring fingered center contact designs, most commonly made with heat treated beryllium copper, have greatly simplified the termination of connector contacts to cable center conductors. This design allows the cable's conductor to simply be pushed into the contact without the need to crimp or solder to maintain the electrical connection between the cable and the connector. The simplicity in cable termination comes from the fact that the contact no longer needs to be supplied loose and can now be supplied captured within the contactor assembly. Therefore, the assembler does not have to deal with separately terminating the contact to the cable and does not need to worry about setting the contact's proper placement location with respect to the connector's interface. The key to this style of contact in providing a reliable connection lies mainly with the manufacturer properly machining, forming and heat treating the contacts to provide the needed tight fit onto the cable's center conductor. Because the center contact is designed

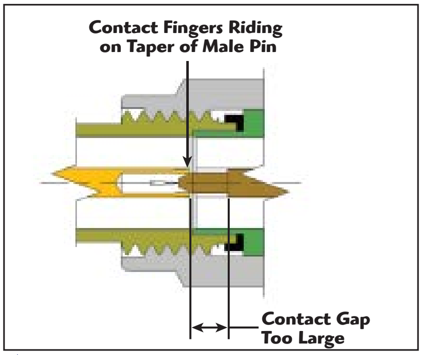


Fig. 5 Increased contact gaps lead to poor electrical performance.

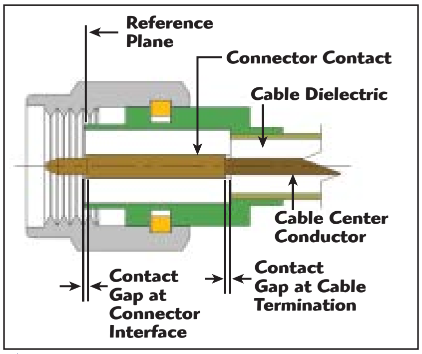


Fig. 6 Connector contact requires a specific gap at the mating interface and cable termination to optimize electrical performance.

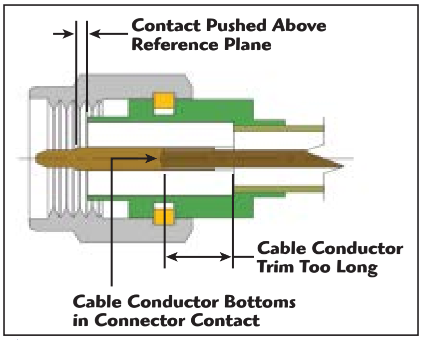
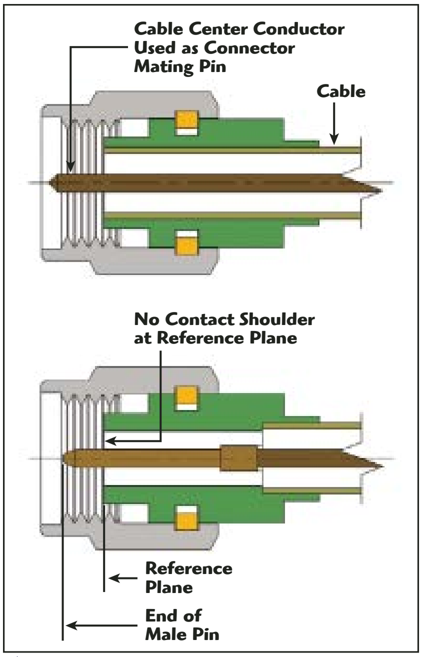


Fig. 7 Connector contact can be pushed above the reference plane by incorrectly trimmed cable center conductor.

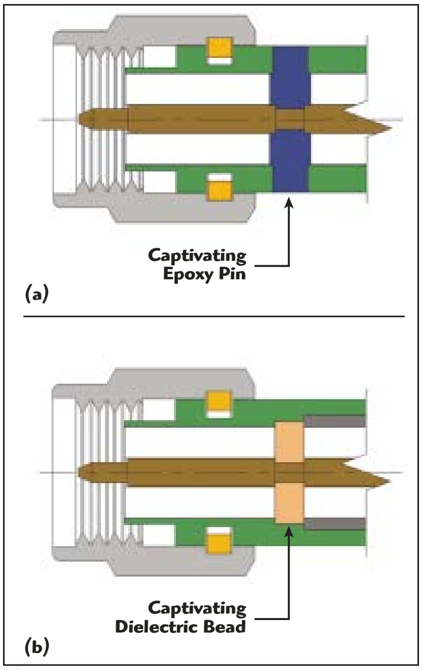
to fit tightly, not only must the center conductor be trimmed to the proper length but also the end needs to be free of all burrs and slightly pointed at the end for proper fit. This part of the assembly to the cable is still left up to the end user and requires some attention to cable prep detail.

Regardless of the type of contact termination to cable, the correct length of cable center conductor must be exposed to accept the center contact. Exposure of too little cable center conductor could result in a weakened and compromised contact attachment for connectors supplied with loose contacts. Exposure of too much cable center conductor will cause the cable conductor to bottom inside the contact and not allow it to be positioned on the cable as intended. This results in pins that are positioned higher in the connector interface with respect to the reference plane. The connector contact could be pushed so far forward that it ends up above the reference plane of the connector and potentially cause damage to the mating female socket as described earlier (see ***Figure 7***).

There are a few connector designs that do not use the traditional pin/shoulder configuration in the mating interface. Although most contacts are attached to a cable's center conductor using methods such as sol-



▲ *Fig. 8 Examples of connector designs without a contact shoulder.*



▲ *Fig. 9 Epoxy pin (a) and dielectric bead (b) used to captivate connector contact.*

dered, crimped or a spring fingered socket, there are a couple of cases in some SMA, F and other connector series where the cable center conductor is actually used as the center contact mating pin of the connector. There are still other designs that use a separate contact but have no shoulder at the connector interface. In these designs, the mating pin diameter is carried straight into the transmission line section within the connector; thus, no shoulder exists at the connector reference plane (see ***Figure 8***). In these cases, one still must be conscious of where the end of the male pin is located in relation to the reference plane even though there is no shoulder to worry about. This is because there is a limit to the amount of male pin that the mating female contact can accommodate.

Even after the contact is fixed to the cable center conductor and the connector secured, the position of the pin can still be moved from its set position. There are influences on the connector pin position other than those subjected by the connector manufacturer and end user during assembly to the cable. The connector pin or contact can be subjected to forces after assembly that influences the contact's position within the connector with respect to the connector's interface. High stresses can be subjected by cable flexure, pulling on the connector, and expansion and contraction of the connector and cable dielectrics over temperature that cause pin movement. These stresses build in compression or tension depending on the force applied, and push the contact forward or pull it backwards into the connector away from its optimally set position. When that happens, the contact could be moved beyond the design or specification limits of the connector interface resulting in one of the performance issues described earlier.

Most of these stresses can be overcome by incorporating some form of captivation into the connector design. The roll of captivation is to hold the contact into position within the connector under a predetermined load condition to prevent it from moving forward or backward with respect to the connector reference plan. Most connectors use Teflon® as a dielectric medium because of its good electrical characteristics and relative cost. However, Teflon is a soft material and may not be suitable to use as a reliable captivating material in high performance connectors or in environments where mechanical stresses could be high. For this reason, other types of materials and captivating schemes have been developed to hold the contact in its place.

There are many different types and ingenious captivation methods used to capture a contact within a connector. Epoxy pins and dielectric beads are the most common methods used to hold contacts in place under higher load applications.

An epoxy pin is a dielectric epoxy that is injected through a hole in the connector dielectric and around the contact and in some designs through a hole in the connector body. The epoxy cures into a hard plastic material that mechanically captures the components together (see ***Figure 9***).

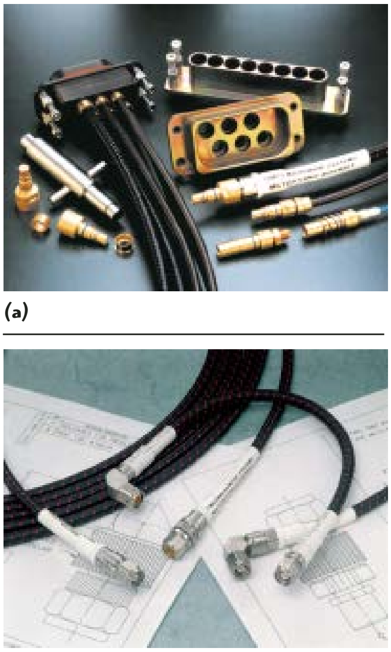
Dielectric beads use a short length of dielectric material having relatively high mechanical strength. These beads are typically machined or molded. The connector contact and body are configured in such a way that they capture the bead to prevent movement (see Figure 9). Some popular high strength bead materials that have relatively good dielectric properties are PEEK,® Ultem,® Torlon® and Vespel.®

The material and method used for captivating a connector center contact is typically selected based on a mechanical force requirement and a price-to-performance trade off.

Other manufacturers of higher performance connectors and cable assemblies that design to meet the highest application requirements with respect to temperature, flexing and vibration while maintaining the highest electrical performance develop their own proprietary materials and captivation methods. This need for super performing connectors and cable assemblies has resulted in new generations of connector products. ***Figure 10*** shows some of the newest products developed by Times Microwave Systems to meet today's toughest application requirements.

The position of the pin is taken for granted because most users have never seen an application failure resulting from an improperly positioned or shifted contact pin. Even so, some engineers are haunted by system-related performance issues caused by a single RF connector within a system with a misaligned pin, broken contact or open circuit caused by an improperly positioned or shifted pin. For those, the importance of maintaining proper connector pin height will remain a critical performance issue.

There are many factors used to control the correct pin position within a connector interface. Manufacturers work to tighten tolerances on connector interfaces by tightly tolerancing components during manufacturing to achieve the desired electrical and mechanical performance of the mating pin. Special care is taken in setting the pin to the



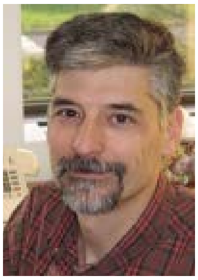
(a)

(b)

▲ *Fig. 10 Multi-port Interconnect Systems (a) and MILTECH Cable Assemblies (b) developed by Times Microwave Systems to meet today's tough application requirements.*

optimal height during connector component assembly. Specifications have been created by standards and government committees to govern pin height on the most common connectors to guarantee intermateability within connector series. Additionally, there has been a myriad of captivations employed to limit or even prevent pin movement in the harshest environments. All these efforts demonstrate that pin height is being given the attention necessary to make it worry free for the end user. ■

Teflon is a registered trademark of DuPont.
PEEK is a trademark of Victrex.
Ultem is a registered trademark of General Electric.
Torlon is a registered trademark of Solvoy Advanced Polymers.
Vespel is a registered trademark of DuPont.



David Critelli *is a regional sales manager for Times Microwave Systems, responsible for all OEM sales in southern New York, northern New Jersey and most of New England. Before joining Times, he worked for AEP and Radiall Co., where he was an engineering manager. He holds both a BS degree in computer science and an MBA degree and has over 25 years experience in the microwave cable and connector industry.*


Microwave
Honolulu, Hawai'i
Reserve a room at conference rates now at www.IMS2007.org
IMS2007
MICROWAVES ACROSS THE PACIFIC
International Microwave Symposium
RFIC Symposium · ARFTG Symposium
IEEE
MTT-S
www.IMS2007.org
www.gohawaii.com
Photo by Laszlo Ilyes

A WATERPROOF QMA COAXIAL CONNECTOR

Five years ago Huber + Suhner developed a range of QMA coaxial connectors to replace the SMA connectors that had been traditionally used. Although they have been primarily used in the telecom market for radio base stations they have also been recognized widely in other market sectors. This wide acceptance instigated an investigation into the development of the QMA waterproof RF coaxial connector, prompted by the fact that there is no snap-on RF connector on the market that is water sealed.

For such a product to be developed the main factor that needed to be addressed was the fact that normally these connectors incorporate a spring member, which makes it difficult to make it waterproof. The challenge was not only to overcome this inherent problem but also to develop a waterproof plug that is backwards compatible with a standard QMA female. However, it was not possible to just put an O-ring inside the existing QMA connector. This is because it has a spring mechanism that has spring fingers, which is a slotted part. This restricts the space so that there is no room to accommodate an O-ring seal.

A COMPLETE REDESIGN

To address this limitation Huber + Suhner came up with a new concept whereby they took the existing female and endeavored to design a new plug around it. However, this meant a complete redesign of the connector interface so that the spring fingers were repositioned differently inside the connector, while maintaining the same outer dimensions of the connector. It needed to be the same size to achieve the same centre line to centre line as the standard QMA. Several concepts were considered before finally settling on one that met all the design and applications criteria to produce a connector plug that is water sealed according to IP68.

The challenge in redesigning the QMA interface was to maintain or even exceed the proven performance parameters of the Quick Lock concept. A critical issue is the fact that the diameter of the male spring part, which snaps onto the female body, will enlarge a

HUBER + SUHNER AG
Herisau, Switzerland

certain amount under mechanical and/or thermal stress. This is the normal behavior of any spring material, and is related to material relaxation. This behaviour will have an impact on the contact force, which determines the transmission characteristics. Careful material selection and spring part layout ensures optimum connector performance under stress.

During the development phase the QMA connector underwent verification testing. Particularly important was environmental testing, which, in order to widen the applications, was conducted to military standards. Hence, a higher level of vibration tolerance was required.

▲ *Fig. 1 The waterproof QMA connector terminated on a flexible cable.*

▲ *Fig. 2 A standard QMA panel jack with O-ring seal.*

▲ *Fig. 3 Application with high density connector population including waterproof QMAs on the right.*

The result of this development and testing is a waterproof version of the high density Quick-Lock connector that can be used for a multitude of RF applications. The waterproof QMA connector terminated on a flexible cable, featuring a crimped cable entry with heat shrink tube, is shown in ***Figure 1***. With its outstanding features like IP68 ingress protection rating, its ability to be intermateable with a QLF® certified standard QMA jack (see ***Figure 2***), having the same outline as a standard QMA, an enhanced temperature rating of +105°C and MIL vibration level, it will not only be applicable for the telecom market but also the defense and industrial sectors.

SPECIFICATIONS

From a specifications standpoint, the QMA interface exhibits its best transmission characteristics in the DC to 6 GHz range. Suitable applications include radio base stations and other radio equipment, especially where high density connector population is required, as shown in ***Figure 3***. The interface's snap-lock mechanism makes it very fast and easy to mate and de-mate, with little force needed. The interface retention force is 60 N.

Advantages of fast mating and demating include reducing the user's total operating costs without loss of quality or functionality, while the replacement of the threaded coupling mechanism by the snap-lock mechanism increases the packing density as no torque wrench clearance is necessary. The QMA connector also allows 360° rotation in the mated position, which improves the flexibility during the installation of terminated cables.

Electrically the waterproof QMA connector has an impedance of 50 Ω, an interface frequency range of DC to 18 GHz, a minimum return loss of –32 dB at DC to 3 GHz and –25 dB at 3 to 6 GHz, and a minimum RF leakage of –80 dB at DC to 3 GHz and –70 dB at 3 to 6 GHz. Mechanically it has a minimum durability of 100 cycles and a typical engagement/disengagement force of 25 N/20 N.

Environmentally the connector is RoHS compliant, has an operating temperature of –40° to +105°C, and is moisture resistance to MIL-STD-202, method 106 F, thermal shock to MIL-STD-202, method 107, condition B, vibration to MIL-STD-202, method 204, condition D, shock to MIL-STD-202, method 213, condition I and corrosion to MIL-STD-202, method 101, condition B.

The watertight QMA product line currently includes straight and angular connectors for flexible and semi-rigid cables as well as terminations. However, as Huber + Suhner is the only company with such a design on the market, it is likely that it will talk to other partners in the QLF® Alliance and issue licenses for the product in order to ensure second sourcing possibility to its customers.

CONCLUSION

The new waterproof QMA coaxial connector may not look any different to a standard connector on the outside but has to be very different on the inside in order for it to be waterproof. It is not just a standard QMA connector with an additional O-ring seal either, as the interface has been completely redesigned. Consequently, the interface complies with the existing standards and is backwards compatible with an existing female QMA connector, so that customers with female connectors on their equipment can mate with the new waterproof QMA plug.

It has also been designed with users in mind who need fast and space saving connections in outdoor applications such as wireless communications and transmission systems, portable radio systems, air traffic control and monitoring systems, and assemblies for mobile radio base stations. The new QMA connector essentially supports all radio frequency connections.

**Huber + Suhner AG,
Herisau, Switzerland
+41 71 353 41 11,
www.hubersuhner.com.**

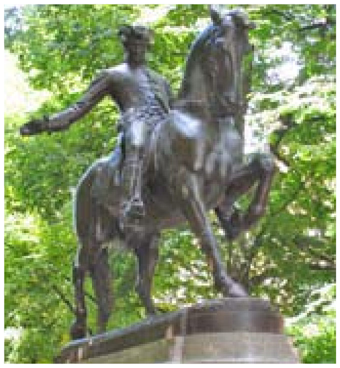
RS No. 302

Visit www.mwjournal.com to review previous editions of *Microwave Journal*'s Cables & Connectors supplement.

Come to Boston Massachusetts...

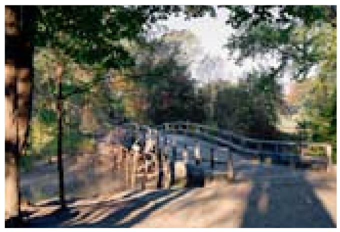
"The place where it all began"

On Patriot's Day
Monday April 16, 2007

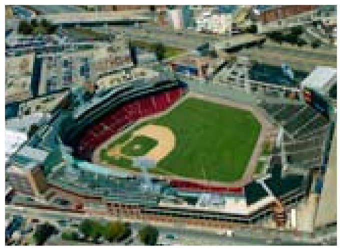


Paul Revere's Midnight Ride

Battle on Lexington Green



Battle at North Bridge



Boston Red Sox Home Game

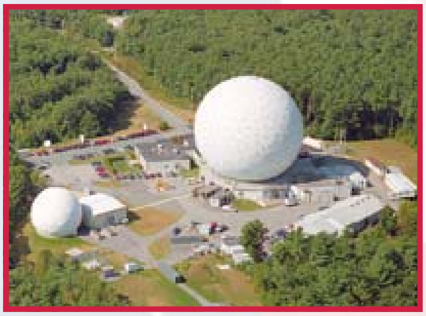
Boston Marathon

IEEE Radar Conference

17-20 April 2007
The Westin Hotel, Waltham, MA

Conference Highlights:

- Over 100 technical papers
- Topics covering all aspects of radar and radar systems
- Two days of short courses from leaders in the field
- Tour MIT Lincoln Laboratory's new 96GHz Haystack Radar in Westford
- Tour Raytheon's premier MMIC Foundry in Andover
- Military radar industry and commercial exhibitors



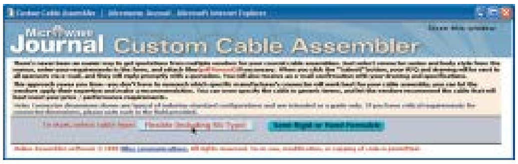
Haystack Upgrade, Westford, MA

Raytheon Foundry, Andover, MA

Sponsored by
IEEE Aerospace & Electronic Systems Society,
IEEE Boston Section

Technical Cosponsors
IEEE Antennas and Propagation Society,
IEEE Space Geoscience & Remote Sensing Society,
IEEE Microwave Theory & Techniques Society,
IEEE Signal Processing Society

www.radar2007.org

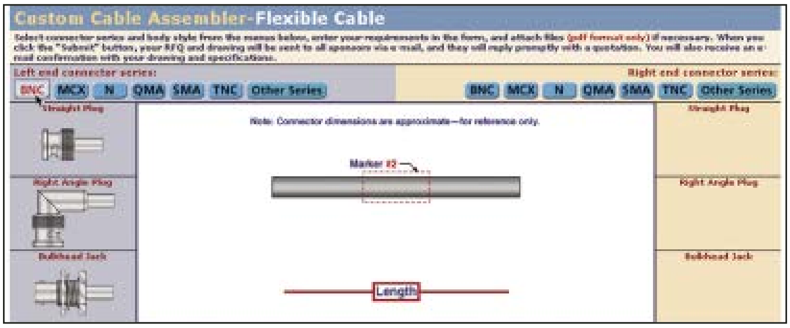


A CUSTOM CABLE ASSEMBLY PROCUREMENT TOOL

All businesses in an increasingly competitive market must continually look for ways to offer real value to their customers, particularly by building web sites that go beyond a simple presentation of product information. A web site built with customer benefit in mind will not just contain product information; it should provide extra services that streamline access to specific information, and provide productivity tools as well.

In order to provide such a productivity tool, *Microwave Journal* (*MWJ*) has unveiled a time-saving tool for its readers who need to solicit quotations from cable assembly manufacturers. The *Custom Cable Assembler* offers *MWJ* readers the ability to visually assemble connectors to cable, type in mechanical and electrical specifications, and send the drawing and specs to multiple vendors with one mouse click. Unlike the majority of existing on-line tools, the *Custom Cable Assembler* works right in the web browser, with *no* software to download and *no* plug-ins required.

Fig. 1 Selecting connector series and configuration.



Using the *Custom Cable Assembler* is simple and intuitive. After choosing between flexible or semi-rigid cable, a window appears with a menu of six different commonly used connector series, with an option to specify any series that is not in the menu. Clicking on a series button (see ***Figure 1***) presents a choice of three configurations in that series. Clicking on a configuration automatically adds it to the drawing in the central window, as shown in ***Figure 2***. Repeating the process for the right-end connector produces a drawing with the length callout properly located for the configurations chosen (see ***Figure 3***). All connector selections are "undoable"—to change a series or configuration, simply click on a different one.

MICROWAVE JOURNAL
Norwood, MA

prepare to engage

Prepare yourself for a new kind of relationship with San-tron. A relationship that combines experience and service with a passion to earn your business. Over the last 50 years, we've taken pride in being a trusted supplier of standard and custom engineered coaxial solutions. We have an extensive catalog of products from SMA to LC to cable assemblies and our custom engineering capabilities are unsurpassed. Engage with us today, and experience the quality, service, selection, and pricing you're looking for.

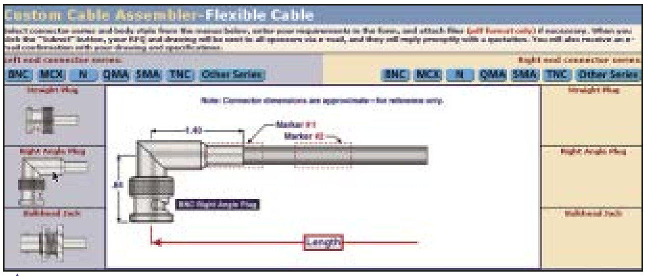
San·tron

ISO 9001

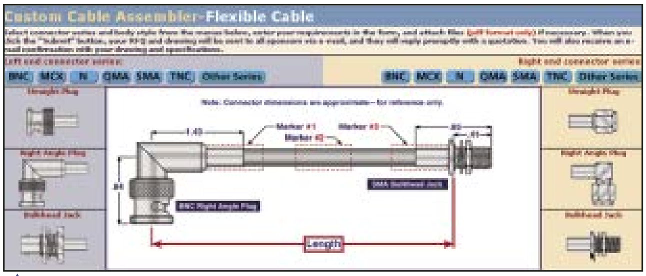
www.santron.com

978-356-1585

ROHS compliant



▲ *Fig. 2 Adding the selected connector.*



▲ *Fig. 3 Adding the second connector.*

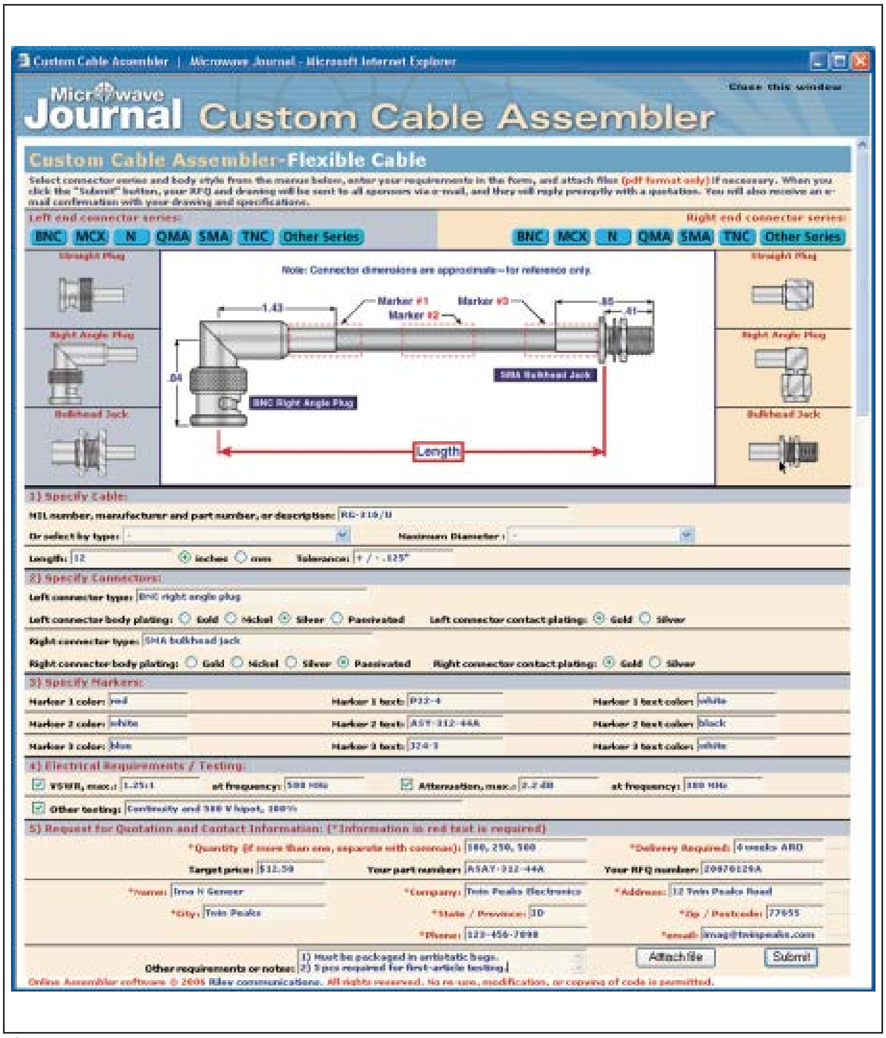
When a connector is chosen, the "connector type" text field in the form is automatically filled in. The form also allows the user to specify length and tolerance, connector plating, marker color and text, electrical specifications and testing requirements, along with other RFQ information, as shown in ***Figure 4***. Users also have the option to attach drawings if necessary, such as when specifying a semi-rigid cable assembly that requires bending to its final configuration.

Custom Cable Assembler users can even save time and research by specifying cable "generically" (see ***Figure 5***), and letting the vendors recommend a specific cable type that will satisfy the user's requirements. This option is available for semi-rigid cables as well.

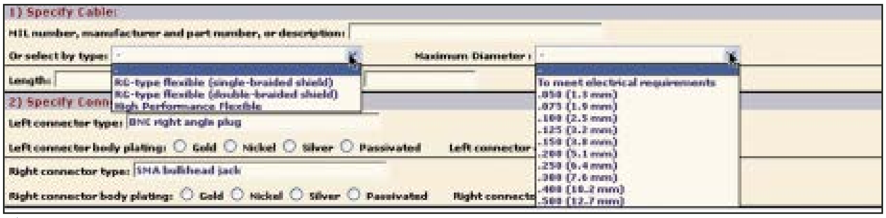
When the "Submit" button is clicked, the form information and the drawing are immediately e-mailed to all vendors for price and delivery quotation, and the form and drawing are e-mailed to the user as well. A confirmation page is automatically generated, giving the user the option to print the drawing and form, and to begin specifying another assembly.

There's never been an easier or more convenient way to specify cable assemblies and send the information to multiple vendors for quotation. A demo version of the tool may be accessed at www.onlineassembler.com/MWJdrawdemo/mwjdraw1.html for anyone wishing to sample the tool inactively. For additional information, visit www.onlineassembler.com. Now procuring custom cable assemblies is just a click away.

The *MWJ Custom Cable Assembler* is a proprietary, licensed derivative of Online Assembler software, ©2006 by Riley Communications. All rights reserved. No copying, recompiling or re-use of code is permitted.



▲ *Fig. 4 Adding the remaining specifications.*



▲ *Fig. 5 Specifying the cable generically.*

Microwave Journal,
Norwood, MA (781) 769-9750,
www.mwjournal.com.

RS No. 304

Cables & Connectors Supplement Advertiser Index

Sales Representatives

Carl Sheffres, Publisher **Ed Johnson, Associate Publisher** **Ken Hernandez, Traffic Administrator**

Eastern and Central Time Zones
Chuck Curley
Northeast Reg. Sales Mgr.
(New England, Upstate NY, Eastern Canada)
685 Canton Street
Norwood, MA 02062
Tel: (781) 769-9750
FAX: (781) 769-5037
ccurley@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

Brian Green
Inside Sales Manager
685 Canton Street
Norwood, MA 02062
Tel: (781) 769-9750
FAX: (781) 769-5037
bgreen@mwjournal.com

Eastern and Central Time Zones
Ed Johnson
Associate Publisher
PO Box 5962
Ocala, FL 34478-5962
Tel: (352) 620-2442
FAX: (352) 620-2443
ejohnson@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
Tel: +44 207 596 8742
rvaughan@horizonhouse.co.uk

Michel Zoghob
Deputy Publisher
Tel: +44 207 596 8741
mzoghob@horizonhouse.co.uk

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

Germany, Austria, and Switzerland (German-speaking)
Juergen Wissling
Wissling Marketing Services
Riedstrasse 5
72813 St. Johann-Wuertingen
Germany
Tel: +49 7122 828140
FAX: +49 7122 828145
jwissling@horizonhouse.com

Israel
Oreet Ben Yaacov
Oreet International Media
15 Kineret Street
51201 Bene-Berak, Israel
Tel: +972 3 570 6527
FAX: +972 3 570 6526
obenyaacov@horizonhouse.com

Korea
Young-Seoh Chinn
JES Media International
2nd Floor, ANA Bldg.
257-1, Myungil-Dong
Kangdong-Gu
Seoul, 134-070 Korea
Tel: +82 2 481-3411
FAX: +82 2 481-3414
yschinn@horizonhouse.com

Japan
Katsuhiro Ishii
Ace Media Service Inc.
12-6, 4-Chome,
Nishiiko, Adachi-Ku
Tokyo 121-0824, Japan
Tel: +81 3 5691 3335
FAX: +81 3 5691 3336
amskatsu@dream.com

China
Alexander Glos
i2i Media
16-602 China Central Place
89# Jian Guo Road
Chaoyang District, Beijing, China - 100025
Tel: ++86-10-65331960/61
FAX: ++86-10-65331959
aglos@i2i-m.com.cn